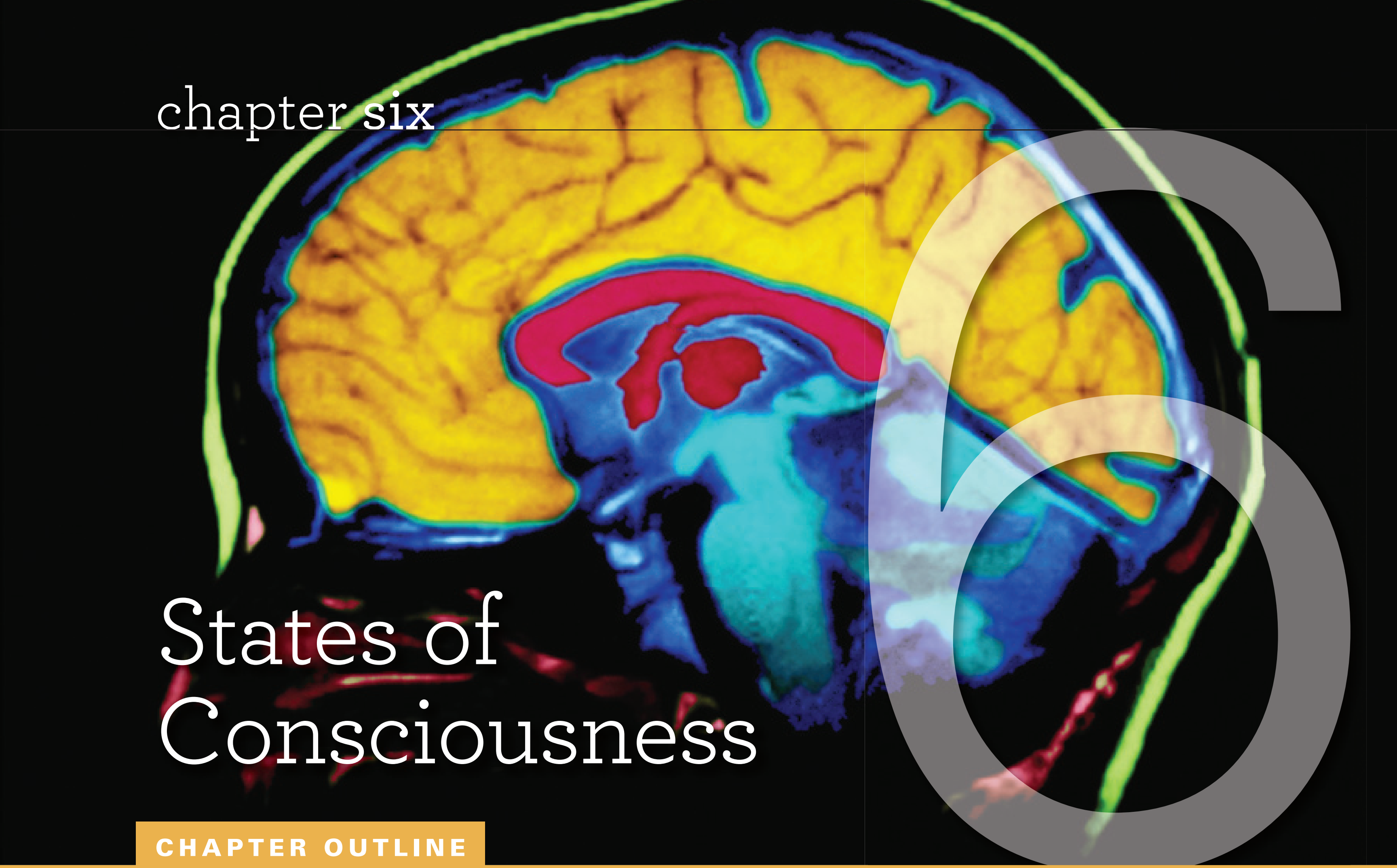
chapter six

States of Consciousness



CHAPTER OUTLINE

Myth or Reality?

Hypnosis Uncovers Eyewitnesses' Hidden Memories (page 207)

A person witnesses a crime but can't remember much about it. Under hypnosis the person recalls more details, which helps the police solve the crime. That's the popular conception of forensic hypnosis, but does it really improve eyewitness memory?

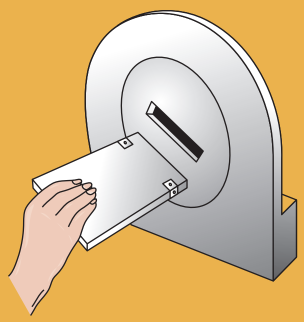


Figure 6.1

Perception without conscious awareness.
A rectangular slot was rotated to different angles on a series of trials. When asked simply to hold and tilt a rectangular card to match the slot's angle, D. F. performed poorly. She could not consciously recognize the orientation of the slot. Despite this, when asked to rapidly insert the card into the slot, as illustrated here, she performed well. Source: Goodale, 1995.

Three unrelated people, whom we'll call Sondra, Jason, and Ellen, had an unusual problem: eating while asleep. Each night they would sleepwalk to the kitchen. Sondra would

> consume cat food or salt sandwiches, buttered cigarettes and . . . large quantities of peanut butter, butter, salt and sugar. . . . Once she awakened while struggling to open a bottle of ammonia cleaning fluid, which she was prepared to drink. (Schenck et al., 1991, p. 430)

While sleepwalking, Jason and Ellen also ate odd foods (such as raw bacon), and sometimes Jason spoke coherently with his wife. Upon awakening, they couldn't remember their experiences.

After evaluation by sleep specialists, Sondra received medication and Jason was referred to his primary physician. Neither drugs nor psychotherapy helped Ellen, so a new plan was tried: locking the kitchen door at bedtime, hiding the key, and placing crackers and a pitcher of water by the bed. Usually, when Ellen awoke in the morning, the crackers and water would be gone, and she had no memory of having consumed them (Whyte & Kavey, 1990).

In contrast to Sondra, Jason, and Ellen's sleepeating, D. F.'s unusual problem takes center stage when she's awake. One day, D. F. lost consciousness and suffered brain damage from carbon-monoxide exposure. As psychologist Melvin Goodale (2000) describes, when D. F. regained consciousness,

> she was unable to recognize the faces of her relatives and friends or identify the visual form of common objects. In fact, she could not even tell the difference between . . . a square and a triangle. At the same time, she had no difficulty recognizing people from their voices or identifying objects placed in her hands; her perceptual problems appeared to be exclusively visual. (p. 367)

D. F.'s condition is called **visual agnosia,** *an inability to visually recognize objects*. It's not blindness: D. F. can see. Rather, brain damage has "left her unable to perceive the size, shape, and orientation of objects" (Goodale, 2000).

But how, then, is D. F. able to walk across a room while easily avoiding obstacles? And if she can't consciously perceive the difference in shape and size between, say, a spoon and a glass, how does she know to open her hand to the proper width to grasp objects? On a laboratory task, how is D. F. able to rapidly insert an object into a tilted rectangular slot when, just moments before, she could not consciously recognize the slot's orientation (Figure 6.1)?

Sleepeating and visual agnosia are intriguing conditions, and they offer potential insights into the nature of consciousness. Psychologists would explore whether these disorders are as far removed from our everyday states of consciousness as we might think. They would be especially interested in how Sondra, Jason, Ellen, and D. F. could perform tasks that seem to require attention and monitoring—making sandwiches or conversing while asleep, grasping objects—yet do so without conscious awareness.

How can someone be asleep yet find the kitchen and prepare food? Well, consider this: Why don't you fall out of bed at night? You are not consciously aware of your many postural shifts when you are sound asleep, yet a part of you somehow knows where the edge of the bed is. And what of D. F.'s ability, while awake, to avoid obstacles and grasp objects without conscious awareness of their shape or size? Again, consider this: Have you ever spaced out while driving because you were deeply engrossed in thought? Suddenly you snap out of it, with no memory of the miles you've just driven. While you were consciously focused inward, some part of you—without conscious awareness—kept track of the road and controlled your hand movements at the wheel.

(a)

(b)

Figure 6.2

(a) During a Sufi religious ceremony in Istanbul, Turkey, whirling dervishes perform a spinning dance—a prayer in motion—that induces an altered state of consciousness. (b) Buddhists believe that meditation produces inner peace, facilitates insight and enlightenment, and opens a path to different dimensions of consciousness.

Philosopher David Chalmers (1995) notes that consciousness "is at once the most familiar thing in the world and the most mysterious." As we now explore, its mysteries range from normal waking states to sleep and dreams, drug-induced experiences, and beyond (Figure 6.2).

THE PUZZLE OF CONSCIOUSNESS

When psychology was founded in the late 1800s, its "great project" was to unravel some of the puzzles of consciousness (Natsoulas, 1999). This interest waned during behaviorism's mid-20th century dominance, but resurgence of the cognitive and biological perspectives has led us to rethink long-standing conceptions about the mind.

Characteristics of Consciousness

In psychology, **consciousness** *is often defined as our moment-to-moment awareness of ourselves and our environment.* Among its characteristics, consciousness is:

- *subjective and private:* Other people cannot directly know what reality is for you, nor can you enter directly into their experience.
- *dynamic (ever changing):* We drift in and out of various states throughout each day. Moreover, although the stimuli of which we are aware constantly change, we typically experience consciousness as a continuously flowing stream of mental activity, rather than as disjointed perceptions and thoughts (James, 1890/1950).
- *self-reflective and central to our sense of self:* The mind is aware of its own consciousness. Thus no matter what your awareness is focused on—a lovely sunset or an itch on your back—you can reflect on the fact that you are the one who is conscious of it.

Finally, consciousness is *intimately linked to selective attention*, discussed in Chapter 5. William James noted that "the mind is at every stage a theatre of simultaneous possibilities. Consciousness consists in . . . the selection of some, and the suppression of the rest by the . . . agency of Attention" (1879, p. 13). **Selective attention** *is the process that focuses awareness on some stimuli to the exclusion of others*. If the mind is a theater of mental activity, then consciousness reflects whatever is illuminated at the moment—the bright spot on the stage—and selective attention is the spotlight or mechanism behind it (Baars, 1997).

Measuring States of Consciousness

Scientists who study consciousness must operationally define private inner states in terms of measurable responses. *Self-report measures* directly ask people to describe their inner experiences, but self-reports are not always verifiable or possible to obtain. While asleep, most of us (thankfully) do not speak; nor can we fill out self-report questionnaires.

Behavioral measures record, among other things, performance on special tasks. By examining D. F.'s performance on the card-slot task under different conditions (see Figure 6.1), researchers concluded that despite being unable to consciously perceive the slot's orientation, her brain nonetheless

Figure 6.3

Gordon Gallup (1970) exposed 4 chimps to a mirror. By day 3, they used it to inspect hard-to-see parts of their own bodies. To further test whether the chimps knew the mirror image was their own reflection, Gallup anesthetized them and put a red mark on each of their foreheads. Later, with no mirror, the chimps rarely touched the red mark. But upon seeing it when a mirror was introduced, they touched the red spot almost 30 times in 30 minutes, suggesting that the chimps had some self-awareness. A similar test in which a red mark was placed on the tip of infants' noses revealed that infants begin to recognize themselves in a mirror around 18 months of age.

processed this information. Behavioral measures are objective, but they require us to infer the person's state of mind. Figure 6.3 illustrates another clever behavioral measure.

Physiological measures establish the correspondence between bodily processes and mental states. Through electrodes attached to the scalp, the electroencephalograph (EEG) measures brain-wave patterns that reflect the ongoing electrical activity of large groups of neurons. Different patterns correspond to different states of consciousness, such as whether you are alert, relaxed, or asleep. Brain imaging allows scientists to more precisely examine brain activity that underlies various mental states. Physiological measures cannot tell us what a person is experiencing subjectively, but they have been invaluable for probing the inner workings of the mind.

Levels of Consciousness

Much of what occurs within your brain is beyond conscious access. You don't consciously perceive the brain processes that lull you to sleep. You're aware of your thoughts but not of how your brain creates them. What else lies outside of conscious awareness?

