

chapter 1

Introduction and Research Methods

Prologue

Just a Game?

Walking into our 9:30 class on the Monday after Thanksgiving break, we could hear our students already engaged in a lively debate. Stacking our notebooks on the table at the front of the class, we started setting up the overhead projector. We were half-listening to the students talking and arguing when several words seemed to suddenly punctuate the air: *Columbine. Massacre. Plot. Guns. Jocks and preppies. Outcasts.*

We glanced at each other. *Another Columbine?*

"I remember how I felt in high school," Tanisha was saying. "It seemed like every other day was just another chance to get picked on. But I can't imagine wanting to kill everybody at school."

"Jared, what are you guys talking about?" Don asked as he fiddled with the focus on the overhead projector.

"There was this thing on the news this morning about the police arresting five high school students in Massachusetts who were supposedly planning a massacre like the one at Columbine," Jared explained.

"Did anyone get hurt?" Sandy asked.

"Nobody got hurt," Nicole answered. "This one girl warned her favorite teacher not to go to the high school because these other students were planning the attack."

"I was telling them that I heard this military psychologist talk at Holland Hall," Carla added. "He claimed that playing violent video games was involved in the school shootings at Columbine, Jonesboro, and that place in Kentucky."

"Was that the presentation by Dave Grossman?" Sandy asked.

"That was him!" Carla responded. "He had all these graphs showing how violent video games teach kids how to kill and make them think that shooting people is cool."

"I went to his talk," Don said. "Grossman made some interesting points."

"Man, that is so *not* true!" Kyle interjected. "I play *Quake III* and *Doom* all the time. They're fun! They're just shoot-'em-up video games!"

Kyle was one of those students who had stood out in class from the first day. Eighteen years old, six-foot-four, almost always wearing a red OU baseball cap and a "Students for Christ" T-shirt or sweatshirt, a professed Scooby-Doo addict, *and* the top scoring student in all of his classes. Not the kind of young man that you'd expect to be spending his free time racking up kills on a video game.

"It may not affect you, Kyle, but I won't let either of my boys play those kinds of games," Kim said. "I think those boys at Columbine were addicted to those violent video games."

Chapter Outline

Prologue: Just a Game?

Introduction: The Origins of Psychology

Contemporary Psychology

Box 1.1: What Is Cross-Cultural Psychology?

The Scientific Method

Box 1.2: What Is Critical Thinking?

Descriptive Research Methods

The Experimental Method

Box 1.3: What Is a Pseudoscience?

Ethics in Psychological Research

Box 1.4: Questions About the Use of Animals in Psychological Research

APPLICATION: Evaluating Mass Media Reports About Psychology

Chapter Review

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What Do Psychologists Study? Flirting and friendship, attraction and relationships. Public behavior, private thoughts. Happiness and hope, stress and pessimism. These are just a few of the wide range of topics studied in *psychology*, the science of behavior and mental processes. But whether psychologists study the behavior of a single brain cell or the behavior of a crowd in a football stadium, they rely on the scientific method to guide their investigations.

"I don't think the video games had anything to do with it," Kyle insisted. "Those kids had other problems, serious psychological problems."

"Maybe so," Sandy said. "Still, it's an interesting question. I think there's quite a bit of research on that topic."

"Let's talk about this," Don said. "How could you test the claim that violent video games make people more aggressive?" As the discussion continued, we volunteered to look up some of the original research studies on the effects of video games and bring them to the next class. Later in the chapter, you'll see what we uncovered.

As this spontaneous class discussion demonstrated, psychology is a science that speaks to our lives in very real and meaningful ways. Indeed, many of the topics we cover strike a responsive chord in our students. As teachers, we've found that building on the many links between psychological knowledge and our students' personal experiences is a very effective way to learn about psychology.

Throughout this text, you'll see that we frequently relate new information to familiar experiences or use personal examples to illustrate abstract concepts. In linking familiar information to new information, our goal is to build a conceptual bridge between your existing knowledge and the new material that you need to learn. A key component of this approach is the Prologue that opens every chapter. Each Prologue is a true story about real people and events. The Prologue lays the groundwork for the chapter by introducing some of its major themes, and it shows you how those themes are linked to everyday life and familiar situations.

In this introductory chapter, we'll establish the foundation for the rest of the text. We'll build a bridge to the past as you learn about some of the key players who helped establish psychology as a science. One was the famous American psychologist William James. James was a master teacher who understood that information that is personally meaningful is better comprehended and remembered. We'll also establish a bridge to the present as we look at how psychologists investigate questions about behavior and mental processes—including whether playing violent video games can make people more aggressive. We hope that you, like our students, will see how psychological findings can make a difference in your own life.

Welcome to psychology!

Introduction

The Origins of Psychology

Key Theme

- Today, psychology is defined as the science of behavior and mental processes, a definition that reflects psychology's origins and history.

Key Questions

- How did philosophy and physiology affect the emergence of psychology as a science?
- What roles did Wundt and James play in establishing psychology?
- What were the early schools and approaches in psychology, and how did their views differ?

We begin this introductory chapter by stepping backward in time to answer several important questions: How did psychology begin? When did psychology begin? Who founded psychology as a science?

It's important to consider these historical issues for several reasons. First, students are often surprised at the wide range of topics studied by contemporary psychologists. Those topics can range from the behavior of a single brain cell to the behavior of people in groups, from prenatal development to old age, and from normal behavior and mental processes to severely maladaptive behavior and mental processes. As you become familiar with how psychology began and developed, you'll have a better appreciation for how it has come to encompass such diverse subjects.

Second, you need to understand how the definition of **psychology** has evolved over the past century to what it is today—the *science of behavior and mental processes*. Indeed, the history of psychology is the history of a field struggling to define itself as a separate and unique scientific discipline. The early psychologists struggled with such fundamental issues as:

- How should psychology be defined?
- What is the proper subject matter of psychology?
- Which areas of human experience should be studied?
- What methods should be used to investigate psychological issues?
- Should psychology include the study of nonhuman animal behavior?
- Should psychological findings be used to change or to enhance human behavior?

These debates helped set the tone of the new science, define its scope, and set its limits. Over the past century, the shifting focus of these debates has influenced the topics studied, the emphasis given to particular areas, and the research methods used.

The Influence of Philosophy and Physiology

The earliest origins of psychology can be traced back several centuries to the writings of the great philosophers. More than two thousand years ago, the Greek philosopher Aristotle wrote extensively about topics like sleep, dreams, the senses, and memory. He also described the traits and dispositions of different animals (Robinson, 1997). Many of Aristotle's ideas remained influential until the beginnings of modern science in the seventeenth century.

At that time, the French philosopher René Descartes (1596–1650) proposed a doctrine called *interactive dualism*—the idea that mind and brain were separate entities that interact to produce sensations, emotions, and other conscious experiences. Today, psychologists continue to debate the relationship between mental activity and the brain.

Philosophers also laid the groundwork for another issue that would become central to psychology—the *nature–nurture issue*. For centuries, philosophers debated which was more important: the inborn *nature* of the individual or the environmental influences that *nurture* the individual. Psychologists continue to focus on this question, which today is usually framed in terms of *heredity versus environment*.

Such philosophical discussions influenced the topics that would be considered in psychology. But the early philosophers



psychology

The scientific study of behavior and mental processes.

Nature or Nurture? Both mother and daughter are clearly enjoying the experience of painting together. Is the child's interest in painting an expression of her natural tendencies, or is it the result of her mother's encouragement and teaching? Are such environmental factors more important than the child's inborn abilities? Originally posed by philosophers hundreds of years ago, such questions continue to interest psychologists today.

Wilhelm Wundt (1832–1920) German physiologist Wilhelm Wundt is generally credited as being the founder of psychology as an experimental science. In 1879, he established the first psychology research laboratory in Leipzig, Germany. By the early 1900s, many American students had come to study at Wundt's facilities, which now occupied several floors at the university. By that time, Wundt's research had expanded to include such topics as cultural psychology and developmental psychology.

could advance the understanding of human behavior only to a certain point. Their methods were limited to intuition, observation, and logic.

The eventual emergence of psychology as a science hinged on advances in other sciences, particularly physiology. *Physiology* is a branch of biology that studies the functions and parts of living organisms, including humans. In the 1600s, physiologists were becoming interested in the human brain and its relation to behavior. By the early 1700s, it was discovered that damage to one side of the brain produced a loss of function in the opposite side of the body. By the early 1800s, the idea that different brain areas were related to different behavioral functions was being vigorously debated. Collectively, the early scientific discoveries made by physiologists were establishing the foundation for an idea that was to prove critical to the emergence of psychology—namely, that scientific methods could be applied to issues of human behavior and thinking.

Wilhelm Wundt

The Founder of Psychology

By the second half of the 1800s, the stage had been set for the emergence of psychology as a distinct scientific discipline. The leading proponent of this idea was a German physiologist named **Wilhelm Wundt**. Wundt used scientific methods to study fundamental psychological processes, such as mental reaction times in response to visual



or auditory stimuli. For example, Wundt tried to measure precisely how long it took a person to consciously detect the sight and sound of a bell being struck.

A major turning point in psychology occurred in 1874, when Wundt published his landmark text, *Principles of Physiological Psychology*. In this book, Wundt outlined the connections between physiology and psychology. He also promoted his belief that psychology should be established as a separate scientific discipline that would use experimental methods to study mental processes (Fancher, 1996). A few years later, in 1879, Wundt realized that goal when he opened the first psychology research lab-

oratory at the University of Leipzig. Many regard this event as marking the formal beginning of psychology as an experimental science (Bringmann & others, 1997).

Wundt defined psychology as the study of consciousness and emphasized the use of experimental methods to study and measure consciousness. Until he died in 1920, Wundt exerted a strong influence on the development of psychology as a science. Two hundred students from around the world, including many from the United States, traveled to Leipzig to earn doctorates in experimental psychology under Wundt's direction (Benjamin, 1997). Over the years, some 17,000 students attended Wundt's afternoon lectures on general psychology, which often included demonstrations of devices he had developed to measure mental processes (Blumenthal, 1998).

Edward B. Titchener

Structuralism

One of Wundt's most devoted students was a young Englishman named **Edward B. Titchener**. After earning his psychology doctorate in Wundt's laboratory in 1892, Titchener accepted a position at Cornell University in Ithaca, New York. There he established a psychology laboratory that ultimately spanned 26 rooms.

Titchener eventually departed from Wundt's position and developed his own ideas on the nature of psychology. Titchener's approach, called *structuralism*, became the first major school of thought in psychology. **Structuralism** held that even our most complex conscious experiences could be broken down into elemental *structures*, or component parts, of sensations and feelings. To identify these structures of conscious thought, Titchener trained subjects in a procedure called *introspection*. The subjects would view a simple stimulus, such as a book, and then try to reconstruct their sensations and feelings immediately after viewing it. (In psychology, a *stimulus* is anything perceptible to the senses, such as a sight, sound, smell, touch or taste. They might first report on the colors they saw, then the smells, and so on, in the attempt to create a total description of their conscious experience (Tweney, 1997).

In addition to being distinguished as the first school of thought in early psychology, Titchener's structuralism holds the dubious distinction of being the first school to disappear. With Titchener's death in 1927, structuralism as an influential school of thought in psychology essentially ended. But even before Titchener's death, structuralism was often criticized for relying too heavily on the method of introspection.

As noted repeatedly by Wundt and others, introspection had significant limitations (Blumenthal, 1998). First, introspection was an unreliable method of investigation. Different subjects often provided very different introspective reports about the same stimulus. Even subjects well trained in introspection varied in their responses to the same stimulus from trial to trial.

Second, introspection could not be used to study children or animals. Third, complex topics, such as learning, development, mental disorders, and personality, could not be investigated using introspection. In the end, the methods and goals of structuralism were simply too limited to accommodate the rapidly expanding interests of the field of psychology.

William James

Functionalism

By the time Titchener arrived at Cornell University, psychology was already well established in the United States. The main proponent of American psychology was one of Harvard's most outstanding teachers—**William James**. James had first become intrigued by the emerging science of psychology after reading one of Wundt's articles, entitled "Recent Advances in the Field of Physiological Psychology," in the late 1860s.

In the early 1870s, James began teaching a physiology and anatomy class at Harvard University. An intense, enthusiastic teacher, James was prone to changing the subject matter of his classes as his own interests changed (B. Ross, 1991). Gradually, his lectures came to focus more on psychology than on physiology. By the late 1870s, James was teaching classes devoted exclusively to the topic of psychology.

At about the same time, James began writing a comprehensive textbook of psychology, a task that would take him more than a decade. James's *Principles of Psychology* was finally published in two volumes in 1890. Despite its length of more than 1,400 pages, *Principles of Psychology* quickly became the leading psychology textbook. In it, James discussed such diverse topics as brain

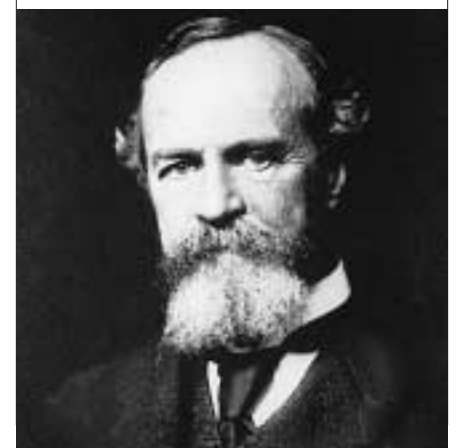
structuralism

Early school of psychology that emphasized studying the most basic components, or structures, of conscious experiences.



Edward B. Titchener (1867–1927) Born in England, Titchener studied with Wundt in Germany and then became a psychology professor at Cornell University in 1892. In contrast to the psychology programs at both Harvard and Columbia Universities at the time, Titchener welcomed women into his graduate program at Cornell. In fact, more women completed their psychology doctorates under Titchener's direction than with any other male psychologist of his generation (Evans, 1991).

William James (1842–1910) Harvard professor William James was instrumental in establishing psychology in the United States. In 1890, James published a highly influential text, *Principles of Psychology*. James's ideas became the basis of another early school of psychology, called *functionalism*, which stressed studying the adaptive and practical functions of human behavior.

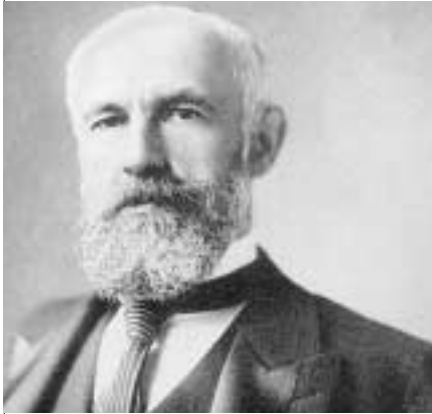


functionalism

Early school of psychology that emphasized studying the purpose, or function, of behavior and mental experiences.

psychoanalysis

Personality theory and form of psychotherapy that emphasizes the role of unconscious factors in personality and behavior.



G. Stanley Hall (1844–1924) G. Stanley Hall helped organize psychology in the United States. Among his many achievements, Hall established the first psychology research laboratory in the United States and founded the American Psychological Association. In 1888, Hall became the first president of Clark University in Worcester, Massachusetts.

Mary Whiton Calkins (1863–1930) Under the direction of William James, Mary Whiton Calkins completed all the requirements for a Ph.D. in psychology. Calkins had a distinguished professional career, establishing a psychology laboratory at Wellesley College and becoming the first woman president of the American Psychological Association.



function, habit, memory, sensation, perception, and emotion. James's dynamic views had an enormous impact on the development of psychology in the United States (Bjork, 1997b).

James's ideas became the basis for a new school of psychology, called functionalism. **Functionalism** stressed the importance of how behavior *functions* to allow people and animals to adapt to their environments. Unlike structuralists, functionalists did not limit their methods to introspection. They expanded the scope of psychology research to include direct observation of living creatures in natural settings. They also examined how psychology could be applied to areas such as education, child rearing, and the work environment.

Both the structuralists and the functionalists thought that psychology should focus on the study of conscious experiences. But the functionalists had very different ideas about the nature of consciousness and how it should be studied. Rather than trying to identify the essential structures of consciousness at a given moment, James saw consciousness as an ongoing stream of mental activity that shifts and changes. As James wrote in *Talks to Teachers* (1899):

Now the *immediate* fact which psychology, the science of mind, has to study is also the most general fact. It is the fact that in each of us, when awake (and often when asleep) *some kind of consciousness, is always going on*. There is a stream, a succession of states, or waves, or fields (or whatever you please to call them), of knowledge, of feeling, of desire, of deliberation, etc., that constantly pass and repass, and that constitute our inner life. The existence of this is the primal fact, [and] the nature and origin of it form the essential problem, of our science.

Like structuralism, functionalism no longer exists as a distinct school of thought in contemporary psychology. Nevertheless, functionalism's twin themes of the importance of the adaptive role of behavior and the application of psychology to enhance human behavior continue to be evident in modern psychology (D. N. Robinson, 1993).

William James and His Students

Like Wundt, James profoundly influenced psychology through his students, many of whom became prominent American psychologists. Two of James's most notable students were G. Stanley Hall and Mary Whiton Calkins.

In 1878, **G. Stanley Hall** received the first Ph.D. in psychology awarded in the United States. Hall founded the first psychology research laboratory in the United States at Johns Hopkins University in 1883. He also began publishing the *American Journal of Psychology*, the first U.S. journal devoted to psychology. Most important, in 1892, Hall founded the American Psychological Association and was elected its first president (Dewsbury, 2000). Today, the American Psychological Association (APA) is the world's largest professional organization of psychologists, with more than 150,000 members.

In 1890, **Mary Whiton Calkins** was assigned the task of teaching experimental psychology at a new women's college—Wellesley College. Calkins studied with James at nearby Harvard University. She completed all the requirements for a Ph.D. in psychology. However, Harvard refused to grant her the Ph.D. degree because she was a woman and at the time Harvard was not a coeducational institution.

Although never awarded the degree she had earned, Calkins made several notable contributions to psychology (Stevens & Gardner, 1982). She conducted research in many areas, including dreams, memory, and personality. In 1891, she established a psychological laboratory at Wellesley College. At the turn of the century, she wrote a well-received textbook, titled *Introduction to Psychology*. In

1905, Calkins was elected president of the American Psychological Association—the first woman, but not the last, to hold that position.

Just for the record, the first American woman to earn an official Ph.D. in psychology was **Margaret Floy Washburn**. Washburn was Edward Titchener's first doctoral student at Cornell University. She strongly advocated the scientific study of the mental processes of different animal species. In 1908, she published an influential text, titled *The Animal Mind*. Her book summarized research on sensation, perception, learning, and other “inner experiences” of different animal species. In 1921, Washburn became the second woman elected president of the American Psychological Association (Carpenter, 1997).

Sigmund Freud

Psychoanalysis

Wundt, James, and other early psychologists emphasized the study of conscious experiences. But at the turn of the century, new approaches challenged the principles of both structuralism and functionalism.

In Vienna, Austria, a physician named **Sigmund Freud** was developing an intriguing theory of personality based on uncovering causes of behavior that were *unconscious*, or hidden from the person's conscious awareness. Freud's school of psychological thought, called **psychoanalysis**, emphasized the role of unconscious conflicts in determining behavior and personality.

Freud's psychoanalytic theory of personality and behavior was based largely on his work with his patients and on insights derived from self-analysis. Freud believed that human behavior was motivated by unconscious conflicts that were almost always sexual or aggressive in nature. Past experiences, especially childhood experiences, were thought to be critical in the formation of adult personality and behavior. According to Freud (1904), glimpses of these unconscious impulses are revealed in everyday life in dreams, memory blocks, slips of the tongue, and spontaneous humor. Freud believed that when unconscious conflicts became extreme, psychological disorders could result.



Margaret Floy Washburn (1871–1939) After becoming the first American woman to earn an official Ph.D. in psychology, Washburn went on to a distinguished career. Despite the discrimination against women that was widespread in higher education during the early twentieth century, Washburn made many contributions to psychology. She was the second woman to be elected president of the American Psychological Association.

Sigmund Freud (1856–1939) In 1909, Freud (*front left*) and several other psychoanalysts were invited by G. Stanley Hall (*front center*) to participate at Clark University's 20th anniversary celebration in Worcester, Massachusetts. Freud delivered five lectures on psychoanalysis. Listening in the audience was William James, who later wrote to a friend that Freud struck him as “a man obsessed with fixed ideas” (Rosenzweig, 1997). Carl Jung (*front right*), who later developed his own theory of personality, also attended this historic conference. Ernest Jones, Freud's biographer and translator, is standing behind Hall.

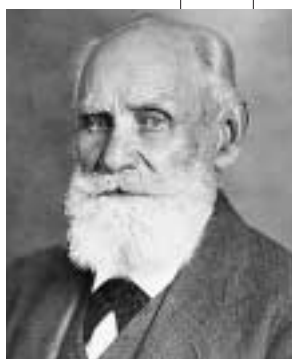
behaviorism

School of psychology and theoretical viewpoint that emphasize the study of observable behaviors, especially as they pertain to the process of learning.

humanistic psychology

School of psychology and theoretical viewpoint that emphasize each person's unique potential for psychological growth and self-direction.

Three Key People in the Development of Behaviorism Building on the pioneering research of Russian physiologist Ivan Pavlov (1849–1936), American psychologist John B. Watson (1878–1958) founded the school of behaviorism. Behaviorism advocated that psychology should study observable behaviors, not mental processes. Following Watson, B. F. Skinner (1904–1990) continued to champion the ideas of behaviorism. Skinner became one of the most influential psychologists of the twentieth century. Like Watson, he strongly advocated the study of observable behaviors rather than mental processes.



Ivan Pavlov



John B. Watson



B. F. Skinner

Freud's psychoanalytic theory of personality also provided the basis for a distinct form of psychotherapy. Many of the fundamental ideas of psychoanalysis continue to influence psychologists and other professionals in the mental health field. In Chapter 10, on personality, and Chapter 14, on psychotherapy, we'll explore Freud's views on personality in more detail.

John B. Watson**Behaviorism**

The course of psychology changed dramatically in the early 1900s when another approach, called **behaviorism**, emerged as a dominating force. Behaviorism rejected the emphasis on consciousness promoted by structuralism and functionalism. It also flatly rejected Freudian notions about unconscious influences. Instead, behaviorism contended that psychology should focus its scientific investigations strictly on *overt behavior*—observable behaviors that could be objectively measured and verified.

Behaviorism is yet another example of the influence of physiology on psychology. Behaviorism grew out of the pioneering work of a Russian physiologist named **Ivan Pavlov**. Pavlov demonstrated that dogs could learn to associate a neutral stimulus, such as the sound of a bell, with an automatic behavior, such as reflexively salivating to food. Once an association between the sound of the bell and the food was formed, the sound of the bell alone would trigger the salivation reflex in the dog. Pavlov enthusiastically believed he had discovered the mechanism by which all behaviors were learned.

In the United States, a young, dynamic psychologist named **John B. Watson** shared Pavlov's enthusiasm. Watson (1913) championed behaviorism as a new school of psychology. Structuralism was still an influential perspective, but Watson strongly objected to both its method of introspection and its focus on conscious mental processes. As Watson (1924) wrote in his classic book, *Behaviorism*:

Behaviorism, on the contrary, holds that the subject matter of human psychology *is the behavior of the human being*. Behaviorism claims that consciousness is neither a definite nor a usable concept. The behaviorist, who has been trained always as an experimentalist, holds, further, that belief in the existence of consciousness goes back to the ancient days of superstition and magic.

The influence of behaviorism on American psychology was enormous. The goal of the behaviorists was to discover the fundamental principles of *learning*—how behavior is acquired and modified in response to environmental influences. For the most part, the behaviorists studied animal behavior under carefully controlled laboratory conditions.

Although Watson left academic psychology in the early 1920s, behaviorism was later championed by an equally forceful proponent—the famous American psychologist **B. F. Skinner**. Like Watson, Skinner believed that psychology should restrict itself to studying outwardly observable behaviors that could be measured and verified. In compelling experimental demonstrations, Skinner systematically used reinforcement or punishment to shape the behavior of rats and pigeons (Bjork, 1997a).

Between Watson and Skinner, behaviorism dominated American psychology for almost half a century (R. Evans, 1999a). During that time, the study of conscious experiences was largely ignored as a topic in psychology (Hilgard, 1992). In Chapter 5, on learning, we'll look at the lives and contributions of Pavlov, Watson, and Skinner in greater detail.

Carl Rogers

Humanistic Psychology

For several decades, behaviorism and psychoanalysis were the perspectives that most influenced the thinking of American psychologists. In the 1950s, a new school of thought emerged, called **humanistic psychology**. Because humanistic psychology was distinctly different from both psychoanalysis and behaviorism, it was sometimes referred to as the “third force” in American psychology (Cain, 2002).

Humanistic psychology was largely founded by American psychologist **Carl Rogers**. Like Freud, Rogers was influenced by his experiences with his psychotherapy clients. However, rather than emphasizing unconscious conflicts, Rogers emphasized the *conscious* experiences of his patients, including each person’s unique potential for psychological growth and self-direction. In contrast to the behaviorists, who saw human behavior as being shaped and maintained by external causes, Rogers emphasized self-determination, free will, and the importance of choice in human behavior (Bozarth & others, 2002).

Abraham Maslow was another advocate of humanistic psychology. Maslow developed a theory of motivation that emphasized psychological growth, which we discuss in Chapter 8. Like psychoanalysis, humanistic psychology included not only influential theories of personality but also a form of psychotherapy, which we’ll discuss in later chapters.

By briefly stepping backward in time, you’ve seen how the debates among the key thinkers in psychology’s history shaped the development of psychology as a whole. Each of the schools that we’ve described had an impact on the topics and methods of psychological research. As you’ll see throughout this textbook, that impact has been a lasting one.

From the founding of Wundt’s laboratory in 1879, psychology has evolved to its current status as a dynamic and multidimensional science. In the next section, we’ll touch on some of the more recent developments in psychology’s evolution. We’ll also explore the diversity that characterizes contemporary psychology.



Carl Rogers (1902–1987) Abraham Maslow (1908–1970)

Two Key People in the Development of Humanistic Psychology Carl Rogers and Abraham Maslow were key figures in establishing humanistic psychology. Humanistic psychology emphasized the importance of self-determination, free will, and human potential. The ideas of Carl Rogers have been particularly influential in modern psychotherapy. Abraham Maslow’s theory of motivation emphasized the importance of psychological growth.

1.1 R · E · V · I · E · W *

C · O · N · C · E · P · T

Major Schools in Psychology

Identify the school or approach *and* the founder associated with each of the following statements.

- 1. Psychology should study how behavior and mental processes allow organisms to adapt to their environments.
School/Approach _____
Founder _____
- 2. Psychology should emphasize each person’s unique potential for psychological growth and self-directedness.
School/Approach _____
Founder _____
- 3. Psychology should focus on the elements of conscious experiences, using the method of introspection.
School/Approach _____
Founder _____

- 4. Human behavior is strongly influenced by unconscious sexual and aggressive conflicts.
School/Approach _____
Founder _____
- 5. Psychology should scientifically investigate observable behaviors that can be measured objectively and should not study consciousness or mental processes.
School/Approach _____
Founder _____

*Note: Answers to Concept Review questions appear on the final page of this and every chapter.

Psychology is the one discipline that uniquely encompasses the complex interplay between intrapersonal, biological, interpersonal, and socio-structural determinants of human functioning.

Albert Bandura (2001)

The Biological Perspective Biological psychologists study the physical aspects of behavior and mental processes. Biological psychologists who specialize in the study of the brain and the rest of the nervous system are often called *neuroscientists*. Here, two neuroscientists are conducting a study using brain-imaging techniques, which we will discuss further in Chapter 2.



Contemporary Psychology

Key Theme

- As psychology has developed as a discipline, the topics it investigates have become progressively more diverse.

Key Questions

- How do the seven perspectives in psychology differ in emphasis and approach?
- What are psychology's major specialty areas?

Since the 1960s, the range of topics in psychology has become progressively more diverse. And, as psychology's knowledge base has increased, psychology itself has become more specialized (Bower, 1993). Rather than being dominated by a particular approach or school of thought, today's psychologists tend to identify themselves according to (1) the *perspective* they emphasize in investigating psychological topics and (2) the *specialty area* in which they have been trained and practice.

Major Perspectives in Psychology

Any given topic in contemporary psychology can be approached from a variety of perspectives. Each perspective discussed here represents a different emphasis or point of view that can be taken in studying a particular behavior, topic, or issue. As you'll see in this section, the influence of the early schools of psychology is apparent in the first four perspectives that characterize contemporary psychology.

The Biological Perspective

As we've already noted, physiology has played an important role in psychology since it was founded. Today, that influence continues, as is shown by the many psychologists who take the biological perspective. The *biological perspective* emphasizes studying the physical bases of human and animal behavior, including the nervous system, endocrine system, immune system, and genetics.

Interest in the biological perspective has grown in the last few decades, partly because of advances in technology and medicine. For example, in the late 1950s and early 1960s, medications were developed that helped control the symptoms of serious psychological disorders, such as schizophrenia and depression.

The relative success of these new drugs sparked new questions about the interaction among biological factors and human behavior, emotions, and thought processes.

Equally important were technological advances that have allowed psychologists and other researchers to explore the human brain as never before. The development of the PET scan, MRI scan, and functional MRI (fMRI) scan has allowed scientists to study the structure and activity of the intact brain. These and other advances have produced new insights into the biological bases of memory, learning, mental disorders, and other behaviors. In Chapter 2, we'll explore the biological foundations of behavior in detail.

The Psychodynamic Perspective

The key ideas and themes of Freud's landmark theory of psychoanalysis continue to be important among many psychologists, especially those working in the mental health field. As you'll see in Chapter 10, on personality, and Chapter 14, on therapies, many of Freud's ideas

have been expanded or modified by his followers. Today, psychologists who take the *psychodynamic perspective* emphasize the importance of unconscious influences, early life experiences, and interpersonal relationships in explaining the underlying dynamics of behavior or in treating people with psychological problems.

The Behavioral Perspective

Watson and Skinner's contention that psychology should focus on observable behaviors and the fundamental laws of learning is evident today in the *behavioral perspective*. Contemporary psychologists who take the behavioral perspective continue to study how behavior is acquired or modified by environmental causes. Many psychologists who work in the area of mental health also emphasize the behavioral perspective in explaining and treating psychological disorders. In Chapter 5, on learning, and Chapter 14, on therapies, we'll discuss different applications of the behavioral perspective.

The Humanistic Perspective

The influence of the work of Carl Rogers and Abraham Maslow continues to be seen among contemporary psychologists who take the humanistic perspective. The *humanistic perspective* focuses on the motivation of people to grow psychologically, the influence of interpersonal relationships on a person's self-concept, and the importance of choice and self-direction in striving to reach one's potential. Like the psychodynamic perspective, the humanistic perspective is often emphasized among psychologists working in the mental health field. You'll encounter the humanistic perspective in the chapters on motivation (8), personality (10), and therapies (14).

The Cognitive Perspective

During the 1960s, psychology experienced a return to the study of how mental processes influence behavior (Evans, 1999c). This movement was called "the cognitive revolution" because it represented a break from traditional behaviorism. Cognitive psychology focused once again on the important role of mental processes in how people process and remember information, develop language, solve problems, and think.

The development of the first computers in the 1950s contributed to the cognitive revolution. Computers gave psychologists a new model for conceptualizing human mental processes—human thinking, memory, and perception could be understood in terms of an information-processing model. We'll consider the cognitive perspective in several chapters, including Chapter 7, on thinking, language, and intelligence.

The Cross-Cultural Perspective

More recently, psychologists have taken a closer look at how cultural factors influence patterns of behavior—the essence of the *cross-cultural perspective*. By the late 1980s, *cross-cultural psychology* had emerged in full force as large numbers of psychologists began studying the diversity of human behavior in different cultural settings and countries (Segall & others, 1998; Triandis, 1996). In the process, psychologists discovered that some well-established psychological findings were not as universal as they had thought.



Studying Behavior from Different Psychological Perspectives Psychologists can study a particular behavior, topic, or issue from different perspectives. For example, consider people who risk their lives to help other people in crisis situations, such as immediately following the attacks on the World Trade Center and the Pentagon. Taking the biological perspective, a psychologist might ask whether there were biological differences between rescue workers and other people, such as a genetic predisposition to be risk-takers. In contrast, a psychologist taking the behavioral perspective might study the ways in which risk-taking behaviors are learned through training and rewarded by social recognition, parental approval, and so forth.

CULTURE AND HUMAN BEHAVIOR 1.1

What Is Cross-Cultural Psychology?

All cultures are simultaneously very similar and very different.

Harry Triandis (1994)

Culture is a broad term that refers to the attitudes, values, beliefs, and behaviors shared by a group of people and communicated from one generation to another (Matsumoto, 2000). A person's sense of cultural identity is influenced by such factors as ethnic background, nationality, race, religion, and language. When this broad definition is applied to people throughout the world, about 4,000 different cultures can be said to exist. Studying the differences among those cultures and the influences of culture on behavior are the fundamental goals of **cross-cultural psychology** (Betancourt & López, 1993; Segall & others, 1998).

People around the globe share many attributes: We all eat, sleep, form families, seek happiness, and mourn losses. Yet the way in which we express our human qualities can vary considerably among cultures. *What* we eat, *where* we sleep, and *how* we form families, define happiness, and express sadness can take very different forms in different cultures.

As we grow up within a given culture, we learn our culture's *norms*, or unwritten rules of behavior. Once those cultural norms are understood and internalized, we tend to act in accordance with them without too much thought. For example, according to the dominant cultural norms in the United States, infants and toddlers are not supposed to routinely sleep in the same bed as their parents. In many other cultures around the world, however, it's taken for granted that babies *will* sleep in the same bed as their parents or other adult relatives (Morelli & others, 1992). Members of these other cultures are often surprised and even shocked at the U.S. practice of separating infants and toddlers from their parents at night. (In Culture and Human Behavior Box 9.1 on page 000, we discuss this topic at greater length.)

Whether considering sleeping habits or hairstyles, most people share a natural tendency to accept their own cultural rules as defining what's "normal." This tendency to use your own culture as the standard for judging other cultures is called **ethnocentrism** (Triandis, 1994). Although it may be a natural

tendency, ethnocentrism can lead to the inability to separate ourselves from our own cultural backgrounds and biases so that we can understand the behaviors of others (Matsumoto, 2000). Ethnocentrism may also prevent us from being aware of how our behavior has been shaped by our own culture.

Some degree of ethnocentrism is probably inevitable, but extreme ethnocentrism can lead to intolerance for other cultures. If we believe that our way of seeing things or behaving is the only proper one, other ways of behaving and thinking may seem not only foreign, but ridiculous, inferior, wrong, or immoral.

In addition to influencing how we behave, culture affects how we define our sense of self (Kitayama & others, 1997; Markus & Kitayama, 1991, 1998). For the most part, the dominant cultures of the United States, Canada, Australia, New Zealand, and Europe can be described as individualistic cultures. **Individualistic cultures** emphasize the needs and goals of the individual over the needs and goals of the group (Triandis, 1996). In individualistic societies, social

culture

The attitudes, values, beliefs, and behaviors shared by a group of people and communicated from one generation to another.

cross-cultural psychology

Branch of psychology that studies the effects of culture on behavior and mental processes.

ethnocentrism

The belief that one's own culture or ethnic group is superior to all others, and the related tendency to use one's own culture as a standard by which to judge other cultures.

individualistic cultures

Cultures that emphasize the needs and goals of the individual over the needs and goals of the group.

For example, one well-established psychological finding was that people exert more effort on a task when working alone than when working as part of a group, a phenomenon called *social loafing*. First demonstrated in the 1970s, social loafing has been a common finding in many psychological studies conducted with American and European subjects. But when similar studies were conducted with Chinese participants during the 1980s, the opposite was found to be true (see Moghaddam & others, 1993). Chinese participants worked harder on a task when they were part of a group than when they were working alone.

These findings were just the tip of the iceberg. Today, psychologists are keenly attuned to the influence of cultural and ethnic factors on behavior (Matsumoto, 2001). We have included Culture and Human Behavior boxes throughout this textbook to help sensitize you to the influence of culture on behavior—including your own. We describe cross-cultural psychology in more detail in Culture and Human Behavior Box 1.1: What Is Cross-Cultural Psychology?

The Evolutionary Perspective

The newest psychological perspective to gain prominence is that of evolutionary psychology. **Evolutionary psychology** refers to the application of the principles of evolution to explain psychological processes and phenomena (Buss, 1999). The evolutionary perspective has grown out of a renewed interest in the work of English naturalist **Charles Darwin**. Darwin's first book on evolution, *On the Origin of Species by Means of Natural Selection*, was published in 1859.

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behavior is more strongly influenced by individual preferences and attitudes than by cultural norms and values. In such cultures, the self is seen as *independent*, autonomous, and distinctive. Personal identity is defined by individual achievements, abilities, and accomplishments.

In contrast, **collectivistic cultures** emphasize the needs and goals of the group over the needs and goals of the individual. Social behavior is more heavily influenced by cultural norms than by individual preferences and attitudes. In a collectivistic culture, the self is seen as being much more *interdependent* with others (Simon & others, 1995). Relationships with others and identification with a larger group, such as the family or tribe, are key components of personal identity. The cultures of Asia, Africa, and Central and South America tend to be collectivistic. According to Triandis (1995), about two-thirds of the world's population live in collectivistic cultures.



Cultural Differences in Subway Norms Like thousands of commuters in the United States, many commuters in Tokyo take the subway to work each day. In Japan, however, commuters line up politely behind white lines on the subway platform and patiently wait their turn to board the train. White-gloved conductors obligingly “assist” passengers in boarding by shoving them in from behind, cramming as many people into the subway car as possible. Clearly, the norms that govern subway-riding behavior are very different in American and Japanese cultures.

The distinction between individualistic and collectivistic societies is useful in cross-cultural psychology. Nevertheless, psychologists are careful not to assume that these generalizations are true of *every* member or *every* aspect of a given culture. Many cultures are neither completely individualistic nor completely collectivistic, but fall somewhere between the two extremes (Kagitçibasi, 1997). Equally important, psychologists recognize that there is a great deal of individual variation among the members of every culture (Gudykunst & Bond, 1997).

It's important to keep that qualification in mind when cross-cultural findings are discussed, as they will be throughout this book.

The Culture and Human Behavior boxes that we have included in this book will help you learn about human behavior in other cultures. They will also help you understand how culture affects *your* behavior, beliefs, attitudes, and values as well. We hope you will find this feature both interesting and enlightening!

The theory of evolution proposes that the individual members of a species compete for survival. Because of inherited differences, some members of a species are better adapted to their environment than are others. Organisms that inherit characteristics that increase their chances of survival in their particular habitat are more likely to survive, reproduce, and pass on their characteristics to their offspring. Conversely, individuals that inherit less-useful characteristics are less likely to survive, reproduce, and pass on their characteristics. This process reflects the principle of *natural selection*: The most adaptive characteristics are “selected” and perpetuated to the next generation.

collectivistic cultures

Cultures that emphasize the needs and goals of the group over the needs and goals of the individual.

evolutionary psychology

The application of principles of evolution, including natural selection, to explain psychological processes and phenomena.



The Evolutionary Perspective The evolutionary perspective analyzes behavior in terms of how it increases a species' chances to survive and reproduce. Comparing behaviors across species can often lead to new insights about the adaptive function of a particular behavior. For example, humans, monkeys, and apes are all members of the primate family. Close bonds with caregivers are essential to the primate infant's survival—whether that infant is a golden monkey at a wildlife preserve in northern China or a human infant at a family picnic in Norway.

How is evolutionary theory applied to psychology? Basically, psychologists who take the evolutionary perspective assume that psychological processes are also subject to the principle of natural selection. As David Buss (1995a) writes, a given psychological process exists in the form it does because it “solved a specific problem of individual survival or reproduction recurring over human evolutionary history.” That is, those psychological processes that helped individuals adapt to their environments also helped them survive, reproduce, and pass those abilities on to their offspring.

As you consider the role of evolution in shaping modern psychological processes, keep a couple of things in mind. We tend to take the trappings of civilization—governments, transportation systems, factories and manufacturing, education and organized medicine—for granted. But these aspects of everyday life developed only recently in the evolutionary history of *Homo sapiens*. What we think of as human history has existed for less than 10,000 years, since the earliest appearance of agriculture.

In contrast, our evolutionary ancestors spent more than 2 million years as primitive hunter-gatherers. Our lives as humans living in agricultural, industrial, and postindustrial societies make up less than 1 percent of the time that humans spent as hunter-gatherers. The important point here is that a few thousand years is not long enough for sweeping evolutionary changes to take place. Psychological processes that were adaptations to a prehistoric way of life may continue to exist in the behavioral repertoire of people today. However, some of those processes may not necessarily be adaptive in our modern world (Cosmides & others, 1992).

As you’ll see in later chapters, the evolutionary perspective has been applied to many different areas of psychology, including human relationships, mate selection, eating behavior, and emotional responses (Caporael, 2001).

Specialty Areas in Psychology

The following list describes some of the important specialty areas in contemporary psychology, which reflect the enormous diversity of psychology today. Figure 1.1 shows the approximate percentage of American psychologists working in the different specialty areas.

Biological psychology focuses on the relationship between behavior and the body’s physical systems, including the brain and the rest of the nervous system, the endocrine system, the immune system, and genetics.

Cognitive psychology investigates mental processes, including reasoning and thinking, problem solving, memory, perception, mental imagery, and language.

Experimental psychology is the term traditionally used to describe research focused on such basic topics as sensory processes, principles of learning, emotion, and motivation. However, note that experiments are conducted by psychologists in every area of psychology.

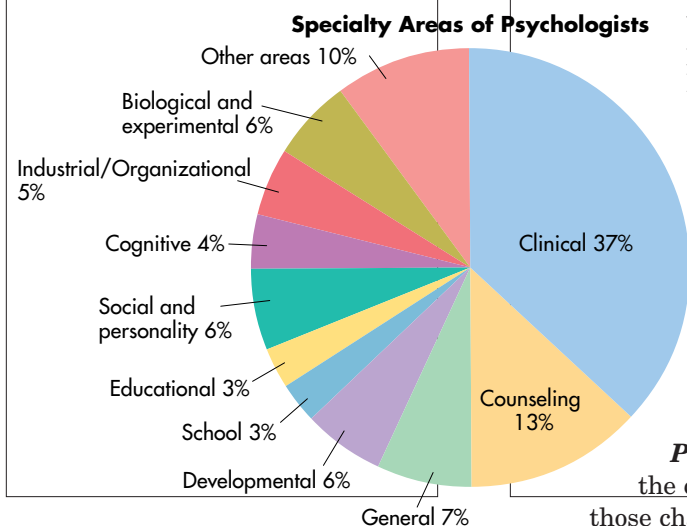
Developmental psychology studies the physical, social, and psychological changes that occur at different ages and stages over the lifespan, from conception to old age.

Social psychology explores how people are affected by their social environments, including how people think about and influence others. Topics as varied as conformity, obedience, persuasion, interpersonal attraction, helping behavior, prejudice, aggression, and social beliefs are studied by social psychologists.

Personality psychology examines individual differences and the characteristics that make each person unique, including how those characteristics originated and developed.

FIGURE 1.1 Specialty Areas and Employment Settings The pie chart below shows the specialty areas of psychologists who recently received their doctorates.

SOURCES: APA Research Office (2001), Fennell (2002).



Health psychology focuses on the role of psychological factors in the development, prevention, and treatment of illness. Health psychology includes such areas as stress and coping, the relationship between psychological factors and physical health, patient–doctor relationships, and ways of promoting health-enhancing behaviors.

Educational psychology studies how people of all ages learn. Educational psychologists help develop the instructional methods and materials used to train people in both educational and work settings. A related field, *school psychology*, focuses on designing programs that promote the intellectual, social, and emotional development of children, including children with special needs.

Industrial/organizational psychology is concerned with the relationship between people and work. This specialty includes such topics as worker productivity and job satisfaction, personnel selection and training, consumer reactions to a company's products or services, and the interaction between people and equipment.

Clinical psychology studies the causes, treatment, and prevention of different types of psychological disorders, such as anxiety or depression, eating disorders, and chronic substance abuse. A related specialty area is *counseling psychology*, which aims to improve everyday functioning by helping people cope more effectively with challenging situations and solve problems in daily living.

Like clinical psychologists, psychiatrists also study the causes, treatment, and prevention of psychological disorders. How are clinical psychologists and psychiatrists different? A *clinical psychologist* typically has a doctorate in psychology, which includes intensive training in treating people with psychological disorders. In contrast, a *psychiatrist* has a medical degree plus years of specialized training in the treatment of psychological disorders. Both clinical psychologists and psychiatrists can treat patients with psychological disorders. However, only psychiatrists can order medical procedures like electroshock treatments. In most of the United States, psychiatrists and some other medical professionals, but not psychologists, can prescribe medications, but that is starting to change. Finally, a *psychoanalyst* is a clinical psychologist, psychiatrist, or other mental health professional with extensive training in Freud's psychoanalytic method of psychotherapy. In Chapter 14, we'll describe other workers in the mental health field, such as clinical social workers, licensed professional counselors, and marriage and family therapists.

Despite the diversity of their work settings and interests, psychologists share common methods of investigating facets of human behavior and mental processes. In the next section, we'll look at how psychologists are guided by the scientific method in their efforts to understand behavior and mental processes.



School Psychology There are about 25,000 school psychologists in the United States who provide a variety of psychological services to children, adolescents, and families in public and private schools. School psychologists help teachers, school administrators, and parents understand how children learn and develop. Some of the activities that school psychologists perform include assessing and counseling students with special needs, consulting with parents and school staff, and working with outside agencies to promote learning and development.

Rx Privileges for Psychologists? In 2002, New Mexico became the first state to enact legislation authorizing properly trained psychologists to prescribe medications for symptoms of psychological disorders. To qualify for prescription privileges, New Mexico psychologists must complete additional coursework and clinical training supervised by a physician. Similar legislation is pending in other states. In areas underserved by mental health professionals, allowing trained psychologists to prescribe medications may help many people who have been unable to gain access to mental health care.

Clinical Psychologists Working in private practice, hospitals, or community mental health centers, clinical psychologists have extensive training in psychological disorders, psychotherapy techniques, and psychological testing. Along with conducting psychotherapy with individuals, clinical psychologists also work with married couples, families, and groups of unrelated people.



scientific method

A set of assumptions, attitudes, and procedures that guide researchers in creating questions to investigate, in generating evidence, and in drawing conclusions.

empirical evidence

Evidence that is based upon objective observation, measurement, and/or experimentation.

critical thinking

The active process of trying to minimize the influence of preconceptions and biases while rationally evaluating evidence, determining what conclusions can be drawn from the evidence, and considering alternative explanations.

hypothesis

(high-POTH-eh-sis) A tentative statement about the relationship between two or more variables.

The Scientific Method

Key Theme

- The scientific method is a set of assumptions, attitudes, and procedures that guide all scientists, including psychologists, in conducting research.

Key Questions

- What are the four goals of psychology?
- What assumptions and attitudes are held by psychologists?
- What characterizes each step of the scientific method?

The four basic goals of psychology are to (1) describe, (2) explain, (3) predict, and (4) control or influence behavior and mental processes. To achieve these goals, psychologists rely on the scientific method. The **scientific method** refers to a set of assumptions, attitudes, and procedures that guide researchers in creating questions to investigate, in generating evidence, and in drawing conclusions.

Like all scientists, psychologists are guided by the basic scientific assumption that *events are lawful* (Rutherford & Ahlgren, 1991). When this scientific assumption is applied to psychology, it means that psychologists assume that behavior and mental processes follow consistent patterns. Psychologists are also guided by the assumption that *events are explainable*. Thus, psychologists assume that behavior and mental processes have a cause or causes that can be understood through careful, systematic study.

In striving to discover and understand consistent patterns of behavior, psychologists are *open-minded*. They are willing to consider new or alternative explanations of behavior and mental processes. However, their open-minded attitude is tempered by a healthy sense of *scientific skepticism*. That is, psychologists critically evaluate the evidence for new findings, especially those that seem contrary to established knowledge. And, in promoting new ideas and findings, psychologists are *cautious* in the claims they make.

Collectively, the assumptions and attitudes that psychologists assume reflect critical thinking. Ideally, you should assume the same set of attitudes as you approach the study of psychology. To learn how to be a better critical thinker, see Critical Thinking Box 1.2: What Is Critical Thinking?

The Steps in the Scientific Method

Seeking Answers

Like any science, psychology is based on **empirical evidence**—evidence that is the result of objective observation, measurement, and experimentation. As part of the overall process of producing empirical evidence, psychologists follow the four basic steps of the scientific method. In a nutshell, these steps are:

- Formulate a specific question that can be tested.
- Design a study to collect relevant data.
- Analyze the data to arrive at conclusions.
- Report the results.

Following the basic guidelines of the scientific method does not guarantee that valid conclusions will be reached. However, these steps do help guard against bias and minimize the chance for error and faulty conclusions. Let's look at some of the key concepts associated with each step of the scientific method.

CRITICAL THINKING 1.2

What Is Critical Thinking?

As you'll see throughout this text, many issues in contemporary psychology are far from being settled. And although research findings may have been arrived at in a very objective manner, the *interpretation* of what findings mean and how they should be applied can be a matter of considerable debate. In short, there is a subjective side to *any* science, but subjectivity is especially prominent in discussions of psychological research because psychology tackles topics and issues that concern people from all walks of life.

As you look at the evidence that psychology has to offer on many topics, we want to encourage you to engage in critical thinking. In general, *critical thinking* refers to *actively questioning* statements rather than blindly accepting them. More precisely, we define **critical thinking** as the active process of:

- Trying to minimize the influence of preconceptions and biases while rationally evaluating evidence.
- Determining the conclusions that can be drawn from the evidence.
- Considering alternative explanations.

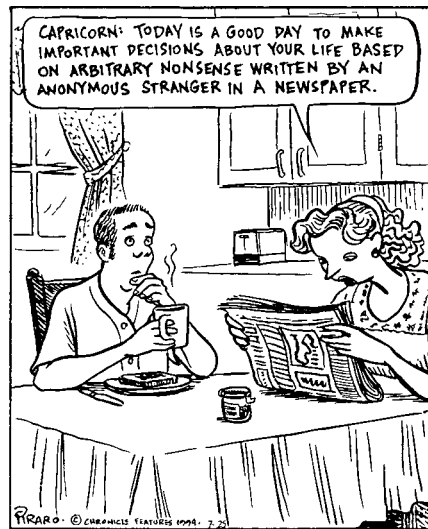
What are the key attitudes and mental skills that characterize critical thinking?

1. The critical thinker can assume other perspectives.

Critical thinkers are not imprisoned by their own points of view. Nor are they limited in their capacity to imagine life experiences and perspectives that are fundamentally different from their own. Rather, the critical thinker strives to understand and evaluate issues from many different angles.

BIZARRO

By DAN PIRARO



The "Bizarro" cartoon by Dan Piraro is reprinted courtesy Universal Press Syndicate. All rights reserved.

2. The critical thinker is aware of biases and assumptions.

In evaluating evidence and ideas, critical thinkers strive to identify the biases and assumptions that are inherent in any argument. Critical thinkers also try to identify and minimize the influence of their *own* biases.

3. The critical thinker is flexible yet maintains an attitude of healthy skepticism.

Critical thinkers are open to new information, ideas, and claims. They genuinely consider alternative explanations and possibilities. However, this open-mindedness is tempered by a healthy sense of skepticism. The critical thinker consistently asks, "What evidence supports this claim?"

4. The critical thinker engages in reflective thinking.

Critical thinkers avoid knee-jerk responses. Instead, critical thinkers are *reflective*. Most complex issues are unlikely

to have a simple resolution. Therefore, critical thinkers resist the temptation to sidestep complexity by boiling an issue down to an either/or, yes/no kind of proposition. Instead, the critical thinker *expects* and *accepts* complexity (Halpern, 1998).

5. The critical thinker scrutinizes the evidence before drawing conclusions.

Critical thinkers strive to weigh all the available evidence *before* arriving at conclusions. And, in evaluating evidence, critical thinkers distinguish between *empirical evidence* and *opinions* based on feelings or personal experience.

As you can see, critical thinking is not a single skill, but rather a *set* of attitudes and thinking skills. As is true with any set of skills, you can get better at these skills with practice. That's one reason we've included Critical Thinking boxes in many chapters of this text.

You'll discover that these Critical Thinking boxes do not follow a rigid formula but are very diverse. Some will challenge your preconceptions about certain topics. Others will invite you to take sides in the debates of some of the most important contributors to modern psychology.

We hope you enjoy this feature!

Critical Thinking Questions

- Why might other people want to discourage you from thinking critically?
- In what situations is it probably most important for you to exercise critical thinking skills?

Step 1. Formulate a Hypothesis That Can Be Tested Empirically

Once a researcher has identified a question or an issue to investigate, he or she must formulate a hypothesis that can be tested empirically. Formally, a **hypothesis** is a tentative statement that describes the relationship between two or more variables. A hypothesis is often stated as a specific prediction that can be empirically tested, such as "psychological stress increases the likelihood of physical illness."



Formulating a Hypothesis: Is It Dangerous to Talk on a Cell Phone While Driving?

Hypotheses are often generated from everyday observations. For example, many people believe that talking on a cell phone while you're driving increases the likelihood that you'll get into a traffic accident. How could a psychologist investigate this question? What kinds of variables would need to be operationally defined?

variable

A factor that can vary, or change, in ways that can be observed, measured, and verified.

operational definition

A precise description of how the variables in a study will be manipulated or measured.

statistics

A branch of mathematics used by researchers to summarize data and draw conclusions based on the data.

statistically significant

A mathematical indication that research results are not very likely to have occurred by chance.

The **variables** contained in any given hypothesis are simply the factors that can vary, or change. These changes must be capable of being observed, measured, and verified. The psychologist must provide an operational definition of each variable to be investigated. An **operational definition** defines the variable in terms of how it is to be measured, manipulated, or changed.

Operational definitions are important because many of the concepts that psychologists investigate—such as memory, happiness, or stress—can be measured in more than one way. In providing operational definitions of the variables in the study, the researcher spells out in very concrete and precise terms how the variables will be manipulated or measured. In this way, other researchers can understand exactly how the variables were measured or manipulated in a particular study.

For example, consider the hypothesis that negativity reduces marital stability (see Karney & Bradbury, 1995). To test this hypothesis, you would need to formulate an operational definition of each variable. How could you operationally define “negativity” and “marital stability”? What could you measure?

You could operationally define negativity in many different ways. For example, you might operationally define negativity as the number of arguments the couple has per month or as the number of critical comments each partner made about the other in a one-hour interview. In a similar way, you would have to devise an operational definition for marital stability, such as the number of times the couple has separated.

Step 2. Design the Study and Collect the Data

This step involves deciding which research method to use for collecting data. There are two basic categories of research methods—*descriptive* and *experimental*. Each research method answers different kinds of questions and provides different kinds of evidence.

Descriptive methods are research strategies for *observing* and *describing* behavior, including identifying the factors that seem to be associated with a particular phenomenon. Descriptive methods answer the who, what, where, and when kinds of questions about behavior. Who engages in a particular behavior? What factors or events seem to be associated with the behavior? Where does the behavior occur? When does the behavior occur? How often? In the next section, we'll discuss commonly used descriptive methods, including *naturalistic observation*, *surveys*, *case studies*, and *correlational studies*.

In contrast, the *experimental method* is used to show that one variable causes change in a second variable. In an experiment, the researcher deliberately varies one factor, then measures the changes produced in a second factor. Ideally, all experimental conditions are kept as constant as possible except for the factor that the researcher systematically varies. Then, if changes occur in the second factor, those changes can be attributed to the variations in the first factor.

Step 3. Analyze the Data and Draw Conclusions

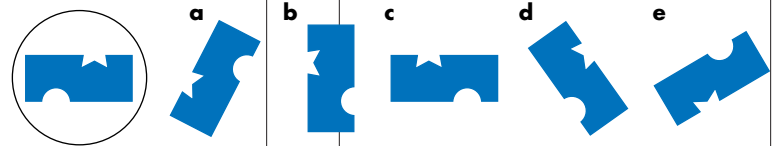
Once observations have been made and measurements have been collected, the raw data need to be summarized and analyzed. Researchers use the methods of a branch of mathematics known as **statistics** to summarize, analyze, and draw conclusions about the data they have collected.

Researchers rely on statistics to determine whether their results support their hypotheses. They also use statistics to determine whether their findings are statistically significant. If a finding is **statistically significant**, it means that the results are not very likely to have occurred by chance. As a rule, statistically significant results confirm the hypothesis. Appendix A provides a more detailed discussion of the use of statistics in psychology research.

Keep in mind that statistical significance and practical significance are not necessarily the same thing. If a study involves a large number of participants, even small differences among groups of subjects may result in a statistically significant finding. But the actual average differences may be so small as to have little practical significance or importance. For example, a recent study tried to identify risk factors for people who attempt suicide (Mann & others, 1999). One statistically significant finding was that suicide attempters had fewer years of education (12.7 years) as compared to non-attempters (14 years). In practical terms, however, the difference was not substantial enough to be clinically meaningful in trying to help identify people who pose a suicide risk. So remember that a statistically significant result is simply one that is not very likely to have occurred by chance. Whether the finding is significant in the everyday sense of being important is another matter altogether.

A statistical technique called **meta-analysis** is increasingly being used in psychology to analyze the results of many research studies on a specific topic. Basically, meta-analysis involves pooling the results of several studies into a single analysis. By creating one large pool of data to be analyzed, meta-analysis can sometimes reveal overall trends that may not be evident in individual studies. Meta-analysis is especially useful when a particular issue has generated a large number of studies, some of which have produced weak or contradictory results.

For example, suppose you wanted to pool research done on gender differences in spatial abilities, such as the ability to mentally rotate an image (see Figure 1.2). Researchers Daniel Voyer, Susan Voyer, and M. P. Bryden (1995) used meta-analysis to combine the results of 286 separate studies investigating gender differences in spatial abilities. The meta-analysis revealed that males tend to do better than do females on some, but not all, tests of spatial ability. The meta-analysis also showed that gender differences in spatial ability have decreased in recent years. One possible explanation for this decrease is that changing educational practices have helped narrow the gap between males and females on spatial abilities.



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meta-analysis

A statistical technique that involves combining and analyzing the results of many research studies on a specific topic in order to identify overall trends.

replicate

To repeat or duplicate a scientific study in order to increase confidence in the validity of the original findings.

Step 4. Report the Findings

For advances to be made in any scientific discipline, researchers must publish or share their findings with other scientists. In addition to reporting their results, psychologists provide a detailed description of the study itself, including the following:

- Who participated in the study
- How participants were selected
- How variables were operationally defined
- What procedures or methods were used
- How the data were analyzed
- What the results seem to suggest

Describing the precise details of the study makes it possible for other investigators to **replicate**, or repeat, the study. Replication is an important part of the scientific process. When a study is replicated and the same basic results are obtained again, scientific *confidence* that the results are accurate is increased. Conversely, if the replication of a study fails to produce the same basic findings, confidence in the original findings is reduced.

One way in which psychologists report their findings is by formally presenting their research at a professional conference. A researcher can also write a paper summarizing the study and submit it to one of the many psychology

FIGURE 1.2 Example of a Spatial Ability

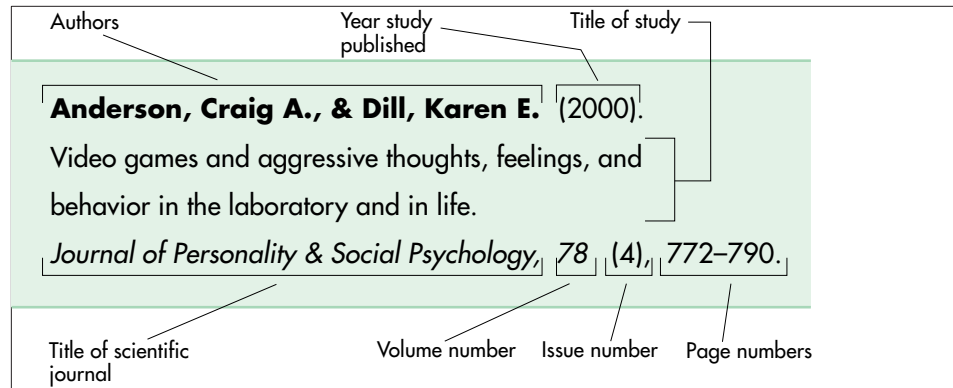
Test Item *Spatial abilities* are involved in tasks that require the actual or mental manipulation of objects in space, such as mentally rotating objects or reading maps.

Shown here is an example from one test of spatial ability, the Card Rotations Test. A meta-analysis conducted by Daniel Voyer, Susan Voyer, and M. P. Bryden (1995) found that males tend to do better than females on this type of spatial ability test.

SOURCE: Plomin & DeFries (1998).



FIGURE 1.3 How to Read a Journal Reference Using the References section at the back of this text, you can find the complete source for each citation that appears in a chapter. This figure shows the different components of a typical journal reference. In the chapter itself, the citation for this particular reference would read “(Anderson & Dill, 2000).”



journals for publication. Before accepting papers for publication, most psychology journals send them to other psychologists to review. The reviewers critically evaluate different aspects of a study, including how the results were analyzed. If the study conforms to the principles of sound scientific research and contributes to the existing knowledge base, the paper is accepted for publication.

Throughout this text, you'll see citations that look like the following: (Anderson & Dill, 2000). These citations identify the sources of the research and ideas that are being discussed. The citation tells you the author or authors (Anderson & Dill) of the published study and the year (2000) in which the study was published. Using this information, you can find the complete reference in the alphabetized References section at the back of this text. The complete reference lists the authors' full names, the article title, and the journal or book in which the article was published. Figure 1.3 shows you how to interpret the different parts of a typical journal reference.

Building Theories

Integrating the Findings

As research findings accumulate from individual studies, eventually theories develop. A **theory**, or *model*, is a tentative explanation that tries to account for diverse findings on the same topic. Note that theories are *not* the same as hypotheses. A hypothesis is a specific question or prediction to be tested. In contrast, a theory integrates and summarizes a large number of findings and observations. Along with explaining existing results, a good theory often generates predictions and new hypotheses that can be tested by further research.

As you encounter different theories, try to remember that theories are *tools* for explaining behavior and mental processes, not statements of absolute fact. Like any tool, the value of a theory is determined by its usefulness. A useful theory is one that furthers the understanding of behavior, allows testable predictions to be made, and stimulates new research. Often, more than one theory proves to be useful in explaining a particular area of behavior or mental processes, such as the development of personality or the experience of emotion.

It's also important to remember that theories often reflect the *self-correcting nature of the scientific enterprise*. In other words, when new research findings challenge established ways of thinking about a phenomenon, theories are expanded, modified, and even replaced. Thus, as the knowledge base of psychology evolves and changes, theories evolve and change to produce more accurate and useful explanations of behavior and mental processes.

theory

A tentative explanation that tries to integrate and account for the relationship of various findings and observations.

Descriptive Research Methods

Key Theme

- Descriptive research methods are used to systematically observe and describe behavior.

Key Questions

- What are naturalistic observation and case study research, and why and how are they conducted?
- What are surveys, and why is random selection important in survey research?
- What are the advantages and disadvantages of each descriptive method?

Descriptive research methods are strategies for observing and describing behavior. Using descriptive methods, researchers can answer important questions, such as when certain behaviors take place, how often they occur, and whether they are related to other factors, such as a person's age, ethnic group, or educational level. As you'll see in this section, descriptive methods can provide a wealth of information about behavior, especially behaviors that would be difficult or impossible to study experimentally.

Naturalistic Observation

The Science of People- and Animal-Watching

When psychologists systematically observe and record behaviors as they occur in their natural settings, they are using the descriptive method called **naturalistic observation**. Usually, researchers engaged in naturalistic observation try to avoid being detected by their subjects, whether people or nonhuman animals. The basic goal of naturalistic observation is to detect the behavior patterns that exist naturally—patterns that might not be apparent in a laboratory or if the subjects knew they were being watched.

As you might expect, psychologists very carefully define the behaviors that they will observe and measure before they begin their research. For example, social psychologist Robert Levine (1997) set out to compare the “pace of life” in 31 different countries. How could you operationally define the “pace of life”? One measure that Levine adopted was “the amount of time it took a pedestrian to walk a distance of 60 feet on a downtown city street.” To collect the data, observers unobtrusively timed at least 35 male and 35 female pedestrians in each country (Levine & Norenzayan, 1999).

The results? The fastest walkers were clocked in Ireland, and the slowest in Brazil. When the 31 countries were ranked from fastest to slowest, the United States came in 6th and Canada ranked 11th.

Often, to increase the accuracy of the observations, two or more observers are used. In some studies, observations are videotaped or audiotaped so that the researchers can carefully analyze the details of the behaviors being studied.

One advantage of naturalistic observation is that it allows researchers to study human behaviors that cannot ethically be manipulated in an experiment. For example, suppose that a psychologist wants to study bullying behavior in children. It would not be ethical to deliberately create a situation in which one child is aggressively bullied by another child. However, it *would* be ethical to study bullying by observing aggressive behavior in children on a crowded school playground (Pepler & Craig, 1995).

As a research tool, naturalistic observation can be used wherever patterns of behavior can be openly observed—from the rain forests of the Amazon to fast-food restaurants, shopping malls, and singles' bars. Because the observations

descriptive research methods

Scientific procedures that involve systematically observing behavior in order to describe the relationship among behaviors and events.

naturalistic observation

The systematic observation and recording of behaviors as they occur in their natural setting.

Naturalistic Observation of Children

Psychologists Debra Pepler and Wendy Craig (1995) used naturalistic observation to study bullying by observing aggressive behavior in children on a school playground. From a vantage point on the school's second floor, they used a camcorder with a telephoto lens and small, wireless microphones to record the spontaneous interactions of schoolchildren. They discovered that instances of physical aggression occurred about once every 11 minutes, and verbal aggression about once every 5 minutes.

1UN21

case study

An intensive study of a single individual or small group of individuals.

survey

A questionnaire or interview designed to investigate the opinions, behaviors, or characteristics of a particular group.

sample

A selected segment of the population used to represent the group that is being studied.

representative sample

A selected segment that very closely parallels the larger population being studied on relevant characteristics.

random selection

Process in which subjects are selected randomly from a larger group such that every group member has an equal chance of being included in the study.

occur in the natural setting, the results of naturalistic observation studies can often be generalized more confidently to real-life situations than can the results of studies using artificially manipulated or staged situations (see Pepler & Craig, 1995).

Case Studies

Details, Details, Details

A **case study** is an intensive, in-depth investigation of an individual or a small group of individuals. Case studies involve compiling a great deal of information, often from a variety of different sources, to construct a detailed picture of the person. The subject may be intensively interviewed, and his or her friends, family, and co-workers may be interviewed as well. Psychological records, medical records, and even school records may be examined. Other sources of information can include extensive psychological testing and observations of the person's behavior. Clinical psychologists and other mental health specialists routinely use case studies to develop a complete profile of a psychotherapy client.

Case studies are also used to investigate rare, unusual, or extreme conditions. Yet case studies often provide psychologists with information that can be used to help understand normal behavior. In Chapters 2 and 6, you'll see how case studies of people with brain damage have contributed to our understanding of such psychological functions as language, emotional control, and memory.

Surveys

(A) Always (B) Sometimes (C) You've Got to Be Kidding!

A direct way to find out about the behavior, attitudes, and opinions of people is simply to ask them. In a **survey**, people respond to a structured set of questions about their experiences, beliefs, behaviors, or attitudes. One key advantage offered by survey research is that information can be gathered from a much larger group of people than is possible with other research methods.

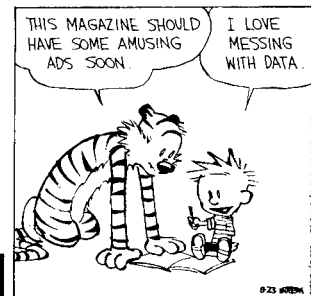
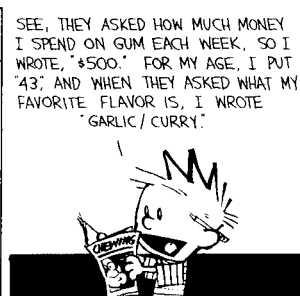
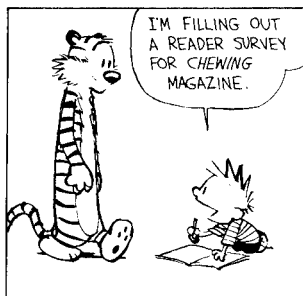
Typically, surveys involve a carefully designed questionnaire in a paper-and-pencil format that is mailed to a select group of people. Computer-based or Internet-based surveys have become increasingly more common. And, surveys are still often conducted over the telephone or in person, with the interviewer recording the person's responses. As with paper-and-pencil surveys, the interviewer usually asks a structured set of questions in a predetermined order. Such interview-based surveys are typically more expensive and time-consuming than questionnaire-based surveys.

Surveys are seldom administered to everyone within the particular group or population under investigation. Instead, researchers usually select a **sample**—a segment of the larger group or population. Selecting a sample that is representative of the larger group is the key to getting accurate survey results. A **representative sample** very closely parallels, or matches, the larger group on relevant characteristics, such as age, sex, race, marital status, and educational level.

Calvin and Hobbes

by Bill Watterson

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How do researchers select the participants for the sample so that they end up with a sample that is representative of the larger group? The most common strategy is to randomly select the sample participants. **Random selection** means that every member of the larger group has an equal chance of being selected for inclusion in the sample.

To illustrate how random selection works, let's look at how the sample was created for the *National Health and Social Life Survey* (abbreviated *NHSLS*). Conducted by researcher Robert T. Michael and his colleagues (1994) at the University of Chicago, the NHSLS focused on the sexual practices of American adults between the ages of 18 and 59. Here is Michael's description of how his team used random selection to choose the survey participants:

Essentially, we chose at random geographic areas of the country, using the statistical equivalent of a coin toss to select them. Within these geographic regions, we randomly selected cities, towns, and rural areas. Within those cities and towns we randomly selected neighborhoods. Within those neighborhoods, we randomly selected households. . . . If there were two people living in a household who were in our age range, we flipped a coin to select which one to interview. If there were three people in the household, we did the equivalent of flipping a three-sided coin to select one of them to interview.

Notice that the participants who were interviewed in the NHSLS did *not* volunteer to participate in the survey. A specific individual was randomly selected through the process described. If that person refused to participate, someone else in the household could *not* substitute for that person. Using this random selection process, more than 3,000 people were interviewed for the National Health and Social Life Survey.

How closely did the NHSLS sample match important characteristics of the U.S. population? You can see for yourself by comparing the two columns in Table 1.1. Clearly, the random selection process used in the NHSLS study resulted in a sample that very closely approximated the characteristics of the U.S. population as a whole.

In constructing the random sample for the National Health and Social Life Survey, the goal was to reflect the entire U.S. adult population. However, some surveys are designed to sample the experiences, behaviors, or opinions of a specific group of people. For example, researchers Craig Anderson and Karen Dill (2000) were interested in how much time young people spend playing video games, especially violent video games. They surveyed 227 college students taking introductory psychology classes at a large midwestern university. The students also completed some personality tests and a questionnaire on past delinquent behaviors.

Figure 1.4 shows some of the survey results. In general, the amount of time spent playing video games decreased as the participants advanced in their level of education. But even at the college level, 88 percent of the female students and 97 percent of the male students reported being regular video game players. *Super Mario Brothers*, *Tetris*, and *Mortal Kombat* were the most popular games.

Although Anderson and Dill's data are interesting, it's important to stress that their survey was not based on a random sample of U.S. youth. Consequently, all you can really conclude from this survey is what it indicated about the characteristics of the college students who participated. To make broader generalizations about the video game habits and preferences of American youth, a survey based on a true random sample of would be needed.

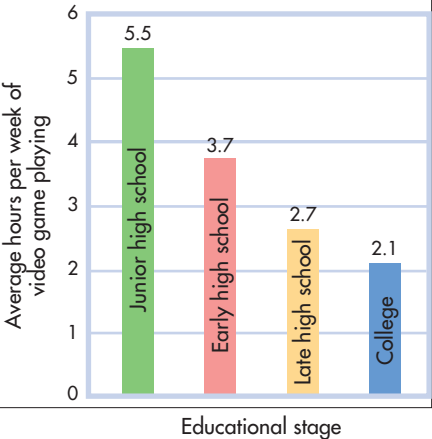


Table 1.1		
Comparing the NHSLS Sample and the U.S. Population		
	NHSLS Sample	U.S. Population
Gender		
Men	44.6%	49.7%
Women	55.4	50.3
	100 %	100 %
Age		
18–24	15.9%	18.2%
25–29	14.5	14.3
30–39	31.3	29.5
40–49	22.9	22.7
50–59	15.3	15.3
	100 %	100 %
Education		
Less than high school	13.9%	15.8%
High school or equivalent	62.2	64.0
Any college	16.6	13.9
Advanced	7.3	6.3
	100 %	100 %
Marital Status		
Never married	28.2%	27.7%
Currently married	53.3	58.3
Divorced, separated	16.2	12.4
Widowed	2.3	1.6
	100 %	100 %
Race/Ethnicity		
White	76.5%	75.9%
Black	12.7	11.7
Hispanic	7.5	9.0
Other	3.3	3.3
	100 %	100 %

SOURCE: Michael & others (1994).

Using random selection, approximately 3,000 people were chosen for the sample used in the National Health and Social Life Survey (NHSLS). In this table, you can see that the overall characteristics of those in the NHSLS sample were very representative of the U.S. population as a whole.

FIGURE 1.4 Time Spent Playing Video Games Anderson and Dill's (2000) survey of 227 college students revealed that the amount of time participants spent playing video games decreased as they attained higher levels of education. Notice that even at the college level, students reported playing video games for more than two hours per week on the average.

SOURCE: Adapted from data reported in Anderson & Dill (2000).

One potential problem with surveys and questionnaires is that people do not always answer honestly. Participants may misrepresent their personal characteristics or lie in their responses. These problems can be addressed in a well-designed survey. One strategy is to rephrase and ask the same basic question at different points in the survey or during the interview. The researchers can then compare the responses to make sure that the participant is responding honestly and consistently.

Correlational Studies

Looking at Relationships and Making Predictions

Key Theme

- Correlational studies show how strongly two factors are related.

Key Questions

- What is a correlation coefficient?
- What is the difference between a positive correlation and a negative correlation?
- Why can't correlational studies be used to demonstrate cause-and-effect relationships?

Along with answering the *who*, *what*, *where*, and *when* questions, the data gathered by descriptive research techniques can be analyzed to show how various factors are related. A **correlational study** examines how strongly two variables are related to, or associated with, each other. Correlations can be used to analyze the data gathered by any type of descriptive method.

To illustrate how correlational analysis can reveal links between different variables, let's return to the survey that Craig Anderson and Karen Dill (2000) conducted on video game playing by college students. Recall that Anderson and Dill collected data on the amount of time the participants spent playing different kinds of video games. The participants also filled out a questionnaire on past delinquent behavior and completed tests designed to measure different personality characteristics. Finally, Anderson and Dill compiled each student's cumulative grade point average.

Anderson and Dill wanted to know if there was any relationship between time spent playing video games and other factors, including personality attributes, delinquent behavior, or academic achievement. Once the data were collected from their survey participants, Anderson and Dill used statistical procedures to calculate a figure called a *correlation coefficient*.

A **correlation coefficient** is a numerical indicator of the strength of the relationship between two factors. A correlation coefficient always falls in the range from -1.00 to $+1.00$. The correlation coefficient has two parts—the number and the sign. The number indicates the *strength* of the relationship, and the sign indicates the *direction* of the relationship between the two variables.

More specifically, the closer a correlation coefficient is to 1.00 , whether it is positive or negative, the stronger is the correlation or association between two factors. Hence, a correlation coefficient of $+.90$ or $-.90$ represents a very strong association, meaning that the two factors almost always occur together. A correlation coefficient of $+.10$ or $-.10$ represents a very weak correlation, meaning that the two factors seldom occur together. (Correlation coefficients are discussed in greater detail in the Appendix on Statistics at the back of this book.)

Notice that correlation coefficients do not function like the algebraic number line. A correlation of $-.80$ represents a stronger relationship than does a correlation of $+.10$. The plus or minus sign in a correlation coefficient tells you the *direction* of the relationship between the two variables.

correlational study

A research strategy that allows the precise calculation of how strongly related two factors are to each other.

correlation coefficient

A numerical indication of the magnitude and direction of the relationship (the correlation) between two variables.

positive correlation

A finding that two factors vary systematically in the same direction, increasing or decreasing together.

negative correlation

A finding that two factors vary systematically in opposite directions, one increasing as the other decreases.

A **positive correlation** is one in which the two factors vary in the *same* direction. That is, the two factors increase or decrease together. For example, Anderson and Dill found that there was a positive correlation of $+.22$ between the amount of time spent playing violent video games and aggressive personality characteristics. That is, as the amount of time spent playing violent video games *increased*, aggression scores on personality tests *increased*.

In contrast, a **negative correlation** is one in which the two variables move in opposite directions: As one factor decreases, the other increases. For example, Anderson and Dill found that there was a *negative* correlation of $-.20$ between the amount of time spent playing video games and academic achievement, as measured by cumulative college grade-point average. As the amount of time spent playing video games *increased*, college grade-point average *decreased*.

Given this basic information about correlation coefficients, what can we conclude about the relationship between the time spent playing video games and academic achievement? Or about the exposure to violent video games and aggressive personality characteristics? Does the evidence allow us to conclude that playing video games *causes* a decrease in grade-point average? Or that playing violent video games *causes* people to develop more aggressive personalities?

Not necessarily. For example, even if playing video games and getting poor grades were very strongly correlated, it's completely possible that some other factor is involved. For example, it could be that students who lack academic motivation tend to spend their free time playing video games rather than studying. Thus, it might be that a lack of academic motivation, rather than video games, is responsible for lower grades.

Similarly, consider the positive correlation between aggressive personality and amount of time spent playing violent video games. We cannot conclude that playing violent video games *causes* an increase in aggression. It's entirely possible that people who are more aggressive are attracted to violent video games or enjoy playing them. Thus, it could be that people with aggressive personalities are more likely to spend more time playing violent video games than people who are less aggressive.

Here is the critical point: Even if two factors are very strongly correlated, *correlation does not necessarily indicate causality*. A correlation tells you only that two factors seem to be related or that they co-vary in a systematic way. Although two factors may be very strongly correlated, correlational studies cannot be used to demonstrate a true cause-and-effect relationship. As you'll see in the next section, the experimental method is the only scientific strategy that provides compelling evidence of a cause-and-effect relationship between two variables.