The Freudian Viewpoint

Sigmund Freud (1900/1953) proposed that the mind consists of three levels of awareness. The *conscious* mind contains thoughts and perceptions of which we are currently aware. *Preconscious* mental events are outside current awareness but can easily be recalled. For instance, you may not have thought about a friend for years, but when someone mentions your friend's name, you become aware of pleasant memories. *Unconscious* events cannot be brought into conscious awareness under ordinary circumstances. Freud proposed that some unconscious content—such as unacceptable sexual and aggressive urges, traumatic memories, and threatening emotional conflicts—is *repressed;* that is, it is kept out of conscious awareness because it would arouse anxiety, guilt, or other negative emotions.

Behaviorists roundly criticized Freud's ideas. After all, they sought to explain behavior without invoking conscious mental processes, much less unconscious ones. Cognitive psychologists and many contemporary psychodynamic psychologists also take issue with specific aspects of Freud's theory. However, as we will see, research supports Freud's general premise that unconscious processes can affect behavior.

The Cognitive Viewpoint

Cognitive psychologists reject the notion of an unconscious mind driven by instinctive urges and repressed conflicts. Rather, they view conscious and unconscious mental life as complementary forms of information processing that work in harmony (Hassin et al., 2005). For example, many activities, such as planning a vacation or studying, require

controlled (conscious) processing, *the conscious use of attention and effort*. Other activities involve **automatic (unconscious) processing** *and can be performed without conscious awareness or effort*. Automatic processing occurs most often when we carry out routine actions or very well-learned tasks.

In everyday life, learning to write, drive, and type on a computer keyboard all involve controlled processing; at first you have to pay a lot of conscious attention to what you are doing. With practice, performance becomes more automatic and certain brain areas involved in conscious thought become less active (Saling & Phillips, 2007). Through years of practice, athletes and musicians program themselves to execute highly complex skills with a minimum of conscious thought.

Automatic processing, however, has a key disadvantage because it can reduce our chances of finding new ways to approach problems (Langer, 1989). Controlled processing is more flexible and open to change. Still, many well-learned behaviors seem to be performed faster and better when our mind is on autopilot, with controlled processing taking a backseat. The baseball player Yogi Berra captured this idea in his classic statement, “You can’t think and hit at the same time.” At tasks ranging from putting a golf ball to playing video games, too much self-focused thinking can hurt performance and cause people to choke under pressure (Beilcock & Carr, 2001).

Automatic processing also facilitates **divided attention,** *the capacity to attend to and perform more than one activity at the same time*. We can talk while we walk, type as we read, and so on. Yet divided attention has limits and is more difficult when two tasks require similar mental resources. For example, we cannot fully attend to separate messages delivered simultaneously through two earphones.

Unconscious Perception and Influence

The concept of unconscious information processing is widely accepted today, but this was not always the case. It has taken painstaking research to reveal that stimuli can be perceived without conscious awareness and influence how we behave or feel. Consider these examples.

Visual Agnosia

Studies of people with brain damage provide scientists with insights into how the mind works. Recall that D. F., the woman with visual agnosia, could not consciously perceive the shape, size, or orientation of objects yet had little difficulty performing a card-insertion task and avoiding obstacles when she walked across a room. To perform these tasks easily, her brain must have processed accurate information about the properties of the various objects. If she professed no conscious awareness of these properties, then this information processing must have occurred unconsciously (Goodale, 2000).

There are many types of visual agnosia. For example, people with *prosopagnosia* can visually recognize objects but not faces. When some of these patients look in the mirror, they do not consciously recognize their own faces. Yet in laboratory tests these patients display different patterns of brain activity, arousal, and eye movements when they look at familiar rather than unfamiliar faces (Young, 2003). In other words, their brains are recognizing a difference between familiar and unfamiliar stimuli, but this recognition doesn’t reach conscious awareness.

Blindsight

People with agnosia are not blind, but those with a rare condition called **blindsight** *are blind in part of their visual field yet in special tests respond to stimuli in that field despite reporting that they can’t see those stimuli* (Kentridge et al., 2004). For example, due to left-hemisphere damage, a blindsight patient may be blind in the right half of the visual field. A stimulus (e.g., a photograph, a vertical line) is flashed on a screen so that it appears within the patient’s blind visual field. On trial after trial, the patient reports seeing nothing. But when asked to point to where the stimulus was, she or he guesses at rates much higher than chance, suggesting that the stimulus was perceived unconsciously. On some tasks, guessing accuracy may reach 80 to 100 percent (Radoeva et al., 2008).

Priming

Here’s a simple task. Starting with the two letters *ho*_____ (this is called a *word stem*), what is the first word that comes to your mind? Was it *hot, how, home, house, hope, hole*, or *honest*? Clearly, you had these and many other words to choose from.

Now imagine that just before completing this word stem you had looked at a screen on which the word *hose* (or perhaps a picture of a hose) was presented *subliminally* (it was displayed so rapidly or weakly that it was below your threshold for conscious perception).

Suppose we conduct an experiment with many participants and many word stems (e.g., *ho*_____, *gr*_____, *ma*_____, etc.). We find that compared to people who are not exposed to subliminal words such as *hose, gripe,* and *manage*, people who are subliminally exposed are more likely to complete the word stems with those particular words. This provides evidence of a process called **priming:** *Exposure to a stimulus influences (i.e., primes) how you subsequently respond to that same or another stimulus*. Thus even if people do not consciously see *hose,* the subliminal word or image primes their response to *ho*_____.

Subliminal stimuli can prime more than our responses to word stems. For example, when people are shown photographs of a person, the degree to which they evaluate that person positively is influenced by whether they have first been subliminally exposed to pleasant or unpleasant images, such as photos of other faces that are happy or fearful (Sweeny et al., 2009). Likewise, being subliminally exposed to words with an aggressive theme causes people to judge another person's ambiguous behavior as being more aggressive (Todorov & Bargh, 2002).

The Emotional Unconscious

Modern psychodynamic psychologists emphasize that beyond the types of unconscious processing we've just discussed, emotional and motivational processes also operate unconsciously and influence behavior (Westen, 1998). Numerous experiments support the view that unconscious processes can have an emotional and motivational flavor (LaBar & LeDoux, 2006). For example, have you ever been in a bad or a good mood and wondered why you were feeling that way? Perhaps it is because you were influenced by events in your environment of which you were not consciously aware.

In one study, Tanya Chartrand and her colleagues (2002) subliminally presented college students with nouns that were either strongly negative (e.g., *cancer, cockroach*), mildly negative (e.g., *Monday, worm*), mildly positive (e.g., *parade, clown*), or strongly positive (e.g., *friends, music*). Later, students rated their moods on psychological tests. Although not consciously aware of seeing the nouns, students shown the strongly negative words reported the saddest mood, whereas those who had seen the strongly positive words reported the happiest mood.

Why Do We Have Consciousness?

Why have we evolved into conscious beings? Surely the subjective richness of your life might evaporate if you lost the ability to consciously reflect on your feelings, thoughts, and memories. But how does consciousness help us adapt to, and survive in, our environment?

In his book *The Quest for Consciousness*, Christof Koch (2004) notes that, "consciousness goes hand-in-hand with the ability to plan, to reflect upon many possible courses of action, and to choose one" (p. 205). Koch suggests that consciousness serves a summarizing function. At any instant, your brain processes many external stimuli (e.g., sights, sounds, etc.) and internal stimuli (e.g., bodily sensations). Conscious awareness provides a summary—a single mental representation—of what is going on in your world at each moment, and it makes this summary available to brain regions involved in planning and decision making. Other scientists agree that consciousness aids the distribution of information to many brain areas (Shanahan & Baars, 2005).

On another front, consciousness helps us override potentially dangerous behaviors governed by impulses or automatic processing. Without the capacity to reflect, you might lash out after every provocation. Without the safety net of consciousness, Sondra almost drank ammonia during a sleepwalking episode.

Consciousness also allows us to deal flexibly with novel situations and helps us plan responses to them (Koch, 2004; Langer, 1989). Self-awareness—coupled with communication—also enables us to express our needs to other people and coordinate actions with them.

The Neural Basis of Consciousness

Within our brains, where does consciousness arise? And if no individual brain cell is conscious (as far as we know), then how does brain activity produce consciousness?

Windows to the Brain

Some researchers have examined the brain functioning of patients who have visual agnosia, blindsight, or other disorders that impair conscious perception. Let's return to the case of D. F. Brain imaging revealed that D. F.'s primary visual cortex was largely undamaged from carbon-monoxide exposure. Why, then, could she not consciously recognize objects and faces?

The answer builds on prior research in which psychologists discovered multiple brain pathways for processing visual information (Ungerleider & Mishkin, 1982). One pathway, extending from the primary visual cortex to the parietal lobe, carries information to support the unconscious guidance of movements (Gabbard & Ammar, 2008). A second pathway, extending from the primary visual cortex to the temporal lobe, carries information to support

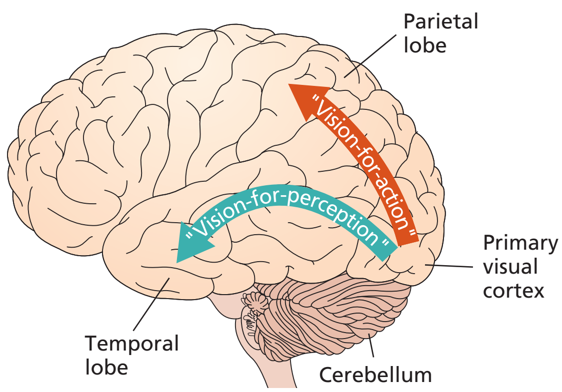


Figure 6.4

Action and perception.
The neural pathway shown in red is sometimes called the *vision-for-action pathway* because it carries information used in the visual control of movement, such as reaching for and grasping something or inserting a card into a slot. The pathway shown in green is sometimes called the *vision-for-perception pathway* because it carries information that helps us recognize objects (Koch, 2004; Milner & Dijkerman, 2001). Both pathways ultimately make connections to the prefrontal cortex.

the conscious recognition of objects (Figure 6.4). Consistent with this view, imaging of D. F.'s brain indicated that parts of this second visual pathway were badly damaged (Goodale, 2000).

Scientists study the neural basis of consciousness in other creative ways. Some explore conscious perceptions created when specific brain areas are electrically stimulated, while others examine how consciousness is lost and regained when patients are put under and recover from anesthesia (Lee et al., 2009). Still others have used a procedure called *masking* (Figure 6.5) to control whether people perceive a stimulus consciously or unconsciously. In experiments, participants undergo brain imaging while exposed to masked and unmasked stimuli. This enables scientists to assess how brain activity differs depending on whether the same stimuli (e.g., photos of angry faces) are consciously or unconsciously perceived.

Building on this technique, neuroscientists have found that emotionally threatening stimuli are processed consciously and unconsciously through different neural pathways. The pathway that produces conscious recognition involves the prefrontal cortex and several other brain regions that are bypassed in the pathway for unconscious processing (Morris & Dolan, 2001).

Consciousness as a Global Workspace

Many neuroscientists believe that there is no single place in the brain that gives rise to consciousness. Instead, they view the mind as a collection of largely separate but interacting information-processing modules that perform tasks related to sensation, perception, memory, movement, planning, problem solving, emotion, and so on. The modules process information in parallel—that is, simultaneously and largely independently. However, there also is cross talk between them, as when the output from one module is carried by neural circuits to provide input for another module. For example, a formula recalled from memory can become input for problem-solving modules that allow you to compute answers during a math exam.

According to one view, consciousness is a *global workspace* that represents the unified activity of multiple modules in different areas of the brain (Baars, 2007). In essence, of the many brain modules and connecting circuits that are active at any instant, a particular subset becomes joined in unified activity that is strong enough to become a conscious perception or thought (Koch, 2004). The specific modules and circuits that make up this dominant subset can vary as our brain responds to changing stimuli—sights, sounds, smells, and so on—that compete for conscious attention.

Subjectively, of course, we experience consciousness as unitary, rather than as a collection of modules and circuits. This is somewhat akin to listening to a choir sing. We are aware of the integrated, harmonious sound of the choir rather than the voice of each individual member. As we now see, many factors influence these modules and, in so doing, alter our consciousness.

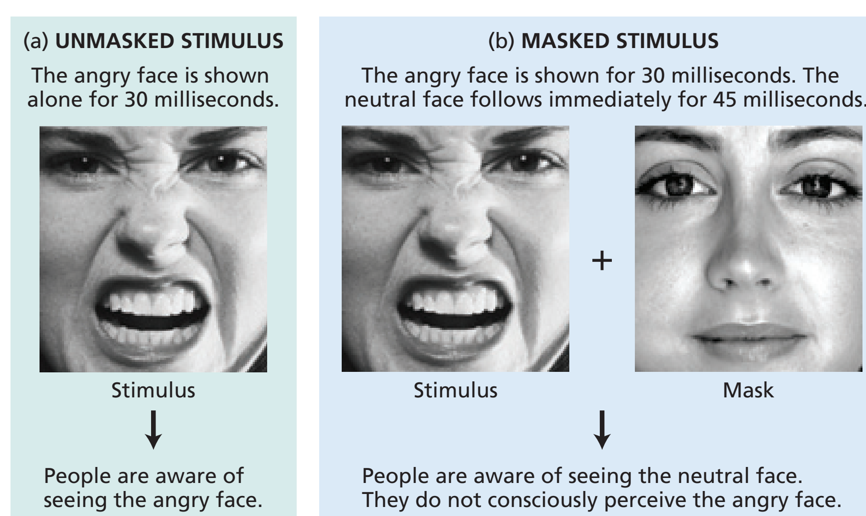


Figure 6.5

An example of masking.
(a) If a picture of an angry face is flashed on a screen for 30 milliseconds, people report seeing it. In this case, the picture is not masked. (b) If the angry face is immediately followed by a photo of a neutral face shown for a longer time (e.g., 45 milliseconds), people report seeing the neutral face but not the angry face. In this approach—called *backward masking*—the presentation of the second photo masks the conscious perception of the first photo. Masking works with many types of stimuli, not just photos of faces. SOURCE: Adapted from Morris & Dolan, 2001.

test yourself The Puzzle of Consciousness

True or false?

1. Self-report measures are the only valid way to measure states of consciousness.
2. According to Freud, the preconscious mind consists of mental events that cannot be brought into conscious awareness.
3. Controlled processing requires the conscious use of attention and effort.
4. Visual agnosia, blindsight, and priming all support the concept of unconscious processing.
5. The brain has a single "consciousness center" located in the right prefrontal cortex.

ANSWERS: 1-false, 2-false, 3-true, 4-true, 5-false

CIRCADIAN RHYTHMS: OUR DAILY BIOLOGICAL CLOCKS

Like other animals, humans have adapted to a world with a 24-hour day-night cycle. Every 24 hours our body temperature, certain hormonal secretions, and other bodily functions undergo a rhythmic change that affects our alertness and readies our passage back and forth between waking consciousness and sleep (Figure 6.6). These *daily biological cycles are called* **circadian rhythms.**

Keeping Time: Brain and Environment

Most circadian rhythms are regulated by the brain's **suprachiasmatic nuclei (SCN),** located in the hypothalamus. SCN neurons have a genetically programmed cycle of activity and inactivity, functioning like a biological clock. They link to the tiny pineal gland, which secretes **melatonin,** *a hormone that has a relaxing effect on the body*. SCN neurons become active during the daytime and reduce the pineal gland's secretion of melatonin, raising body temperature and heightening alertness. At night, SCN neurons are inactive, allowing melatonin levels to increase and promoting relaxation and sleepiness (Zee & Lu, 2008).

Our circadian clock is biological, but environmental cues such as the day-night cycle help keep SCN neurons on a 24-hour schedule. Your eyes have neural connections to the SCN, and after a night's sleep, the light of day increases SCN activity and helps reset your 24-hour biological clock. What would happen, then, if you lived in a laboratory or underground cave without clocks and could not tell whether it was day or night outside? In experiments in which people did just that, most participants drifted into a natural wake-sleep cycle, called a *free-running circadian rhythm*, that is longer than 24 hours (Hillman et al., 1994).

For decades, research suggested that our free-running rhythm was about 25 hours long. In these studies, however, the bright room lights that participants kept on artificially lengthened their circadian rhythms. Under more controlled conditions, the free-running rhythm averages around 24.2 hours (Lavie, 2000). Yet even this small deviation from the 24-hour day is significant. If you were to follow your free-running rhythm, two months from now you would be going to bed at noon and awakening at midnight.

Early Birds and Night Owls

Circadian rhythms also influence our tendency to be a morning person or a night person (Emens et al., 2009). Compared to night people ("night owls"), morning people ("early birds") go to bed

Figure 6.6

Circadian rhythms.
(a) Changes in our core body temperature, (b) levels of melatonin in our blood, and (c) degrees of alertness are a few of the bodily functions that follow a cyclical 24-hour pattern called a *circadian rhythm.* Humans also have longer and shorter biological cycles, such as the 28-day female menstrual cycle and a roughly 90-minute brain activity cycle during sleep. SOURCE: Adapted from Monk et al., 1996.

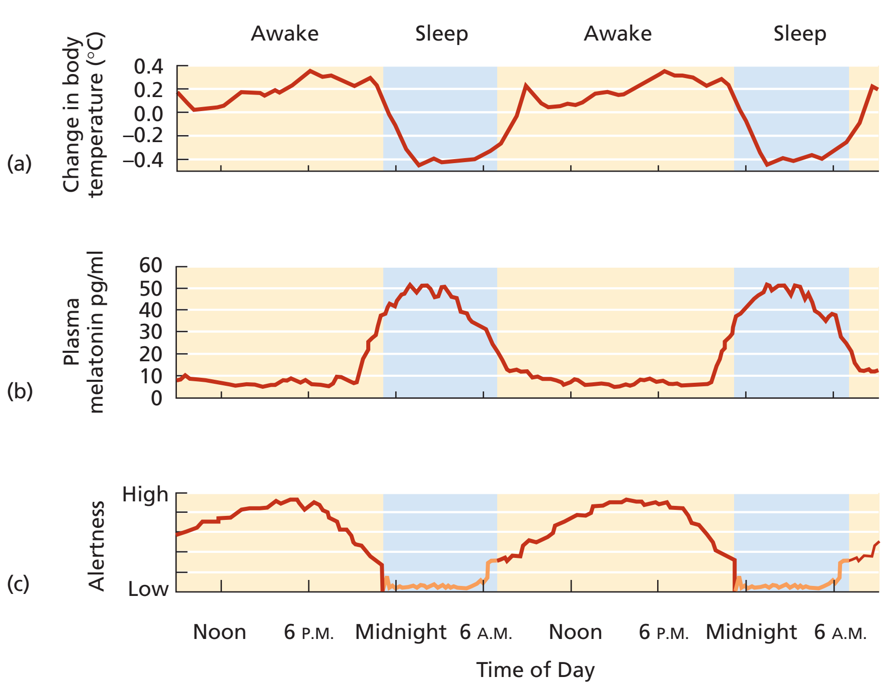


Table 6.1 Morningness among College Students from Six Countries

Country	Morningness Score
Colombia	42.4
India	39.4
Spain	33.9
England	31.6
United States	31.4
Netherlands	30.1

NOTE: Scores can range from 13 ("extreme evening type") to 55 ("extreme morning type").
SOURCE: Smith et al., 2002.

and rise earlier, and their body temperature, blood pressure, and alertness peak earlier in the day.

Cultures may differ in their overall tendency toward "morningness." Carlla Smith and her coworkers (2002) used questionnaires to measure the degree of morningness among college students from six countries. They predicted and found that students from Colombia, India, and Spain—regions with warmer annual climates—exhibited greater morningness than students from England, the United States, and the Netherlands (Table 6.1).

thinking critically

EARLY BIRDS, CLIMATE, AND CULTURE

Is this study of morningness correlational or experimental? What factors other than climate might explain why people from warmer regions display greater morningness? Think about it, then see page 212.

Environmental Disruptions of Circadian Rhythms

Environmental changes can disrupt our circadian rhythms. Jet lag is a sudden circadian disruption caused by flying across several time zones in one day. Flying east, you lose hours from your day; flying west extends your day to more than 24 hours. Jet lag, which often causes insomnia and decreased alertness, is a significant concern for businesspeople, athletes, airline crews, and others who frequently travel across many time zones (Reilly, 2009). The body naturally adjusts about one hour or less per day to time-zone changes. Typically, people adjust faster when flying west, presumably because lengthening the travel day is more compatible with our natural free-running circadian cycle (Revell & Eastman, 2005).

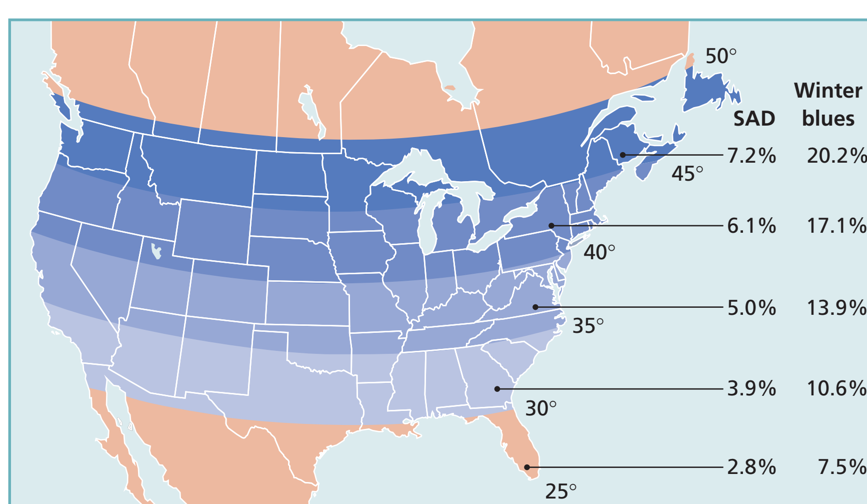
Night-shift work is the most problematic circadian disruption for society. Imagine beginning an 8-hour work shift at 11 P.M. or midnight, a time when your biological clock is promoting sleepiness. After work you head home in morning daylight, making it harder to alter your biological clock (Sasseville et al., 2009). Daytime becomes bedtime, and you may sleep less than you did before. Over time you may become fatigued, stressed, and more accident-prone (Folkard, 2008). On days off, reverting to a typical day-night schedule to spend time with family and friends will disrupt any hard-earned circadian adjustments you have made. If you work for a company that requires employees to rotate shifts every few days or weeks, then after adapting to night work, you'll have to switch to a day or evening shift and readjust your biological clock again.

These circadian disruptions, combined with fatigue from poor daytime sleep, can be a recipe for disaster. Job performance errors, fatal traffic accidents, and engineering and industrial disasters peak between midnight and 6 A.M. (Akerstedt et al., 2001). In some cases, night operators at nuclear power plants have been found asleep at the controls. On-the-job sleepiness is also a major concern among long-distance truck drivers, airline crews, doctors and nurses, and others who work at night.

Seasonal affective disorder (SAD) *is a cyclic tendency to become psychologically depressed during certain seasons of the year*. In most cases, SAD begins in fall or winter, when there is less daylight, and then lifts in spring (Rosenthal & Rosenthal, 2006). The circadian rhythms of SAD sufferers may be particularly sensitive to light, so as sunrises occur later in winter, the daily onset time of their circadian clocks may be pushed back to an unusual degree. On late-fall and winter mornings, when many people must arise for work and school in darkness, SAD sufferers remain in sleepiness mode long after the morning alarm clock sounds (Figure 6.7).

Figure 6.7

The latitude puzzle. In North America, the rates of winter SAD and milder depression ("winter blues") increase at more northerly latitudes, where the hours of daylight diminish more severely in late fall and winter. Yet European studies report lower winter SAD rates and a weaker SAD–latitude relation. In fact, most studies in Sweden, Norway, Finland, and Iceland report winter SAD rates similar to those in the southern United States. The reason for this discrepancy is not clear. SOURCES: Data adapted from Mersch et al., 1999. Map graphic from *The New York Times*, 29 December 1993, p. B7; copyright © 1993 The New York Times.



Applying Psychological Science

Outsmarting Jet Lag, Night-Work Disruptions, and Winter Depression

Circadian research provides important insights on the nature of consciousness. It also offers several treatments for circadian disruptions affecting millions of people.

CONTROLLING EXPOSURE TO LIGHT

Reducing Jet Lag

Flying east across time zones, your body's internal clock falls behind the time at your destination. Exposure to outdoor light in the morning—and avoiding light late in the day—moves the circadian clock forward and helps it catch up to local time. (Think of morning light as jump-starting your circadian clock at a time when you would be asleep back home.) Flying west, your body clock moves ahead of local time. So to reduce jet lag, you want to delay your circadian cycle by avoiding bright light in the morning and exposing yourself to light in the afternoon or early evening. These are general rules, but the specific timing of light exposure depends on the number of time zones crossed (Waterhouse & Reilly, 2009). For jet travelers, spending time outside (even on cloudy days) is the easiest way to get the needed exposure to light.