Even though you can't draw conclusions about causality from it, correlational research is very valuable. First, correlational research can be used to rule out some factors and identify others that merit more intensive study. Second, the results of correlational research can sometimes allow you to make meaningful predictions. For example, when Anderson and Dill (2000) analyzed data from their survey, they discovered that there was a moderately strong correlation of $+.46$ between the amount of



Jazzing Up Your Love Life with Correlation Coefficients Using data from the University of Chicago's ongoing General Social Survey, researchers John Robinson and Geoffrey Godbey (1998) discovered that adult sexual behavior was positively correlated with certain musical preferences. After controlling for age and race, the researchers found that people who have a strong preference for jazz are 30 percent more sexually active than the average American. Liking other types of music, such as rock or rap, was unrelated to sexual activity. Does this mean that listening to jazz *causes* an increase in sexual activity? Not necessarily. Remember, a correlation between two factors does not necessarily indicate causality—only that the two factors co-vary in a systematic way.



A Perfect Positive Correlation: The Clock and the Bell Tower If a $+1.00$ correlation occurred between two variables, it would be termed a *perfect positive correlation*. This means that every time Factor A occurred, Factor B would also occur. This might seem to suggest that Factor A is causing Factor B to occur, but that's not necessarily the case. For example, every time the big hand on the clock tower gets to 12, two miles away the bell starts ringing. The two events are perfectly correlated yet, in this case, one does not cause the other.

time spent playing violent video games and aggressive delinquent behavior, such as damaging public or private property. That is, the more time that was spent playing violent video games, the higher was the incidence of aggressive delinquent behavior. Looking at the overall results of their survey, Anderson and Dill concluded that there *were* legitimate reasons to be concerned about the potential negative consequences of long-term or excessive exposure to video games, especially violent video games. And, their findings led them to design an experiment to study the association between playing violent video games and actual aggressive behavior.

Each of the descriptive research methods we've looked at in this section can provide information about when behavior happens, how often it happens, and whether other factors or events are related to the behavior being studied. Next, we'll take an in-depth look at how Anderson and Dill used the experimental method to study the relationship between playing violent video games and aggressive behavior.

1.2 R · E · V · I · E · W

C · O · N · C · E · P · T

Descriptive Research Methods

Fill in each blank with one of these terms: naturalistic observation, the case study method, correlational research, positive correlation, negative correlation.

1. A psychologist discovers that as negative life events increase, episodes of depression also increase. The psychologist concludes that there is a _____ between negative life events and episodes of depression.
2. A psychologist is interested in what hospital staff members say about their patients in public. His research assistants spend four hours riding elevators in various hospitals and unobtrusively recording the public conversations. This psychologist is using _____.
3. A psychologist is using police reports and weather reports to determine whether there is any relationship between the frequency of arrests for aggressive behavior and the temperature. She is using _____ to study this relationship.
4. Researchers have found that the more credit cards people have, the less money they tend to have in their savings accounts. These researchers have discovered a _____ between the number of credit cards and the amount of savings.
5. Dr. Romano conducts an in-depth interview and gives extensive psychological tests to an individual who claims to have been abducted by aliens. Dr. Romano is using _____ in this investigation.

The Experimental Method

Key Theme

- The experimental method is used to demonstrate a cause-and-effect relationship between two variables.

Key Questions

- What were the hypothesis, independent variable, and dependent variable in the Anderson and Dill video game experiment?
- What are the roles of random assignment, the experimental group, and the control group?
- What are some important variations in experimental design, and what are the limitations of experiments?

The **experimental method** is a research method used to demonstrate a cause-and-effect relationship between changes in one variable and the effect that is produced on another variable. Conducting an experiment involves deliberately varying one factor, which is called the **independent variable**. The researcher then measures the changes, if any, that are produced in a second factor, called the

dependent variable. The dependent variable is so named because changes in it *depend* on variations in the independent variable.

To the greatest degree possible, all other conditions in the experiment are held constant. Thus, when the data are analyzed, any changes that occur in the dependent variable can be attributed to the deliberate variations of the independent variable. In this way, an experiment can demonstrate a cause-and-effect relationship between the independent and dependent variables.

Do Violent Video Games Increase Aggressive Behavior? An Experiment

Remember the chapter Prologue and our students' questions about the influence of video games on aggressive behavior? To help you understand the experimental method, let's look at part of an experiment conducted by psychologists Craig Anderson and Karen Dill.

Anderson and Dill (2000) wanted to study the effects of playing violent video games on behavior, especially aggressive behavior. In the previous section, we noted that Anderson and Dill conducted a correlational study based on questionnaires and personality measures that were administered to a large number of college students. Analysis of the data indicated that playing violent video games was strongly and positively correlated with two factors: aggressive delinquent behavior in real life and, to a lesser degree, aggressive personality characteristics. However, as Anderson and Dill noted, such correlational evidence *cannot* be used to draw conclusions about cause-and-effect relationships. Experimental evidence is needed to show that a causal relationship exists between two variables—in this case, between playing violent video games and exhibiting real-life aggression.

The Hypothesis, Participants, and Random Assignment

Anderson and Dill set out to experimentally test the hypothesis that playing violent video games would increase aggressive behavior. The participants in their study were 210 undergraduate students—104 females and 106 males—taking an introductory psychology class. All students received partial credit in the class for voluntarily participating in the experiment. An alternate activity was available for class credit for students who did not want to participate in the study.

The researchers used a process called *random assignment* to assign participants to the different experimental groups. **Random assignment** means that all participants in the study have an equal chance of being assigned to any of the groups in the experiment. Random assignment is an important element of good experimental design, because it helps ensure that potential differences among the participants are spread out across all experimental conditions. And, because the same criteria are used to assign all participants to the different groups in the experiment, random assignment helps make certain that the assignment of participants is done in an unbiased manner.

The Experimental and Control Groups

In this experiment, the *independent variable*, which is also sometimes referred to as the *treatment of interest*, was playing a violent video game. Those participants who were randomly assigned to play the violent video game constituted the **experimental group**, or the **experimental condition**. Participants in the experimental group go through all the different phases of the experiment and are exposed to the independent variable, or treatment of interest.

experimental method

A method of investigation used to demonstrate cause-and-effect relationships by purposely manipulating one factor thought to produce change in another factor.

independent variable

The purposely manipulated factor thought to produce change in an experiment; also referred to as the *treatment of interest*.

dependent variable

The factor that is observed and measured for change in an experiment; thought to be influenced by the independent variable.

random assignment

The process of assigning participants to experimental conditions so that all participants have an equal chance of being assigned to any of the conditions or groups in the study.

experimental group or experimental condition

In an experiment, the group of participants who are exposed to all experimental conditions, including the independent variable or treatment of interest.



Violent Video Games and Aggressive Behavior

As you can see in this screen shot from a best-selling video game, *Grand Theft Auto 3*, graphic violence is a core theme of many popular computer games. These games use realistic sounds and sophisticated 3-D visual effects. The player typically assumes the role of the main character, firing a variety of weapons and racking up points for killing and mutilating opponents or even innocent bystanders. Are such games harmless entertainment? Or do they encourage real-life aggressive behavior?

In any well-designed experiment, there is at least one **control group**, or **control condition**. In Anderson and Dill's experiment, the control group consisted of the participants who were assigned to play a *nonviolent* video game. In a typical experiment, the participants assigned to the control group go through all the experimental phases but are *not* exposed to the independent variable. Thus, the control group serves as a baseline against which changes in the experimental group can be compared.

How were the violent and nonviolent video games chosen? Anderson and Dill selected them on the basis of a previous study they had done in which participants rated several video games. That study had indicated that two video games were essentially the same in terms of difficulty, enjoyment, and frustration, but differed in the amount of violence. Those two video games were *Wolfenstein 3D* and *Myst*.

Here's the basic storyline of *Wolfenstein 3D*: It's World War II. You, the hero, have been imprisoned by the Nazis in the dungeon of Castle Wolfenstein. You escape (of course) and gain access to an arsenal of weapons, including a machine gun, a revolver, a knife, and a flame thrower. Your goal? Kill the Nazi guards as you make your way through the maze of tunnels and halls that wind through Castle Wolfenstein, progressively advancing in game levels so that you can kill the most nefarious Nazi of all—Adolf Hitler.

In contrast, *Myst* is an engaging, interactive game set on a mysterious island. Lush scenery, background music, and three-dimensional effects enhance the game, which was deliberately designed to be nonviolent. To play the game, you explore the island, uncover secrets, collect clues, and solve a variety of puzzles with logic and the information you've gathered.

The Dependent Variable: Aggressive Behavior

The hypothesis predicted that playing violent video games (the independent variable) would increase aggressive behavior (the dependent variable). How did Anderson and Dill operationally define "aggressive behavior"? Ethically, of course, the researchers could not create an experimental situation in which participants could actually attack or harm one another, either physically or otherwise. Instead, they used a standard measure of aggressive behavior called the *Competitive Reaction Time Task*.

Here's how the Competitive Reaction Time Task works. Two research participants are situated in different rooms, each wearing headphones and sitting in front of a computer screen. As soon as the participants hear a signal tone, each tries to push the mouse button faster than his opponent in the other room. Whichever participant loses the race gets blasted with noise through the headphones. There are a total of 25 reaction time races.

How does the Competitive Reaction Time Task provide a measure of aggressive behavior? Before each race, each participant sets the noise level and duration that will be delivered to his opponent if his opponent loses. Participants can choose a sound blast level that ranges from Level 1, which corresponds to 50 decibels, to a high of Level 10, which corresponds to a very loud 100 decibels. On their computer screens, the participants can see the penalty for losing that has been set by their opponents.

Because the players determine the penalty that will be delivered to the loser of the game, the Competitive Reaction Time Task allows researchers to precisely measure the level of aggression that a research participant is willing to mete out to another participant. In this experiment, then, Anderson and Dill operationally defined aggressive behavior as "the intensity and duration of noise blasts the participant chooses to deliver to the opponent."

control group or control condition

In an experiment, the group of participants who are exposed to all experimental conditions, except the independent variable or treatment of interest; the group against which changes in the experimental group are compared.

Although the Competitive Reaction Time Task appears convincing, the game is actually rigged. The research participant is not really competing against another person in a different room. Instead, the computer is programmed so that each research participant experiences the exact same outcome—13 wins and 12 losses. The intensity and duration of the noise blasts that they receive when they lose are also predetermined, and they are the same for all participants.

The Experimental Procedure

To give participants ample playing experience with the assigned video game, the researchers had them come to the laboratory for two separate sessions approximately one week apart. When participants first arrived at the laboratory, they were told they were taking part in a study to investigate how people learn and develop skills at motor tasks such as those involved in playing video games and how these skills affect other mental and motor tasks. They were also told that they would be recorded in order to carefully analyze their motor skill development. To help make this believable, a VCR was set up and running near their computer, complete with bogus wires connecting the VCR and the computer.

During the first laboratory session, each participant was instructed on how to play the assigned video game. Then, they played either *Wolfenstein 3D* or *Myst* for 30 minutes, depending on whether they were part of the experimental or control group. At the second laboratory session a week later, participants played their assigned video game for another 15-minute period. This was followed by the Competitive Reaction Time Task, in which they had multiple opportunities to blast their opponent with noise. Given the opportunity to behave aggressively against an invisible opponent, would those who had just played *Wolfenstein 3D* (the violent game) behave more aggressively than those who had just played *Myst* (the nonviolent game)?

At the conclusion of the second experimental session, each participant received a debriefing statement that explained the study's actual hypotheses and procedures and debunked the cover story. The research assistant also answered any questions about the experiment. Figure 1.5 outlines the basic steps in this study.

Independent variable:

Dependent variable:

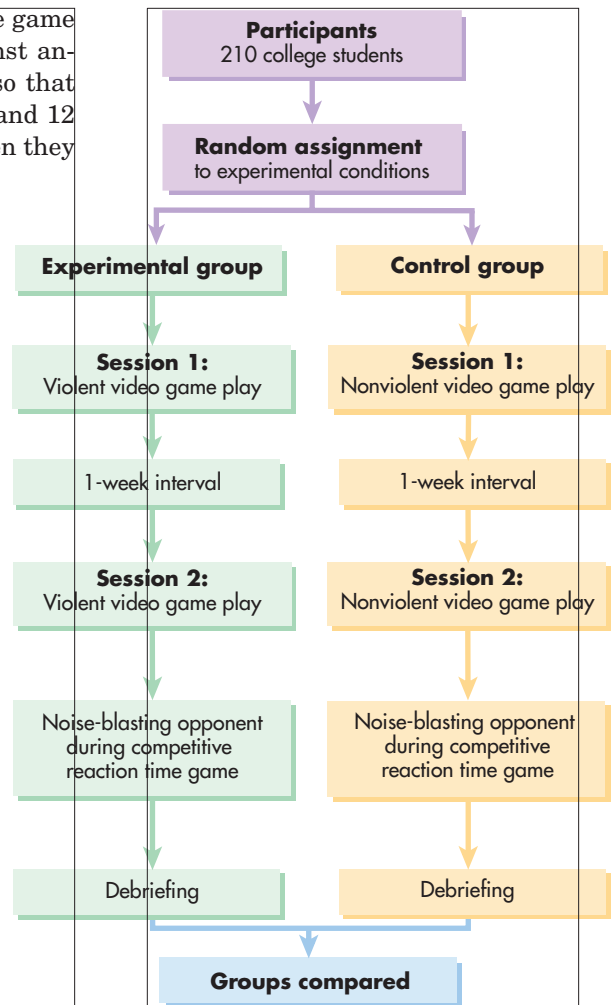
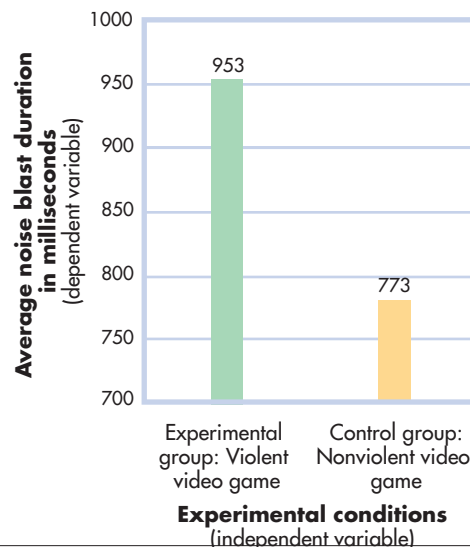


FIGURE 1.5 The Experimental Design of Anderson and Dill's (2000) Violent Video Game Study

The Results and Discussion

What did Anderson and Dill find? Let's look at the experimental results. As Figure 1.6 shows, there was a statistically significant difference between the experimental and control conditions. Students who had played *Wolfenstein 3D*, the violent game, scored higher on one measure of aggressive behavior than students who had played *Myst*, the nonviolent video game. On average, they delivered longer blasts of noise to their opponents. This result confirmed that participants who had played a violent video game behaved more aggressively than people who had played a nonviolent video game.



ED: We felt the colors G-6 and Y-5 for the bars in Figure 1.6 were too light, so we used the colors G-4 and Y-2 instead. Okay? —Comp.

FIGURE 1.6 Results of the Violent Video Game Experiment In the graph you can see that briefly playing a violent video game increased aggressive behavior. As compared to those who played a nonviolent video game, the participants who played the violent video game blasted their opponents with longer noise bursts in the Competitive Reaction Time Task. The difference between the two groups was statistically significant.

SOURCE: Data adapted from Anderson & Dill (2000).

Psychologist Craig Anderson Testifying before the U.S. Senate Commerce Committee, Anderson said, “Of course, most people who consume high levels of violent media, adults or youth, do not end up in prison for violent crimes. The more relevant question is whether many (or most) people become more angry, aggressive, and violent as a result of being exposed to high levels of media violence. Are they more likely to slap a child or spouse when provoked? Are they more likely to drive aggressively and display ‘road rage’? Are they more likely to assault co-workers? The answer is a clear ‘yes.’”



However, remember that Anderson and Dill (2000) operationally defined aggressive behavior as “the intensity and duration of noise blasts the participant chooses to deliver to the opponent.” Although there were statistically significant differences between the two groups on the *duration* of the noise blasts, the two groups did not differ significantly on *intensity* of the sound setting. In other words, playing the violent versus the nonviolent video game had no effect on how loudly the research participants blasted their opponents. The researchers were surprised by the lack of significant group differences on intensity of the noise blasts.

Nonetheless, combining these experimental results with Anderson and Dill’s correlational study that we described earlier provides converging lines of real world and laboratory evidence. As Anderson and Dill (2000) explain:

In the laboratory, college students who played a violent video game behaved more aggressively toward an opponent than did students who had played a nonviolent video game. Outside the laboratory, students who reported playing more violent video games over a period of years also engaged in more aggressive behavior in their own lives. This convergence of findings across such disparate methods lends considerable strength to the main hypothesis that exposure to violent video games can increase aggressive behavior.

Reporting the Findings

On April 23, 2000, the headline of the American Psychological Association’s news release read:

Violent Video Games Can Increase Aggression: May Be More Harmful Than Violent Television and Movies Because of the Interactive Nature of the Games

The news release was issued on the day that Anderson and Dill’s study was published in the *Journal of Personality and Social Psychology*, one of psychology’s premier scientific journals. Because of the amount of public interest in the study, the American Psychological Association made the full text of the study available on the Internet at <http://www.apa.org/journals/psp/psp784772.html>.

Needless to say, the study attracted considerable attention—and provoked considerable debate—in the mass media when it was published. Adding fuel to that debate was the fact that shortly before the study was published, Anderson had testified before the U.S. Senate Commerce Committee in a hearing on “The Impact of Interactive Violence on Children.” You can read a transcript of Anderson’s testimony at <http://psych-server.iastate.edu/faculty/caa/abstracts/2000-2004/00Senate.html>.

At the Senate hearing and in the published study, Anderson and Dill argued that playing violent video games may be more harmful than watching violent television and movies. Why? One reason is that in violent video games, the player takes on the role of and identifies with the aggressor. Another reason is that violent video games are interactive, requiring the player to actively choose to act aggressively.

And how did our students in the 9:30 class react to the Anderson and Dill study? Kim was even more determined to keep her boys away from violent computer games. Kyle, however, remained unconvinced. “Maybe some people get frustrated when they play those kinds of games,” he argued. “But still, there’s a big difference between playing some make-believe video game and killing real people.” Tanisha had another idea: “Not everyone is as self-disciplined as you, Kyle. Maybe the effects aren’t the same for everybody. Maybe some kids are very easily influenced by playing violent video games and we need to identify those kids.”

“A new hypothesis!” Sandy exclaimed.

Variations in Experimental Design

The design of any particular experiment depends on the issues being investigated. In this section, we'll look at two specific variations in experimental designs—the use of a placebo control group and natural experiments.

Placebo Control Group

Some experiments are designed to assess the effectiveness of a therapeutic treatment, such as a particular medication or a type of psychotherapy. In this kind of experiment, participants assigned to the experimental group receive the treatment of interest—the actual drug or therapy. Other participants are assigned to a **placebo control group** and receive a placebo. Definitions vary, but essentially a *placebo* is an inert substance or a treatment that has no known effects (Straus & von Ammon Cavanaugh, 1996). In a typical therapeutic effectiveness study, participants are told the purpose of the study and that they have a 50–50 chance of receiving the actual versus the placebo treatment.

For example, psychologist Paul Solomon and his colleagues (2002) used a placebo control group to test claims that an herb called *gingko biloba* improves memory, concentration, and mental focus in older adults. Participants were randomly assigned to two groups. One group took the manufacturer's recommended dosage of *gingko biloba* daily for six weeks, while the control group took an identical dosage of capsules containing a placebo. At the beginning and end of the six-week study, all participants took a battery of cognitive tests.

The results? At the end of the six-week study, the test scores of *both* groups rose. However, there were no significant differences between the improvement in the placebo group and the improvement in the *gingko biloba* group. Because a placebo control group was used, the researchers were able to conclude that the participants' experience with the tests—simply taking the same tests twice—was probably the reason for the general improvement in test scores. This phenomenon is called a **practice effect**.

A placebo control group can also help researchers check for **expectancy effects**, which are changes that may occur simply because subjects expect change to occur. Expectancy effects are also sometimes referred to as *placebo effects*. Using this method, researchers can compare the effects of the actual treatment versus the expectancy effects, if any, that are demonstrated by the placebo control group.

In therapeutic effectiveness studies, researchers often use a double-blind technique. A **double-blind study** is one in which neither the participants nor the researcher who interacts with the participants is aware of the treatment or condition to which the participants have been assigned. For example, in the *gingko biloba* study, the researchers who interacted with the participants did not know which were receiving the placebo and which the actual treatment. The researchers who *did* know which participants had been assigned to each group did not interact with or evaluate the participants. In contrast, a *single-blind study* is one in which the researchers, but not the subjects, are aware of critical information.

The purpose of the double-blind technique is to guard against the possibility that the researcher will inadvertently display **demand characteristics**, which are subtle cues or signals that communicate what is expected of certain subjects (Kihlstrom, 1995). A behavior as subtle as smiling when dealing with some participants, but not when dealing with others, could bias the outcome of a study.

Natural Experiments

Psychologists often want to study phenomena that would be impossible or unethical to duplicate in a controlled laboratory setting. For example, a psychologist might want to know whether prolonged exposure to a noisy urban environment creates psychological and physical stress in young children. Obviously, it would be unethical to subject children to loud noise for a prolonged (or even a short) period of time.

1UN27

Can *Gingko Biloba* Enhance Your Mental Abilities?

Sales of the herbal supplement *gingko biloba* are booming: More than \$300 million is spent on the dietary supplement every year in the United States alone. Manufacturers market the herb as a “cognitive enhancer,” claiming that it improves memory, alertness, mental focus, and concentration, especially in older adults. Studies of *gingko biloba*'s effectiveness have produced inconsistent results (see Gold & others, 2002). The use of a placebo control group in a recent study by Paul Solomon and his colleagues (2002) provided clear evidence, however, that *gingko biloba* was no more effective than a placebo in improving memory, mental alertness, or concentration.

placebo control group

(pluh-SEE-bo) In an experiment, a control group in which the participants are exposed to a fake independent variable, or placebo. The effects of the placebo are compared to the effects of the actual independent variable treatment of interest on the experimental group.

practice effect

Any change in performance that results from mere repetition of a task.

expectancy effects

Changes in a subject's behavior produced by the subject's belief that change should happen; also called *placebo effects*.

double-blind study

Experimental technique in which neither the participants nor the researcher interacting with the participants is aware of the group or condition to which the participants have been assigned.

demand characteristics

In a research study, subtle cues or signals expressed by the researcher that communicate the kind of response or behavior that is expected from the participant.

pseudoscience

A fake or false science that makes claims based on little or no scientific evidence.

paranormal phenomena

Alleged abilities or events that fall outside the range of normal experience and established scientific explanations.

rule of falsifiability

In order for a claim to be scientifically tested and proved true, there must be identifiable evidence that could prove the claim false.

illusory correlation

The mistaken belief that two factors or events are related when they are not.

Sometimes researchers are able to study such phenomena by taking advantage of naturally occurring events. In a *natural experiment*, researchers carefully observe and measure the impact of a naturally occurring event on their study participants. Gary Evans and his colleagues (1998) used this strategy to study the effects of exposure to chronic noise on children. They compared stress levels in elementary school children before and after a large international airport was built in their once-quiet community near Munich, Germany. The researchers measured both physical and psychological indicators of stress, such as blood pressure, levels of stress hormones, and perceptions of the daily quality of life. They also measured the same indicators over the same period of time in a matched control group of children who lived in a community that remained quiet.

What were the results of this natural experiment? The children who were exposed to chronic noise (the independent variable) showed increased psychological and physical stress (the dependent variable). In contrast, the control-group children, who were not exposed to constant noise, showed little change in stress. Evans and his colleagues (1998) concluded that chronic noise does cause a significant increase in psychological stress in children.

Limitations of Experiments

The strength of a well-designed experiment is that it can provide convincing evidence of a cause-and-effect relationship between the independent and dependent variables. Experiments do have limitations, however. Because experiments are often conducted in highly controlled laboratory situations, they are frequently criticized for having little to do with actual behavior. That is, the artificial conditions of some experiments may produce results that do not *generalize* well, meaning that the results cannot be applied to real situations or to a more general population beyond the participants in the study. In order to make experimental conditions less artificial, experiments are sometimes conducted in a natural setting rather than in a laboratory.

Another limitation of the experimental method is that even when it is possible to create the conditions that the researchers want to study, it may be unethical to do so. In the final section of this chapter, we'll look at the kinds of ethical considerations that psychologists must take into account in conducting any kind of research. While the conclusions of psychology rest on empirical evidence gathered using the scientific method, the same is not true of *pseudoscientific* claims. As you'll read in Science Versus Pseudoscience Box 1.3: What Is a Pseudoscience?, pseudosciences often violate the basic rules of science.

1.3 R · E · V · I · E · W

C · O · N · C · E · P · T

The Experimental Method

Identify each component of the video game and aggression experiment conducted by Anderson and Dill (2000). Choose from the following terms:

- | | | |
|-------------------------|-----------------------|---------------------------|
| a. independent variable | d. experimental group | f. random assignment |
| b. control group | e. hypothesis | g. operational definition |
| c. dependent variable | | |

- | | |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|
| _____ 1. The measured duration and intensity of the noise blast delivered to opponents in the Competitive Reaction Time Task. | _____ 4. Group of participants who played the video game <i>Myst</i> . |
| _____ 2. The prediction that aggressive behavior increases after violent video game play. | _____ 5. Group of participants who played the video game <i>Wolfenstein 3D</i> . |
| _____ 3. "Aggressive behavior" is measured by a participant's choice of level and length of noise delivered to his or her opponent after winning in the Competitive Reaction Time Task. | _____ 6. Participants had an equal chance of being assigned to either the experimental or control group. |
| | _____ 7. Playing a violent video game. |

SCIENCE VERSUS PSEUDOSCIENCE 1.3

What Is a Pseudoscience?

What do astrology, numerology, graphology, palmistry, aura reading, and crystal therapy have in common? All of these are examples of *pseudosciences*. The word *pseudo* means “fake” or “phony,” so a pseudoscience is a *fake science*. More specifically, a **pseudoscience** is a theory, method, or practice that promotes claims in a way that appears to be scientific and plausible even though supporting empirical evidence is lacking or nonexistent (Lilienfeld & others, 2001; Shermer, 1997).

Some claims of paranormal phenomena also fall into the category of pseudoscience. **Paranormal phenomena** are alleged abilities or events that fall outside the range of normal experience and established scientific explanations. Examples of paranormal phenomena include *extra-sensory perception* (ESP), such as mental telepathy, psychic predictions, and channeling (in which a spirit entity supposedly speaks through a human medium).

Many pseudoscientific claims violate a basic rule of science, called the **rule of falsifiability**: In order for a claim to be proved true, you must be able to identify some type of evidence that would refute the claim or prove that it is *false*. If there is no conceivable evidence that could disprove a claim, the claim is irrefutable—and examining evidence is pointless. *Irrefutable claims* often take the form of broad or vague statements that are essentially meaningless.

For instance, take the claim that “Wearing a quartz crystal will align your aura and balance your spiritual energy.” How could such a statement be tested? Is there any kind of evidence that would *disprove* such a claim?

Pseudosciences often use anecdotes or testimonials as evidence to support their claims (Hines, 1988). For example, “My sister wore a quartz crystal for a month and she lost 15 pounds!” Although such testimonials may sound convincing, they are *not* acceptable scientific evidence because they lack the basic

controls used in experimental research. Many different factors could account for the apparent success of the claim, some of which we’ll describe in future chapters. These include simple coincidence, expectancy or placebo effects, misremembering, and illusory correlation. An **illusory correlation** is the mistaken belief that two factors or events are related when they are not—like the person’s sister wearing a crystal and losing weight.

Mixing established scientific facts with unfounded claims is another common pseudoscience strategy. For example, astrology claims that the gravitational forces of distant planets influence human personality and behavior on earth (Dean & others, 1996). But pseudosciences typically apply scientific principles in ways that are *not* substantiated by empirical evidence and are actually *contradicted* by scientific explanations. In the case of astrology, the gravitational effects of even the closest planets are far too weak to have any impact on earth-bound humans (Hines, 1988).

Many pseudosciences claim to enhance human behavior or abilities. To bolster the credibility of their claims, pseudosciences typically use lots of scientific jargon. Vague references to “leading researchers,” “controlled psychological studies,” “technological breakthroughs,” and so forth may be cited without any documentation or specific sources.

One of our goals as the authors of your text is to help you develop the ability to think scientifically. This includes using scientific thinking to evaluate claims about behavior or mental processes that seem farfetched. To help you understand how the scientific method could be used to test any claim, we created the **Is It TRUE?** model (Hockenbury & Hockenbury, 1999). Each letter of the word *TRUE* refers to a different step in the evaluation process, as follows:

T = Is It Testable? Can the claim be stated as a testable hypothesis? If the procedure to test the claim is an experiment, what are the independent and dependent variables? What are the operational definitions of the variables? What controls are needed for the test? If the claim is not testable, is there physical evidence to support the claim?

R = Is It Reliable? How many times was the claim tested? Has evidence for the claim been replicated? If the test was repeated by others, were the same results obtained?

U = Is It Unusual? Are the results significantly different from what you would expect if nothing more than chance or guessing were operating during the test?

E = Is It Explainable? How would a reasonable person explain the outcome? Are there other possible explanations for the outcome? If the results fail to provide support, how do proponents of the claim account for the results? Why would people be motivated to believe in the claim despite a lack of evidence supporting it?

Using the “Is It TRUE?” model can help you evaluate the evidence for or against pseudoscientific and paranormal claims. In the coming chapters, you’ll see how a variety of pseudoscience claims have stood up to scientific testing. We hope you enjoy the Science Versus Pseudoscience feature boxes throughout this text!



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Ethics in Psychological Research

Key Theme

- Psychological research conducted in the United States is subject to ethical guidelines developed by the American Psychological Association.

Key Questions

- What are five key provisions of the APA ethics code for research involving humans?
- Why do psychologists sometimes conduct research with nonhuman animals?

What might happen if you were to volunteer to participate in a psychology experiment or study? Are psychologists allowed to manipulate or control you without your knowledge or consent? Could a psychologist force you to reveal your innermost secrets? Could he or she administer electric shocks? Trick you into doing something embarrassing against your will?

The answer to all these questions is “no.” The American Psychological Association (APA) has developed a strict code of ethics for conducting research with both human and animal subjects. This code is contained in a document called *Ethical Principles of Psychologists and Code of Conduct* (APA, 1992a). You can access the complete guidelines at <http://www.apa.org/ethics/code.html>.

In general, psychologists must respect the dignity and welfare of participants. Psychologists cannot expose research participants to dangerous or harmful conditions that might cause either physical or emotional harm. And, any psychological research using human or animal subjects must be approved by an ethics panel at the institution where the study is to be conducted.

Not surprisingly, the ethical guidelines for research with human and animal subjects are somewhat different. However, the use of animals in psychological research is also governed by specific ethical guidelines (APA, 1992b). These guidelines, as well as other issues, are discussed in In Focus Box 1.4: Questions About the Use of Animals in Psychological Research.

Here are five of the key provisions in the most recent version of the APA ethical guidelines regulating research with human participants:

- **Informed consent and voluntary participation.** In reasonably understandable language, the psychologist must inform the participants of the nature of the research, including significant factors that might influence a person’s willingness to participate in the study, such as physical risks, discomfort, or unpleasant emotional experiences. The psychologist must also explain to the participants that they are free to decline to participate or to withdraw from the research at any time.
- **Students as research participants.** When research participation is a course requirement or an opportunity for extra credit, the student must be given the choice of an alternative activity to fulfill the course requirement or earn extra credit.
- **The use of deception.** Psychologists can use deceptive techniques as part of the study only when two conditions have been met: (1) It is not feasible to use alternatives that do not involve deception, and (2) the potential findings justify the use of deception because of their scientific, educational, or applied value.
- **Confidentiality of records.** Psychologists may not publicly disclose personally identifiable information about research participants.
- **Information about the study and debriefing.** All participants must be provided with the opportunity to obtain information about the nature, results, and conclusions of the research. Psychologists are also obligated to *debrief* the participants and to correct any misconceptions that participants may have had about the research.

IN FOCUS 1.4

Questions About the Use of Animals in Psychological Research

The use of nonhuman animal subjects in psychological and other research is based on the premise that human life is intrinsically more valuable than animal life (Morrison, 2001). Not everyone agrees with this position (see Mukerjee, 1997; Plous, 1996; Rowan, 1997).

The American Psychological Association (1992b) condones the use of animals in psychological research, but only under certain conditions. First, research using animal subjects must have an *acceptable scientific purpose*. Second, there must be a reasonable expectation that the research will (a) increase knowledge about behavior, (b) increase understanding of the species under study, or (c) produce results that benefit the health or welfare of humans or other animals.

What standards must psychologists meet in using animal subjects?

The American Psychological Association (1992b) publishes the *Guidelines for Ethical Conduct in the Care and Use of Animals*, which you can read at <http://www.apa.org/science/anguide.html>. The APA Guidelines for animal care have been praised as being the most comprehensive set of guidelines of their kind (Fisher, 1986). In addition, federal and state laws govern the care and use of research animals (Overmier & Carroll, 2001).

How many animal subjects are used in psychological research?

The majority of psychological research involves human subjects, not animals. Animals are used in only about 7 to 8 percent of psychological studies conducted in a given year. Most psychological research with animal subjects does *not* involve pain, suffering, or deprivation (APA, 1995; Shapiro, 1991).

In a survey conducted by the APA, the total number of animals used by psychology departments throughout the United States was about 200,000. Of these, about 170,000 were rats, mice, or other rodents. Approximately 1,200 were primates, 800 dogs, and 600 cats. The rest

of the total comprised a variety of creatures, from bats to sea snails (APA, 1986). To help put these numbers in perspective, more than 5 million dogs and cats are destroyed in pounds every year.

Why are animals used in psychological research?

Here are a few of the key reasons that psychologists might use animal subjects rather than human subjects in research:

1. Many psychologists are interested in the study of animal behavior for its own sake.

The branch of psychology that focuses on the study of the behavior of different species is called *comparative psychology*. Some psychologists also do research in the area called *animal cognition*, which is the study of animal learning, memory, thinking, and language (Boysen & Hines, 1999).

Animal research is also pursued for its potential benefit to animals themselves. For example, psychological research on animal behavior has been used to improve the quality of life of animals in zoos and to increase the likelihood of survival of endangered species in the wild.

2. Animal subjects are sometimes used for research that could not feasibly be conducted on human subjects.

There are many similarities between human and animal behavior, but animal behavior tends to be less complex. Thus, it is sometimes easier to identify basic principles of behavior by studying

animals. Psychologists can also observe some animals throughout their entire lifespan, from the prenatal stage to old age. To track such changes in humans would take many decades of research. Finally, psychologists can exercise much greater control over animal subjects than over human subjects. If necessary, researchers can control every aspect of the animals' environment and even their genetic background.

In what areas of psychology has research using animals produced valuable information?

Psychological research with animal subjects has made essential contributions to virtually every area of psychology (Domjan & Purdy, 1995; Overmier & Carroll, 2001). Along with contributing to knowledge of the workings of the human brain, animal research has contributed to psychological knowledge in the areas of learning, memory, cognition, psychological disorders, therapies, and stress. Research with animals has produced significant gains in the treatment of many conditions, including substance abuse, spinal cord injury, hypertension, and sleep disorders (see Carroll & Overmier, 2001). Significant gains have also been made in helping animals, including the successful breeding and preservation of endangered species, improvements in the care of zoo animals, and the prevention of animal diseases (APA, 1995, 2002; Miller, 1985).



Psychologists Helping Animals Psychologist Benjamin Beck directs a program that has successfully reintroduced over 250 golden lion tamarins, an endangered species, to the wild (Ruiz-Miranda & others, 1999). The tamarin is a small, tree-dwelling monkey that inhabits a small area of Brazilian rain forest. As associate director of the National Zoo in Washington, D.C., Beck is also actively involved in developing enrichment activities for the zoo's residents—from orangutans to dung beetles (Cohn, 2002).

Who makes sure that these ethical guidelines are followed? First, all institutions where psychological research is conducted have ethics committees that must review and approve all research proposals. Second, the APA has established the Committee on Scientific and Professional Ethics, which investigates all complaints it receives. Any psychologist who is found to be in violation of the ethics code may be suspended or expelled from the APA.

In this chapter, we've laid the foundation for exploring a wide range of topics in psychology. Throughout this textbook, you'll see how psychologists have applied the tools of science, sometimes very ingeniously, to understand why we humans do what we do. Whether it is dealing with the common experiences of everyday life or with more extreme events, psychology can provide many insights into human behavior and mental processes. As you'll discover, psychology has much to teach you, not only about other people, but about yourself as well. It's a fascinating journey and one that we look forward to sharing with you.

APPLICATION

Evaluating Mass Media Reports About Psychology

Psychologists and psychological findings are often featured in the media. Sometimes it's a researcher, such as Craig Anderson, who is being interviewed about the published results of a study that has caught the interest of the popular press. Or it may be a psychologist who is appearing on a television or radio talk show to discuss a particular topic, such as the degree to which parents influence a child's personality.

How can you evaluate the information about psychology and psychological topics reported in the mass media? The following guidelines will help you critically evaluate what you see and hear in the news.

1. Be especially skeptical of sensationalistic claims or findings.

News headlines proclaiming "discoveries" or "breakthroughs" in psychological research are designed to grab your attention. Almost always, if you listen or read further, you'll encounter a much more cautious tone in the statements of the psychologists themselves. As scientists, psychologists tend to be conservative in stating their research results so as not to mislead the public. Reporters, however, are sometimes more interested in attracting readers or viewers than in accurately portraying scientific results (Connor-Greene, 1993). As media psychologist Rhea Farberman (1999) explains:

What the researcher sees in his or her research results—one piece of the overall research puzzle that can be

applied within the limits of this particular study—is different from what the reporter wants to find in a research study—the all-encompassing headline. The challenge for the psychologist is how to translate the research into a meaningful sound bite.

Given the difficulty of compressing complicated information into a 10-second sound bite, it's common for researchers to be quoted out of context or for important qualifying statements to be left out by a reporter or producer (Broder, 1999). A 60-minute interview may be edited down to just 30 seconds of air time.

2. Anecdotes are the essence of talk shows, not scientific evidence.

Because psychology investigates the entire range of human experience, psychology-related topics are standard fare on news and talk shows. Although such programs often feature psychologists with research experience and expertise in a particular area, the shows tend to quickly abandon discussions of scientific evidence in favor of anecdotal evidence.

Anecdotal evidence consists of personal stories told to confirm or support a particular claim. The personal stories are often dramatic, funny, or heartrending, making them subjectively very compelling. However, an anecdote by definition is one person's experience. There's no way to know if the person's experience is representative of other people's—or if it is exceptional or unusual. In contrast, descriptive and experimental research

typically involves large groups of carefully selected subjects. When the number of participants in a study is small, researchers usually take that limitation into account when they draw conclusions from their findings.

3. Remember that the goal of "shock" radio and television is ratings.

Let's face it. The mass media are not educational institutions. They are a profit-driven industry, and the size of the audience is crucial to realizing those profits. So what draws viewers and listeners? Shock value is a big draw. As media psychologist Michael Broder (1999) explains, "It's not how nice, professional, smart, loyal, helpful, or thorough you are, but how well you attract numbers of people."

4. Look for the original source of professional publication.

When the mass media report on a study that has been conducted by a reputable researcher, the original source of professional publication is almost always noted in the news report. Usually, psychological research is published in a professional psychology journal before it is shared with the general public. For example, it was only *after* Craig Anderson and Karen Dill (2000) published their findings about playing violent video games in the *Journal of Personality and Social Psychology* that they discussed their findings with reporters. Even so, reporters don't always read the research report or understand the research issues under discussion. And, they may add their own interpretations to those of the

researchers, thereby distorting or misrepresenting the actual findings (Farberman, 1999).

There's another reason why it's important to look for the original source of professional publication. The research published in most of the professional psychology journals is reviewed by peers. Before the research is accepted for publication, psychologists with expert knowledge in research methods and statistics review the study. In doing so, they verify that all aspects of the study were carefully designed to guard against erroneous conclusions. Thus, peer review helps ensure that psychological research adheres to the rigorous standards of scientific evidence.

5. Consider how the research was funded.

It costs money to conduct research. Research published in professional journals usually notes the funding sources in a footnote or endnote. Given that, would you be wary of research that was funded by a company or agency whose motive is to convince you to buy some product or service? Such situations do

not necessarily invalidate the research, but they do raise concerns about conflicts of interest.

6. Consider the methods and operational definitions used.

At this point, you should understand the importance of such elements as control groups in experiments, operational definitions of variables, the use of multiple observers in descriptive research, random assignment of subjects to experimental conditions, and the use of a sample that is representative of the population being studied. Look for these elements in the description of the study to increase your confidence in the research findings.

7. Remember the distinction between correlation and causality.

Remember the correlation we mentioned between higher levels of sexual activity and a preference for jazz? Many research results reported in the mass media are correlational studies, yet the news reports imply that a cause-and-effect relationship has been discovered (Connor-Greene, 1993). From our earlier

discussion, you now understand that two factors may be correlated, but one does not necessarily cause the other. It is entirely possible that a third factor is responsible for the behavior in question. As a general rule, whenever the words *link*, *tie*, *connection*, *association*, or *relationship* are used in headlines describing psychological findings, the research being described is correlational.

8. Skepticism is the rule, not the exception, in science.

It seems as if it is basic to human nature to look for easy answers to life's dilemmas—whether that involves increasing your motivation and self-discipline, improving your memory, combating stress, or enhancing relationships. As you'll see in the Application sections at the end of each chapter, psychological research has much to say about these and other practical topics. But achieving these goals is rarely as easy as the popular press portrays it. Therefore, remember one final axiom in evaluating research claims reported in the mass media: If it sounds too good to be true, it probably is!

Chapter Review

Introduction and Research Methods

Key Points

Introduction: The Origins of Psychology

- **Psychology** is now defined as the science of behavior and mental processes. However, the definition of psychology has evolved over time.
- Early philosophers, such as Aristotle and Descartes, used logic and intuition to understand psychological topics. Later, the discoveries of physiologists demonstrated that scientific methods could be applied to psychological topics.
- Wilhelm Wundt, a German physiologist, is credited with founding psychology as an experimental science. Wundt's student Edward B. Titchener established **structuralism**, the first school of psychology. The structuralists used introspection to try to identify the structures of conscious experiences.
- William James founded and promoted psychology in the United States. James established **functionalism**, a school of psychology that emphasized the adaptive role of behavior. James's students G. Stanley Hall and Mary Whiton Calkins were two important figures in early American psychology.
- Sigmund Freud established **psychoanalysis** as a theory of personality and form of psychotherapy. Psychoanalysis emphasized the role of unconscious conflicts in determining behavior and personality.
- **Behaviorism** emerged in the early 1900s, based on Ivan Pavlov's research. Behaviorism was first championed by John Watson and further developed by B. F. Skinner. Behaviorism rejected the study of mental processes and emphasized the study of observable behavior, especially the principles of learning.
- Carl Rogers and Abraham Maslow promoted **humanistic psychology**, which emphasized psychological growth and the importance of choice in human behavior.

Contemporary Psychology

- Psychology today is a diverse field. Topics can be approached from different perspectives, which include the biological, psychodynamic, behavioral, humanistic, cognitive, cross-cultural, and **evolutionary psychology** perspectives.
- Important specialty areas of psychology include biological psychology, cognitive psychology, experimental psychology, developmental psychology, social psychology, personality psychology, health psychology, educational psychology, industrial/organizational psychology, and clinical psychology.

The Scientific Method

- The four goals of psychology are to describe, explain, predict, and influence human behavior and mental processes. Psychology is based on **empirical evidence**.
- Psychologists are trained in the **scientific method**, which has four steps: (1) generate a **hypothesis** that can be tested empirically, (2) design the study and collect the data, (3) analyze the data and draw conclusions, and (4) report the findings. **Variables** must be **operationally defined**.
- Research methods include descriptive methods and the experimental method. **Statistics** are used to analyze the data and to determine whether findings are **statistically significant**. **Meta-analysis** can be used to combine and analyze multiple studies on a single topic. Reporting the results of a study allows other researchers to **replicate** the study.
- As research findings accumulate from individual studies, **theories** or models develop to explain the different findings on a related topic. Theories are tools for understanding and explaining behavior and mental processes. Theories evolve and change as new evidence emerges.

Descriptive Methods

- **Descriptive methods** are research strategies used to observe and describe behavior. The goal of **naturalistic observation** is to detect behavior patterns as they exist in their natural settings. The **case study** method involves intensive study of a single subject or a small group of subjects.
- **Surveys**, questionnaires, and interviews are administered to a **sample** of the larger group to be investigated. For results to be generalizable to the larger population, the sample must be a **representative sample**. Participants are usually chosen through **random selection**.

- **Correlational studies** investigate how strongly two factors are related to each other. The relationship is expressed in terms of a **correlation coefficient**. A **positive correlation** indicates that two factors vary in the same direction, whereas a **negative correlation** indicates that two factors vary in opposite directions.
- Even when two factors are strongly related, conclusions cannot be drawn about causality because a third factor may actually be responsible for the association. However, correlational evidence can be used to identify important relationships and to make meaningful predictions.

The Experimental Method

- The **experimental method** can demonstrate a cause-and-effect relationship between one variable and another. Experiments involve manipulating the **independent variable** and measuring the effects of the manipulation on the **dependent variable**.
- An experiment testing the effects of playing violent video games on aggressive behavior was used to help illustrate **random assignment** of subjects to experimental conditions, **experimental groups** compared to a **control group**, systematic manipulation of the independent variable, and objective measurement of the dependent variable.
- There are many variations in experimental design. A **placebo control group** is used to check for **expectancy effects**. The use of a **double-blind study** helps guard against **demand characteristics**. Natural experiments involve measuring the impact of a naturally occurring event on subjects. Although experiments can provide evidence of causality, they are sometimes criticized for creating artificial conditions. Not all questions can be studied experimentally.

Ethics in Psychological Research

- All psychological research is subject to regulations contained in an ethical code developed by the American Psychological Association. For research with human subjects, the ethical code requires that informed consent and voluntary participation must be ensured, student subjects must be given alternatives to participating in research, deceptive techniques can be used only under specific conditions, records are kept confidential, and participants are to be debriefed and given the opportunity to learn more about the study.
- Research with animal subjects is also governed by an ethical code developed by the American Psychological Association.

Key Terms

psychology, p. 3	culture, p. 12	collectivistic cultures, p. 13	operational definition, p. 18
structuralism, p. 5	cross-cultural psychology, p. 12	scientific method, p. 16	statistics, p. 18
functionalism, p. 6	ethnocentrism, p. 12	empirical evidence, p. 16	statistically significant, p. 18
psychoanalysis, p. 7	individualistic cultures, p. 12	critical thinking, p. 17	meta-analysis, p. 19
behaviorism, p. 8	evolutionary psychology, p. 12	hypothesis, p. 17	replicate, p. 19
humanistic psychology, p. 9		variable, p. 18	theory, p. 20

descriptive research methods, p. 21	random selection, p. 23	dependent variable, p. 27	expectancy effects, p. 31
naturalistic observation, p. 21	correlational study, p. 24	random assignment, p. 27	double-blind study, p. 31
case study, p. 22	correlation coefficient, p. 24	experimental group (experimental condition), p. 27	demand characteristics, p. 31
survey, p. 22	positive correlation, p. 25	control group (control condition), p. 28	pseudoscience, p. 32
sample, p. 22	negative correlation, p. 25	placebo control group, p. 31	paranormal phenomena, p. 32
representative sample, p. 22	experimental method, p. 26	practice effect, p. 31	rule of falsifiability, p. 32
	independent variable, p. 26		illusory correlation, p. 32

Key People

Mary Whiton Calkins (1863–1930) American psychologist who conducted research on memory, personality, and dreams; established one of the first U.S. psychology research laboratories; first woman president of the American Psychological Association. (p. 6)

Charles Darwin (1809–1882) English naturalist and scientist whose theory of evolution through natural selection was first published in *On the Origin of Species* in 1859. (p. 12)

Sigmund Freud (1856–1939) Austrian physician and founder of psychoanalysis. (p. 7)

G. Stanley Hall (1844–1924) American psychologist who established the first psychology research laboratory in the United States; founded the American Psychological Association. (p. 6)

William James (1842–1910) American philosopher and psychologist who founded psychology in the United States and established the psychological school called functionalism. (p. 5)

Abraham Maslow (1908–1970) American humanistic psychologist who developed a theory of motivation. (p. 9)

Ivan Pavlov (1849–1936) Russian physiologist whose pioneering research on learning contributed to the development of

behaviorism; discovered the basic learning process that is now called classical conditioning. (p. 8)

Carl Rogers (1902–1987) American psychologist who founded the school of humanistic psychology. (p. 9)

B. F. Skinner (1904–1990) American psychologist and leading proponent of behaviorism; developed a model of learning called operant conditioning; emphasized studying the relationship between environmental factors and observable behavior. (p. 8)

Edward B. Titchener (1867–1927) British-born American psychologist who founded structuralism, the first school of psychology. (p. 4)

Margaret Floy Washburn (1871–1939) American psychologist who was the first woman to earn a doctorate in psychology in the United States; published research on mental processes in animals. (p. 7)

John B. Watson (1878–1958) American psychologist who founded behaviorism, emphasizing the study of observable behavior and rejecting the study of mental processes. (p. 8)

Wilhelm Wundt (1832–1920) German physiologist who founded psychology as a formal science; opened first psychology research laboratory in 1879. (p. 4)

Concept Review Answers

1.1 page 9

1. functionalism; William James
2. humanistic psychology; Carl Rogers
3. structuralism; Edward Titchener
4. psychoanalysis; Sigmund Freud
5. behaviorism; John Watson

1.2 page 26

1. positive correlation
2. naturalistic observation
3. correlational research
4. negative correlation
5. the case study method

1.3 page 32

1. c
2. e
3. g
4. b
5. d
6. f
7. a

Web Companion Review Activities

You can find additional review activities at www.worthpublishers.com/hockenbury. The *Discovering Psychology* 3e Web Companion has a self-scoring practice quiz, flashcards, two interactive crossword puzzles, and other activities to help you master the material in this chapter.

chapter

Neuroscience and Behavior

2

Chapter Outline

Prologue: Asha's Story

Introduction: Neuroscience and Behavior

The Neuron: The Basic Unit of Communication

The Nervous System and the Endocrine System: Communication Throughout the Body

A Guided Tour of the Brain

Box 2.1: Phrenology: The Bumpy Road to Scientific Progress

Focus on Neuroscience: Understanding Brain-Imaging Techniques

Specialization in the Cerebral Hemispheres

Plasticity: The Malleable Brain

APPLICATION: Pumping Neurons: Maximizing Your Brain's Potential

Chapter Review

Prologue

Asha's Story

The headaches began without warning. A pounding, intense pain just over Asha's left temple. Asha just couldn't seem to shake it—the pain was unrelenting. She was uncharacteristically tired, too.

But our friend Asha, a 32-year-old university professor, chalked up her constant headache and fatigue to stress and exhaustion. After all, the end of her demanding first semester of teaching and research was drawing near. Still, Asha had always been very healthy and usually tolerated stress well. She didn't drink or smoke. And no matter how late she stayed up working on her lectures and research proposals, she still got up at 5:30 every morning to work out at the university gym.

There were other, more subtle signs that something was wrong. Asha's husband Paul noticed that she had been behaving rather oddly in recent weeks. For example, at Thanksgiving dinner, Asha had picked up a knife by the wrong end and tried to cut her turkey with the handle instead of the blade. A few hours later, Asha had made the same mistake trying to use scissors: She held the blades and tried to cut with the handle.

Asha laughed these incidents off, and for that matter, so did Paul. They both thought she was simply under too much stress. And when Asha occasionally got her words mixed up, neither Paul nor anyone else was terribly surprised. Asha was born in India, and her first language was Tulu. Although Asha was extremely fluent in English, she often got English phrases slightly wrong—like the time she said that Paul was a “straight dart” instead of a “straight arrow.” Or when she said that it was “storming cats and birds” instead of “raining cats and dogs.”

There were other odd lapses in language. “I would say something thinking it was correct,” Asha recalled, “and people would say to me, ‘What are you saying?’ I wouldn't realize I was saying something wrong. I would open my mouth and just nonsense would come out. But it made perfect sense to me. At other times, the word was on the tip of my tongue—I knew I knew the word, but I couldn't find it. I would fumble for the word, but it would come out wrong. Sometimes I would slur words, like I'd try to say ‘Saturday,’ only it would come out ‘salad-day.’ ”

On Christmas morning, Paul and Asha were with Paul's family, opening presents. Asha walked over to Paul's father to look at the pool cue he had received as a gift. As she bent down, she fell forward onto her father-in-law. At first, everyone thought

Neuroscience and Behavior Maintaining your balance on a bicycle, smiling, talking with a friend—all your behaviors involve the complex integration of many physical processes working in harmony. For that matter, so does your ability to perceive and recognize the image in this photograph. What kinds of questions might neuroscientists ask about the common behaviors shown here?



Asha was just joking around. But then she fell to the floor, her body stiff. Seconds later, it was apparent that Asha had lost consciousness and was having a seizure.

Asha remembers nothing of the seizure or of being taken by ambulance to the hospital intensive care unit. She floated in and out of consciousness for the first day and night. A CAT scan showed some sort of blockage in Asha's brain. An MRI scan revealed a large white spot on the left side of her brain. At only 32 years of age, Asha had suffered a stroke—brain damage caused by a disruption of the blood flow to the brain.

She remained in the hospital for 12 days. It was only after Asha was transferred out of intensive care that both she and Paul began to realize just how serious the repercussions of the stroke were. Asha couldn't read or write and had difficulty comprehending what was being said. Although she could speak, she couldn't name even simple objects, such as a tree, a clock, or her doctor's tie. In this chapter, you will discover why the damage to Asha's brain impaired her ability to perform simple behaviors, like naming common objects.

Introduction

Neuroscience and Behavior

As we discussed in Chapter 1, **biological psychology** is the scientific study of the biological bases of behavior and mental processes. This area of research is also called *biopsychology*. Both terms emphasize the idea of a biological approach to the study of psychological processes. Biological psychology is one of the scientific disciplines that makes important contributions to **neuroscience**—the scientific study of the nervous system. As *neuroscientists*, biopsychologists bring their expertise in behavior and behavioral research to this scientific endeavor. Some of the other scientific disciplines that contribute to neuroscience include *physiology*, *pharmacology*, *biology*, and *neurology*.

Neuroscience and biological psychology are not limited to the study of the brain and the nervous system. Throughout this textbook, you'll encounter questions that have been studied by neuroscientists. Here are some examples:

- How do we tell the difference between red and blue, cold and hot, loud and soft? (Chapter 3)
- What happens in the brain when we sleep, dream, or meditate? (Chapter 4)
- What exactly is a memory, and how are memories stored in the brain? (Chapter 6)
- Why do we get hungry? How do emotions occur? (Chapter 8)
- How do emotions and attitudes affect our vulnerability to infection and disease? (Chapter 12)
- How does heredity influence our development? What role does genetics play in personality traits? (Chapters 9, 11, and 13)
- What role does abnormal brain chemistry play in psychological disorders? How do medications alleviate the symptoms of serious psychological disorders? (Chapters 13 and 14)

This chapter will lay an important foundation for the rest of this book by helping you develop a broad appreciation of the *nervous system*—the body's primary communication network. We'll start by looking at *neurons*, the basic cells of the nervous system. We'll also consider the organization of the nervous system and a closely linked communication network, the *endocrine system*. We'll then move on to a guided tour of the brain. We'll look at how certain brain areas are specialized to handle different functions, such as language,

vision, and touch. In the Application, we'll discuss how the brain responds to environmental stimulation by literally altering its structure. And at several points, we'll return to Asha's story and tell you how she fared after her stroke.

The Neuron

The Basic Unit of Communication

Key Theme

- Information in the nervous system is transmitted by specialized cells, called neurons.

Key Questions

- What are the basic components of the neuron, and what are their functions?
- What are glial cells, and what is their role in the nervous system?
- What is an action potential, and how is it produced?

Communication throughout the nervous system takes place via **neurons**—cells that are highly specialized to receive and transmit information from one part of the body to another. Most neurons, especially those in your brain, are extremely small. A bit of brain tissue no larger than a grain of rice contains about 10,000 neurons! Your entire brain contains an estimated 100 *billion* neurons. Special magnifying equipment, such as an electron microscope, is usually used to study neurons.

Fortunately for neuroscientists, there are often striking similarities between the workings of the human nervous system and those of the nervous systems of many other creatures in the animal kingdom. Very simple creatures, such as sea snails and squid, tend to have larger neurons and simpler nervous systems than do humans. Neuroscientists have been able to closely observe the actions and reactions of a single neuron by studying the nervous systems of such simple animals.

Along with neurons, the human nervous system is made up of other types of specialized cells, called **glial cells** (see Figure 2.1). Glial cells outnumber neurons by about 10 to 1, but are much smaller. Unlike neurons, glial cells do not send or receive information. Rather, they are cast in supporting roles to the major player, the neuron. *Glia* is Greek for “glue,” and at one time it was believed that glial cells were the glue that held the neurons of the brain together. Although they don't actually glue neurons together, glial cells do provide structural support for neurons. Glial cells also provide nutrition, enhance the speed of communication between neurons, and remove waste products, including dead or damaged neurons.

Neurons vary greatly in size and shape, reflecting their specialized functions. There are three basic types of neurons, each communicating different kinds of information. **Sensory neurons** convey information about the environment, such as light or sound, from specialized receptor cells in the sense organs to the brain. Sensory neurons also carry information from the skin and internal organs to the brain. **Motor neurons** communicate information to the muscles and glands of the body. Simply

biological psychology

Specialized branch of psychology that studies the relationship between behavior and bodily processes and systems; also called *biopsychology*.

neuroscience

The study of the nervous system, especially the brain.

neuron

Highly specialized cell that communicates information in electrical and chemical form; a nerve cell.

glial cells

(GLEE-ull) Support cells that assist neurons by providing structural support, nutrition, and removal of cell wastes; manufacture myelin.

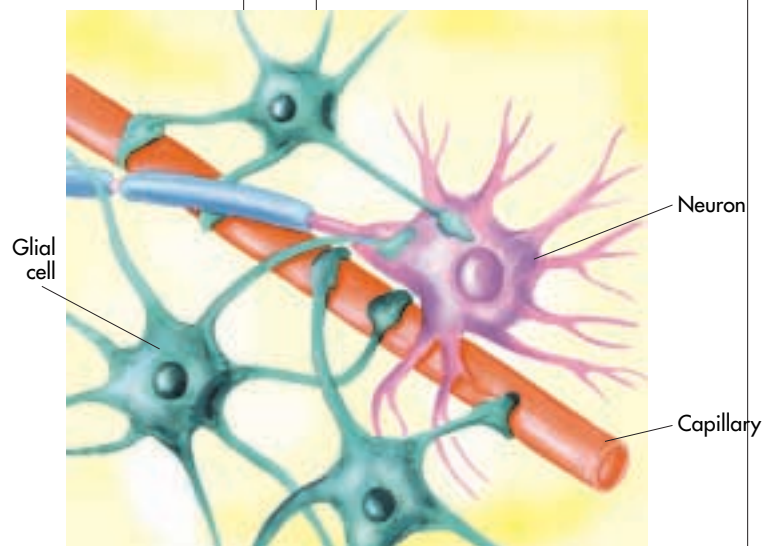
sensory neuron

Type of neuron that conveys information to the brain from specialized receptor cells in sense organs and internal organs.

motor neuron

Type of neuron that signals muscles to relax or contract.

FIGURE 2.1 Glial Cells Glial cells vastly outnumber neurons in the brain. They provide support and nutrition for the neuron. One type of glial cell, shown here, provides a connection between neurons and blood vessels in the brain. Another type of glial cell produces the myelin sheath that surrounds some neuron axons.



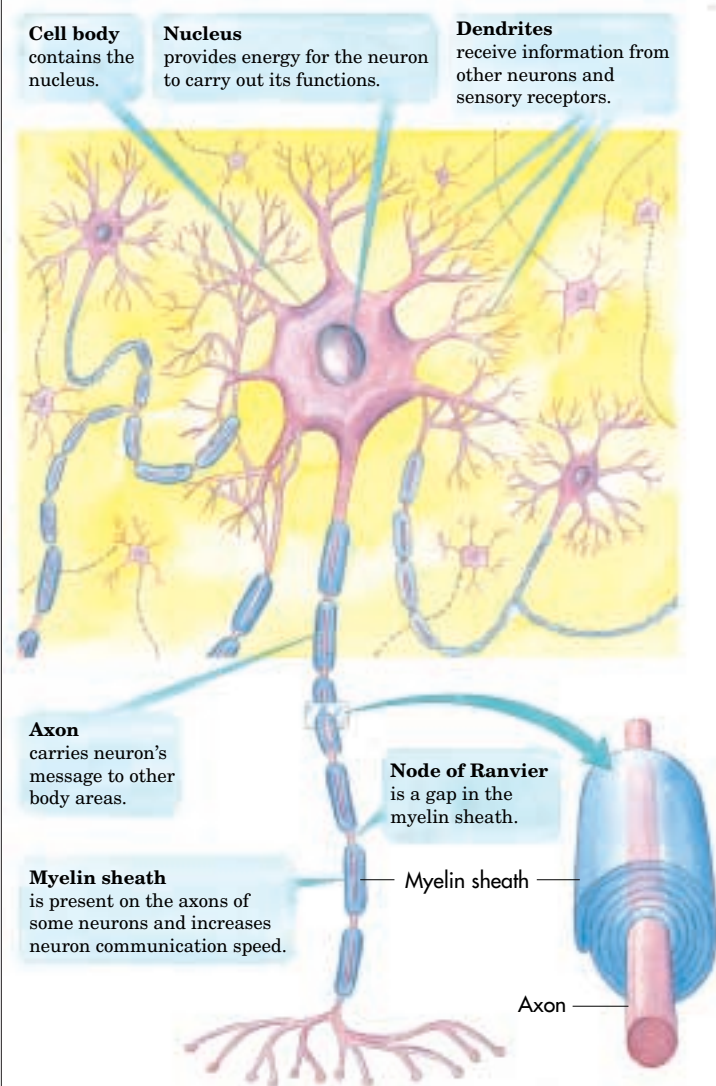
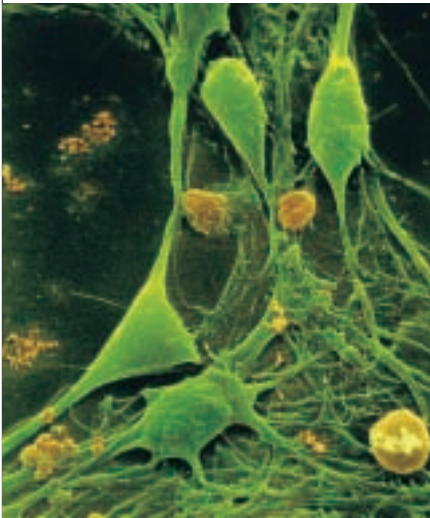
blinking your eyes activates thousands of motor neurons. Finally, **interneurons** communicate information *between* neurons. By far, most of the neurons in the human nervous system are interneurons, and many interneurons connect to other interneurons.

Characteristics of the Neuron

Most neurons have three basic components: a **cell body**, **dendrites**, and an **axon** (see Figure 2.2). The **cell body** contains the nucleus, which provides energy for the neuron to carry out its functions. The cell body also contains genetic material and other structures that are found in virtually all the cells in the body.

Extending out from the cell body are many short, branching fibers, called **dendrites**. The term *dendrite* comes from a Greek word meaning “tree.” If you have a good imagination, the intricate branching of the dendrites do often resemble the branches of a tree. Dendrites *receive* messages from other neurons or specialized cells. Dendrites with many branches have a greater surface area, which increases the amount of information the neuron can receive. Some neurons have thousands of dendrites.

FIGURE 2.2 The Parts of a Typical Neuron The drawing shows the location and function of key parts of a neuron. The photograph, made with the aid of an electron microscope, reveals actual cell bodies, dendrites, and axons in a cluster of neurons. The green coloring was added to provide contrast in the photograph to make the neurons more visible.



The **axon** is a single, elongated tube that extends from the cell body in most, though not all, neurons. (Some neurons do not have axons.) Axons carry information *from* the neuron *to* other cells in the body, including other neurons, glands, and muscles. In contrast to the potentially large number of dendrites, a neuron has no more than one axon exiting from the cell body. However, many axons have branches near their tips that allow the neuron to communicate information to more than one target.

Axons can vary enormously in length. Most axons are very small; some are no more than a few thousandths of an inch long. Other axons are quite long. For example, the longest axon in your body is that of the motor neuron that controls your big toe. This neuron extends from the base of your spine into your foot. If you happen to be a seven-foot-tall basketball player, this axon could be four feet long! For most of us, of course, this axon is closer to three feet long.

The axons of many, though not all, neurons are surrounded by the **myelin sheath**. The myelin sheath is a white, fatty covering manufactured by special glial cells. In much the same way that you can bundle together electrical wires if they are insulated with plastic, myelin helps insulate one axon from the axons of other neurons. Rather than forming a continuous coating of the axon, the myelin sheath occurs in segments that are separated by small gaps where there is no myelin. The small gaps are called the *nodes of Ranvier*, or simply *nodes* (see Figure 2.2). Neurons wrapped in myelin communicate their messages up to 20 times faster than do unmyelinated neurons.

The importance of myelin becomes readily apparent when it is damaged. For example, *multiple sclerosis* is a disease that involves the degeneration of patches of the myelin sheath. This degeneration causes the transmission of neural messages to be slowed or interrupted, resulting in disturbances in sensation and movement. Muscular weakness, loss of coordination, and speech and visual disturbances are some of the symptoms that characterize multiple sclerosis.

Communication Within the Neuron

The All-or-None Action Potential

Essentially, the function of neurons is to transmit information throughout the nervous system. But exactly *how* do neurons transmit information? What form does this information take? In this section, we'll consider the nature of communication *within* a neuron, and in the following section we'll describe communication *between* neurons. As you'll see, communication in and between neurons is an electrochemical process.

In general, messages are gathered by the dendrites and cell body and then transmitted along the axon in the form of a brief electrical impulse called an **action potential**. The action potential is produced by the movement of electrically charged particles, called *ions*, across the membrane of the axon. Some ions are negatively charged, others positively charged.

Think of the axon membrane as a gatekeeper that carefully controls the balance of positive and negative ions on the interior and exterior of the axon. As the gatekeeper, the axon membrane opens and closes *ion channels* that allow ions to flow into and out of the axon.

Each neuron requires a minimum level of stimulation from other neurons or sensory receptors to activate it. This minimum level of stimulation is called the neuron's **stimulus threshold**. While waiting for sufficient stimulation to activate it, the neuron is said to be *polarized*. In this state the axon's interior is more negatively charged than is the exterior fluid surrounding the axon.

Just in case you're wondering, scientists have measured the negative electrical charge of the neuron's interior, using giant squid neurons to do so. And how much electricity are we discussing? About -70 millivolts (thousandths of a volt).

interneuron

Type of neuron that communicates information from one neuron to the next.

cell body

The part of a neuron that contains the nucleus.

dendrites

Multiple short fibers that extend from the neuron's cell body and receive information from other neurons or from sensory receptor cells.

axon

The long, fluid-filled tube that carries a neuron's messages to other body areas.

myelin sheath

(MY-eh-lin) A white, fatty covering wrapped around the axons of some neurons that increases their communication speed.

action potential

A brief electrical impulse by which information is transmitted along the axon of a neuron.

stimulus threshold

The minimum level of stimulation required to activate a particular neuron.

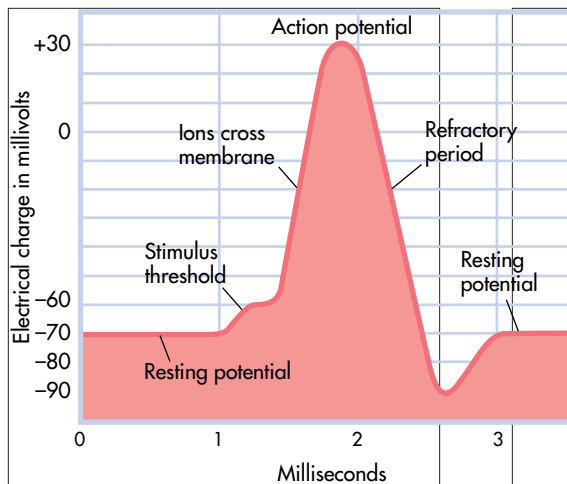


FIGURE 2.3a Electrical Changes During an Action Potential This graph shows the changing electrical charge of the neuron during an action potential. When the neuron depolarizes and ions cross the axon membrane, the result is a positive electrical impulse of +30 millivolts—the action potential. During the refractory period, the neuron reestablishes the resting potential negative charge of −70 millivolts and then is ready to activate again.

(see Figure 2.3a). The −70 millivolts is referred to as the neuron's **resting potential**.

This polarized, negative-inside/positive-outside condition is primarily due to the different concentrations of two particular ions: sodium and potassium. While the neuron is in resting potential, the fluid surrounding the axon contains a larger concentration of *sodium* ions than does the fluid within the axon. The fluid within the axon contains a larger concentration of *potassium* ions than is found in the fluid outside the axon.

When sufficiently stimulated by other neurons or sensory receptors, the neuron *depolarizes*, beginning the action potential. At each successive axon segment, sodium ion channels open for a mere thousandth of a second. The sodium ions rush to the axon interior from the surrounding fluid, and then the sodium ion channels close. Less than a thousandth of a second later, the potassium ion channels open, allowing potassium to rush out of the axon and into the fluid surrounding it. Then the potassium ion channels close (see Figure 2.3b). This sequence

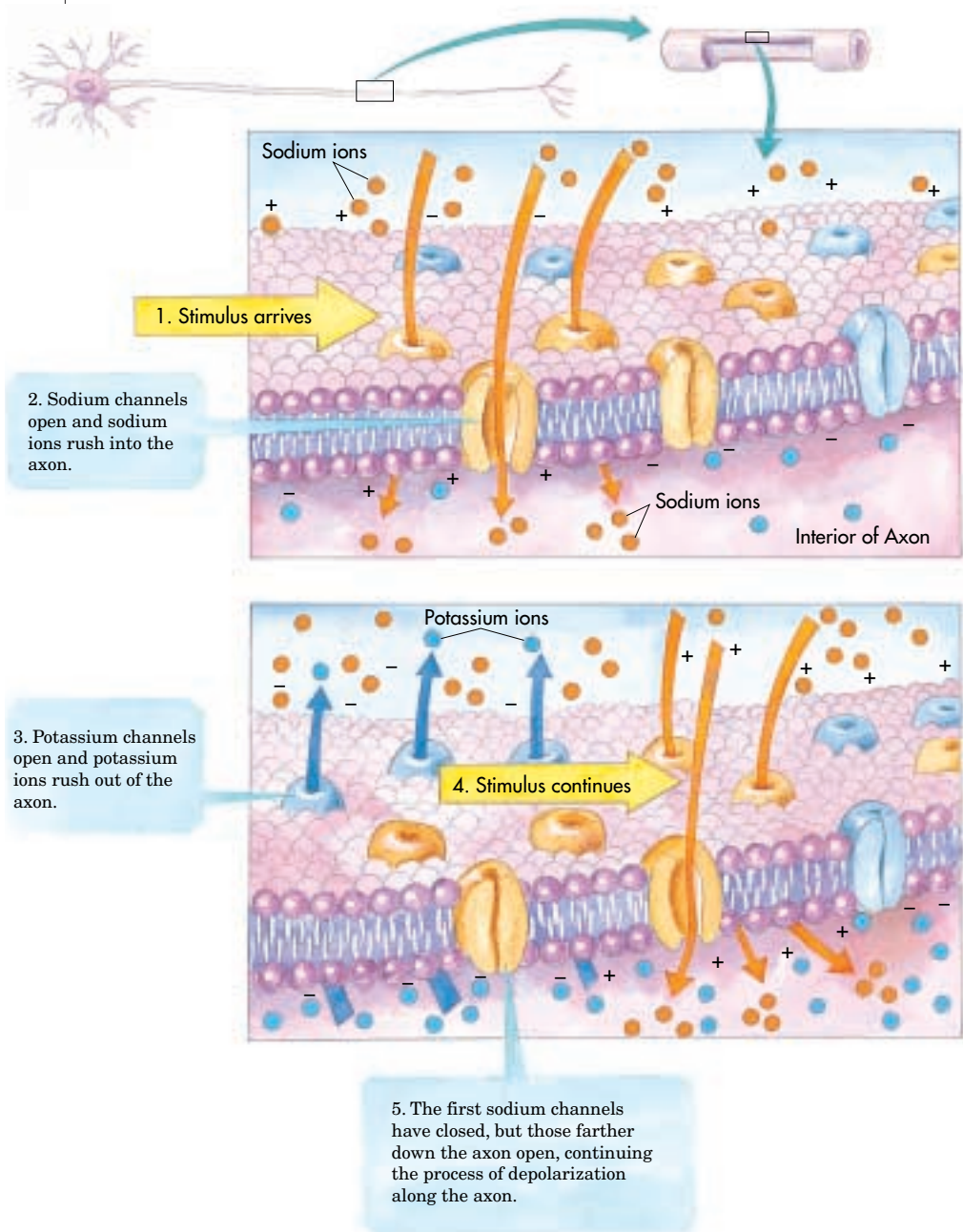


FIGURE 2.3b Communication Within the Neuron: The Action Potential These drawings depict the ion channels in the membrane of a neuron's axon. When sufficiently stimulated, the neuron depolarizes and an action potential begins. At each progressive segment of the axon's membrane, sodium ion channels open and sodium ions rush into the interior of the axon. A split second later, the sodium ion channels close and potassium channels open, allowing potassium ions to rush out of the axon. As this sequence occurs, the electrical charge on the interior of the axon briefly changes from negative to positive. Once started, an action potential is self-sustaining and continues to the end of the axon. Following the action potential, the neuron repolarizes and reestablishes its negative electrical charge.

of depolarization and ion movement continues in a self-sustaining fashion down the entire length of the axon.

As sodium ions penetrate the axon membrane and potassium ions exit, the electrical charge on the inside of the axon momentarily changes to a positive electrical charge of about +30 millivolts. The result is a brief positive electrical impulse that progressively occurs at each segment down the axon—the *action potential*.

Although it's tempting to think of the action potential as being conducted much as electricity is conducted through a wire, that's *not* what takes place in the neuron. The axon is actually a poor conductor of electricity. At each successive segment of the axon, the action potential is *regenerated* in the same way in which it was generated in the previous segment—by depolarization and the movement of ions.

Once the action potential is started, it is *self-sustaining* and continues to the end of the axon. In other words, there is no such thing as a partial action potential. Either the neuron is sufficiently stimulated and an action potential occurs, or the neuron is not sufficiently stimulated and an action potential does not occur. This principle is referred to as the **all-or-none law**.

Following the action potential, a *refractory period* occurs during which the neuron is unable to fire. This period lasts for a mere thousandth of a second or less. During the refractory period, the neuron *repolarizes* and reestablishes the negative-inside/positive-outside condition. Like depolarization, repolarization occurs progressively at each segment down the axon. This process of pumping sodium ions out and drawing potassium ions back in reestablishes the *resting potential* conditions so that the neuron is capable of firing again. The graph in Figure 2.3a depicts the complete sequence from resting potential to action potential and back to resting potential.

Remember, action potentials are generated in mere thousandths of a second. Thus, a single neuron can potentially generate hundreds of neural impulses per second. Given these minute increments of time, just how fast do neural impulses zip around the body?

The fastest neurons in your body communicate at speeds of up to 270 miles per hour. In the slowest neurons, messages creep along at about 2 miles per hour. This variation in communication speed is due to two factors: the axon diameter and the myelin sheath. The greater the axon's diameter, the faster the axon conducts action potentials. And, as we said earlier, myelinated neurons communicate faster than unmyelinated neurons. In myelinated neurons, the sodium ion channels are concentrated at each of the nodes of Ranvier where the myelin is missing. So, in myelinated neurons the action potential jumps from node to node rather than progressing down the entire length of the axon.

Communication Between Neurons

Bridging the Gap

Key Theme

- Communication between neurons takes place at the synapse, the junction between two adjoining neurons.

Key Questions

- How is information communicated at the synapse?
- What is a neurotransmitter, and what is its role in synaptic transmission?
- What are five important neurotransmitters, and how do psychoactive drugs affect synaptic transmission?

The primary function of a neuron is to communicate information to other cells, most notably other neurons. The point of communication between two neurons is called the **synapse**. At this communication junction, the message-sending

resting potential

State in which a neuron is prepared to activate and communicate its message if it receives sufficient stimulation.

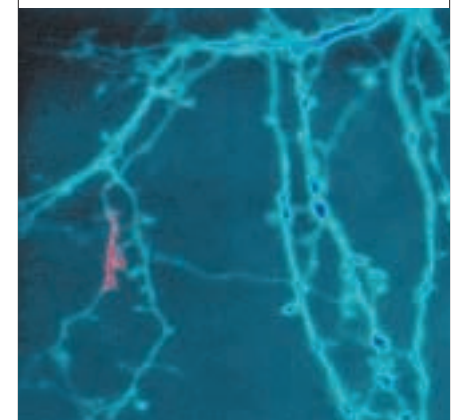
all-or-none law

The principle that either a neuron is sufficiently stimulated and an action potential occurs or a neuron is not sufficiently stimulated and an action potential does not occur.

synapse

(SIN-aps) The point of communication between two neurons.

The Brain Capturing a Thought In the brain, as in the rest of the nervous system, information is transmitted by electrical impulses (red area) that speed from one neuron to the next.



synaptic gap

(sin-AP-tick) The tiny space between the axon terminal of one neuron and the dendrite of an adjoining neuron.

axon terminals

Branches at the end of the axon that contain tiny pouches, or sacs, called synaptic vesicles.

synaptic vesicles

(sin-AP-tick VESS-ick-ulls) Tiny pouches or sacs in the axon terminals that contain chemicals called neurotransmitters.

neurotransmitters

Chemical messengers manufactured by a neuron.

synaptic transmission

(sin-AP-tick) The process through which neurotransmitters are released by one neuron, cross the synaptic gap, and affect adjoining neurons.

reuptake

The process by which neurotransmitter molecules detach from a postsynaptic neuron and are reabsorbed by a presynaptic neuron so they can be recycled and used again.

neuron is referred to as the *presynaptic neuron*. The message-receiving neuron is called the *postsynaptic neuron*. For cells that are specialized to communicate information, neurons have a surprising characteristic: They don't touch each other. The presynaptic and postsynaptic neurons are separated by a tiny, fluid-filled space, called the **synaptic gap**, which is only about *five-millionths* of an inch wide.

The transmission of information between two neurons occurs in one of two ways: electrically or chemically. When communication is electrical, the synaptic gap is extremely narrow, and special ion channels serve as a bridge between the neurons. Electrical communication between the two neurons is virtually instantaneous.

Although some neurons in the human nervous system communicate electrically, over 99 percent of the synapses in the brain use chemical transmission (Greengard, 2001). In general terms, chemical communication occurs when the presynaptic neuron creates a chemical substance that diffuses across the synaptic gap and is detected by the postsynaptic neuron. This one-way communication process between one neuron and another has many important implications for human behavior.

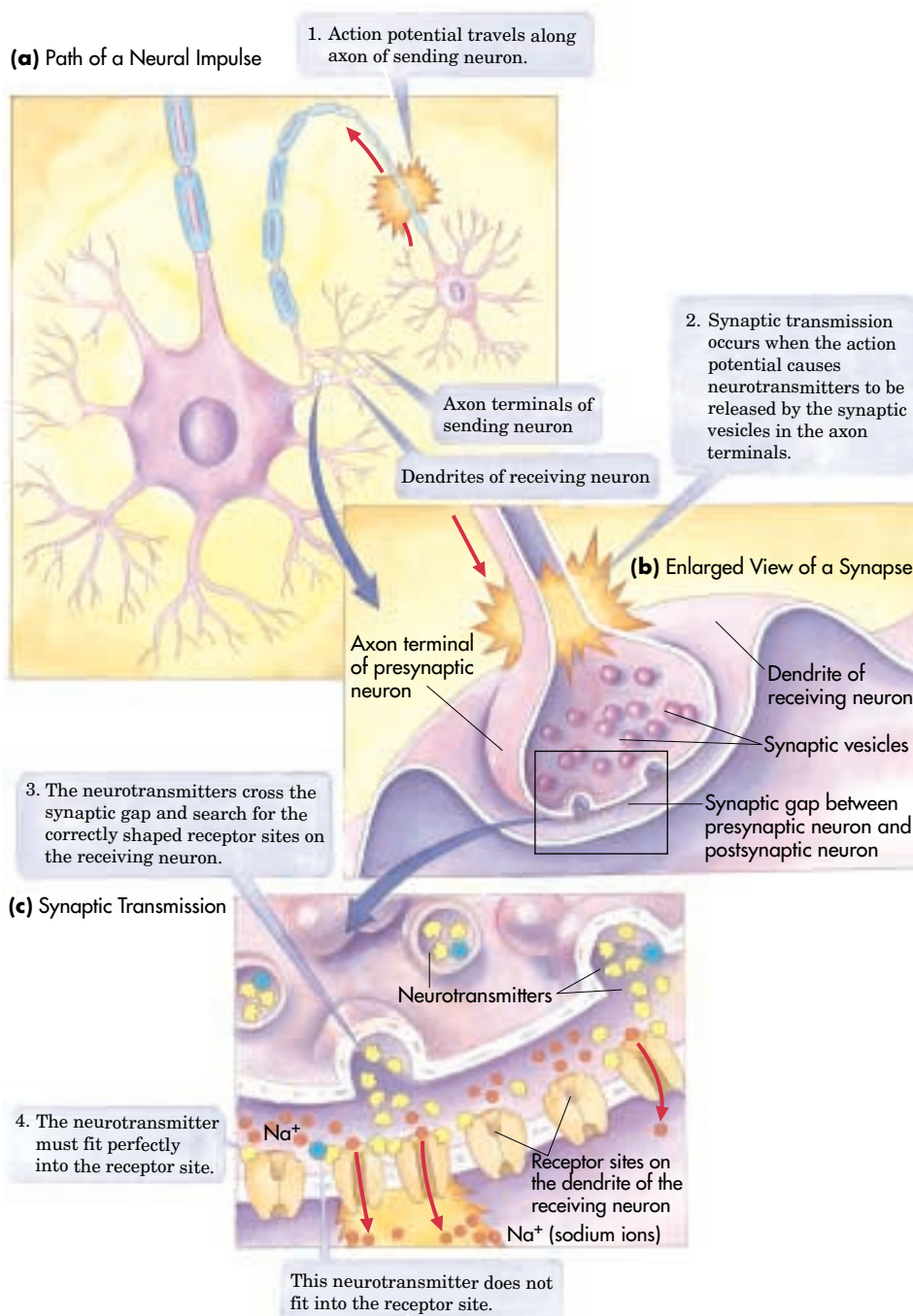
More specifically, here's how chemical communication takes place between neurons. As we've seen, when the presynaptic neuron is activated, it generates an action potential that travels to the end of the axon. At the end of the axon are several small branches called **axon terminals**. Floating in the interior fluid of the axon terminals are tiny sacs called **synaptic vesicles** (see Figure 2.4). The synaptic vesicles hold special chemical messengers manufactured by the neuron, called **neurotransmitters**.

When the action potential reaches the axon terminals, some of the synaptic vesicles "dock" on the axon terminal membrane, then release their neurotransmitters into the synaptic gap. These chemical messengers cross the synaptic gap and attach to *receptor sites* on the dendrites of the surrounding neurons. This journey across the synaptic gap is slower than electrical transmission, but is still extremely rapid; it takes less than ten-millionths of a second. The entire process of transmitting information at the synapse is called **synaptic transmission**.

What happens to the neurotransmitter molecules after they've attached to the receptor sites of the postsynaptic neuron? Most often, they detach from the receptor and are reabsorbed by the presynaptic neuron so they can be recycled and used again. This process is called **reuptake**. Reuptake also occurs with many of the neurotransmitters that failed to attach to a receptor and are left floating in the synaptic gap. Neurotransmitter molecules that are not reabsorbed or that remain attached to the receptor site are broken down or destroyed by enzymes. As you'll see in the next section, certain drugs can interfere with both of these processes, prolonging the presence of the neurotransmitter in the synaptic gap.

The number of neurotransmitters that a neuron can manufacture varies. Some neurons produce only one type of neurotransmitter, whereas others manufacture three or more. Although estimates vary, scientists have thus far identified more than 100 different compounds that function as neurotransmitters in the brain (Greengard, 2001).

Each type of neurotransmitter has a chemically distinct, different shape. When released by the presynaptic neuron, neurotransmitters search for the correctly shaped receptor sites on the dendrites of the postsynaptic neurons. Like a key in a lock, a neurotransmitter's shape must precisely match that of a receptor site on the postsynaptic neuron's dendrites for the neurotransmitter to affect that neuron. Keep in mind that the postsynaptic neuron can have many differently shaped receptor sites on its dendrites and thus may accommodate several different neurotransmitters. The distinctive shapes of neurotransmitters and their receptor sites are shown schematically in Figure 2.5.



Excitatory and Inhibitory Messages

A neurotransmitter communicates either an excitatory or an inhibitory message to a postsynaptic neuron. An *excitatory message* increases the likelihood that the postsynaptic neuron will activate and generate an action potential. Conversely, an *inhibitory message* decreases the likelihood that the postsynaptic neuron will activate. If a postsynaptic neuron receives an excitatory and an inhibitory message simultaneously, the two messages cancel each other out.

It's important to note that the effect of any particular neurotransmitter depends on the particular *receptor* to which it binds. So, the same neurotransmitter can have an inhibitory effect on one neuron and an excitatory effect on another.

Depending on the number and kind of neurotransmitter chemicals that are taken up by the dendrites of the adjoining neurons, the postsynaptic neurons are

FIGURE 2.4 Communication Between Neurons: The Process of Synaptic Transmission As you follow the steps in this progressive graphic, you can trace the sequence of synaptic transmission in which neurotransmitters are released by the sending, or presynaptic, neuron, cross the tiny fluid-filled space called the synaptic gap, and attach to receptor sites on the receiving or postsynaptic neuron.

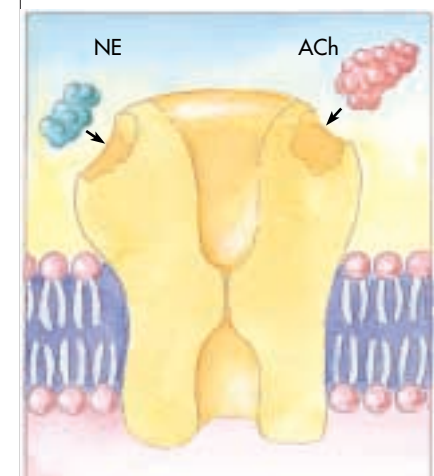


FIGURE 2.5 Neurotransmitter and Receptor Site Shapes Each neurotransmitter has a chemically distinct shape. Like a key in a lock, a neurotransmitter must perfectly fit the receptor site on the receiving neuron for its message to be communicated. In this figure, NE is the abbreviation for the neurotransmitter norepinephrine and ACh is the abbreviation for acetylcholine.

more or less likely to activate. If the net result is a sufficient number of excitatory messages, the postsynaptic neuron depolarizes, generates an action potential, and releases its own neurotransmitters.

When released by a presynaptic neuron, neurotransmitter chemicals cross hundreds, even thousands, of synaptic gaps and affect the intertwined dendrites of adjacent neurons. Because the receiving neuron can have thousands of dendrites that intertwine with the axon terminals of many presynaptic neurons, the number of potential synaptic interconnections between neurons is mind-boggling. On the average, each neuron in the brain communicates directly with 1,000 other neurons (Greengard, 2001). Thus, in your brain alone, there are up to 100 *trillion* synaptic interconnections.

Table 2.1

Summary of Important Neurotransmitters

Neurotransmitter	Primary Roles	Associated Disorders
Acetylcholine	Learning, memory	Alzheimer's disease
	Muscle contractions	
Dopamine	Movement	Parkinson's disease
	Thought processes	Schizophrenia
	Rewarding sensations	Drug addiction
Serotonin	Emotional states	Depression
	Sleep	
Norepinephrine	Physical arousal	Depression, stress
	Learning	
	Memory	
GABA	Inhibition of brain activity	Anxiety disorders
Endorphins	Pain perception	Opiate addiction
	Positive emotions	

Neurotransmitters and Their Effects

Your ability to perceive, feel, think, move, act, and react depends on the delicate balance of neurotransmitters in your nervous system. Too much or too little of a given neurotransmitter can have devastating effects. Yet neurotransmitters are present in only minuscule amounts in the human body. If you imagine trying to detect a pinch of salt dissolved in an Olympic-sized swimming pool, you will have some idea of the infinitesimal amounts of neurotransmitters present in brain tissue.

In this section, you'll see that researchers have linked abnormal levels of specific neurotransmitters to various physical and behavioral problems (see Table 2.1). Nevertheless, it's important to remember that any connection between a particular neurotransmitter and a particular effect is not a simple one-to-one relationship. Many behaviors are the result of the complex interaction of different neurotransmitters. Further, neurotransmitters sometimes have different effects in different areas of the brain.

Important Neurotransmitters

Acetylcholine, the first neurotransmitter discovered, is found in all motor neurons. It stimulates muscles to contract, including the heart and stomach muscles. Whether it is as simple as the flick of an eyelash or as complex as a back flip, all movement involves acetylcholine.

Acetylcholine is also found in many neurons in the brain, and it is important in memory, learning, and general intellectual functioning. People with *Alzheimer's disease*, which is characterized by progressive loss of memory and deterioration of intellectual functioning, have a severe depletion of several neurotransmitters in the brain, most notably acetylcholine.



Nerve Gas and Acetylcholine By filtering the air, the gas mask protects this soldier against chemical weapons, like nerve gas. Nerve gas kills by causing acetylcholine to be continuously released by the motor neurons. Excessive acetylcholine builds up in the synaptic gap, causing muscle spasms that are so severe the victim is unable to breathe and quickly suffocates. Atropine, a drug that was carried by U.S. troops in the Persian Gulf War, is an effective antidote for nerve gas. When injected, atropine counteracts the effects of nerve gas by blocking acetylcholine receptor sites.

The neurotransmitter **dopamine** is involved in movement, attention, learning, and pleasurable or rewarding sensations (Nader & others, 1997; Schultz & others, 1997). Evidence suggests that the addictiveness of many drugs, including cocaine and nicotine, is related to their dopamine-increasing properties (Greengard, 2001; Volkow & others, 2001a).

The degeneration of the neurons that produce dopamine in one brain area causes *Parkinson's disease*, which is characterized by rigidity, muscle tremors, poor balance, and

difficulty in initiating movements. Symptoms can be alleviated by a drug called *L-dopa*, which converts to dopamine in the brain (Youdim & Riederer, 1997).

Excessive brain levels of dopamine are sometimes involved in the hallucinations and perceptual distortions that characterize the severe mental disorder called *schizophrenia*. Some antipsychotic drugs that relieve schizophrenic symptoms work by blocking dopamine receptors and reducing dopamine activity in the brain. Unfortunately, these antipsychotic drugs can also produce undesirable side effects. Because the drugs reduce dopamine in several different areas of the brain, long-term use sometimes produces symptoms that are very similar to those of Parkinson's disease. In the chapters on psychological disorders (Chapter 13) and therapies (Chapter 14), we'll discuss schizophrenia, dopamine, and antipsychotic drugs in more detail.



"A Place for Cures" Actor Michael J. Fox was diagnosed with Parkinson's disease in 1990 at the age of 30. Since then, Fox has experienced progressively worsening muscle stiffness, trembling, and difficulties initiating speech and movements. To help control the symptoms, he takes a medication containing L-dopa, which increases brain levels of the neurotransmitter dopamine. As Fox (1998) said in an interview, "The ugly truth is that I am flesh and blood and I am a bunch of neurotransmitters that may or may not work."

Fox is keenly aware that the disease is progressive. After leaving his hit TV series, *Spin City*, he established the Michael J. Fox Foundation for Parkinson's Research (www.michaeljfox.org). Fox is convinced that a cure for Parkinson's disease is possible within the next 10 years. When he appeared before the U.S. Senate in May 2002, Fox said, "The time has come where the brain is no longer just a place for research; it is a place for cures." Also among the estimated 1 million Americans who are afflicted with Parkinson's disease are former U.S. Attorney General Janet Reno, singer Johnny Cash, and the Reverend Billy Graham.

The neurotransmitters **serotonin** and **norepinephrine** are found in many different brain areas. Serotonin is involved in sleep, moods, and emotional states, including depression. Antidepressant drugs such as *Prozac* increase the availability of serotonin in certain brain regions. Norepinephrine is implicated in the activation of neurons throughout the brain and helps the body gear up in the face of danger or threat. Norepinephrine also seems to be a key player in learning and memory retrieval. Like serotonin and dopamine, norepinephrine dysfunction is implicated in some mental disorders, especially depression (Nemeroff, 1998).

GABA is the abbreviation for **gamma-aminobutyric acid**, a neurotransmitter found primarily in the brain. GABA usually communicates an inhibitory message to other neurons, helping to balance and offset excitatory messages. Alcohol makes people feel relaxed and less inhibited partly by increasing GABA activity, which reduces brain activity. Antianxiety medications, such as Valium and Xanax, also work by increasing GABA activity, which inhibits action potentials and slows brain activity.

Interestingly, GABA seems to play a dual role in the brain area that regulates daily sleep-wake cycles. During the day, GABA communicates an excitatory message to other neurons in this brain area. At night, however, GABA communicates an inhibitory message to these same neurons (Wagner & others, 1997).

Endorphins: Regulating the Perception of Pain

In 1973, researchers Candace Pert and Solomon Snyder of Johns Hopkins University made the startling discovery that the brain contains receptor sites that are specific for the group of painkilling drugs called *opiates* (Pert & Snyder, 1973). Opiates include morphine, heroin, and codeine, all derived from the opium poppy. In addition to alleviating pain, opiates often produce a state of euphoria. Why would the brain have receptor sites for specific drugs like morphine? Pert, Snyder, and other researchers concluded that the brain must manufacture its own painkillers, morphinelike chemicals that act as neurotransmitters.

Within a few years, researchers identified a number of such chemicals manufactured by the brain (Snyder, 1984). Collectively, they are called **endorphins**, a term derived from the phrase "endogenous morphines." (The word *endogenous* means "produced internally in the body.") Although chemically similar to morphine, endorphins are 100 times more potent. Today, it is known that endorphins are released in response to stress or trauma and that they reduce the perception of pain.

Researchers have found that endorphins are implicated in the pain-reducing effects of *acupuncture*, an ancient Chinese medical technique that involves inserting needles at various locations in the body (Chao & others, 1999). Endorphins are also

acetylcholine

(uh-seet-ull-KO-leen) Neurotransmitter that causes muscle contraction and is involved in memory function.

dopamine

(DOPE-uh-meen) Neurotransmitter involved in the regulation of bodily movement, thought processes, and rewarding sensations.

serotonin

(ser-ah-TONE-in) Neurotransmitter involved in sleep and emotions.

norepinephrine

(nor-ep-in-EF-rin) Neurotransmitter involved in learning and memory; also a hormone manufactured by adrenal glands.

GABA (gamma-aminobutyric acid)

Neurotransmitter that usually communicates an inhibitory message.

endorphins

(en-DORF-ins) Neurotransmitters that regulate pain perceptions.

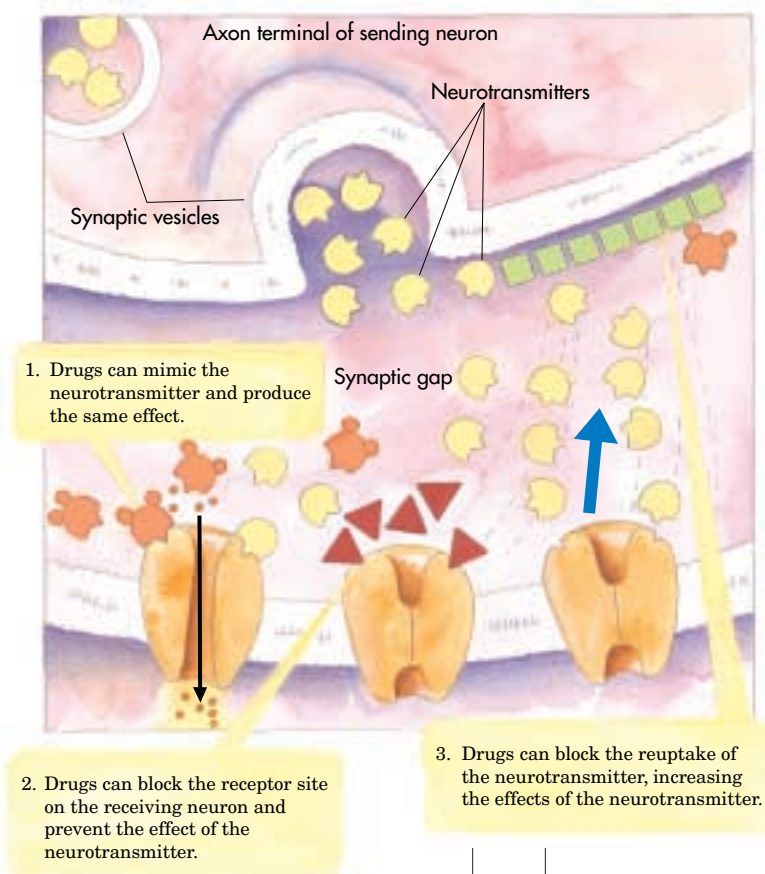


FIGURE 2.6 How Drugs Affect Synaptic Transmission Drugs affect brain activity by interfering with neurotransmitter functioning in the synapse. Drugs may also affect synaptic transmission by increasing or decreasing the amount of a particular neurotransmitter that is produced.

associated with positive mood. For example, the “runner’s high” associated with aerobic exercise has been attributed to endorphins. In marathon runners, endorphin levels have been found to increase up to four times over their normal levels (Mahler & others, 1989).

How Drugs Affect Synaptic Transmission

Much of what is known about different neurotransmitters has been learned from observing the effects of drugs and other substances. Many drugs, especially those that affect moods or behavior, work by interfering with the normal functioning of neurotransmitters in the synapse.

As Figure 2.6 illustrates, some drugs increase or decrease the amount of neurotransmitter released by neurons. For example, the venom of a black widow spider bite causes acetylcholine to be released continuously by motor neurons, causing severe muscle spasms. Drugs may also affect the length of time the neurotransmitter remains in the synaptic gap, either increasing or decreasing the amount available to the postsynaptic receptor.

One way in which drugs can prolong the effects of the neurotransmitter is by blocking the reuptake of the neurotransmitter by the sending neuron. For example, Prozac inhibits the reuptake of serotonin, increasing the availability of serotonin in the brain. The illegal drug cocaine produces its exhilarating rush by interfering with the reuptake of dopamine (Volkow & others, 1997).

Drugs can also mimic specific neurotransmitters. When a drug is chemically similar to a specific neurotransmitter, it may produce the same effect as that neurotransmitter. It is partly through this mechanism that nicotine works as a stimulant. Nicotine is chemically similar to acetylcholine and can occupy acetylcholine receptor sites, stimulating skeletal muscles and causing the heart to beat more rapidly.

Alternatively, a drug can mimic and block the effect of a neurotransmitter by fitting into receptor sites and preventing the neurotransmitter from acting. For example, the drug *curare* mimics acetylcholine and blocks acetylcholine receptor sites, causing almost instantaneous paralysis. The brain sends signals to the motor neurons, but the muscles can’t respond because the motor neuron receptor sites are blocked by the curare. Similarly, a drug called *naloxone* eliminates the effects of both endorphins and opiates by blocking opiate receptor sites.

2.1 R · E · V · I · E · W *

C · O · N · C · E · P · T

The Neuron

Match the part of the neuron in the list with its function in neural communication.

- | | | |
|---------------------|------------------|----------------------|
| a. action potential | c. synapse | e. neurotransmitters |
| b. axon | d. myelin sheath | f. dendrite |

- _____ 1. A fluid-filled tube that carries information to other neurons, glands, and muscles
- _____ 2. Receives information from other neurons
- _____ 3. Brief electrical charge that communicates information within the neuron
- _____ 4. Fluid-filled space between sending and receiving neurons

- _____ 5. Chemical messengers manufactured by a neuron
- _____ 6. White, fatty covering surrounding an axon that increases speed of neural communication

***Note:** Answers to Concept Review questions appear on the final page of this and every chapter.

The Nervous System and the Endocrine System

Communication Throughout the Body

Key Theme

- Two major communication systems in the body are the nervous system and the endocrine system.

Key Questions

- What are the divisions of the nervous system and their functions?
- How is information transmitted in the endocrine system, and what are its major structures?
- How do the nervous and endocrine systems interact to produce the fight-or-flight response?

Specialized for communication, up to 1 *trillion* neurons are linked throughout your body in a complex, organized communication network called the **nervous system**. The human nervous system is divided into two main divisions: the *central nervous system* and the *peripheral nervous system* (see Figure 2.7). In order for even simple behaviors to occur, such as curling your toes or scratching your nose, these two divisions must function as a single, integrated unit. Yet each of these divisions is highly specialized and performs different tasks.

The neuron is the most important transmitter of messages in the central nervous system. In the peripheral nervous system, communication occurs along **nerves**. Nerves and neurons are not the same thing (see Figure 2.8). Nerves are made up of large bundles of neuron axons. Unlike neurons, many nerves are large enough to be seen easily with the unaided eye.

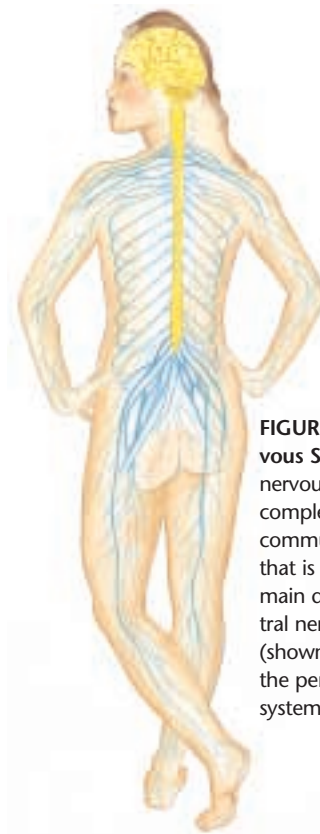
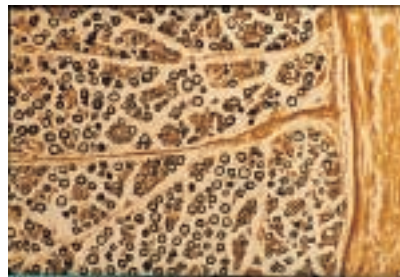


FIGURE 2.7 The Nervous System The nervous system is a complex, organized communication network that is divided into two main divisions: the central nervous system (shown in yellow) and the peripheral nervous system (shown in blue).

FIGURE 2.8 Nerves and Neurons Are Not the Same A cross section of a peripheral nerve is shown in this electron micrograph. You can see that a nerve is actually composed of bundles of neuron axons.

The Central Nervous System

The **central nervous system** includes the brain and the spinal cord. The central nervous system is so critical to your ability to function that it is entirely protected by bone—the brain by your skull and the spinal cord by your spinal column. As an added measure of protection, the brain and spinal cord are suspended in *cerebrospinal fluid* to protect them from being jarred.

The central nervous system is aptly named. It is central to all your behaviors and mental processes. And it is the central processing center—every action, thought, feeling, and sensation you experience is processed through the central nervous system. The most important element of the central nervous system is, of course, the brain, which acts as the command center. We'll take a tour of the human brain in a later section.

Think of the spinal cord as an old-fashioned but very busy telephone switchboard, handling both incoming and outgoing messages. Sensory receptors send messages along sensory nerves to the spinal cord, then up to the brain. To activate muscles, the brain sends signals down the spinal cord, which are relayed out along motor nerves to the muscles.

Most behaviors are controlled by your brain. However, the spinal cord can produce **spinal reflexes**—simple, automatic behaviors that occur without any brain involvement. One of the simplest spinal reflexes involves a three-neuron loop of

nervous system

The primary internal communication network of the body; divided into the central nervous system and the peripheral nervous system.

nerves

Bundles of neuron axons that carry information in the peripheral nervous system.

central nervous system

Division of the nervous system that consists of the brain and spinal cord.

spinal reflexes

Simple, automatic behaviors that are processed in the spinal cord.

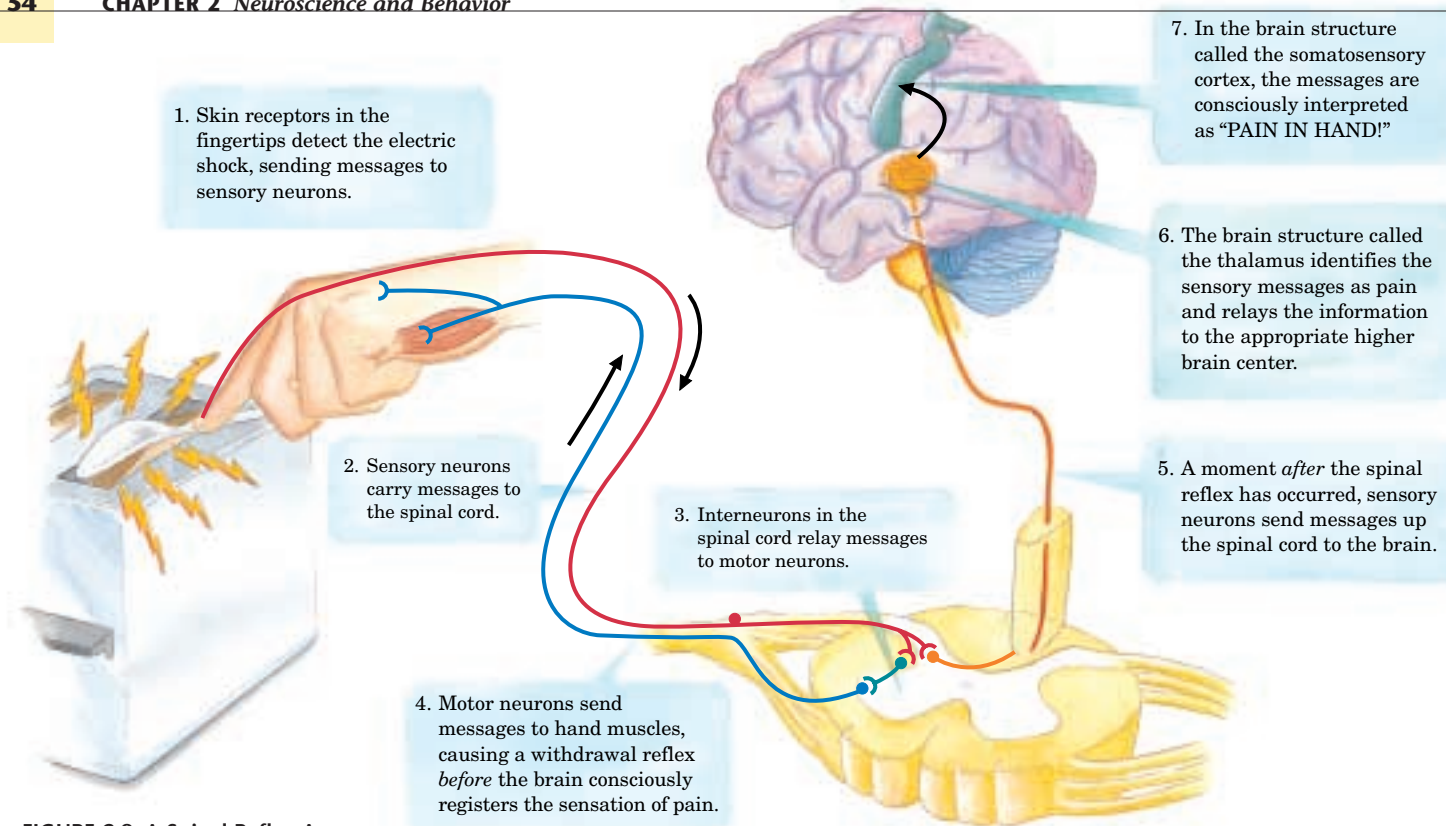


FIGURE 2.9 A Spinal Reflex Arc

A spinal reflex is a simple, involuntary behavior that is processed in the spinal cord without brain involvement. As you follow the sequence, you can see that the withdrawal reflex occurs before the brain processes the conscious perception of pain.



Activating the Sympathetic Nervous System

The sympathetic branch of the autonomic nervous system gears the body up in response to perceived threats. This arousal of the body's systems prepares organisms to flee from danger or confront it head-on—the essence of the *fight-or-flight syndrome*. When the sympathetic nervous system activates in humans, tiny muscles in the skin contract, which elevates your hair follicles, producing the familiar sensation of “goose bumps” and making your hair stand on end. A similar process takes place in many mammals, making the fur or hair bristle, with rather spectacular results in this long-haired cat.

rapid communication—a *sensory neuron* that communicates sensation to the spinal cord, an *interneuron* that relays information within the spinal cord, and a *motor neuron* leading from the spinal cord that signals muscles to react (see Figure 2.9).

Spinal reflexes are crucial to your survival. The additional few seconds that it would take you to consciously process sensations and decide how to react could result in serious injury. Spinal reflexes are also important as indicators that the neural pathways in your spinal cord are working correctly. That's why physicians test spinal reflexes during neurological examinations by tapping just below your kneecap for the knee-jerk spinal reflex or scratching the sole of your foot for the toe-curl spinal reflex.

The Peripheral Nervous System

The **peripheral nervous system** is the other major division of your nervous system. The word *peripheral* means “lying at the outer edges.” Thus, the peripheral nervous system comprises all the nerves outside the central nervous system that extend to the outermost borders of your body, including your skin. The communication functions of the peripheral nervous system are handled by its two subdivisions: the *somatic nervous system* and the *autonomic nervous system*.

The **somatic nervous system** takes its name from the Greek word *soma*, which means “body.” It plays a key role in communication throughout the entire body. First, the somatic nervous system communicates sensory information received by sensory receptors along sensory nerves to the central nervous system. Second, it carries messages from the central nervous system along motor nerves to perform voluntary muscle movements. All the different sensations that you're experiencing right now are being communicated by your somatic nervous system to your spinal cord and on to your brain. When you perform a voluntary action, such as turning a page of this book, messages from the brain are communicated down the spinal cord, then out to the muscles via the somatic nervous system.

The other subdivision of the peripheral nervous system is the **autonomic nervous system**. The word *autonomic* means “self-governing.” Thus, the autonomic nervous system regulates *involuntary* functions, such as heartbeat, blood

pressure, breathing, and digestion. These processes occur with little or no conscious involvement. This is fortunate, because if you had to mentally command your heart to beat or your stomach to digest the pizza you had for lunch, it would be difficult to focus your attention on anything else.

However, the autonomic nervous system is not completely self-regulating. By engaging in physical activity or purposely tensing or relaxing your muscles, you can increase or decrease autonomic activity. Emotions and mental imagery also influence your autonomic nervous system. Vividly imagining a situation that makes you feel angry, frightened, or even sexually aroused can dramatically increase your heart rate and blood pressure. A peaceful mental image can lower many autonomic functions.

The involuntary functions regulated by the autonomic nervous system are controlled by two different branches: the *sympathetic* and *parasympathetic nervous systems*. These two systems control many of the same organs in your body but cause them to respond in opposite ways (see Figure 2.10). In general, the

peripheral nervous system

(per-IF-er-ull) Division of the nervous system that includes all the nerves lying outside the central nervous system.

somatic nervous system

Subdivision of the peripheral nervous system that communicates sensory information to the central nervous system and carries motor messages from the central nervous system to the muscles.

autonomic nervous system

(aw-toe-NOM-ick) Subdivision of the peripheral nervous system that regulates involuntary functions.

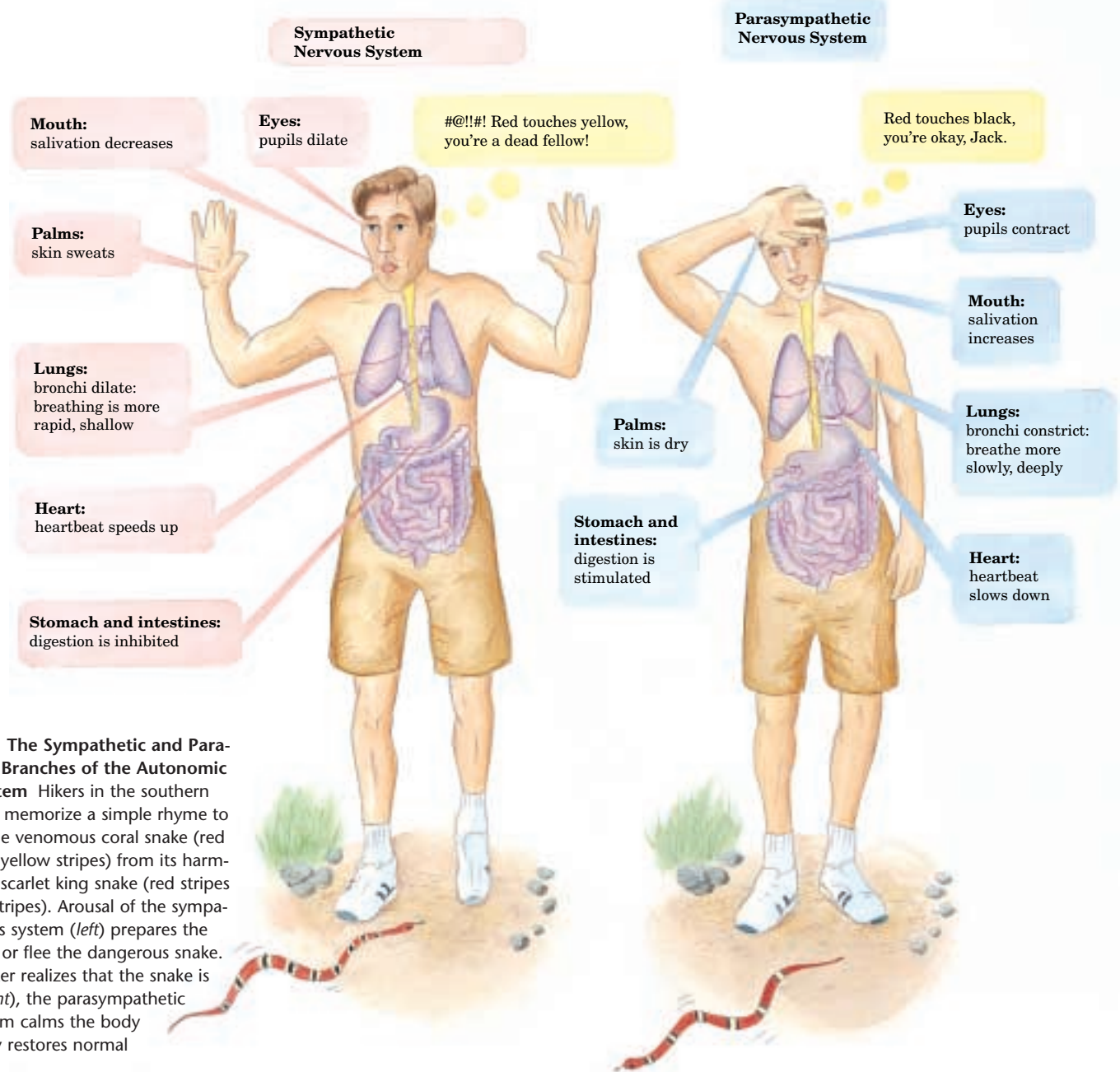


FIGURE 2.10 The Sympathetic and Parasympathetic Branches of the Autonomic Nervous System Hikers in the southern United States memorize a simple rhyme to distinguish the venomous coral snake (red stripes touch yellow stripes) from its harmless mimic, a scarlet king snake (red stripes touch black stripes). Arousal of the sympathetic nervous system (*left*) prepares the hiker to fight or flee the dangerous snake. When the hiker realizes that the snake is harmless (*right*), the parasympathetic nervous system calms the body and gradually restores normal functioning.

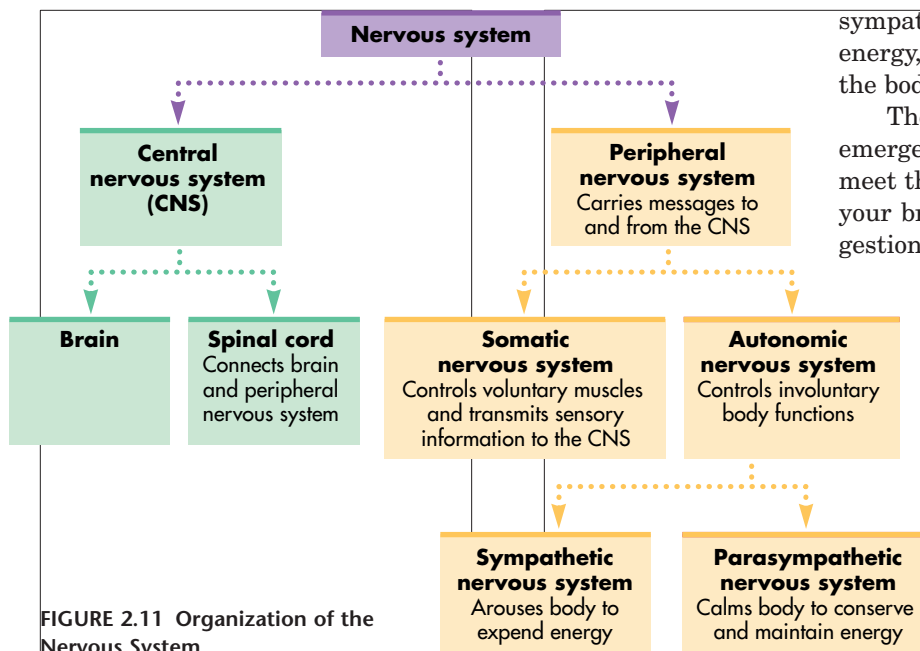


FIGURE 2.11 Organization of the Nervous System

sympathetic nervous system arouses the body to expend energy, and the parasympathetic nervous system helps the body conserve energy.

The **sympathetic nervous system** is the body's emergency system, rapidly activating bodily systems to meet threats or emergencies. When you are frightened, your breathing accelerates, your heart beats faster, digestion stops, and the bronchial tubes in your lungs expand. All these physiological responses increase the amount of oxygen available to your brain and muscles. Your pupils dilate to increase your field of vision, and your mouth becomes dry, because salivation stops. You begin to sweat in response to your body's expenditure of greater energy and heat. These bodily changes collectively represent the *fight-or-flight response*—they physically prepare you to fight or flee from a perceived danger. We'll discuss the fight-or-flight response in greater detail in Chapter 8, on emotion, and Chapter 12, on stress.

Whereas the sympathetic nervous system mobilizes your body's physical resources, the **parasympathetic nervous system** conserves and maintains your physical resources. It calms you down after an emergency. Acting much more slowly than the sympathetic nervous system, the parasympathetic nervous system gradually returns your body's systems to normal. Heart rate, breathing, and blood pressure level out. Pupils constrict back to their normal size. Saliva returns, and the digestive system begins operating again.

Although the sympathetic and parasympathetic nervous systems produce opposite effects, they act together, keeping the nervous system in balance (see Figure 2.11). Each division handles different functions, yet the whole nervous system works in unison so that both automatic and voluntary behaviors are carried out smoothly.

The Endocrine System

As you can see in Figure 2.12, the **endocrine system** is made up of glands that are located throughout the body. Like the nervous system, the endocrine system involves the use of chemical messengers to transmit information from one part of the body to another. Although the endocrine system is not part of the nervous system, it interacts with the nervous system in some important ways.

Endocrine glands communicate information from one part of the body to another by secreting messenger chemicals called **hormones** into the bloodstream. The hormones circulate throughout the bloodstream until they reach specific hormone receptors on target organs or tissue. By interacting with the nervous system and affecting internal organs and body tissues, hormones regulate physical processes and influence behavior in a variety of ways. Metabolism, growth rate, digestion, blood pressure, and sexual development and reproduction are just some of the processes that are regulated by the endocrine hormones. Hormones are also involved in emotional response and your response to stress.

Endocrine hormones are closely linked to the workings of the nervous system. For example, the release of hormones may be stimulated or inhibited by certain parts of the nervous system. In turn, hormones can promote or inhibit the generation of nerve impulses. Finally, some hormones and neurotransmitters are chemically identical. The same molecule can act as a hormone in the endocrine system and as a neurotransmitter in the nervous system.

In contrast to the rapid speed of information transmission in the nervous system, communication in the endocrine system takes place much more slowly. Hor-

sympathetic nervous system

Branch of the autonomic nervous system that produces rapid physical arousal in response to perceived emergencies or threats.

parasympathetic nervous system

Branch of the autonomic nervous system that maintains normal bodily functions and conserves the body's physical resources.

endocrine system

(EN-doe-krin) System of glands located throughout the body that secrete hormones into the bloodstream.

hormones

Chemical messengers secreted into the bloodstream primarily by endocrine glands.

Pineal gland

produces *melatonin*, which helps regulate sleep–wake cycles

Hypothalamus

brain structure that controls the pituitary gland; links nervous system and endocrine system

Pituitary gland

is often described as the master gland; regulates activities of several other glands; produces *growth hormone*, *prolactin*, and *oxytocin*

Thyroid gland

controls body metabolism rate

Adrenal glands

(adrenal cortex and adrenal medulla) produce *epinephrine* (adrenaline) and *norepinephrine*, which cause physical arousal in response to danger, fear, anger, stress, and other strong emotions

Pancreas

regulates blood sugar and insulin levels; involved in hunger

Ovaries

secrete *estrogen* and *progesterone*, which regulate female sexual development and reproduction and influence sexual behavior

Testes

secrete *testosterone*, which regulates male sexual development and reproduction and influences sexual behavior

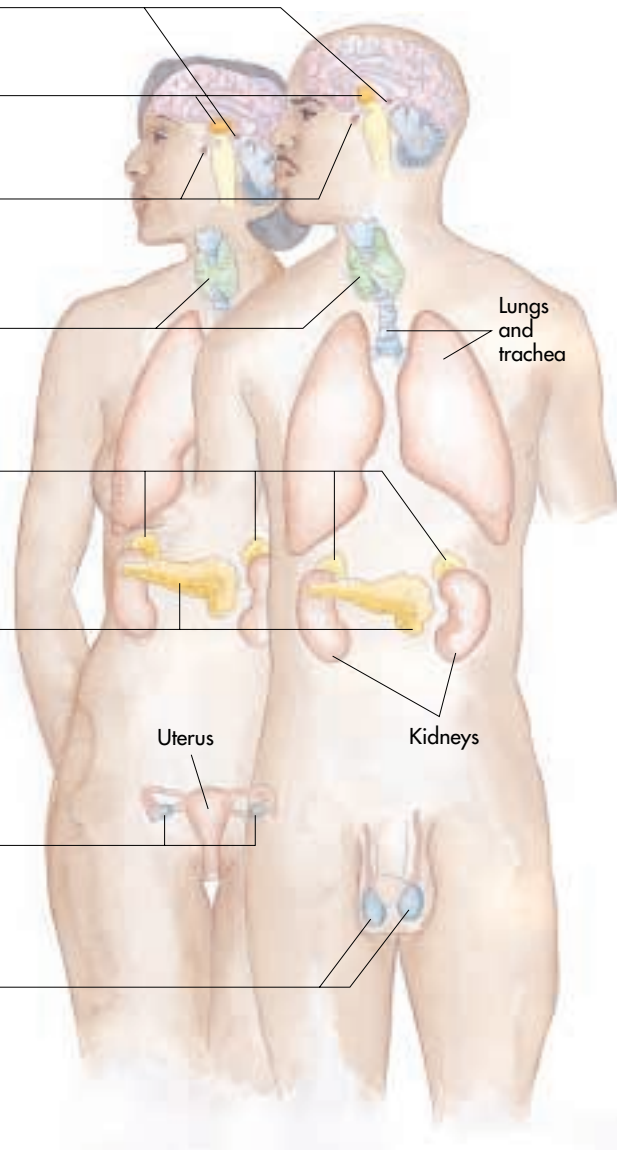


FIGURE 2.12 The Endocrine System The endocrine system and the nervous system are directly linked by the hypothalamus in the brain, which controls the pituitary gland. In turn, the pituitary releases hormones that affect the hormone production of several other endocrine glands. In the male and female figures shown here, you can see the location and main functions of several important endocrine glands.

hormones rely on the circulation of the blood to deliver their chemical messages to target organs, so it may take a few seconds or longer for the hormone to reach its target organ after it has been secreted by the originating gland.

The signals that trigger the secretion of hormones are regulated by the brain, primarily by a brain structure called the *hypothalamus*. (You'll learn more about the hypothalamus later in the chapter.) The hypothalamus serves as the main link between the endocrine system and the nervous system. The hypothalamus directly regulates the release of hormones by the **pituitary gland**, a pea-sized gland just under the brain. The pituitary's hormones, in turn, regulate the production of other hormones by many of the glands in the endocrine system. This is why the pituitary gland is often referred to as the body's master gland. Under the direction of the hypothalamus, the pituitary gland controls hormone production in other endocrine glands.

The pituitary gland also produces some hormones that act directly. For example, the pituitary produces *growth hormone*, which stimulates normal skeletal growth during childhood. In nursing mothers, the pituitary produces both *prolactin*, the hormone that stimulates milk production, and *oxytocin*, the hormone that produces the let-down reflex, in which stored milk is "let down" into the nipple. Interestingly, the pituitary gland can also secrete endorphins to reduce the perception of pain.

Another set of glands, called the **adrenal glands**, is of particular interest to psychologists. The adrenal glands consist of the **adrenal cortex**, which is the outer gland, and the **adrenal medulla**, which is the inner gland. Both the

pituitary gland

(pi-TOO-ih-tare-ee) Endocrine gland attached to the base of the brain that secretes hormones that affect the function of other glands as well as hormones that act directly on physical processes.

adrenal glands

Pair of endocrine glands that are involved in the human stress response.

adrenal cortex

The outer portion of the adrenal glands.

adrenal medulla

The inner portion of the adrenal glands; secretes epinephrine and norepinephrine.

adrenal cortex and the adrenal medulla produce hormones that are involved in the human stress response. As you'll see in Chapter 12, on stress, hormones secreted by the adrenal cortex also interact with the *immune system*, the body's defense against invading viruses or bacteria.

The adrenal medulla plays a key role in the fight-or-flight response, described earlier. When aroused, the sympathetic nervous system stimulates the adrenal medulla. In turn, the adrenal medulla produces *epinephrine* and *norepinephrine*. (You may be more familiar with the word *adrenaline*, which is another name for epinephrine.)

As they circulate through the bloodstream to the heart and other target organs, epinephrine and norepinephrine complement and enhance the effects of the sympathetic nervous system. These hormones also act as neurotransmitters, stimulating activity at the synapses in the sympathetic nervous system. The action of epinephrine and norepinephrine is a good illustration of the long-lasting effects of hormones. If you've noticed that it takes a while for you to calm down after a particularly upsetting or stressful experience, it's because of the lingering effects of epinephrine and norepinephrine in your body.

2.2 R · E · V · I · E · W

C · O · N · C · E · P · T

The Nervous System and the Endocrine System

Circle the letter of the item that correctly completes each statement.

1. While watching a suspenseful video late at night, you hear a sudden crash in another room. You leap out of your chair in fear, then realize that your dog has knocked over the trash again. Your fear reaction involved the activation of the _____ of the nervous system. Calming down involved the _____ of the nervous system.

a. hypothalamus; endocrine branch

b. somatic branch; sympathetic division

c. sympathetic division; parasympathetic division

d. parasympathetic division; sympathetic division
2. The part of the nervous system that controls voluntary movement is the _____.

a. parasympathetic nervous system

b. somatic nervous system

c. autonomic nervous system

d. fight-or-flight response
3. The glands of the endocrine system communicate via _____.

a. electrically charged ion channels

b. neural impulses along the axon

c. spinal reflexes

d. messenger chemicals called hormones
4. The main link between the nervous system and the endocrine system occurs at the _____.

a. adrenal glands

b. pineal gland

c. somatic nervous system

d. hypothalamus
5. In response to stress, epinephrine is pumped into the bloodstream by the _____.

a. adrenal glands

b. pineal gland

c. thyroid gland

d. pituitary gland

A Guided Tour of the Brain

Key Theme

- The brain is a highly complex, integrated, and organized system of neurons.

Key Questions

- What methods have been used to study the human brain, and how has each contributed to knowledge of the brain?
- What are neural pathways?
- How does the brain develop, and what is neurogenesis?

Forget all the hype about the Internet. The *real* information superhighway is the human brain. In fact, the most complex mass of matter in the universe sits right between your two ears: your brain.

ls __
le __
ll __

In this section we'll take you on a guided tour of the human brain. As your tour guides, our goal here is not to tell you everything that is known or suspected about the human brain. Such an endeavor would take stacks of books rather than a single chapter in a college textbook. Instead, our first goal is to familiarize you with the basic organization and structures of the brain. Our second goal is to give you a general sense of *how* the brain works. In later chapters, we'll add to your knowledge of the brain as we discuss the brain's involvement in specific psychological processes.

At the beginning of this tour, it's important to note that the brain generally does not lend itself to simple explanations. As we describe different areas of the brain, we'll identify important centers where particular functions seem to be localized. Nevertheless, keep in mind that specific functions seldom correspond neatly to a single, specific brain site. Many psychological processes, particularly complex ones, involve multiple brain structures and regions. Even seemingly simple tasks—such as carrying on a conversation or catching a ball—involve the smoothly coordinated synthesis of information among many different areas of your brain.

How is information communicated and shared among these multiple brain regions? Many brain functions involve the activation of neural pathways that link different brain structures. *Neural pathways* are formed by groups of neuron cell bodies in one area of the brain that project their axons to other brain areas. These neural pathways form communication networks and circuits that link different brain areas. As a result, damage to one area of the brain may disrupt many neural pathways and affect many different functions. Thus, even though we'll talk about brain centers and structures that are involved in different aspects of behavior, the best way to think of the brain is as an *integrated system*.

As part of our tour, let's start with an overview of the methods that have been used to study the human brain.

Studying the Brain

The Toughest Case to Crack

Imagine how difficult it would be to try to figure out how something works without being able to open it, take it apart, or watch it operate. Such has long been the challenge faced by scientists investigating the workings of the human brain. Because the brain is encased entirely by bone, it has been impossible to directly observe a normal, living brain in action. One early approach to mapping brain functions involved examining the bumps on a person's skull. As you can see in Science Versus Pseudoscience Box 2.1, this approach was not very successful.

Another obstacle is the complexity of the brain itself—complex not only in its enormous number of interconnected neurons, but also in the intricate structures, regions, and pathways formed by those neurons. But scientists are not an easily discouraged lot.

Some of the oldest methods of studying the brain are still commonly used. In the *case study*, researchers systematically observe and record the behavior of people whose brains have been damaged by illness or injury. Case studies of individuals with brain damage have provided valuable insights into behavior in such areas as memory, speech, emotion, movement, and personality. As you'll see later, the knowledge gained from such observations allowed scientists to begin mapping the functions of the brain.

However, generalizing results from a case study must be done cautiously. By their very nature, case studies usually focus on unusual situations or behaviors—in this case, brain disease or injury. Because these behaviors or situations are out of the ordinary, they may not reflect typical behavior.

Another potential limitation to using case studies in brain research is that injuries to the brain are rarely limited to specific, localized areas or contained within well-defined anatomical boundaries. It's often difficult to be sure exactly



The Human Brain Weighing roughly three pounds, the human brain is about the size of a small cauliflower. Although your brain makes up only about 2 percent of your total body weight, it uses some 20 percent of the oxygen your body needs while at rest. The oxygen is used in breaking down glucose to supply the brain with energy.

which brain area is responsible for specific behavioral problems. In addition, many brain areas are linked to other brain areas, and damage in one area may disrupt functioning in another, otherwise normal area.

A related research method involves producing *lesions*—surgically altering, removing, or destroying specific portions of the brain—and observing subsequent behavior. In humans, lesions are sometimes produced for medical reasons, such as when part of the brain is surgically altered or removed to relieve uncontrollable seizures. Following such medical treatment, researchers can study the behavioral effects of the lesions. Lesions are sometimes produced in animals to systematically investigate the behavioral effects of damage in specific brain areas.

Researchers have also studied the behavioral effects of electrically stimulating specific brain areas. This procedure usually involves implanting tiny electrified disks or wires, called *bipolar electrodes*, into a specific brain area. Electrical stimulation causes activation of the neurons in the area around the tip of the electrode and usually produces the opposite behavioral effect of a lesion in the same brain area.

The invention of the **electroencephalograph** allowed scientists to record the brain's electrical activity through the use of large, disk-shaped electrodes placed harmlessly on a person's scalp. The graphic record of the brain's electrical activity that this instrument produces is called an *electroencephalogram*, abbreviated as *EEG*. Modern electroencephalographs provide sophisticated computerized analyses of the brain's electrical activity, recording the electrical activity of the brain from millisecond to millisecond.

As technology has become more advanced, so have the tools used to study the brain. In the Focus on Neuroscience on page 62, we take a look at the new imaging techniques that allow neuroscientists to see the human brain at work.

The Developing Brain

New Neurons Throughout Life?

Our guided tour will follow the same general sequence that the brain follows in its development before birth. The human brain begins as a fluid-filled *neural tube* that forms about two weeks after conception. Gradually, the neural tube expands and develops into separate, fluid-filled cavities, called *ventricles*, which are at the core of the fully developed brain. *Cerebrospinal fluid* is manufactured in the ventricles by special glial cells. We noted previously that cerebrospinal fluid acts as a shock absorber for the central nervous system and cushions the brain.

As the human fetus develops, brain cells multiply, differentiate, and migrate to their final locations. By the fourth week of prenatal development, new neurons are being generated at the rate of 500,000 per minute. By 24 weeks of prenatal age, the brain has nearly its full complement of neurons. These neurons will continue to function for decades throughout the person's lifespan.

The fetal brain is constantly changing, forming as many as 2 million synaptic connections per second. Connections that are used are strengthened, while unused connections are pruned (Rakic, 1995). Progressively, the three major regions of the brain develop: the *hindbrain*, the *midbrain*, and the *forebrain*. Over the course of fetal development, the forebrain structures eventually



2UN09

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phrenology

(freh-NOL-uh-gee) A discredited pseudoscientific theory of the brain that claimed that personality characteristics, moral character, and intelligence could be determined by examining the bumps on a person's skull.

cortical localization

The notion that different functions are located or localized in different areas of the brain; also referred to as *localization of function*.

electroencephalograph

An instrument that produces a graphic record of the brain's electrical activity by using electrodes placed on the scalp.

Human Embryo at Six Weeks Though the embryo is less than an inch long, the prominent structures of the hindbrain and the beginnings of the forebrain can clearly be seen at this early stage of prenatal development.

Neuroscience

Understanding Brain-Imaging Techniques

2UN11

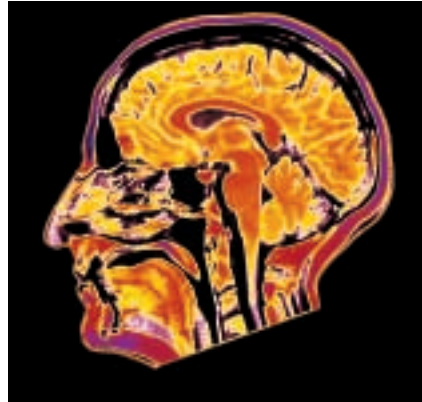
Positron emission tomography, or a PET scan, generates images of the brain's activity by tracking the brain's use of a radioactively tagged compound, such as glucose, oxygen, or a particular drug. An invasive procedure, PET involves injecting participants with a radioactive substance before the scan. The PET scan then measures the amount of the radioactively tagged substance used in thousands of brain areas while the person engages in some type of mental activity. Over the course of several minutes, the information is collected, analyzed, and averaged by computer. In the resulting color-coded images, the areas of greatest brain activity are indicated by red and yellow colors.

Commonly Used Brain-Imaging Techniques

Brain scan images have become so commonplace in news articles and popular magazines that it's easy to forget just how revolutionary brain imaging technology has been to the field of neuroscience (Posner & DiGirolamo, 2000). Shown above are the three types of brain-imaging techniques most commonly used in psychological research—**PET scans**, **MRI**, and **functional MRI**, which is abbreviated **fMRI**. The descriptions explain how each brain-imaging technique works and the kind of information it provides.

How Psychologists Use Brain-Imaging Technology

Like other scientific data-gathering methods described in Chapter 1, brain imaging is used for both descriptive and experimental research. A descriptive study utilizing brain scans might compare the brain structure or functioning of one carefully defined group of people with another. For example, MRI scans were used to compare London taxi drivers, who are required to have an encyclopedic knowledge of the city streets to pass their licensing exam, with matched participants who were not London taxi drivers (Maguire & others, 2000). The MRI scans showed that part of a brain structure involved in spatial memory, the *hippocampus*, was significantly larger in the experienced taxi drivers than in the control subjects. The size of the hippocampus was also positively correlated with the length of time the participants had been driving taxis in London. One implica-



Magnetic resonance imaging, or MRI, is a noninvasive procedure that provides highly detailed images of the body's internal structures, including the brain. MRI is very versatile, producing thin "slice" images of body tissue from virtually any angle. As the person lies motionless in a long magnetic tube, powerful but harmless magnetic fields bombard the brain or other body area. In response to these magnetic fields, the molecules of the body generate electromagnetic signals, which are analyzed by computer to create the highly detailed images. Tissues with high concentrations of water, such as fat, appear lighter in color, while bone and other tissues with less water appear darker.

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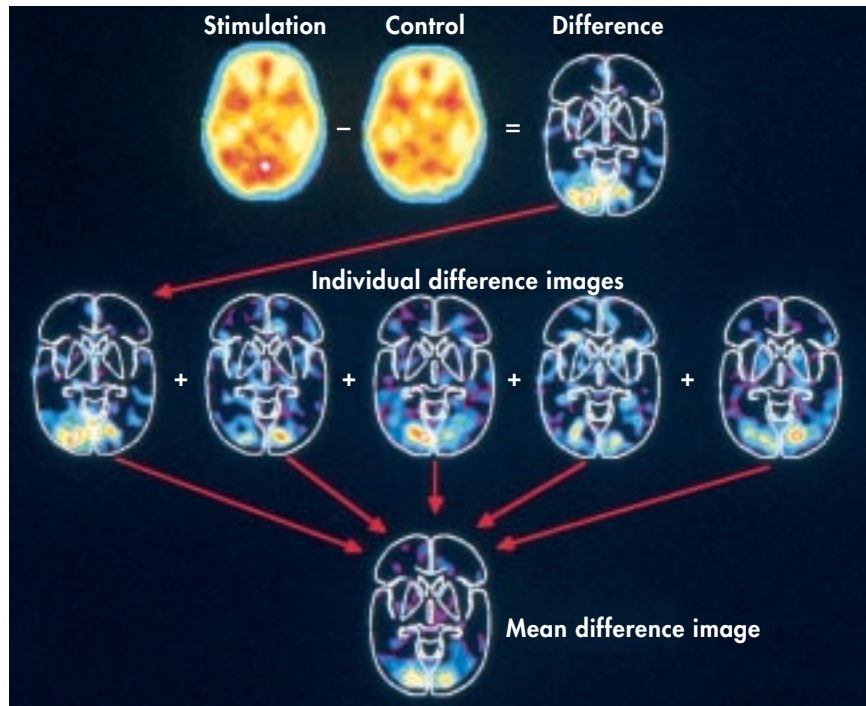
Functional magnetic resonance imaging, or fMRI, provides moment-by-moment images of the brain's changing activity. Using the same scanning hardware as an MRI, fMRI also tracks changes in the brain's blood flow and oxygen levels. Compared to PET scans, fMRI produces a much sharper picture and can detail much smaller brain structures. Another advantage of fMRI is that it provides a picture of brain activity averaged over seconds rather than the several minutes required by PET scans. Because fMRI is a noninvasive procedure, researchers can repeatedly scan a single subject. In an fMRI image, the areas of greatest brain activity are indicated by red and orange colors.

tion of this study is that structures in the adult human brain can change in response to learning and environmental demands—an important topic that we'll explore later in the chapter.

Brain-imaging technology is also used in experimental research, especially in an important new field called cognitive neuroscience. Integrating contributions from psychology, neuroscience, and computer science, **cognitive neuroscience** is the study of the neural basis of cognitive processes.

How is brain imaging used in cognitive neuroscience research? In a typical experiment, a brain scan is taken during a control task or condition, such as lying down with eyes closed. In the top row of PET scans in the image on page 63, the control condition is shown in the middle PET scan. In that particular study, the control condition consisted of resting while staring at a fixed point.

The control scan is compared to brain scans taken while the participant is exposed to the experimental treatment or performing the experimental task. In the top row of PET scans, the first PET scan is the treatment task, which is labeled "Stimulation." More specifically, the treatment task in that study was looking at a flickering checkerboard pattern. The difference between the PET scans is calculated to determine the brain activity that can be attributed to the experimental condition (Gusnard & Raichle, 2001). In the chapters to come, you'll see several examples of experimental research that use brain-imaging techniques.



Cognitive neuroscience research often follows the procedure shown on the left. In this particular study, the researchers used positron emission tomography to track changes in the participant's brain activity. In the *Control* condition, the participant's brain is scanned while looking at a fixed point on a blank screen. In the *Stimulation* (experimental) condition, the participant is scanned while engaged in the treatment task. In this study, the treatment task was looking at a flickering checkerboard pattern. After the control scan is "subtracted" from the experimental condition scan, the *Difference* image reveals the brain activity that is assumed to be uniquely attributable to the experimental task. In the next phase of the research (center row), difference images from the individual subjects are *combined and averaged*. This step helps minimize any idiosyncratic responses among the participants. It also provides a composite PET image identifying the brain regions selectively activated by the experimental task.

Potential Limitations of Brain-Imaging Studies

As technological advances occur, brain-imaging technology continues to improve, offering increasingly detailed pictures of the intact living brain. Nevertheless, brain-imaging research has some limitations. When you consider the results of brain-imaging studies, including those presented in this textbook, keep the following points in mind:

- 1. Most brain-imaging studies involve small groups of subjects.**
Because of the limited availability of sophisticated equipment and the high cost of brain-imaging technology, brain-scan research tends to involve small groups of subjects, often as few as a dozen or less. As is true with any research that involves a small number of participants, caution must be exercised in generalizing results to a wider population.
- 2. Most brain-imaging studies involve simple aspects of behavior.**
Human behavior is extraordinarily complex, and even seemingly simple tasks involve the smooth coordination of multiple brain regions. Reading this paragraph, for example, activates visual, language, memory, and auditory centers in your brain. As psychologist William Uttal (2001) observes, "The more complex the psychological process, the less likely it is that a narrowly circumscribed [brain] region uniquely associated with that process will be found."

3. Knowing what brain area is involved may tell us little about the psychological process being investigated.

Knowing the brain location of a psychological process does not necessarily translate into an understanding of that process. For example, identifying a particular brain structure as being involved in fear does little to explain our psychological experience of fear (Miller & Keller, 2000). Snapshots of brain activity can only be interpreted within the context of psychological knowledge about the behavior being studied.

Looking at Brain-Scan Images

What should you notice when you look at a brain scan image? First, read the text description carefully, so that you understand the task or condition that is being measured. Second, when a control-condition brain scan is shown, carefully compare the control scan with the treatment scan, noting how the two scans differ. Third, keep the limitations of brain-scan technology in mind, remembering that human experience is much too complex to be captured by a single snapshot of brain activity.

Although brain-imaging research has its limitations, the advent of sophisticated imaging technology has revolutionized our understanding of the human brain. But brain-imaging technology has also revealed just how much remains to be discovered about the most complex piece of matter known to exist in the universe—the human brain.

magnetic resonance imaging (MRI)

An imaging technique that provides three-dimensional, highly detailed images of the brain using electrical signals generated by the brain in response to magnetic fields.

positron emission tomography (PET scan)

An imaging technique that provides color-coded images of brain activity by measuring the amount of a radioactive compound, glucose, or oxygen used in different brain regions.

functional magnetic resonance imaging (fMRI)

An imaging technique that uses magnetic fields to map brain activity by measuring changes in the brain's blood supply during different mental activities.

cognitive neuroscience

The study of the neural basis of cognitive process that integrates contributions from psychology, neuroscience, and computer science.

Neurogenesis in the Adult Human Brain

Using laser microscopes to examine sections of the adult hippocampus, researchers Peter Eriksson and Fred Gage (1998) documented the presence of new neurons, shown in green, amid already established neurons, shown in red. In the area of the hippocampus studied, each cubic centimeter of brain tissue contained from 100 to 300 new neurons. New research on adult mice has shown that the newly generated neurons develop into fully functional neurons that form synaptic connections with existing cells in the hippocampus (van Praag & others, 2002).

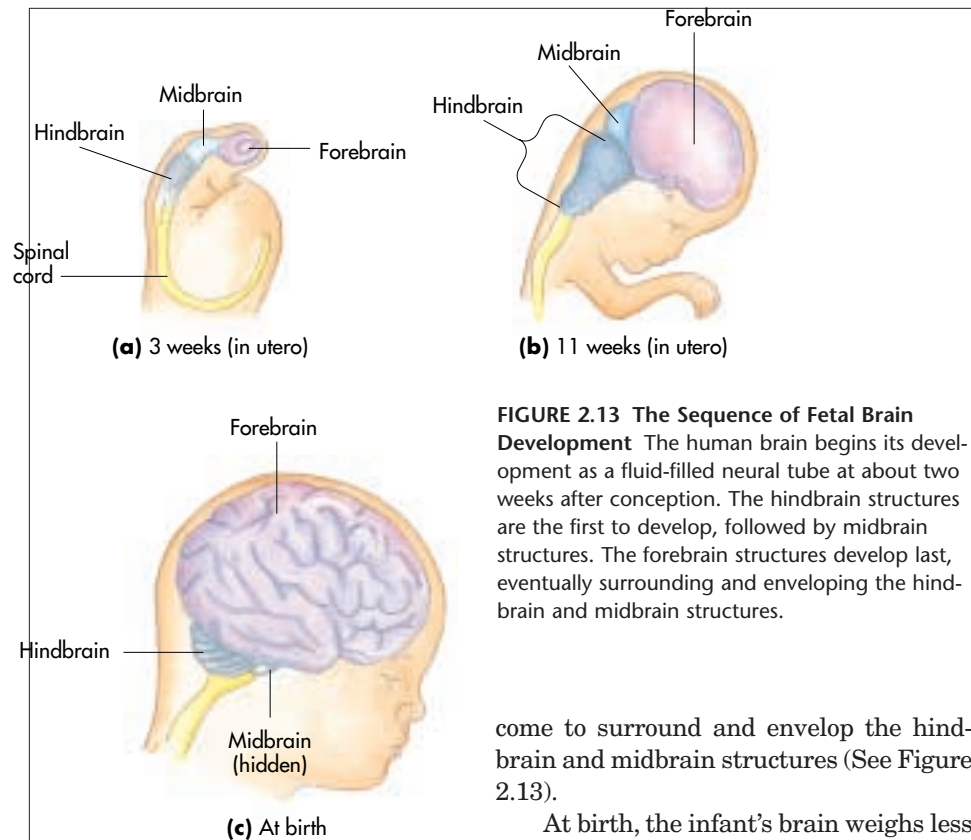
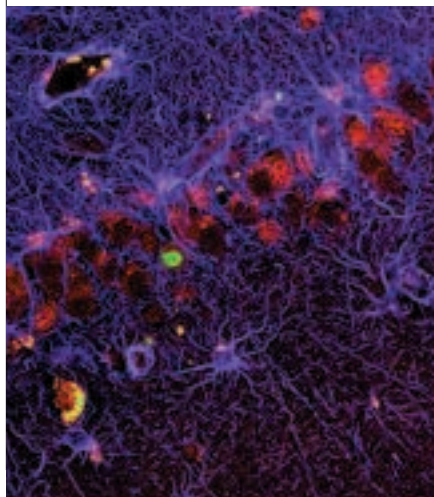


FIGURE 2.13 The Sequence of Fetal Brain Development The human brain begins its development as a fluid-filled neural tube at about two weeks after conception. The hindbrain structures are the first to develop, followed by midbrain structures. The forebrain structures develop last, eventually surrounding and enveloping the hindbrain and midbrain structures.

come to surround and envelop the hindbrain and midbrain structures (See Figure 2.13).

At birth, the infant's brain weighs less than a pound and is only about one-fourth the size of an adult brain. After birth, the neurons grow in size and continue to develop new dendrites. Myelin forms on neuron axons in key areas of the brain, such as those involved in motor control. Axons also grow longer, and the branching at the ends of axons becomes more dense. By adulthood, the fully mature human brain weighs about three pounds.

For many years, scientists believed that people and most animals did not experience **neurogenesis**—the development of new neurons—after birth. With the exception of birds, tree shrews, and some rodents, it was thought that the mature brain could lose neurons but could not grow new ones. But new studies offered compelling evidence that persuaded most neuroscientists to abandon that dogma (Gross, 2000).

First, research by psychologist Elizabeth Gould and her colleagues (1998) showed that adult marmoset monkeys were generating a significant number of new neurons every day in the *hippocampus*, a brain structure that plays a critical role in the ability to form new memories. Gould's groundbreaking research provided the first demonstration that new neurons could develop in an adult primate brain. Could it be that the human brain also has the capacity to generate new neurons in adulthood?

Researchers Peter Eriksson, Fred Gage, and their colleagues (1998) provided evidence that it does. The subjects were five adult cancer patients, whose ages ranged from the late fifties to the early seventies. These patients were all being treated with a drug to determine whether tumor cells are multiplying. The drug is incorporated into newly dividing cells and colors the cells. Under fluorescent light, this chemical tracer can be detected in the newly created cells. The reasoning was that if new neurons were being generated, the drug would be present in their genetic material.

Within hours after each patient died, an autopsy was performed and the hippocampus was removed and examined. The results were unequivocal. In each patient, *hundreds* of new neurons had been generated since the drug had been administered, even though all the patients were over 50 years old (see photo at left). The conclusion? Contrary to the traditional scientific view, the hippocampus has the capacity to generate new neurons throughout the lifespan (Eriksson & others, 1998; Kempermann & Gage, 1999).

Is the capacity to generate new neurons limited to just the hippocampus? Not according to later research by Gould and her colleagues (1999b), which showed that adult macaque monkeys continually develop new neurons that migrate to *multiple* brain locations. These brain areas are involved in sophisticated cognitive abilities, including memory, learning, and decision making.

In the next section, we'll continue our guided tour of the brain. Following the general sequence of the brain's development, we'll start with the structures at the base of the brain and work our way up to the higher brain regions, which are responsible for complex mental activity.

The Brainstem

Hindbrain and Midbrain Structures

Key Theme

- The brainstem includes the hindbrain and midbrain, located at the base of the brain.

Key Questions

- Why does damage to one side of the brain affect the opposite side of the body?
- What are the key structures of the hindbrain and midbrain, and what are their functions?

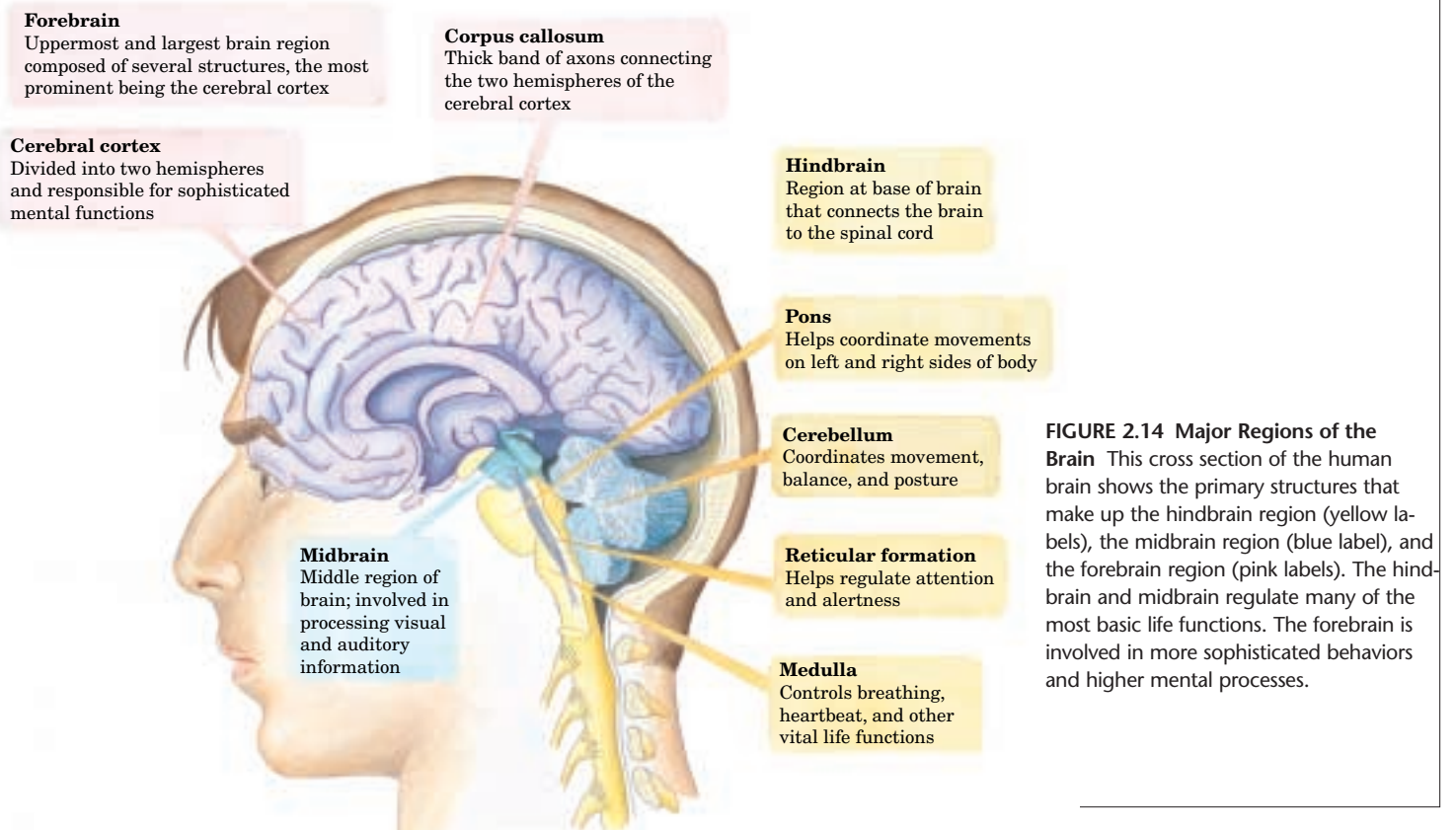
The major regions of the brain are illustrated in Figure 2.14, which can serve as a map to keep you oriented during our tour. At the base of the brain lie the hindbrain and, directly above it, the midbrain. Combined, the structures of the hindbrain and midbrain make up the brain region that is also called the **brainstem**.

neurogenesis

The development of new neurons.

brainstem

A region of the brain made up of the hindbrain and the midbrain.



hindbrain

A region at the base of the brain that contains several structures that regulate basic life functions.

medulla

(meh-DOOL-uh) A hindbrain structure that controls vital life functions such as breathing and circulation.

pons

A hindbrain structure that connects the medulla to the two sides of the cerebellum; helps coordinate and integrate movements on each side of the body.

cerebellum

(sare-uh-BELL-um) A large, two-sided hindbrain structure at the back of the brain; responsible for muscle coordination and maintaining posture and equilibrium.

reticular formation

(reh-TICK-you-ler) A network of nerve fibers located in the center of the medulla that helps regulate attention, arousal, and sleep; also called the *reticular activating system*.

midbrain

The middle and smallest brain region, involved in processing auditory and visual sensory information.

substantia nigra

(sub-STAN-she-uh NYE-gruh) An area of the midbrain that is involved in motor control and contains a large concentration of dopamine-producing neurons.

forebrain

The largest and most complex brain region, which contains centers for complex behaviors and mental processes; also called the *cerebrum*.

cerebral cortex

(suh-REE-brull or SARE-uh-brull) The wrinkled outer portion of the forebrain, which contains the most sophisticated brain centers.

cerebral hemispheres

The nearly symmetrical left and right halves of the cerebral cortex.

corpus callosum

A thick band of nerve fibers that connects the two cerebral hemispheres and acts as a communication link between them.

The Hindbrain

The **hindbrain** connects the spinal cord with the rest of the brain. Sensory and motor pathways pass through the hindbrain to and from regions that are situated higher up in the brain. Sensory information coming in from one side of the body crosses over at the hindbrain level, projecting to the opposite side of the brain. And outgoing motor messages from one side of the brain also cross over at the hindbrain level, controlling movement and other motor functions on the opposite side of the body.

This crossover accounts for why people who suffer strokes on one side of their brain experience muscle weakness or paralysis on the opposite side of their body. Our friend Asha, for example, suffered only minor damage to motor control areas in her brain. However, because the stroke occurred on the *left* side of her brain, what muscle weakness she did experience was localized on the *right* side of her body, primarily in her right hand.