Adjusting to Night Work

When night employees go home after work, their circadian adjustment can be increased by (1) keeping the bedroom dark and quiet to foster daytime sleep and (2) maintaining a schedule of daytime sleep even during days off (Boulos, 1998). Day sleepers are advised to install light-blocking window shades, unplug the phone, and use earplugs.

Treating SAD

Many experts believe that phototherapy, which involves properly timed exposure to specially prescribed bright artificial lights, is an effective treatment for SAD (Strong et al., 2009). Several hours of daily phototherapy, especially in the early morning, can shift circadian rhythms by as much as 2 to 3 hours per day (Neumeister, 2004). The fact that phototherapy effectively treats SAD is the strongest evidence that SAD is triggered by winter's lack of sunlight rather than by its colder temperatures (Figure 6.8).

Figure 6.8

For many people, the depression from SAD can be reduced by daily exposure to bright fluorescent lights.

MELATONIN TREATMENT: USES AND CAUTIONS

The hormone melatonin is a key player in the brain's circadian clock. Melatonin also exists in pill or capsule form; it is a prescription drug in some countries and is unavailable to the public in others. In the United States, it is a nonprescription dietary supplement. Depending on when it is taken, oral melatonin can shift some circadian cycles forward or backward by as much as 30 to 60 minutes per day of use. Melatonin treatment has been used with some success to decrease jet lag, help employees adapt to night-shift work, and alleviate SAD (Arendt, 2009; Lewy et al., 2006).

But there is reason for caution. Doses of 0.1 to 0.5 milligram are often sufficient to produce circadian shifts, but tablet doses are often 3 to 5 milligrams, producing blood melatonin levels that are more than 10 times the normal concentration (Sack et al., 1997). Melatonin use is supervised during research, but individuals who self-administer it may do more harm than good. Taking melatonin at the wrong time can backfire and make circadian adjustments more difficult. Daytime use may decrease alertness (Graw et al., 2001).

REGULATING ACTIVITY SCHEDULES

Properly timed physical exercise may help shift the circadian clock (Mistlberger et al., 2000). For example, compared to merely staying up later than normal, exercising when you normally go to bed may push back your circadian clock, as you would want to do when flying west (Baehr, 2001). To reduce jet lag, you can also begin synchronizing your biological clock to the new time zone in advance. To do so, adjust your sleep and eating schedules by 1 to 2 hours per day, starting several days before you leave (Eastman et al., 2005). Schedule management also applies to night-shift work. For workers on 8-hour rotating shifts, circadian disruptions can be reduced by a forward-rotating shift schedule—moving from day to evening to night shifts—rather than a schedule that rotates backward from day to night to evening shifts (Driscoll et al., 2007). Forward schedules take advantage of free-running circadian rhythms. When work shifts change, it is easier to extend the waking day than to compress it.

test yourself Circadian Rhythms

Fill in the blank.

1. The ________, located in the hypothalamus, are the brain's master circadian clock.
2. At night, the pineal gland secretes more ________, a hormone that promotes sleepiness.
3. Without day-night and time cues, our ________ circadian rhythm is slightly longer than 24 hours.
4. ________ is a circadian disorder in which people become psychologically depressed during certain seasons of the year, usually fall and winter.

ANSWERS: 1-suprachiasmatic nuclei; 2-melatonin; 3-free-running; 4-Seasonal affective disorder

SLEEP AND DREAMING

Sweet, mysterious sleep. We spend much of our lives in this altered state, relinquishing conscious control of our thoughts, dreaming and remembering little of it upon awakening. Yet sleep, like other behaviors, can be studied at biological, psychological, and environmental levels.

Stages of Sleep

Circadian rhythms promote a readiness for sleep by decreasing alertness, but they do not regulate sleep directly. Instead, roughly every 90 minutes while asleep, we cycle through different stages in which brain activity and other physiological responses change in a generally predictable way (Dement, 2005; Kleitman, 1963).

Sleep research is often carried out in specially equipped laboratories where sleepers' physiological responses are recorded (Figure 6.9). EEG recordings of your brain's electrical activity would show a pattern of **beta waves** *when you are awake and alert*. Beta waves have a high frequency (of about 15 to 30 cycles per second, or cps) but a low amplitude, or height (Figure 6.10). As you close your eyes, *feeling relaxed and drowsy, your brain waves slow down and* **alpha waves** occur at about 8 to 12 cps.

Stage 1 through Stage 4

As sleep begins, your brain-wave pattern becomes more irregular, and slower *theta waves* (3.5 to 7.5 cps) increase. You are now in *stage 1*, a form of light sleep from which you can easily be awakened. You'll probably spend just a few minutes in stage 1, during which time some people experience dreams, vivid images, and sudden body jerks. As sleep becomes deeper, *sleep spindles*—periodic

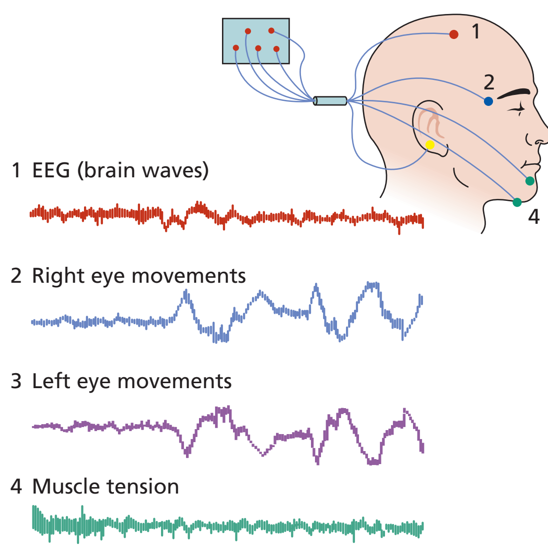


Figure 6.9

The sleep laboratory. In a modern sleep laboratory, people sleep while their physiological responses are monitored. Electrodes attached to the scalp record the person's EEG brain-wave patterns. Electrodes attached beside the eyes record eye movements during sleep. Electrodes attached to the jaw record muscle tension. A neutral electrode is attached to the ear.

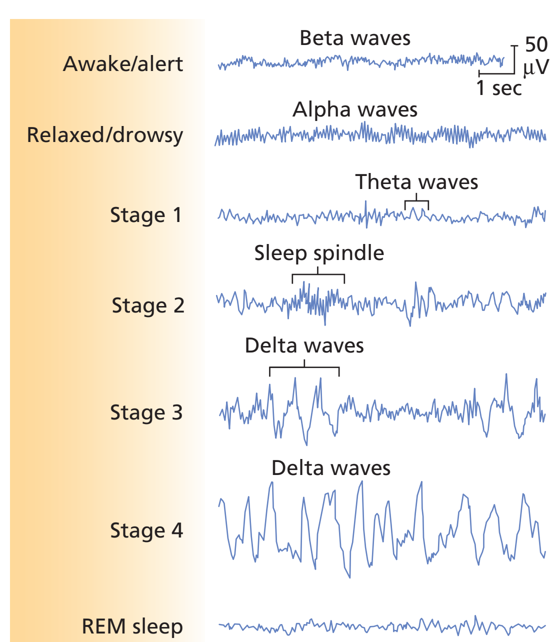


Figure 6.10

Stages of sleep. Changing patterns of brain-wave activity help define the various stages of sleep. Note that brain waves become slower as sleep deepens from stage 1 through stage 4. SOURCE: Based on Hauri, 1982.

1- to 2-second bursts of rapid brain-wave activity (12 to 15 cps)—begin to appear. Sleep spindles indicate that you are now in *stage 2* (see Figure 6.10). Your muscles are more relaxed, breathing and heart rate are slower, dreams may occur, and you are harder to awaken.

Sleep deepens as you move into *stage 3*, marked by the regular appearance of *very slow (0.5 to 2 cps) and large* **delta waves.** As time passes, they occur more often, and when delta waves dominate the EEG pattern, you have reached *stage 4*. *Together, stage 3 and stage 4 are often referred to as* **slow-wave sleep.** Your body is relaxed, activity in various parts of your brain has decreased, you are hard to awaken, and you may have dreams. After 20 to 30 minutes of stage-4 sleep, your EEG pattern changes as you go back through stages 3 and 2, spending a little time in each. Overall, within 60 to 90 minutes of going to sleep, you have completed a cycle of stages: 1-2-3-4-3-2. At this point, a remarkably different sleep stage ensues.

REM Sleep

In 1953, Eugene Aserinsky and Nathaniel Kleitman of the University of Chicago struck scientific gold when they identified a unique sleep stage called **REM sleep,** *characterized by rapid eye movements (REM), high arousal, and frequent dreaming*. They found that every half minute or so during REM sleep, bursts of muscular activity caused sleepers' eyeballs to vigorously move back and forth beneath their closed eyelids. Moreover, sleepers awakened from REM periods almost always reported a dream—including people who swore they "never had dreams." At last, scientists could examine dreaming more closely. Wait for REM, awaken the sleeper, and catch a dream.

During REM sleep, physiological arousal may increase to daytime levels. The heart rate quickens, breathing becomes more rapid and irregular, and brain-wave activity resembles that of active wakefulness. Regardless of dream content (most dreams are not sexual), men have penile erections and women experience vaginal lubrication. The brain also sends signals making it more difficult for voluntary muscles to contract. As a result, muscles in the arms, legs, and torso lose tone and become relaxed. These muscles may twitch, but in effect you are paralyzed, unable to move. This state is called *REM sleep paralysis* and, because of it, REM sleep is sometimes called *paradoxical sleep:* your body is highly aroused, yet it looks like you are sleeping peacefully because there is so little movement.

Although each cycle through the sleep stages takes an average of 90 minutes, Figure 6.11 shows that as the hours pass, stage 4 and then stage 3 drop out and REM periods become longer.

Getting a Night's Sleep: From Brain to Culture

The brain steers our passage through sleep, but it has no single "sleep center." Certain areas at the base of the forebrain (called the *basal forebrain*) and within the brain stem regulate our falling asleep. Other brain stem areas—including where

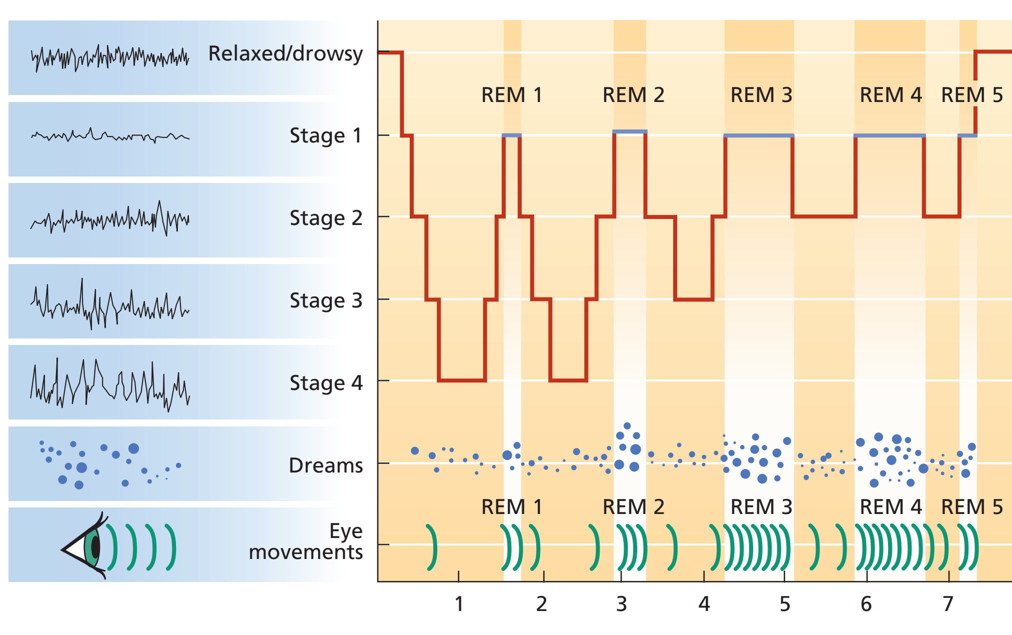


Figure 6.11

Cycling through a night's sleep. This graph shows a record of a night's sleep. The REM stages are shown in blue. People typically average four to five REM periods during the night, and these tend to become longer as the night wears on. On this night, the REM 5 period has been cut short because the person awakened.

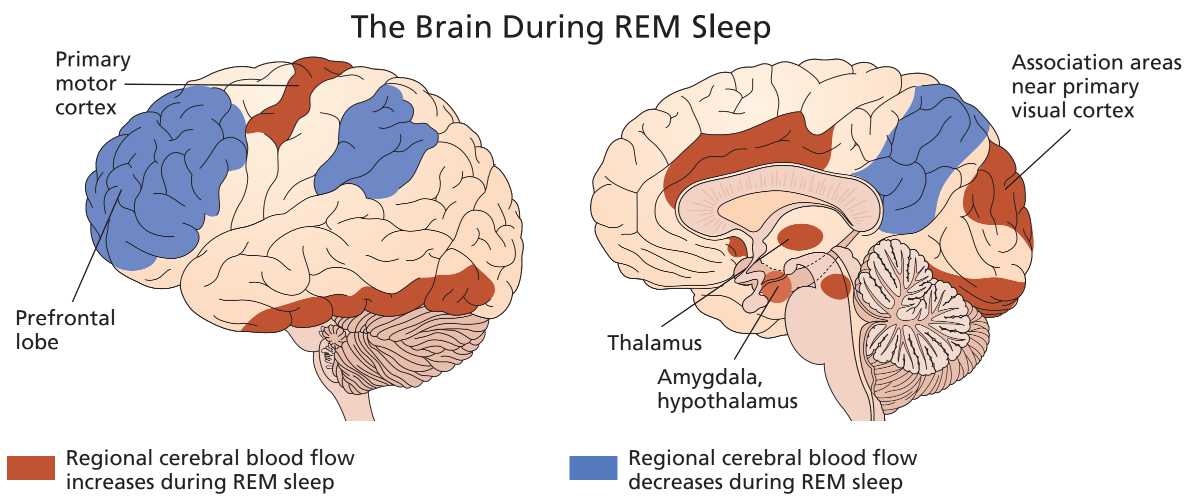


Figure 6.12

Brain activity during REM sleep.

During REM sleep, as compared to wakefulness, several brain regions display markedly decreased (blue) and increased (rust) activity. Note the decreased activation in certain prefrontal lobe regions and increased activity in parts of the amygdala and hypothalamus, thalamus, primary motor cortex, and association areas near the primary visual cortex in the occipital lobe. Source: Schwartz & Maquet, 2002.

the reticular formation passes through the pons (called the *pontine reticular formation*)—play a key role in regulating REM sleep (Izac & Eeg, 2006). This region contains neurons that periodically activate other brain systems, each of which controls a different aspect of REM sleep, such as eye movement and muscular paralysis.

Brain images taken during REM sleep reveal intense activity in limbic system structures, such as the amygdala, that regulate emotions. This pattern may reflect the emotional nature of many REM-sleep dreams (Figure 6.12). The primary motor cortex is active, but its signals for movement are blocked and don't reach our limbs. Association areas near the primary visual cortex are active, which may reflect the processing of visual dream images. In contrast, decreased activity occurs in regions of the prefrontal cortex involved in high-level mental functions, such as planning and logical analysis. This may indicate that our sleeping mind does not monitor and organize its mental activity as carefully as when awake, enabling dreams to be illogical and bizarre (Hobson et al., 2000).

Environmental factors, such as changes in season, also affect sleep. In fall and winter, most people sleep about 15 to 60 minutes longer per night. Shift work, stress at work and school, and nighttime noise can decrease sleep quality (Saremi et al., 2008).

Several aspects of sleep, such as its timing and length, vary across cultures. One study of 818 Japanese and Slovak adolescents found that, on average, the Japanese teenagers went to sleep later at night and slept for a shorter time than their Slovak peers (Iwawaki & Sarmany-Schuller, 2001). Many people, particularly those living in cultures in tropical climates, enjoy the traditional ritual of a 1- to 2-hour midday nap and reduce the length of nighttime sleep (Kribbs, 1993).

Cultural norms also influence several behaviors related to sleep. Do you sleep on a cushioned bed? In some cultures, people sleep on floors or suspended in hammocks (Figure 6.13). *Co-sleeping*, in which children sleep with their parents in the same bed or room, is not common in the United States, as children's sleeping alone is

Figure 6.13

In warmer regions of the Americas, the use of hammocks for sleeping has been common among various indigenous peoples for centuries. This photo shows a Mayan family in the Yucatán, Mexico.

seen as a way to foster independence. But in many cultures, co-sleeping is common (Li et al., 2009).

How Much Do We Sleep?

The question seems simple, as does the answer for many of us: not enough! In reality, the issue is complex. First, Figure 6.14 reveals that there are differences in how much people sleep at various ages. Newborns average 16 hours of sleep a day, almost half of it in REM. As we age, three important changes occur:

- We sleep less; 19- to 30-year-olds average around 7 to 8 hours of sleep a night, and elderly adults average just under 6 hours.
- REM sleep decreases dramatically during infancy and early childhood but remains relatively stable thereafter.
- Time spent in stages 3 and 4 declines. By old age we get relatively little slow-wave sleep.

Second, individual differences in the amount of sleep occur at every age. For example, sleep surveys indicate that one-third of preschoolers sleep between 10 and 10.9 hours a night (National Sleep Foundation, 2004). About 2 percent sleep 14 hours or more a night and 3 percent less than 8 hours.

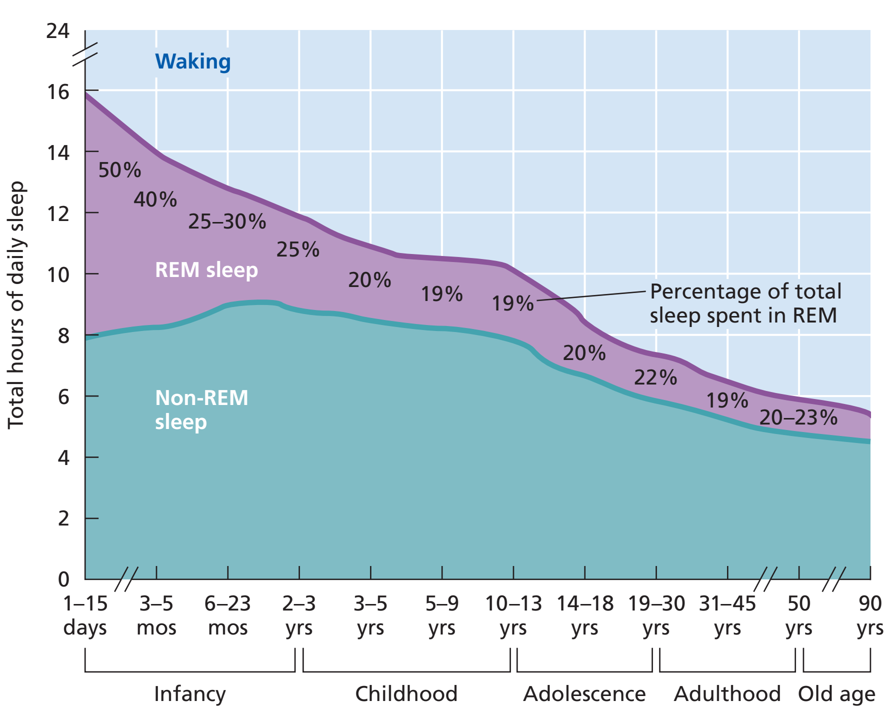


Figure 6.14

Aging and sleep.

Daily total sleep time and the percentage of sleep time in REM and non-REM sleep change with age.

SOURCE: Adapted from Roffwarg, H. P., Muzio, J. N., & Dement, W. C. (1966). Ontogenic development of human dream-sleep cycle. *Science, 152,* 604, figure 1. Copyright © American Association for the Advancement of Science. Reprinted with permission.

Do We Need Eight Hours of Nightly Sleep?

Sleep surveys describe how much sleep people believe they get, not how much they need. Still, it appears that the adage, "everyone needs 8 hours of sleep a night," isn't true (Monk et al., 2001). Indeed, studies reveal that a few people function well on little sleep. Researchers in London examined a healthy, energetic 70-year-old woman who claimed to sleep less than 1 hour a night (Meddis et al., 1973). Over five consecutive nights at the sleep lab, she averaged 67 minutes of sleep a night and showed no ill effects. Such extreme short-sleepers, however, are rare.

What accounts for differences in how much we sleep? Part of the answer appears to reside in our genes. Surveys of thousands of twins in Finland and Australia reveal that identical twins have more similar sleep lengths, bedtimes, and sleep patterns than do fraternal twins (Heath et al., 1990). Using selective breeding, researchers have developed some genetic strains of mice that are long- versus short-sleepers, other strains that spend more or less time in REM, and still others that spend more or less time in slow-wave sleep (Ouyang et al., 2004).

Studies indicate that sleep length and sleep patterns are also related to nongenetic factors. Differences in marital status, employment, work hours, and lifestyle pressures are some of the many factors contributing to the variability in people's sleep (Vincent et al., 2009).

Sleep Deprivation

Sleep deprivation is a way of life for many college students and other adults (National Sleep Foundation, 2009). June Pilcher and Allen Huffcutt (1996) meta-analyzed 19 studies in which participants underwent either "short-term total sleep deprivation" (up to 45 hours without sleep), "long-term total sleep deprivation" (more than 45 hours without sleep), or "partial deprivation" (being allowed to sleep no more than 5 hours a night for one or more consecutive nights). The researchers measured participants' mood (e.g., irritability) and responses on mental tasks (e.g., logical reasoning, word memory) and physical tasks (e.g., manual dexterity, treadmill walking).

What would you predict? Would all types of deprivation affect behavior, and which behaviors would be affected the most? In fact, all three types of sleep deprivation impaired functioning. The typical sleep-deprived person functioned only as well as someone in the bottom 9 percent of nondeprived participants. Overall, mood suffered most, followed by cognitive and then physical performance, although sleep loss significantly impaired *all three* behaviors.

What about students who pull all-nighters and claim they still perform as well as ever? June Pilcher and Amy Walters (1997) found that college students deprived of one night's sleep performed more poorly on a critical-thinking task than students allowed to sleep—yet incorrectly perceived that they had performed better. In short, the students underestimated the negative effects of sleep loss on performance.

Most total-sleep-deprivation studies with humans last less than 5 days, but 17-year-old Randy Gardner set a world record (since broken) of staying awake for 11 days for his 1964 high school science-fair project in San Diego. Grateful sleep researchers received permission to study him (Gulevich et al., 1966). Contrary to a popular myth that Randy suffered few negative effects, at times during the first few days he became irritable, forgetful, and nauseated. By the fifth he had periods of disorientation and mild hallucinations. Over the last 4 days he developed finger tremors and slurred speech. Still, in his final day without sleep he beat sleep researcher William Dement 100 consecutive times at a pinball-type game. When Randy finally went to bed, he slept almost 15 hours the first night and returned to his normal amount of sleep within a week. In general, it takes several nights to recover from extended sleep deprivation, and we do not make up all the sleep time that we have lost.

Why Do We Sleep?

Given that we spend almost a third of our lives sleeping, it must serve an important purpose. But what might that purpose be?

Sleep and Bodily Restoration

According to the **restoration model,** *sleep recharges our run-down bodies and allows us to recover from physical and mental fatigue* (Hess, 1965; Walker, 2008). Sleep-deprivation research supports this view, indicating that we need sleep to function at our best.

If the restoration model is correct, activities that increase daily wear on the body should increase sleep. Evidence is mildly supportive. A study of 18- to 26-year-old ultramarathon runners found that they slept much longer and spent a greater percentage of time in slow-wave sleep on the two nights following their 57-mile run (Shapiro et al., 1981). For the rest of us mere mortals, a meta-analysis of 38 studies found that we tend to sleep longer by about 10 minutes on days we have exercised (Youngstedt et al., 1997).

What is it that gets restored in our bodies while we sleep? We don't know precisely, but many researchers believe that a cellular waste product called *adenosine* plays a role (Alam et al., 2009). Like a car's exhaust emissions, adenosine is produced as cells consume fuel. As adenosine accumulates, it inhibits brain circuits responsible for keeping us awake, thereby signaling the body to slow down because too much cellular fuel has been burned. During sleep, our adenosine levels decrease.