Three structures make up the hindbrain—the medulla, the pons, and the cerebellum. The **medulla** lies directly above the spinal cord and contains centers active in the control of such vital autonomic functions as breathing, heart rate, and digestion. Because the medulla is involved in such critical life functions, damage to it can result in death. The medulla also controls a number of vital reflexes, such as swallowing, coughing, vomiting, and sneezing.

Above the medulla is a swelling of tissue called the **pons**, which represents the uppermost level of the hindbrain. Bulging out behind the pons is the large **cerebellum**. On each side of the pons, a large bundle of axons connects it to the cerebellum. The word *pons* means “bridge,” and the pons is a bridge of sorts: Information from various other brain regions located higher up in the brain is relayed to the cerebellum via the pons.

The cerebellum functions in the control of balance, muscle tone, and coordinated muscle movements. It is also involved in the learning of habitual or automatic movements and motor skills, such as typing, writing, or gracefully backhanding a tennis ball.

Jerky, uncoordinated movements can result from damage to the cerebellum. Simple movements, such as walking or standing upright, may become difficult or impossible. The cerebellum is also one of the brain areas affected by alcohol consumption, which is why a person who is intoxicated may stagger and have difficulty walking a straight line or standing on one foot. (This is also why a police officer will ask a suspected drunk driver to execute these normally effortless movements.)

At the core of the medulla and the pons is a network of neurons called the **reticular formation**, or the *reticular activating system*. The reticular formation is composed of many groups of specialized neurons that project up to higher brain regions and down to the spinal cord. The reticular formation plays an important role in regulating attention and sleep.

The Midbrain

The **midbrain** is an important relay station that contains centers important to the processing of auditory and visual sensory information. Auditory sensations from the left and right ears are processed through the midbrain, helping you orient toward the direction of a sound. The midbrain is also involved in processing visual information, including eye movements, helping you visually locate objects and track their movements. After passing through the midbrain level, auditory and visual information is relayed to sensory processing centers farther up in the forebrain region, which will be discussed shortly.

A midbrain area called the **substantia nigra** is involved in motor control and contains a large concentration of dopamine-producing neurons. *Substantia nigra* means “dark substance,” and as the name suggests, this area is darkly pigmented. The substantia nigra is part of a larger neural pathway that helps prepare other

brain regions to initiate organized movements or actions. In the section on neurotransmitters, we noted that Parkinson's disease involves symptoms of abnormal movement, including difficulty initiating or starting a particular movement. Many of those movement-related symptoms are associated with the degeneration of dopamine-producing neurons in the substantia nigra.

The Forebrain

Key Theme

- The forebrain includes the cerebral cortex and the limbic system structures.

Key Questions

- What are the four lobes of the cerebral cortex and their functions?
- What is the limbic system?
- What functions are associated with the thalamus, hypothalamus, hippocampus, and amygdala?

Situated above the midbrain is the largest region of the brain: the **forebrain**. In humans, the forebrain, also called the *cerebrum*, represents about 90 percent of the brain. In Figure 2.15, you can see how the size of the forebrain has increased during evolution, although the general structure of the human brain is similar to that of other species (Clark & others, 2001). Many important structures are found in the forebrain region, but we'll begin by describing the most prominent—the cerebral cortex.

The Cerebral Cortex

The outer portion of the forebrain, the **cerebral cortex**, is divided into two **cerebral hemispheres**. The word *cortex* means “bark,” and much like the bark of a tree, the cerebral cortex is the outer covering of the forebrain. A thick bundle of axons, called the **corpus callosum**, connects the two cerebral hemispheres, as shown in Figure 2.16. The corpus callosum serves as the primary communication link between the left and right cerebral hemispheres.

The cerebral cortex is only about a quarter of an inch thick. It is mainly composed of glial cells and neuron cell bodies and axons, giving it a grayish appearance—which is why the cerebral cortex is sometimes described as being composed of *gray matter*. Extending inward from the cerebral cortex are white myelinated axons that are sometimes referred to as *white matter*. These myelinated axons connect the cerebral cortex to other brain regions.

Numerous folds, grooves, and bulges characterize the human cerebral cortex. The purpose of these ridges and valleys is easy to illustrate. Imagine a flat, three-foot by three-foot piece of paper. You can compact the surface area of this piece of paper by scrunching it up into a wad. In much the same way, the grooves and bulges of the cerebral cortex allow about three square feet of surface area to be packed into the small space of the human skull.

Look again at Figure 2.15. The drawing of the human brain is cut through the center to show how the cerebral

FIGURE 2.15 Evolution and the Cerebral Cortex The brains of these different animal species have many structures in common, including a cerebellum and cortex. However, the proportion devoted to the cortex is much higher in mammals than in species that evolved earlier, such as fish and amphibians. The relative size of the different structures reflects their functional importance (Kaas & Collins, 2001). The cross section of the human brain shows how the cerebral cortex has developed around and above more primitive brain structures.

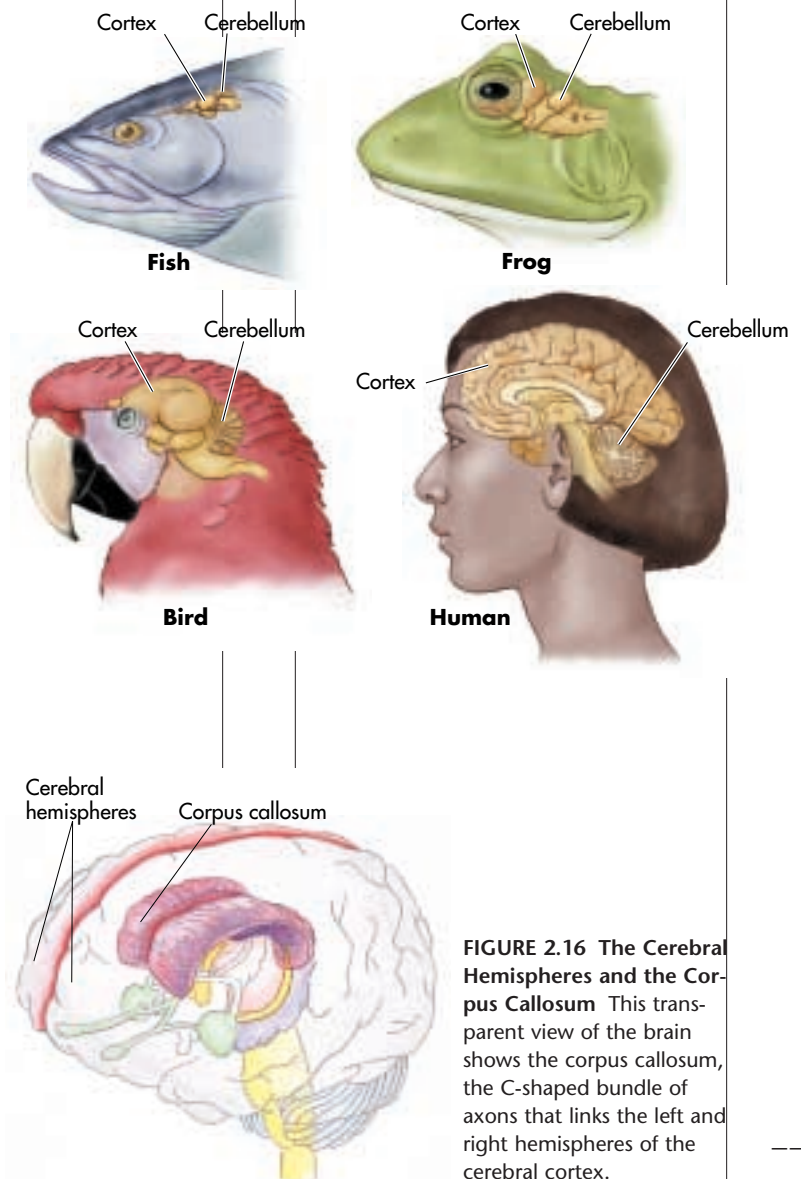


FIGURE 2.16 The Cerebral Hemispheres and the Corpus Callosum This transparent view of the brain shows the corpus callosum, the C-shaped bundle of axons that links the left and right hemispheres of the cerebral cortex.

temporal lobe

An area on each hemisphere of the cerebral cortex near the temples that is the primary receiving area for auditory information.

occipital lobe

(ock-SIP-it-ull) An area at the back of each cerebral hemisphere that is the primary receiving area for visual information.

parietal lobe

(puh-RYE-et-ull) An area on each hemisphere of the cerebral cortex located above the temporal lobe that processes somatic sensations.

cortex has folded above and around the rest of the brain. In contrast to the numerous folds and wrinkles of the human cerebral cortex, notice the smooth appearance of the cortex in fish, amphibians, and birds. Mammals with large brains—such as cats, dogs, and nonhuman primates—also have wrinkles and folds in the cerebral cortex, but to a lesser extent than humans (Allman, 1999).

Each cerebral hemisphere can be roughly divided into four regions, or *lobes*: the *temporal*, *occipital*, *parietal*, and *frontal* lobes (see Figure 2.17). Each lobe is associated with distinct functions. Located near your temples, the **temporal lobe** contains the *primary auditory cortex*, which receives auditory information. At the very back of the brain is the **occipital lobe**. The occipital lobe includes the *primary visual cortex*, where visual information is received.

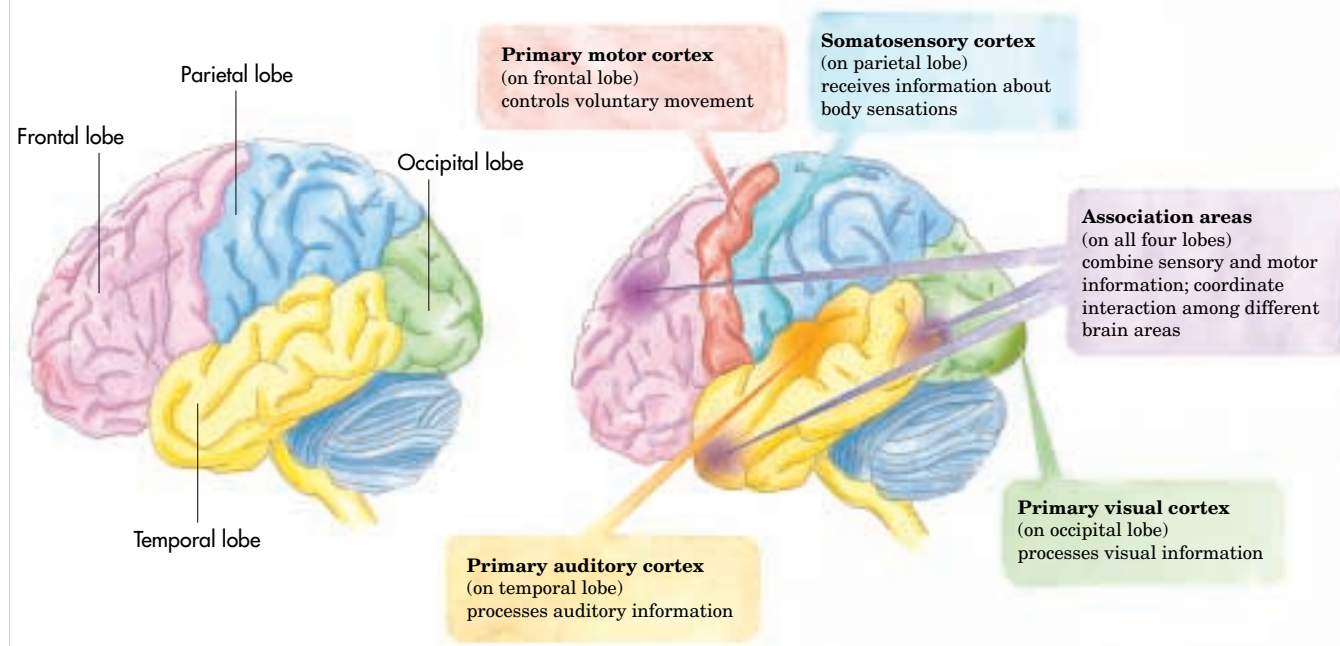
The **parietal lobe** is involved in processing bodily, or *somatosensory*, information, including touch, temperature, pressure, and information from receptors in the muscles and joints. A band of tissue on the parietal lobe, called the *somatosensory cortex*, receives information from touch receptors in different parts of the body.

Each part of the body is represented on the somatosensory cortex, but this representation is not equally distributed. Instead, body parts are represented in proportion to their sensitivity to somatic sensations. For example, your hands and face, which are very responsive to touch, have much greater representation on the somatosensory cortex than do the backs of your legs, which are far less sensitive to touch. If body areas were actually proportional to the amount of representation on the somatosensory cortex, humans would resemble the misshapen character on the right side of Figure 2.18.

The largest lobe of the cerebral cortex, the **frontal lobe**, is involved in planning, initiating, and executing voluntary movements. The movements of different body parts are represented in a band of tissue on the frontal lobe called the *primary motor cortex*. The degree of representation on the primary motor cortex for a particular body part reflects the diversity and precision of its potential movements, as shown



FIGURE 2.17 Lobes of the Cerebral Cortex Each hemisphere of the cerebral cortex can be divided into four regions, or *lobes*. Each lobe is associated with distinct functions. The association areas, shaded in purple, make up most of the cerebral cortex.



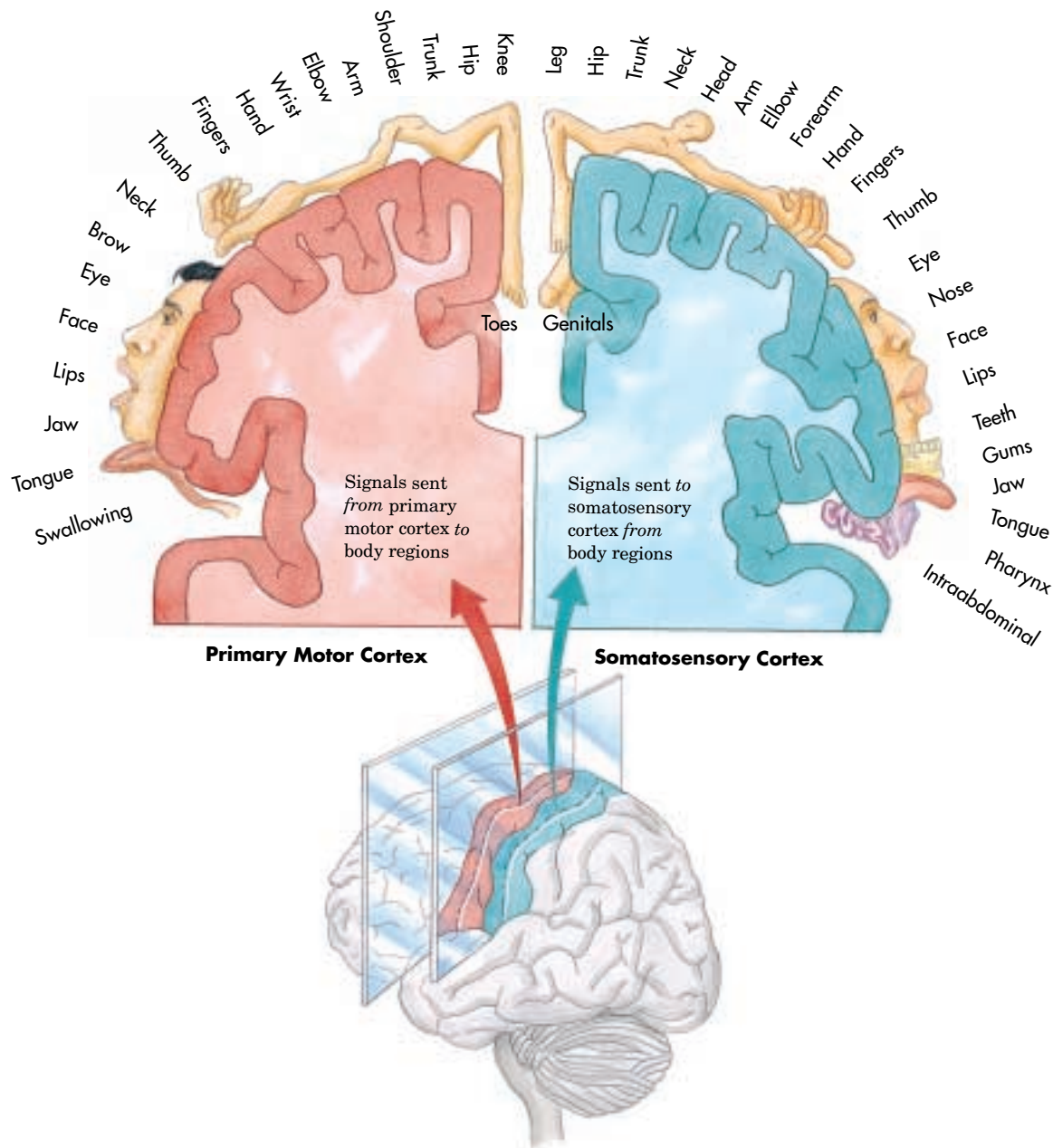


FIGURE 2.18 The Body's Representation on the Primary Motor Cortex and on the Somatosensory Cortex Touch, temperature, pressure, and pain sensations for different areas of the body occur at distinct locations on the parietal lobe's somatosensory cortex. Similarly, the initiation of movement for different parts of the body occurs at distinct locations on the frontal lobe's primary motor cortex. If body parts were proportional to their representation on the somatosensory and primary motor cortex, they would look like the misshapen human figures on the outer edges of the drawing.

on the left side of Figure 2.18. Thus, it's not surprising that almost one-third of the primary motor cortex is devoted to the hands and another third is devoted to facial muscles. The disproportionate representation of these two body areas on the primary motor cortex is reflected in the human capacity to produce an extremely wide range of hand movements and facial expressions.

The primary sensory and motor areas found on the different lobes represent just a small portion of the cerebral cortex. The remaining bulk of the cerebral cortex consists mostly of three large *association areas*. These areas are generally thought to be involved in processing and integrating sensory and motor information. For example, the *prefrontal association cortex*, situated in front of the primary motor cortex, is involved in the planning of voluntary movements. Another association area includes parts of the temporal, parietal, and occipital lobes. This association area is involved in the formation of perceptions and in the integration of perceptions and memories.

frontal lobe

The largest lobe of each cerebral hemisphere; processes voluntary muscle movements and is involved in thinking, planning, and emotional control.

FIGURE 2.19 Key Structures of the Forebrain and Limbic System In the cross-sectional view shown here, you can see the locations and functions of four important subcortical brain structures. In combination, these structures make up the *limbic system*, which regulates emotional control, learning, and memory.

The Limbic System

Beneath the cerebral cortex are several other important forebrain structures, which are components of the **limbic system**. The word *limbic* means “border,” and as you can see in Figure 2.19, the structures that make up the limbic system form a border of sorts around the brainstem. In various combinations, the limbic system structures form complex neural circuits that play critical roles in learning, memory, and emotional control (Squire & Knowlton, 1995).

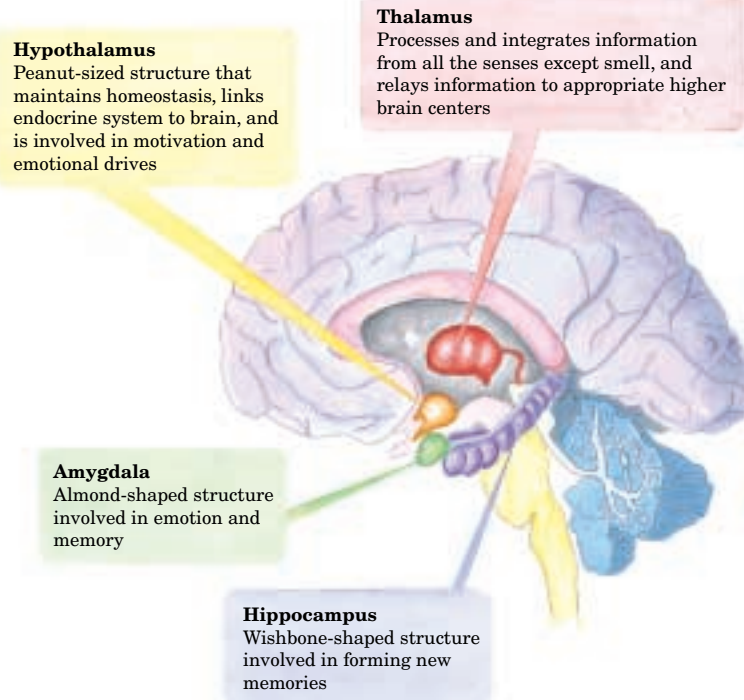
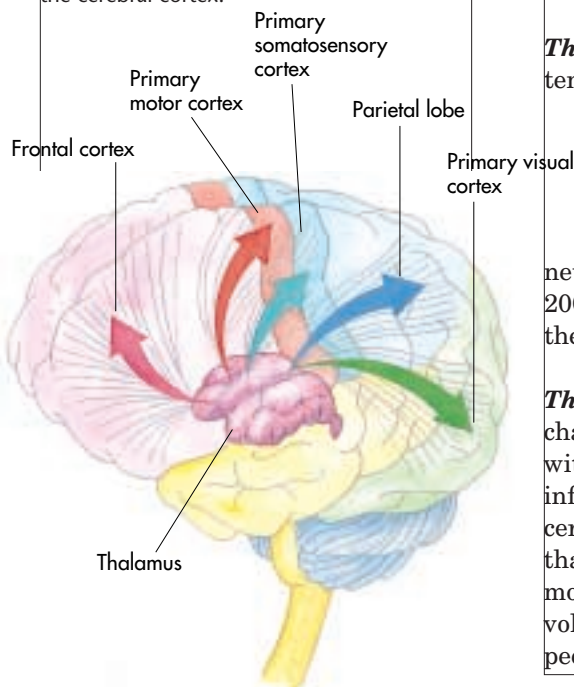


FIGURE 2.20 The Thalamus Almost all sensory and motor information going to and from the cerebral cortex is processed through the thalamus. This figure depicts some of the neural pathways from different regions of the thalamus to specific lobes of the cerebral cortex.



Let's briefly consider some of the key limbic system structures and the roles they play in behavior.

The Hippocampus The **hippocampus** is a large structure embedded in the temporal lobe in each cerebral hemisphere (see Figure 2.19). The word *hippocampus* comes from a Latin word meaning “sea horse.” If you have a vivid imagination, the hippocampus does look a bit like the curved tail of a sea horse. The hippocampus plays an important role in the ability to form new memories of events and information (Gabrieli, 1998). As noted earlier, neurogenesis takes place in the adult hippocampus. The possible role of new neurons in memory formation is an active area of neuroscience research (Gross, 2000; Shors & others, 2001). In Chapter 6, we'll take a closer look at the role of the hippocampus and other brain structures in memory.

The Thalamus The word *thalamus* comes from a Greek word meaning “inner chamber.” And indeed, the **thalamus** is a rounded mass of cell bodies located within each cerebral hemisphere. The thalamus processes and distributes motor information and sensory information (except for smell) going to and from the cerebral cortex. Figure 2.20 depicts some of the neural pathways going from the thalamus to the different lobes of the cerebral cortex. However, the thalamus is more than just a sensory relay station. The thalamus is also thought to be involved in regulating levels of awareness, attention, motivation, and emotional aspects of sensations.

The Hypothalamus *Hypo* means “beneath” or “below.” As its name implies, the **hypothalamus** is located below the thalamus. Although it is only about the size of a peanut, the hypothalamus contains more than forty neural pathways. These neural pathways ascend to other forebrain areas and descend to the midbrain, hindbrain, and spinal cord. The hypothalamus is involved in so many different functions, it is sometimes referred to as “the brain within the brain.”

The hypothalamus regulates both divisions of the autonomic nervous system, increasing and decreasing such functions as heart rate and blood pressure. It also helps regulate a variety of behaviors related to survival, such as eating, drinking, frequency of sexual activity, fear, and aggression. One area of the hypothalamus, called the *suprachiasmatic nucleus* (SCN), plays a key role in regulating daily sleep–wake cycles and other rhythms of the body. We’ll take a closer look at the SCN in Chapter 4.

The hypothalamus exerts considerable control over the secretion of endocrine hormones by directly influencing the pituitary gland. The *pituitary gland* is situated just below the hypothalamus and is attached to it by a short stalk. The hypothalamus produces both neurotransmitters and hormones that directly affect the pituitary gland. As we noted in the section on the endocrine system, the pituitary gland releases hormones that influence the activity of other glands.

The Amygdala The **amygdala** is an almond-shaped clump of neuron cell bodies at the base of the temporal lobe. The amygdala is involved in a variety of emotional response patterns, including fear, anger, and disgust (Aggleton, 1992). Studies with animals have shown that electrical stimulation of the amygdala can produce these emotions. In contrast, destruction of the amygdala reduces or disrupts behaviors that are linked to fear and rage. For example, when their amygdala is destroyed, monkeys lose their fear of natural predators, such as snakes. In humans, electrical stimulation of the amygdala produces feelings of fear and apprehension. The amygdala is also involved in learning and forming memories, especially those with a strong emotional component (Le Doux, 2000; Morris & others, 1998). In Chapter 8, we’ll take a closer look at the amygdala’s role in emotion.

Specialization in the Cerebral Hemispheres

Key Theme

- The two hemispheres of the cerebral cortex are specialized for different tasks, although they have many functions in common.

Key Questions

- How did Broca, Wernicke, and Sperry contribute to our knowledge of the brain?
- What is the corpus callosum, and what happens when it is cut?
- How do the functions of the right and left cerebral hemispheres differ?

If you were to hold a human brain in your hand, the two cerebral hemispheres would appear to be symmetrical. Although the left and right hemispheres are very similar in appearance, they are not identical. Anatomically, one hemisphere may be slightly larger than the other. There are also subtle differences in the sizes of particular structures; in the distribution of gray matter and white matter; and in the patterns of folds, bulges, and grooves that make up the surface of the cerebral cortex.

limbic system

A group of forebrain structures that form a border around the brainstem and are involved in emotion, motivation, learning, and memory.

hippocampus

A curved forebrain structure that is part of the limbic system and is involved in learning and forming new memories.

thalamus

(THAL-uh-muss) A forebrain structure that processes sensory information for all senses, except smell, and relays it to the cerebral cortex.

hypothalamus

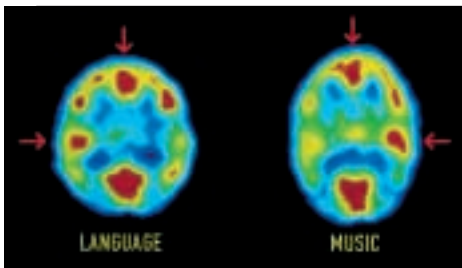
(hi-poe-THAL-uh-muss) A peanut-sized forebrain structure that is part of the limbic system and regulates behaviors related to survival, such as eating, drinking, and sexual activity.

amygdala

(uh-MIG-dull-uh) An almond-shaped forebrain structure that is part of the limbic system and is involved in emotion and memory.

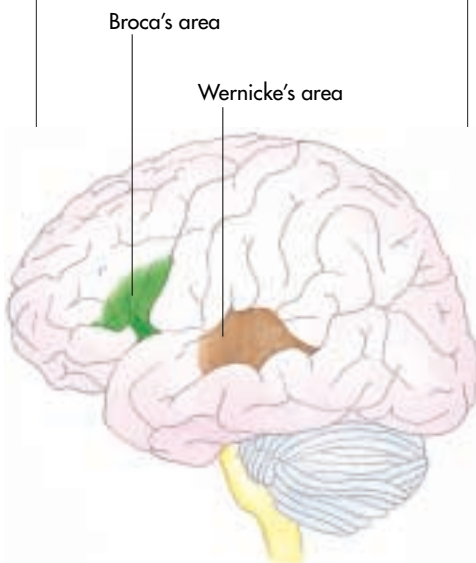
The Corpus Callosum Brain tissue from the top of the brain has been cut away to expose the thick fibers of the corpus callosum, the structure that connects the left and right hemispheres of the brain. As you’ll read in this section, cutting the corpus callosum eliminates the transfer of information between the two hemispheres, with some surprising consequences.





Specialization in the Left and Right Hemispheres The red arrow at the top of each PET scan points to the front of the brain. The red and yellow colors indicate the areas of greatest brain activity. Listening to speech involves a greater degree of activation of the language areas of the left hemisphere. Listening to music involves more activation in right-hemisphere areas. Notice, however, that there is some degree of activation in both hemispheres during these tasks.

FIGURE 2.21 Broca's and Wernicke's Areas of the Cerebral Cortex Broca's area, located in the lower frontal lobe, is involved in the production of speech. Wernicke's area, found in the temporal lobe, is important in the comprehension of written or spoken language. Damage to either of these areas will produce different types of speech disturbances, or aphasia. In most people, both areas are found on the left hemisphere.



What about differences in the functions of the two hemispheres? In many cases, the functioning of the left and right hemispheres is symmetrical, meaning that the same functions are located in roughly the same places on each hemisphere. Examples of such functional symmetry include the primary motor cortex and the somatosensory cortex, which we discussed in the previous section. With regard to other important processes, however, the left and right cerebral hemispheres do differ—each cerebral hemisphere is specialized for particular abilities.

Here's a rough analogy. Imagine two computers that are linked through a network. One computer is optimized for handling word processing, the other for handling graphic design. Although specialized for different functions, the two computers actively share information and can communicate with each other across the network. In this analogy, the two computers correspond to the left and right cerebral hemispheres, and the network that links them is the corpus callosum.

As you'll see in this section, the first discoveries about the differing abilities of the two brain hemispheres were made more than a hundred years ago by two important pioneers in brain research, Pierre Broca and Karl Wernicke.

Language and the Left Hemisphere

The Early Work of Broca and Wernicke

By the end of the 1700s it had already been well established that injury to one side of the brain could produce muscle paralysis or loss of sensation on the opposite side of the body. By the early 1800s, animal experiments had shown that specific functions would be lost if particular brain areas were destroyed. And, as discussed in Box 2.1 on phrenology, scientists were beginning to debate the notion of **cortical localization**—the idea that particular areas of the human brain are associated with particular functions.

In the 1860s, more conclusive evidence for cortical localization was gathered by a French surgeon and neuroanatomist named **Pierre Paul Broca**. Broca treated a series of patients who had great difficulty speaking but could comprehend written or spoken language. Subsequent autopsies of these patients revealed a consistent finding—brain damage to an area on the *lower left frontal lobe*. Today, this area on the left hemisphere is referred to as *Broca's area*, and it is known to play a crucial role in speech production (see Figure 2.21).

About a decade after Broca's discovery, a young German neurologist named **Karl Wernicke** discovered another area in the left hemisphere that, when damaged, produced a different type of language disturbance. Unlike Broca's patients, Wernicke's patients had great difficulty understanding spoken or written communications. They could speak quickly and easily, but their speech sometimes made no sense. They sometimes used meaningless words or even nonsense syllables, though their sentences seemed to be grammatical. In response to the question "How are you feeling?" a patient might say something like, "Don't glow Glover. Yes, uh, ummm, bick, bo chipickers the dallydoo mick more work mittle." Autopsies of these patients' brains revealed consistent damage to an area on the *left temporal lobe* that today is called *Wernicke's area* (see Figure 2.21).

The discoveries of Broca and Wernicke provided the first compelling clinical evidence that language and speech functions are performed primarily by the left cerebral hemisphere. If similar brain damage occurs in the exact same locations on the *right* hemisphere, these severe disruptions in language and speech are usually *not* seen.

The notion that one hemisphere exerts more control over or is more involved in the processing of a particular psychological function is termed **lateralization of function**. Speech and language functions are *lateralized* on the left hemisphere. Generally, the left hemisphere exerts greater control over speech and

language abilities in virtually all right-handed and the majority of left-handed people.

The language disruptions demonstrated by Broca's and Wernicke's patients represent different types of aphasia. **Aphasia** refers to the partial or complete inability to articulate ideas or understand spoken or written language because of brain injury or damage. There are many different types of aphasia. People with *Broca's aphasia* find it difficult or impossible to produce speech, but their comprehension of verbal or written words is relatively unaffected. People with *Wernicke's aphasia* can speak, but they often have trouble finding the correct words and have great difficulty comprehending written or spoken communication. In more severe cases of Wernicke's aphasia, speech can be characterized by nonsensical, meaningless, incoherent words, as in the example given earlier.

At the beginning of this chapter, we described the symptoms experienced by our friend Asha in the weeks before and the months following her stroke. Asha, who is right-handed, experienced the stroke in her left hemisphere. About three days after her stroke, an MRI brain scan showed where the damage had occurred: the left temporal lobe.

Asha experienced many symptoms of Wernicke's aphasia. Talking was difficult, not because Asha couldn't speak, but because she had to stop frequently to search for the right words. Asha was unable to name even simple objects, like the cup on her hospital dinner tray or her doctor's necktie. She recognized the objects but was unable to say what they were. She had great difficulty following a normal conversation and understanding speech, both in English and in her native language, Tulu.

Asha also discovered that she had lost the ability to read. She could see the words on the page, but they seemed to have no meaning. Paul brought some of their Christmas cards to the hospital. Asha recalls, "When I realized I couldn't read the Christmas cards, I thought my life was over. I just lost it. I remember crying and telling the nurse, 'I have a doctorate and I can't read, write, or talk!'"

When we visited Asha in the hospital, we brought her a Christmas present: a portable cassette tape player with headphones and some tapes of relaxing instrumental music. Little did we realize how helpful the music would be for her. One tape was a recording of Native American flute music called *Sky of Dreams*. The music was beautiful and rather unusual, with intricate melodies and unexpected, complex harmonies. Although it was very difficult for Asha to follow normal speech, listening to *Sky of Dreams* was an entirely different experience. As Asha explained:

I tried cranking up the music very high and it soothed me. I could sleep. At the time, the flute music seemed to be just perfectly timed with the way my brain was working. It was tuning out all the other noises so I could focus on just one thing and sleep. So I would play the music over and over again at a very high level. I did that for a long time because my mind was so active and jumbled that I couldn't think.

Asha's language functions were severely disrupted, yet she was able to listen to and appreciate instrumental music—even very complex music. Why? At the end of the next section, we'll offer a possible explanation for what seems to have been a disparity in Asha's cognitive abilities following her stroke.

Cutting the Corpus Callosum

The Split Brain

Since the discoveries by Broca and Wernicke, the most dramatic evidence illustrating the independent functions of the two cerebral hemispheres has come from a surgical procedure called the **split-brain operation**. This operation is used to

cortical localization

The notion that different functions are located or localized in different areas of the brain.

lateralization of function

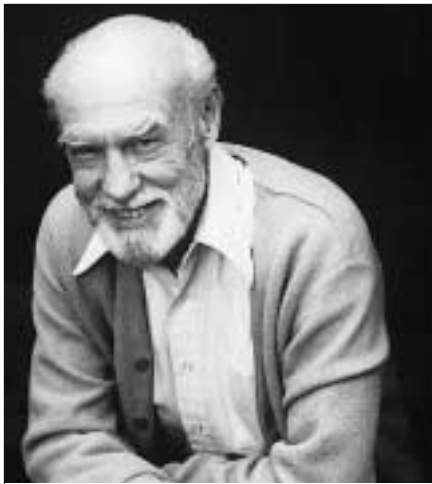
The notion that specific psychological or cognitive functions are processed primarily on one side of the brain.

aphasia

(uh-FAZE-yuh) The partial or complete inability to articulate ideas or understand spoken or written language because of brain injury or damage.

split-brain operation

A surgical procedure that involves cutting the corpus callosum.



Roger Sperry (1913–1994) For his pioneering research using split-brain patients to investigate the relationship between brain and behavior, Sperry received the 1981 Nobel Prize in Physiology or Medicine.

FIGURE 2.22 The Experimental Setup in Split-Brain Research In a typical split-brain experiment, as shown here, the participant focuses his attention on the midpoint of the screen. Notice that he is unable to verbally identify the picture that is flashed to the nonverbal right hemisphere, but he is able to grasp the hammer with his left hand. In contrast, when the image of the apple is flashed to his verbal left hemisphere, he can easily name it.

stop or reduce recurring seizures in severe cases of epilepsy that can't be treated in any other fashion. The procedure involves surgically cutting the corpus callosum, the thick band of axons that connects the two hemispheres.

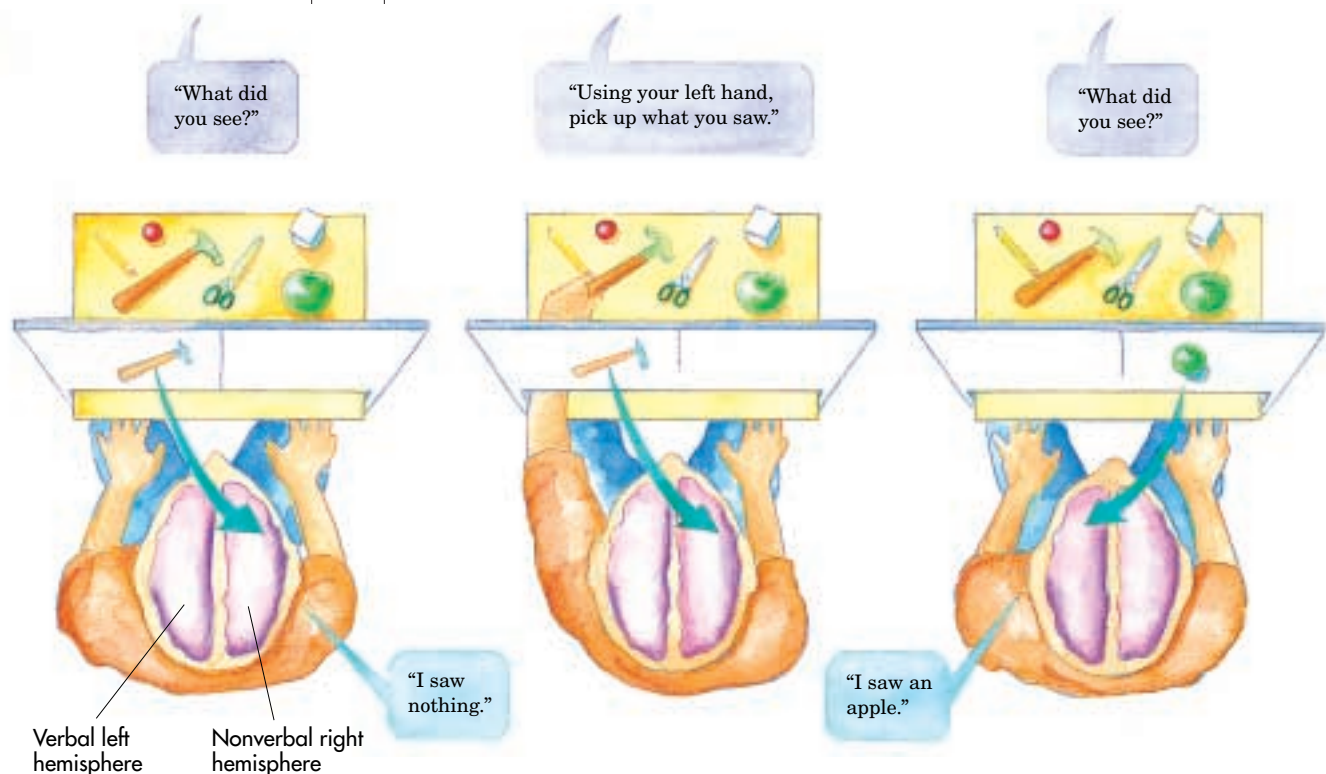
What was the logic behind cutting the corpus callosum? An epileptic seizure typically occurs when neurons begin firing in a disorganized fashion in one region of the brain. The disorganized neuronal firing quickly spreads from one hemisphere to the other via the corpus callosum. If the corpus callosum is cut, seizures should be contained in just one hemisphere, reducing their severity or eliminating them altogether. This is exactly what happened when the split-brain operation was first tried in this country in the 1940s (Springer & Deutsch, 1998).

Surprisingly, cutting the corpus callosum initially seemed to produce no noticeable effect on the patients, other than reducing their epileptic seizures. Their ability to engage in routine conversations and tasks seemed to be unaffected. On the basis of these early observations, some brain researchers speculated that the corpus callosum served no function whatsoever (see Gazzaniga, 1995). One famous psychologist, Karl Lashley, joked that its primary function seemed to be to keep the two hemispheres from sagging (Hoptman & Davidson, 1994).

In the 1960s, however, psychologist and neuroscientist **Roger Sperry** and his colleagues began unraveling the puzzle of the left and right hemispheres. Sperry and his colleagues used the apparatus shown in Figure 2.22 to test the abilities of split-brain patients. They would direct a split-brain subject to focus on a point in the middle of a screen, while briefly flashing a word or picture to the left or right of the midpoint.

In this procedure, visual information to the right of the midpoint is projected to the person's *left* hemisphere, and visual information to the left of the midpoint is projected to the *right* hemisphere. Behind the screen several objects were hidden from the split-brain subject. The subject could reach under a partition below the screen to pick up the concealed objects but could not see them (Sperry, 1982).

In a typical experiment, Sperry projected the image of an object concealed behind the screen, such as a hammer, to the left of the midpoint. Thus, the image of the hammer was sent to the right, nonverbal hemisphere. If a split-brain subject



was asked to *verbally* identify the image flashed on the screen, he could not do so and often denied that anything had appeared on the screen. Why? Because his verbal left hemisphere had no way of knowing the information that had been sent to his right hemisphere. However, if a split-brain subject was asked to use his left hand to reach under the partition for the object that had been displayed, he would correctly pick up the hammer. This was because his left hand was controlled by the same right hemisphere that saw the image of the hammer.

Sperry's experiments reconfirmed the specialized language abilities of the left hemisphere that Broca and Wernicke had discovered more than a hundred years earlier. But notice, even though the split-brain subject's right hemisphere could not express itself verbally, it still processed information and expressed itself *nonverbally*: The subject was able to pick up the correct object.

Over the last four decades, researchers have gained numerous insights about the brain's lateralization of functions by studying split-brain patients, using brain-imaging techniques with normal subjects, and other techniques (Gazzaniga, 1998). On the basis of this evidence, researchers have concluded that—in most people—the left hemisphere is superior in language abilities, speech, reading, and writing.

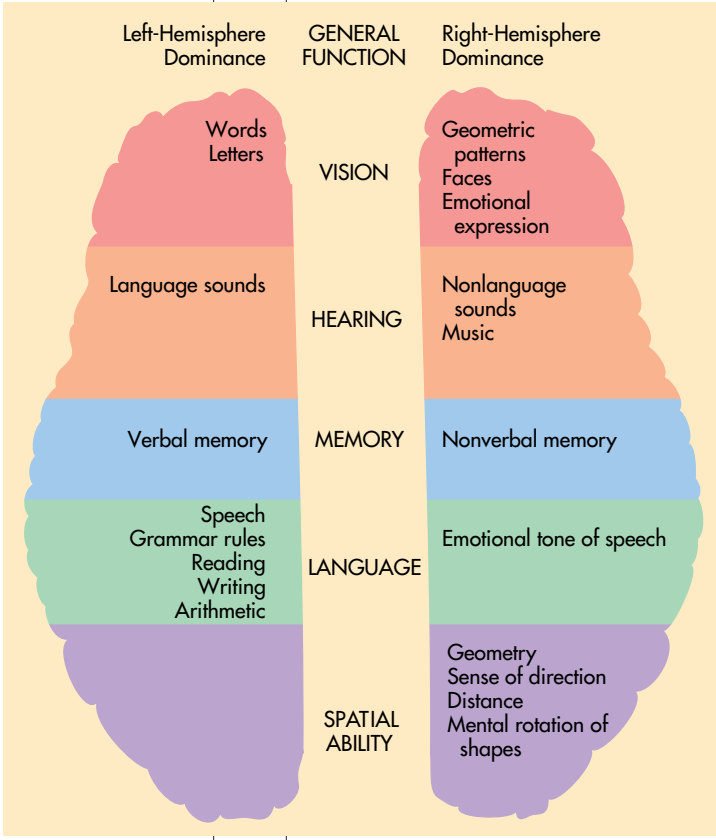
In contrast, the right hemisphere is more involved in nonverbal emotional expression and visual-spatial tasks (Corballis & others, 2002). Deciphering complex visual cues, such as completing a puzzle or manipulating blocks to match a particular design, also relies on right-hemisphere processing (Gazzaniga, 1995). And the right hemisphere excels in recognizing faces and emotional facial cues, reading maps, copying designs, and drawing (Heller & others, 1998; Reuter-Lorenz & Miller, 1998). Finally, the right hemisphere shows a higher degree of specialization for musical appreciation or responsiveness—but not necessarily for musical ability, which involves the use of the left hemisphere as well (Springer & Deutsch, 1998).

Figure 2.23 summarizes the research findings for the different specialized abilities of the two hemispheres for right-handed people. As you look at the figure, it's important to keep two points in mind. First, the differences between the left and right hemispheres are almost always relative differences, *not* absolute differences. In other words, *both* hemispheres of your brain are activated to some extent as you perform virtually any task (Beeman & Chiarello, 1998; Chabris & Kosslyn, 1998). In the normal brain, the left and right hemispheres function in an integrated fashion, constantly exchanging information (Banich, 1998). Thus, Figure 2.23 indicates the hemisphere that typically displays greater activation or exerts greater control over a particular function. Second, many functions of the cerebral hemispheres, such as those involving the primary sensory and motor areas, *are* symmetrical. They are located in the same place and are performed in the same way on both the left and the right hemisphere.

Given the basic findings on the laterality of different functions in the two hemispheres, can you speculate about why Asha was unable to read or follow a simple conversation but could easily concentrate on a complex piece of music? Why were her language abilities so disrupted, while her ability to focus on and appreciate music remained intact after her stroke?

A plausible explanation has to do with the location of the stroke's damage on Asha's left temporal lobe. Because language functions are usually localized on the left hemisphere, the stroke produced serious disruptions in Asha's language abilities. However, her *right* cerebral hemisphere sustained no detectable damage. Because one of the right hemisphere's abilities is the appreciation of musical sounds, Asha retained the ability to concentrate on and appreciate music.

FIGURE 2.23 Specialized Abilities of the Two Hemispheres



2.3

R·E·V·I·E·W

C·O·N·C·E·P·T

The Brain

Fill in the blanks in the following statements.

1. The three major regions of the brain are the _____, _____, and _____.
2. Coordinated muscle movements and balance are regulated by the _____.
3. Auditory information is processed in the _____ lobe.
4. The signals for voluntary movements originate in the _____, which is located on the _____ lobe.
5. The _____ plays a critical role in the formation of new memories.
6. The hypothalamus, hippocampus, amygdala, and parts of the thalamus and frontal cortex make up the _____.
7. Damage to _____ on the brain's left hemisphere disrupts the ability to speak but not the ability to understand spoken or written communication.
8. The _____ is surgically cut in the split-brain operation.
9. About _____ percent of left-handed people are left-hemisphere dominant for language functions.

Asha's Recovery After leaving the hospital, Asha began retraining her brain with speech therapy. Asha's husband, Paul, and her mother, Nalini, helped her with the speech drills. Day after day, Asha repeatedly paired words with objects or identified numbers, weekdays, or months. As Asha recalls, "My mom was a Montessori teacher for many years and she was incredibly patient with me, like she was with her own students and with us as children." As Asha gradually made progress, Nalini began taking her to stores. "She'd tell the clerk I was from India and that my English wasn't very good and ask them to please be patient with me. She basically forced me to talk to the sales clerks." Today, more than three years after the stroke, Asha has completely recovered and resumed teaching.

**Plasticity****The Malleable Brain**

In our exploration of the biological foundations of behavior, we've traveled from the activities of individual neurons to the complex interaction of the billions of neurons that make up the human nervous system, including the brain. Crucial to the development of a scientific understanding of brain functioning were two areas—localization and lateralization.

Phrenology's incorrect interpretation of bumps on the head helped trigger scientific debate on the notion of *localization*—that different functions are localized in different brain areas. The early clinical evidence provided by Broca and Wernicke, and the later split-brain evidence provided by Sperry and his colleagues, confirmed the idea of *lateralization*—that some functions are performed primarily by one cerebral hemisphere.

The ideas of localization and lateralization are complemented by another theme evident in this chapter—*integration*. Despite the high degree of specialization in the human nervous system, the smooth functioning of the nervous system demands an equally high degree of integration and harmony. Your ability to process new information and experiences, your memories of previous experiences, your sense of who you are and what you know, your actions and reactions—all are products of your brain working in harmony with the rest of your nervous system.

The story of Asha's stroke illustrated what can happen when this harmony is disrupted. Your physical survival and conscious experience are mediated by the delicate balance of chemicals and the complex, intricate connections in your nervous system. Asha survived her stroke, but many people who suffer strokes do not. Of those who do survive a stroke, about one-third are left with severe impairments in their ability to function.

What happened to Asha? Fortunately, Asha's story has a happy ending. She was luckier than many stroke victims—she was young, strong, and otherwise healthy. Asha's recovery was also aided by her high level of motivation, willingness to work hard, and sheer will to recover. After being discharged from the hospital, Asha began months of intensive speech therapy. Her speech therapist assigned a great deal of homework that consisted of repeatedly pairing pictures with words, objects with words, and words with objects.

Asha set a very high goal for herself: to return to teaching at the university by the fall semester. With the help of her husband, Paul, and her mother, Nalini, who traveled from India to stay with her for four months, Asha made significant gains.

With remarkable determination, Asha reached the goal she had set for herself. She returned to her teaching and research at the university the following fall semester. Today, more than three years after her stroke, you would be unable to detect any signs of impairment indicating that Asha had sustained significant brain damage.

Asha's story also illustrates the brain's incredible ability to shift functions from damaged to undamaged areas, a phenomenon called **functional plasticity**. Even more astonishing, the uninjured brain has the ability to change and grow throughout life. As researchers have discovered, the brain can literally change its structure in response to the quality of environmental stimulation. In the chapter Application, we'll take a look at how researchers have documented the remarkable **structural plasticity** of which the brain is capable. And you'll learn how you can use the research findings on brain plasticity to enhance your own dendritic potential!

functional plasticity

A phenomenon in which brain functions are shifted from damaged to undamaged brain areas.

structural plasticity

A phenomenon in which brain structures physically change in response to environmental influences.

APPLICATION

Pumping Neurons: Maximizing Your Brain's Potential

Researchers once believed that by early adulthood the brain's physical structure was *hardwired*, or fixed for life. It's now known that the brain's physical structure is sculpted by experience. This phenomenon, called **structural plasticity**, was first demonstrated in the early 1960s in studies with rats (Rosenzweig, 1996).

In these studies, rats were systematically exposed to either an enriched or an impoverished environment at different ages and for varying lengths of time. The enriched environment is spacious, houses several rats, and has assorted wheels, ladders, tunnels, and objects to explore. The environment is also regularly changed for further variety. In the impoverished environment, a solitary rat lives in a small, bare laboratory cage with only a water bottle and food tray to keep it company.

Using this basic design, researchers found that enrichment increases the number and length of dendrites, enlarges the size of neurons, and increases the number of potential connections with other neurons (Johnston & others, 1996). Enrichment also increases the number of glial cells, which manufacture the myelin sheath that increases communication speed between neurons.

Enrichment produces more synaptic connections between brain neurons, whereas



Rats in an Enriched Environment Compared with solitary rats raised in bare laboratory cages, rats raised in groups in an enriched environment, like the one shown here, show significant increases in brain growth and number of synaptic interconnections.

impoverishment decreases synaptic connections. In young rats, enrichment increases the number of synapses in the cortex by as much as 20 percent (Kolb & Whishaw, 1998). With more synapses, the brain has a greater capacity to integrate and process information and to do so more quickly. Collectively, these changes result in increased processing and communication capacity in the brain.

The cerebral cortex, where sophisticated mental functions occur, is the area most strongly affected by enrichment or impoverishment. Structures below the cerebral cortex, such as those in the limbic system, apparently change very little in response to environmental enrichment or impoverishment.

Even the aged brain can change in response to environmental stimulation. Researchers investigated this issue by raising rats in impoverished environments until an age equivalent to that of 75 years in humans. (Ten days of rat life is roughly equivalent to one year of the human life-span.) The rats were then placed in enriched environments until they reached the equivalent of 90 human years of age.

The result? Despite the normal decline expected in the aged brain, the senior-citizen rats showed significant increases in brain growth and synaptic interconnections (Diamond, 1988). In fact, no matter what the age of the rats studied, environmental enrichment or impoverishment had a significant impact on brain structure (Kempermann & others, 1998).

From Animal Studies to Humans

Enrichment studies have been carried out with many other species, including monkeys, cats, birds, honeybees, and even

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fruit flies (Kolb & Whishaw, 1998). In all cases, enriched environments are associated with striking changes in the brain, however primitive. As psychologists Bryan Kolb and Ian Whishaw (1998) observed, “There is little doubt . . . that experience is a major force in shaping the nervous system of all animals.”

Can the conclusions drawn from studies on rats, monkeys, and other animals be applied to human brains? Obviously, researchers cannot directly study the effects of enriched or impoverished environments on human brain tissue as they can with rats. However, psychologists and other researchers have amassed an impressive array of correlational evidence showing that the human brain also seems to benefit from enriched, stimulating environments (Rosenzweig, 1996).

For example, autopsy studies have compared the brains of university graduates with those of high school dropouts. The brains of university graduates had up to 40 percent more synaptic connections than those of high school dropouts (Jacobs & others, 1993). According to UCLA neuroscientist Bob Jacobs (1993), “This is the human equivalent of the animals exposed to enriched environments having smarter brains. As you go up the educational ladder there is a dramatic increase in dendritic material.”

Of course, it’s possible that people with more synapses are also more likely to attend college than are people with fewer synaptic connections. However, the key is not just getting a higher education. University graduates who led mentally unstimulating lives had fewer dendritic connections than did those who remained mentally active throughout their lives.

Another line of evidence comes from studies comparing symptoms of Alzheimer’s disease in elderly individuals with different levels of education (Katzman,

1993; Stern & others, 1992, 1994). Autopsies showed that the more educated individuals had just as much damage to their brain cells as did the poorly educated individuals. However, because the better-educated people had more synaptic connections, their symptoms were much less severe than those experienced by the less-educated people.

Research has shown the importance of a stimulating lifestyle throughout the lifespan. For example, neurologist Robert Friedland and his colleagues (2001) discovered that people who had developed the symptoms of Alzheimer’s disease by the age of 70 were much less active, both physically and intellectually, in early and middle adulthood—long before they developed symptoms of the disease—than healthy seniors who were free of Alzheimer’s symptoms.

Analyzing the life histories of the Alzheimer’s patients and the matched control group of healthy seniors, the researchers discovered that the healthy seniors had spent less time in passive pursuits than the Alzheimer’s patients had. The *best* protection against developing Alzheimer’s? Engaging in intellectually stimulating hobbies, such as reading or playing a musical instrument, or taking up creative hobbies, such as woodworking or knitting. Solving puzzles and playing mind-challenging games like chess or board games were other intellectual activities that predicted a cognitively healthy old age. But there was *one* activity that the Alzheimer’s patients had engaged in more than their healthy counterparts had: The Alzheimer’s patients had spent a lot more time watching television.

The results of this study echo earlier research on intellectual enrichment: A mentally stimulating, intellectually challenging environment is associated with enhanced cognitive functioning. Just as

physical activity strengthens the heart and muscles, mental activity strengthens the brain. Even in late adulthood, remaining mentally active can help prevent or lessen mental decline (Inouye & others, 1993; White & others, 1994).

More generally, the results of the enrichment research have fundamentally changed our understanding of the brain. As Kolb and Whishaw (1998) conclude, “Experience alters the synaptic organization of the brain in species as diverse as fruit flies and humans.”

Pumping Neurons: Exercising Your Brain

So, here’s the critical question: Are you a mental athlete—or a cerebral couch potato? Whatever your age, there seems to be a simple prescription for keeping your brain fit. According to neuroscientist Arnold Scheibel (1994), “The important thing is to be actively involved in areas unfamiliar to you. Anything that’s intellectually challenging can probably serve as a kind of stimulus for dendritic growth, which means it adds to the computational reserves in your brain.” In short, you must actively exercise your brain cells. Try the new and unfamiliar. Here are just a few suggestions:

- If you are a “number” or “word” person, sign up for an art class.
- If you are a “math” or “spatial” person, start a personal journal or take a creative writing class.
- Unplug your television set for two weeks—or longer.
- Go to the library and browse until you find at least three books that spark your interest. Check them out and read them.
- Try all kinds of puzzles—word, visual, matching, and maze puzzles.
- Attend a play, an art exhibit, or a performance of classical or jazz music.
- Go to a museum.
- Read or reread a classic work of fiction or poetry.
- Pick a topic that interests you, log onto the Internet, and follow the links to other Web sites.
- Sign up for a class on a subject that you want to know more about.

Better yet, take a few minutes and generate your own list of mind-expanding opportunities!

Chapter Review

Neuroscience and Behavior

Key Points

Introduction: Neuroscience and Behavior

- Psychological and biological processes are closely linked. **Biological psychologists** investigate the physical processes that underlie psychological experience and behavior. **Neuroscience** is the study of the nervous system, especially the brain.

The Neuron: The Basic Unit of Communication

- Information in the nervous system is transmitted via cells specialized for communication, called **neurons**. **Glial cells** help neurons by providing nutrition, removing waste products, and producing the **myelin sheath**. There are three basic types of neurons: **sensory neurons**, **motor neurons**, and **interneurons**.
- Most neurons have three basic components: a **cell body**, **dendrites**, and an **axon**. The axons of some neurons are wrapped in a myelin sheath, which speeds the rate at which neural messages are sent.
- Within the neuron, information is communicated in the form of brief electrical messages called **action potentials**. The minimum level of stimulation required to activate a neuron is called the **stimulus threshold**. A neuron's **resting potential** is the state in which it is ready to activate and communicate its message, if sufficiently stimulated. According to the **all-or-none law**, either a neuron is sufficiently stimulated and an action potential results, or it isn't sufficiently stimulated and an action potential doesn't occur.
- The point of communication between two neurons is called the **synapse**. Neurons communicate information to other neurons either electrically or chemically. In chemical communication, **neurotransmitters** cross the **synaptic gap** and affect neighboring neurons. These neurotransmitters are held within **synaptic vesicles**, which float in **axon terminals**. The entire process of transmitting information at the synapse is called **synaptic transmission**. **Reuptake** is the process in which neurotransmitter molecules detach from the receptor and are reabsorbed and recycled. There are many different kinds of neurotransmitters, which send either excitatory or inhibitory messages to the receiving neuron. Some drugs influence behavior and mental processes by influencing neurotransmitter activity. Important neurotransmitters include **acetylcholine**, **dopamine**, **serotonin**, **norepinephrine**, **GABA**, and **endorphins**.

The Nervous System and the Endocrine System: Communication Throughout the Body

- The **nervous system** is divided into two main divisions: the **central nervous system** and the **peripheral nervous system**. The central nervous system is composed of

the brain and the spinal cord. The spinal cord can produce **spinal reflexes**.

- The peripheral nervous system consists of all the **nerves** outside the central nervous system. The two main subdivisions of the peripheral nervous system are the **somatic nervous system** and the **autonomic nervous system**. The autonomic nervous system is divided into the **sympathetic nervous system** and the **parasympathetic nervous system**.
- The **endocrine system** is composed of glands that secrete **hormones** into the bloodstream, regulating many body functions, including physical growth, stress response, and sexual development. The endocrine system itself is regulated by the hypothalamus in the brain. Under the direction of the hypothalamus, the **pituitary gland** directly controls hormone production in other endocrine glands as well as hormones that act on physical processes. Another set of glands, called the **adrenal glands**, which include the **adrenal cortex** and the **adrenal medulla**, produce hormones that are involved in the human stress response. The **gonads** are endocrine glands that secrete hormones that regulate sexual characteristics and reproductive processes.

A Guided Tour of the Brain

- Most psychological processes involve the integrated processing of information via neural pathways in multiple brain structures and regions.
- Case studies of individuals with brain damage or injury have provided information about the brain's function. Researchers have also observed the behavioral effects of surgically altering or electrically stimulating a specific area of the brain. The **electroencephalograph** records the brain's electrical activity. **MRI** scanners use magnetic signals to produce highly detailed images of the brain's structures. **PET** scans use radioactive substances to produce color-coded images of the brain's activity. **Functional MRI** scans track the brain's activity by measuring changes in blood flow in brain areas.
- During prenatal development, the human brain begins as a fluid-filled neural tube, which ultimately forms the three key brain regions: the hindbrain, midbrain, and forebrain. Evidence now suggests that **neurogenesis**, the development of new neurons, can occur in the adult brain.
- Combined, the hindbrain and midbrain structures constitute the **brainstem**. Sensory and motor pathways cross over in the **hindbrain**. The key structures of the hindbrain are the **medulla**, the **cerebellum**, and the **pons**. The **reticular formation** is located in the core of the medulla and the pons.
- Auditory and visual information is integrated and coordinated in the midbrain. The **substantia nigra** is involved

- in motor control and contains a concentration of neurons that produce dopamine.
- The outer portion of the **forebrain** is called the **cerebral cortex**. The cerebral cortex is divided into the left and right **cerebral hemispheres**, with the **corpus callosum** serving as the main communication link between them. Each hemisphere is divided into four lobes. The **temporal lobe** contains the primary auditory cortex. The **occipital lobe** contains the primary visual cortex. The **parietal lobe** contains the somatosensory cortex. The **frontal lobe** contains the primary motor cortex. The remainder of the cerebral cortex is composed of association areas.
 - The **limbic system** structures are found beneath the cerebral cortex and form neural circuits that play critical roles in learning, memory, and emotional control. The limbic system includes part of the frontal cortex and the **hippocampus**, **thalamus**, **hypothalamus**, and **amygdala**.

Specialization in the Cerebral Hemispheres

- The notion that particular areas of the brain are associated with particular functions is called **cortical localization**. In the mid-1800s, it was discovered that damage to the left hemisphere produced disruptions in speech and language called **aphasia**. Different forms of aphasia include Broca’s aphasia and Wernicke’s aphasia. Damage to the same areas of the right hemisphere did not produce aphasia. The notion that specific psychological or cognitive functions are processed primarily on one side of the brain is called **lateralization of function**.
- More evidence for the specialized abilities of the two hemispheres has resulted from the **split-brain operation**, in which the corpus callosum connecting the two hemispheres is cut. Roger Sperry and his colleagues demonstrated the different strengths of each hemisphere in split-brain patients. The left hemisphere is specialized for language tasks, and the right hemisphere is specialized for visual-spatial tasks.

Key Terms

biological psychology, p. 42
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glial cells, p. 43
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split-brain operation, p. 73
functional plasticity, p. 77
structural plasticity, p. 77

Key People

<p>Pierre Paul Broca (1824–1880) French surgeon and neuroanatomist who in 1861 discovered an area on the lower left frontal lobe of the cerebral cortex that, when damaged, produces speech disturbances but no loss of comprehension. (p. 72)</p> <p>Roger Sperry (1913–1994) American psychologist who received the Nobel Prize in 1981 for his pioneering research on brain specialization in split-brain patients. (p. 74)</p>	<p>Karl Wernicke (1848–1905) German neurologist who in 1874 discovered an area on the left temporal lobe of the cerebral cortex that, when damaged, produces meaningless or nonsensical speech and difficulties in verbal or written comprehension. (p. 72)</p>
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Concept Review Answers

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| <p>2.1 page 52</p> <p>1. b 2. f 3. a 4. c 5. e 6. d</p> <p>2.2 page 58</p> <p>1. c 2. b 3. d 4. d 5. a</p> | <p>2.3 page 76</p> <table><tr><td>1. hindbrain; midbrain; forebrain</td><td>6. limbic system</td></tr><tr><td>2. cerebellum</td><td>7. Broca’s area</td></tr><tr><td>3. temporal</td><td>8. corpus callosum</td></tr><tr><td>4. primary motor cortex; frontal</td><td>9. 70</td></tr><tr><td>5. hippocampus</td><td></td></tr></table> | 1. hindbrain; midbrain; forebrain | 6. limbic system | 2. cerebellum | 7. Broca’s area | 3. temporal | 8. corpus callosum | 4. primary motor cortex; frontal | 9. 70 | 5. hippocampus | |
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| 2. cerebellum | 7. Broca’s area | | | | | | | | | | |
| 3. temporal | 8. corpus callosum | | | | | | | | | | |
| 4. primary motor cortex; frontal | 9. 70 | | | | | | | | | | |
| 5. hippocampus | | | | | | | | | | | |

Web Companion

Review Activities

You can find additional review activities at www.worthpublishers.com/hockenbury. The *Discovering Psychology* 3e Web Companion has a self-scoring practice quiz, flashcards, two interactive crossword puzzles, and other activities to help you master the material in this chapter.

3CO

chapter

Sensation and Perception

3

Prologue

Don't Ask These Guys to Stop and Smell the Roses

We have two good friends, quite dissimilar in most ways, who share one common characteristic—they have no sense of smell. Paul is an electrical engineer in his early thirties. Warren is a well-known professor of psychology some 20 years older. Although you might expect this condition to be extremely rare, the inability to smell, called *anosmia*, is relatively common, occurring in about 1 in 500 people (Doty, 2001).

Paul was born without a sense of smell. But he was completely unaware that he lacked this ability until he was about 10 years old. Paul's mother asked him to smell an arrangement of freshly cut flowers, but the puzzled child couldn't detect a thing. Because Paul has never experienced smell, it's impossible for him to imagine what a smell smells like. Friends have tried to describe the aroma of garlic, flowers, burning leaves, and so forth. But it's almost impossible to describe one smell without relating it to another. Try it, and you'll see what we mean. How would you describe the smell of steaks barbecuing? A new car? A locker room? Sour milk?

As you'll discover in this chapter, the senses of taste and smell are closely related, and the flavor of a food is strongly tied to its aroma. That's part of the reason that food often tastes bland, or cardboardy, when you have a bad head cold. What does food taste like for Paul? Paul is married to Asha, whom you met in Chapter 2. Asha cooks some wonderfully spicy Indian meals. Asha has discovered that Paul bases many of his food preferences on the *texture* of foods rather than on their flavor. For example, Paul dislikes noodles because their texture seems "slimy" to him. He also dislikes the sensation of certain textures combined, such as nuts in ice cream or brownies. Other foods, like chocolate, have no taste at all.

Unlike Paul, Warren knows what he's missing. Warren was born with a normal sense of smell. Then, as a young man, he underwent major surgery to repair an artery at the front of his brain. To get to the artery, the surgeon cut through the neural tract for smell, destroying Warren's sense of smell.

For several days following the surgery, Warren's eyes were swollen shut. Deprived of both visual and odor cues, he was unable to identify many of the foods he was fed. For example, he couldn't tell the difference among strawberry, chocolate, and vanilla pudding—they all tasted the same to him. And, like Paul, Warren found

Chapter Outline

Prologue: Don't Ask These Guys to Stop and Smell the Roses

Introduction: What Are Sensation and Perception?

Box 3.1: Subliminal Perception

Vision: From Light to Sight
Focus on Neuroscience: Watching the Brain Watch Objects

Hearing: From Vibration to Sound

The Chemical and Body Senses: Smell, Taste, Touch, and Position
Box 3.2: Do Pheromones Influence Human Behavior?

Perception
Box 3.3: ESP: Can Perception Occur Without Sensation?

Perceptual Illusions

The Effects of Experience on Perceptual Interpretations
Box 3.4: Culture and the Müller-Lyer Illusion: The Carpentered-World Hypothesis

APPLICATION: Strategies to Control Pain

Chapter Review

that the texture of different foods became much more significant. For example, peanut butter now tasted like “oily sand” to Warren.

The experience of taste was very different for Warren following the surgery. He experimented with familiar as well as new and unusual foods to see how they would taste. As time went on, Warren learned to compensate for the missing sense of smell—at least for its role in taste. Now, many years later, Warren has become accustomed to the way foods taste in the absence of aromas.

In this chapter, we’ll explore how we sense the world around us and how the brain integrates and interprets those sensory signals to form meaningful perceptions. We’ll also tell you more about our friends Paul and Warren.

Introduction

What Are Sensation and Perception?

Glance around you. Notice the incredible variety of colors, shades, shadows, and images. Listen carefully to the diversity of sounds, loud and soft, near and far. Focus on everything that’s touching you—your clothes, your shoes, the chair you’re sitting on. Now, inhale deeply through your nose and identify the aromas in the air.

With these simple observations you have exercised four of your senses: vision, hearing, touch, and smell. As we saw in Chapter 2, the primary function of the nervous system is communication—the transmission of information from one part of the body to the other. Where does that information come from? Put simply, your senses are the gateway through which your brain receives all its information about the environment. It’s a process that is so natural and automatic that we typically take it for granted until it is disrupted by illness or injury. Nevertheless, as the stories of Paul and Warren demonstrate, people with one non-functional sense are amazingly adaptive. Often, they learn to compensate for the missing environmental information by relying on their other senses.

In this chapter, we will explore the overlapping processes of *sensation* and *perception*. **Sensation** refers to the detection and basic sensory experience of environmental stimuli, such as sounds, objects, and odors. **Perception** occurs when we integrate, organize, and interpret sensory information in a way that is meaningful. Here’s a simple example to contrast the two terms. Your eyes’ physical response to light, splotches of color, and lines reflects *sensation*. Integrating and organizing

those sensations so that you interpret the light, splotches of color, and lines as a painting, a flag, or some other object reflects *perception*.

Where does the process of sensation leave off and the process of perception begin? There is no clear boundary line between the two processes as we actually experience them. In fact, many researchers in this area of psychology regard sensation and perception as a single process.

Although the two processes overlap, in this chapter we will present sensation and perception as separate discussions. In the first half of the chapter, we’ll discuss the basics of *sensation*—how our sensory receptors respond to stimulation and transmit that information in usable form to the brain. In the second half of the chapter, we’ll explore *perception*—how the brain actively organizes and interprets the signals sent from our sensory receptors.

Experiencing the World Through

Our Senses Imagine biting into a crisp, red apple. All your senses are involved in your experience—vision, smell, taste, hearing, and touch. Although we’re accustomed to thinking of our different senses as being quite distinct, all forms of sensation involve the stimulation of specialized cells called sensory receptors.



Basic Principles of Sensation

Key Theme

- Sensation is the result of neural impulses transmitted to the brain from sensory receptors that have been stimulated by physical energy from the external environment.

Key Questions

- What is the process of transduction?
- What is a sensory threshold, and what are two main types of sensory threshold?
- How do sensory adaptation and Weber's law demonstrate that sensation is relative rather than absolute?

We're accustomed to thinking of the senses as being quite different from one another. However, all our senses involve some common processes. All sensation is a result of the stimulation of specialized cells, called **sensory receptors**, by some form of *energy*.

Imagine biting into a crisp, red apple. Your experience of hearing the apple crunch is a response to the physical energy of vibrations in the air, or *sound waves*. The sweet taste of the apple is a response to the physical energy of *dissolvable chemicals* in your mouth, just as the distinctive sharp aroma of the apple is a response to *airborne chemical molecules* that you inhale through your nose. The smooth feel of the apple's skin is a response to the *pressure* of the apple against your hand. And the mellow red color of the apple is a response to the physical energy of *light waves* reflecting from the irregularly shaped object you've just bitten into.

Sensory receptors convert these different forms of physical energy into electrical impulses that are transmitted via neurons to the brain. The process by which a form of physical energy is converted into a coded neural signal that can be processed by the nervous system is called **transduction**. These neural signals are sent to the brain, where the perceptual processes of organizing and interpreting the coded messages occur. In Figure 3.1, you can see the basic steps involved in sensation and perception.

We are constantly being bombarded by many different forms of energy. For instance, at this very moment radio and television waves are bouncing around the atmosphere and passing through your body. However, sensory receptors are so highly specialized that they are sensitive only to very specific types of energy

sensation

The process of detecting a physical stimulus, such as light, sound, heat, or pressure.

perception

The process of integrating, organizing, and interpreting sensations.

sensory receptors

Specialized cells unique to each sense organ that respond to a particular form of sensory stimulation.

transduction

The process by which a form of physical energy is converted into a coded neural signal that can be processed by the nervous system.

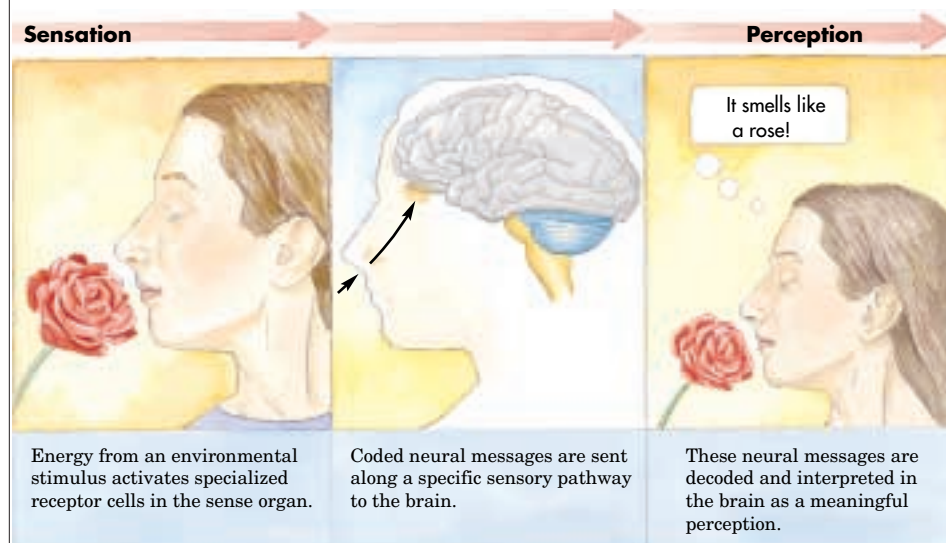


FIGURE 3.1 The Basic Steps of Sensation and Perception

absolute threshold

The smallest possible strength of a stimulus that can be detected half the time.

difference threshold

The smallest possible difference between two stimuli that can be detected half the time; also called *just noticeable difference*.

Weber's law

(VAY-berz) A principle of sensation that holds that the size of the just noticeable difference will vary depending on its relation to the strength of the original stimulus.

Psychologist Eugene Galanter (1962) provided these classic examples of the absolute thresholds for our senses. In each case, people are able to sense these faint stimuli at least half the time.

(which is lucky, or you might be seeing *I Love Lucy* reruns in your brain right now). So, for any type of stimulation to be sensed, the stimulus energy must first be in a form that can be detected by our sensory receptor cells. Otherwise, transduction cannot occur.

Sensory Thresholds

Along with being specialized as to the types of energy that can be detected, our senses are specialized in other ways as well. We do not have an infinite capacity to detect all levels of energy. To be sensed, a stimulus must first be strong enough to be detected—loud enough to be heard, concentrated enough to be smelled, bright enough to be seen. The point at which a stimulus is strong enough to be detected because it activates a sensory receptor cell is called a *threshold*. There are two general kinds of sensory thresholds for each sense—the absolute threshold and the difference threshold.

The **absolute threshold** refers to the smallest possible strength of a stimulus that can be detected half the time. Why just half the time? Because the minimum level of stimulation that can be detected varies from person to person and from trial to trial. Because of this human variability, researchers have arbitrarily set the limit as the minimum level of stimulation that can be detected half the time. Under ideal conditions (which rarely occur in normal daily life), our sensory abilities are far more sensitive than you might think (see Table 3.1). Can stimuli that are below the absolute threshold affect us? We discuss this question in Science versus Pseudoscience Box 3.1, “Subliminal Perception.”

The other important threshold involves detecting the *difference* between two stimuli. The **difference threshold** is the smallest possible difference between two stimuli that can be detected half the time. Another term for the difference threshold is *just noticeable difference*, which is abbreviated *jnd*.

The just noticeable difference will vary depending on its relation to the original stimulus. This principle of sensation is called *Weber's law*, after the German physiologist Ernst Weber (1795–1878). **Weber's law** holds that for each sense, the size of a just noticeable difference is a constant proportion of the size of the initial stimulus. So, whether we can detect a change in the strength of a stimulus depends on the intensity of the *original* stimulus. For example, if you are holding

a pebble (the original stimulus), you will notice an increase in weight if a second pebble is placed in your hand. But if you start off holding a very heavy rock (the original stimulus), you probably won't detect an increase in weight when the same pebble is balanced on it.

What Weber's law underscores is that our psychological experience of sensation is *relative*. There is no simple, one-to-one correspondence between the objective characteristics of a physical stimulus, such as the weight of a pebble, and our psychological experience of it.

Sensory Adaptation

Suppose your best friend has invited you over for a spaghetti dinner. As you walk in the front door, you're almost overwhelmed by the odor of onions and garlic cooking on the stove. However, after just a few moments, you no longer notice the smell. Why? Because your sensory receptor cells become less responsive to a

Table 3.1

Absolute Thresholds

Sense	Absolute Threshold
Vision	A candle flame seen from 30 miles away on a clear, dark night
Hearing	The tick of a watch at 20 feet
Taste	One teaspoon of sugar in two gallons of water
Smell	One drop of perfume throughout a three-room apartment
Touch	A bee's wing falling on your cheek from a height of about half an inch

ls __
le __
ll __

SCIENCE VERSUS PSEUDOSCIENCE 3.1

Subliminal Perception

During the U.S. presidential election campaign of 2000, one political party (let's call them the "Democrats") accused the other political party (let's call them the "Republicans") of using subliminal techniques in a political ad. When the ad was played at slower-than-normal speed, the word "RATS" appeared in large white letters while the announcer criticized candidate Al Gore's prescription drug plan as one in which "bureaucrats decide." Democrats accused the Republicans of embedding a subliminal message in their ad, Republicans denied the accusation, and the firm that created the advertisement claimed that it was just a coincidence.

What are subliminal messages? Can they be used to persuade people to change their attitudes or buy products? **Subliminal perception** refers to the perception of stimuli that are below the threshold of conscious perception or awareness. (The word *limen* is Latin for "threshold.") Subliminal stimuli could be sounds presented too faintly for a person to consciously hear or visual images presented too rapidly for a person to consciously recognize.

Psychologists have studied subliminal perception for more than 60 years (e.g., Collier, 1940; A. C. Williams, 1938). But the idea that people's behavior could be manipulated by subliminal messages first attracted public attention in 1957. James Vicary, a marketing executive, claimed to have increased popcorn and Coca-Cola sales at a New Jersey movie theater by subliminally flashing the words "Eat popcorn" and "Drink Coke" during the movie.

Controlled tests, however, failed to replicate Vicary's claims (Bornstein, 1989). Vicary later admitted that his boast was a hoax to drum up customers for his failing marketing business (Pratkanis, 1992). Nevertheless, some people still believe that subliminal messages can exert a powerful and irresistible influence.