Sleep as an Evolved Adaptation

Evolutionary/circadian sleep models *emphasize that sleep's main purpose is to increase a species' chances of survival in relation to its environmental demands* (Webb, 1974). Our prehistoric ancestors had little to gain—and much to lose—by being active at night. Hunting, food gathering, and traveling were accomplished more easily and safely during daylight. Leaving the protection of one's shelter at night would have served little purpose other than to become dinner for nighttime predators.

Over the course of evolution, each species developed a circadian sleep-wake pattern that was adaptive in terms of its status as predator or prey, its food requirements, and its methods of defense from attack. For small prey animals such as mice and squirrels, which reside in burrows or trees safely away from predators, spending a lot of time asleep is adaptive. For large prey animals such as horses, deer, and zebras, which sleep in relatively exposed environments and whose safety from predators depends on running away, spending a lot of time asleep would be hazardous (Figure 6.15). Sleep may also have evolved as a mechanism for conserving energy. Our body's overall metabolic rate during sleep is about 10 to 20 percent slower than during waking rest (Wouters-Adriaens & Westerterp, 2006). The restoration and evolutionary theories highlight complementary functions of sleep, and both contribute to a two-factor model of why we sleep (Webb, 1994).

Sleep and Memory Consolidation

Do specific sleep stages have special functions? To answer this question, imagine volunteering for a sleep-deprivation study in which we will awaken you only when you enter REM sleep; you will be undisturbed through the other sleep stages. How will your body respond? First, on successive nights, we will have to awaken you more often,

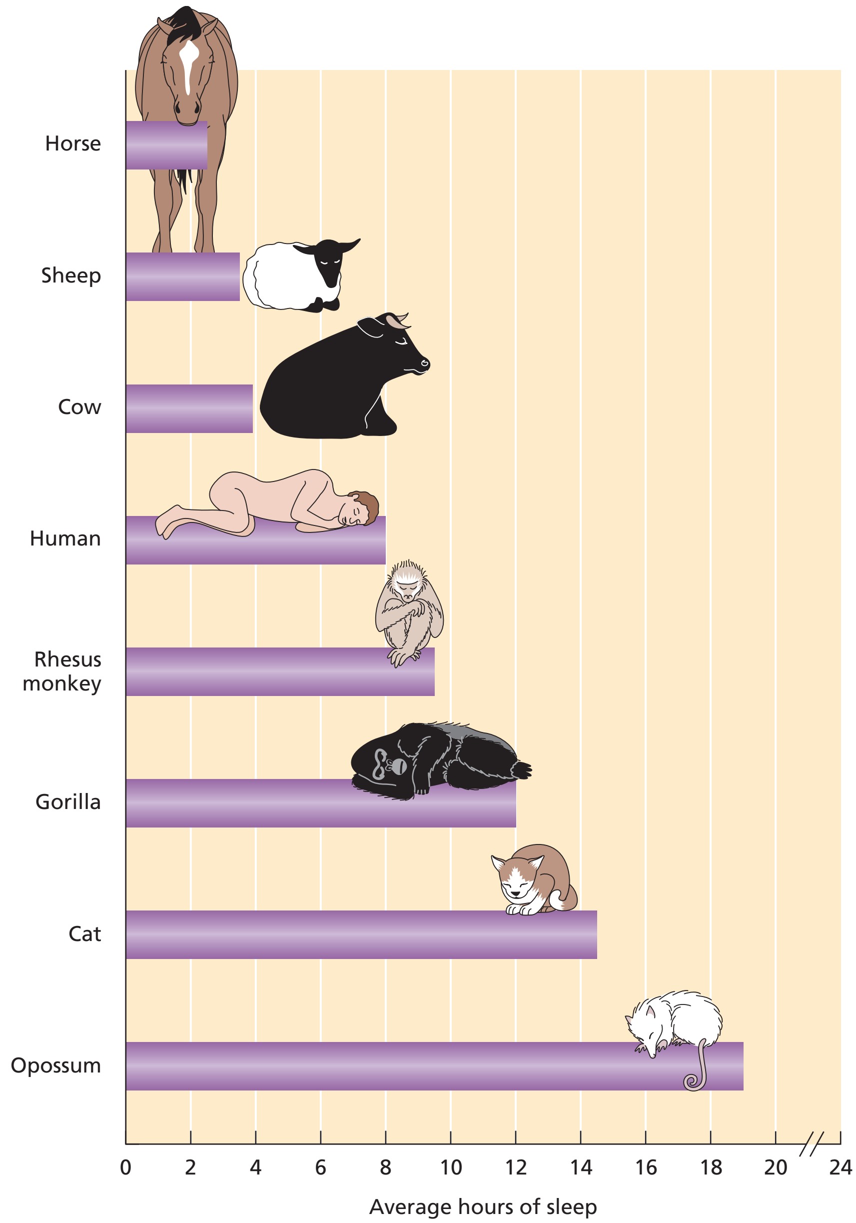


Figure 6.15

Daily hours of sleep.
The average daily hours of sleep vary across species.

because your brain will fight back to get REM sleep. Second, when the study ends, for the first few nights you probably will experience a *REM-rebound effect*, a tendency to increase the amount of REM sleep after being deprived of it.

This suggests that the body needs REM sleep, and similar effects are found for slow-wave sleep. But for what purpose? Many researchers believe that these sleep stages help us remember important information by enhancing **memory consolidation,** *a gradual process by which the brain transfers information into long-term memory* (Verleger et al., 2008; Winson, 1990). Despite many supportive experiments, including brain-imaging studies, the issue remains controversial (Saxvig et al., 2008). For example, the consolidation hypothesis is contradicted by the fact that although many antidepressant drugs greatly suppress or nearly eliminate REM sleep, patients taking these drugs do not show impaired abilities to remember new information, experiences, or skills.

Some researchers argue that the function of REM sleep—particularly the high brain activation of REM sleep—is to keep the brain healthy by offsetting the periods of low brain arousal during restful slow-wave sleep (Vertes & Eastman, 2003). At present, the unique functions of REM and other sleep stages are still being debated (Schabus, 2009).

Sleep Disorders

As the sleepeating cases of Sondra, Jason, and Ellen illustrate, the processes that regulate sleep are complex and can go wrong in many ways. In a national survey, 64 percent of the American adults sampled felt that they had some type of sleep problem (National Sleep Foundation, 2009).

Insomnia

True or False: someone who falls asleep easily can still have insomnia. The statement is true because **insomnia** *refers to chronic difficulty in falling asleep, staying asleep, or experiencing restful sleep*. If you occasionally have trouble getting a good night's sleep, don't worry. Almost everyone does. People with true insomnia have frequent and persistent sleep troubles.

Insomnia is the most common sleep disorder, experienced by 10 to 40 percent of the population of various countries (Bartlett et al., 2008). Some people are genetically predisposed toward insomnia. Moreover, medical conditions, mental disorders such as anxiety and depression, and many drugs can disrupt sleep, as can general worrying, stress at home and work, poor lifestyle habits, and circadian disruptions such as jet lag and night-shift work.

Psychologists have pioneered many nondrug treatments to reduce insomnia and improve sleep quality. One treatment, called *stimulus control*, involves conditioning your body to associate stimuli in your sleep environment (such as your bed) with sleep, rather than with waking activities and sleeplessness (Bootzin, 2002). For example, if you are having sleep difficulties, do not study, watch TV, or snack in your bedroom. Use your bed only for sleeping. If you cannot fall asleep within 10 minutes, get up and leave the bedroom. Do something relaxing until you feel sleepy, then return to bed. Table 6.2 contains more guidelines from sleep experts for reducing insomnia and achieving better sleep.

Narcolepsy

About 1 out of every 2,000 people suffers not from an inability to sleep but from an inability to stay awake (Ohayon, 2008). **Narcolepsy** *involves extreme daytime sleepiness and sudden, uncontrollable sleep attacks that may last from less than a minute to an hour*. No matter how much they rest at night, individuals with narcolepsy may experience sleep attacks at any time. When a sleep attack occurs, they may go right into a REM stage.

People with narcolepsy also may experience attacks of *cataplexy*, a sudden loss of muscle tone often triggered by excitement and other strong emotions. In severe cases, the knees buckle and the person collapses, conscious but unable to move for a few seconds to a few minutes. Cataplexy is an abnormal version of the normal muscular paralysis that takes place during nighttime REM sleep, and some experts view narcolepsy as a disorder in which REM sleep intrudes into waking consciousness.

Narcolepsy can be devastating. People with narcolepsy are more prone to accidents, feel that their quality of life is impaired, and may be misdiagnosed by doctors as having a mental disorder rather than a sleep disorder (Rovere et al., 2008).

Some people may be genetically predisposed toward developing narcolepsy. It can be selectively bred in dogs (Figure 6.16). In humans, if one identical twin has narcolepsy, the other has a 30-percent chance of developing it (Mignot, 1998). At present there is no cure for narcolepsy, but stimulant drugs and daytime naps often reduce daytime sleepiness, and antidepressant drugs (which suppress REM sleep) can decrease attacks of cataplexy.

REM-Sleep Behavior Disorder

Kaku Kimura and his colleagues in Japan (1997) reported the case of a 72-year-old woman who, during a night in a sleep laboratory, repeatedly sang and waved her hands during REM sleep. One episode lasted 3 minutes. She was experiencing **REM-sleep behavior disorder (RBD),** *in which the loss of muscle tone that causes normal REM-sleep paralysis is absent*. If awakened, RBD patients often report dream content that matches their behavior, as if they were acting out their dreams: "A 67-year-old man . . . was awakened one night by his wife's yelling as he was choking her. He was dreaming of breaking the neck of a deer he had just knocked down" (Schenck et al., 1989, p. 1169).

RBD sleepers may kick violently, throw punches, or get out of bed and move about wildly, leaving the bedroom in shambles. Many RBD patients have injured themselves or their sleeping partners. Research suggests that brain abnormalities may interfere with signals from the brain stem that normally inhibit movement during REM sleep, but in many cases the causes of RBD are unknown (Iranzo & Aparicio, 2009).

Table 6.2 How to Improve the Quality of Your Sleep

Sleep experts recommend a variety of procedures to reduce insomnia and improve the general quality of sleep.

- Maintain a regular sleep-wake pattern to establish a stable circadian rhythm.
- Get the amount of sleep you need during the week, and avoid sleeping in on weekends, as doing so will disrupt your sleep rhythm. Even if you sleep poorly or not at all one night, try to maintain your regular schedule the next.
- If you have trouble falling asleep at night, avoid napping if possible. Evening naps should be especially avoided because they will make you less sleepy when you go to bed.
- Avoid stimulants. This includes not just tobacco products and coffee but also caffeinated soft drinks and chocolate (sorry), which contain caffeine. It can take the body 4 to 5 hours to reduce the amount of caffeine in the bloodstream by 50 percent.
- Avoid alcohol and sleeping pills. As a depressant, alcohol may make it easier to go to sleep, but it disrupts the sleep cycle and interferes with REM sleep. Sleeping pills also impair REM sleep, and their constant use can lead to dependence and insomnia.
- Try to go to bed in a relaxed state. Muscle-relaxation techniques and meditation can reduce tension, remove worrisome thoughts, and help induce sleep.
- Avoid physical exercise before bedtime because it is too stimulating. If you are unable to fall asleep, do not use exercise to try to wear yourself out.
- If you are having sleep difficulties, avoid performing nonsleep activities in your bedroom.

SOURCES: Bootzin, 2002; King et al., 2001.

Figure 6.16

This dog lapses suddenly from alert wakefulness into a limp sleep while being held by sleep researcher William Dement. Using selective breeding, researchers at Stanford's Sleep Disorders Center have established a colony of narcoleptic canines.

Sleepwalking

Sleepwalking usually occurs during a stage-3 or stage-4 period of slow-wave sleep (Zadra et al., 2008). Sleepwalkers often stare blankly and are unresponsive to other people. Many seem vaguely conscious of the environment as they navigate around furniture, yet they can injure themselves accidentally, such as by falling down stairs. The pattern, however, is variable. Recall that Jason, while eating during his sleepwalking episodes, could have intelligible conversations with his wife. People who sleepwalk often return to bed and awaken in the morning with no memory of the event.

About 10 to 30 percent of children sleepwalk at least once, but less than 5 percent of adults do. If you did not sleepwalk as a child, the odds are less than 1 percent that you will do so as an adult (Hublin et al., 1997).

A tendency to sleepwalk may be inherited, and daytime stress, alcohol, and certain illnesses and medications can increase sleepwalking (Pressman, 2007). Treatments may include psychotherapy and awakening children before the time they typically sleepwalk (Frank et al., 1997). For children, the most common approach is simply to wait for the child to outgrow it while creating a safe sleep environment to prevent injury.

Nightmares and Night Terrors

Nightmares are bad dreams, and virtually everyone has them. Like all dreams, they occur more often during REM sleep. Arousal during nightmares typically is similar to levels experienced during pleasant dreams.

Night terrors *are frightening dreams that arouse the sleeper to a near-panic state*. In contrast to nightmares, night terrors are most common during slow-wave sleep (stages 3 and 4), are more intense, and involve greatly elevated physiological arousal; the heart rate may double or triple. In some cases the terrified sleeper may suddenly sit up, scream, or flee the room—as if trying to escape from something. Come morning the sleeper usually has no memory of the episode (Szelenberger et al., 2005).

Up to 6 percent of children, but only 1 to 2 percent of adults, experience night terrors (Ohayon et al., 1999). In most childhood cases, treatment is simply to wait for the night terrors to diminish with age.

Sleep Apnea

People with **sleep apnea** *repeatedly stop and restart breathing during sleep*. Stoppages usually last 20 to 40 seconds but can continue for 1 to 2 minutes. In severe cases they occur 400 to 500 times a night. Sleep apnea is most commonly caused by an obstruction in the upper airways, such as sagging tissue as muscles lose tone during sleep. The chest and abdomen keep moving, but no air gets through to the lungs. Finally, reflexes kick in and the person gasps or produces a loud, startling snore, followed by a several-second awakening. The person typically falls asleep again without remembering having been awake.

About 3 percent of people have obstructive sleep apnea, which is most common among overweight, middle-aged males (Krishnan & Collop, 2006). Surgery may be performed to remove the obstruction, and sleep apnea sometimes is treated by having the sleeper wear a mask that continuously pumps air to keep the air passages open (Villar et al., 2009).

The Nature of Dreams

Dreaming is highly valued in many traditional cultures. In the Caribbean island nation of Dominica, for example, indigenous inhabitants believe that dreams can reveal the future and guide current actions, and they interpret dreams using symbols passed down orally across generations (George-Joseph & Smith, 2008). Even in industrialized societies that generally attach less importance to dreams, many people believe that dreams can be meaningful (Morewedge & Norton, 2009).

When Do We Dream?

Mental activity occurs throughout the sleep cycle. When Jason Rowley and his colleagues (1998) awakened college students merely 45 seconds after sleep onset, about 25 percent of the students reported that they had been experiencing visual hallucinations (visual images that seemed real). As this *hypnagogic state*—the transitional state from wakefulness through early stage-2 sleep—continued, mental activity became less "thoughtlike" and more "dreamlike."

Throughout the night we dream most often during REM sleep, when activity in many brain areas is highest. Awaken a REM sleeper and you have about an 80- to 85-percent chance of catching a dream. In contrast, people awakened from non-REM (NREM) sleep report dreams about 15 to 50 percent of the time. Also, our REM dreams are more likely to be vivid, bizarre, and storylike than NREM dreams.

Despite these REM-NREM differences, don't believe the fallacy (often reinforced by the popular media) that dreaming happens only during REM sleep. Figure 6.17 shows an analysis of 1,576 reports collected from 16 college students awakened from various sleep stages (Fosse et al., 2001). Even during NREM sleep, hallucinatory images were more common than non-dreamlike thoughts. By some estimates, about 25 percent of the vivid dreams we have each night actually occur during NREM periods (Solms, 2002).

What Do We Dream About?

Much of our knowledge about dream content derives from 45 years of research using a coding system developed by Calvin Hall and Robert Van de Castle (1966). Analyzing 1,000 dream reports (mostly from college students), they found that although some dreams certainly are bizarre, overall dreams are not nearly as strange as they are stereotyped to be. Most take place in familiar settings and often involve people we know.

Given the stereotype of "blissful dreaming," it may surprise you that across many cultures, most dreams contain negative content (Domhoff & Schneider, 2008). Hall and Van de Castle (1966) found that 80 percent of dream reports involved negative emotions, almost half contained aggressive acts, and a third involved some type of misfortune. Also, women dreamt almost equally about male and female characters, whereas about two thirds of men's dream characters were male. Although the reason for this gender difference is not clear, a similar pattern has been found across several cultures and age groups.

Our life experience and current concerns can shape dream content (Bulkeley & Kahan, 2008). Pregnant women, for example, have dreams with many pregnancy themes, and in the weeks following the September 11, 2001, terrorist attacks, a study of 1,000 residents of Manhattan found that 1 in 10 experienced distressing dreams about the attacks (Galea et al., 2002).

Cross-culturally, dream content displays commonalities and differences. For example, negatively themed dreams are prevalent, and in dreams that involve aggressive content the dreamer more often is the victim than the perpetrator (Domhoff & Schneider, 2008). Yet, although dreams that involve physical and nonphysical aggression (e.g., verbal threats) are found across cultures, Table 6.3 shows that the percentage of physically aggressive dream content (out of all aggressive dream content) varies widely across societies. In part, this reflects differences in how often people from various cultural groups have dreams that involve

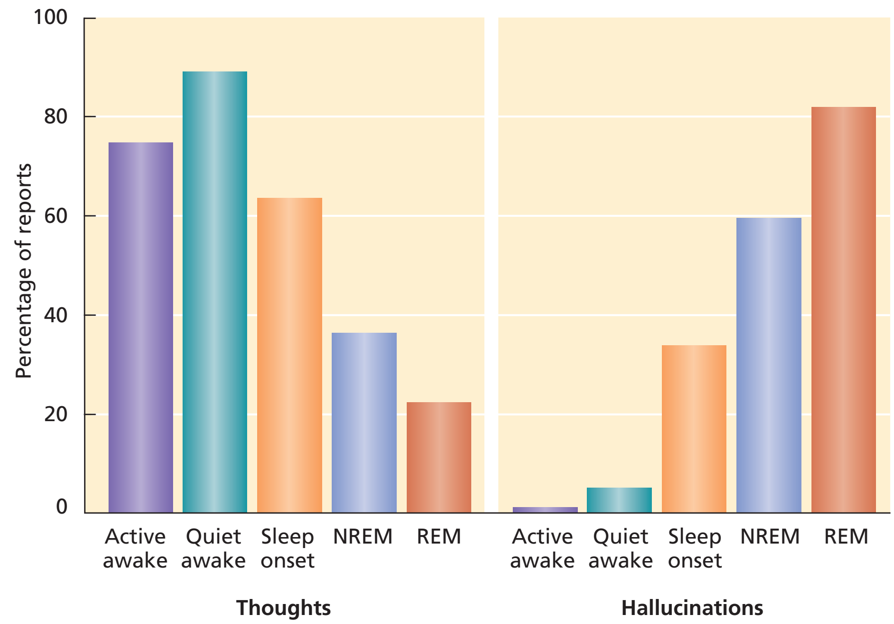


Figure 6.17

Mental activity during sleep.
This graph shows the percentage of verbal reports that reflected thoughts and visual hallucinations recorded during active and quiet wakefulness and when awakened during sleep onset, REM sleep, and NREM sleep.
SOURCE: Adapted from Fosse et al., 2001.

fights or attacks between humans and animals (Domhoff & Schneider, 2008).

Why Do We Dream?

Questions about the purpose and meaning of dreams have intrigued humankind for ages. Let's examine a few viewpoints.

Table **6.3** **In Dreams, the Percentage of Aggressive Acts That Involve Physical (versus Nonphysical) Aggression**

Society	Men's Dreams	Women's Dreams
Yir Yiront (Australia)	92	n/a*
Baiga (India)	86	n/a*
Navaho (North America)	77	n/a*
Skolt (Finland)	70	68
Ifaluk (Micronesia)	60	40
Tinguian (Philippines)	55	46
Alor (Indonesia)	53	61
United States	50	34
Hopi (North America)	40	39
French Canadians	n/a*	31
The Netherlands	32	14
Switzerland	29	23

*These data are based on earlier studies by various researchers of dream content in preindustrial and industrial societies, and "n/a" means that data were not available.
SOURCE: Domhoff & Schneider 2008, Table 1, p. 1260.

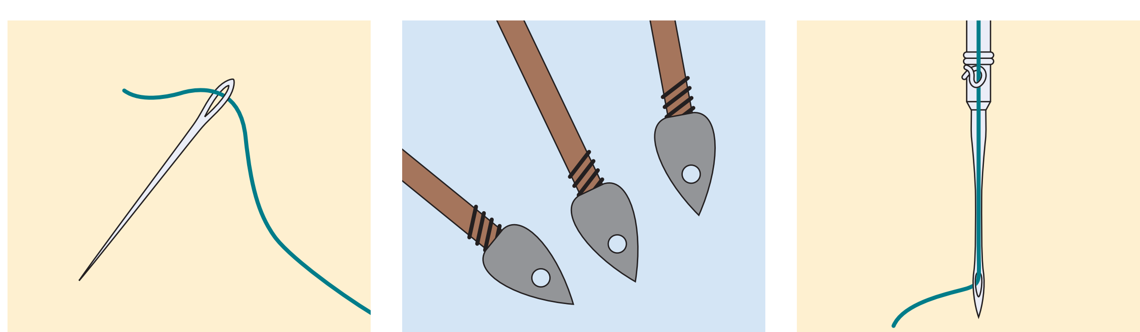
Freud's Psychoanalytic Theory Sigmund Freud (1900/1953) believed that the main purpose of dreaming is **wish fulfillment,** *the gratification of our unconscious desires and needs*. These desires include sexual and aggressive urges that are too unacceptable to be consciously acknowledged and fulfilled in real life. Freud distinguished between (1) a dream's *manifest content*, the surface story that the dreamer reports, and (2) its *latent content*, which is its disguised psychological meaning. Thus a dream about being with a stranger on a train that goes through a tunnel (manifest content) might represent a hidden desire for sexual intercourse with a forbidden partner (latent content).

Dream work was Freud's term for the process by which a dream's latent content is transformed into the manifest content. It occurs through symbols (e.g., train = penis; tunnel = vagina) and by creating individual dream characters who combine features of several people in real life. This way unconscious needs can be fulfilled, and because they are disguised within the dream, the sleeper does not become anxious and can sleep peacefully.

Although dreams often reflect ongoing emotional concerns, many researchers reject the specific postulates of Freud's theory. They find little evidence that dreams have disguised meaning or that their general purpose is to satisfy forbidden, unconscious needs and conflicts (Domhoff, 1999). Critics of dream analysis say that it is highly subjective; the same dream can be interpreted differently to fit the particular analyst's point of view.

Cognitive Theories According to **problem-solving dream models,** *because dreams are not constrained by reality they can help us find creative solutions to our problems and ongoing concerns* (Cartwright, 1977). Self-help books and numerous Web sites promote this idea, and history offers some intriguing examples of inventors, scientists, and authors who allegedly came upon creative ideas or solutions to problems in a dream (Figure 6.18). But critics argue that because so many of our dreams don't focus on personal problems, it's difficult to see how problem solving can be the broad underlying reason for *why* we dream. They also note that just because a problem shows up in a dream does not mean that the dream involved an attempt to solve it. We may think about our dreams after awakening and obtain new insights; in this sense dreams may help us work through ongoing concerns. However, this is not the same as solving problems *while* dreaming (Squier & Domhoff, 1998).

Cognitive-process dream theories *focus on the process of how we dream and propose that dreaming and waking thought are produced by the same mental systems in the brain* (Foulkes, 1982). There is more similarity between dreaming and waking mental processes than is commonly believed (Domhoff, 2005). For example, one reason many dreams appear bizarre is because their content shifts rapidly. "I was dreaming about an exam and suddenly, the next thing I knew, I was in Hawaii on the beach." (Don't we wish!) Yet if you reflect on the contents of your waking thoughts—your stream of consciousness—you will realize they also shift suddenly. About half of REM dream reports involve rapid content shifts, but when people are awake and placed in the same environmental conditions as sleepers (a dark, quiet room), about 90 percent of their reports involve rapid content shifts (Antrobus, 1991). Thus, rapid shifting of attention is a process common to dreaming and waking mental activity.