Subliminal Advertising in Politics In the original campaign ad, the words "RATS" appeared in large white letters, superimposed over the words "The Gore Prescription Plan." In a fraction of a second, "RATS" disappeared and the words "BUREAUCRATS DECIDE" appeared in smaller letters. If you were aware of the word's presence, you might have been able to spot it when the ad played at normal speed, but most viewers couldn't detect it.

Can your behavior be profoundly influenced by subliminal self-help tapes? By backward soundtracks on music albums? Or by vague sexual images or words embedded in advertisements? In a word, no. Numerous studies have shown that subliminal self-help tapes do *not* produce the changes they claim to produce (e.g., Greenwald & others, 1991). Studies of backward soundtracks show that they have *no* effect (Begg & others, 1993; Swart & Morgan, 1992). And numerous studies on subliminal messages in advertising have shown that they do *not* influence consumer decisions (Trappey, 1996).

So, do subliminal stimuli have *any* effect? Surprisingly, the answer is a qualified yes (Epley & others, 1999; Bargh & Churchland, 1999). For example, in a 1959 study, Morris Eagle flashed subliminal images of a boy either angrily throwing a birthday cake or pleasantly

presenting a birthday cake. When subjects were shown a picture of the same boy in a neutral posture, those who had been exposed to the angry image evaluated the boy's personality in much more negative terms than did those who had seen the pleasant image of the same boy. A more recent experiment showed that subliminally presenting subjects with a pleasant scene (cute kittens) or with an unpleasant scene (a skull) can influence how they judge a person shown in a neutral context (Krosnick & others, 1992).

Another area of research in subliminal perception involves a phenomenon called the mere exposure effect. The *mere exposure effect* refers to the fact that when people are repeatedly exposed to a novel stimulus, like a shape or a Chinese ideograph, their liking for that particular stimulus will increase (Zajonc, 2001). The mere exposure effect also holds true for subliminal exposure to stimuli (Bornstein, 1993; Murphy & others, 1995). For example, when people are exposed to a subliminal image of a geometric shape and later asked to pick the shape they prefer from a group of geometric shapes, they are more likely to choose the subliminally presented shape.

Today it is known that emotions, thoughts, and attitudes can be influenced by subliminal stimuli (Merikle & Daneman, 1998; Katkin & others, 2001). However, note that there is a difference between subliminal *perception* and subliminal *persuasion* (Epley & others, 1999). There is *no* evidence that subliminally presented stimuli can change behavior or personality in any long-lasting or significant way.

Rather, psychologists have found that the effects of subliminal stimuli tend to be weak and short-lived, usually lasting only seconds or minutes (Greenwald, 1992; Kihlstrom, 1993).

constant stimulus. This gradual decline in sensitivity to a constant stimulus is called **sensory adaptation**. Once again, we see that our experience of sensation is relative—in this case, relative to the *duration of exposure*.

Because of sensory adaptation, we become accustomed to constant stimuli, which allows us to quickly notice new or changing stimuli. This makes sense. If we were continually aware of all incoming stimuli, we'd be so overwhelmed with sensory information that we wouldn't be able to focus our attention. So, for example, once you manage to land your posterior on the sofa, you don't need to be constantly reminded that the sofa is beneath you.

sensory adaptation

The decline in sensitivity to a constant stimulus.

subliminal perception

The perception of stimuli that are below the threshold of conscious awareness.

wavelength

The distance from one wave peak to another.

cornea

(CORE-nee-uh) A clear membrane covering the visible part of the eye that helps gather and direct incoming light.

pupil

The opening in the middle of the iris that changes size to let in different amounts of light.

iris

(EYE-riss) The colored part of the eye, which is the muscle that controls the size of the pupil.

lens

A transparent structure located behind the pupil that actively focuses, or bends, light as it enters the eye.

accommodation

The process by which the lens changes shape to focus incoming light so that it falls on the retina.

Vision

From Light to Sight

Key Theme

- The receptor cells for vision respond to the physical energy of light waves and are located in the retina of the eye.

Key Questions

- What is the visible spectrum?
- What are the key structures of the eye and their functions?
- What are rods and cones, and how do their functions differ?

A lone caterpillar on the screen door, the pile of dirty laundry in the closet corner, a spectacular autumn sunset, the intricate play of color, light, and texture in a painting by Monet. The sense organ for vision is the eye, which contains receptor cells that are sensitive to the physical energy of *light*. Before we can talk about how the eye functions, we need to briefly discuss some characteristics of light as the visual stimulus.

What We See

The Nature of Light

Light is just one of many different kinds of electromagnetic energy that travel in the form of waves. Other forms of electromagnetic energy include X-rays, the microwaves you use to bake a potato, and the ultraviolet rays that give you a sunburn. The various types of electromagnetic energy differ in **wavelength**, which is the distance from one wave peak to another. Figure 3.2 shows the spectrum of different forms of electromagnetic energy.

Humans are capable of visually detecting only a minuscule portion of the electromagnetic energy range. In Figure 3.2, notice that the visible portion of the electromagnetic energy spectrum can be further divided into different wavelengths. As we'll discuss in more detail later, the different wavelengths of visible light correspond to our psychological perception of different colors.

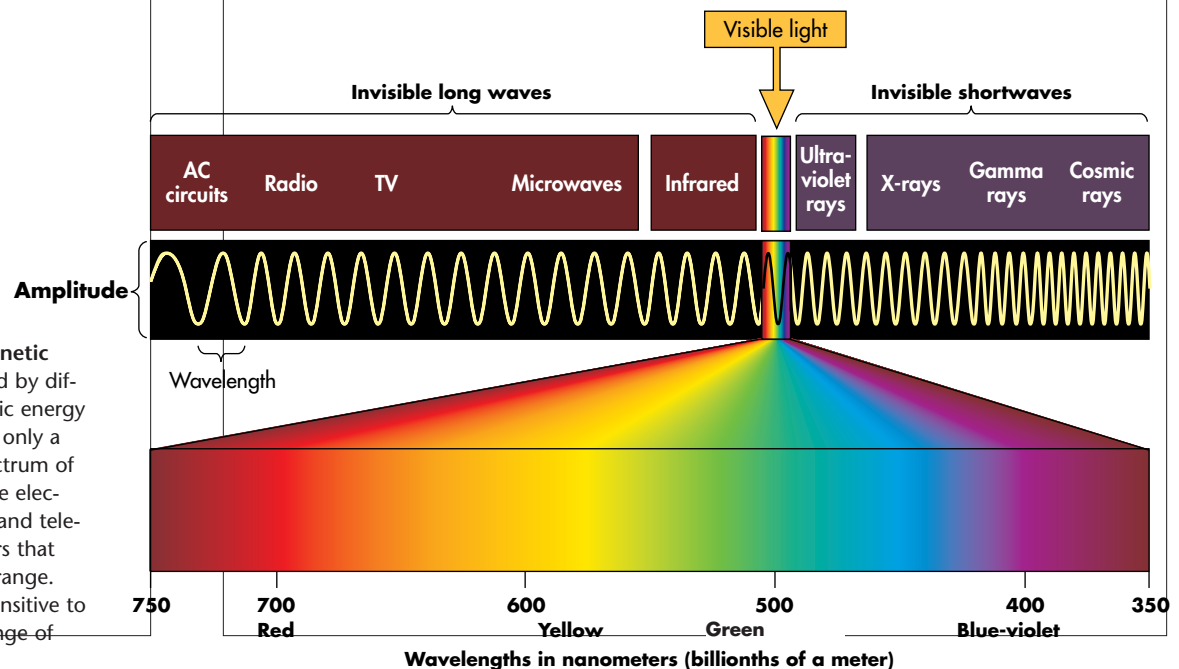


FIGURE 3.2 The Electromagnetic Spectrum We are surrounded by different kinds of electromagnetic energy waves, yet we are able to see only a tiny portion of the entire spectrum of electromagnetic energy. Some electronic instruments, like radio and television, are specialized receivers that detect a specific wavelength range. Similarly, the human eye is sensitive to a specific and very narrow range of wavelengths.

How We See

The Human Visual System

Suppose you're watching your neighbor's yellow and white tabby cat sunning himself on the front steps. How do you see the cat? Simply seeing a yellow tabby cat involves a complex chain of events. We'll describe the process of vision from the object to the brain. You can trace the path of light waves through the eye in Figure 3.3.

First, light waves reflected from the cat enter your eye, passing through the **cornea**, **pupil**, and **lens**. The **cornea**, a clear membrane that covers the front of the eye, helps gather and direct incoming light. The **sclera**, or white portion of the eye, is a tough, fibrous tissue that covers the eyeball except for the cornea. The **pupil** is the black opening in the middle of the eye. The pupil is surrounded by the **iris**, the colored structure that we refer to when we say that someone has brown or blue eyes. The iris is actually a ring of muscles that contract or expand to precisely control the size of the pupil and thus the amount of light entering the eye. In dim light, the iris widens the pupil to let light in; in bright light, the iris narrows the pupil.

Behind the pupil is the **lens**, another transparent structure. In a process called **accommodation**, the lens thins or thickens to bend or focus the incoming light so that the light falls on the retina. If the eyeball is abnormally shaped, the lens may not properly focus the incoming light on the retina. The result is a visual disorder, such as *nearsightedness*, *farsightedness*, or *astigmatism*. In nearsightedness, or *myopia*, light from a distant object is focused in front of the retina. In farsightedness, or *hyperopia*, light from an object or image close by is focused



How a Pit Viper Sees a Mouse at Night

Does the world look different to other species? In many cases, yes. Each species has evolved a unique set of sensory capabilities. Pit vipers see infrared light, which we sense only as warmth. The mouse here has been photographed through an infrared viewer. The image shows how a pit viper uses its infrared "vision" to detect warm-blooded prey at night (Gould & Gould, 1994). Similarly, many insect and bird species can detect ultraviolet light, which is invisible to humans.

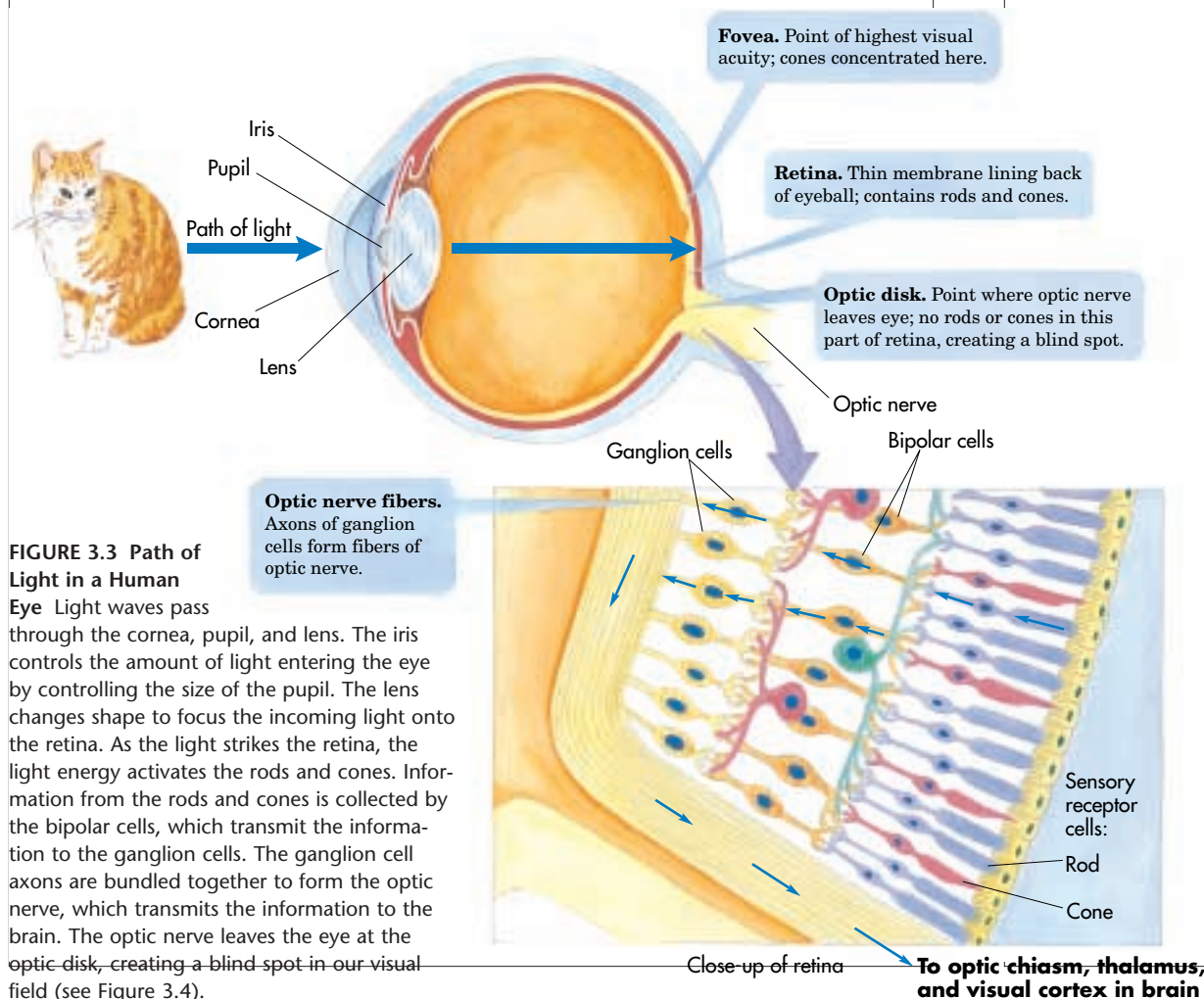
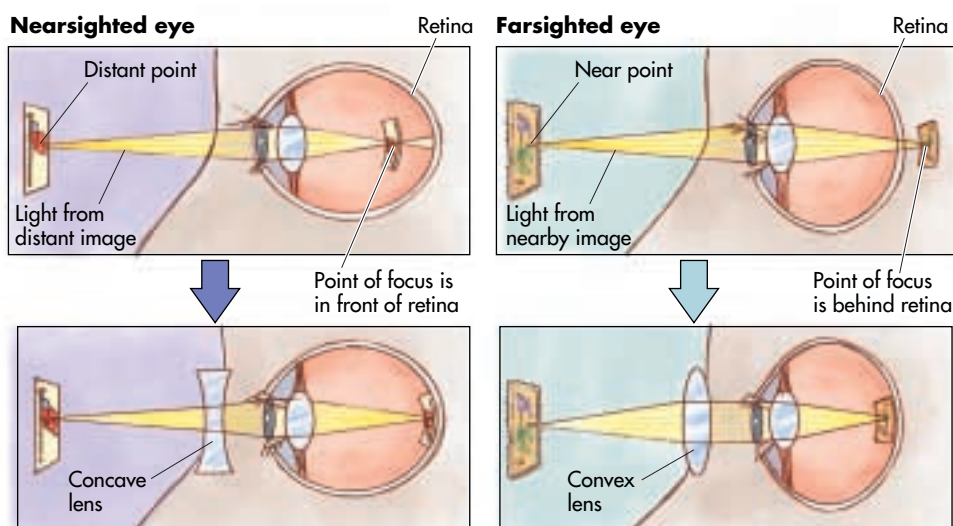


FIGURE 3.4 Common Visual Disorders: **Nearsightedness and Farsightedness** Nearsightedness and farsightedness, common visual disorders, are both caused by an abnormally shaped eyeball. In each case, the lens does not properly focus the incoming light onto the retina. Corrective lenses intercept and bend the light before it reaches the eye, so that the image falls properly on the retina. The thickness and curvature of the corrective lens will determine where the image falls.



behind the retina (Figure 3.4). During middle age, another form of farsightedness often occurs, called *presbyopia*. Presbyopia is caused when the lens becomes brittle and inflexible. In *astigmatism*, an abnormally curved eyeball results in blurry vision for lines in a particular direction. Corrective glasses remedy these conditions by intercepting and bending the light so that the image falls properly on the retina. New surgical techniques, such as LASIK, correct visual disorders by reshaping the cornea. A laser removes microscopic layers of corneal tissue to change the cornea's shape, allowing light rays to focus more directly on the retina.

The Retina

Rods and Cones

The **retina** is a thin, light-sensitive membrane that lies at the back of the eye, covering most of its inner surface (see Figure 3.3). The retina contains the two kinds of sensory receptors for light: **rods** and **cones**. When exposed to light, rods and cones undergo a chemical reaction that results in a neural signal.

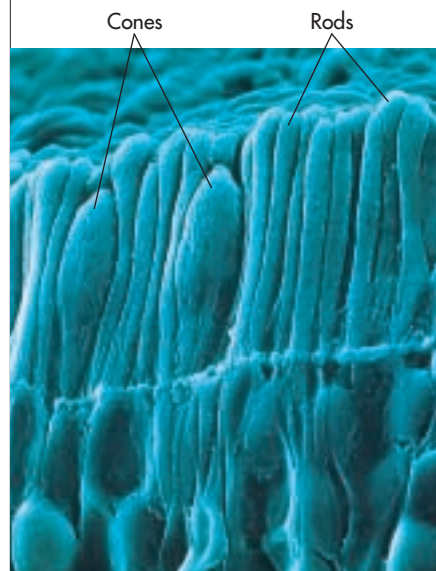
Rods and cones differ in many ways. First, as their names imply, rods and cones are shaped differently. Rods are long and thin, with blunt ends. Cones are shorter and fatter, with one end that tapers to a point. The eye contains far more rods than cones. It is estimated that each eye contains about 7 million cones and about 125 million rods!

Rods and cones are also specialized for different visual functions. Although both are light receptors, rods are much more sensitive to light than are cones. Once the rods are fully adapted to the dark, they are about a thousand times better than cones at detecting weak visual stimuli (Masland, 2001). We therefore rely primarily on rods for our vision in dim light and at night.

Rods and cones also react differently to *changes* in the amount of light. Rods adapt relatively slowly, reaching maximum sensitivity to light in about 30 minutes. In contrast, cones adapt quickly to bright light, reaching maximum sensitivity in about 5 minutes. That's why it takes several minutes for your eyes to adapt to the dim light of a darkened room, but only a few moments to adapt to the brightness when you switch on the lights.

You may have noticed that it is difficult or impossible to distinguish colors in very dim light. This difficulty occurs because only the cones are sensitive to the different wavelengths that produce the sensation of color, and cones require much more light than rods do to function effectively. Cones are also specialized for seeing fine details and for vision in bright light.

Most of the cones are concentrated in the **fovea**, which is a region in the very center of the retina. Cones are scattered throughout the rest of the retina,



Slim Rods and Fat Cones The rods and cones in the retina are the sensory receptors for vision. They convert light into electrical impulses that are ultimately transmitted to the brain. This photograph shows the rods and cones magnified about 45,000 times. The rods are long and thin; the cones are shorter, fatter, and tapered at one end. As you can see, the rods and cones are densely packed in the retina, with many rods surrounding a single cone or pair of cones.

but they become progressively less common toward the periphery of the retina. There are no rods in the fovea. Images that do not fall on the fovea tend to be perceived as blurry or indistinct. For example, focus your eyes on the word *For* at the beginning of this sentence. In contrast to the sharpness of the letters in *For*, the words to the left and right are somewhat blurry. The image of the outlying words is striking the peripheral areas of the retina, where rods are more prevalent and there are very few cones.

The Blind Spot

One part of the retina lacks rods and cones altogether. This area, called the **optic disk**, is the point at which the fibers that make up the optic nerve leave the back of the eye and project to the brain. Because there are no photoreceptors in the optic disk, we have a tiny hole, or **blind spot**, in our field of vision. To experience the blind spot, try the demonstration in Figure 3.5.

Why don't we notice this hole in our visual field? Some researchers have suggested that we simply don't notice that any information is missing because the blind spot is located in an area that has few receptors. Other researchers have suggested that the left eye compensates for the missing information in the right eye and vice versa. A more compelling explanation is that the brain actually fills in the missing background information (Ramachandran, 1992a, 1992b). In effect, the brain "paves over" the blind spot with the color and pattern of the surrounding visual information.

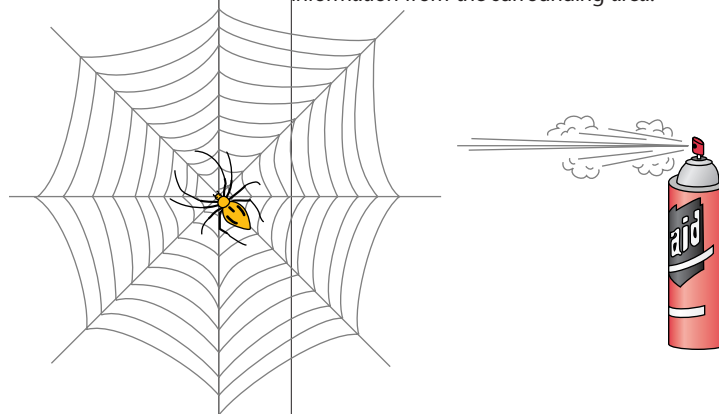


FIGURE 3.5 Demonstration of the Blind Spot Hold the book a few feet in front of you. Close your right eye and stare at the insect spray can with your left eye. Slowly bring the book toward your face. At some point the spider will disappear, because you have focused it onto the part of your retina where the blind spot is located. Notice, however, that you still perceive the spider web. That's because your brain has filled in information from the surrounding area.

Processing Visual Information

Key Theme

- Signals from the rods and cones undergo preliminary processing in the retina before they are transmitted to the brain.

Key Questions

- What are the bipolar and ganglion cells, and how do their functions differ?
- How is visual information transmitted from the retina to the brain?
- What properties of light correspond to color perceptions, and how is color vision explained?

Visual information is processed primarily in the brain. However, before visual information is sent to the brain, it undergoes some preliminary processing in the retina by specialized neurons called **ganglion cells**. This preliminary processing of visual data in the cells of the retina is possible because the retina develops from a bit of brain tissue that "migrates" to the eye during fetal development (see Hubel, 1995).

When the numbers of rods and cones are combined, there are over 130 million receptor cells in each retina. However, there are only about 1 million ganglion cells. How do just 1 million ganglion cells transmit messages from 130 million visual receptor cells?

Visual Processing in the Retina

Information from the sensory receptors, the rods and cones, is first collected by specialized neurons, called **bipolar cells** (see lower part of Figure 3.3 on page 89). The bipolar cells then funnel the collection of raw data on to the ganglion

retina

(RET-in-uh) A thin, light-sensitive membrane located at the back of the eye that contains the sensory receptors for vision.

rods

The long, thin, blunt sensory receptors of the eye that are highly sensitive to light, but not to color, and that are primarily responsible for peripheral vision and night vision.

cones

The short, thick, pointed sensory receptors of the eye that detect color and are responsible for color vision and visual acuity.

fovea

(FO-vee-uh) A small area in the center of the retina, composed entirely of cones, where visual information is most sharply focused.

optic disk

Area of the retina without rods or cones, where the optic nerve exits the back of the eye.

blind spot

The point at which the optic nerve leaves the eye, producing a small gap in the field of vision.

ganglion cells

In the retina, the specialized neurons that connect to the bipolar cells; the bundled axons of the ganglion cells form the optic nerve.

bipolar cells

In the retina, the specialized neurons that connect the rods and cones with the ganglion cells.

optic nerve

The thick nerve that exits from the back of the eye and carries visual information to the visual cortex in the brain.

optic chiasm

(KI-az-em) Point in the brain where the optic nerve fibers from each eye meet and partly cross over to the opposite side of the brain.

color

The perceptual experience of different wavelengths of light, involving hue, saturation (purity), and brightness (intensity).

hue

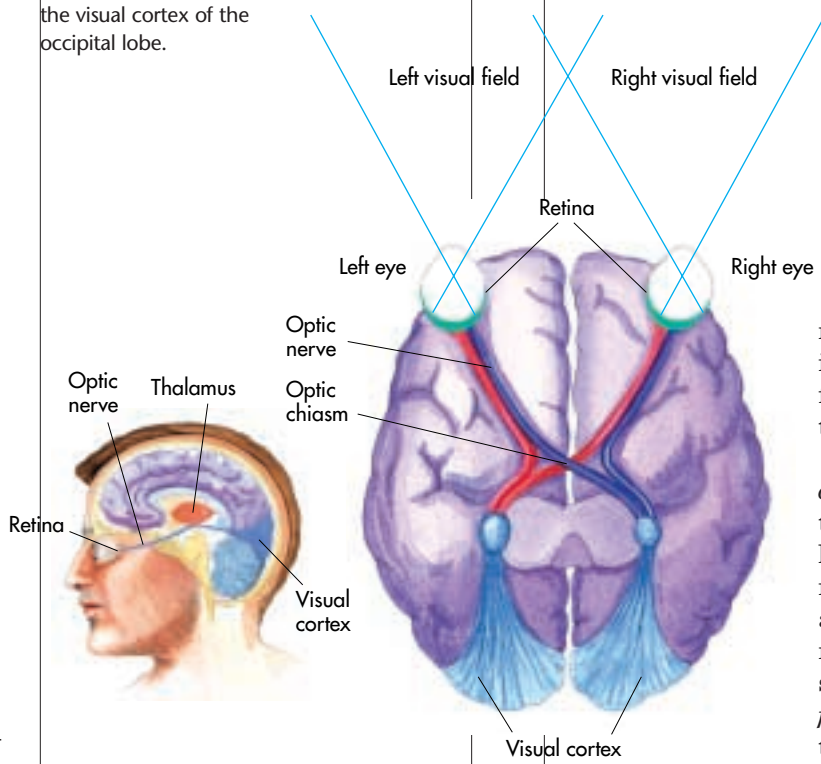
The property of wavelengths of light known as color; different wavelengths correspond to our subjective experience of different colors.

saturation

The property of color that corresponds to the purity of the light wave.

FIGURE 3.6 Neural Pathways from Eye to Brain

The bundled axons of the ganglion cells form the optic nerve, which exits the retina at the optic disk. The optic nerves from the left and right eyes meet at the optic chiasm, then split apart. One set of nerve fibers crosses over and projects to the opposite side of the brain, and another set of nerve fibers continues along the same side of the brain. Most of the nerve fibers travel to the thalamus and then on to the visual cortex of the occipital lobe.



cells. Each ganglion cell receives information from photoreceptors in its *receptive field*, a particular area of the retina. In this early stage of visual processing, each ganglion cell combines, analyzes, and encodes the information from the photoreceptors in its receptive field before transmitting the information to the brain (Masland, 2001).

Signals from rods and signals from cones are processed differently in the ganglion cells. For the most part, a single ganglion cell receives information from only one or two cones, but might well receive information from a hundred or more rods. The messages from these many different rods are combined in the retina before they are sent to the brain. Thus, the brain receives less specific visual information from the rods and messages of much greater visual detail from the cones.

Imagine listening to a hundred people trying to talk at once over the same telephone line. You would hear the sound of many people talking, but individual voices would be blurred. This is analogous to how rod information is processed. Now, imagine listening to the voice of a single individual being transmitted across the same telephone line. Every syllable and sound would be clear and distinct. In much the same way, cones use the ganglion cells to provide the brain with more specific visual information than is received from rods.

Because of this difference in how information is processed, cones are especially important in *visual acuity*—the ability to see fine details. Visual acuity is strongest when images are focused on the fovea, because of the high concentration of cones there.

From Eye to Brain

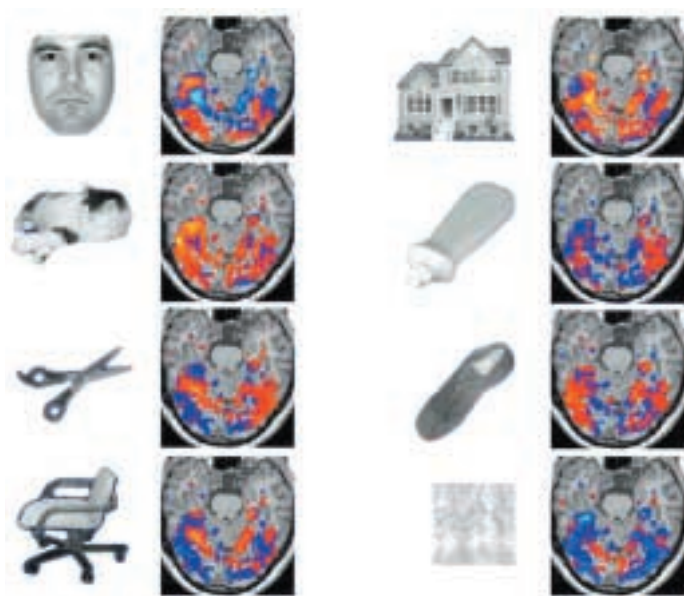
How is information transmitted from the ganglion cells of the retina to the brain? The 1 million axons of the ganglion cells are bundled together to form the **optic nerve**, a thick nerve that exits from the back of the eye at the optic disk and extends to the brain (see Figure 3.6). The optic nerve has about the same diameter as a pencil. After exiting the eyes, the left and right optic nerves meet at the **optic chiasm**. Then the fibers of the left and right optic nerves split in two. One set of axons crosses over and projects to the opposite side of the brain. The other set of axons forms a pathway that continues along the same side of the brain (see Figure 3.6).

From the optic chiasm, most of the optic nerve axons project to the brain structure called the *thalamus*. This primary pathway seems to be responsible for processing information about form, color, brightness, and depth. A smaller number of axons follow a detour to areas in the *midbrain* before they make their way to the thalamus. This secondary pathway seems to be involved in processing information about the location of an object. Neuroscientists now know that there are several distinct neural pathways in the visual system, each responsible for handling a different aspect of vision (Zeki, 2001). Although specialized, the separate pathways are highly interconnected.

From the thalamus, the signals are sent to the *visual cortex*, where they are decoded and interpreted. Most of the receiving neurons in the visual cortex of the brain are highly specialized (Logothetis & Sheinberg, 1996). Each responds to a particular type of visual stimulation, such as angles, edges, lines, and other forms, and even to the movement and distance of objects (Hubel, 1995; Livingstone & Hubel, 1988). These neurons are sometimes called *feature detectors*, because they detect, or respond to, particular features or aspects of more complex visual stimuli.

Neuroscience

focus on



Watching the Brain Watch Objects Neuroscientists still can't read your mind, but they're getting closer—a lot closer. In a recent study, neuroscientist James Haxby and his colleagues (2001) were able to look at brain scans and correctly identify the objects that research participants were viewing. The neuroscientists used functional magnetic resonance imaging (fMRI) to measure brain response patterns in six people while they looked at pictures of human faces, cats, and five other types of objects: houses, chairs, scissors, shoes, and bottles. A scrambled nonsense picture was used as a control. Shown at the left are the fMRI scans of one individual. Remember that red and yellow areas indicate higher levels of brain activity.

As you study the scans, notice that all of the objects triggered brain activity in roughly the same brain region—a visual processing area of the brain called the *extrastriate cortex*. However, you should also note that each category of object evoked a unique activity pattern. By looking at the activation pattern, the researchers were able to identify which object the person was viewing at the time the scan was made. Overall, the researchers were 96 percent accurate in identifying the object being viewed. When it came to identifying faces or houses, their accuracy rate was 100 percent.

One important finding in Haxby's study was that multiple brain areas were activated when people viewed each category of objects. The fMRI study presented here emphasizes that even simple visual processes rely on the integrated interaction of multiple brain areas (Cohen & Tong, 2001).

Reassembling the features into a recognizable image involves additional levels of processing in the visual cortex and other regions of the brain, including the *frontal lobes* (Lumer & others, 1998).

Understanding exactly how neural responses of individual feature detection cells become integrated into the visual perceptions of faces and objects is a major goal in contemporary neuroscience (Cohen & Tong, 2001). In Focus on Neuroscience, we look at how such integration takes place in the brain's visual system.

Color Vision

We see images of an apple, a banana, and an orange because these objects reflect light waves. But why do we perceive that the apple is red and the banana yellow? What makes an orange orange?

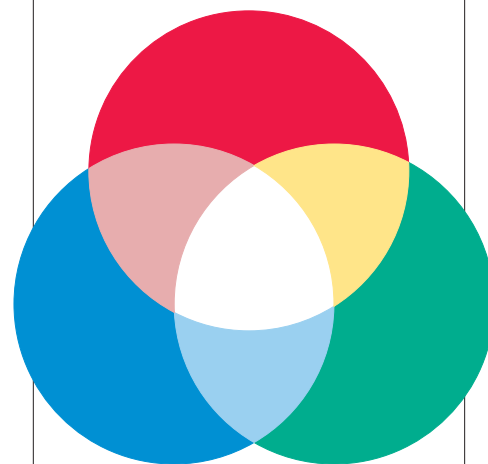
The Experience of Color

What Makes an Orange Orange?

To explain the nature of color, we must go back to the visual stimulus—light. Our experience of **color** involves three properties of the light wave. First, what we usually refer to as color is a property more accurately termed **hue**. Hue varies with the wavelength of light. Look again at Figure 3.2 on page 88. *Different wavelengths correspond to our subjective experience of different colors*. Wavelengths of about 400 nanometers are perceived as violet. Wavelengths of about 700 nanometers are perceived as red. In between are orange, yellow, green, blue, and indigo.

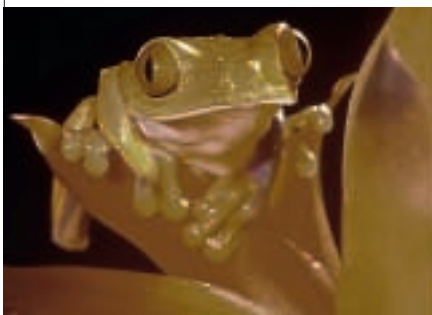
Second, the **saturation**, or *purity*, of the color corresponds to the purity of the light wave. Pure red, for example, produced by a single wavelength, is more *saturated* than pink, which is produced by a combination of wavelengths (red plus white light). In everyday language, saturation refers to the richness of a color. A highly saturated color is vivid and rich, whereas a less saturated color is faded and washed out.

When Red + Blue + Green = White When light waves of different wavelengths are combined, the wavelengths are added together, producing the perception of a different color. Thus, when green light is combined with red light, yellow light is produced. When the wavelengths of red, green, and blue light are added together, we perceive the blended light as white.



The Most Common Form of Color Blindness

To someone with red-green color blindness, these two photographs look almost exactly the same. People with this form of color blindness have normal blue-sensitive cones, but their other cones are sensitive to either red or green. Because of the way red-green color blindness is genetically transmitted, it is much more common in men than in women. People who are completely color-blind and see the world only in shades of black, white, and gray are extremely rare—only one in a million people suffers from this disorder (Hurvich, 1981).



The third property of color is **brightness**, or perceived intensity. Brightness corresponds to the amplitude of the light wave: the higher the amplitude, the greater the degree of brightness.

These three properties of color—hue, saturation, and brightness—are responsible for the amazing range of colors we experience. A person with normal color vision can discriminate from 120 to 150 color differences based on differences in hue, or wavelength, alone. When saturation and brightness are also factored in, we can potentially perceive millions of different colors (Bornstein & Marks, 1982).

Many people mistakenly believe that white light contains no color. White light actually contains all wavelengths, and thus all colors, of the visible part of the electromagnetic spectrum. A glass prism placed in sunlight creates a rainbow because it separates sunlight into all the colors of the visible light spectrum.

So we're back to the question: Why is an orange orange? Common sense tells us that the color of any object is an inseparable property of the object (unless we paint it, dye it, or spill spaghetti sauce on it). But, actually, *the color of an object is determined by the wavelength of light that the object reflects*. If your T-shirt is red, it's red because the cloth is *reflecting* only the wavelength of light that corresponds to the red portion of the spectrum. The T-shirt is *absorbing* the wavelengths that correspond to all other colors. An object appears white because it *reflects* all the wavelengths of visible light and absorbs none. An object appears black when it *absorbs* all the wavelengths of visible light and reflects none.

How We See Color

Color vision has interested scientists for hundreds of years. The first scientific theory of color vision, proposed by Hermann von Helmholtz (1821–1894) in the mid-1800s, was called the *trichromatic theory*. A rival theory, the *opponent-process theory*, was proposed in the late 1800s. Each theory was capable of explaining some aspects of color vision, but neither theory could explain all aspects of color vision. Technological advances in the last few decades have allowed researchers to gather direct physiological evidence to test both theories. The resulting evidence indicates that *both* theories of color vision are accurate. Each simply describes color vision at a different stage of visual processing (Hubel, 1995).

The Trichromatic Theory As you'll recall, only the cones are involved in color vision. According to the **trichromatic theory of color vision**, there are three varieties of cones. Each type of cone is especially sensitive to certain wavelengths—red light (long wavelengths), green light (medium wavelengths), and blue light (short wavelengths). For the sake of simplicity, we will refer to red-sensitive, green-sensitive, and blue-sensitive cones, but keep in mind that there is some overlap in the wavelengths to which a cone is sensitive (Abramov & Gordon, 1994). A given cone will be *very* sensitive to one of the three colors and only slightly responsive to the other two.

When a color other than red, green, or blue strikes the retina, it stimulates a *combination* of cones. For example, if yellow light strikes the retina, both the red-sensitive and green-sensitive cones are stimulated; purple light evokes strong reactions from red-sensitive and blue-sensitive cones. The trichromatic theory of color vision received compelling research support in 1964, when George Wald showed that different cones were indeed activated by red, blue, and green light.

The trichromatic theory provides a good explanation for the most common form of **color blindness**: red–green color blindness. People with red–green color blindness cannot discriminate between red and green. That's because they have normal blue-sensitive cones, but their other cones are *either* red-sensitive or green-sensitive. Thus, red and green look the same to them. Because red–green color blindness is so common, stoplights are designed so that the location of the light as well as its color provides information to drivers. In vertical stoplights the red light is always on top, and in horizontal stoplights the red light is always on the far left.

The Opponent-Process Theory The trichromatic theory cannot account for all aspects of color vision. One important phenomenon that the theory does not explain is the afterimage. An **afterimage** is a visual experience that occurs after the original source of stimulation is no longer present. To experience an afterimage firsthand, follow the instructions in Figure 3.7. What do you see?

Afterimages can be explained by the opponent-process theory of color vision, which proposes a different mechanism of color detection from the one set forth in the trichromatic theory. According to the **opponent-process theory of color vision**, there are four basic colors, which are divided into two pairs of color-sensitive neurons: red–green and blue–yellow. The members of each pair *oppose* each other. If red is stimulated, green is inhibited; if green is stimulated, red is inhibited. Green and red cannot both be stimulated simultaneously. The same is true for the blue–yellow pair. In addition, black and white act as an opposing pair. Color, then, is sensed and encoded in terms of its proportion of red OR green, and blue OR yellow.

For example, red light evokes a response of RED-YES–GREEN-NO in the red–green opponent pair. Yellow light evokes a response of BLUE-NO–YELLOW-YES. Colors other than red, green, blue, and yellow activate one member of each of these pairs to differing degrees. Purple stimulates the *red* of the red–green pair plus the *blue* of the blue–yellow pair. Orange activates *red* in the red–green pair and *yellow* in the blue–yellow pair.

Afterimages can be explained when the opponent-process theory is combined with the general principle of sensory adaptation (Jameson & Hurvich, 1989). If you stare continuously at one color, sensory adaptation eventually occurs and your visual receptors become less sensitive to that color. What happens when you subsequently stare at a white surface?

If you remember that white light is made up of the wavelengths for *all* colors, you may be able to predict the result. The receptors for the original color have adapted to the constant stimulation and are temporarily “off duty.” Thus they do not respond to that color. Instead, only the receptors for the opposing color will be activated, and you perceive the wavelength of only the *opposing* color. For example, if you stare at a patch of green, your green receptors eventually become “tired.” The wavelengths for both green and red light are reflected by the white surface, but since the green receptors are “off,” only the red receptors are activated. Staring at the green, black, and yellow flag in Figure 3.7 should have produced an afterimage of opposing colors: a red, white, and blue American flag.

An Integrated Explanation of Color Vision At the beginning of this section we said that current research has shown that *both* the trichromatic theory and the opponent-process theory of color vision are accurate. How can both theories be right? It turns out that each theory correctly describes color vision at a *different level* of visual processing.

As described by the *trichromatic theory*, the cones of the retina do indeed respond to and encode color in terms of red, green, and blue. But recall that signals from the cones and rods are partially processed in the ganglion cells before being transmitted along the optic nerve to the brain. Researchers now believe that an additional level of color processing takes place in the ganglion cells.

As described by the *opponent-process theory*, the ganglion cells respond to and encode color in terms of opposing pairs (DeValois & DeValois, 1975). In the brain, the thalamus and visual cortex also encode color in terms of opponent pairs (Boynton, 1988; Engel, 1999). Consequently, both theories contribute to our understanding of the process of color vision. Each theory simply describes color vision at a different stage of visual processing (Hubel, 1995).

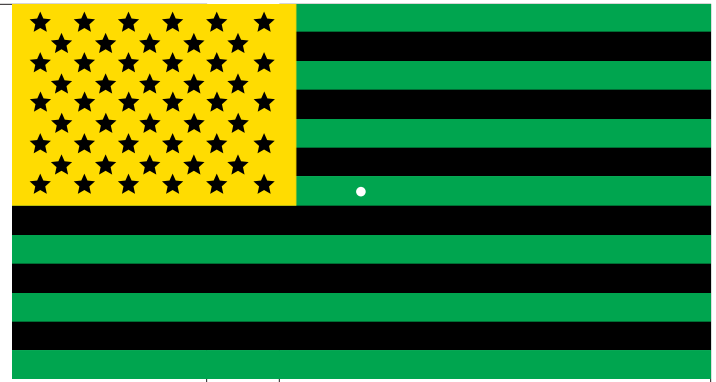


FIGURE 3.7 Demonstration of Afterimage Stare at the white dot in the center of this oddly colored flag for about 30 seconds, and then look at a white wall or white sheet of paper. What do you see?

brightness

The perceived intensity of a color, which corresponds to the amplitude of the light wave.

trichromatic theory of color vision

The theory that the sensation of color results because cones in the retina are especially sensitive to red light (long wavelengths), green light (medium wavelengths), or blue light (short wavelengths).

color blindness

One of several inherited forms of color deficiency or weakness in which an individual cannot distinguish between certain colors.

afterimage

A visual experience that occurs after the original source of stimulation is no longer present.

opponent-process theory of color vision

The theory that color vision is the product of opposing pairs of color receptors, red/green, blue/yellow, and black/white; when one member of a color pair is stimulated, the other member is inhibited.

3.1 R · E · V · I · E · W

C · O · N · C · E · P · T

Principles of Sensation and Vision

Fill in the missing words to complete each statement.

1. Sensory receptors convert different forms of physical energy into neural signals through the process of _____.
2. The sensory receptors for vision are contained in the _____.
3. Complete the sequence of visual information transmission: rods and cones, _____ cells, _____ cells, optic nerve, _____, thalamus, _____.
4. According to the _____ theory of color vision, the person with red–green color blindness has normal blue-sensitive cones.
5. When people stare at a yellow circle and then shift their eyes to a white surface, the afterimage of the circle appears _____. This phenomenon can best be explained by the _____ theory of color vision.

Hearing

From Vibration to Sound

Key Theme

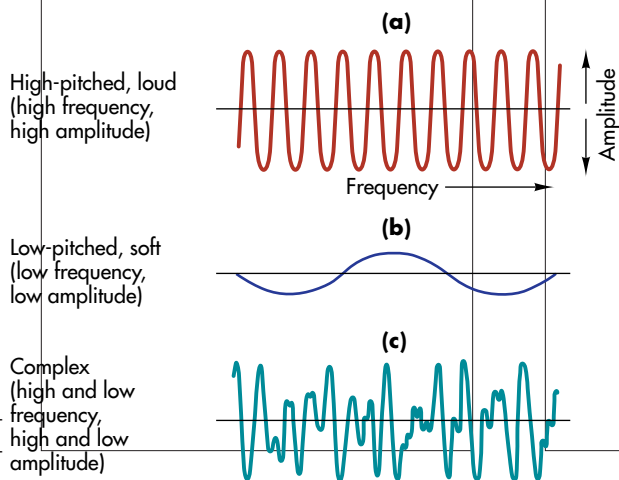
- Auditory sensation, or hearing, results when sound waves are collected in the outer ear, amplified in the middle ear, and converted to neural messages in the inner ear.

Key Questions

- How do sound waves produce different auditory sensations?
- What are the key structures of the ear and their functions?
- How do place theory and frequency theory explain pitch perception?

FIGURE 3.8 Characteristics of Sound

Waves The length of a wave, its height, and its complexity determine the loudness, pitch, and timbre that we hear. In (a) the sound would be high-pitched and loud. In (b) the sound would be soft and low. The sound in (c) is complex, like the sounds we usually experience in the natural world.



What We Hear

The Nature of Sound

Whether it's the ear-splitting screech of metal on metal or the subtle whir of a grasshopper's wings, *sound waves* are the physical stimuli that produce our sensory experience of sound. Usually, sound waves are produced by the rhythmic vibration of air molecules, but sound waves can be transmitted through other media, too, such as water. Our perception of sound is directly related to the physical properties of sound waves (see Figure 3.8).

One of the first things that we notice about a sound is how loud it is. **Loudness** is determined by the intensity, or **amplitude**, of a sound wave and is measured in units called **decibels**. Zero decibels represents the loudness of the softest sound that humans can hear, or the absolute threshold for hearing. As decibels increase, perceived loudness increases.

Pitch refers to the relative “highness” or “lowness” of a sound. Pitch is determined by the frequency of a sound wave. **Frequency** refers to the rate of vibration, or number of waves per second, and is measured in units called *hertz*. Hertz simply refers to the number of wave peaks per second. The faster the vibration, the higher the frequency, the closer together the waves are—and the higher the tone produced. If you pluck the high E and the low E strings on a guitar, you’ll notice that the low E vibrates far fewer times per second than does the high E.

Most of the sounds we experience do not consist of a single frequency but are *complex*, consisting of several sound-wave frequencies. This combination of frequencies produces the distinctive quality, or **timbre**, of a sound, which enables us to distinguish easily between the same note played on a saxophone or a piano. Every human voice has its own distinctive timbre, which is why you can immediately identify a friend’s voice on the telephone from just a few words, even if you haven’t talked to each other for years.

How We Hear

The Path of Sound

The ear is made up of the outer ear, the middle ear, and the inner ear. Sound waves are *collected* in the outer ear, *amplified* in the middle ear, and *transduced*, or *transformed into neural messages*, in the inner ear (see Figure 3.9).

audition

The technical term for the sense of hearing.

loudness

The intensity (or amplitude) of a sound wave, measured in decibels.

amplitude

The intensity or amount of energy of a wave, reflected in the height of the wave; the amplitude of a sound wave determines a sound’s loudness.

decibel

(DESS-uh-bell) The unit of measurement for loudness.

pitch

The relative highness or lowness of a sound, determined by the frequency of a sound wave.

frequency

The rate of vibration, or the number of sound waves per second.

timbre

(TAM-ber) The distinctive quality of a sound, determined by the complexity of the sound wave.

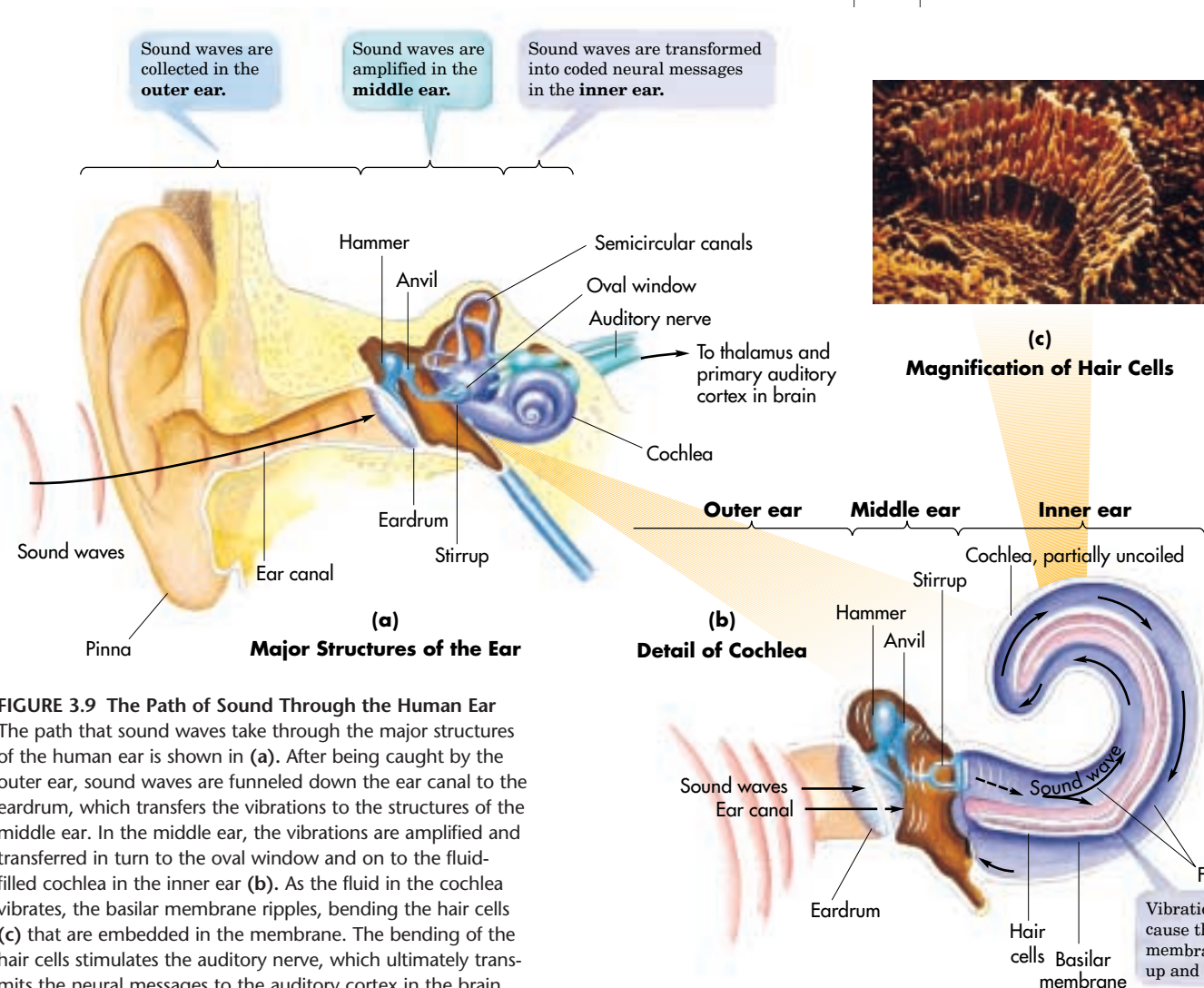


FIGURE 3.9 The Path of Sound Through the Human Ear

The path that sound waves take through the major structures of the human ear is shown in (a). After being caught by the outer ear, sound waves are funneled down the ear canal to the eardrum, which transfers the vibrations to the structures of the middle ear. In the middle ear, the vibrations are amplified and transferred in turn to the oval window and on to the fluid-filled cochlea in the inner ear (b). As the fluid in the cochlea vibrates, the basilar membrane ripples, bending the hair cells (c) that are embedded in the membrane. The bending of the hair cells stimulates the auditory nerve, which ultimately transmits the neural messages to the auditory cortex in the brain.

outer ear

The part of the ear that collects sound waves; consists of the pinna, the ear canal, and the eardrum.

eardrum

A tightly stretched membrane at the end of the ear canal that vibrates when hit by sound waves.

middle ear

The part of the ear that amplifies sound waves; consists of three small bones, the hammer, the anvil, and the stirrup.

inner ear

The part of the ear where sound is transduced into neural impulses; consists of the cochlea and semicircular canals.

cochlea

(COCK-lee-uh) The coiled, fluid-filled inner-ear structure that contains the sensory receptors for sound.

basilar membrane

(BAZ-uh-ler or BAZE-uh-ler) The membrane within the cochlea of the ear that contains the hair cells.

hair cells

The hairlike sensory receptors for sound, found in the basilar membrane of the cochlea.

The **outer ear** includes the *pinna*, the *ear canal*, and the *eardrum*. The pinna is that oddly shaped flap of skin and cartilage that's attached to each side of your head. The pinna helps us pinpoint the location of a sound. But the pinna's primary role is to catch sound waves and funnel them into the ear canal. The sound wave travels down the ear canal, then bounces into the **eardrum**, a tightly stretched membrane. When the sound wave hits the eardrum, the eardrum vibrates, matching the vibrations of the sound wave in both intensity and frequency.

The eardrum separates the outer ear from the **middle ear**. The eardrum's vibration is transferred to three tiny bones in the middle ear—the *hammer*, the *anvil*, and the *stirrup*. Each bone sets the next bone in motion. The joint action of these three bones almost doubles the amplification of the sound. The innermost bone, the stirrup, transmits the amplified vibration to the *oval window*. If the tiny bones of the middle ear are damaged or become brittle, as they sometimes do in old age, *conduction deafness* may result. Conduction deafness can be helped by a hearing aid, which amplifies sounds.

Like the eardrum, the oval window is a membrane, but it is many times smaller than the eardrum. The oval window separates the middle ear from the **inner ear**. As the oval window vibrates, the vibration is next relayed to an inner structure called the **cochlea**, a fluid-filled tube that's coiled in a spiral. The word *cochlea* comes from the Greek word for "snail," and the spiral shape of the cochlea does resemble a snail's shell. Although the cochlea is a very complex structure, it is quite tiny—no larger than a pea.

As the fluid in the cochlea ripples, the vibration in turn is transmitted to the **basilar membrane**, which runs the length of the coiled cochlea. Embedded in the basilar membrane are the sensory receptors for sound, called **hair cells**, which have tiny, projecting fibers that look like hairs. Damage to the hair cells or auditory nerve can result in *nerve deafness*, which cannot be helped by a hearing aid. Exposure to loud noise can cause nerve deafness (see Table 3.2).

The hair cells bend as the basilar membrane ripples. It is here that transduction finally takes place: The physical vibration of the sound waves is converted into neural impulses. As the hair cells bend, they stimulate the cells of the auditory nerve, which carries the neural information to the thalamus and the auditory cortex in the brain.

Table 3.2

Decibel Level of Some Common Sounds

Decibels	Examples	Exposure Danger
180	Rocket launching pad	Hearing loss inevitable
140	Shotgun blast, jet plane	Any exposure is dangerous
120	Speakers at rock concert, sandblasting, thunderclap	Immediate danger
100	Chain saw, pneumatic drill	2 hours
90	Truck traffic, noisy home appliances, lawn mower	Less than 8 hours
80	Subway, heavy city traffic, alarm clock at 2 feet	More than 8 hours
70	Busy traffic, noisy restaurant	Critical level begins with constant exposure
60	Air conditioner at 20 feet, conversation, sewing machine	
50	Light traffic at a distance, refrigerator	
40	Quiet office, living room	
30	Quiet library, soft whisper	
0	Lowest sound audible to human ear	

The Chemical and Body Senses

Smell, Taste, Touch, and Position

Key Theme

- Chemical stimuli produce the sensations of smell and taste, while pressure and other stimuli are involved in touch, pain, position, and balance sensations.

Key Questions

- How do airborne molecules result in the sensation of an odor?
- What are the primary tastes, and how does the sensation of taste arise?
- What is the gate-control theory of pain, and how do body sensations of movement, position, and balance arise?

Remember Paul and Warren, who both lack a sense of smell? As Paul and Warren are well aware, the senses of smell and taste are closely linked. If you've ever temporarily lost your sense of smell because of a bad cold, you've probably noticed that your sense of taste was also disrupted. Even a hot fudge sundae tastes bland.

Smell and taste are linked in other ways, too. Unlike vision and hearing, which involve sensitivity to different forms of energy, the sensory receptors for taste and smell are specialized to respond to different types of *chemical* substances. That's why smell, or **olfaction**, and taste, or **gustation**, are sometimes called the "chemical senses" (Bartoshuk & Beauchamp, 1994).

As the cases of Paul and Warren illustrate, people can get along quite well without a sense of smell. A surprisingly large number of people are unable to smell specific odors or lack a sense of smell completely, a condition called *anosmia*. Fortunately, humans gather most of their information about the world through vision and hearing. However, many animal species depend on chemical signals as their primary source of information (Agosta, 1992).

Even for humans, smell and taste can provide important information about the environment. Tastes help us determine whether a particular substance is to be savored or spat out. Smells, such as the odor of a smoldering fire, leaking gas, or spoiled food, alert us to potential dangers.

How We Smell (Don't Answer That!)

The sensory stimuli that produce our sensation of an odor are *molecules in the air*. These airborne molecules are emitted by the substance we are smelling. We inhale them through the nose and through the opening in the palate at the back of the throat. In the nose, the molecules encounter millions of *olfactory receptor cells* located high in the nasal cavity.

Unlike the sensory receptors for hearing and vision, the olfactory receptors are constantly being replaced. Each cell lasts for only about 30 to 60 days. In 1991, neuroscientists Linda Buck and Richard Axel identified the odor receptors that are present on the hairlike fibers of the olfactory neurons. Like synaptic receptors, each odor receptor seems to be specialized to respond to molecules of a different chemical structure. When these olfactory receptor cells are stimulated by the airborne molecules, the stimulation is converted into neural messages that pass along their axons, bundles of which make up the *olfactory nerves*.

So far, hundreds of different odor receptors have been identified (Mombaerts, 1999). We probably don't have a separate receptor for each of the estimated 10,000 different odors that we can identify, however. Rather, each receptor is like a letter in an olfactory alphabet. Just as different combinations of letters in the alphabet are used to produce recognizable words, different combinations of olfactory receptors produce the sensation of distinct odors. Thus, the



The Chemical Senses: Smell and Taste Andrea Immer is one of only ten women in the world to hold the title of Master Sommelier, and is the Dean of Wine Studies at the world-famous French Culinary Institute in New York City. Why does she sniff the wine before tasting it? Professional (and amateur) wine-tasters are keenly aware of the fact that the senses of smell and taste are closely intertwined. Specialized receptors in the nasal passages are able to detect the subtle aromas that differentiate among fine wines, and a wine expert relies as much on her sense of smell as she does her sense of taste to evaluate the wine's overall quality.

olfaction

Technical name for the sense of smell.

gustation

Technical name for the sense of taste.

1s
1e
11

IN FOCUS 3.2

Do Pheromones Influence Human Behavior?

Many animals communicate by releasing **pheromones**, chemical signals that affect the behavior of other animals of the same species. Pheromones may mark territories and serve as warning signals to other members of the same species (Agosta, 1992). Ants use pheromones to mark trails for other ants, as do snakes and snails (Dusenberry, 1992). Pheromones are also extremely important in regulating sexual attraction, mating, and reproductive behavior in many animals (Lerner & others, 1990; Rutowski, 1998). A lusty male cabbage moth, for example, can detect pheromones released from a sexually receptive female cabbage moth that is several miles away.

Do humans produce pheromones as other animals do? The best evidence for the existence of human pheromones comes from studies of the female menstrual cycle by University of Chicago biopsychologist Martha McClintock (1992). While still a college student, McClintock (1971) set out to scientifically investigate the folk notion that women who live in the same dorm eventually develop synchronized menstrual periods. McClintock was able to show that the more time women spent together, the more likely their cycles were to be in sync.

Later research showed that smelling an unknown chemical substance in underarm sweat from female donors synchronized the recipients' menstrual cycles with the donors' cycles (Preti & others, 1986; Stern & McClintock, 1998).



The Scent of Attraction Some perfume manufacturers claim that their products contain human pheromones that will make you irresistible to members of the opposite sex. But is there any evidence that pheromones affect human sexual attraction?

Since this finding, McClintock and her co-researchers have made a number of discoveries in their quest to identify human pheromones, which they prefer to call *human chemosignals*. Their search has narrowed to chemicals found in steroid compounds that are naturally produced by the human body and found in sweat, armpit hair, blood, and semen. In one study, Suma Jacob and McClintock (2000) found that exposure to the male or the female steroid helped women

maintain a positive mood after spending two hours filling out a tedious, frustrating questionnaire. Men, however, had a totally different response. Their moods tended to deteriorate after exposure to either steroid.

In another experiment, Jacob and her colleagues (2001) used PET scans to track brain changes in women after they were exposed to the same male steroid. Comparing the PET images to scans made before exposure, the researchers discovered that exposure to the steroid increased activity in several key brain regions involved in emotion and attention, including the prefrontal cortex, amygdala, and cerebellum. Interestingly, olfactory regions in the brain were also activated, although the women could not consciously detect the odor of the steroid, another example of the effects of unconscious or subliminal perception.

However, no study has yet shown that human chemosignals function as a sexual signal (see Benson, 2002). Rather than producing sexual attraction, McClintock (2001) believes, it's more likely that human chemosignals affect mood and emotional states. It may be that these chemical signals can subliminally affect social interactions and relationships in ways that we don't consciously recognize. Rather than simply triggering specific behaviors, including sexual behavior, human chemosignals may be social signals, affecting how people react and work together in groups.

pheromones

Chemical signals released by an animal that communicate information and affect the behavior of other animals of the same species.

olfactory bulb

(ole-FACK-toe-ree) The enlarged ending of the olfactory cortex at the front of the brain where the sensation of smell is registered.

taste buds

The specialized sensory receptors for taste that are located on the tongue and inside the mouth and throat.

airborne molecules activate specific combinations of receptors, and the brain identifies an odor by interpreting the *pattern* of olfactory receptors that are stimulated (Buck, 2000).

As shown in Figure 3.10, the olfactory nerves directly connect to the **olfactory bulb** in the brain, which is actually the enlarged ending of the *olfactory cortex* at the front of the brain. Warren lost his sense of smell because the surgeon cut through the nerve fibers leading to his olfactory bulb. Axons from the olfactory bulb form the *olfactory tract*. These neural pathways project to different brain areas, including the temporal lobe and structures in the limbic system (Angier, 1995). The projections to the *temporal lobe* are thought to be part of the neural pathway involved in our conscious recognition of smells. The projections to the *limbic system* are thought to regulate our emotional response to odors.

The direct connection of olfactory receptor cells to areas of the cortex and limbic system is unique to our sense of smell. As discussed in Chapter 2, all other bodily sensations are first processed in the thalamus before being relayed to the

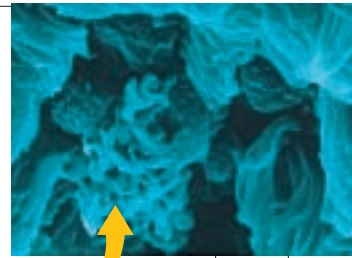
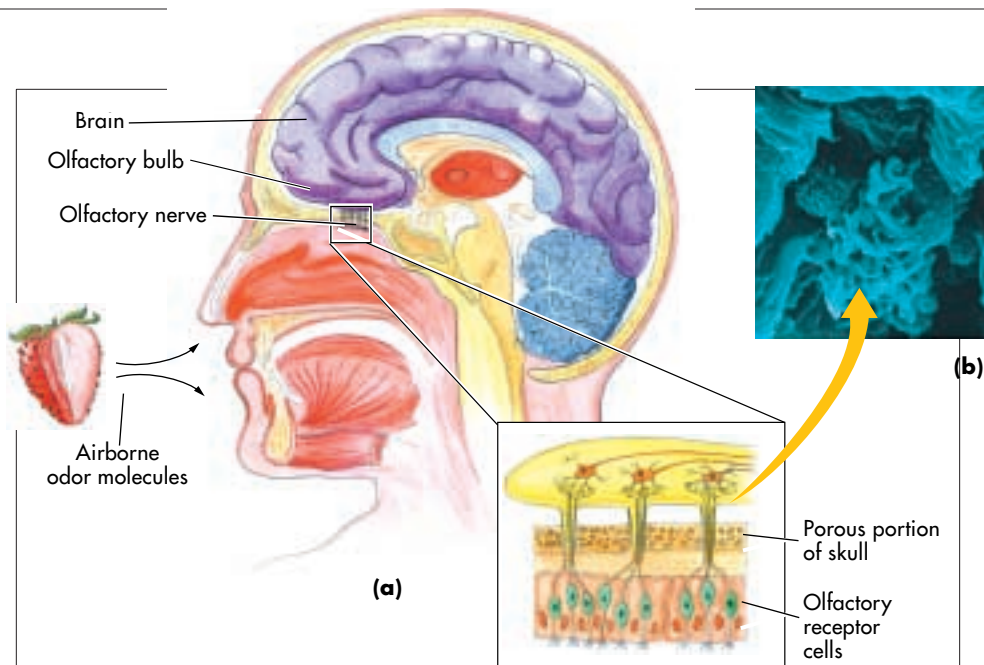


FIGURE 3.10 (a) The Olfactory System Inhaled through the nose or the mouth, airborne molecules travel to the top of the nasal cavity and stimulate the olfactory receptors. When stimulated, these receptor cells communicate neural messages to the olfactory bulb, which is part of the olfactory cortex of the brain, where the sense of smell is registered.

(b) The Olfactory Receptor Cells More than 5 million olfactory neurons make up the moist, mucus-bathed tissue at the back of the nose. Projecting from the olfactory neurons are the fiberlike olfactory hairs, which can be clearly seen in this photograph. Olfactory neurons are replaced every month or two.

higher brain centers in the cortex. Olfactory neurons are unique in another way, too. They are the only neurons that *directly* link the brain and the outside world (Axel, 1995). The axons of the sensory neurons that are located in your nose extend directly into your brain!

As with the other senses, we experience sensory adaptation to odors when exposed to them for a period of time. In general, we reach maximum adaptation to an odor in less than a minute. We continue to smell the odor, but we have become about 70 percent less sensitive to it.

Taste

This Bud's for You!

Our sense of taste, or *gustation*, results from the stimulation of special receptors in the mouth. The stimuli that produce the sensation of taste are chemical substances in whatever you eat or drink. These substances are dissolved by saliva, allowing the chemicals to activate the **taste buds**. Each taste bud contains about 50 receptor cells that are specialized for taste.

The surface of the tongue is covered with thousands of little bumps with grooves in between (see Figure 3.11). These grooves are lined with the taste buds. Taste buds are also located on the insides of your cheeks, on the roof of your mouth, and in your throat (Oakley, 1986). When activated, special receptor cells in the taste buds send neural messages along pathways to the thalamus in the brain. In turn, the thalamus directs the information to several regions in the cortex (O'Doherty & others, 2001b).

There were long thought to be four basic taste categories: sweet, salty, sour, and bitter. Recently, the receptor cells for a fifth basic taste, *umami*, were

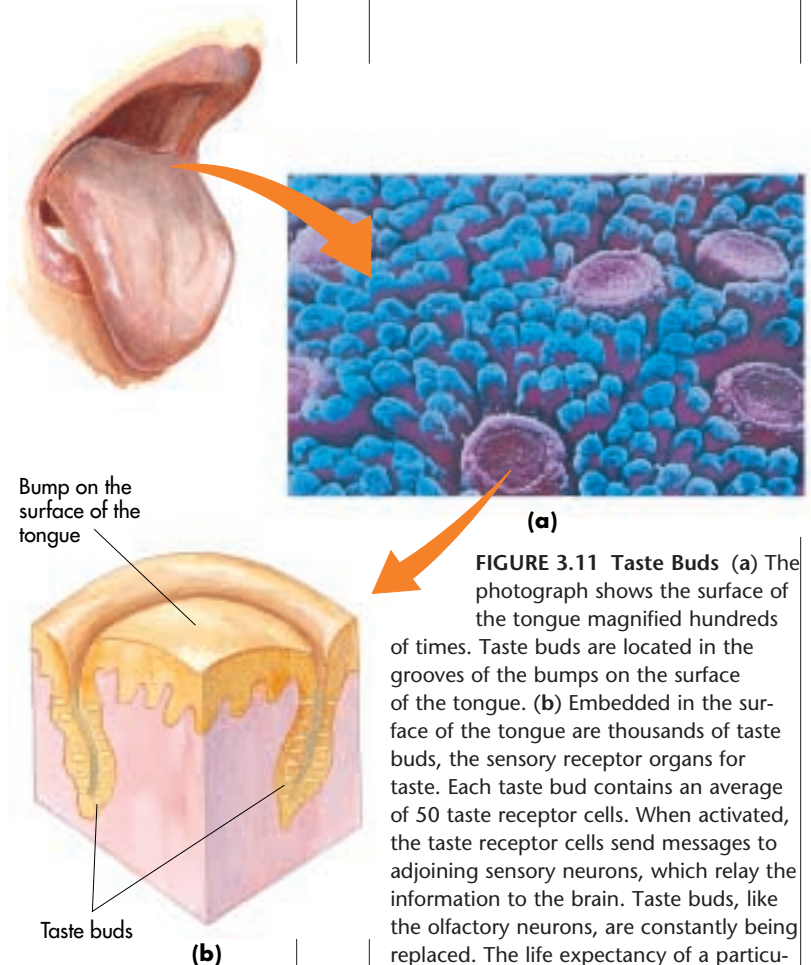


FIGURE 3.11 Taste Buds (a) The photograph shows the surface of the tongue magnified hundreds of times. Taste buds are located in the grooves of the bumps on the surface of the tongue. **(b)** Embedded in the surface of the tongue are thousands of taste buds, the sensory receptor organs for taste. Each taste bud contains an average of 50 taste receptor cells. When activated, the taste receptor cells send messages to adjoining sensory neurons, which relay the information to the brain. Taste buds, like the olfactory neurons, are constantly being replaced. The life expectancy of a particular taste bud is only about 10 days.

pain

The unpleasant sensation of physical discomfort or suffering that can occur in varying degrees of intensity.

gate-control theory

The theory that pain is a product of both physiological and psychological factors that cause spinal gates to open and relay patterns of intense stimulation to the brain, which perceives them as pain.

substance P

A neurotransmitter that is involved in the transmission of pain messages to the brain.

kinesthetic sense

(kin-ess-THET-ick) The technical name for the sense of location and position of body parts in relation to one another.

proprioceptors

(pro-pree-oh-SEP-ters) Sensory receptors, located in the muscles and joints, that provide information about body position and movement.

vestibular sense

(vess-TIB-you-ler) The technical name for the sense of balance, or equilibrium.

Table 3.3

Sensitivity of Different Body Areas to Pain

Most Sensitive	Least Sensitive
Back of the knee	Tip of the nose
Neck region	Sole of the foot
Bend of the elbow	Ball of the thumb

SOURCE: Geldard (1972)

identified (Chaudhari & others, 2000). Loosely translated, *umami* means “yummy” or “delicious” in Japanese. *Umami* is the distinctive taste of monosodium glutamate and is associated with protein-rich foods and the savory flavor of Parmesan and other aged cheeses, mushrooms, seaweed, and meat.

Each taste bud shows maximum sensitivity to one particular taste, and lesser sensitivity to other tastes. Most tastes are complex and result from the activation of different combinations of basic taste receptors. Taste is just one aspect of *flavor*, which involves several sensations, including the aroma, temperature, texture, and appearance of food.

The Skin and Body Senses

While vision, hearing, smell, and taste provide you with important information about your environment, another group of senses provides you with information that comes from a source much closer to home: your own body. In this section, we'll first consider the *skin senses*, which provide essential information about your physical status and your physical interaction with objects in your environment. We'll next consider the *body senses*, which keep you informed as to your position and orientation in space.

Touch

We usually don't think of our skin as a sense organ. But the skin is in fact the largest and heaviest sense organ. The skin of an average adult covers about 20 square feet of surface area and weighs about six pounds.

There are many different kinds of sensory receptors in the skin. Some of these sensory receptors are specialized to respond to just one kind of stimulus, such as pressure, warmth, or cold. Other skin receptors respond to more than one type of stimulus.

One important receptor involved with the sense of touch, called the *Pacinian corpuscle*, is located beneath the skin. When stimulated by pressure, the Pacinian corpuscle converts the stimulation into a neural message that is relayed to the brain. If a pressure is constant, sensory adaptation takes place. The Pacinian corpuscle either reduces the number of signals sent or quits responding altogether (which is fortunate, or you'd be unable to forget the fact that you're wearing underwear).

Sensory receptors are distributed unevenly among different areas of the body, which is why sensitivity to touch and temperature varies from one area of the body to another. Your hands, face, and lips, for example, are much more sensitive to touch than are your back, arms, and legs. That's because your hands, face, and lips are much more densely packed with sensory receptors.

Pain

Pain is important to our survival. It provides us with important information about our body, telling us to pay attention, to stop what we are doing, or to pull away from some object or stimulus that is injuring us.

A wide variety of stimuli can produce **pain**—the sensation of discomfort or suffering. Virtually any external stimulus that can produce tissue damage can cause pain, including certain chemicals, electric shock, and extreme heat, cold, pressure, or noise. Pain can also be caused by internal stimuli, such as disease, infection, or deterioration of bodily functions. Some areas of the body are more sensitive to pain than are other areas (see Table 3.3).

The most influential theory of pain is the **gate-control theory**, developed by psychologist Ronald Melzack and anatomist Patrick Wall (1965, 1996). The gate-control theory suggests that the sensation of pain is controlled by a series of “gates” that open and close in the spinal cord. If the spinal gates are open, pain is experienced. If the spinal gates are closed, no pain is experienced.

Pain begins when an intense stimulus activates small-diameter sensory fibers, called *free nerve endings*, in the skin, muscles, or internal organs. The free nerve endings carry their messages to the spinal cord, releasing a neurotransmitter called **substance P**. In the spinal cord, substance P causes other neurons to become activated, sending their messages through open spinal gates to the thalamus in the brain (Turk & Nash, 1993). Other areas of the brain involved in the experience of pain are the somatosensory cortex and areas in the frontal lobes and limbic system that are involved in emotion (Hunt & Mantyh, 2001; Rainville & others, 1997).



Pain Relief Through Acupuncture Acupuncture is a pain-relieving technique that has been used in traditional Chinese medicine for thousands of years. Acupuncture involves inserting tiny needles at specific points in the body. The needles are then twirled, heated, or, as shown here, stimulated with a mild electrical current. Although it is not yet understood exactly how acupuncture interrupts the transmission of pain signals, it is known that acupuncture stimulates the release of endorphins (Chao & others, 1999).

When the sensory pain signals reach the brain, the sensory information is integrated with psychological information. Depending on how the brain interprets the pain experience, it regulates pain by sending signals down the spinal cord that either open or close the gates. If, because of psychological factors, the brain signals the gates to open, pain is experienced or intensified. If the brain signals the gates to close, pain is reduced.

Anxiety, fear, and a sense of helplessness are some of the psychological factors that can intensify the experience of pain. Positive emotions, laughter, distraction, and a sense of control can reduce the perception of pain. The experience of pain is also influenced by social and cultural learning experiences about the meaning of pain and how people should react to pain (Turk, 1994; Turk & Rudy, 1992).

Psychological factors also influence the release of *endorphins*, the body's natural painkillers that are produced in many parts of the brain and the body (see Chapter 2). Endorphins are released as part of the brain's overall response to physical pain or stress. In the brain, endorphins can inhibit the transmission of pain signals. In the spinal cord, endorphins inhibit the release of substance P.

Finally, a person's mental or emotional state can influence other bodily processes that affect the experience of pain. Muscle tension, psychological arousal, and rapid heart rate can all produce or intensify pain (Turk & Nash, 1993). Today, a variety of techniques and procedures can effectively eliminate or reduce pain. These techniques are explored in the chapter Application, Strategies to Control Pain, on page 120.

Movement, Position, and Balance

The phone rings. Without looking up from your textbook, you reach for the receiver, pick it up, and guide it to the side of your head. You have just demonstrated your **kinesthetic sense**—the sense that involves the location and position of body parts in relation to one another. (The word *kinesthetics* literally means “feelings of motion.”) The kinesthetic sense involves specialized sensory neurons, called **proprioceptors**, which are located in the muscles and joints. The proprioceptors constantly communicate information to the brain about changes in body position and muscle tension.

Closely related to the kinesthetic sense is the **vestibular sense**, which provides a sense of balance, or equilibrium, by responding to changes in gravity, motion, and body position. The two sources of vestibular sensory information, the *semicircular canals* and the *vestibular sacs*, are both located in the ear (see Figure 3.12). These structures are filled with fluid and lined with hairlike receptor cells that shift in response to motion, changes in body position, or changes in gravity.

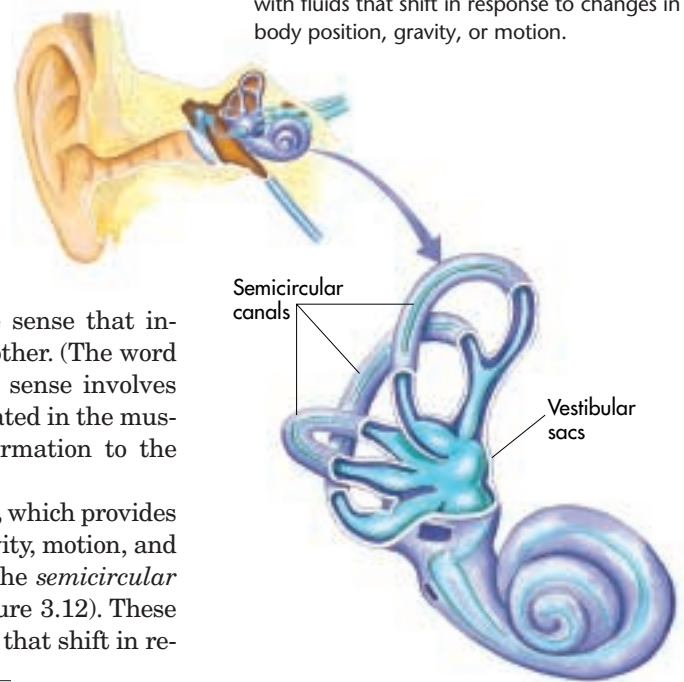


FIGURE 3.12 The Vestibular Sense The vestibular sense provides our sense of balance, or equilibrium. Shown here are the two sources of vestibular sensory information, both located in the ear: the semicircular canals and the vestibular sacs. Both structures are filled with fluids that shift in response to changes in body position, gravity, or motion.

Table 3.4

Summary Table of the Senses

Sense	Stimulus	Sense Organ	Sensory Receptor Cells
Hearing (audition)	Sound waves	Ear	Hair cells in cochlea
Vision	Light waves	Eye	Rods and cones in retina
Color vision	Different wavelengths of light	Eye	Cones in retina
Smell (olfaction)	Airborne odor molecules	Nose	Hairlike receptor cells at top of nasal cavity
Taste (gustation)	Chemicals dissolved in saliva	Mouth	Taste buds
Touch	Pressure	Skin	Pacinian corpuscle
Pain	Tissue injury or damage; varied	Skin, organs, and other body sites	No single specific receptor; pattern of messages from many kinds of receptors
Movement (kinesthetic sense)	Movement of the body	None; muscle and joint tissue	Proprioceptors in muscle and joint tissue
Balance (vestibular sense)	Changes in position, gravity	Semicircular canals and vestibular sacs	Hairlike receptor cells in semicircular canals and vestibular sacs

When you experience environmental motion, like the rocking of a boat in choppy water, the fluids in the semicircular canals and the vestibular sacs are affected. Changes in your body’s position, such as falling backward in a heroic attempt to return a volleyball serve, also affect the fluids. Your vestibular sense supplies the critical information that allows you to compensate for such changes and quickly reestablish your sense of balance.

Maintaining equilibrium also involves information from other senses, particularly vision. Under normal circumstances, this works to our advantage. However, when information from the eyes conflicts with information from the vestibular system, the result can be dizziness, disorientation, and nausea. These are the symptoms commonly experienced in motion sickness, the bane of many travelers in cars, on planes, on boats, and even in space. One strategy that can be used to combat motion sickness is to minimize sensory conflicts by focusing on a distant point or an object that is fixed, such as the horizon.

In the first part of this chapter, we’ve described how the body’s senses respond to stimuli in the environment. Table 3.4 summarizes these different sensory systems. To make use of this raw sensory data, the brain must organize and interpret the data and relate it to existing knowledge. Next, we’ll look at the process of perception—how we make sense out of the information that we receive from our environment.

3.2 R · E · V · I · E · W

C · O · N · C · E · P · T

The Nonvisual Senses

Fill in the blanks with the correct term.

1. The sensory receptors for hearing are embedded in the _____ membrane in the _____.

2. When activated, taste receptor cells send messages along neural pathways to the _____.

3. The bundled axons of the olfactory receptors project to a brain structure called the _____.
4. Hearing loss caused by damage to the bones of the middle ear is called _____.

5. The neurotransmitter called _____ plays an important role in the processing of pain signals.

6. Because of your _____ sense, you can touch your chin with your index finger even when your eyes are closed.

Perception

Key Theme

- Perception refers to the process of integrating, organizing, and interpreting sensory information into meaningful representations.

Key Questions

- What are bottom-up and top-down processing, and how do they differ?
- What is Gestalt psychology?
- What Gestalt principles determine our perceptions of objects and their relationship to their surroundings?

As we've seen, our senses are constantly registering a diverse range of stimuli from the environment and transmitting that information to the brain. But to make use of this raw sensory data, we must organize, interpret, and relate the data to existing knowledge.

Psychologists sometimes refer to this flow of sensory data from the sensory receptors to the brain as **bottom-up processing**. Also called *data-driven processing*, bottom-up processing is often at work when we're confronted with an ambiguous stimulus. For example, imagine trying to assemble a jigsaw puzzle one piece at a time, without knowing what the final picture will be. To accomplish this task, you would work with the individual puzzle pieces to build the image from the "bottom up," that is, from its constituent parts.

But as we interact with our environment, many of our perceptions are shaped by **top-down processing**, which is also referred to as *conceptually driven processing*. Top-down processing occurs when we draw on our knowledge, experiences, expectations, and other cognitive processes to arrive at meaningful perceptions, such as people or objects in a particular context.

Both top-down and bottom-up processing are involved in our everyday perceptions. As a simple illustration, look at this photograph which sits on Don's desk. Top-down processing was involved as you reached a number of perceptual conclusions about the image. You quickly perceived a little girl holding a black cat—our daughter Laura holding her cat, Nubbin. You also perceived a child as a whole object even though the cat is actually blocking a good portion of the view of Laura.

But now look at the background in the photograph, which is more ambiguous. Deciphering these images involves both bottom-up and top-down processing. Bottom-up processes help you determine that behind the little girl looms a large, irregularly shaped, dark green object with brightly colored splotches on it. But what is it?

To identify the mysterious object, you must interpret the meaning of the sensory data. Top-down processes help you identify the large green blotch as a Christmas tree—a conclusion that you probably would *not* reach if you had no familiarity with the way many Americans celebrate the Christmas holiday. The Christmas tree branches, ornaments, and lights are really just fuzzy images at best, but other images work as clues—a happy child, a stuffed bear with a red-and-white stocking cap. Our learning experiences create a conceptual knowledge base from which we can identify and interpret many objects, including kids, cats, and Christmas trees.



bottom-up processing

Information processing that emphasizes the importance of the sensory receptors in detecting the basic features of a stimulus in the process of recognizing a whole pattern; analysis that moves from the parts to the whole; also called *data-driven processing*.

top-down processing

Information processing that emphasizes the importance of the observer's knowledge, expectations, and other cognitive processes in arriving at meaningful perceptions; analysis that moves from the whole to the parts; also called *conceptually driven processing*.

Organizing Sensations into Meaningful Perceptions With virtually no conscious effort, the psychological process of perception allows you to integrate, organize, and interpret the lines, colors, and contours in this image as meaningful objects—a laughing child holding a panicky black cat in front of a Christmas tree. How did you reach those perceptual conclusions?

CRITICAL THINKING 3.3

ESP: Can Perception Occur Without Sensation?

Do you believe in ESP? If you do, you're not alone. A Gallup poll found that almost half of American adults believed in ESP and another quarter thought ESP might exist (Gallup & Newport, 1991). In fact, Americans spend over \$600 million a year calling psychic hotlines (Nisbet, 1998).

ESP, or extrasensory perception, means detecting information in some way other than through the normal processes of sensation. Forms of ESP include:

- **Telepathy**—direct communication between the minds of two individuals
- **Clairvoyance**—the perception of a remote object or event, such as sensing that a friend has been injured in a car accident
- **Psychokinesis**—the ability to influence a physical object, process, or event, such as bending a key or stopping a clock, without touching it
- **Precognition**—the ability to predict future events

The general term for such unusual abilities is *paranormal phenomena*. *Paranormal* means “outside the range of normal experience.” Thus, these phenomena cannot be explained by known laws of science and nature. **Parapsychology** refers to the scientific investigation of claims of various paranormal phenomena. Only a small percentage of psychologists are parapsychologists.

Have you ever felt as if you had just experienced ESP? Consider the following two examples:

- Your sister was supposed to stop by around 7:00. It's now 7:15, and you “sense” that something has happened to her. Shortly after 8:00 she calls, informing you that she's been involved in a fender bender. Did you experience clairvoyance?
- Sandy had a vivid dream that our cat Nubbin got lost. The next morning, Nubbin sneaked out the back door, went for an unauthorized stroll in the woods, and was gone for three days. Did Sandy have a precognitive dream?

Such common experiences may be used to “prove” that ESP exists. However, two less extraordinary concepts can explain both occurrences: coincidence and the fallacy of positive instances.

Coincidence describes an event that occurs simply by chance. For example, you have over a thousand dreams per year, most of which are about familiar people and situations. By mere chance, some aspect of some dream will occasionally correspond with reality.

The *fallacy of positive instances* is the tendency to remember coincidental events that seem to confirm our belief about unusual phenomena and to forget all the instances that do not. For example, think of the number of times you've thought something happened to someone

but nothing did. Such situations are far more common than their opposites, but we quickly forget about the hunches that are not confirmed.

Why do people attribute chance events to ESP? Research has shown that believers in ESP are less likely to accurately estimate the probability of an event occurring by chance alone. Nonbelievers tend to be more realistic about the probability of events being the result of simple coincidence or chance (Blackmore, 1985).

Parapsychologists attempt to study ESP in the laboratory under controlled conditions. Many initially convincing demonstrations of ESP are later shown to be the result of research design problems or of the researcher's unintentional cuing of the subject. Occasionally, outright fraud is involved on the part of either the subject or experimenter (Randi, 1980, 1982).

Another problem involves *replication*. To be considered valid, experimental results must be able to be replicated, or repeated, by other scientists under identical laboratory conditions. To date, no parapsychology experiment claiming to show evidence of the existence of ESP has been successfully replicated (Hyman, 1994; Milton & Wiseman, 2001).

One active area of parapsychological research is the study of clairvoyance using an experimental procedure called the *ganzfeld procedure*. (*Ganzfeld* is a German word that means “total field.”) In a ganzfeld study, a “sender” in one room

Max Wertheimer (1880–1943) Arguing that the whole is always greater than the sum of its parts, Wertheimer founded Gestalt psychology. Wertheimer and other Gestalt psychologists began by studying the principles of perception but later extended their approach to other areas of psychology.



ESP (extrasensory perception)

Perception of information by some means other than through the normal processes of sensation.

parapsychology

The scientific investigation of claims of paranormal phenomena and abilities.

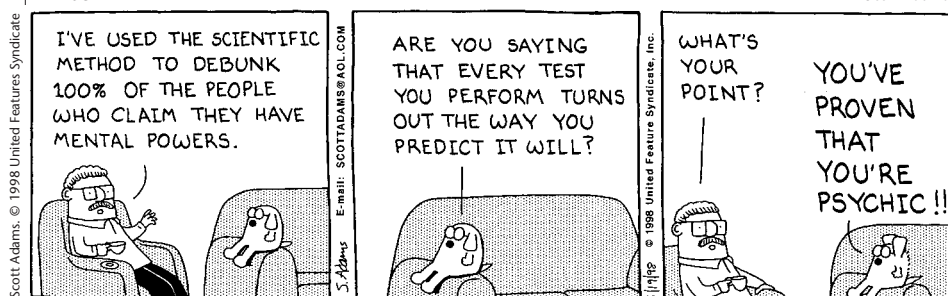
Clearly, bottom-up and top-down processing are both necessary to explain how we arrive at perceptual conclusions. But whether we are using bottom-up or top-down processing, a useful way to think about perception is to consider the basic perceptual questions we must answer in order to survive. We exist in an ever-changing environment that is filled with objects that may be standing still or moving, just like ourselves. Whether it's a bulldozer or a bowling ball, we need to be able

to identify objects, locate objects in space, and, if they are moving, track their motion. Thus, our perceptual processes must help us organize our sensations to answer three basic, important questions: (1) What is it? (2) How far away is it? and (3) Where is it going?

In the next few sections, we will look at what psychologists have learned about the principles we use to answer these perceptual questions. Much of our discussion

Dilbert

Scott Adams



attempts to communicate the content of pictures or short video clips to a receiver in a separate room. Isolated from all contact and wearing goggles and headphones to block external sensory stimuli, the “receiver” attempts to detect the image that is being sent.

One set of carefully controlled ganzfeld studies showed a “hit” rate that was well above chance, implying that some sort of transfer of information had taken place between sender and receiver (Bem & Honorton, 1994). These results, published in a well-respected psychology journal, *Psychological Bulletin*, led some psychologists to speculate that there might be something to extrasensory perception after all—and that the ganzfeld procedure might be the way to detect it. But other psychologists, like Ray Hyman (1994), argued that the study did *not* offer conclusive proof that ESP had been demonstrated.

In the past decade, many ganzfeld studies have been published, some showing positive results, some negative. Psy-

chologists have used meta-analysis to try to determine whether the so-called ganzfeld effect has been successfully replicated. The verdict? British psychologists Julie Milton and Richard Wiseman (1999, 2001) concluded that the ganzfeld effect has *not* produced replicable evidence of an ESP effect in the laboratory. Other psychologists, however, dispute *that* conclusion with their own meta-analyses (Storm & Ertel, 2001). Most psychologists agree with Milton and Wiseman’s (2001) bottom line: “The final verdict on [ESP] depends upon replication of an effect across experimenters under methodologically stringent conditions.” To date, that bottom-line requirement has not been met.

Of course, the history of science is filled with examples of phenomena that were initially scoffed at and later found to be real. For example, the pain-relieving effects of acupuncture were initially dismissed by Western scientists as mere superstition or the power of suggestion. However, controlled studies have shown

that acupuncture does effectively relieve pain and may be helpful in treating other conditions (J. B. Murray, 1995; Ulett & others, 1998).

So keep an open mind about ESP, but also maintain a healthy sense of scientific skepticism. It is entirely possible that someday convincing experimental evidence will demonstrate the existence of ESP abilities (see Bem & Honorton, 1994; Milton & Wiseman, 2001; Storm & Ertel, 2001). In the final analysis, all psychologists, including those who accept the possibility of ESP, recognize the need for evidence that meets the requirements of the scientific method.

Critical Thinking Questions

- Why do you think that people who believe in ESP are less likely to attribute events to chance than people who don’t think ESP is a real phenomenon?
- Can you think of any reasons why replication might be particularly elusive in research on extrasensory perception?
- Why is replication important in all psychological research, but particularly so in studies attempting to prove extraordinary claims, like the existence of ESP?

reflects the work of an early school of psychology called **Gestalt psychology**, which was founded by German psychologist **Max Wertheimer** in the early 1900s. The Gestalt psychologists emphasized that we perceive whole objects or figures (*gestalts*) rather than isolated bits and pieces of sensory information. Roughly translated, the German word *Gestalt* means a unified whole, form, or shape. Although the Gestalt school of psychology no longer formally exists, the pioneering work of the Gestalt psychologists established many basic perceptual principles (Palmer, 2002).

The Perception of Shape

What Is It?

When you look around your world, you don’t see random edges, curves, colors, or splotches of light and dark. Rather, you see countless distinct objects against a variety of backgrounds. Although to some degree we rely on size, color, and texture to determine what an object might be, we rely primarily on an object’s *shape* to identify it.

Simply stated, the problem of perceptual organization is that the objects of conscious perception are not directly given in any simple or direct way in the retinal image, but must be constructed through activity of the visual nervous system.

Stephen E. Palmer (2002)

Gestalt psychology

(geh-SHTALT) A school of psychology founded in Germany in the early 1900s that maintained that our sensations are actively processed according to consistent perceptual rules that result in meaningful whole perceptions, or *gestalts*.

Survival and Figure–Ground Relationships

The natural camouflage that protects some animals from predators illustrates the importance of figure–ground relationships in survival. When an animal's coloring and markings blend with its background, a predator cannot distinguish the animal (the *figure*) from its environment (the *ground*). In much the same way, military personnel and equipment are often concealed from enemy forces by clothing or tarps that are designed to blend in with the terrain, whether it be jungle, desert, forest, or snowy mountain range.

FIGURE 3.13 Figures Have Shape, but Ground Doesn't Which shape in (b) can also be found in (a)? The answer is that *both* shapes are in (a). It's easy to spot the top shape, because it corresponds to one of the shapes perceived as a figure in (a). The bottom shape is harder to find because it is part of the ground or background of the total scene. Because we place more importance on figures, we're more likely to notice their shape while ignoring the shape of background regions.

SOURCE: N. Rubin (2001).

FIGURE 3.14 A Classic Example of Figure–Ground Reversal Figure–ground reversals illustrate the psychological nature of our ability to perceptually sort a scene into the main element and the background. If you perceive the white area as the figure and the dark area as the ground, you'll perceive a vase. If you perceive the dark area as the figure, you'll perceive two faces.

figure–ground relationship

A Gestalt principle of perceptual organization that states that we automatically separate the elements of a perception into the feature that clearly stands out (the figure) and its less distinct background (the ground).

Figure–Ground Relationship

How do we organize our perceptions so that we see an object as separate from other objects? The early Gestalt psychologists identified an important perceptual principle called the **figure–ground relationship**, which describes how this works. When we view a scene, we automatically separate the elements of that scene into the *figure*, which is the main element of the scene, and the *ground*, which is its background.

You can experience the figure–ground relationship by looking at a coffee cup on a table. The coffee cup is the figure, and the table is the ground. Notice that usually the figure has a definite shape, tends to stand out clearly, and is perceptually meaningful in some

way. In contrast, the ground tends to be less clearly defined, even fuzzy, and usually appears to be behind and farther away than the figure.

The early Gestalt psychologists noted that figure and ground have vastly different perceptual qualities (N. Rubin, 2001). As Gestalt psychologist

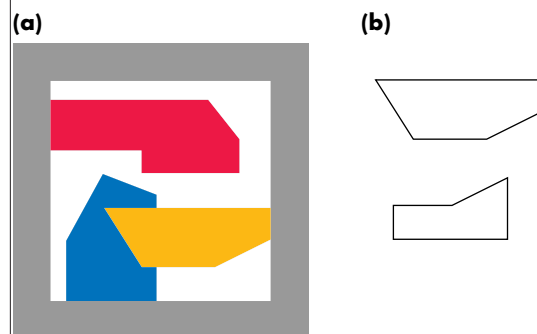
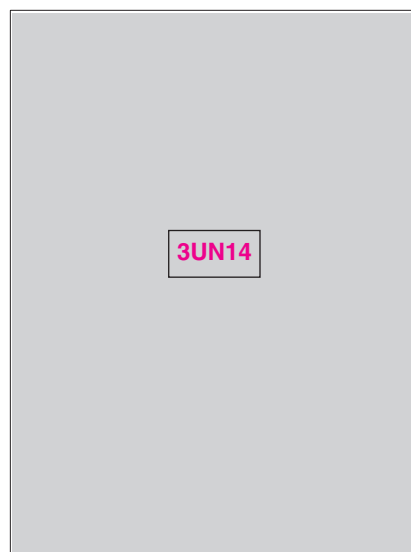
Edgar Rubin (1921) observed, “In a certain sense, the ground has no shape.” We notice the shape of the figure but *not* the shape of the background, even when that ground is used as a well-defined frame (see Figure 3.13). It turns out that brain neurons *also* respond differently to a stimulus that is perceived as a figure versus a stimulus that is part of the ground (Baylis & Driver, 2001).

Particular neurons in the cortex that responded to a specific shape when it was the shape of the figure did *not* respond when the same shape was presented as part of the background.

The separation of a scene into figure and ground is not a property of the actual elements of the scene you're looking at. Rather, your ability to separate a scene into figure and ground is a psychological accomplishment. To illustrate, look at the classic example shown in Figure 3.14. This perception of a single image in two different ways is called a *figure–ground reversal*.

Perceptual Grouping

Many of the forms we perceive are composed of a number of different elements that seem to go together (Prinzmetal, 1995). It would be more accurate to say that we actively organize the elements to try to produce the stable perception of well-defined,



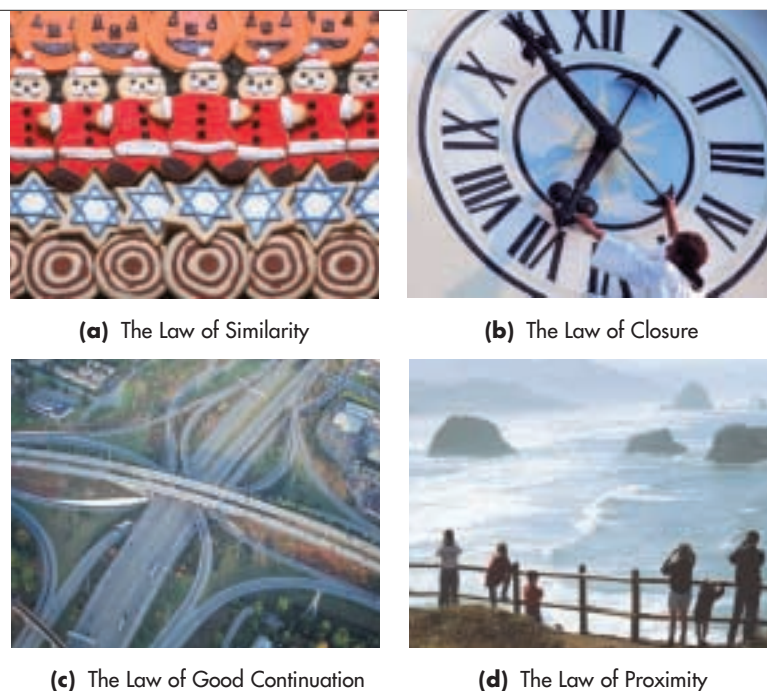


FIGURE 3.15 The Gestalt Principles of Organization (a) The *law of similarity* is the tendency to perceive objects of a similar size, shape, or color as a unit or figure. Thus, you perceive four horizontal rows rather than six vertical columns of holiday cookies.

(b) The *law of closure* is the tendency to fill in the gaps in an incomplete image. Thus, you perceive the curved lines on the clock as smooth, continuous circles, even though they are interrupted by a person and the clock's hands.

(c) The *law of good continuation* is the tendency to group elements that appear to follow in the same direction as a single unit or figure. Thus, you tend to see the curved sections of the highways as continuous units.

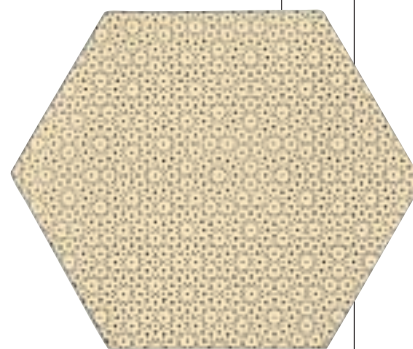
(d) The *law of proximity* is the tendency to perceive objects that are close to one another as a single unit. Thus, you perceive these six people as two groups of three.

whole objects. This is what perceptual psychologists refer to as “the urge to organize.” What sort of principles do we follow when we try to organize visual elements?

The Gestalt psychologists studied how the perception of visual elements becomes organized into patterns, shapes, and forms. They identified several laws, or principles, that we tend to follow in grouping elements together to arrive at the perception of forms, shapes, and figures. These principles include *similarity*, *closure*, *good continuation*, and *proximity*. Examples and descriptions of these perceptual laws are shown in Figure 3.15.

The Gestalt psychologists also formulated a general principle called the *law of Prägnanz*, or the *law of simplicity*. This law states that when several perceptual organizations of an assortment of visual elements are possible, the perceptual interpretation that occurs will be the one that produces the “best, simplest, and most stable shape” (Koffka, 1935). To illustrate, look at Figure 3.16. Do you perceive the image as two six-sided objects and one four-sided object? If you are following the law of Prägnanz, you don’t. Instead, you perceptually organize the elements in the most cognitively efficient and simple way, perceiving them as three overlapping squares.

According to the Gestalt psychologists, the law of Prägnanz encompasses all the other Gestalt principles, including the figure–ground relationship. The implication of the law of Prägnanz is that our perceptual system works in an economical way to promote the interpretation of stable and consistent forms (van der Helm, 2000). The ability to efficiently organize elements into stable objects helps us perceive the world accurately. In effect, we actively and automatically construct a perception that reveals “the essence of something,” which is roughly what the German word *Prägnanz* means.



The Perceptual Urge to Organize As you scan this image, you’ll experience firsthand the strong psychological tendency to organize visual elements to arrive at the perception of whole figures, forms, and shapes. Notice that as you shift your gaze across the pattern, you momentarily perceive circles, squares, and other geometric forms.

FIGURE 3.16 What Do You See? The law of simplicity refers to our tendency to efficiently organize the visual elements of a scene in a way that produces the simplest and most stable forms or objects. You probably perceived this image as that of three overlapping squares rather than as two six-sided objects and one four-sided object.

Depth Perception

How Far Away Is It?

Key Theme

- Perception of distance and motion helps us gauge the position of stationary objects and predict the path of moving objects.

Key Questions

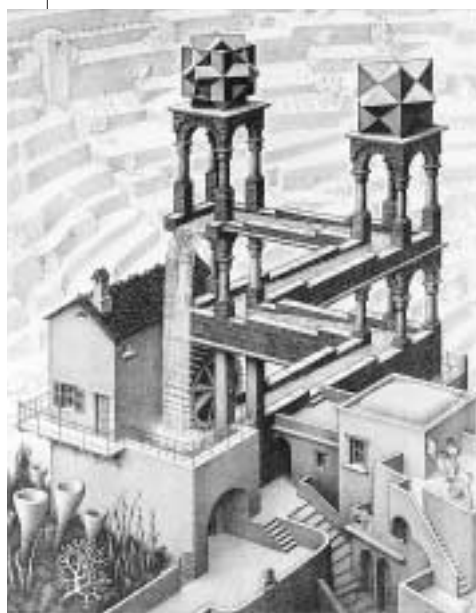
- What are the monocular and binocular cues, and how does binocular disparity explain our ability to see three-dimensional forms in two-dimensional images?
- What visual cues help us perceive motion and distance?
- Why do we perceive the size and shape of objects as unchanging despite changes in sensory input?

Being able to perceive the distance of an object has obvious survival value, especially regarding potential threats, such as snarling dogs or oncoming trains. But simply walking through your house or apartment also requires that you accurately judge the distance of furniture, walls, other people, and so forth. Otherwise, you'd be constantly bumping into doors, walls, and tables. The ability to perceive the distance of an object as well as the three-dimensional characteristics of an object is called **depth perception**.

Monocular Cues

We use a variety of cues to judge the distance of objects. The following cues require the use of only one eye. Hence, they are called **monocular cues** (*mono* means "one"). After familiarizing yourself with these cues, look at the photographs on the next page. Try to identify the monocular cues you used to determine the distance of the objects in each photograph.

1. *Relative size.* If two or more objects are assumed to be similar in size, the object that appears larger is perceived as being closer.
2. *Overlap.* When one object partially blocks or obscures the view of another object, the partially blocked object is perceived as being farther away.
3. *Aerial perspective.* Faraway objects often appear hazy or slightly blurred by the atmosphere.
4. *Texture gradient.* As a surface with a distinct texture extends into the distance, the details of the surface texture gradually become less clearly defined. The texture of the surface seems to undergo a gradient, or continuous pattern of change, from crisp and distinct when close to fuzzy and blended when farther away.
5. *Linear perspective.* Parallel lines seem to meet in the distance. For example, if you stand in the middle of a railroad track and look down the rails, you'll notice that the parallel rails seem to meet in the distance. The closer together the lines appear to be, the greater the perception of distance.
6. *Motion parallax.* When you are moving, you use the speed of passing objects to estimate the distance of the objects. Nearby objects seem to zip by faster than do distant objects. When riding on a commuter train, for example, houses and parked cars along the tracks seem to whiz by, while the distant downtown skyline seems to move very slowly.



M. C. Escher's Lithograph *Waterfall* (1961)
Misleading depth cues trick the viewer into
perceiving the water as flowing uphill.



Texture Gradient, Overlap, and Aerial Perspective When you look at a photograph, you rely on monocular cues to gauge the distance of the objects depicted. Here, the details of the tall grass are crisp in the foreground and fuzzy in the background, an example of texture gradient. The bushes are perceived as being closer than the house they overlap. Finally, the haze of the low-hanging cloud blurs the foothills, contributing to the perception of even greater distance. Linear perspective is also evident in the parallel wheel tracks in the grass that seem to converge.



Relative Size, Linear Perspective, and Aerial Perspective Several monocular depth cues are operating in this photograph. Relative size is particularly influential: The very small image of the jogger and the decreasing size of the street lamps contribute to the perception of distance. Linear perspective is evident in the apparent convergence of the walkway railings. Aerial perspective contributes to the perception of depth from the hazy background.



Motion Parallax This photograph of waiters in India passing a tray from one train car to the next captures the visual flavor of motion parallax. Objects that whiz by faster are perceptually judged as being closer, as in the case here of the blurred ground and bushes. Objects that pass by more slowly are judged as being farther away, as conveyed by the clearer details of buildings and more distant objects.

When monocular cues are used by artists to create the perception of distance or depth in paintings, they are referred to as *pictorial cues*. If you look at the cover of this book, you can see how artist Phoebe Beasley used pictorial cues, including overlap and relative size, to create the perception of depth in her artwork.

Another monocular cue is *accommodation*. Unlike pictorial cues, accommodation utilizes information about changes in the shape of the lens of the eye to help us estimate distance. When you focus on a distant object, the lens is flat, but focusing on a nearby object causes the lens to thicken. Thus, to some degree, we use information provided by the muscles controlling the shape of the lens to judge depth. In general, however, we rely more on pictorial cues than on accommodation for depth perception.

Binocular Cues

Binocular cues for distance or depth perception require information from both eyes. One binocular cue is *convergence*—the degree to which muscles rotate your eyes to focus on an object. The more the eyes converge, or rotate inward, to focus on an object, the greater the strength of the muscle signals and the closer the object is perceived to be. For example, if you hold a dime about six inches in front of your nose, you'll notice the slight strain on your eye muscles as your eyes converge to focus on the coin. If you hold the dime at arm's length, less convergence is needed. Perceptually, the information provided by these signals from your eye muscles is used to judge the distance of an object.

ED: Still true re: 3/e
cover art?

depth perception

The use of visual cues to perceive the distance or three-dimensional characteristics of objects.

monocular cues

(moe-NOCK-you-ler) Distance or depth cues that can be processed by either eye alone.

binocular cues

(by-NOCK-you-ler) Distance or depth cues that require the use of both eyes.



Binocular Disparity and the Perception of Depth in Stereograms This stereogram, *Rustling Hares*, was created by artist Hiroshi Kunoh (Kunoh & Takaoki, 1994). To see the three-dimensional images, first hold the picture close to your face. Focus your eyes as though you are looking at an object that is beyond the book and farther away. Without changing your focus, slowly extend your arms and move the picture away from you. The image of the leaves will initially be blurry, then details will come into focus and you should see three rabbits. The three-dimensional images that can be perceived in stereograms occur because of binocular disparity—each eye is presented with slightly different visual information.

Another binocular distance cue is *binocular disparity*. Because our eyes are set a couple of inches apart, a slightly different image of an object is cast on the retina of each eye. When the two retinal images are very different, we interpret the object as being close by. When the two retinal images are more nearly identical, the object is perceived as being farther away.

Here's a simple example that illustrates how you use binocular disparity to perceive distance. Hold a pencil just in front of your nose. Close your left eye, then your right. These images are quite different—that is, there is a great deal of binocular disparity between them. Thus you perceive the pencil as being very close. Now focus on another object across the room and look at it first with one eye closed, then the other. These images are much more similar. Because

there is less binocular disparity between the two images, the object is perceived as being farther away. Finally, notice that with both eyes open, the two images are fused into one.

A *stereogram* is a picture that uses the principle of binocular disparity to create the perception of a three-dimensional image (Kunoh & Takaoki, 1994). Look at the stereogram shown here. When you first look at it, you perceive a two-dimensional picture of leaves. Although the pictorial cues of overlap and texture gradient provide some sense of depth to the image, the elements in the picture appear to be roughly the same distance from you.

However, a stereogram is actually composed of repeating columns of carefully arranged visual information. If you focus as if you are looking at some object that is farther away than the stereogram, the repeating columns of information will present a slightly different image to each eye. This disparate visual information then fuses into a single image, enabling you to perceive a three-dimensional image—three rabbits! To see the rabbits, follow the directions in the caption.

3.3 R · E · V · I · E · W

C · O · N · C · E · P · T

Depth Perception

Several monocular depth cues are evident in this photograph of the Ginza, a major shopping and entertainment district of Tokyo, Japan. After studying the photograph, identify examples of the following monocular depth cues:

1. Relative size
2. Overlap
3. Aerial perspective
4. Texture gradient
5. Linear perspective



The Perception of Motion

Where Is It Going?

In addition to the ability to perceive the distance of stationary objects, we need the ability to gauge the path of moving objects, whether it's a baseball whizzing through the air, a falling tree branch, or an egg about to roll off the kitchen counter. How do we perceive movement?

As we follow a moving object with our gaze, the image of the object moves across the retina. Our eye muscles make microfine movements to keep the object in focus. We also compare the moving object to the background, which is usually stationary. When the retinal image of an object enlarges, we perceive the object as moving toward us. And our perception of the speed of the object's approach is based on our estimate of the object's rate of enlargement (Schrater & others, 2001). Neural pathways in the brain combine information about eye-muscle activity, the changing retinal image, and the contrast of the moving object with its stationary background (Wallach, 1987). The end result? We perceive the object as moving.

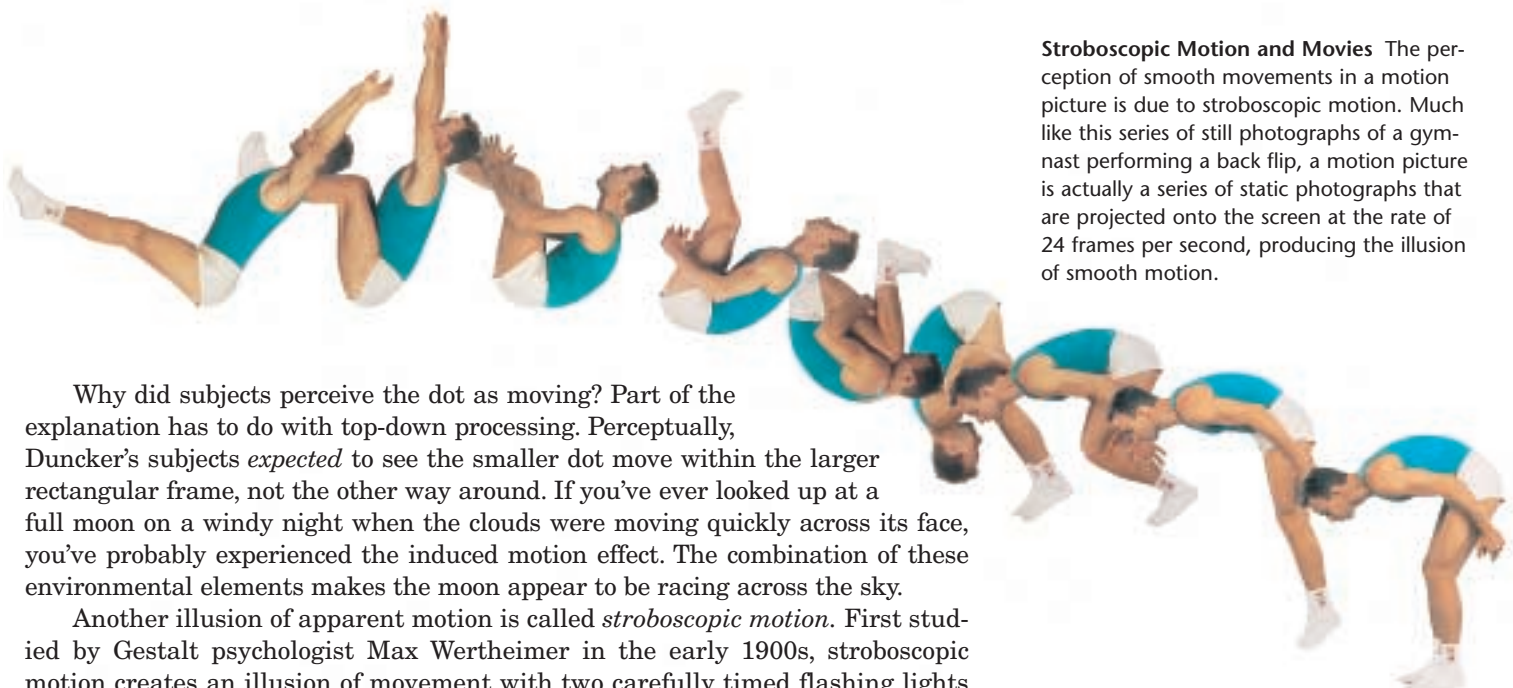
Neuroscientists do not completely understand how the brain's visual system processes movement. It's known that some neurons are highly specialized to detect motion in one direction but not in the opposite direction. Other neurons are specialized to detect motion at one particular speed. Research also shows that different neural pathways in the cerebral cortex process information about the depth of objects, movement, form, and color (Livingstone & Hubel, 1988; Zeki, 2001).

Psychologically, we tend to make certain assumptions when we perceive movement. For example, we typically assume that the *object*, or figure, moves while the background, or frame, remains stationary (Rock, 1995). Thus, as you visually follow a bowling ball down the alley, you perceive the bowling ball as moving and not the alley, which serves as the background.

Because we have a strong tendency to assume that the background is stationary, we sometimes experience an illusion of motion called *induced motion*. Induced motion was first studied by Gestalt psychologist **Karl Duncker** in the 1920s (King & others, 1998). Duncker (1929) had subjects sit in a darkened room and look at a luminous dot that was surrounded by a larger luminous rectangular frame. When the *frame* slowly moved to the right, the subjects perceived the *dot* as moving to the left.



Motion Perception As this center fielder dives for a fly ball, his brain is rapidly calculating information about the location, speed, and trajectory of the baseball. Psychologists still don't completely understand how the visual system perceives and predicts the motion of objects. Most of the time, we accomplish this complex feat with remarkable accuracy. But in this case, center fielder Jason Neilsen missed the ball!



Stroboscopic Motion and Movies The perception of smooth movements in a motion picture is due to stroboscopic motion. Much like this series of still photographs of a gymnast performing a back flip, a motion picture is actually a series of static photographs that are projected onto the screen at the rate of 24 frames per second, producing the illusion of smooth motion.

Why did subjects perceive the dot as moving? Part of the explanation has to do with top-down processing. Perceptually, Duncker's subjects *expected* to see the smaller dot move within the larger rectangular frame, not the other way around. If you've ever looked up at a full moon on a windy night when the clouds were moving quickly across its face, you've probably experienced the induced motion effect. The combination of these environmental elements makes the moon appear to be racing across the sky.

Another illusion of apparent motion is called *stroboscopic motion*. First studied by Gestalt psychologist Max Wertheimer in the early 1900s, stroboscopic motion creates an illusion of movement with two carefully timed flashing lights

perceptual constancy

The tendency to perceive objects, especially familiar objects, as constant and unchanging despite changes in sensory input.

size constancy

The perception of an object as maintaining the same size despite changing images on the retina.

shape constancy

The perception of a familiar object as maintaining the same shape regardless of the image produced on the retina.

perceptual illusion

The misperception of the true characteristics of an object or an image.

Müller-Lyer illusion

A famous visual illusion involving the misperception of the identical length of two lines, one with arrows pointed inward, one with arrows pointed outward.

The Doors of Perception Each door in the photograph is positioned at a different angle and thus produces a differently shaped image on your retinas. Nevertheless, because of the perceptual principle of shape constancy, you easily identify all five shapes as rectangular doors.



(Wertheimer, 1912). A light briefly flashes at one location, followed about a tenth of a second later by another light briefly flashing at a second location. If the time interval and distance between the two flashing lights are just right, a very compelling illusion of movement is created.

What causes the perception of stroboscopic motion? Although different theories have been proposed, researchers aren't completely sure. The perception of motion typically involves the movement of an image across the retina. However, during stroboscopic motion the image does *not* move across the surface of the retina. Rather, the two different flashing lights are detected at two different points on the surface of the retina. Somehow the brain's visual system combines this rapid sequence of visual information to arrive at the perceptual conclusion of motion, even though no movement has occurred. The perception of smooth motion in a movie is also due to stroboscopic motion.

Perceptual Constancies

Consider this scenario. As you're driving on a flat stretch of highway, a red SUV zips past you and speeds far ahead. As the distance between you and the SUV grows, its image becomes progressively smaller until it is no more than a dot on the horizon. Yet, even though the image of the SUV on your retinas has become progressively smaller, you don't perceive the vehicle as shrinking. Instead, you perceive its shape, size, and brightness as unchanged.

This tendency to perceive objects, especially familiar objects, as constant and unchanging despite changes in sensory input is called **perceptual constancy**. Without this perceptual ability, our perception of reality would be in a continual state of flux. If we simply responded to retinal images, our perceptions of objects would change as lighting, viewing angle, and distance from the object changed from one moment to the next. Instead, the various forms of perceptual constancy promote a stable view of the world.

Size Constancy

Size constancy is the perception that an object remains the same size despite its changing image on the retina. When our distance from an object changes, the image of the object that is cast on the retinas of our eyes also changes, yet we still perceive it to be the same size. The example of the red SUV illustrates the perception of size constancy. As the distance between you and the red SUV increased, you could eventually block out the retinal image of the vehicle with your hand, but you don't believe that your hand has suddenly become larger than the SUV. Instead, your brain automatically adjusts your perception of the vehicle's size by combining information about retinal image size and distance.

An important aspect of size constancy is that if the retinal image of an object does *not* change but the perception of its distance *increases*, the object is perceived as larger. To illustrate, try this: Stare at a 75-watt light bulb for about 10 seconds. Then focus on a bright, distant wall. You should see an afterimage of the light bulb on the wall that will look several times larger than the original light bulb. Why? When you looked at the wall, the lingering afterimage of the light bulb on your retina remained constant, but your perception of distance increased. When your brain combined and interpreted this information, your perception of the light bulb's size increased. Remember this demonstration. We'll mention it again when we explain how some perceptual illusions occur.

Shape Constancy

Shape constancy is the tendency to perceive familiar objects as having a fixed shape regardless of the image they cast on our retinas. Try looking at a familiar object, such as a door, from different angles, as in the accompanying photograph.

Your perception of the door's rectangular shape remains constant despite changes in its retinal image.

Shape constancy has a greater influence on your perceptions than you probably realize. Look at Figure 3.17, count the right angles, and write the number in the margin. If you're like most people, you probably counted 12 right angles in the drawing of the slightly tilted cube. Now look at it again, this time more carefully. There are *no* right angles in the drawing. Because of shape constancy, you perceived an image of a cube with right angles despite the lack of sensory information to support that perception.

Perceptual Illusions

Key Theme

- Perceptual illusions underscore the idea that we actively construct our perceptual representations of the world according to psychological principles.

Key Questions

- How can the Müller-Lyer and moon illusions be explained?
- What do perceptual illusions and impossible figures reveal about perceptual processes?
- What roles do perceptual sets, learning experiences, and culture play in perception?

Our perceptual processes are largely automatic and unconscious. On the one hand, this arrangement is mentally efficient. With a minimum of cognitive effort, we decipher our surroundings, answering important perceptual questions and making sense of the environment. On the other hand, because perceptual processing is largely automatic, we can inadvertently arrive at the wrong perceptual conclusion. When we misperceive the true characteristics of an object or an image, we experience a **perceptual illusion**.

During the last century, well over 200 perceptual illusions have been discovered. The perceptual contradictions of illusions are not only fascinating, but can also shed light on how the normal processes of perception guide us to perceptual conclusions. Given the basics of perception that we've covered thus far, you're in a good position to understand how and why some famous illusions seem to occur.

The Müller-Lyer Illusion

Look at the center line in each of the two photographs in Figure 3.18. Which line is longer? If you said the one in the bottom photo, then you've just experienced the **Müller-Lyer illusion**. In fact, the two center lines are the same length, even though they *appear* to have different lengths. You can confirm that they are the same length by measuring them. The same illusion occurs when you look at a simple drawing of the Müller-Lyer illusion, which is also shown in Figure 3.18.

The Müller-Lyer illusion is caused in part by visual depth cues that promote the perception that the bottom line is *farther* from you (Gregory, 1968; Rock, 1995). When you look at the photograph on the right, the center line is that of a wall jutting away from you. When you look at the drawing of the Müller-Lyer illusion on the right, the outward-pointing arrows create much the same visual effect—a corner jutting away from you. In the left photograph

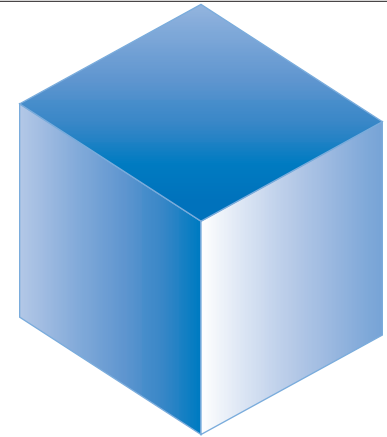
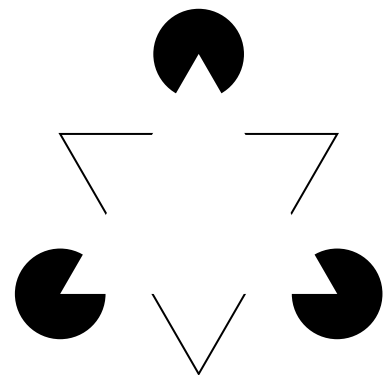


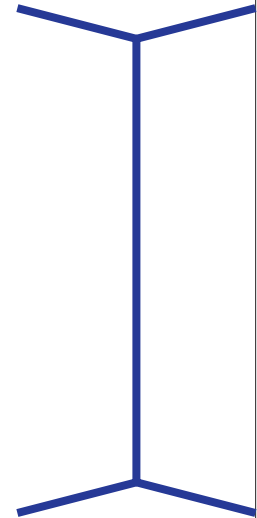
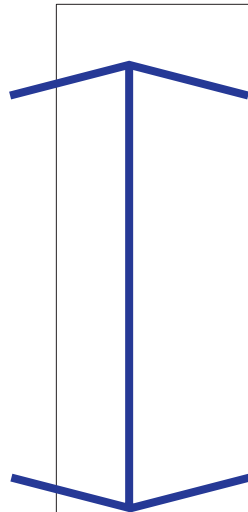
FIGURE 3.17 How many right angles do you see?



Illusory Contours The Gestalt principles of perceptual organization contribute to the illusion of triangular contours of this image. The second you look at this ambiguous image, you instantly reverse figure and ground so that the black circular regions become the ground, while the white region is visually favored as the figure. In organizing these visual fragments, which are lined up very precisely, the Gestalt principles of closure and good continuation contribute to the perceptual construction of a solid white triangle covering three black disks and an inverted triangle. An intriguing second illusion is also occurring: The pure white illusory triangle seems brighter than the surrounding white paper.



FIGURE 3.18 The Müller-Lyer Illusion Compare the two photographs. Which corner line is longer? Now compare the two line drawings. Which center line is longer? In reality, the center lines in the photographs and the line drawings are all exactly the same length, which you can prove to yourself with a ruler.



and line drawing, visual depth cues promote the perception of *lesser* distance—a corner that is jutting toward you.

Size constancy also seems to play an important role in the Müller-Lyer illusion. Because they are the same length, the two center lines in the photographs and the line drawings produce retinal images that are the same size. However, we noted in our earlier discussion of size constancy that if the retinal size of an object stays the same but the perception of its distance increases, we will perceive the object as being larger. Previously, we demonstrated this with the afterimage of a light bulb that seemed much larger when viewed against a distant wall.

The same basic principle seems to occur with the Müller-Lyer illusion. Although the two corner lines produce retinal images that are the same size, the bottom corner line is embedded in visual depth cues that make you perceive it as farther away. Hence, you perceive the bottom corner line as being longer, just as you perceived the afterimage of the light bulb as being larger when viewed on a distant wall.

Keep in mind that the arrows pointing inward or outward are responsible for creating the illusion in the Müller-Lyer illusion. Take away those potent depth cues and the Müller-Lyer illusion evaporates. You perceive the two lines just as they are—the same length.

The Moon Illusion

Another famous illusion is one you've probably experienced firsthand—the **moon illusion**, shown in Figure 3.19. When a full moon is rising on a clear, dark night, it appears much larger when viewed on the horizon against buildings and trees than it does when viewed in the clear sky overhead. But the moon, of course, doesn't shrink as it rises. In fact, *the retinal size of the full moon is the same in all positions*. Still, if you've ever watched the moon rise from the horizon to the night sky, it does *appear* to shrink in size. What causes this illusion?

Part of the explanation has to do with our perception of the distance of objects at different locations in the sky (Kaufman & Kaufman, 2000; Rock, 1995). Researchers have found that people perceive objects on the horizon as farther away than objects that are directly overhead in the sky. The horizon contains many familiar distance cues, such as buildings, trees, and the smoothing of the texture of the landscape as it fades into the distance. The moon on the horizon is

FIGURE 3.19 The Moon Illusion Dispelled The moon illusion is subjectively very compelling. When viewed on the horizon, the moon appears to be much larger than when it is viewed higher in the sky. But as this time-lapse sequence of the moon rising over the Seattle skyline shows, the size of the moon remains the same as it ascends in the sky.



perceived as being *behind* these depth cues, so the depth perception cue of overlap adds to the perception that the moon on the horizon is farther away.

The moon illusion also involves the misapplication of the principle of size constancy. Like the afterimage of the glowing light bulb, which looked larger on a distant wall, the moon looks larger when the perception of its distance increases. Remember, the retinal image of the moon is the *same* in all locations, as was the afterimage of the light bulb. Thus, even though the retinal image of the moon remains constant, we perceive the moon as being larger because it seems farther away on the horizon (Kaufman & Kaufman, 2000).

If you look at a full moon on the horizon through a cardboard tube, you'll remove the distance cues provided by the horizon. The moon on the horizon shrinks immediately—and looks the same size as it does when directly overhead.

Perceptual illusions underscore the fact that what we see is *not* merely a simple reflection of the world, but our subjective perceptual interpretation of it. And although seeing is said to be believing, in the case of illusions, believing can lead to seeing something that isn't really there.

Like any psychological process, perception can be influenced by many factors, including our expectations (Bruner, 1992). In the final section of this chapter, we'll consider how our prior experiences and cultural factors can influence our perceptions of reality.

The Effects of Experience on Perceptual Interpretations

Our educational, cultural, and life experiences shape what we perceive. As a simple example, consider airplane cockpits. If your knowledge of the instruments contained in an airplane cockpit is limited, as is the case with your author Sandy, an airplane cockpit looks like a confusing, meaningless jumble of dials. But your author Don, who is a pilot, has a very different perception of an airplane cockpit. Rather than a blur of dials, he sees altimeters, VORs, airspeed and RPM indicators, and other instruments, each with a specific function. Our different perceptions of an airplane cockpit are shaped by our prior learning experiences.

Learning experiences can vary not just from person to person but also from culture to culture. In Culture and Human Behavior Box 3.4 (on p. 118), we discuss the important role that experiences unique to a particular culture can play in the perception of illusions.

Past experience often predisposes us to perceive a situation in a particular way, even though other perceptions are possible. Consider this experience, which one of our students shared in class. As he was driving home late at night, he stopped at a convenience store to buy a pack of cigarettes. Standing at the counter and rummaging through his wallet for some cash, he requested “a pack of Nows.” When he looked up, the young female clerk had put a copy of *Penthouse* on the counter. Obviously, the clerk perceived what she had expected to hear.

This example illustrates the notion of **perceptual set**—the expectancies and predispositions that the observer brings to a perceptual situation. We're often mentally primed to interpret a particular perception in a particular way. Our perceptual sets are, of course, influenced by our prior learning experiences. One person's mystery dial is another person's altimeter.

Perceptual sets can exert a strong influence on the perceptual conclusions we reach. Our perceptual sets usually lead us to reasonably accurate conclusions. If they didn't, we would develop new perceptual sets that were more accurate. But sometimes a perceptual set can lead us astray. For example, when the partially decomposed body of a large, hairy creature was discovered in upstate New York, it generated much excitement because the remains were perceived by several people as

moon illusion

A visual illusion involving the misperception that the moon is larger when it is on the horizon than when it is directly overhead.

perceptual set

The influence of prior assumptions and expectations on perceptual interpretations.

CULTURE AND HUMAN BEHAVIOR 3.4

Culture and the Müller-Lyer Illusion: The Carpentered-World Hypothesis

The Gestalt psychologists believed that perceptual processes are inborn, a viewpoint called the *nativist position*. According to this position, people everywhere, whatever their background, see the world in the same way because they share the same perceptual rules. Other psychologists have advocated the *empiricist position*, believing that people actively construct their perceptions by drawing on their prior learning experiences, including cultural experiences.

The Müller-Lyer illusion has played a key role in the debate on this issue. Since the early 1900s, it has been known that people in industrialized societies are far more susceptible to the Müller-Lyer illusion than are people in some nonindustrialized societies (see Matsumoto, 1994). How can this difference be explained?

Cross-cultural psychologist Marshall Segall and his colleagues (1963, 1966) proposed the *carpentered-world hypothesis*. They suggested that people living in urban, industrialized environments have a great deal of perceptual experience in judging lines, corners, edges, and other rectangular, manufactured objects. Thus, people in carpentered cultures would be more susceptible to the Müller-Lyer illusion, which involves arrows mimicking a corner that is jutting toward or away from the perceiver.

In contrast, people who live in noncarpentered cultures more frequently encounter natural objects. In these cultures, perceptual experiences with straight lines and right angles are relatively rare. Segall predicted that people from these cultures would be less susceptible to the Müller-Lyer illusion.



A Noncarpentered Environment People who live in urban, industrialized environments have a great deal of perceptual experience with straight lines, edges, and right angles. In contrast, people who live in a noncarpentered environment, like the village shown here, have little experience with right angles and perfectly straight lines. Are people who grow up in a noncarpentered environment equally susceptible to the Müller-Lyer illusion?

To test this idea, Segall and his colleagues (1963, 1966) compared the responses of people living in carpentered societies, such as Evanston, Illinois, with those of people living in noncarpentered societies, such as remote areas of Africa. The results confirmed their hypothesis. The Müller-Lyer illusion was stronger for those living in carpentered societies. The findings provided strong support for the idea that culture could influence perception.

However, nativists were quick to suggest that Segall's results might be due to racial rather than cultural differences. After all, they pointed out, the non-Western subjects in Segall's research

were mostly Africans, and racial differences in eye pigmentation had been shown to affect the ability to visually detect contours (see Segall, 1994). Could the difference in illusion susceptibility be due to some sort of physiological difference rather than a cultural difference?

To address this issue, psychologist V. M. Stewart (1973) returned to Evanston and compared groups of white and African-American schoolchildren living there. Stewart found that the Evanston children, regardless of race, were equally susceptible to the Müller-Lyer illusion. She then compared groups of black African children in five different areas of Zambia—ranging from the very carpentered capital city of Lusaka to rural, noncarpentered areas of the country.

The results of this second comparison? The African children living in the carpentered society of Lusaka were just as susceptible to the illusion as were the white and African-American children living in Evanston. And the children living in the rural, noncarpentered countryside were far less susceptible. In other words, the children's race made no difference at all. What mattered was the children's experience, or lack of experience, with a carpentered environment.

Clearly, differences in susceptibility to the Müller-Lyer illusion underscore the important role that cultural experiences can play in shaping our perceptions. Segall (1994) summarized the empiricist view: "Every perception is the result of an interaction between a stimulus and a perceiver shaped by prior experience." Thus, people from very different cultural backgrounds might well perceive aspects of the world differently.

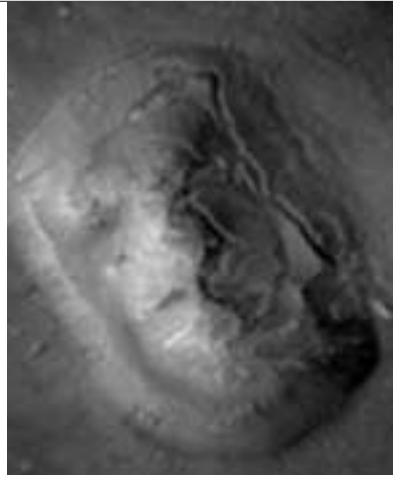
proof of the existence of "Bigfoot" (Hines, 1988). Scientists operating with a different perceptual set examined the dead creature and duly proclaimed it for what it was—the remains of a brown bear.

Similar examples of erroneous perceptual sets have occurred with supposed sightings of UFOs, the Loch Ness monster, mermaids, and ghosts. In each case, observers interpreted ambiguous stimuli in terms of the perceptual set they held in that situation and saw what their expectations led them to see.

In this chapter, we've seen the interaction of biological, behavioral, and psychological factors. As Paul's and Warren's stories illustrated, our experience



(a)



(b)

Evidence of Extra-Terrestrial Civilizations?

(a) Perceptual set may lead the avid believer in UFOs to see this photograph of unusual cloud formations as evidence for the existence of flying saucers. (b) Was it built by ancient astronauts, or perhaps by the artisans of an ancient Martian civilization? Perceptual set led many people to see a “face” in this dimly lit rock formation on Mars, photographed by NASA’s *Viking 1* expedition. Higher-resolution photos taken at a later date revealed the mile-long “face” to be nothing more than one of many similar features sculpted into the planet’s rocky surface by wind.

of the world is highly dependent on our physiology, specifically, our sense organs. Paul and Warren both live in a world without odor or aroma—olfactory cues that are important to many people, and as essential as sight to many other species.

The process of sensation results in the transmission of neural messages to the brain, where the psychological process of perception occurs. We actively construct perceptual conclusions about this sensory information. In arriving at those perceptual conclusions, we are guided by well-established perceptual principles, such as the cues that typically indicate distance, movement, form, and so forth. But our perceptual conclusions can also be influenced by a variety of psychological factors, including our expectations, learning experiences, and experiences that are unique to our culture.

3.4 R · E · V · I · E · W

C · O · N · C · E · P · T

Perceptual Principles

Fill in the blanks using the correct term.

1. When Jenny was flying to the South Pacific, she saw several lush green islands that stood out in a sea of bright blue. In this example, the islands are the _____ and the sea is the _____.
2. As the football is hurtling toward you, it creates a progressively larger image on your retina, and the angle of the ball is constantly changing. Despite these drastic changes in sensory output, the phenomena of _____ and _____ enable you to continue to perceive the object as a football.
3. •••• •••• •••• If you followed the law of _____, you perceived this arrangement as three groups of four dots.
4. ○○○○••••○○○○•••• If you followed the law of _____, you perceived this arrangement as two groups of four circles and two groups of four dots.
5. Hundreds of people flocked to an Indiana town when it was reported that the face of a religious figure had appeared in a rust stain on the side of a water tower. This perception was probably an example of _____.

APPLICATION

Strategies to Control Pain

There are several strategies for controlling pain. Each of the following simple self-administered techniques can be useful for dealing with the everyday pain of a headache, an injury, or a trip to the dentist. Of course, the techniques described here are not a substitute for seeking appropriate medical attention, especially when pain is severe, recurring, or of unknown origin.

1. Distraction

By actively focusing your attention on some nonpainful stimulus, you can often reduce pain (see Cohen, 2002; Turk & Nash, 1993). For example, you can mentally count backward by 7s from 901; multiply pairs of two-digit numbers; draw different geometric figures in your head; or count ceiling tiles. You can also stare at the details of a picture or other object or intently listen to music.

2. Imagery

One form of distraction is imagery. Creating a vivid mental image can help control pain (Rossman, 1993). Usually people create a pleasant and progressive scenario, such as walking along the beach or hiking in the mountains. Aggressive imagery can also be useful, such as imagining fighting an enemy or driving a race car (Lyles & others, 1982). Whatever scenario you use, try to imagine all the different sensations involved, including the sights, sounds, aromas, touches, and tastes. The goal is to become so absorbed in your fantasy that you distract yourself from sensations of pain.

3. Positive self-talk

This strategy involves making positive coping statements, either silently or out

loud, during a painful episode or procedure (Cioffi & Holloway, 1993; Fernandez, 1986). Examples of positive self-talk include statements such as “It hurts, but I’m okay, I’m in control”; “I’m uncomfortable, but I can handle it”; and “The pain is uncomfortable but not unbearable.”

Such self-talk can also include redefining the pain. By using realistic and constructive thoughts about the pain experience in place of threatening or harmful thoughts, you can minimize pain (McCaul & Malott, 1984). For example, an athlete in training might say, “The pain means my muscles are getting stronger.” Someone wearing orthodontic braces might tell himself that the pain means that his teeth are moving into place.

4. Counterirritation

The technique of counterirritation has been used for centuries. Counterirritation decreases pain by creating a strong, competing sensation that’s mildly stimulating or irritating. People often do this naturally, as when they vigorously rub an injury or bite their lip during an injection. How does rubbing the area where an injury has occurred reduce pain? The intense sensations of pain and the normal sensations of touch are processed through different nerve fibers going to the spinal cord. Increasing normal sensations of touch interferes with the transmission of high-intensity pain signals.

While undergoing a painful procedure, you can create and control a competing discomfort by pressing your thumbnail into your index finger. Focusing your at-

tention on the competing discomfort may lessen your overall experience of pain.

5. Relaxation

Deep relaxation can be a very effective strategy for deterring pain sensations (Benson, 1993; Turk & Nash, 1993). Relaxation procedures can be used in a particular situation or can be practiced repeatedly during prolonged pain. One simple strategy to achieve relaxation is deep breathing: Inhale deeply, then exhale very slowly and completely, releasing tension throughout your body. As you exhale, consciously note the feelings of relaxation and warmth you’ve produced in your body.

Beyond these self-administered strategies, pain specialists use a variety of techniques to control pain, including painkilling drugs and hypnosis. Both of these topics will be discussed in the next chapter. Another strategy is biofeedback. *Biofeedback* is a process of learning voluntary control over largely automatic body functions, such as heart rate, blood pressure, and muscle tension. Using sensitive equipment that signals subtle changes in a specific bodily function, people can learn to become more aware of their body’s signals and exercise conscious control over a particular bodily process. For example, an individual who experiences chronic tension headaches might use biofeedback to learn to relax shoulder, neck, and facial muscles. Biofeedback has proven effective in helping many people who experience tension headaches, migraine headaches, jaw pain, and back pain (M. S. Schwartz & N. M. Schwartz, 1993).

Chapter Review

Sensation and Perception

Key Points

Introduction: What Are Sensation and Perception?

- **Sensation** refers to the response of sensory receptors in the sense organs to stimulation and the transmission of that information to the brain. **Perception** refers to the process through which the brain organizes and interprets sensory information.
- When **sensory receptors** are stimulated by an appropriate form of energy, **transduction** converts the energy into neural impulses, which are transmitted to the brain.
- Each sense is specialized in terms of the type and level of energy to which it will respond. Sensory thresholds include the **absolute threshold** and the **difference threshold**. **Weber's law** states that the just noticeable difference will vary depending on the strength of the original stimulus. **Sensory adaptation** takes place when the sensory receptor cells gradually decline in sensitivity to a constant stimulus.

Vision: From Light to Sight

- The sensory receptors for vision respond to light waves. The human eye is sensitive to a very narrow, specific range of **wavelengths** in the electromagnetic energy spectrum.
- Light waves enter the eye and pass through the **cornea** and the **pupil**. The **iris** controls how much light is allowed in. Behind the pupil is the **lens**, which focuses light on the **retina** through **accommodation**. The retina contains the sensory receptors for vision, the rods and cones.
- **Rods** are used for vision in dim light and for peripheral vision. **Cones** are used for color vision, for vision in bright light, and for seeing fine details. Cones are concentrated in the **fovea**, whereas rods are more prevalent in the periphery of the retina. There are no rods or cones in the **optic disk**, which creates a **blind spot** in the visual field.
- Rods and cones send information to the **bipolar** and **ganglion cells**. The ratio of cones to ganglion cells is much smaller than the ratio of rods to ganglion cells. The **optic nerve** fibers exit the back of each retina at the optic disk and meet at the **optic chiasm**, where some of the fibers cross over to the opposite side of the brain and then transmit information from the thalamus to the visual cortex. Feature detectors are highly specialized neurons in the visual cortex.
- **Color** is the psychological experience of different wavelengths of light and involves **hue**, **brightness**, and **saturation**. The color of an object is determined by the light wave it reflects. In combination, the **trichromatic theory** and the **opponent-process theory** explain color vision. The trichromatic theory explains red-green **color blindness** and color processing in the retina. The opponent-process theory explains **afterimages** and color processing in the ganglion cells and the brain.

Hearing: From Vibration to Sound

- The sense of hearing is called **audition**. The **loudness**, **pitch**, and **timbre** of a sound are determined by the **amplitude**, **frequency**, and complexity of a sound wave. Loudness is measured in **decibels**.
- Sound waves are collected in the **outer ear**, amplified by the **eardrum** in the **middle ear**, and transduced in the **inner ear**. The sensory receptors for hearing are the **hair cells**, which are located on the **basilar membrane** in the **cochlea**. The auditory nerve carries information to the thalamus and auditory cortex in the brain.

The Chemical and Body Senses: Smell, Taste, Touch, and Position

- The sensory receptors for smell (**olfaction**) and taste (**gustation**) are specialized to respond to chemical substances. The sensation of smell is caused by airborne molecules stimulating odor receptors on the olfactory receptor cells in the nasal lining. Olfactory information travels via the axons of the receptor cells to the **olfactory bulb** and is transmitted along the olfactory tract to different brain areas, including the temporal lobe and limbic system.
- Taste results from the stimulation of sensory receptors in the **taste buds**, which are located on the tongue and the inside of the mouth. When activated by chemical substances dissolved in saliva, the taste buds send neural messages to the thalamus in the brain. There are five primary tastes: sweet, salty, sour, bitter, and umami.
- The skin includes several kinds of sensory receptors, which are unevenly distributed among the parts of the body. The Pacinian corpuscle is the skin receptor that is sensitive to pressure.
- **Pain** sensation is partly explained by the **gate-control theory**. Pain sensations result from the release of a neurotransmitter called **substance P**. The transmission of pain signals is inhibited by the release of endorphins. Psychological factors mediate the experience of pain.
- The **kinesthetic sense** involves the location and position of body parts in relation to one another, which is detected by specialized neurons called **proprioceptors**. The **vestibular sense** provides information about balance, equilibrium, and orientation.

Perception

- Both **bottom-up** and **top-down processing** are involved in everyday perception. The **Gestalt** psychologists emphasized the perception of *gestalts*, or whole forms.
- We rely primarily on shape to identify an object. **Figure-ground relationships** are important in distinguishing an object from its background. The Gestalt psychologists noted

perceptual principles of organization including proximity, similarity, closure, good continuation, and the law of Prägnanz.

- **Depth perception** involves both monocular and binocular cues. **Monocular depth cues** include relative size, overlap, aerial perspective, texture gradient, linear perspective, motion parallax, and accommodation. **Binocular depth cues** include convergence and binocular disparity.
- The perception of movement involves integrating information from the eye muscles, the retina, and the environment. The illusion of induced motion is a result of our assumption that the background is stationary. The perception of stroboscopic motion results from images being rapidly registered on the retina.
- Objects are perceived as stable despite changes in sensory input and retinal image, a concept called **perceptual constancy**. **Size constancy** and **shape constancy** are two important forms of perceptual constancy.

Perceptual Illusions

- **Perceptual illusions** and impossible figures are used to study perceptual principles. The **Müller-Lyer illusion** involves the principles of depth cues and size constancy. The **moon illusion** results from the principles of overlap and size constancy.

The Effects of Experience on Perceptual Interpretations

- Perceptual interpretations can be influenced by learning experiences, culture, and expectations. **Perceptual set** often determines the interpretation of an ambiguous stimulus.

Key Terms

sensation, p. 84	optic disk, p. 91	pitch, p. 97	proprioceptors, p. 103
perception, p. 84	blind spot, p. 91	frequency, p. 97	vestibular sense, p. 103
sensory receptors, p. 85	ganglion cells, p. 91	timbre, p. 97	bottom-up processing, p. 105
transduction, p. 85	bipolar cells, p. 91	outer ear, p. 98	top-down processing, p. 105
absolute threshold, p. 86	optic nerve, p. 92	eardrum, p. 98	ESP (extrasensory perception), p. 106
difference threshold, p. 86	optic chiasm, p. 92	middle ear, p. 98	parapsychology, p. 106
Weber's law, p. 86	color, p. 93	inner ear, p. 98	Gestalt psychology, p. 107
sensory adaptation, p. 87	hue, p. 93	cochlea, p. 98	figure-ground relationship, p. 108
subliminal perception, p. 87	saturation, p. 93	basilar membrane, p. 98	depth perception, p. 110
wavelength, p. 88	brightness, p. 94	hair cells, p. 98	monocular cues, p. 110
cornea, p. 89	trichromatic theory of color vision, p. 94	olfaction, p. 99	binocular cues, p. 111
pupil, p. 89	color blindness, p. 94	gustation, p. 99	perceptual constancy, p. 114
iris, p. 89	afterimage, p. 95	olfactory bulb, p. 100	size constancy, p. 114
lens, p. 89	opponent-process theory of color vision, p. 95	pheromones, p. 100	shape constancy, p. 114
accommodation, p. 89	audition, p. 96	taste buds, p. 101	perceptual illusion, p. 115
retina, p. 90	loudness, p. 96	pain, p. 102	Müller-Lyer illusion, p. 115
rods, p. 90	amplitude, p. 96	gate-control theory, p. 102	moon illusion, p. 116
cones, p. 90	decibel, p. 96	substance P, p. 103	perceptual set, p. 117
fovea, p. 90		kinesthetic sense, p. 103	

Key People

Karl Duncker (1903–1940) German Gestalt psychologist who is best known for his studies on the perception of motion; also studied the perception of pain and the effects of past experience on perception; immigrated to the United States in 1938. (p. 113)	Max Wertheimer (1880–1943) German psychologist who founded Gestalt psychology in the early 1900s, immigrated to the United States in 1933, studied the optical illusion of apparent movement, and described principles of perception. (p. 107)
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Concept Review Answers

3.1 page 96

- 1. transduction
- 2. retina
- 3. bipolar; ganglion; optic chiasm; visual cortex
- 4. trichromatic
- 5. blue; opponent-process

3.2 page 104

- 1. basilar; cochlea
- 2. thalamus
- 3. olfactory bulb
- 4. conduction deafness
- 5. substance P
- 6. kinesthetic

3.3 page 112

- 1. *Relative size.* The cars, people, street posts, and banners at the bottom of the photo seem closer because they are larger than those toward the top of the photo.
- 2. *Overlap.* Many objects in the photograph are partially obscured by other objects—such as the signs, people, and vehicles. In each case, the object that is not obscured is perceived as being closer.

- 3. *Aerial perspective.* The buildings in the upper middle of the photograph are fuzzy and slightly blurred, and thus are perceived as being farther away.
- 4. *Texture gradient.* Details of the sidewalk, street, and cars are crisp in the foreground but become progressively more blurred as you move toward the top of the photograph.
- 5. *Linear perspective.* The parallel boundaries of the street, the lines of yellow and orange banners, and the lines of parked cars seem to converge at the top of the photo, creating a sense of greater distance.

3.4 page 119

- 1. figure; ground
- 2. size constancy; shape constancy
- 3. proximity
- 4. similarity
- 5. perceptual set

Web Companion Review Activities

You can find additional review activities at www.worthpublishers.com/hockenbury. The *Discovering Psychology* 3e Web Companion has a self-scoring practice quiz, flashcards, two interactive crossword puzzles, and other activities to help you master the material in this chapter.

4CO

chapter

Consciousness and Its Variations

4

Chapter Outline

Prologue: A Scream in the Night

Introduction: Consciousness: Experiencing the "Private I"

Biological and Environmental "Clocks" That Regulate Consciousness

Sleep

Box 4.1: What You Really Want to
Know About Sleep

Dreams and Mental Activity During Sleep

Focus on Neuroscience: Brain Changes
During REM Sleep

Box 4.2: What You Really Want to
Know About Dreams

Hypnosis

Box 4.3: Is Hypnosis a Special State of
Consciousness?

Meditation

Focus on Neuroscience: Brain Changes
During Peak Meditation Experiences

Psychoactive Drugs

APPLICATION: Improving Sleep and Mental Alertness

Chapter Review

A Scream in the Night

Our friends Mike and Nina had been married for only four months, but they already had their nighttime routine down. Both of them needed to get up early in the morning—Nina worked the 7 A.M. to 3 P.M. shift as a neurology nurse, and Mike had to open the gift shop he managed at a large downtown hotel by 7:30 A.M. A confirmed night person, Nina had worked the 3-to-11 shift ever since she became a registered nurse. She had recently switched to the day shift so her schedule would mesh better with Mike's. But even after a couple of weeks, she was still having difficulty adjusting to the early morning schedule. "My brain feels foggy until about noon," she complained to Mike.

One night, Nina and Mike crawled into bed, both exhausted. As they drifted off to sleep, Mike kept thinking about his job. His new boss had hinted that he really didn't like the way Mike was running the store. Mike closed his eyes and waited for his thoughts to slow down. As he relaxed, he thought about the shipment of greeting cards that was supposed to arrive early the next morning and imagined himself sorting through boxes at work. Just as he felt himself gently drifting off . . . "Ouch! Nina, stop kicking me!" he cried.

"I was sound asleep," Nina replied sleepily. "How could I have kicked you? You're imagining things, Michael. Just go to sleep."

Mike closed his eyes. A few moments later, he felt Nina's leg twitching and jerking against his, her breathing rhythmical as she snored lightly. He sighed and rolled over.

A few hours later, Mike was having a vivid dream about his new boss. His boss was standing at the top of a giant staircase, and Mike was at the bottom looking up. The dream scene switched quickly. Now Mike was at the top of a very tall escalator that wound around downward in a tight spiral in empty space, the escalator steps moving faster and faster. Terrified, he grabbed the edge of the escalator and held on, falling away, then struggling to swim back through midair. Suddenly, a blood-curdling scream cut through his dream.

Heart pounding, Mike jolted awake. *Am I dreaming?*

In the darkness, Nina screamed again.

Oh my God, there's someone in the apartment!

Mike leaped out of bed and fumbled for the baseball bat he kept underneath the bed. Shaking, he switched on the light. Nina was sitting up in bed, her eyes wide open, hands clasping her throat. Staring straight ahead, she screamed a third time, kicking at the blankets.

"Nina! What's wrong?!" Mike quickly scanned the bedroom. He ran out into the living room and turned on the lights. The front door was still securely locked and bolted from the inside. Baseball bat in hand, he ran into the kitchen. The back door was locked, the chain latch undisturbed. Completely baffled, he took a deep breath and walked back to the bedroom. "Nina, why did you scream?"

Nina didn't answer. She was slumped back down in bed, her eyes closed, sound asleep. She was the picture of blissful slumber. His heart still pounding, Mike stood in the doorway for another minute or so, watching Nina sleep. Nina sighed deeply and rolled over, snuggling toward Mike's side of the bed.

Finally, Mike shut off the lights and climbed into bed, his mind racing as he mentally replayed the incident. Now, every creak of the floor and rattle of the windows seemed to signal an intruder or some other danger. He glanced at the clock—12:47 A.M. Another 15 minutes passed before he got out of bed and padded into the kitchen. Reaching into the freezer for some ice cubes, he fixed himself a vodka and tonic. Toby, the cat, rounded the corner and joined him in the kitchen. As Toby rubbed up against his leg, Mike lit a cigarette and stared out the kitchen window into the darkness. *Why did Nina scream?*

In this chapter, we'll answer that question and tell you more about Nina's history of sleep disturbances. As you'll learn, this was not the first time—nor the last—that Nina screamed in her sleep for no apparent reason.

Sleep and dreaming are among the topics that we'll cover in this chapter as we look at consciousness and how it changes over the course of each day. Psychologists have learned a great deal about the daily fluctuations of consciousness as well as about the different ways that alterations in consciousness can be induced, such as through the use of hypnosis, meditation, or psychoactive drugs.

Introduction

Consciousness

Experiencing the "Private I"

Key Theme

- Consciousness refers to your immediate awareness of internal and external stimuli.

Key Questions

- What did William James mean by the phrase *stream of consciousness*?
- How has research on consciousness evolved over the past century?

Your immediate awareness of thoughts, sensations, memories, and the world around you represents the experience of **consciousness** (Hobson, 1999). That the experience of consciousness can vary enormously from moment to moment is easy to illustrate. Imagine that we could videotape three one-minute segments of your conscious activities at different times while your psychology instructor lectures in class. What might those three one-minute segments of consciousness reveal? Here are just a few of the possibilities:

- Focused concentration on your instructor's words and gestures
- Drifting from one fleeting thought, memory, or image to another

consciousness

Personal awareness of mental activities, internal sensations, and the external environment.

- Awareness of physical sensations, such as the beginnings of a headache or the sharp sting of a paper cut
- Replaying an emotionally charged conversation and thinking about what you wish you had said
- Sexual fantasies
- Mentally rehearsing what you'll say and how you'll act when you meet a friend later in the day
- Wishful, grandiose daydreams about the future

Most likely, the three video clips would reveal very different scenes, dialogues, and content as your consciousness changed from one minute to the next. Yet even though your conscious experience is constantly changing, you don't experience your personal consciousness as disjointed. Rather, the subjective experience of consciousness has a sense of continuity. One stream of conscious mental activity seems to blend into another, effortlessly and seamlessly.

This characteristic of consciousness led the influential American psychologist **William James** (1892) to describe consciousness as a "stream" or "river." Although always changing, consciousness is perceived as unified and unbroken, much like a stream. Despite the changing focus of our awareness, our experience of consciousness as unbroken helps provide us with a sense of personal identity that has continuity from one day to the next.

The nature of human consciousness was one of the first topics to be tackled by the fledgling science of psychology in the late 1800s. In Chapter 1, we discussed how the first psychologists tried to determine the nature of the human mind through *introspection*—verbal self-reports that tried to capture the "structure" of conscious experiences. But because such self-reports were not objectively verifiable, many of the leading psychologists at the turn of the twentieth century rejected the study of consciousness. Instead, they emphasized the scientific study of *overt behavior*, which could be directly observed, measured, and verified.

Beginning in the late 1950s, many psychologists once again turned their attention to the study of consciousness. This shift occurred for two main reasons. First, it was becoming clear that a complete understanding of behavior would *not* be possible unless psychologists considered the role of conscious mental processes in behavior.

Second, although the experience of consciousness is personal and subjective, psychologists had devised more objective ways to study conscious experiences. For example, psychologists could often *infer* the conscious experience that seemed to be occurring by carefully observing behavior. Technological advances in studying brain activity were also producing intriguing correlations between brain activity and different states of consciousness.

Today, the scientific study of consciousness is incredibly diverse. Working from a variety of perspectives, psychologists and other neuroscientists are piecing together a picture of consciousness that takes into account the role of psychological, physiological, social, and cultural influences.



Consciousness, then, does not appear to itself chopped up in bits. . . . It is nothing jointed; it flows. A "river" or a "stream" are the metaphors by which it is most naturally described. In talking of it hereafter, let us call it the stream of thought, or consciousness, of subjective life.

William James (1892)



Circadian Rhythms, Mental Alertness, and Traffic Accidents We experience two dips in mental alertness each day, at about 3:00 P.M. and 3:00 A.M. It's not surprising, then, that traffic accidents are more likely when mental alertness is low. When more than 6,000 fatigue-related traffic accidents were analyzed, it was found that the highest number of accidents occurred at 3:00 A.M. During the daytime, traffic accidents peaked at around 3:00 P.M. (Mitler, 1994).

circadian rhythm
(ser-KADE-ee-en) A cycle or rhythm that is roughly 24 hours long; the cyclical daily fluctuations in biological and psychological processes.

suprachiasmatic nucleus (SCN)
(soup-rah-kye-az-MAT-ick) A cluster of neurons in the hypothalamus in the brain that governs the timing of circadian rhythms.

melatonin
(mel-ah-TONE-in) A hormone manufactured by the pineal gland that produces sleepiness.

Biological and Environmental “Clocks” That Regulate Consciousness

- Key Theme**
- Many body functions, including mental alertness, are regulated by circadian rhythms, which systematically vary over a 24-hour period.
- Key Questions**
- How do sunlight, the suprachiasmatic nucleus, and melatonin regulate the sleep–wake cycle?
 - How do free-running conditions affect circadian rhythms?
 - What is jet lag, and how is it produced?

Throughout the course of the day, there is a natural ebb and flow to consciousness. The most obvious variation of consciousness that we experience is the daily sleep–wake cycle. But conscious states also change in more subtle ways.

For example, you’ve probably noticed that your mental alertness varies throughout the day in a relatively consistent way. Most people experience two distinct peaks of mental alertness: one in the morning, usually around 9:00 or 10:00 A.M., and one in the evening, around 8:00 or 9:00 P.M. In between these two peaks, you’ll probably experience a slump in mental alertness at about 3:00 P.M. And, should you manage to stay awake, your mental alertness will probably reach its lowest point at about 3:00 A.M. One practical implication of this consistent daily pattern is the increase in the number of traffic accidents at the times when mental alertness is at its lowest points.

Mental alertness and the sleep–wake cycle are just two examples of the daily highs and lows you experience in a wide variety of bodily processes. These daily cycles are called **circadian rhythms**. The word *circadian* combines the Latin words for “about” and “day.” So, the term *circadian rhythms* refers to biological processes that systematically vary over a period of about 24 hours.

You actually experience many different circadian rhythms that ebb and flow over the course of any given 24-hour period (see Table 4.1). Researchers have discovered over 100 bodily processes that rhythmically peak and dip each day, including blood pressure, the secretion of different hormones, and pain sensitivity.

Table 4.1

Examples of Human Circadian Rhythms

Function	Typical Circadian Rhythm
Peak mental alertness and memory functions	Two daily peaks: around 9:00 A.M. and 9:00 P.M.
Lowest body temperature	About 97°F around 4:00 A.M.
Highest body temperature	About 99°F around 4:00 P.M.
Peak physical strength	Two daily peaks: around 11:00 A.M. and 7:00 P.M.
Peak hearing, visual, taste, and smell sensitivity	Two daily peaks: around 3:00 A.M. and 6:00 P.M.
Lowest sensitivity to pain	Around 4:00 P.M.
Peak sensitivity to pain	Around 4:00 A.M.
Peak degree of sleepiness	Two daily peaks: around 3:00 A.M. and 3:00 P.M.
Peak melatonin hormone in blood	Between 1:00 A.M. and 3:00 A.M.
Peak allergic sensitivity to pollen and dust	Between 11:00 P.M. and 1:00 A.M.

SOURCES: Campbell (1997); Czeisler & Dijk (2001); Refinetti (2000); M. Young (2000).

Normally, your circadian rhythms are closely synchronized with one another. For example, the circadian rhythm for the release of growth hormone is synchronized with the sleep–wake circadian rhythm so that growth hormone is released only during sleep.

The Suprachiasmatic Nucleus

The Body's Clock

Your many circadian rhythms are controlled by a master biological clock—a tiny cluster of neurons in the *hypothalamus* in the brain. As shown in Figure 4.1, this cluster of neurons is called the **suprachiasmatic nucleus**, abbreviated **SCN**. The SCN is the internal pacemaker that governs the timing of circadian rhythms, including the sleep–wake cycle and the mental alertness cycle (Weaver, 1998).

Keeping the circadian rhythms synchronized with one another and on a 24-hour schedule also involves environmental time cues. The most important of these cues is bright light, especially sunlight. In people, light detected by special photoreceptors in the eye is communicated via the visual system to the SCN in the hypothalamus (Brainard & others, 2001a, 2001b).

How does sunlight help regulate the sleep–wake cycle and other circadian rhythms? As the sun sets each day, the decrease in available light is detected by the SCN through its connections with the visual system. In turn, the SCN triggers an increase in the production of a hormone called **melatonin**. Melatonin is manufactured by the *pineal gland*, an endocrine gland located in the brain.

Increased blood levels of melatonin make you sleepy and reduce activity levels. At night, blood levels of melatonin rise, peaking between 1:00 and 3:00 A.M. Shortly before sunrise, the pineal gland all but stops producing melatonin, and you soon wake up. As the sun rises, exposure to sunlight and other bright light suppresses melatonin levels, and they remain very low throughout the day. In this way, sunlight *entrains*, or sets, the SCN so that it keeps circadian cycles synchronized and operating on a 24-hour schedule (Czeisler & Wright, 1999; Lavie, 2001).

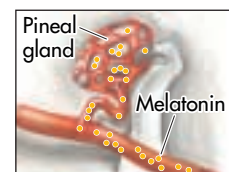
Life Without a Sundial

Free-Running Circadian Rhythms

Given that sunlight is responsible for setting your internal clock, what would happen to the timing of your circadian rhythms if they were allowed to “run free” in the absence of environmental time cues like sunlight and clocks? To create *free-running conditions*, researchers typically use underground isolation units. In some studies, they have even constructed rooms in caves. Volunteers live in these underground bunkers for weeks or months at a time, deprived of all environmental time cues (Webb, 1994).

Under free-running conditions, two distinct effects occur (Kronauer, 1994; Lewy & Sack, 1987). First, in the absence of normal

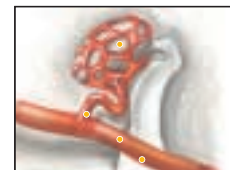
FIGURE 4.1 The Biological Clock Special photoreceptors in the retina regulate the effects of light on the body's circadian rhythms (Brainard & others, 2001a). In response to morning light, signals from these special photoreceptors are relayed via the optic nerve to the suprachiasmatic nucleus. In turn, the suprachiasmatic nucleus causes the pineal gland to reduce the production of melatonin, a hormone that causes sleepiness. As blood levels of melatonin decrease, mental alertness increases. Daily exposure to bright light, especially sunlight, helps keep the body's circadian rhythms synchronized and operating on a 24-hour schedule.



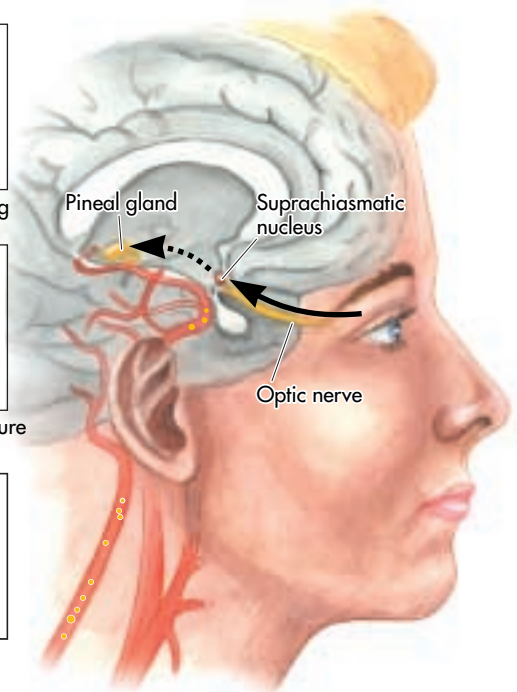
First thing in the morning



Shortly after light exposure



Later in the day



Circadian Rhythms and the Blind Many blind people have free-running circadian cycles because they are unable to detect the light that normally sets the SCN. Like people deprived of environmental time cues, blind people can experience free-running melatonin, body temperature, and sleep–wake circadian cycles (Czeisler & others, 1995; Klerman & others, 1998). Consequently, many blind people suffer from recurring bouts of insomnia and other sleep problems (Leger & others, 1999; Sack & others, 1992).

Jet Lag and the Direction of Travel Most people find it easier to adjust to the time changes when flying westward than eastward. Why? Flying westward adds hours to a traveler's day, which corresponds with the natural tendency of your internal body clock to drift toward longer days. As a general rule, it takes considerably longer to resynchronize your circadian rhythms to a new time zone when you fly eastward, which shortens your day.



light, darkness, and other time cues, people tend to drift to the natural rhythm of the suprachiasmatic nucleus—roughly a 25-hour day, not a 24-hour day. Thus, people in a free-running condition go to sleep about an hour later each day. Exactly why the human sleep–wake cycle gravitates toward a 25-hour cycle—and under what conditions—is an issue that continues to be actively researched and debated (S. Campbell, 2000; Czeisler & others, 2000; Wright & others, 2001).

Second, under free-running conditions, circadian rhythms lose their normal synchronization with one another (Aschoff, 1993, 1994). All circadian rhythms become longer, but to different degrees. For example, normally the sleep–wake cycle, body temperature, and the melatonin cycle are closely coordinated. At about 3:00 A.M., your body temperature dips to its lowest point, just as melatonin is reaching its highest level and you are at your sleepest. But in the absence of environmental cues, the sleep–wake, body temperature, and melatonin–circadian rhythms become desynchronized, so that they are no longer properly coordinated with one another.

What happens when people leave the free-running condition and are once again exposed to normal daylight and darkness cues? Within days, sunlight resets the biological clock. Circadian rhythms become synchronized again and resume operating on a 24-hour rather than a 25-hour cycle (Lewy & Sack, 1987).

Circadian Rhythms and Sunlight

Some Practical Implications

The close tie between your internal biological clock and environmental time cues has some very important practical applications. For example, imagine that you leave Denver at 2:00 P.M. on a 10-hour flight to London. When you arrive in London, it's 7:00 A.M. and the sun is shining. However, your body is still on Denver time. As far as your internal biological clock is concerned, it's midnight.

The result? Your circadian rhythms are drastically out of synchronization with daylight and darkness cues. The psychological and physiological effects of this disruption in circadian rhythms can be severe. Thinking, concentration, and memory get fuzzy. You experience physical and mental fatigue, depression or irritability, and disrupted sleep (Zammit, 1997). Collectively, these symptoms are called *jet lag*.

Although numerous physiological variables are involved in jet lag, the circadian cycle of the hormone melatonin plays a key role. When it's 10:00 A.M. in London, it's 3:00 A.M. in Denver. Since your body is still operating on Denver time, your melatonin production is peaking. Rather than feeling awake, you feel very sleepy, sluggish, and groggy. For many people, it can take a week or longer to adjust to such an extreme time change (Moore-Ede, 1993).

You don't need to travel across multiple time zones to experience symptoms of jet lag. People who work night shifts or rotating shifts often suffer from jet lag symptoms because their circadian rhythms are out of sync with daylight and darkness time cues (Monk, 1997). Like Nina in the Prologue, nurses, doctors, and other medical personnel often have to work night shifts or rotating shifts. So do people working in law enforcement and the military, broadcasting and weather services, and other businesses that operate around the clock.

For night workers, the problem of being out of sync with the environmental clock is compounded every morning when they return home in the bright morning light. Exposure to bright morning light is a potent stimulus that can reset the body clock to a day schedule (Shanahan & Czeisler, 1991). Even traces of sunlight through curtains can prevent a person's body clock from staying in sync with the night work schedule. Because sunlight time cues exert such a powerful influence on circadian rhythms, many night-shift workers never fully adjust to a night-time work schedule.

Sleep

Key Theme

- Modern sleep research began with the invention of the EEG and the discovery that sleep was a state marked by distinct physiological processes and stages.

Key Questions

- What are REM sleep and NREM sleep?
- What characterizes sleep onset, each of the NREM sleep stages, and REM sleep?
- What is the typical progression of sleep cycles, and how do sleep patterns change over the lifespan?

Birds do it. Giraffes do it. Cats do it a lot, mostly during the day. Dolphins do it, too, but only one brain hemisphere at a time. And, of course, you do it and we do it, but not as much as we'd like to. Sleep, that is. In fact, if you live a long life, you'll spend approximately 22 years of your life sleeping.

From Aristotle to Shakespeare to Freud, history is filled with examples of scholars, writers, and scientists who have been fascinated by sleep and dreams. But prior to the twentieth century, there was no objective way to study the internal processes that might be occurring during sleep. Instead, sleep was largely viewed as a period of restful inactivity in which dreams sometimes occurred.

The Dawn of Modern Sleep Research

The invention of the **electroencephalograph** by German psychiatrist Hans Berger in the 1920s gave sleep researchers an important tool for measuring the rhythmic electrical activity of the brain (Stern, 2001). These rhythmical patterns of electrical activity are referred to as *brain waves*. The electroencephalograph produces a graphic record called an **EEG**, or *electroencephalogram*. By studying EEGs, sleep researchers have firmly established that brain-wave activity systematically changes throughout sleep.

Along with brain activity, today's sleep researchers monitor a variety of other physical functions during sleep. Eye movements, muscle movements, breathing rate, airflow, pulse, blood pressure, amount of exhaled carbon dioxide, body temperature, and breathing sounds are just some of the body's functions that are measured in contemporary sleep research (Ancoli-Israel, 1997; Cooper & Bradbury, 1994).

The next milestone in sleep research occurred in the early 1950s. Eugene Aserinsky, a graduate student at the University of Chicago, was working in the laboratory of renowned sleep researcher Nathaniel Kleitman. Using his eight-year-old son as a subject, Aserinsky discovered that particular EEG patterns during sleep were often associated with rapid movements of the sleeper's eyes (Alvarez, 1995). Moreover, these periods of rapid eye movement were highly correlated with the subject's reports of dreaming. In 1953, Aserinsky and Kleitman published their findings, heralding the discovery of *rapid-eye-movement sleep*, usually abbreviated **REM sleep**.

Today, sleep researchers distinguish between two basic types of sleep. **REM sleep** is often called *active sleep* or *paradoxical sleep* because it is associated with heightened body and brain activity during which dreaming consistently occurs. **NREM sleep**, or *non-rapid-eye-movement sleep*, is often referred to as *quiet sleep* because the body's physiological functions and brain activity slow down during this period of slumber. NREM sleep is further divided into four stages, as we'll describe shortly.

electroencephalograph

(e-lec-tro-en-SEFF-uh-low-graph) An instrument that uses electrodes placed on the scalp to measure and record the brain's electrical activity.

EEG (electroencephalogram)

The graphic record of brain activity produced by an electroencephalograph.

REM sleep

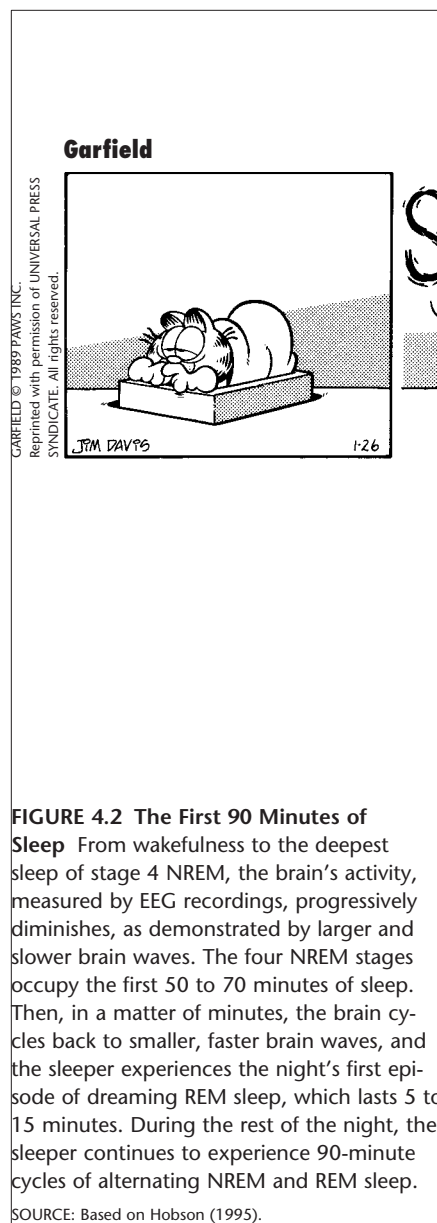
Type of sleep during which rapid eye movements (REM) and dreaming usually occur and voluntary muscle activity is suppressed; also called *active sleep* or *paradoxical sleep*.

NREM sleep

Quiet, typically dreamless sleep in which rapid eye movements are absent; divided into four stages; also called *quiet sleep*.

Monitoring Sleep Using electrodes that are attached harmlessly to the face and scalp, the electroencephalograph records the brain's electrical activity throughout the night. Although the equipment may look cumbersome and uncomfortable, people generally sleep just fine with all the wires attached.





The Onset of Sleep and Hypnagogic Hallucinations

Awake and reasonably alert as you prepare for bed, your brain generates small, fast brain waves, called **beta brain waves**. After your head hits the pillow and

you close your eyes, your muscles relax. Your brain's electrical activity gradually gears down, generating slightly larger and slower **alpha brain waves**. As drowsiness sets in, your thoughts may wander and become less logical.

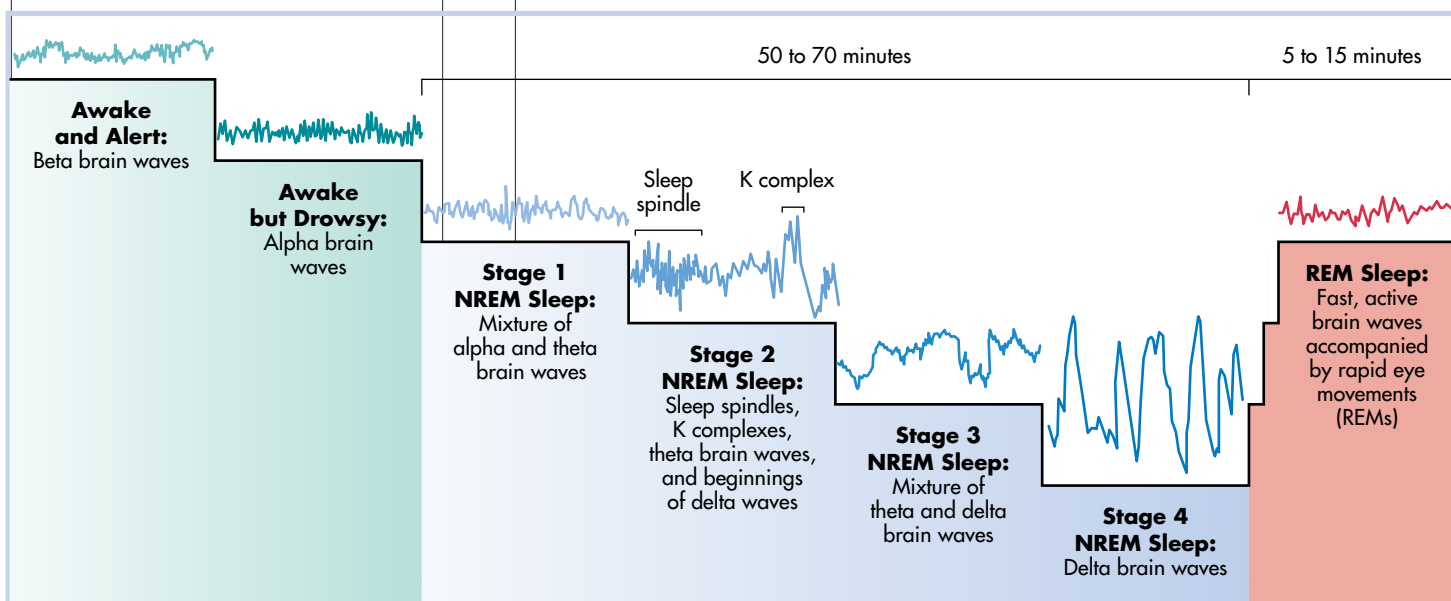
During this drowsy, presleep phase, you may experience odd but vividly realistic sensations. You may hear your name called or a loud crash, feel as if you're

falling or floating, smell something burning, or see kaleidoscopic patterns or an unfolding landscape. These vivid sensory phenomena that occasionally occur during the transition from wakefulness to light sleep are called **hypnagogic hallucinations** (Mavromatis, 1987). Some hypnagogic hallucinations can be so vivid or startling that they cause a sudden awakening.

Probably the most common hypnagogic hallucination is the vivid sensation of falling. The sensation of falling is often accompanied by a *myoclonic jerk*—an involuntary muscle spasm of the whole body that jolts the person completely awake (Cooper, 1994). Also known as *sleep starts*, these experiences can seem really weird (or embarrassing) when they occur. But, you can rest assured, they are not abnormal. Almost all of our students have reported occasionally experiencing the hypnagogic hallucination of falling combined with a myoclonic jerk.

The First 90 Minutes of Sleep and Beyond

The course of a normal night's sleep follows a relatively consistent cyclical pattern. As you drift off to sleep, you enter NREM sleep and begin a progression through the four NREM sleep stages (see Figure 4.2). Each progressive NREM sleep stage is characterized by corresponding decreases in brain and body activity. On average, the progression through the first four stages of NREM sleep occupies the first 50 to 70 minutes of sleep (Cooper, 1994).



Stage 1 NREM

As the alpha brain waves of drowsiness are replaced by even slower *theta brain waves*, you enter the first stage of sleep. Lasting only a few minutes, stage 1 is a transitional stage during which you gradually disengage from the sensations of the surrounding world. Familiar sounds, such as the hum of the refrigerator or the sound of traffic, gradually fade from conscious awareness. During stage 1 NREM, you can quickly regain conscious alertness if needed. Although hypnagogic experiences can occur in stage 1, less vivid mental imagery is common, such as imagining yourself engaged in some everyday activity, much as Mike imagined himself unpacking boxes at work. Although dreamlike, these images lack the unfolding, sometimes bizarre details of a true dream.

Stage 2 NREM

Stage 2 represents the onset of true sleep. Stage 2 sleep is defined by the appearance of **sleep spindles**, brief bursts of brain activity that last a second or two, and **K complexes**, single but large high-voltage spikes of brain activity that periodically occur (see Figure 4.2). Other than these occasional sleep spindles, brain activity continues to slow down considerably. Breathing becomes rhythmical. Slight muscle twitches may occur. Theta waves are predominant in stage 2, but large, slow brain waves, called *delta brain waves*, also begin to emerge. During the 15 to 20 minutes initially spent in stage 2, delta brain-wave activity gradually increases.

Stage 3 and Stage 4 NREM

Stages 3 and 4 of NREM are physiologically very similar. Both stages are defined by the amount of delta brain-wave activity. In combination, stages 3 and 4 are sometimes referred to as *slow-wave sleep*. When delta brain waves represent more than 20 percent of total brain activity, the sleeper is said to be in stage 3 NREM. When delta brain waves exceed 50 percent of total brain activity, the sleeper is said to be in stage 4 NREM (Cooper, 1994).

During the 20 to 40 minutes spent in the night's first episode of stage 4 NREM, delta waves eventually come to represent 100 percent of brain activity. At that point, heart rate, blood pressure, and breathing rate drop to their lowest levels. Not surprisingly, the sleeper in stage 4 NREM is virtually oblivious to the world. Noises as loud as 90 decibels may fail to wake him (Empson, 1993). However, his muscles are still capable of movement. For example, if sleepwalking occurs, it typically happens during stage 4 NREM sleep (see In Focus Box 4.1).

It can easily take 15 minutes or longer to regain full waking consciousness from stage 4. It's even possible to answer a ringing phone, carry on a conversation for several minutes, and hang up without ever leaving stage 4 sleep—and without remembering the conversation the next day. When people are briefly awakened by sleep researchers during stage 4 NREM and asked to perform some simple task, they often don't remember it the next morning (Dinges, 1990; Goodenough, 1991).

beta brain waves

Brain-wave pattern associated with alert wakefulness.

alpha brain waves

Brain-wave pattern associated with relaxed wakefulness and drowsiness.

hypnagogic hallucinations

(hip-na-GAH-jick) Vivid sensory phenomena that occur during the onset of sleep.

sleep spindles

Short bursts of brain activity that characterize stage 2 NREM sleep.

K complex

Single but large high-voltage spike of brain activity that characterizes stage 2 NREM sleep.



Synchronized Sleepers As these time-lapse photographs show, couples who regularly sleep in the same bed tend to have synchronized sleep cycles. Since bed partners fall asleep at about the same time, they are likely to have similarly timed NREM–REM sleep cycles. The movements of this couple are also synchronized. Both sleepers shift position just before and after episodes of REM sleep.

IN FOCUS 4.1

What You Really Want to Know About Sleep

Why do I yawn? Is yawning contagious?

Research has contradicted the popular notion that too little oxygen or too much carbon dioxide causes yawning. Rather, yawning regulates and increases your level of arousal. Yawning is typically followed by an *increase* in activity level. Hence, you frequently yawn after waking up in the morning or while attempting to stay awake in the late evening. When dealing with repetitive, uninteresting stimuli, yawning is one way your body maintains mental and physical arousal.

If you think or read about yawning, it can trigger the behavior. (Have you yawned yet?) However, the idea that watching other people yawn causes yawning has little research support. For example, students in a lecture class often yawn, but the instructor doesn't, despite seeing the students yawning.

Why do I get sleepy?

Research suggests that a naturally occurring compound in the body called *adenosine* may be the culprit. In studies with cats, prolonged wakefulness results in a sharp increase in adenosine levels, which reflect energy used for brain and body activity. As adenosine levels shoot up, so does the need for sleep. Slow-wave NREM sleep reduces adenosine levels. In humans, the common stimulant drug caffeine blocks adenosine receptors, promoting wakefulness.

Sometimes in the morning when I first wake up, I can't move. I'm literally paralyzed! Is this normal?

REM sleep is characterized by paralysis of the voluntary muscles, which keeps you from acting out your dreams. In a relatively common phenomenon called *sleep paralysis*, the paralysis of REM sleep carries over to the waking state for up to 10 minutes. If preceded by an unpleasant dream or hypnagogic experience, this sensation can be frightening. Sleep paralysis can also occur as you're falling asleep. In either case, the sleep paralysis lasts for only a few minutes. So, if this happens to you, relax—voluntary muscle control will soon return.

Do deaf people who use sign language sometimes "sleep sign" during sleep?

Yes.

Do the things people say when they talk in their sleep make any sense?

Sleeptalking typically occurs during NREM stages 3 and 4. There are many anecdotes of spouses who have supposedly engaged their sleeptalking mates in extended conversations, but sleep researchers have been unsuccessful in having extended dialogues with people who chronically talk in their sleep. As

far as the truthfulness of the sleep-talker's utterances go, they're reasonably accurate insofar as they reflect whatever the person is responding to while asleep. By the way, not only do people talk in their sleep, but they can also sing in their sleep. In one case we know of, a little boy sleepsang "Frosty the Snowman."

Is it dangerous to wake a sleepwalker?

It's not dangerous to wake a sleepwalker, it's just difficult, because sleepwalkers are in deep sleep. However, as sleepwalkers usually respond to verbal suggestions, it's relatively easy to guide them back to bed.

Sleepwalking may be genetically determined. Identical twins are much more likely to share this characteristic than are nontwin siblings. One college student confided to sleep researcher Jacob Empson (1993) that her whole family sleepwalked. She reported that one morning, her entire family woke up to find themselves seated around the kitchen table, where they had all gathered in their sleep!

SOURCES: Arkin (1981); Baenninger (1997); Empson (1993); National Sleep Foundation (2002); Ozbayrak & Berlin (1995); Porkka-Heiskanen & others (1997); Portas & others (1997); Rothenberg (1997); Spanos & others (1995a); Tankova & others (1994).

Thus far in our description, the sleeper is approximately 70 minutes into a typical night's sleep and immersed in deeply relaxed stage 4 NREM sleep. At this point, the sequence reverses. In a matter of minutes, the sleeper cycles back from stage 4 to stage 3 to stage 2 and enters a dramatic new phase: the night's first episode of REM sleep.

REM Sleep

During REM sleep, the brain becomes more active, generating smaller and faster brain waves. Visual and motor neurons in the brain activate repeatedly, just as they do during wakefulness. Dreams usually occur during REM sleep. Although the brain is very active, voluntary muscle activity is suppressed, which prevents the dreaming sleeper from acting out those dreams (Hirshkowitz & others, 1997).

REM sleep is accompanied by considerable physiological arousal. The sleeper's eyes dart back and forth behind closed eyelids—the rapid eye movements. Heart

sleep paralysis

A temporary condition in which a person is unable to move upon awakening in the morning or during the night.

rate, blood pressure, and respirations can fluctuate up and down, sometimes extremely. Muscle twitches occur. In both sexes, sexual arousal may occur, which is not necessarily related to dream content.

This first REM episode tends to be brief, about 5 to 15 minutes. From the beginning of stage 1 NREM sleep through the completion of the first episode of REM sleep, about 90 minutes have elapsed.

Beyond the First 90 Minutes

Throughout the rest of the night, the sleeper cycles between NREM and REM sleep. Each cycle lasts about 90 minutes on average, but the duration of cycles may vary from 70 to 120 minutes. Usually, four more 90-minute cycles of NREM and REM sleep occur during the night. Just before and after REM periods, the sleeper typically shifts position (Hobson, 1995).

The progression of a typical night's sleep cycles is depicted in Figure 4.3. Stages 3 and 4 NREM, slow-wave sleep usually occur only during the first two 90-minute cycles. As the night progresses, REM sleep episodes become increasingly longer and less time is spent in NREM. During the last two 90-minute sleep cycles before awakening, NREM sleep is composed primarily of stage 2 sleep and periods of REM sleep can last as long as 40 minutes. In a later section, we'll look at dreaming and REM sleep in more detail.

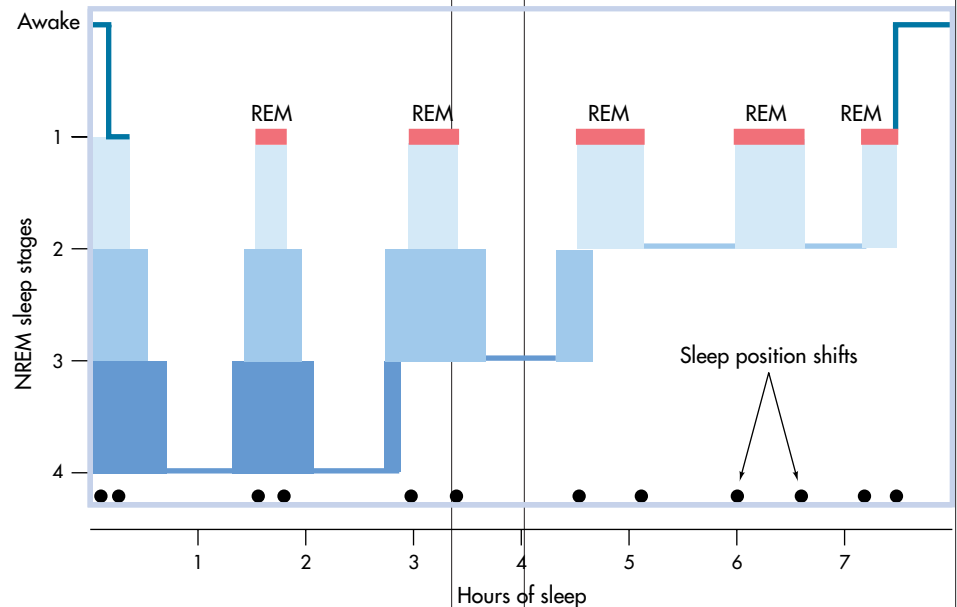


FIGURE 4.3 The 90-Minute Cycles of Sleep During a typical night, you experience five 90-minute cycles of alternating NREM and REM sleep. The deepest stages of NREM sleep, stages 3 and 4, occur during the first two 90-minute cycles. Dreaming REM sleep episodes become progressively longer as the night goes on. Sleep position shifts, indicated by the dots, usually occur immediately before and after REM episodes.

SOURCE: Based on Hobson (1995).

Changes in Sleep Patterns over the Lifespan

Over the course of our lives, the quantity and quality of our sleep change considerably (see Figure 4.4). REM sleep begins long before birth, as scientists have discovered by using ultrasound to document fetal eye movements and by studying the sleep of premature infants. Four months before birth, REM sleep seems to constitute virtually all of fetal life. By one month before birth, the fetus demonstrates

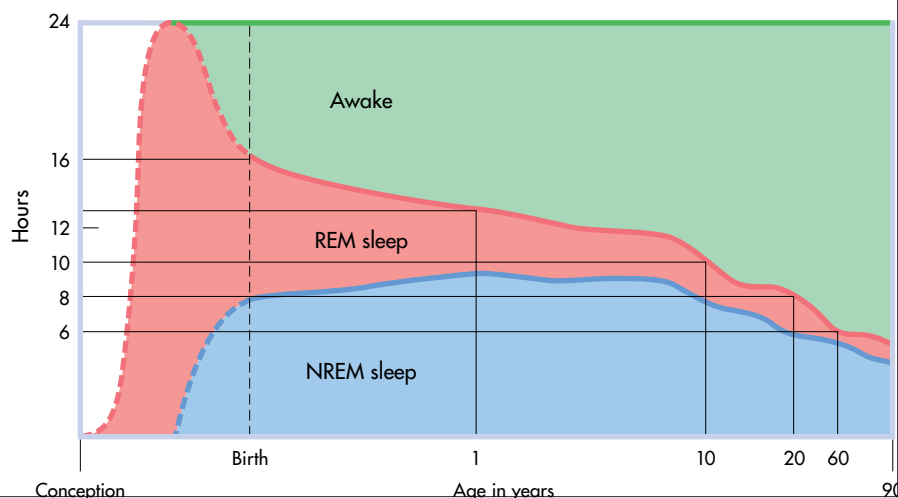


FIGURE 4.4 Changes in REM and NREM Sleep Both the quality and quantity of sleep change over the lifespan. Even before birth, the cycles of REM and NREM sleep are evident. A newborn infant sleeps about 16 hours per day, with about 50 percent of sleep time devoted to REM. From birth onward, total sleep time, REM sleep, and NREM sleep slowly decrease. Time spent in stages 3 and 4, the deepest stages of NREM, also decreases over the lifespan.

SOURCE: Based on Hobson (1995).



The Beginnings of REM Sleep By using ultrasound to create images of the developing fetus in the uterus, researchers have documented the beginnings of REM sleep and rapid eye movements months before birth.

REM rebound

A phenomenon in which a person who is deprived of REM sleep greatly increases the amount of time spent in REM sleep at the first opportunity to sleep uninterrupted.

restorative theory of sleep

The view that sleep and dreaming are essential to normal physical and mental functioning.

distinct sleep–wake cycles, spending around 12 hours each day in REM sleep (Mindell, 1997).

A newborn sleeps about 16 hours a day, about 50 percent of which is REM sleep. By the end of the first year of life, total sleep time drops to around 13 hours a day, about one-third of which is REM sleep.

In general, from birth onward, the average amount of time spent sleeping each day gradually decreases (see Figure 4.4). The amount of time devoted to REM sleep and slow-wave NREM sleep each night also gradually decreases over the lifespan (Bliwise, 1997). Young children can easily spend two hours or more each night in the deep sleep of stages 3 and 4 NREM. By early adulthood, about an hour is spent in deep sleep each night. And by late adulthood, only about 20 minutes of a night's sleep is spent in stages 3 and 4 NREM sleep (Williams & others, 1994). By the time people reach their sixties, total sleep time averages about six hours per night and the quality of sleep is much more shallow.

Why Do We Sleep?

Key Theme

- Sleep deprivation studies demonstrate that we have a biological need for sleep, but the functions of sleep are not completely understood.

Key Questions

- What are REM and NREM rebound, and what insights do they provide into the function of sleep?
- How do the restorative and adaptive theories of sleep explain the function of sleep?

That we have a biological need for sleep is clearly demonstrated by *sleep deprivation studies*. After as little as one night's sleep deprivation, research subjects develop *microsleeps*, which are episodes of sleep lasting only a few seconds that occur during wakefulness. People who go without sleep for a day or more also experience disruptions in mood, mental abilities, reaction time, perceptual skills, and complex motor skills (Gökcebay & others, 1994).

Getting *less* sleep than you need (as many adults do) can also have negative effects. In one study, young men whose sleep was restricted to four hours a night for as few as six consecutive nights experienced harmful changes in metabolic and endocrine functioning (Spiegel & others, 1999). As sleep researcher Eve Van Cauter (1999) explained, “After only one week of sleep restriction, young, healthy males had glucose levels that were no longer normal. That’s a rapid deterioration of the body’s functions.”

Sleep researchers have also selectively deprived people of different components of normal sleep. For example, to study the effects of *REM deprivation*, researchers wake sleepers whenever the monitoring instruments indicate that they are entering REM sleep. After several nights of being selectively deprived of REM sleep, the subjects are allowed to sleep uninterrupted. What happens? The first time subjects are allowed to sleep without interruption, they experience **REM rebound**—the amount of time spent in REM sleep increases by as much as 50 percent (Ellman & others, 1991). Similarly, when people are selectively deprived of NREM stages 3 and 4, they experience *NREM rebound*, spending more time in NREM sleep.

The phenomena of REM rebound and NREM rebound seem to indicate that the brain needs to make up for missing components of sleep. Clearly, we need both to sleep and to experience the full range of sleep stages. But what particular functions does sleep serve?

The **restorative theory of sleep** suggests that sleep promotes physiological processes that restore and rejuvenate the body and the mind (Gökcebay & others, 1994). According to this theory, NREM and REM sleep serve different purposes.

NREM sleep is thought to be important for restoring the body, whereas REM sleep is thought to restore mental and brain functions (Maquet, 2001; Stickgold & others, 2001).

Evidence supporting the role of NREM sleep in restoring the body comes from studies that have demonstrated increased deep sleep following sleep deprivation, starvation, and strenuous athletic activity. The secretion of growth hormone, testosterone, prolactin, and other hormones increases during NREM sleep (Hirshkowitz & others, 1997).

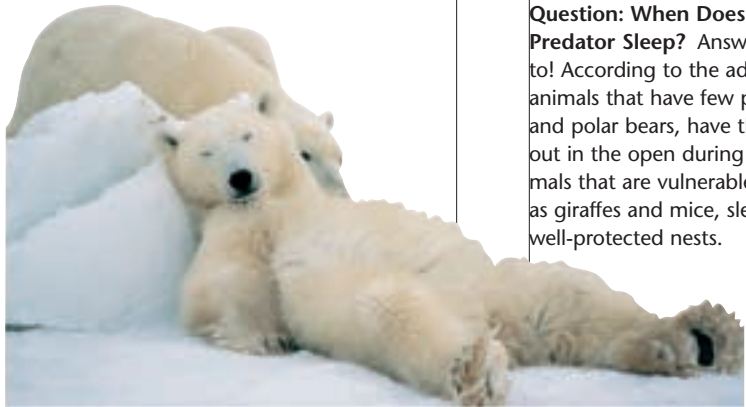
The importance of REM sleep in mental and brain functions is suggested by the abundance of REM sleep in the developing fetus, in infants, and in young children and its subsequent decrease throughout adulthood (see Figure 4.4). Tentatively, this suggests that REM sleep plays some role in stimulating the high rate of brain development that occurs in the early stages of the lifespan.

In contrast to the restorative theory, the **adaptive theory of sleep** suggests that the sleep patterns exhibited by different animals, including humans, are the result of evolutionary adaptation (Webb, 1975). Also called the *evolutionary theory of sleep*, the basic idea is that different sleep patterns evolved as a way of preventing a particular species from interacting with the environment when doing so is most hazardous. Animals with few natural predators, such as gorillas and lions, sleep as much as 15 hours a day. In contrast, grazing animals, such as cattle and horses, tend to sleep in short bursts that total only about 4 hours per day. Hibernation patterns of animals such as bears and gophers also coincide with periods during which environmental conditions pose the greatest threat to survival.

Although there is evidence to support both the restorative and the adaptive theories of sleep, many questions remain. The bottom line is that researchers still aren't sure exactly what physiological functions are served by sleep (Maquet, 2001). Sleep may well fulfill multiple purposes.

adaptive theory of sleep

The view that the unique sleep patterns of different animals evolved over time to help promote survival and environmental adaptation; also referred to as the *evolutionary theory of sleep*.



Question: When Does an 800-Pound Predator Sleep? Answer: Any time it wants to! According to the adaptive theory of sleep, animals that have few predators, such as lions and polar bears, have the luxury of sleeping out in the open during daylight hours. Animals that are vulnerable to predators, such as giraffes and mice, sleep only fitfully or in well-protected nests.

4.1 R · E · V · I · E · W

C · O · N · C · E · P · T

Circadian Rhythms and Stages of Sleep

Fill in the blanks with the missing terms.

1. Sheila works the night shift. Despite getting adequate sleep before going to work, Sheila feels extremely tired and sleepy at about 3:00 A.M. Her fatigue at 3:00 A.M. is probably due to increased levels of _____.
2. As a research volunteer, Keith agreed to live in an underground bunker for two months without a clock or other time cues. Over the first few weeks, his _____ will naturally drift to a _____-hour cycle, and his circadian rhythms may become desynchronized.
3. Within days after leaving the underground bunker, Keith's exposure to _____ resets his circadian rhythms so that they become synchronized and operate on a _____-hour cycle.
4. You have been asleep for about 10 minutes and are experiencing brief bursts of brain activity, called sleep spindles. It is likely that you are in _____ sleep.
5. Marsha has been asleep for well over an hour. Her eyes start to dart back and forth beneath her closed eyelids. Her heart rate and blood pressure fluctuate up and down, yet her voluntary muscle activity is suppressed. Marsha is experiencing _____ sleep, and _____ is occurring.
6. During your first night in a sleep research lab, a lab assistant wakes you up and asks you to recite the alphabet. You do so, but you remember nothing about this incident the next morning. You were probably awakened during _____ sleep.

Insomnia Following the September 11th Attacks A surge in the number of Americans experiencing symptoms of insomnia occurred in the weeks and months following the terrorist attacks on the Pentagon and the World Trade Center on September 11, 2001. According to a survey conducted by the National Sleep Foundation (2002), seven out of ten Americans experienced one or more symptoms of insomnia, such as having trouble falling asleep at night or frequent awakenings during the night. The psychological toll of the attacks was more pronounced in women. Females were more likely than males (78% vs. 59%) to report that they had experienced symptoms of insomnia during the weeks immediately following the attacks.



Sleep Disorders: Troubled Sleep

- Key Theme**
- Sleep disorders take many different forms and are surprisingly common.
- Key Questions**
- How is insomnia defined, and how common is it?
 - What are the most important parasomnias?
 - What is narcolepsy?

Sleep disorders are serious disturbances in the normal sleep pattern that interfere with daytime functioning and cause subjective distress (American Psychiatric Association, 2000a). Virtually everyone is seriously troubled by the quality or quantity of their sleep at some point. And, if you happen to be someone who regularly experiences sleep-related problems, you're not alone. According to the 2002 Sleep in America Poll, seven out of ten American adults report frequent sleep problems, including inadequate amounts of sleep. Other highlights from the National Sleep Foundation's survey are presented in Table 4.2.

Table 4.2

The National Sleep Foundation Survey: Asleep at the Wheel?

Key findings from the 2002 Sleep in America Poll, a national survey of randomly selected American adults:

- 37% reported being so sleepy during the day that it interfered with their daily activities.
- 40% compensated for sleep lost during the week by sleeping an extra hour or more on the weekends.
- 43% use caffeine to help them stay awake during the day.
- 51% have driven when drowsy during the past year.
- 17% have actually fallen asleep at the wheel in the past year.
- 1% have had a traffic accident due to being drowsy or falling asleep at the wheel.

SOURCE: National Sleep Foundation (2002).

Insomnia

By far the most common sleep complaint among adults is insomnia (Dement & Pelayo, 1997). According to the 2002 National Sleep Foundation survey, 58 percent of adults are affected a few nights or more each week by at least one symptom of insomnia, such as waking up and being unable to go back to sleep.

Insomnia is not defined solely on the basis of the amount of time a person sleeps, because people vary in how much sleep they need to feel refreshed. Rather, people are said to experience **insomnia** when they repeatedly complain about the quality or duration of their sleep, have difficulty going to sleep or staying asleep, or wake before it is time to get up.

For an estimated 12 million Americans, complaints of insomnia are related to a condition called **restless legs syndrome**, abbreviated **RLS**. People with RLS complain of unpleasant creeping, crawling, tingling, itching, or prickling sensations deep inside their lower legs accompanied by an irresistible urge to move (National Institute of Neurological Disorders and Stroke, 2001). These sensations are most prominent in the evening and at night, especially when the individual lies down or sits still for any length of time (Rothenberg, 1997). Moving the legs

temporarily reduces the unpleasant sensations but also interferes with the person's ability to fall asleep or stay asleep.

More commonly, insomnia can often be traced to stressful life events, such as job or school difficulties, troubled relationships, the death of a loved one, or financial problems. Concerns about sleeping can add to whatever waking anxieties the person may already be experiencing. This can create a *vicious circle*—worrying about the inability to sleep makes troubled sleep even more likely, further intensifying anxiety.

Numerous studies have shown that behavior therapy and different medications are effective in the short-term treatment of insomnia (M. T. Smith & others, 2002). Behavioral techniques often help people develop better sleep habits. For example, a treatment called *stimulus control* conditions the person to associate the bed only with sleepiness and sleep, rather than with watching television, talking on the phone, or other nonsleep activities. Relaxation training and meditation, which we will discuss later in the chapter, are also commonly used to treat insomnia (Murtagh & Greenwood, 1995).

Educating people on sleep hygiene is often part of the successful treatment of insomnia. For example, many people troubled by the inability to sleep use alcohol or over-the-counter sleep medications to induce sleep. In the Prologue to this chapter, you saw how Mike resorted to a stiff drink to help him relax and go back to sleep. Although such remedies may temporarily help people fall asleep, both sleeping pills and alcohol disrupt normal sleep cycles, including REM sleep (Roehrs & Roth, 2001). Even the sleep-inducing medications sometimes prescribed by physicians to treat insomnia must be carefully managed to avoid drug dependence.

Sleep Apnea

The second most common sleep disorder, sleep apnea, affects some 20 million Americans (Carskadon & Taylor, 1997). In **sleep apnea**, the sleeper repeatedly stops breathing during the night. Carbon dioxide builds up in the blood, causing a momentary awakening, during which the sleeper snorts or gulps in air. Breathing may stop for as little as 10 seconds or for so long that the sleeper's skin turns blue before he or she wakes up. During a single night, more than 300 sleep apnea attacks can occur. Often the person has no recollection of the repeated awakenings but feels sleepy throughout the following day (Orr, 1997).

Sleep apnea is more common in men over the age of 50, especially those who are overweight. Special mouthpieces, weight loss, and surgical intervention have been effective in treating sleep apnea. For people who suffer from sleep apnea only when they sleep on their backs, treatment is sometimes as simple as sewing a tennis ball to the back of their pajama tops, which forces them to sleep on their sides (Saskin, 1997).

Sleepwalking and Night Terrors

Unlike insomnia, sleepwalking and night terrors are much more common in children than in adults (Lask, 1995; Mindell, 1993). These sleep disturbances occur during the deepest stages of NREM sleep, stages 3 and 4. As noted previously, young children spend considerably more time each night in deep sleep than do adolescents or adults (Whyte & Schaefer, 1995). Not surprisingly, most instances of bedwetting, or *nocturnal enuresis*, also tend to occur when the child is in deep sleep (Barclay & Houts, 1995a).

About 25 percent of all children have at least one episode of **sleepwalking**, also known as *somnambulism*. Sleepwalking typically occurs during the first three hours after the child has gone to sleep. The child gets out of bed and moves about in a slow, poorly coordinated, automatic manner, usually with a blank, staring look on his face. Surprisingly, the sleepwalking child is usually able to navigate around objects without much difficulty. However, the child's general lack of awareness of his surroundings is evident. The sleepwalker may try to dress, eat,

sleep disorders

Serious disturbances in the normal sleep pattern that interfere with daytime functioning and cause subjective distress.

insomnia

A condition in which a person regularly experiences an inability to fall asleep, to stay asleep, or to feel adequately rested by sleep.

restless legs syndrome (RLS)

A condition in which unpleasant sensations in the lower legs are accompanied by an irresistible urge to move the legs, temporarily relieving the unpleasant sensation but disrupting sleep.

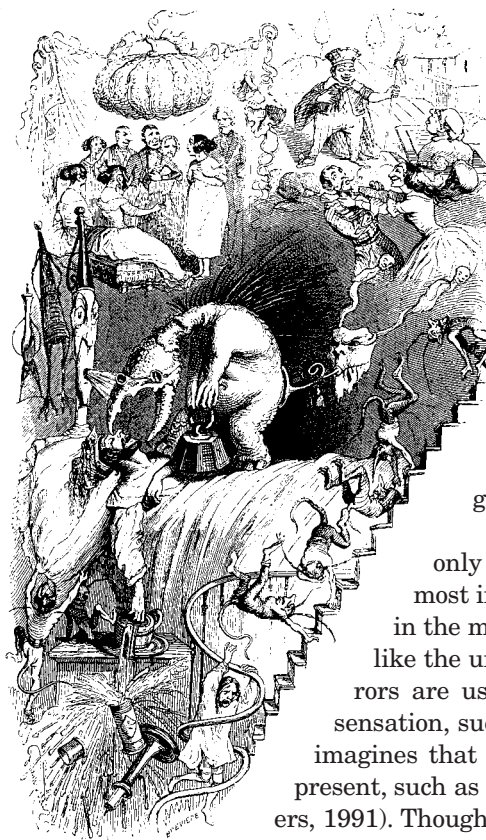
sleep apnea

(APP-nee-uh) A sleep disorder in which the person repeatedly stops breathing during sleep.

sleepwalking

A sleep disturbance characterized by an episode of walking or performing other actions during stage 3 or stage 4 NREM sleep; also called *somnambulism*.

Terror in the Night This print by French artist Jean Ignace Gérard is titled *The Nightmare*. However, the image of a monster lowering a weight on the sleeper's chest suggests instead the frightening experience of a night terror. Night terrors occur during NREM sleep and are almost always accompanied by a sensation of being crushed or smothered.



or go to the bathroom in the wrong location (Ozbayrak & Berlin, 1995).

Night terrors, or *sleep terrors*, also typically occur during stage 3 or 4 NREM sleep in the first few hours of sleep. Physiologically, a night terror is much more intense than a run-of-the-mill nightmare. The first sign of a night terror is sharply increased physiological arousal—restlessness, sweating, and a racing heart. Typically, the child experiencing night terrors abruptly sits up in bed and lets out a panic-stricken scream or cry for help as she thrashes about in bed or even sleepwalks. Terrified and disoriented, the child may struggle with a parent who tries to calm her down.

Night terrors tend to be brief, usually lasting only a matter of seconds. Amazingly, the child almost immediately goes back to quiet sleep and wakes in the morning with no recollection of the incident. Unlike the unfolding dream story of a nightmare, night terrors are usually accompanied by a single but terrifying sensation, such as being crushed or falling. Often, the child imagines that she is choking or that a frightening figure is present, such as a threatening animal or monster (Kahn & others, 1991). Though dramatic, night terrors are not regarded as a true sleep disorder or psychological problem unless they occur frequently. For the vast majority of children who often experience night terrors, the problem usually resolves itself by early adolescence (Lask, 1995).

Our friend Nina, whom we described in the Prologue, is among the small percentage of people whose night terrors continue into adulthood. Just as when she was a child, Nina doesn't remember her sleep terror episodes the next morning. However, her husband Mike has found that she seems most likely to experience a sleep terror episode when she is very tired or under stress.

Nina's parents told us that both Nina and her sister were sleepwalkers until their teenage years. As a child, Nina also experienced *sleep bruxism*—she would grind her teeth loudly in her sleep. Collectively, night terrors, sleepwalking, and sleep bruxism are referred to as parasomnias. The **parasomnias** are a general category of sleep disorders that involve arousal or activation during sleep or sleep transitions.

night terrors

A sleep disturbance characterized by an episode of increased physiological arousal, intense fear and panic, frightening hallucinations, and no recall of the episode the next morning; typically occurs during stage 3 or stage 4 NREM sleep; also called *sleep terrors*.

parasomnias

(pare-uh-SOM-nee-uz) A category of sleep disorders characterized by arousal or activation during sleep or sleep transitions; includes *sleepwalking*, *night terrors*, *sleep bruxism*, and *REM sleep behavior disorder*.

REM sleep behavior disorder

A sleep disorder in which the sleeper acts out his or her dreams.

narcolepsy

(NAR-ko-lep-see) A sleep disorder characterized by excessive daytime sleepiness and brief lapses into sleep throughout the day.

REM Sleep Behavior Disorder

Another, more serious parasomnia is **REM sleep behavior disorder** (Mahowald & Schenck, 1990). REM sleep behavior disorder typically affects men over the age of 60 and is characterized by the brain's failure to suppress voluntary muscle movements during REM sleep. Consequently, the dreamer acts out his dreams, sometimes leaping out of bed, lashing out at imagined intruders, or tackling a chest of drawers. Such behavior might seem comical if the potential for serious injury to the sleeper or the sleeper's bed partner weren't so great. Evidence suggests that the cause of REM sleep behavior disorder is deterioration or damage in the lower brain centers that control physical and mental arousal during sleep (Zoltoski & Gillin, 1994).

Narcolepsy

If you've ever tried to stay awake for 36 hours or longer, you know how incredibly sleepy you can get. That experience gives you an inkling of what life is like for people with narcolepsy. The most common, and most troubling, symptom of **narcolepsy** is excessive and recurring bouts of daytime sleepiness. People with

narcolepsy experience an overwhelming sleepiness, lapsing into brief periods of sleep throughout the day that usually last an hour or less. These daytime sleep episodes occur regardless of how much nighttime sleep the person has had. They also often occur at inappropriate times, such as in the middle of a meeting.

The onset of these daytime sleep episodes is sometimes accompanied by frightening *hypnagogic hallucinations*, such as the house or building being on fire (see page 132). As the person awakens, he or she may briefly experience the sensation of being unable to move, which is termed *sleep paralysis* (see In Focus Box 4.1 on page 134). When these daytime sleep episodes occur suddenly, they are termed “sleep attacks.”

Along with excessive daytime sleepiness, narcolepsy is often characterized by regular episodes of cataplexy. **Cataplexy** is the sudden loss of voluntary muscle strength and control, lasting from several seconds to several minutes. Cataplexy is usually triggered by a sudden, intense emotion, such as laughter, anger, or surprise. In mild episodes, the person’s head may droop or facial muscles sag (Siegel, 2000). In more severe episodes, the person may completely lose muscle control. As shown in the accompanying series of photos, the person’s knees buckle and he collapses on the floor.

The onset of narcolepsy typically occurs during adolescence, and it is considered a chronic, lifelong condition. Although estimates vary, approximately 250,000 Americans have narcolepsy, and it affects men and women equally (Carskadon & Taylor, 1997; Littner, 2001). Genetics seems to play an important role, as the disorder tends to run in families (Mignot, 1998). Adding to the genetic evidence, scientists have identified the genes that produce narcoleptic symptoms in mice and dogs (Chemelli & others, 1999; Lin & others, 1999).

Although the cause of narcolepsy is still unknown, recent evidence suggests that people with narcolepsy lack a hormone called *hypocretin*, which is manufactured in the brain’s hypothalamus (Nishino & others, 2000). Hypocretin is involved in regulating arousal, sleep, and eating behavior (Hungs & Mignot, 2001; Mignot, 2001). Many sleep researchers are hopeful that such discoveries will lead to new treatments for this debilitating sleep disorder.

Although narcolepsy cannot be cured, a drug called *modafinil* (Provigil), reduces daytime sleepiness in people with narcolepsy (Schwartz & others, 2000). Antidepressant medications can reduce episodes of cataplexy, hypnagogic hallucinations, and sleep paralysis. Stimulant drugs, such as Dexedrine and Ritalin, are also used to minimize narcoleptic symptoms.

An Episode of Cataplexy in Narcolepsy In this sequence of images, a man with narcolepsy experiences one of its most dramatic symptoms – cataplexy. Cataplexy involves the sudden and complete loss of muscle tone, and is typically triggered by laughter, embarrassment, or some other type of emotional arousal. Although he is unable to move, the person remains conscious and aware of what is going on around him.



Dreams and Mental Activity During Sleep

Key Theme

- A dream is an unfolding episode of vivid mental images that occurs during sleep.

Key Questions

- What patterns of brain activity are associated with dreaming sleep?
- How are dreams thought to aid memory consolidation?
- What do people dream about, and why don’t we remember our dreams?

Dreams have fascinated people since the beginning of time. On average, about 25 percent of a night’s sleep, or almost two hours every night, is spent dreaming. So, assuming you live to a ripe old age, you’ll devote more than 50,000 hours, or about six years of your life, to dreaming.

cataplexy

A sudden loss of voluntary muscle strength and control that is usually triggered by an intense emotion.



Dream Images Although people tend to emphasize visual imagery when they describe their dreams, sounds and physical sensations are also commonly present. Sensations of falling, flying, spinning, or trying to run may be experienced. We tend to dream of familiar people and places, but the combinations of characters, objects, and events are typically illogical, even bizarre. Nevertheless, the dreamer rarely questions a dream's details—until he or she wakes up!

Although dreams may be the most spectacular brain productions during sleep, they are *not* the most common. More prevalent is **sleep thinking**, which takes place during NREM sleep and consists of vague, uncreative, bland, and thought-like ruminations about real-life events (Hobson & Stickgold, 1995; Schatzman & Fenwick, 1994). For example, just before an important exam, students may review terms and concepts during NREM sleep.

In contrast to sleep thinking, a **dream** is an unfolding episode of mental images that is storylike, involving characters and events. According to sleep researcher J. Allan Hobson (1988), dreams have five basic characteristics:

- Emotions can be intense.
- Content and organization are usually illogical.
- Sensations are sometimes bizarre.
- Even bizarre details are uncritically accepted.
- Dream images are difficult to remember.

Many people believe that dreams occur only during REM sleep, but this is not the case. Dreams occur during both NREM and REM sleep (Rosenlicht & Feinberg, 1997). However, dreams during REM sleep are more frequent and of longer duration than are dreams during NREM sleep (Foulkes, 1997). When people are awakened during REM sleep, they will report a dream up to 90 percent of the time—even people who claim that they never dream.

People usually have four or five episodes of dreaming each night. Early-morning dreams, which can last as long as 40 minutes, are the dreams people are most likely to remember. Contrary to popular belief, dreams happen in real time, not in split seconds. In fact, dreamers tend to be quite accurate in estimating how long they've been dreaming (Empson, 1993).

The Brain During REM Sleep

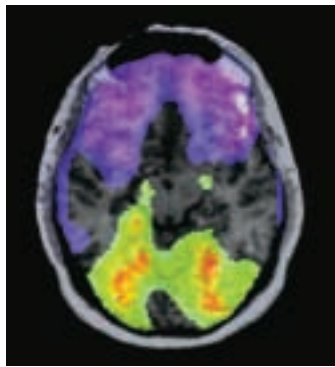
What happens in the brain during REM sleep? Earlier in the chapter, we noted that EEG measurements show that the brain is highly active during REM sleep. In a recent series of PET scans of sleeping subjects, neuroscientist Allen Braun and his colleagues (1998) showed that the brain's activity during REM sleep is distinctly different from its activity during either wakefulness or slow-wave (NREM) sleep.

Braun found that both the primary visual cortex and the frontal lobes are essentially shut down during REM sleep. As we discussed in Chapter 2, the *primary visual cortex* is the area at the back of the brain that first registers visual information transmitted by the retinas of the eye. The *frontal lobes* are the brain areas responsible for higher-level cognitive processes, including reasoning, planning, and integrating perceptual information. Thus, during REM sleep, the sleeper is cut off from information about the external world *and* from the brain centers most involved in rational thought.

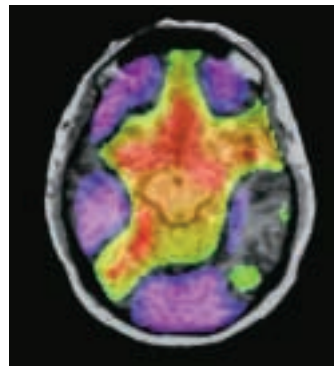
Other brain areas, however, are highly active during REM sleep. Activated areas include the *amygdala* and the *hippocampus*, structures of the limbic system that are involved in emotion, motivation, and memory (see Figure 2.20 on page 70). Also highly active are other parts of the brain's visual system that are involved in generating visual images (see Focus on Neuroscience).

These results suggest that the dreamer's uncritical acceptance of bizarre and chaotic dream images and narrative can be explained in terms of the inactivity of the frontal lobes—the very areas of the brain that are normally most active in analyzing and interpreting new information. In the absence of meaningful stimuli from the outside world, emotions and stored memories provide the raw data for the vivid visual images conjured up by the sleeping brain.

Neuroscience



(a) REM sleep compared to wakefulness



(b) REM sleep compared to slow-wave sleep

Brain Changes During REM Sleep These PET scans reveal how brain activity during REM sleep differs from wakefulness (scan *a*) and slow-wave sleep (scan *b*). The PET scans are color-coded: Yellow-red indicates areas of increased brain activity, and bluish-purple indicates areas of decreased brain activity.

Compared to wakefulness, scan (*a*) reveals that REM sleep involves decreased activity in the frontal lobes, which are involved in rational thinking, and the primary visual cortex, which processes external visual stimuli. The yellow-red areas indicate increased activity in visual areas associated with visual imagery—the images occurring in a dream.

Compared to slow-wave sleep, the yellow-red areas in scan (*b*) indicate that REM sleep is characterized by a sharp increase in areas of the limbic system that are associated with emotion, motivation, and memory. The activation of these brain areas reflects the intense emotions that often characterize dreams.

In combination, these two PET scans document the high degree of mental imagery and emotionality that takes place in the dreaming brain. But the brain changes that occur during REM sleep also show that the dreamer is cut off from the reality-testing functions of the frontal lobes—a fact that no doubt contributes to the sometimes bizarre nature of dreams.

REM Sleep and Memory Consolidation

As you'll see in Chapter 6, *memory consolidation* refers to the gradual process of converting new memories into a long-term, relatively permanent form. Research suggests that REM sleep helps consolidate memories, especially *procedural memories* (Stickgold & others, 2001). Procedural memories are essentially memories for *how* to perform sequences of behaviors. For example, when you play a video game or the piano, you're drawing on your procedural memories.

Studies have shown that REM sleep increases after learning a novel task and that deprivation of REM sleep following training disrupts learning (Maquet, 2001). The importance of REM sleep was demonstrated in one study in which volunteers were trained on a simple but challenging perceptual task before going to sleep (Karni & others, 1994). Half the participants were repeatedly awakened during NREM sleep stages, while the other half were repeatedly awakened during REM sleep. The volunteers who enjoyed uninterrupted REM (dreaming) sleep improved their performance on the test the next day, but the participants whose REM sleep was disrupted did not.

While REM sleep appears to play an important role in memory consolidation, exactly how it does so is still unknown. Recent studies have shown that brain areas activated during training on a particular task are actually *reactivated* during REM sleep (Louie & Wilson, 2001; Maquet & others, 2000). Thus, REM sleep may help stabilize the neural connections acquired through recent experience.

sleep thinking

Repetitive, bland, and uncreative ruminations about real-life events during sleep.

dream

A storylike episode of unfolding mental imagery during sleep.

Table 4.3

Common Dream Themes Across Cultures

	Percentage of Students Saying Yes	
	American	Japanese
Have you ever dreamed of . . . ?		
1. being attacked or pursued	77	91
2. falling	83	74
3. trying again and again to do something	71	87
4. school, teachers, studying	71	86
5. being frozen with fright	58	87
6. sexual experiences	66	68
7. arriving too late (e.g., missing train)	64	49
8. dead people as though alive	46	57
9. loved person being dead	57	42
10. being on the verge of falling	47	45
11. failing an examination	39	41
12. flying or soaring through air	34	46
13. being smothered, unable to breathe	44	33
14. seeing self as dead	33	35
15. being nude	43	17

SOURCE: Adapted from data reported in Empson (1993).

What Do We Dream About?

Although nearly everyone can remember an unusually bizarre dream, most dreams are a reflection of everyday life, including people we know and familiar settings (Domhoff, 1999; Weinstein & others, 1991). Recall Mike’s nightmare about his new boss, which was described in the Prologue. The giant staircase and spiral escalators were exaggerated versions of real architectural features of the atrium-style lobby of the hotel where he works.

Dream researcher Calvin Hall collected and analyzed over 10,000 dreams from hundreds of people. He found that a dream’s themes often reflect the daily concerns of the dreamer (Hall & Van de Castle, 1966). Worries about exams, money, health, troubled relationships, or jobs are all likely to be reflected in our dreams—as was Mike’s anxiety about his new boss.

Certain themes, such as falling, being chased, or being attacked, are surprisingly common across cultures. As you can see in Table 4.3, although thousands of miles apart and immersed in two very different cultures, American and Japanese college students share many dream themes. Surveys of dream content in many cultures have shown that dreamers around the world report more instances of negative events than of positive events (Domhoff, 1996). Instances of aggression are more common than are instances of friendliness, and dreamers are more likely to be victims of aggression than aggressors in their dreams. There is more aggression in men’s dreams than in women’s dreams, but women are more likely to dream that they are the victims of physical aggression.

Environmental cues *during* dreaming can also influence dream content. In sleep labs, researchers have played recordings of a rooster crowing, a bugle playing reveille, and a dog barking. Researchers have even sprayed water on sleeping subjects. Depending on the stimulus, up to half the dreamers incorporated the external stimulation into their dream content (Arkin & Antrobus, 1991).

Why Don’t We Remember Our Dreams?

Even the best dream recallers forget the vast majority of their dreams—at least 95 percent, according to one estimate (Hobson, 1995). Why are dreams so much more difficult to remember than waking experiences? Several theories have been proposed, each with at least some evidence to support it.

As we’ll discuss in more detail in Chapter 6, memory requires information to be processed and stored in such a way that it can be retrieved at a later time. One theory is that the fundamental changes in brain chemistry and functioning that occur during sleep fail to support such information processing and storage.

For example, frontal lobe areas are involved in the formation of new memories. But as you read earlier, PET scans of sleeping volunteers have shown that the frontal lobes are inactive during REM sleep (Braun & others, 1998). Research has also shown that the neurotransmitters needed to acquire new memories—including serotonin, norepinephrine, and dopamine—are greatly reduced during REM sleep (J. A. Hobson & others, 1998; Siegel, 2001).

Some dreams are remembered, however, and several factors have been found to influence dream recall. First, you’re much more likely to recall a dream if you wake up during it (Schredl & Montasser, 1997). When people are intentionally awakened during REM sleep, they usually recall the dream content. There are also individual differences in



“Off with his head! Off with his head!”

IN FOCUS 4.2

*What You Really Want to Know About Dreams***If I fall off a cliff in my dreams and don't wake up before I hit the bottom, will I die?**

The first obvious problem with this bit of folklore is that if you did die before you woke up, how would anyone know what you'd been dreaming about? Beyond this basic contradiction, studies have shown that about a third of dreamers can recall a dream in which they died or were killed. Dream sensations such as falling, soaring through the air, and being paralyzed seem to be universal.

Do animals dream?

Virtually all mammals experience sleep cycles in which REM sleep alternates with slow-wave NREM sleep. Animals clearly demonstrate perception and memory. They also communicate using vocalizations, facial expressions, posture, and gestures to show territoriality and sexual receptiveness. Thus, it's quite reasonable to conclude that the brain and other physiological changes

that occur during animal REM sleep are coupled with mental images. One bit of anecdotal evidence supporting this idea involved a gorilla that had been taught sign language to communicate. The gorilla signed "sleep pictures," presumably referring to REM dream activity while it slept.

What do blind people "see" when they dream?

People who become totally blind before the age of five typically do not have visual dreams as adults. Even so, their dreams are just as complex and vivid as sighted people's dreams; they just involve other sensations—of sound, taste, smell, and touch.

Is it possible to control your dreams?

Yes, if you have lucid dreams. A *lucid dream* is one in which you become aware that you are dreaming while you are still asleep. About half of all people can recall at least one lucid dream, and some

people frequently have lucid dreams. The dreamer can often consciously guide the course of a lucid dream, including backing it up and making it go in a different direction.

Can you predict the future with your dreams?

History is filled with stories of dream prophecies. Over the course of your life, you will have over 100,000 dreams. Simply by chance, it's not surprising that every now and then a dream contains elements that coincide with future events.

Are dreams in color or black and white?

Up to 80 percent of our dreams contain color. When dreamers are awakened and asked to match dream colors to standard color charts, soft pastel colors are frequently chosen.

SOURCES: Anch & others (1988); Blackmore (1998); Empson (1993); Halliday (1995); Hobson (1995); Hurovitz & others (1999); Schatzman & Fenwick (1994); Weinstein & others (1991).

dream recall. Some people frequently remember their dreams in vivid detail. Other people hardly ever remember their dreams. Research has shown that people who are better at remembering visual details while awake are also better at recalling their dreams (Schredl & others, 1995).

Second, the more vivid, bizarre, or emotionally intense a dream is, the more likely it is to be recalled the following morning. Vivid dreams are also more likely to be remembered days or weeks after the dream has occurred (Goodenough, 1991). In many respects, this is very similar to waking experiences. Whether you're awake or asleep, mundane and routine experiences are most likely to be forgotten.

Third, distractions on awakening interfere with our ability to recall dreams, as noted by psychologist Mary Calkins (1893) over a century ago:

To recall a dream requires usually extreme and immediate attention to the content of the dream. Sometimes the slight movement of reaching for paper and pencil or of lighting one's candle seems to dissipate the dream-memory, and one is left with the tantalizing consciousness of having lived through an interesting dream-experience of which one has not the faintest memory.

Finally, it's difficult to remember *any* experience that occurs during sleep, not just dreams. Sleep researchers have found that people who are briefly awakened during the night to give reports or perform simple tasks frequently do not remember the incident the next morning (Goodenough, 1991). It seems clear, then, that the brain is largely programmed to forget not only the vast majority of dream experiences but also other experiences that happen during sleep.

Nightmares

An unpleasant anxiety dream that occurs during REM sleep is called a **nightmare**. Nightmares often produce spontaneous awakenings, during which the vivid and frightening dream content is immediately recalled. The general theme of nightmares is of being helpless or powerless in the face of great danger or destruction.

Nightmares are especially common in young children (Halliday, 1995). For example, when our daughter Laura was four years old, she told us about this vivid nightmare:

There was a big monster chasing me and Nubbin the Cat! And we jumped on a golden horse but the monster kept chasing us! Then Nubbin jumped off and started to eat the monster. And then Mommy came and saved me! And then Daddy took a sword and killed the monster! And then me and Mommy and Nubbin rode the horse into the clouds.

Like Laura, young children often have nightmares in which they are attacked by an animal or monster. In dealing with a child who has experienced a nightmare, simple reassurance is a good first step, followed by an attempt to help the child understand the difference between an imaginary dream and a real waking experience. In adults, an occasional nightmare is a natural and relatively common experience (Wood & Bootzin, 1990). Nightmares are not considered indicative of a psychological or sleep disorder unless they frequently cause personal distress.

The Significance of Dreams

Key Theme

- Theoretical approaches vary greatly in their explanations of the meaning of dreams.

Key Questions

- How did Freud explain dreams?
- How does the activation-synthesis model explain dreams?
- What general conclusions can be drawn about the nature of dreams?

For thousands of years and throughout many cultures, dreams have been thought to contain highly significant, cryptic messages. Do dreams mean anything? Do they contain symbolic messages? In this final section on dreaming, we will look at two theories that try to account for the purpose of dreaming, starting with the most famous one.

Sigmund Freud: Dreams as Fulfilled Wishes

In the chapters on personality and psychotherapy (Chapters 10 and 14), we'll look in detail at the ideas of **Sigmund Freud**, the founder of psychoanalysis. As we discussed in Chapter 1, Freud believed that sexual and aggressive instincts are the motivating forces that dictate human behavior. Because these instinctual urges are so consciously unacceptable, sexual and aggressive thoughts, feelings, and wishes are pushed into the unconscious, or *repressed*. However, Freud believed that these repressed urges and wishes could surface in dreams.

In his landmark work, *The Interpretation of Dreams* (1900), Freud wrote that dreams are the “disguised fulfillments of repressed wishes” and provide “the royal road to a knowledge of the unconscious mind.” Freud believed that dreams function as a sort of psychological “safety valve” for the release of unconscious and unacceptable urges.

Freud (1904) believed that dreams have two components: the **manifest content**, or the dream images themselves, and the **latent content**, the disguised

nightmare

A frightening or unpleasant anxiety dream that occurs during REM sleep.

manifest content

In Freud's psychoanalytic theory, the elements of a dream that are consciously experienced and remembered by the dreamer.

latent content

In Freud's psychoanalytic theory, the unconscious wishes, thoughts, and urges that are concealed in the manifest content of a dream.

activation-synthesis model of dreaming

The theory that brain activity during sleep produces dream images (*activation*), which are combined by the brain into a dream story (*synthesis*).

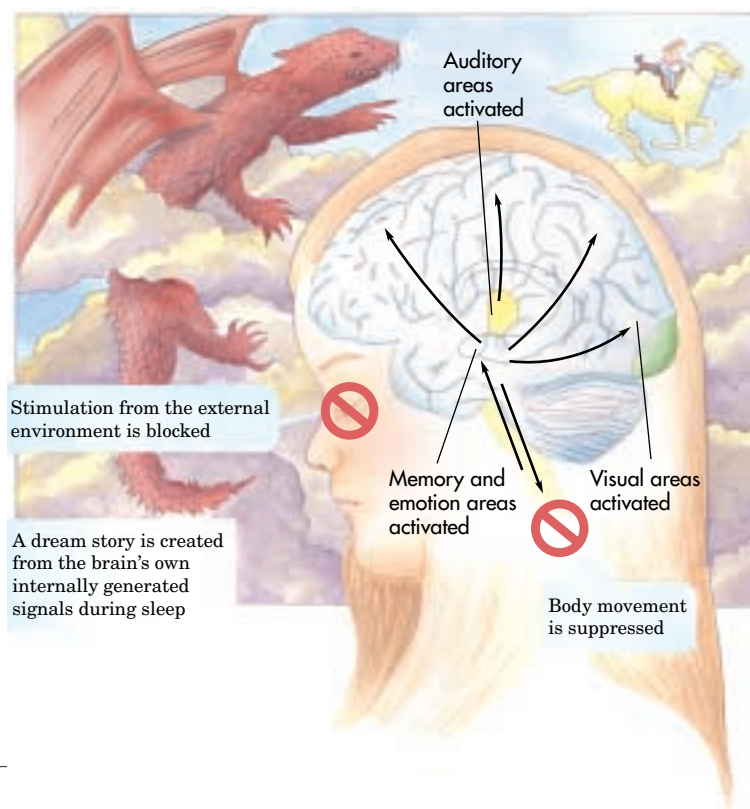
psychological meaning of the dream. For example, Freud (1911) believed that dream images of sticks, swords, and other elongated objects were phallic symbols, representing the penis. Dream images of cupboards, boxes, and ovens supposedly symbolized the vagina.

In many types of psychotherapy today, especially those that follow Freud's ideas, dreams are still seen as an important source of information about psychological conflicts. However, Freud's belief that dreams represent the fulfillment of repressed wishes has not been substantiated by psychological research (Fisher & Greenberg, 1996; Schatzman & Fenwick, 1994). Furthermore, research does not support Freud's belief that the dream images themselves—the manifest content of dreams—are symbols that disguise the dream's true psychological meaning (Domhoff, 1996).

The Activation–Synthesis Model of Dreaming

Armed with an array of evidence that dreaming involves the activation of different brain areas during REM sleep, researcher **J. Allan Hobson** and his colleague Robert McCarley first proposed a new model of dreaming in 1977. Called the **activation–synthesis model of dreaming**, this model maintains that dreaming is our subjective awareness of the brain's internally generated signals during sleep (Hobson, 1995; Hobson & Stickgold, 1995). Since it was first proposed, the model has evolved as new findings have been reported (Hobson & others, 1998; Stickgold & others, 2001).

Specifically, the activation–synthesis model maintains that the experience of dreaming sleep is due to the automatic activation of brainstem circuits at the base of the brain (see Figure 4.5). These circuits arouse more sophisticated brain areas, including visual and auditory pathways. As noted earlier, limbic system structures involved in emotion, such as the amygdala and hippocampus, are also activated during REM sleep. When we're awake, these pathways and brain structures are involved in registering stimuli from the external world. But rather than responding to stimulation from the external environment, the dreaming brain is responding to its own internally generated signals.



Dream Researcher J. Allan Hobson

Neuroscientist J. Allan Hobson developed the activation–synthesis model of dreams with his colleague Robert McCarley. Although Hobson believes that dreams are the by-products of physiological processes in the brain, he does not believe that dreams are meaningless. Hobson (1999) observed, "Dreaming may be our most creative conscious state, one in which the chaotic, spontaneous recombination of cognitive elements produces novel configurations of information: new ideas. While many or even most of these ideas may be nonsensical, if even a few of its fanciful products are truly useful, our dream time will not have been wasted."



FIGURE 4.5 The Activation–Synthesis Model of Dreaming: Laura's Dream According to the activation–synthesis model, dreaming is caused by the activation of brainstem circuits that arouse other brain areas involved in sensations, emotions, and memories. The results of these internally generated signals are the dream images and sensations that the activated brain synthesizes, or combines. The dreaming person imposes a personal meaning on the dream story (Hobson, 1995; Hobson & others, 1998).

In the absence of external sensory input, the activated brain combines, or synthesizes, these internally generated sensory signals and imposes meaning on them. The dream story itself is derived from a hodgepodge of memories, emotions, and sensations that are triggered by the brain's activation and chemical changes during sleep. According to this model, then, dreaming is essentially the brain's synthesizing and integrating memory fragments, emotions, and sensations that are internally triggered (Hobson & others, 1998).

The activation–synthesis theory does *not* state that dreams are completely meaningless (Hobson & Stickgold, 1995). But if there is a meaning to dreams, that meaning lies in the deeply personal way in which the images are organized, or synthesized. In other words, the meaning is to be found not by decoding the dream symbols, but by analyzing the way the dreamer makes sense of the progression of chaotic dream images.

Some Observations About the Meaning of Dreams

Subjectively, it seems obvious that at least some of our dreams mirror our real life concerns, frustrations, anxieties, and desires. Less subjectively, this observation is consistent with sleep research on the content of dreams (Weinstein & others, 1991). Large-scale analyses of dream reports demonstrate that dreams reflect the waking concerns and preoccupations of the dreamer (Domhoff, 1993, 1996). Thus, the topics you think about during the day are most likely to influence the topics you dream about at night (Nikles & others, 1998). Some dream researchers believe that most dreams, however chaotic or disorganized, are meaningfully related to the dreamers' current concerns, problems, and waking lives (Domhoff, 1998).

It may well be that the more bizarre aspects of dream sequences—the sudden scene changes, intense emotions, and vivid, unrealistic images—are due to physiological changes in the brain during REM and NREM sleep. Dream researcher David Foulkes (1993, 1997) argues that dreaming consciousness is no different from waking consciousness in its attempt to make sense of the information that is available to it. What differs is the *source* of the information. When we're awake, we monitor the external environment, making sense of the stimuli that impinge upon us from the environment as well as our own thoughts, feelings, and fantasies. During sleep, we try—as best we can—to make sense of the less orderly stimuli produced by the brain itself.

If nothing else, remember that the interpretation of dreams occurs when we're awake. It seems reasonable, then, to suggest that conscious speculations about the meaning of these elusive nightly productions might reveal more about the psychological characteristics of the interpreter than about the dream itself (Cartwright & Kaszniak, 1991).

Hypnosis

Key Theme

- During hypnosis, people respond to suggestions with changes in perception, memory, and behavior.

Key Questions

- What characteristics are associated with responsiveness to hypnotic suggestions?
- What are some important effects of hypnosis?
- How has hypnosis been explained?

What is hypnosis? Definitions vary, but **hypnosis** can be defined as a cooperative social interaction in which the hypnotic participant responds to suggestions made by the hypnotist. These suggestions for imaginative experiences can produce

changes in perception, memory, thoughts, and behavior (American Psychological Association, 2001).

For many people the word *hypnosis* conjures up the classic but sinister image of a hypnotist inducing hypnosis by slowly swinging a pocket watch back and forth. But, as psychologist John Kihlstrom (2001) explains, “The hypnotist does not hypnotize the individual. Rather, the hypnotist serves as a sort of coach or tutor whose job is to help the person become hypnotized.” After experiencing hypnosis, some people are able to self-induce hypnosis.

The word *hypnosis* is derived from the Greek *hypnos*, meaning “sleep.” The idea that the hypnotized person is in a sleep-like trance is still very popular among the general public. However, the phrase *hypnotic trance* is misleading and rarely used by researchers today (Wagstaff, 1999). When hypnotized, people do *not* lose control of their behavior. Instead, they typically remain aware of where they are, who they are, and what is transpiring.

Rather than being a sleeplike trance, hypnosis is characterized by highly focused attention, increased responsiveness to suggestions, vivid images and fantasies, and a willingness to accept distortions of logic or reality. During hypnosis, the person temporarily suspends her sense of initiative and voluntarily accepts and follows the hypnotist’s instructions (Hilgard, 1986a).

Although most adults are moderately hypnotizable, people vary in their responsiveness to hypnotic suggestions. About 15 percent of adults are highly susceptible to hypnosis, and 10 percent are difficult or impossible to hypnotize (Hilgard, 1982; Register & Kihlstrom, 1986). Children tend to be more responsive to hypnosis than are adults, and children as young as five years old can be hypnotized (Kohen & Olness, 1993). Evidence suggests that the degree of susceptibility to hypnosis tends to run in families. For example, identical twins are more similar in their susceptibility to hypnosis than are fraternal twins (Nash, 2001).

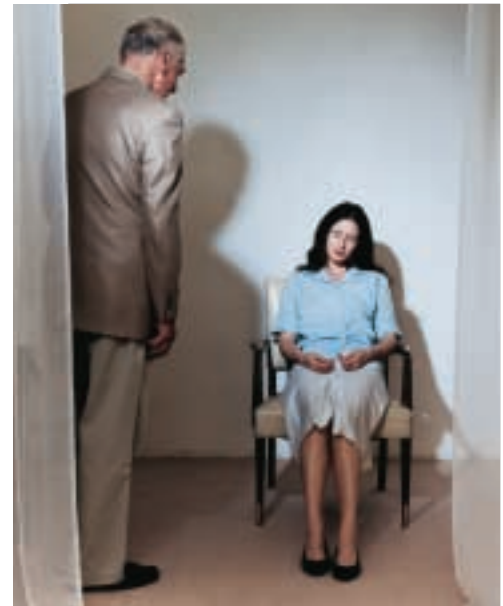
The best candidates for hypnosis are individuals who approach the experience with positive, receptive attitudes. The expectation that you will be responsive to hypnosis also plays an important role (Kirsch & others, 1995; Spanos & others, 1993). People who are highly susceptible to hypnosis have the ability to become deeply absorbed in fantasy and imaginary experience. For instance, they easily become absorbed in reading fiction, watching movies, and listening to music (Barnier & McConkey, 1999; Kihlstrom, 2001).

Effects of Hypnosis

Deeply hypnotized subjects sometimes experience profound changes in their subjective experience of consciousness. They may report feelings of detachment from their bodies, profound relaxation, or sensations of timelessness. More commonly, hypnotized people converse normally and remain fully aware of their surroundings. Often, they will later report that carrying out the hypnotist’s suggestions seemed to happen by itself. The action seems to take place outside the hypnotized person’s will or volition.

Sensory and Perceptual Changes

Some of the most dramatic effects that can be produced with hypnosis are alterations in sensation and perception. Sensory changes that can be induced through hypnosis include temporary blindness, deafness, or a complete loss of sensation in some part of the body (Hilgard, 1986a). For example, when the suggestion is made to a highly responsive subject that her arm is numb and cannot feel pain, she will not consciously experience the pain of a pinprick or of having her arm immersed in ice water. This property of hypnosis has led to its use as a technique



How Is the Hypnotic State Produced? In a willing volunteer, hypnosis can be induced in a variety of ways, but swinging a pocket watch is usually not one of them. Instead, as psychologist Michael Nash demonstrates, hypnosis is more commonly induced by speaking in a calm, monotonous voice, suggesting that the person is becoming drowsy, sleepy, and progressively more relaxed. To help the volunteer focus her attention, the hypnotist may also ask her to concentrate on a simple visual stimulus, such as a spot on the wall.

hypnosis

(hip-NO-sis) A cooperative social interaction in which the hypnotized person responds to the hypnotist’s suggestions with changes in perception, memory, and behavior.

posthypnotic suggestion

A suggestion made during hypnosis that the person should carry out a specific instruction following the hypnotic session.

posthypnotic amnesia

The inability to recall specific information because of a hypnotic suggestion.

hypermnnesia

(high-perm-NEE-zha) The supposed enhancement of a person's memory for past events through a hypnotic suggestion.

Hypnotic Suppression of Pain In this classic photo taken at the Stanford Laboratory of Hypnosis Research, psychologist Ernest Hilgard (1904–2001) instructs this hypnotized young woman that she will feel no pain in her arm. Her arm is then immersed in circulating ice water for several minutes, and she reports that she does not experience any pain. In contrast, a nonhypnotized subject perceives the same experience as extremely painful and can keep his arm in the ice water for no more than a few seconds.

Hypnosis and Memory Some people believe that hypnosis can allow you to re-experience an earlier stage of your life—a phenomenon called *age regression* (J. Green, 1999b). Under hypnosis, some adults *do* appear to relive experiences from their childhood, confidently displaying childlike speech patterns and behaviors. However, when attempts are made to verify specific details of the experiences, they generally prove to be inaccurate (Spanos, 1987–1988). Just as actual deafness and blindness are not produced by hypnotic suggestion, neither is a true return to childhood. Instead, hypnotic subjects combine fragments of actual memories with fantasies and their ideas about how children of a particular age should behave.

in pain control (Montgomery & others, 2000). Painful dental and medical procedures, including surgery, have been successfully performed with hypnosis as the only anesthesia (Hilgard & others, 1994).

People can experience hallucinations under hypnosis. If a highly responsive hypnotic subject is told that a close friend is sitting in a chair on the other side of the room, she will not only report seeing the friend in vivid detail but will walk over and “touch” the other person. Under hypnosis, people can also *not* perceive something that *is* there. For example, if the suggestion is made that a jar of rotten eggs has no smell, a highly suggestible person will not consciously perceive any odor.



Hypnosis can also influence behavior *outside* the hypnotic state. When a **posthypnotic suggestion** is given, the person will carry out that specific suggestion after the hypnotic session is over. For example, under hypnosis, a student was given the posthypnotic suggestion that the number 5 no longer existed. He was brought out of hypnosis and then asked to count his fingers. He counted 11 fingers! Counting again, the baffled young man was at a loss to explain his results.

Some posthypnotic suggestions have been reported to last for months, but most last only a few hours or days (Barnier & McConkey, 1998). So, even if the hypnotist does not include some posthypnotic signal to cancel the posthypnotic suggestion, the suggestion will eventually wear off.

Hypnosis and Memory

Memory can be significantly affected by hypnosis. In **posthypnotic amnesia**, a subject is unable to recall specific information or events that occurred before or during hypnosis. Posthypnotic amnesia is produced by a hypnotic suggestion that suppresses the memory of specific information, such as the subject's street address. The effects of posthypnotic amnesia are usually temporary, disappearing either spontaneously or when a posthypnotic signal is suggested by the hypnotist. When the signal is given, the information floods back into the subject's mind.

The opposite effect is called **hypermnnesia**, which is enhancement of memory for past events through hypnotic suggestion. Police investigators sometimes use hypnosis in an attempt to enhance the memories of crime victims and witnesses. Despite the common belief that you can “zoom in” on briefly seen crime details under hypnosis, such claims are extremely exaggerated (Smith, 1983). Compared with regular police

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interview methods, hypnosis does *not* significantly enhance memory or improve the accuracy of memories (Nash, 2001; Register & Kihlstrom, 1987).

Many studies have shown that efforts to enhance memories hypnotically can lead to distortions and inaccuracies (Burgess & Kirsch, 1999). In fact, hypnosis can greatly increase confidence in memories that are actually incorrect (Kihlstrom & Barnhardt, 1993). False memories, also called *pseudomemories*, can be inadvertently created when hypnosis is used to aid recall (Lynn & Nash, 1994; Yapko, 1994a).

The Limits of Hypnosis

Although the effects of hypnosis can be dramatic, there are limits to the behaviors that can be influenced by hypnosis. First, contrary to popular belief, you cannot be hypnotized against your will. Second, hypnosis cannot make you perform behaviors that are contrary to your morals and values. Thus, you're very unlikely to commit criminal or immoral acts under the influence of hypnosis—unless, of course, you find such actions acceptable (Hilgard, 1986b).

Third, hypnosis cannot make you stronger than your physical capabilities or bestow new talents. However, hypnosis *can* enhance physical skills or athletic ability by increasing motivation and concentration (Morgan, 1993). Table 4.4 provides additional examples of how hypnosis can be used to help people.

Can hypnosis be used to help you lose weight, stop smoking, or stop biting your nails? The effectiveness of hypnosis in modifying habitual behaviors varies. For example, research provides little evidence to support the notion that hypnosis is more effective than other methods in controlling smoking behavior (Green & Lynn, 2000). In study after study, hypnosis has failed to produce long-term cessation of smoking (Spanos & others, 1995b). In contrast, hypnosis coupled with cognitive-behavior therapy does enhance the effectiveness of weight-loss programs (J. Green, 1999a; Kirsch, 1996). In Chapter 14, on therapies, we'll explore cognitive and behavior therapy techniques in detail.

Explaining Hypnosis

Consciousness Divided?

How can hypnosis be explained? Psychologist **Ernest Hilgard** (1986a, 1991, 1992) believed that the hypnotized person experiences **dissociation**—the splitting of consciousness into two or more simultaneous streams of mental activity. According to Hilgard's **neodissociation theory of hypnosis**, a hypnotized person consciously experiences one stream of mental activity that is responding to the hypnotist's suggestions. But a second, dissociated stream of mental activity is also operating, processing information that is unavailable to the consciousness of the hypnotized subject. Hilgard (1986a, 1992) referred to this second, dissociated stream of mental activity as the **hidden observer**. (The phrase *hidden observer* does *not* mean that the hypnotized person has multiple personalities.)

Table 4.4

Help Through Hypnosis

Research has demonstrated that hypnosis can effectively:

- Reduce pain and discomfort associated with cancer, rheumatoid arthritis, burn wounds, and other chronic conditions
- Reduce pain and discomfort associated with childbirth
- Reduce the use of narcotics to relieve postoperative pain
- Improve the concentration, motivation, and performance of athletes
- Lessen the severity and frequency of asthma attacks
- Eliminate recurring nightmares
- Enhance the effectiveness of psychotherapy in the treatment of obesity, hypertension, and anxiety
- Remove warts
- Eliminate or reduce stuttering
- Suppress the gag reflex during dental procedures

dissociation

The splitting of consciousness into two or more simultaneous streams of mental activity.

neodissociation theory of hypnosis

Theory proposed by Ernest Hilgard that explains hypnotic effects as being due to the splitting of consciousness into two simultaneous streams of mental activity, only one of which the hypnotic participant is consciously aware of during hypnosis.

hidden observer

Hilgard's term for the hidden, or dissociated, stream of mental activity that continues during hypnosis.

CRITICAL THINKING BOX 4.3

Is Hypnosis a Special State of Consciousness?

One of the great debates in modern psychology comes down to this question: Are the changes in perception, thinking, and behaviors that occur during hypnosis the result of a “special” or “altered” state of consciousness? Here, we’ll touch on some of the evidence for three competing points of view on this issue.

The State View: Hypnosis Involves a Special State of Consciousness

Considered the traditional viewpoint, the “state” explanation contends that hypnosis is a unique state of consciousness, distinctly different from our normal waking consciousness (Kosslyn & others, 2000). The state view is perhaps best represented by Hilgard’s *neodissociation theory of hypnosis*. According to this view, consciousness is split into two simultaneous streams of mental activity during hypnosis. One stream of mental activity remains conscious, but a second stream of mental activity—the one responding to the hypnotist’s suggestions—is “dissociated” from awareness. So according to the neodissociation explanation, the hypnotized young woman shown on page 150, whose hand is immersed in ice water, reported no pain because the painful sensations were dissociated from awareness.

The Non-State View: Ordinary Social Psychological Processes Can Explain Hypnosis

Some psychologists flatly reject the notion that hypnotically induced changes involve a “special” state of consciousness. According to the *social-cognitive view* of

hypnosis, subjects are responding to the *social demands* of the hypnosis situation. They act the way they think good hypnotic subjects are supposed to act, conforming to the expectations of the hypnotist, their own expectations, and situational cues. In this view, the “hypnotized” young woman on page 150 reported no pain because that’s what she expected to happen during the hypnosis session.

To back up the social-cognitive theory of hypnosis, Nicholas Spanos (1991, 1994, 1996) and his colleagues have amassed an impressive array of evidence showing that highly motivated people often perform just as well as hypnotized subjects in demonstrating pain reduction, amnesia, age regression, and hallucinations. Studies of people who simply *pretended* to be hypnotized have shown similar results. On the basis of such findings, non-state theorists contend that hypnosis can be explained in terms of rather ordinary psychological processes, including imagination, situational expectations, role enactment, compliance, and conformity (Wagstaff, 1999).

PET Scans During Hypnosis: Does the Brain Respond Differently?

In trying to reconcile the state and non-state explanations of hypnosis, researcher Stephen Kosslyn and his colleagues (2000) conducted a brain-imaging study. Highly hypnotizable volunteers viewed two images of rectangles, one in bright colors and one in shades of gray, while lying in a PET scanner. During the study, the researchers measured activity

in brain regions known to be involved in color perception. While hypnotized, the participants were instructed to perform three tasks: to see the images as they were; to mentally “drain” color from the colored rectangles in order to see them in shades of gray; and to mentally “add” color to the gray rectangles. Essentially, these last two tasks were hypnosis-induced hallucinations.

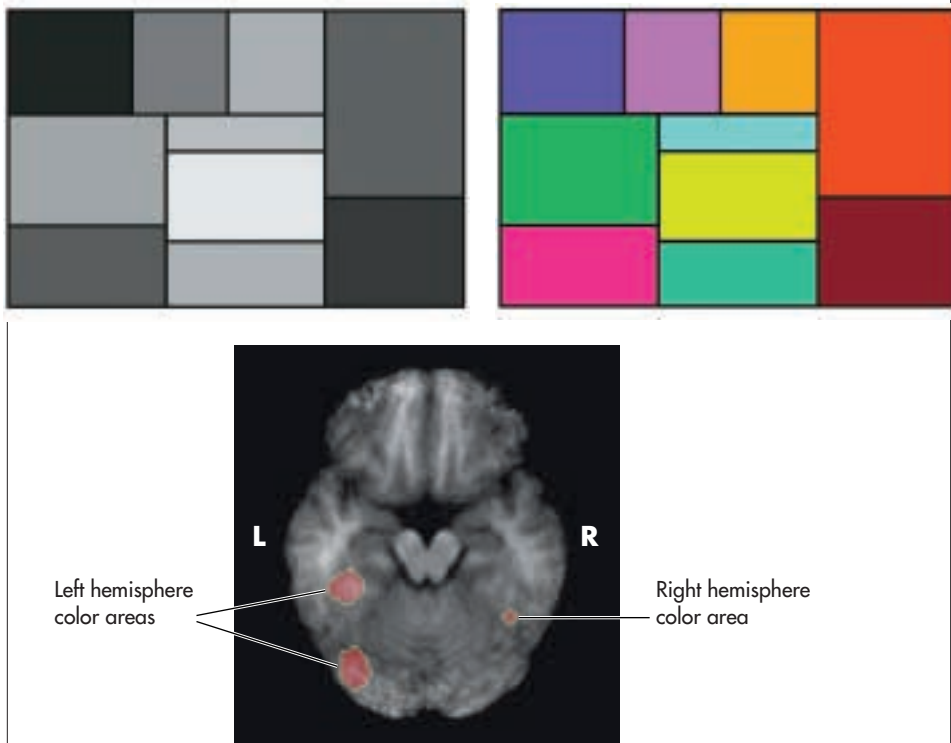
What did the PET scans reveal? In contrast to what might be expected if the participants were merely playing the role of hypnotic subject, hypnosis produced distinct effects on brain activity. When the hypnotized participants were instructed to perceive colored rectangles, color regions in the brain activated, *regardless* of whether the participants were shown colored or gray rectangles. When participants were instructed to perceive gray rectangles, color regions in the brain deactivated, *regardless* of whether the participants were shown colored or gray rectangles. In other words, brain activity reflected the hypnosis-induced hallucinations—not the actual images that were shown to the participants. These findings led Kosslyn (2001) to conclude that “Hypnosis is not simply ‘role playing,’ but does in fact reflect the existence of a distinct mental brain state.”

The Imaginative Suggestibility View: Some People Are Highly Suggestible

Psychologists Irving Kirsch and Wayne Braffman (2001) dismiss the idea that hypnotic subjects are merely acting. But they also contend that brain-imaging

Hilgard accidentally discovered the “hidden observer” while conducting a classroom demonstration. Hilgard hypnotized a student and induced hypnotic deafness. The student was completely unresponsive to very loud, sudden sounds, such as the sound of a starter pistol firing or of wooden blocks being banged together.

Another student, observing the demonstration, asked Hilgard if “some part” of the hypnotized person was actually aware of the sounds. Hilgard instructed the hypnotized student to raise his right index finger if some part of him could still hear. To Hilgard’s surprise, the hypnotized student’s right index finger rose!



Brain Activation During Hypnosis The rectangles shown here—one in bright colors and the other in shades of gray—were used as stimuli to test brain activity during hypnosis. When hypnotized participants were asked to mentally add color to the gray rectangles, activity in brain regions involved in color perception sharply increased, as this PET scan shows. Conversely, when hypnotized participants were instructed to mentally drain color from the colored rectangles, the brain's color-perception regions deactivated. In other words, brain activity reflected the participants' subjective experience of the hypnosis-induced hallucinations—not the actual stimuli that were shown. According to the researchers, such findings contradict the notion that hypnosis is merely role playing (Kosslyn & others, 2001).

studies don't necessarily prove that hypnosis is a unique or distinct state. Rather, Kirsch and Braffman maintain that such studies emphasize individual differences in *imaginative suggestibility*—the degree

to which a person is able to experience an imaginary state of affairs as if it were real.

In previous research, Braffman and Kirsch (1999) found that many participants were just as responsive to sugges-

tions when they had *not* been hypnotized as when they had been hypnotized. They concluded that the effects of hypnosis are neither due to a unique psychological state nor role playing. "Hypnotic responses reveal an astounding capacity that some people have to alter their experience in profound ways," Kirsch and Braffman (2001) write. "Hypnosis is only one of the ways in which this capacity is revealed. It can also be evoked—and almost to the same extent—without inducing hypnosis."

Psychologists continue to debate the essential nature of hypnosis and the best explanation of hypnotic effects (Kihlstrom, 2001). Despite the controversy over how best to explain hypnotic effects, psychologists do agree that hypnosis can be a highly effective therapeutic technique (Kirsch & others, 1995; Montgomery & others, 2000).

Critical Thinking Questions

- Does the fact that highly motivated subjects can "fake" hypnotic effects invalidate the notion of hypnosis as a unique state of consciousness?
- Do individual differences in "imaginative suggestibility" provide a simpler explanation than "dissociation" in explaining responsiveness to hypnotic suggestions?
- What kinds of evidence could prove or disprove the notion that hypnosis is a unique state of consciousness?

When brought out of hypnosis, the student had no recall of any sounds during the hypnotically induced deafness, *including* Hilgard's suggestion to raise his index finger. Hypnosis, it seems, had produced a split in consciousness. A conscious segment complied with the hypnotic suggestion of deafness, but a separate, dissociated segment unavailable to consciousness—the hidden observer—continued to process information.

Not all psychologists agree that hypnotic phenomena are due to dissociation, divided consciousness, or a hidden observer. In Critical Thinking Box 4.3, we examine this controversy more fully.

4.2 R · E · V · I · E · W

C.O.N.C.E.P.T

Sleep Disorders, Dreams, and Hypnosis

1. Mrs. Johnson is unable to sleep because her husband snores so loudly. He snorts as though he is gulping for air throughout the night, especially when he sleeps on his back. During the day Mr. Johnson is constantly tired. Mr. Johnson is probably suffering from _____.
 - a. insomnia
 - b. REM sleep behavior disorder
 - c. narcolepsy
 - d. sleep apnea
2. The night before an important job interview, Marjorie doesn't sleep well. Each time she briefly awakens, the vague, thoughtlike imagery filling her mind is that of rehearsing details she wants to remember to say during the interview. These ruminations during sleep represent _____.
 - a. dreams
 - b. nightmares
 - c. sleep apnea
 - d. sleep thinking
3. According to the activation-synthesis model, dreams are _____.
 - a. meaningless.
 - b. symbolic representations of repressed wishes.
 - c. the subjective awareness of the brain's internally generated signals during sleep.
 - d. produced by newly consolidated memories.
4. While Marshall is under hypnosis, the hypnotist tells him that he remembers being lost in a shopping mall as a young child. After being brought out of hypnosis, Marshall is completely convinced that the incident occurred and describes it in detail. The hypnotist has successfully created _____.
 - a. a posthypnotic suggestion
 - b. posthypnotic amnesia
 - c. hypermnnesia
 - d. a pseudomemory
5. Dr. Kildare used hypnosis instead of an anesthetic when setting a patient's broken toe. The patient insisted that she felt no pain, but when instructed to raise her right index finger if some part of her felt any pain, she raised her finger. This example best illustrates the notion of _____.
 - a. the hidden observer
 - b. posthypnotic suggestion
 - c. hypermnnesia
 - d. the social-cognitive theory of hypnosis

Meditation

Key Theme

- Meditation involves using one of various techniques to deliberately change conscious experience, inducing a state of focused attention and awareness.

Key Questions

- What are two general types of meditation?
- What are the effects of meditation?

Meditation refers to a group of techniques that induce an altered state of focused attention and heightened awareness. Meditation takes many forms and has been used for thousands of years as part of religious practices throughout the world. Virtually every major religion—Hindu, Taoist, Buddhist, Jewish, Christian, and Muslim—has a rich tradition of meditative practices (Nelson, 2001). However, many people practice meditation independently of any religious tradition or spiritual context. Some forms of psychotherapy also include meditative practice as a component of the overall therapy (Epstein, 1995; Snaith, 1998).

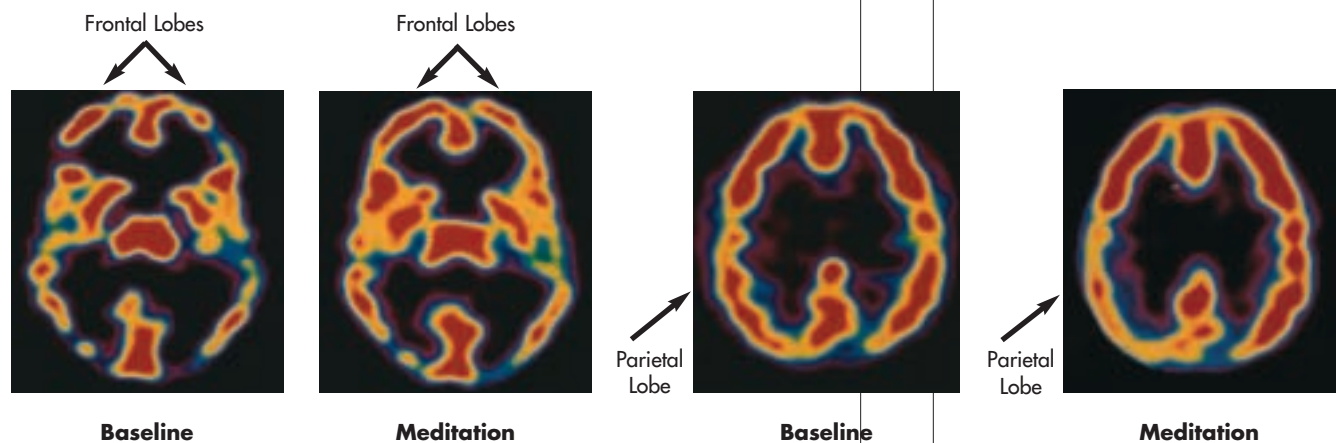
Common to all forms of meditation is the goal of controlling or retraining attention. Although meditation techniques vary a great deal, they can be divided into two general categories. *Concentration techniques* involve focusing awareness on a visual image, your breathing, a word, or a phrase. When a sound is used, it is typically a short word or a religious phrase, called a *mantra*, that is repeated mentally. *Opening-up techniques* involve a present-centered

meditation

Any one of a number of sustained concentration techniques that focus attention and heighten awareness.

Neuroscience

focus on



Brain Changes During Peak Meditation Experiences Experienced meditators frequently report a heightened sense of concentration and attention, a sense of timelessness and infinity, and a profound sense of connectedness to everyone and everything in existence (Newberg & d'Aquili, 2000). How is brain functioning different during these intense meditation experiences?

To answer that question, researcher Andrew Newberg and his colleagues (2001) studied eight highly experienced Tibetan Buddhist meditators—four men and four women. A baseline brain scan was performed on each person, and then the person meditated until he or she had achieved the “peak” moment of the meditation. The meditator signaled this moment by tugging a string. In the next room, the researchers injected a radioactive tracer into a long intravenous tube connected to a vein in the meditator’s arm. When the meditation ended a few minutes later, the meditator was scanned.

In the brain images above, increased blood flow is indicated by red and yellow colors, which correspond with heightened brain activity. If

you look closely at the brain scans, two distinct changes are evident during the meditation: (1) increased blood flow to both *frontal lobes* and (2) decreased blood flow to the left *parietal lobe*.

According to Newberg, these brain changes make sense. Why? Because the frontal lobes are involved in attention-focusing tasks, which are heightened during meditation. In contrast, the parietal lobes are involved in visual-spatial tasks, such as helping us stay oriented in physical space, judging distances, and gauging elapsed time. During meditation experiences, the usual sense of time and space is altered and the meditator often experiences a profound sense of timelessness and connectedness to the world. Hence, Newberg predicted that activity in the parietal lobe would be decreased.

What do these findings mean? “Spiritual experience, at its very root, is intimately interwoven with human biology,” contends Newberg. “In the study with the Buddhist meditators, we believe that we were seeing colorful evidence on the computer screen of the brain’s capacity to make spiritual experience real.”

awareness of the passing moment, without mental judgment (Tart, 1994). Rather than concentrating on an object, sound, or activity, the meditator engages in quiet awareness of the “here and now” without distracting thoughts. The *zazen*, or “just sitting,” technique of Zen Buddhism is a form of opening-up meditation (Austin, 1998).

Effects of Meditation

One meditation technique that has been widely used in research is called *transcendental meditation*, or *TM*. TM is a form of concentrative meditation that can be quickly mastered, follows a simple format, and does not require any changes in lifestyle or beliefs. Meditators sit quietly with eyes closed and mentally repeat the mantra they have been given. Rather than struggling to clear the mind of thoughts, meditators are taught to allow distracting thoughts to simply “fall away” while they focus their attention on their mantra.

Numerous studies have shown that even beginning meditators practicing TM experience a state of lowered physiological arousal, including a decrease in heart rate, lowered blood pressure, and changes in brain waves (Dillbeck & Orme-Johnson, 1987). Advocates of TM claim that such physical changes produce a unique state of consciousness with a wide variety of benefits, including stress reduction.



Meditation in Different Cultures Meditation is an important part of many cultures. A Buddhist monk (top), wearing a traditional saffron robe, practices meditation at a temple in Thailand. People practice tai chi in a park in Hong Kong (bottom). Tai chi is a form of meditation that involves a structured series of slow, smooth movements. Throughout China, many people begin their day with tai chi, often meeting in parks and other public places.



relaxing but boring. Many studies have shown that regular meditation can enhance physical and psychological functioning beyond that provided by relaxation alone (C. N. Alexander & others, 1994; Andresen, 2000; Austin, 1998).

Meditation and hypnosis are similar in that both involve the deliberate use of mental techniques to change the experience of consciousness. In the final section of this chapter, we'll consider one of the oldest strategies for deliberately altering conscious awareness—psychoactive drugs.

psychoactive drug

A drug that alters consciousness, perception, mood, and behavior.

physical dependence

A condition in which a person has physically adapted to a drug so that he or she must take the drug regularly in order to avoid withdrawal symptoms.

drug tolerance

A condition in which increasing amounts of a physically addictive drug are needed to produce the original, desired effect.

withdrawal symptoms

Unpleasant physical reactions, combined with intense drug cravings, that occur when a person abstains from a drug on which he or she is physically dependent.

drug rebound effect

Withdrawal symptoms that are the opposite of a physically addictive drug's action.

drug abuse

Recurrent drug use that results in disruptions in academic, social, or occupational functioning or in legal or psychological problems.

Psychoactive Drugs

Key Theme

- Psychoactive drugs alter consciousness by changing arousal, mood, thinking, sensations, and perceptions.

Key Questions

- What are four broad categories of psychoactive drugs?
- What are some common properties of psychoactive drugs?
- What factors influence the effects, use, and abuse of drugs?

Psychoactive drugs are chemical substances that can alter arousal, mood, thinking, sensation, and perception. In this section, we will look at the characteristics of four broad categories of psychoactive drugs:

1. *Depressants*—drugs that depress, or inhibit, brain activity
2. *Opiates*—drugs that are chemically similar to morphine and that relieve pain and produce euphoria
3. *Stimulants*—drugs that stimulate, or excite, brain activity
4. *Psychedelic drugs*—drugs that distort sensory perceptions

Common Properties of Psychoactive Drugs

Addiction is a broad term that refers to a condition in which a person feels psychologically and physically compelled to take a specific drug. People experience **physical dependence** when their body and brain chemistry have physically adapted to a drug. Many physically addictive drugs gradually produce **drug tolerance**, which means that increasing amounts of the drug are needed to gain the original, desired effect.

For people who are physically dependent on a drug, abstaining from the drug produces withdrawal symptoms. **Withdrawal symptoms** are unpleasant physical reactions to the lack of the drug, plus an intense craving for it. Withdrawal symptoms are alleviated by taking the drug again. Often, the withdrawal symptoms are opposite to the drug's action, a phenomenon called the **drug rebound effect**. For example, withdrawing from stimulating drugs, like the caffeine in coffee, may produce depression and fatigue. Withdrawal from depressant drugs, such as alcohol, may produce excitability.



Each psychoactive drug has a distinct biological effect. Psychoactive drugs may influence many different bodily systems, but their consciousness-altering effects are primarily due to their effect on the brain. Typically, these drugs influence brain activity by altering synaptic transmission among neurons. As we discussed in Chapter 2, drugs affect synaptic transmission by increasing or decreasing neurotransmitter amounts or by blocking, mimicking, or influencing a particular neurotransmitter's effects (see p. 00).

The biological effects of a given drug vary somewhat from one person to another. The person's weight, gender, and age may influence the intensity of the drug's effects. Whether the drug is taken on a full or empty stomach or in combination with other drugs also plays a role. Racial and ethnic differences may affect how a drug is metabolized. For example, African-Americans seem to absorb more nicotine from cigarettes than do European-Americans or Mexican-Americans, and they metabolize the nicotine more slowly (Caraballo & others, 1998; Pérez-Stable & others, 1998).

Psychological and environmental factors can also influence the effects of a drug. The response to a drug can be significantly affected by personality characteristics, mood, expectations, experience with the drug, and by the setting in which the drug is taken (Marlatt & others, 1988; Stacy & others, 1990).

Why do people abuse drugs? There is no easy answer to that question. It's difficult to draw a hard-and-fast line between drug *use* and drug *abuse*, especially when the drug in question is legal, such as alcohol. Most people would not consider having a cold beer or two at a summer picnic an instance of drug abuse. Chugging a six-pack, however, is a different matter.

In contrast to drug use, **drug abuse** refers to recurrent drug use that results in the disruption of academic, social, or occupational functioning, or in legal or psychological problems (American Psychiatric Association, 2000a). Some authorities widen the definition of drug abuse to refer to *any* form of drug taking that results in harmful effects.

Many factors influence what is considered drug abuse. For example, determining what level of alcohol use constitutes "abuse" varies from one culture to another (Tanaka-Matsumi & Draguns, 1997). Even in the United States, different ethnic groups have very different norms regarding the use of al-



Psychoactive Drugs As they take a break in a Sarajevo cafe, these young Bosnian soldiers talk and relax—with the help of beer, coffee, and cigarettes. Alcohol, caffeine, and nicotine are three of the most widely used psychoactive substances in the world.

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Dangerous Drugs, Tragic Deaths Comedian Chris Farley was only 33 when he died of an accidental drug overdose. His death was caused by a lethal mixture of morphine (an opiate) and cocaine (a stimulant). Farley was also known to be a heavy drinker.

cohol. Jewish-, Italian-, Greek-, and Chinese-Americans have a tradition of moderate drinking. Drinking alcohol may be restricted to particular social occasions, such as weddings and other formal celebrations. Some U.S. religious groups, such as the Mormons, Amish, and Muslims, forbid drinking alcohol under any circumstances. Asian-Americans and African-Americans have the lowest rates of alcohol use (Substance Abuse and Mental Health Services Administration, 2002).

In the United States, the media stereotype is that drug abuse occurs largely among members of minorities. However, national surveys have consistently shown that a much higher percentage of white teenagers than African-American or other minority teenagers use illegal drugs (Substance Abuse and Mental Health Services Administration, 1994).

The Depressants

Alcohol, Barbiturates, and Tranquilizers

Key Theme

- Depressants inhibit central nervous system activity, while opiates are addictive drugs that relieve pain and produce euphoria.

Key Questions

- What are the physical and psychological effects of alcohol?
- How do barbiturates and tranquilizers affect the body?
- What are the effects of opiates, and how do they affect the brain?

The **depressants** are a class of drugs that depress or inhibit central nervous system activity. In general, depressants produce drowsiness, sedation, or sleep. Depressants also relieve anxiety and lower inhibitions. All depressant drugs are potentially physically addictive. Further, the effects of depressant drugs are *additive*, meaning that the sedative effects are increased when depressants are combined.

Alcohol

A staple of the human diet for thousands of years, alcoholic beverages provide a good example of the potential for a psychoactive drug to be misused (Vallee, 1998). Used in small amounts, alcohol reduces tension and anxiety. Evidence exists that light drinking reduces the risk of heart disease, probably because of its beneficial effects on cholesterol levels. Weddings, parties, and other social gatherings often include alcohol, a tribute to its relaxing and social lubricating properties.

But even though alcohol is a legal and readily available drug for adults, it's also a dangerous drug with a high potential for abuse. Consider these facts:

- Many drug experts believe that alcohol abuse has the highest social cost of all drug addictions.
- Alcohol is involved in at least 50 percent of all homicides, assaults, and highway fatalities (American Psychiatric Association, 2000a; Caetano & others, 2001).
- Approximately two-thirds of all cases of spousal abuse and violent child abuse involves alcohol use (Steele & Josephs, 1990).
- Drinking by pregnant women is the leading cause of birth defects and mental retardation—and the only preventable one (National Organization on Fetal Alcohol Syndrome, 2002).

More than half of all Americans who are old enough to drink legally do so at least occasionally. An estimated 14 million Americans have serious alcohol problems. They drink excessively on a regular basis and suffer social, occupational, and

depressants

A category of psychoactive drugs that depress or inhibit brain activity.

health problems as a result of their drinking (Rosenberg, 1993). How many Americans are *alcoholic*—that is, physically addicted to alcohol? Estimates vary, but a recent survey conducted by the Substance Abuse and Mental Health Services Administration (2002) found that some 11 million people aged 12 and older were dependent upon or abused alcohol. Another 2 million people abused alcohol *and* one or more illegal drugs.

How Does Alcohol Affect the Body? Generally, it takes about one hour to metabolize the alcohol in one drink, which is defined as 1 ounce of 80-proof whiskey, 4 ounces of wine, or 12 ounces of beer. All three drinks contain the same amount of alcohol; the alcohol is simply more diluted in beer than in hard liquor.

Factors such as body weight, gender, food consumption, and the rate of alcohol consumption also affect blood alcohol levels. A slender person who quickly consumes three drinks on an empty stomach will become more than twice as intoxicated as a heavier person who consumes three drinks with food. Women metabolize alcohol more slowly than do men. If a man and a woman of equal weight consume the same number of drinks, the woman will become more intoxicated.

Alcohol depresses the activity of neurons throughout the brain. Alcohol impairs cognitive abilities, such as concentration, memory, and speech, and physical abilities, such as muscle coordination and balance. As blood levels of alcohol rise, more brain activity is impaired, until the person loses consciousness. If blood alcohol levels continue to rise, death can occur, because the brain's respiratory center can no longer function. For this reason, drinking contests are potentially lethal.

Binge drinking is a particularly risky practice. *Binge drinking* is defined as five or more drinks in a row for men, or four or more drinks in a row for women. Every year, several college students die of alcohol poisoning after ingesting large amounts of liquor in a short amount of time. Less well publicized are the other negative effects associated with binge drinking, including aggressive behavior, sexual assault, accidents, and property damage (Hingson & others, 2002; Wechsler & others, 2002).

A national survey of college students at 119 colleges found that close to 50 percent of all male students and 40 percent of all female students were binge drinkers (Wechsler & others, 2002). White students were most likely to binge-drink, while African-American students were least likely. While close to half of dormitory residents binged at least occasionally, more than 75 percent of fraternity and sorority house residents were binge drinkers. Table 4.5 shows the behavioral and physical effects of blood alcohol levels.

Because alcohol is physically addictive, the person with alcoholism who stops drinking may suffer from physical withdrawal symptoms. Alcohol withdrawal causes rebound hyperexcitability in the brain. The severity of the withdrawal symptoms depends on the level of physical dependence (Schuckit & others, 1998). With a low level of dependence, withdrawal may involve disrupted sleep, anxiety, and mild tremors ("the shakes"). At higher levels of physical dependence on alcohol, withdrawal may involve confusion, hallucinations, and severe tremors or seizures. Collectively, these severe symptoms are sometimes called *delirium tremens*, or the *DTs*. In cases of extreme physical dependence, withdrawal can cause seizures, convulsions, and even death in the absence of medical supervision (O'Brien, 1997).

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The Dangers of Driving Under the Influence Intoxicated drivers have impaired perceptual ability and psychomotor functions, delayed reaction time, and poor coordination. They are also likely to display impaired judgment, poor impulse control, and an inflated self-image. This deadly combination results in more than 25,000 U.S. traffic deaths each year.

Table 4.5

Behavioral Effects of Blood Alcohol Levels

Blood Alcohol Level	Behavioral Effects
0.05%	Lowered alertness; release of inhibitions; impaired judgment
0.10%	Slowed reaction times; impaired motor function; less caution
0.15%	Large, consistent increases in reaction time
0.20%	Marked depression in sensory and motor capability; decidedly intoxicated
0.25%	Severe motor disturbance; staggering; sensory perceptions greatly impaired
0.30%	Stuporous but conscious; no comprehension of the world around them
0.35%	Surgical anesthesia; minimal level causing death
0.40%	About half of those at this level die



This Is Fun? According to a national survey of college students, more than half “drank to get drunk” in the previous year (Wechsler & others, 2002). Approximately 75 percent of students who are members of fraternities and sororities admit to binge drinking. Despite the deaths from alcohol poisoning of several college students each year, binge drinking and public drunkenness remain common at spring break celebrations.

What Are Alcohol’s Psychological Effects? People are often surprised that alcohol is classified as a depressant. Initially, alcohol produces a mild euphoria, talkativeness, and feelings of good humor and friendliness, leading many people to think of alcohol as a stimulant. But these subjective experiences occur because alcohol *lessens inhibitions* by depressing the brain centers responsible for judgment and self-control. Reduced inhibitions and self-control contribute to the aggressive and violent behavior sometimes associated with alcohol abuse. But the loss of inhibitions affects individuals differently, depending on their environment and expectations regarding alcohol’s effects (Bushman, 1993).

Barbiturates and Tranquilizers

Barbiturates are powerful depressant drugs that reduce anxiety and promote sleep, which is why they are sometimes called “downers.” Barbiturates depress activity in the brain centers that control arousal, wakefulness, and alertness. They also depress the brain’s respiratory centers.

Like alcohol, barbiturates at low doses cause relaxation, mild euphoria, and reduced inhibitions. Larger doses produce a loss of coordination, impaired mental functioning, and depression. High doses can produce unconsciousness, coma, and death. Barbiturates produce a very deep but abnormal sleep in which REM sleep is greatly reduced. Because of the additive effect of depressants, barbiturates combined with alcohol are particularly dangerous.

Is ___
le ___
ll ___

Common barbiturates include the prescription sedatives *Seconal* and *Nembutal*. The illegal drug *methaqualone* (street name *quaalude*) is almost identical chemically to barbiturates and has similar effects.

Barbiturates produce both physical and psychological dependence. Withdrawal from low doses of barbiturates produces irritability and REM rebound nightmares. Withdrawal from high doses of barbiturates can produce hallucinations, disorientation, restlessness, and life-threatening convulsions.

Tranquilizers are depressants that relieve anxiety. Commonly prescribed tranquilizers include *Xanax*, *Valium*, *Librium*, and *Ativan*. Chemically different from barbiturates, tranquilizers produce similar, although less powerful, effects. We will discuss these drugs in more detail in Chapter 14, on therapies.

The Opiates

From Poppies to Demerol

Often called *narcotics*, the **opiates** are a group of addictive drugs that relieve pain and produce feelings of euphoria. Natural opiates include *opium*, which is derived from the opium poppy; *morphine*, the active ingredient in opium; and *codeine*, which can be derived from either opium or morphine. Synthetic and semisynthetic opiates include *heroin*, *methadone*, and the prescription painkillers *Oxycontin*, *Percodan*, and *Demerol*.

Opiates produce their powerful effects by mimicking the brain's own natural painkillers, called *endorphins*. Opiates occupy endorphin receptor sites in the brain. As you may recall from Chapter 2, the word *endorphin* literally means "the morphine within."

When used medically, opiates alter an individual's reaction to pain, not by acting at the pain site but by reducing the brain's perception of pain. Many people recovering from surgery experience a wave of pain relief after receiving narcotics such as morphine, Demerol, or Percodan. People who take opiates in such circumstances rarely develop drug tolerance or dependence (Jacox & others, 1994).

The most frequently used opiate is heroin. When injected into a vein, heroin reaches the brain in seconds, creating an intense rush of euphoria that is followed by feelings of contentment, peacefulness, and warmth. Withdrawing from heroin is not life-threatening, but it does produce unpleasant drug rebound symptoms (O'Brien, 1997). Withdrawal symptoms include an intense craving for heroin, fever, chills, muscle cramps, and gastrointestinal problems.

The Stimulants

Caffeine, Nicotine, Amphetamines, and Cocaine

Key Theme

- Stimulant drugs increase brain activity, while the psychedelic drugs create perceptual distortions, alter mood, and affect thinking.

Key Questions

- What are the general effects of stimulants and the specific effects of caffeine, nicotine, amphetamines, and cocaine?
- What are the effects of mescaline, LSD, and marijuana?
- What are the "club drugs," and what are their effects?

Stimulants vary in the strength of their effects, legal status, and the manner in which they are taken. All stimulant drugs, however, are at least mildly addicting, and all tend to increase brain activity. We'll first look at the most widely used and legal stimulants, caffeine and nicotine. Then we'll examine much more potent stimulants, cocaine and the amphetamines.

barbiturates

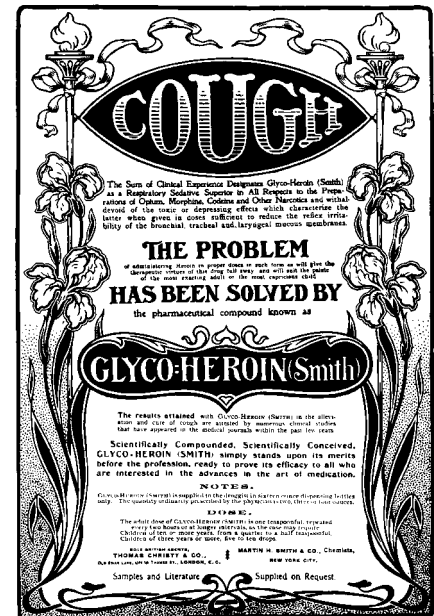
(barb-ITCH-yer-ets) A category of depressant drugs that reduce anxiety and produce sleepiness.

tranquilizers

Depressant drugs that relieve anxiety.

opiates

(OH-pee-ets) A category of psychoactive drugs that are chemically similar to morphine and have strong pain-relieving properties.



Heroin Cough Syrup Opium and its derivatives, including heroin, morphine, and codeine, were legal in the United States until 1914. In the late nineteenth and early twentieth centuries, opiates were commonly used in over-the-counter medications for a variety of ailments, from sleeplessness to "female problems" (Musto, 1991). This ad for "Glyco-Heroin" cough syrup appeared in 1904. Codeine is still used in some prescription cough syrups.

stimulants
A category of psychoactive drugs that increase brain activity, arouse behavior, and increase mental alertness.

caffeine
(kaff-EEN) A stimulant drug found in coffee, tea, cola drinks, chocolate, and many over-the-counter medications.

nicotine
A stimulant drug found in tobacco products.

Caffeine and Nicotine

Caffeine is found in coffee, tea, cola drinks, chocolate, and many over-the-counter medications (see Table 4.6). Most Americans consume caffeine in some form every day (DeAngelis, 1994b). In fact, caffeine is the most widely used psychoactive drug in the world.

Caffeine stimulates the cerebral cortex in the brain, resulting in an increase in mental alertness and wakefulness. Even a single cup of coffee has a noticeable effect on the cerebral cortex.

Yes, coffee drinkers, caffeine *is* physically addictive. Regular coffee, tea, or cola drinkers will experience withdrawal symptoms if they abruptly stop their caffeine intake. Headaches, irritability, drowsiness, and fatigue may last up to a week. Even just a few hours of caffeine deprivation can produce noticeable withdrawal symptoms of sleepiness and fatigue (Phillips-Bute & Lane, 1997). At high doses, caffeine can produce anxiety, restlessness, insomnia, and increased heart rate—symptoms that are collectively called “coffee nerves.”

When Mike, in the Prologue, lit up a cigarette, he did so under the mistaken impression that smoking would help him relax and fall asleep. But cigarettes contain **nicotine**, an extremely addictive stimulant. Nicotine is found in all tobacco products, including pipe tobacco, cigars, cigarettes, and smokeless tobacco. About 25 percent of American adults use tobacco regularly. The proportion of smokers is much higher in Japan, many European countries, and developing countries (Bartecchi & others, 1995).

Like coffee, nicotine increases mental alertness and reduces fatigue or drowsiness. Functional MRI scans show that nicotine increases neural activity in many areas of the brain, including the frontal lobes, thalamus, hippocampus, and amygdala (Stein & others, 1998). Thus, it’s not surprising that smokers report that tobacco enhances mood, attention, arousal, and vigilance.

When cigarette smoke is inhaled, nicotine reaches the brain in seconds. But within 30 minutes or so, nicotine has left the brain. Thus, the addicted pack-a-day smoker will light a cigarette every 30 to 40 minutes to maintain a relatively constant nicotine level in the brain. Over the course of a year, that averages out to 70,000 “hits” of nicotine.

Nicotine is highly addictive, both physically and psychologically. People who start smoking for nicotine’s stimulating properties often continue smoking to avoid the withdrawal symptoms. Along with an intense craving for cigarettes, withdrawal symptoms include jumpiness, irritability, tremors, headaches, drowsiness, “brain fog,” and lightheadedness (Shiffman & others, 1995).

Amphetamines and Cocaine

Like caffeine and nicotine, amphetamines and cocaine are addictive substances that stimulate brain activity, increasing mental alertness and reducing fatigue. However, amphetamines and cocaine also elevate mood and produce a sense of euphoria. When abused, both drugs can produce severe psychological and physical problems.

Table 4.6

Common Sources of Caffeine

Item	Caffeine Content (average, in milligrams)
Coffee (5 ounces)	100
Tea (5 ounces)	50
Cocoa (5 ounces)	5
Chocolate (semisweet, baking; 1 ounce)	25
Chocolate milk (1 ounce)	5
Cola drink (12 ounces)	40
Over-the-counter stimulants (Nō-Dōz®, Vivarin®)	100+
Over-the-counter analgesics (Anacin®, Midol™)	33
Over-the-counter cold remedies (Triaminic)	30
Over-the-counter diuretics (Aqua-ban®)	100

SOURCE: Julien (2001)



Caffeine and Conversation Caffeine is the most widely used psychoactive drug in the world and is commonly consumed in social settings. These French college students are enjoying a cup of espresso at an outdoor café.



Sometimes called “speed” or “uppers,” **amphetamines** suppress appetite and were once widely prescribed as diet pills. Tolerance to the appetite-suppressant effects occurs quickly, so progressive increases in amphetamine dosage are required to maintain the effect. Consequently, amphetamines are rarely prescribed today for weight control.

Using any type of amphetamines for an extended period of time is followed by “crashing”—withdrawal symptoms of fatigue, deep sleep, intense mental depression, and increased appetite. This is another example of a drug rebound effect. Users also become psychologically dependent on the drug for the euphoric state, or “rush,” that it produces, especially when injected.

Benzedrine and *dexedrine* are prescription amphetamines. *Methamphetamine*, also known as *meth*, is an illegal drug that can be easily manufactured in home or street laboratories. Providing an intense high that is longer-lasting and less expensive than cocaine, meth usage has spread from the western United States to the rest of the country, including small towns in the rural Midwest and South.

As the popularity of methamphetamine has increased, so have concerns about the drug's long-term effects. PET scans of former methamphetamine users have shown abnormalities in brain structure and functioning (Volkow & others, 2001a, 2001b, 2001c). Even after several months of abstinence, the brains of former meth users showed a significant reduction in the number of dopamine receptors and transporters (see Figure 4.6). Dopamine transporters help transport “used” dopamine back into the neurons that produce it. Some former methamphetamine users had lost up to 24 percent of the normal level of dopamine transporters. Memory and motor skill problems were common in the former abusers and were most severe in those with the greatest loss of dopamine transporters.

Cocaine is an illegal stimulant derived from the leaves of the coca tree, which is found in South America. (The coca plant is not the source of cocoa or chocolate, which is made from the beans of the *cacao* plant.) When inhaled, or “snorted,” in purified, powdered form, cocaine reaches the brain within a few minutes. Inhaling cocaine produces intense euphoria, mental alertness, and

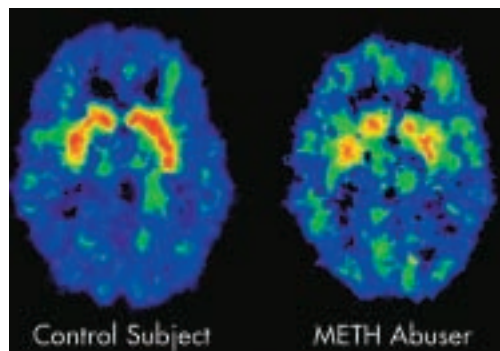


FIGURE 4.6 The Damaging Effects of Methamphetamine on the Brain Methamphetamine not only is highly addictive but also causes long-term damage to brain structures and functioning. The red and yellow areas on these PET scans show the concentration of dopamine transporters in a normal brain (left) and in the brain of a former methamphetamine abuser (right). Damage to the brain's dopamine system was associated with memory and motor skill defects.

amphetamines

(am-FET-uh-meens) A class of stimulant drugs that arouse the central nervous system and suppress appetite.

cocaine

A stimulant drug derived from the coca tree.



Peyote-Inspired Visions The Huichol Indians of Mexico have used peyote in religious ceremonies for hundreds of years. Huichol yarn paintings, like the one shown here, are flat pieces of wood inlaid with designs made with colored yarn. The yarn paintings often depict imagery and scenes inspired by traditional peyote visions, which resemble the geometric shapes and radiating patterns of hallucinations induced by psychedelic drugs. Today, peyote continues to be used as a sacrament in the religious ceremonies of the Native American Church, a religion with more than 600,000 members (Swan & Big Bow, 1995).

self-confidence, which lasts for several minutes. A more concentrated form of cocaine, called *crack*, is smoked rather than inhaled.

Prolonged use of amphetamines or cocaine can result in **stimulant-induced psychosis**, also called *amphetamine psychosis* or *cocaine psychosis*. Schizophrenia-like symptoms develop, including auditory hallucinations of voices and bizarrely paranoid ideas.

Psychedelic Drugs

Mescaline, LSD, and Marijuana

The term **psychedelic drug** was coined in the 1950s to describe a group of drugs that create profound perceptual distortions, alter mood, and affect thinking. *Psychedelic* literally means “mind manifesting” (Tart, 1990).

Mescaline and LSD

Naturally occurring psychedelic drugs have been used for thousands of years. **Mescaline**, which is derived from the peyote cactus, has been used for centuries in the religious ceremonies of Mexican Indians. Another psychedelic drug, called *psilocybin*, is derived from *Psilocybe* mushrooms, sometimes called magic mushrooms. Psilocybin has been used since 500 B.C. in religious rites in Mexico and Central America.

In contrast to these naturally occurring psychedelics, **LSD** (*lysergic acid diethylamide*) is a powerful psychedelic drug that was first synthesized in the late 1930s. LSD is far more potent than mescaline or psilocybin. Just 25 micrograms, or one-millionth of an ounce, of LSD can produce profound psychological effects with relatively few physiological changes.

LSD and psilocybin are very similar chemically to the neurotransmitter *serotonin*, which is involved in regulating moods and sensations (see Chapter 2). LSD and psilocybin mimic serotonin in the brain, stimulating serotonin receptor sites (Aghajanian, 1994).

The effects of a psychedelic experience vary greatly, depending on an individual’s personality, current emotional state, surroundings, and the other people present. A “bad trip” can produce extreme anxiety, panic, and even psychotic episodes. Tolerance to psychedelic drugs may occur after heavy use. However, even heavy users of LSD do not develop physical dependence, nor do they experience withdrawal symptoms if the drug is not taken.

Adverse reactions to LSD include flashbacks (recurrences of the drug’s effects), depression, long-term psychological instability, and prolonged psychotic reactions (Smith & Seymour, 1994). In a psychologically unstable or susceptible person, even a single dose of LSD can precipitate a severe psychotic reaction.

Marijuana

The common hemp plant, *Cannabis sativa*, is used to make rope and cloth. But when its leaves, stems, flowers, and seeds are dried and crushed, the mixture is called **marijuana**, one of the most widely used illegal drugs. Marijuana’s active ingredient is the chemical *tetrahydrocannabinol*, abbreviated *THC*. When marijuana is smoked, THC reaches the brain in less than 30 seconds. One potent form of marijuana, *hashish*, is made from the resin of the hemp plant. Hashish is sometimes eaten.

To lump marijuana with the highly psychedelic drugs mescaline and LSD is somewhat misleading. At high doses, marijuana can sometimes produce sensory distortions that resemble a mild psychedelic experience. Low-to-moderate doses of THC typically produce a sense of well-being, mild euphoria, and a dreamy state of relaxation. Senses become more focused and sensations more vivid. Taste, touch, and smell may be enhanced; time perception may be altered.

A little more than a decade ago, researchers discovered receptor sites in the brain that are specific for THC. They've also discovered a naturally occurring brain chemical, called *anandamide*, that is structurally similar to THC and that binds to the THC receptors in the brain (Devane & others, 1992). Anandamide appears to be involved in regulating the transmission of pain signals and may reduce painful sensations (Calignano & others, 1998; Walker & others, 1999). Researchers also suspect that anandamide may be involved in mood and memory.

There are very few THC receptors in the brainstem, the part of the brain that controls such life support functions as breathing and heartbeat. Thus, high doses of THC do not interfere with respiratory and cardiac functions as depressants and opiates do.

Most marijuana users do not develop tolerance or physical dependence. Chronic users of extremely high doses can develop some tolerance to THC and may experience withdrawal symptoms when its use is discontinued (de Fonseca & others, 1997). Such symptoms include irritability, restlessness, insomnia, tremors, and decreased appetite.

Marijuana and its active ingredient, THC, have been shown to be helpful in the treatment of pain, epilepsy, hypertension, nausea, glaucoma, and asthma (Snyder, 1990). In cancer patients, THC can prevent the nausea and vomiting caused by chemotherapy. However, the medical use of marijuana is limited and politically controversial.

On the negative side, marijuana interferes with muscle coordination and perception and may impair driving ability. When marijuana and alcohol use are combined, marijuana's effects are intensified—a dangerous combination for drivers. Marijuana has also been shown to interfere with learning, memory, and cognitive functioning (Pope & others, 2001).

Designer “Club” Drugs

Ecstasy and the Dissociative Anesthetic Drugs

Some drugs don't fit into neat categories. The “club drugs” are a loose collection of psychoactive drugs that are popular at dance clubs, parties, and the all-night dance parties called “raves.” Many of these drugs are *designer drugs*, meaning that they were synthesized in a laboratory rather than derived from naturally occurring compounds. In this section, we'll take a look at three of the most popular club drugs—*ecstasy*, *ketamine*, and *PCP*.

The initials **MDMA** stand for the long chemical name of the quintessential club drug better known as **ecstasy**. Other street names are *X*, *XTC*, *Adam*, and the “love drug.” Ecstasy was developed by a German pharmaceutical company in 1912 for possible use as an appetite suppressant, but it was not tested on humans until the 1970s. Structurally similar to both mescaline and amphetamine, MDMA has stimulant and psychedelic effects. While the use of other illegal drugs has remained stable or declined over the past decade, the use of ecstasy has sharply increased in western Europe and the United States (Zickler, 2001).

At low doses, MDMA acts as a stimulant, but at high doses it has mild psychedelic effects. Its popularity, however, results from its emotional effects: Feelings of euphoria and increased well-being are common. People who have taken ecstasy also say that the drug makes them feel loving, open, and closer to others—effects that led to its use in psychotherapy for a brief time until its adverse effects became apparent (Braun, 2001). Ecstasy's side effects hint at the problems that can be associated with its use: dehydration, rapid heartbeat, tremors, muscle tension and involuntary teeth-clenching, and hyperthermia (abnormally high body temperature). Rave party-goers who take MDMA in crowded, hot surroundings are particularly at risk for collapse or death from dehydration and hyperthermia.

stimulant-induced psychosis

Schizophrenia-like symptoms that can occur as the result of prolonged amphetamine or cocaine use; also called *amphetamine psychosis* or *cocaine psychosis*.

psychedelic drugs

(sy-kuh-DEL-ick) A category of psychoactive drugs that create sensory and perceptual distortions, alter mood, and affect thinking.

mescaline

(MESS-kuh-lin) A psychedelic drug derived from the peyote cactus.

LSD

A synthetic psychedelic drug.

marijuana

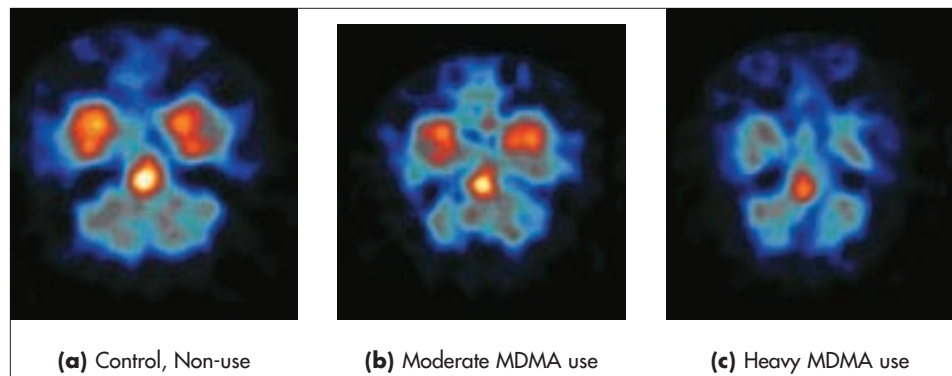
A psychoactive drug derived from the hemp plant.

MDMA or ecstasy

Synthetic club drug that combines stimulant and mild psychedelic effects.

FIGURE 4.7 Effects of Ecstasy on the Brain

The “ecstasy” of an MDMA trip takes a heavy toll on the brain, especially in women. These brain-scan images show serotonin activity (red) in the brains of (a) a normal female volunteer who had never taken ecstasy, (b) a moderate ecstasy user, and (c) a heavy ecstasy user. The study by Dutch scientist Liesbeth Reneman and her colleagues (2001a) included both male and female participants, but the female participants were more susceptible to brain damage from ecstasy use than men were.



The “love drug” effects of ecstasy may result from its unique effect on serotonin in the brain. Along with causing neurons to release serotonin, MDMA also blocks serotonin reuptake, amplifying and prolonging serotonin effects (Braun, 2001). While flooding the brain with serotonin may temporarily enhance feelings of emotional well-being, there are adverse trade-offs. First, the “high” of ecstasy is often followed by depression when the drug wears off. More ominously, animal studies have shown that moderate or heavy use of ecstasy can lead to long-term, potentially irreversible damage to serotonin nerve endings in the brain (Ricaurte & others, 1998). Several studies have shown similar damage to serotonin neurons in the human brain (Croft & others, 2001; Reneman & others, 2001a). Female users may be more susceptible to brain damage than male users (see Figure 4.7). Other studies have shown that serotonin levels become severely depleted after long-term use, possibly causing the depression that follows when the drug wears off (Kuhn & Wilson, 2001). Equally troubling are cognitive effects: In one study, memory and verbal reasoning problems persisted up to a year after the last dose was taken (Reneman & others, 2001b).

Another class of drugs that make their appearance at dance clubs and raves are the **dissociative anesthetics**, including phencyclidine, better known as *PCP* or *angel dust*, and *ketamine* (street name *Special K*). Originally developed to serve as general anesthetics for surgery in the late 1950s, both PCP and ketamine deaden pain and, at high doses, can induce a stupor or coma. Because of their psychological effects, these drugs were largely abandoned for general surgical use in humans.

Rather than producing actual hallucinations, PCP and ketamine produce marked feelings of dissociation and depersonalization. Feelings of detachment from reality—including distortions of space, time, and body image—are common. Generally, the effects of PCP are more intense and of a longer duration than those of ketamine.

PCP can be eaten, snorted, or injected, but it is most often smoked or sprinkled on tobacco or marijuana. The effects are unpredictable, and a PCP trip can last for several days. Some users of PCP report feelings of invulnerability and exaggerated strength. PCP users can become severely disoriented, violent, aggressive, or suicidal. High doses of PCP can cause hyperthermia, convulsions, and death. PCP affects levels of the neurotransmitter *glutamate*, indirectly stimulating the release of dopamine in the brain. Thus, PCP is highly addictive. Memory problems and depression are common effects of long-term use.

In this chapter, we’ve taken a close look at the rather elusive topic of consciousness. We hope that you have gained some insight into your own daily changes in consciousness and some understanding of how conscious experience can be influenced. In the chapter Application, we’ll suggest some ways in which you can use the findings of psychological research to improve the quality of *your* consciousness.

dissociative anesthetics

Class of drugs that reduce sensitivity to pain and produce feelings of detachment and dissociation; includes the club drugs phencyclidine (PCP) and ketamine.

sleep inertia

(in-ER-shuh) Feeling of grogginess on awakening that interferes with the ability to perform mental or physical tasks.

4.3

R · E · V · I · E · W

C · O · N · C · E · P · T

Psychoactive Drugs

For each of the following descriptions, name the drug class, and give two (or more) examples.

	Drug Class	Examples
1. Drugs that create perceptual distortions, alter mood, and affect thinking	_____	_____
2. Drugs that inhibit central nervous system activity; produce drowsiness, sedation, or sleep; and may reduce anxiety and lower inhibitions	_____	_____
3. Synthetic drugs with a variety of effects, often used at dance clubs or “raves”	_____	_____
4. Addictive drugs that mimic endorphins and relieve pain and produce euphoria	_____	_____
5. Drugs developed as surgical anesthetics that produce feelings of detachment and depersonalization	_____	_____
6. Addictive drugs that increase brain activity and mental alertness	_____	_____

APPLICATION

Improving Sleep and Mental Alertness

In this section we'll give you some research-based, practical suggestions to help you wake up in the morning, improve the quality of your sleep, and minimize the mental and physical disruptions that can occur when your body clock is out of sync with environmental time cues.

Dealing with Morning Brain Fog

There is surprisingly little research on how to deal with **sleep inertia**—sleepiness on awakening that interferes with your ability to perform mental or physical tasks. For some people, “morning brain fog” can last an hour or more before they feel fully alert (Jewett & others, 1999).

People who have trouble getting up in the morning tend to stay in bed until the last possible moment. This strategy, of course, only intensifies their disorientation, because they are forced to hustle out the door before they are fully awake.

The simplest antidote for sleep inertia seems to be the passage of time. So if you suffer from sleep inertia, try setting your alarm clock (and possibly a second one in the next room) to wake you 15 minutes *earlier* than usual. Resolve to hit the floor when the alarm goes off. The extra 15 minutes will help give your mind time to clear

During that 15 minutes, sip a cup of coffee or tea, which promotes wakefulness. It takes approximately half an hour to feel the full effects of the caffeine. If the sun is up, sit near a window. If it's not, turn on the lights. Bright light, especially sunlight, helps brain fog dissipate by reducing blood levels of the hormone melatonin. To help engage your brain, glance at the newspaper or start a list of what you want to accomplish for the day. Though simple, these suggestions really do help, as your night-owl authors, neither of whom exactly greets the morning with enthusiasm, have discovered.

Improving the Quality of Your Sleep

Sleep researchers have identified many ways to improve the quality of your sleep:

- Timing is more important than you probably realize. In the early-evening hours, usually between 8:00 and 10:00 P.M., we normally experience a period of increased wakefulness that occurs prior to sleepiness. Sleep researchers call this presleep burst of wakefulness the “forbidden zone for sleep” (Lavie, 1989). So to avoid suddenly feeling wide awake in bed, you should go to bed after the

forbidden zone, when your brain has begun to gear down to sleepiness.

- Monitor your caffeine intake, and don't drink caffeine-containing beverages or eat chocolate for at least three or four hours before going to bed. Look again at Table 4.6 on page 162, which lists some common sources of caffeine. Many over-the-counter medications include caffeine. Check the label if you take such medications before bedtime.
- Going to bed very hungry or very full will disrupt sleep, but a light snack will help reduce nighttime restlessness and increase total sleep time.
- Moderate exercise during the day seems to promote deep sleep, but exercise in the evening or shortly before going to bed may keep you awake.
- Soaking in a very warm bath shortly before retiring promotes deep sleep by raising your core body temperature.
- A consistent bedtime routine and familiar surroundings enhance the quality of sleep. Try to go to bed about the same time each night and get up at approximately the same time every

morning so that you stay in sync with your own pattern of circadian rhythms.

- Depressant drugs, such as alcohol and barbiturates, may produce drowsiness, but they also reduce REM sleep, disrupting the quality of your sleep. Hence, they should be avoided.

Finally, you may be pleased to discover that sex promotes sleep. For example, rabbits tend to sleep very little—with the exception of quickly nodding off into REM sleep after some amorous activity in the old rabbit hutch. The same phenomenon also seems to occur in humans, which is why sleep so often follows sexual interaction. As sleep researcher J. Allan Hobson (1995) put it, sex “not only leads to muscle relaxation, but also clears the cerebral circuits of tedious humdrum.”

Almost everyone occasionally has trouble falling asleep or staying asleep. Often this occurs because we’re fretting about some problem or conflict. One

strategy to help you let go of the problem for the night is to write down your concerns and what you plan to do about them the next day. Another strategy is to redirect your thoughts. Try vividly imagining yourself exploring a tranquil landscape or walking along a familiar route.

If you still can’t fall asleep or stay asleep, don’t overreact. Instead, get up and read in a comfortable chair until you feel drowsy, and then return to bed. If your sleeping problems persist for a week or more, ask your family doctor for advice or a referral to a sleep specialist.

Coping with the Night Shift

People vary in the ease with which they develop tolerance for working the night shift or rotating shifts. Here are some suggestions for minimizing the negative effects of night work:

- If you have a choice in your work schedule, the longer you can stay with

one shift, the better. Frequent shift changes increase jet lag symptoms.

- If you work rotating shifts, try to make your schedule changes more compatible with circadian rhythms. Because of our natural tendency to drift toward longer days, it is easier to lengthen our days than to shorten them. Therefore, try to arrange your shift changes to progress from the morning to evening to night shifts.
- If you work the midnight shift, bright lights in the workplace, especially during the early part of the shift, will help your circadian cycles adjust to the night schedule (Dawson & Campbell, 1991).
- To promote sleep during the daytime, ask your doctor about taking melatonin. Melatonin supplements can help induce daytime sleep, improving mental alertness during night shifts (Dawson, 1995).

Chapter Review

Consciousness and Its Variations

Key Points

Introduction: Consciousness: Experiencing the “Private I”

- **Consciousness** refers to the immediate awareness of internal and external stimuli. Most psychologists today consider consciousness an important area of research, as did early psychologists.

Biological and Environmental “Clocks” That Regulate Consciousness

- **Circadian rhythms** are regulated by the **suprachiasmatic nucleus (SCN)**, the “master clock” located in the hypothalamus of the brain. In response to light detected by special photoreceptors, the SCN reduces the production of **melatonin** by the pineal gland. Increased melatonin makes you sleepy.

- Under free-running conditions, human circadian rhythms drift toward a 25-hour day. Circadian rhythms become disrupted when environmental time cues are out of sync with the body clock. Symptoms of jet lag can be produced by travel across time zones or by rotating shift work.

Sleep

- The invention of the **electroencephalograph**, which produces an **EEG** or **electroencephalogram**, and the discovery of rapid eye movements (REM) changed scientific views about sleep. The two basic types of sleep are **REM sleep** and **NREM sleep**.
- When we are awake and alert, the brain generates **beta brain waves**. As brain activity gears down and drowsiness sets in, **alpha brain waves** are generated. **Hypnagogic hallucinations** can occur during this drowsy, presleep phase.

- Each sleep stage is characterized by a specific pattern of brain activity. In the first 90 minutes of sleep, four different stages of NREM sleep are followed by a brief episode of REM sleep. Stage 2 of sleep is defined by the appearance of **sleep spindles** and **K complexes**. Throughout the night, episodes of REM sleep become progressively longer and NREM episodes become shorter.
- As people age, periods of REM sleep and deep sleep become shorter, and more time is spent in stage 2 NREM.
- Sleep deprivation studies and the phenomenon of **REM rebound** demonstrate the biological need to sleep. The **restorative theory** and the **adaptive theory** offer different explanations for the function of sleep.
- **Sleep disorders** are serious disturbances in the normal sleep pattern that interfere with daytime functioning and cause subjective distress.
- The most common sleep disorder is **insomnia**; the next most common is **sleep apnea**. For many, insomnia is related to a condition called **restless legs syndrome (RLS)**. The **parasomnias** include **sleepwalking**, **night terrors**, **bruxism**, and **REM sleep behavior disorder**. The symptoms of **narcolepsy** are experienced during the day.

Dreams and Mental Activity During Sleep

- **Sleep thinking** occurs during NREM sleep. A **dream** is a storylike, unfolding episode of mental images that occurs during NREM or REM sleep.
- During REM sleep, the brain is cut off from external stimuli. The frontal lobes and primary visual cortex are inactivated, but the hippocampus, amygdala, and other visual centers are highly active. REM sleep is needed for the consolidation of certain types of memories.
- Most dreams reflect everyday concerns and include familiar people and settings. Changes in brain chemistry and functioning that occur during sleep probably contribute to the inability to remember dreams. There are individual differences in dream recall. **Nightmares** are unpleasant anxiety dreams.
- Sigmund Freud believed that dream images are symbols of unconscious wishes. According to Freud, dreams are composed of **manifest content** and **latent content**. The **activation-synthesis model of dreaming** proposes that dreams reflect our subjective awareness of brain activation during sleep. Some researchers believe that dreaming consciousness is similar in its functions to waking consciousness.

Hypnosis

- **Hypnosis** is an unusual state of awareness, defined as a cooperative social interaction in which the hypnotic participant responds to suggestions made by the hypnotist. Changes in perception, memory, and behavior may be produced. People vary in hypnotic susceptibility.
- Under hypnosis, profound sensory and perceptual changes may be experienced, including pain reduction and hallucinations. **Posthypnotic suggestions** influence behavior outside the hypnotic state. Hypnosis is used in habit control, but its effectiveness varies. Hypnosis can produce **posthypnotic amnesia**, but not **hypermnnesia**. Although hypnosis

does not increase the accuracy of memories, it does increase confidence in memories and can produce false memories. Hypnosis cannot be used to make people perform behaviors that are contrary to their morals or values.

- The **neodissociation theory** of Ernest Hilgard explains hypnosis as involving **dissociation** and a **hidden observer**. Some psychologists believe that hypnosis is not a special state of consciousness but can be explained by social and cognitive processes.

Meditation

- **Meditation** refers to techniques used to control attention so as to induce an altered state of focused attention and awareness.
- Research suggests that regular meditation enhances physical and psychological functioning.

Psychoactive Drugs

- **Psychoactive drugs** can alter arousal, mood, thinking, sensation, and perception. Many psychoactive drugs are addictive, producing **physical dependence** and **drug tolerance**. The physically dependent person who stops taking a drug experiences **withdrawal symptoms**, which often include the **drug rebound effect**.
- Psychoactive drugs affect brain activity by influencing synaptic transmission. Drug effects can be influenced by the person's weight, gender, race, metabolic rate, and the presence of other drugs. Personality characteristics, mood, expectations, experience with the drug, and the setting in which the drug is taken also affect the drug response.
- **Drug abuse** refers to recurrent drug use that leads to disruptions in academic, social, or occupational functioning and to legal or psychological problems. Many factors contribute to drug abuse, including social and cultural influences.
- **Depressants** are physically addictive drugs that inhibit central nervous system activity. Depressants include alcohol, **barbiturates**, and **tranquilizers**. Psychologically, alcohol lessens inhibitions, but its effects vary, depending on the person's environment and expectations. Barbiturates and tranquilizers produce relaxation and reduce inhibitions.
- **Opiates** are addictive drugs that relieve pain and produce feelings of euphoria. The opiates include opium, morphine, codeine, heroin, methadone, and prescription painkillers. Opiates relieve pain by mimicking the effect of endorphins in the brain.
- **Stimulants** include **caffeine**, **nicotine**, **amphetamines**, and **cocaine**. The stimulants increase brain activity, and all stimulants are addictive. Prolonged use of amphetamines or cocaine can lead to **stimulant-induced psychosis**.
- **Psychedelic drugs** include **mescaline**, **LSD**, and **marijuana**. The psychedelics create perceptual distortions, alter mood, and affect thinking. Although psychedelic drugs are not physically addictive, they can cause a variety of harmful effects.
- The "club drugs" are synthetic drugs used at dance clubs, parties, and "raves." These drugs include **MDMA (ecstasy)** and the **dissociative anesthetics** PCP and ketamine.

Key Terms

consciousness, p. 126	adaptive theory of sleep, p. 137	activation–synthesis model of dreaming, p. 147	depressants, p. 158
circadian rhythm, p. 128	sleep disorders, p. 138	hypnosis, p. 148	barbiturates, p. 160
suprachiasmatic nucleus (SCN), p. 129	insomnia, p. 138	posthypnotic suggestion, p. 150	tranquilizers, p. 161
melatonin, p. 129	restless legs syndrome (RLS), p. 138	posthypnotic amnesia, p. 150	opiates, p. 161
electroencephalograph, p. 131	sleep apnea, p. 139	hypermnesia, p. 150	stimulants, p. 162
EEG (electroencephalogram), p. 131	sleepwalking, p. 139	dissociation, p. 151	caffeine, p. 162
REM sleep, p. 131	night terrors, p. 140	neodissociation theory of hypnosis, p. 151	nicotine, p. 162
NREM sleep, p. 131	parasomnias, p. 140	hidden observer, p. 151	amphetamines, p. 163
beta brain waves, p. 132	REM sleep behavior disorder, p. 140	meditation, p. 154	cocaine, p. 163
alpha brain waves, p. 132	narcolepsy, p. 140	psychoactive drug, p. 156	stimulant-induced psychosis, p. 164
hypnagogic hallucinations, p. 132	cataplexy, p. 141	physical dependence, p. 156	psychedelic drugs, p. 164
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sleep paralysis, p. 134	nightmare, p. 146	drug rebound effect, p. 157	marijuana, p. 164
REM rebound, p. 136	manifest content, p. 146	drug abuse, p. 157	MDMA (ecstasy), p. 165
restorative theory of sleep, p. 136	latent content, p. 146		dissociative anesthetics, p. 166
			sleep inertia, p. 167

Key People

<p>Sigmund Freud (1856–1939) Founder of psychoanalysis; proposed that dream images are disguised and symbolic expressions of unconscious wishes and urges. (p. 146)</p> <p>Ernest R. Hilgard (1904–2001) American psychologist who extensively studied hypnosis and advanced the <i>neodissociation theory of hypnosis</i>. (p. 151)</p>	<p>J. Allan Hobson (b. 1933) Contemporary American psychiatrist and neurobiologist who has extensively researched sleep and dreaming; proposed the <i>activation–synthesis model</i> of dreaming. (p. 147)</p> <p>William James (1842–1910) American psychologist and philosopher who proposed that the subjective experience of consciousness is not episodic, but an ongoing stream of mental activity. (p. 127)</p>
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Concept Review Answers

4.1 page 137

- 1. melatonin
- 2. suprachiasmatic nucleus; 25
- 3. sunlight; 24
- 4. stage 2 NREM
- 5. REM; dreaming
- 6. stage 4 NREM

4.2 page 154

1. d 2. d 3. c 4. d 5. a

4.3 page 167

- 1. psychedelic drugs: LSD, mescaline, marijuana
- 2. depressants: alcohol, barbiturates, tranquilizers, inhalants
- 3. club drugs: ecstasy (MDMA)
- 4. opiates: opium, morphine, heroin, methadone, Demerol, Percodan, Oxycontin
- 5. dissociative anesthetics: PCP, ketamine
- 6. stimulants: caffeine, nicotine, amphetamines, methamphetamines, cocaine

Web Companion Review Activities

You can find additional review activities at www.worthpublishers.com/hockenbury
The *Discovering Psychology* 3e Web Companion has a self-scoring practice quiz, flashcards, two interactive crossword puzzles, and other activities to help you master the material in this chapter.