Hand-held needle Spears in Howe's dream Sewing machine needle

Figure 6.18

Dreams and problem solving.

In 1846, American inventor Elias Howe patented a sewing machine that could sew 250 stitches per minute. He had struggled unsuccessfully for years to figure out how to get a machine to stitch using a needle with the threading hole in the back (blunt) end—as in a traditional hand-held needle. Allegedly, one night he had a dream that he was being pursued by spear-throwing tribesmen. In the dream he saw that each spearhead had a hole in it. When Howe awoke, he recognized that, for a sewing machine to work, the threading hole needed to be at the front (sharp) end of the needle, as it had been on the spears.

Activation-Synthesis Theory Is it possible that dreams serve no special purpose? In 1977, J. Allan Hobson and Robert McCarley proposed a physiological theory of dreaming.

According to the **activation-synthesis theory,** *dreams do not serve any particular function—they are merely a by-product of REM neural activity*. When we are awake, neural circuits in our brain are activated by sensory input—sights, sounds, tastes, and so on. The cerebral cortex interprets these patterns of neural activation, producing meaningful perceptions. During REM sleep the brain stem bombards our higher brain centers with random neural activity (the activation component). Because we are asleep, this neural activity does not match any external sensory events, but our cerebral cortex continues to perform its job of interpretation. It does this by creating a dream—a perception—that provides the best fit to the particular pattern of neural activity that exists at any moment (the synthesis component). This helps to explain the bizarreness of many dreams, as the brain is trying to make sense out of random neural activity. Our memories, experiences, desires, and needs can influence the stories that our brain develops, and therefore dream content may reflect themes pertaining to our lives. In this sense, dreams can have meaning, but they serve no special function (McCarley, 1998).

Critics claim that activation-synthesis theory overestimates the bizarreness of dreams and pays too little attention to NREM dreaming (Solms, 2002). Nevertheless, this theory revolutionized dream research by calling attention to a physiological basis for dreaming (Domhoff, 2005; Hobson et al., 2000).

So Why *Do* We Dream? In the court of popular opinion, Freudian dream theory may reign supreme. As Figure 6.19 shows, in a recent study (Morewedge & Norton, 2009), American, South Korean, and Indian college students were far more likely to endorse a key Freudian principle—that dreams allow unconscious content to rise to the surface—than theories that explain dreams as solutions to problems, as by-products of random neural activation, or as a means of helping the brain discard unwanted information (a "learning theory" of dreams).

Popular opinion, however, doesn't determine why dreaming actually occurs. But among scientists there is still no agreement as to why we dream, and the explosion of brain research on sleep hasn't dampened the debate (Hobson, 2007; Solms, 2007). Still, neuroscience research indicates that dreaming involves an integration of perceptual, emotional, motivational, and cognitive processes performed by various brain modules. *Neurocognitive theories*, such as activation-synthesis, bridge the cognitive and biological perspectives by attempting to explain how subjective aspects of dreaming correspond to physiological changes that occur during sleep (Hobson et al., 2000). These models acknowledge that motivational factors—our needs and desires—can influence how the brain attaches meaning and emotion to the neural activity that underlies our dreams (Hobson, 2007).

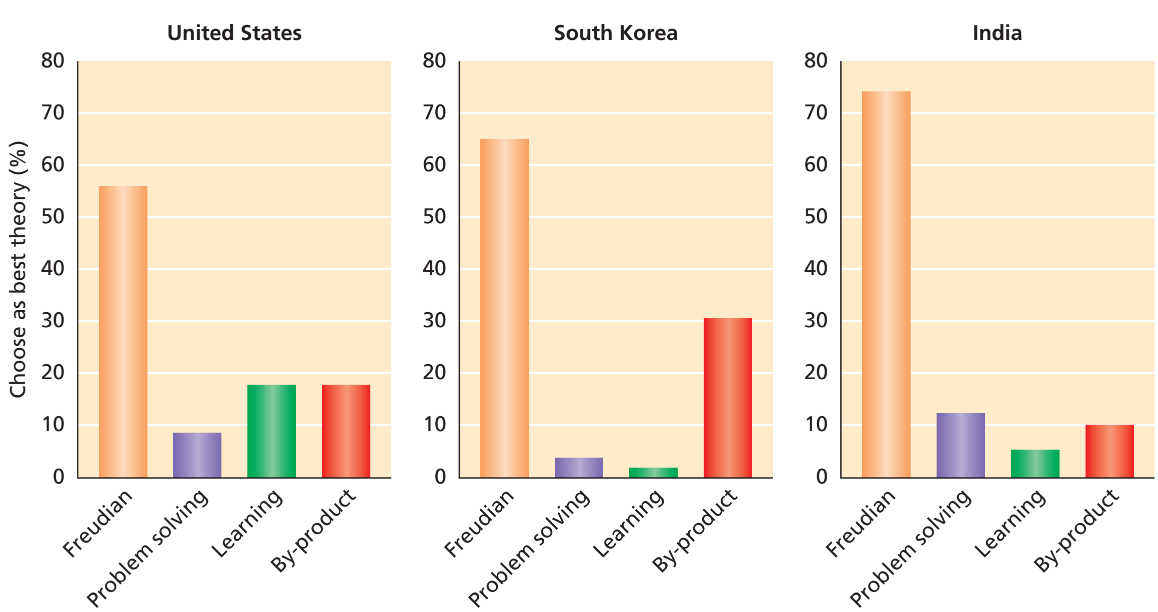


Figure 6.19

Belief in dream theories among college students in three countries.
Regardless of nationality, most students considered Freudian dream theory to provide the truest explanation of why we dream.
SOURCE: Morewedge & Norton, 2009.

Levels of Analysis

Sleep and Dreaming

We've seen that science has unraveled some, though certainly not all, of the mysteries surrounding sleep and dreaming. Let's review how the study of sleep and dreaming spans the biological, psychological, and environmental levels of analysis.

BIOLOGICAL LEVEL

- Circadian rhythms affect our readiness for sleep.
- Different species have evolved different sleep-wake cycles.
- Certain brain circuits actively promote falling asleep, while others regulate various sleep stages.
- Sleep stages are marked by distinct patterns of physiological activity.
- Heredity partly accounts for differences among people in sleep length and the likelihood of developing sleep disorders.

ENVIRONMENTAL LEVEL

- The day-night cycle and time cues help regulate our circadian rhythms and sleep readiness.
- Night-shift work and jet travel across time zones can disrupt circadian rhythms and impair sleep.
- A noisy sleep environment can impair sleep quality.
- Experiences from waking life can show up in our dream content.
- Cultural norms influence sleep-related behaviors (e.g., co-sleeping) and the meaning attached to dreams.

PSYCHOLOGICAL LEVEL

- Worries and stress may hinder falling asleep or contribute to other sleep problems.
- Learned sleep habits can facilitate or impair a sound night's sleep.
- Mental activity occurs throughout sleep, ranging from fragmented thoughts and images to storylike dreams.
- Ongoing psychological problems or concerns may show up in our dream content.
- Dreaming has been theorized to serve various psychological functions, including memory consolidation, unconscious wish fulfillment, and problem solving.

How do environmental and psychological factors affect your own sleep and dreaming? Do personal experiences or events show up in your dreams? Do environmental or psychological factors ever impair your ability to fall or stay asleep?

test yourself

Sleep and Dreaming

True or false?

1. Delta waves occur primarily in stage-2 sleep.
2. During REM sleep, voluntary muscles become paralyzed.
3. As we age, average nightly REM sleep time increases.
4. The evolutionary/circadian model proposes that sleep's purpose is to help us recover from fatigue.
5. Dreaming occurs only during REM sleep.
6. Activation-synthesis theory proposes that dreams have no special function.

ANSWERS: 1-false, 2-true, 3-false, 4-false, 5-false, 6-true

DRUG-INDUCED STATES

Three thousand years ago, the Aztecs considered hallucinogenic mushrooms to be a sacred substance for communicating with the spirit world. Today drugs are a cornerstone of medical practice and, as Figure 6.20 shows, a pervasive part of social life. They alter consciousness by modifying brain chemistry, but drug effects are also influenced by psychological, environmental, and cultural factors (Kassel et al., 2010).

Drugs and the Brain

Drugs enter the bloodstream and are carried throughout the brain by small blood vessels called capillaries. Capillaries contain a **blood-brain barrier,** *a special lining of tightly packed cells that lets vital nutrients pass through so neurons can function*. The blood-brain barrier screens out many foreign substances, but some, including various drugs, can pass through. Once inside, they alter consciousness by facilitating or inhibiting synaptic transmission (Julien, 2008).

How Drugs Facilitate Synaptic Transmission

Synaptic transmission involves several basic steps. First, neurotransmitters are synthesized inside presynaptic (sending) neurons and stored in vesicles. Next, they are released into the synaptic space, where they bind with and stimulate receptor sites on postsynaptic (receiving) neurons. Finally, neurotransmitter molecules are deactivated by enzymes or by reuptake.

An **agonist** *is a drug that increases the activity of a neurotransmitter*. Figure 6.21 shows that agonists may

- enhance a neuron's ability to synthesize, store, or release neurotransmitters;
- bind with and stimulate postsynaptic receptor sites (or make it easier for neurotransmitters to stimulate these sites);
- make deactivation more difficult, such as by inhibiting reuptake.

Consider two examples. First, *opiates* (such as morphine and codeine) are effective pain relievers. The brain contains its own chemicals, endorphins, which promote pain relief. Opiates have a molecular structure similar to that of endorphins. They bind to and activate receptor sites that receive endorphins. To draw an analogy, think of opening a lock with a key. Normally an endorphin molecule acts as the key, but due to its similar shape, an opiate molecule can fit into the lock and open it.

Second, *amphetamines* boost arousal and mood by causing neurons to release greater amounts of dopamine and norepinephrine and by inhibiting reuptake. During reuptake, neurotransmitters in the synapse are absorbed back into presynaptic neurons through special channels. As shown in Figure 6.21c, amphetamine molecules block this process. Therefore, dopamine and norepinephrine remain in the synaptic space longer and keep stimulating postsynaptic neurons.

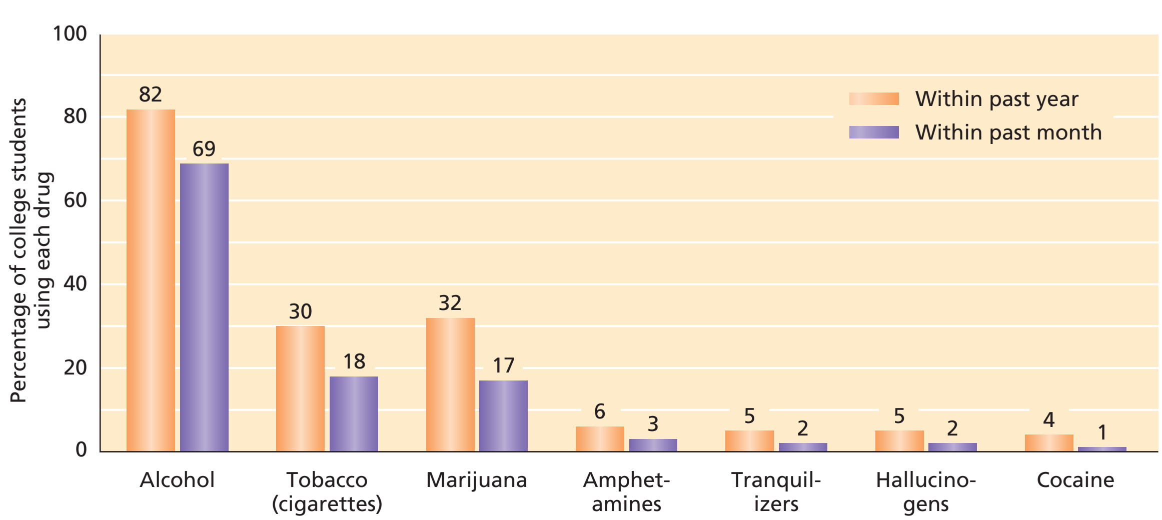


Figure 6.20

Drug use among college students.

This graph illustrates nonmedical drug use among American college students who are 1 to 4 years beyond high school. These data are based on a nationally representative survey. Source: Johnston et al., 2009.

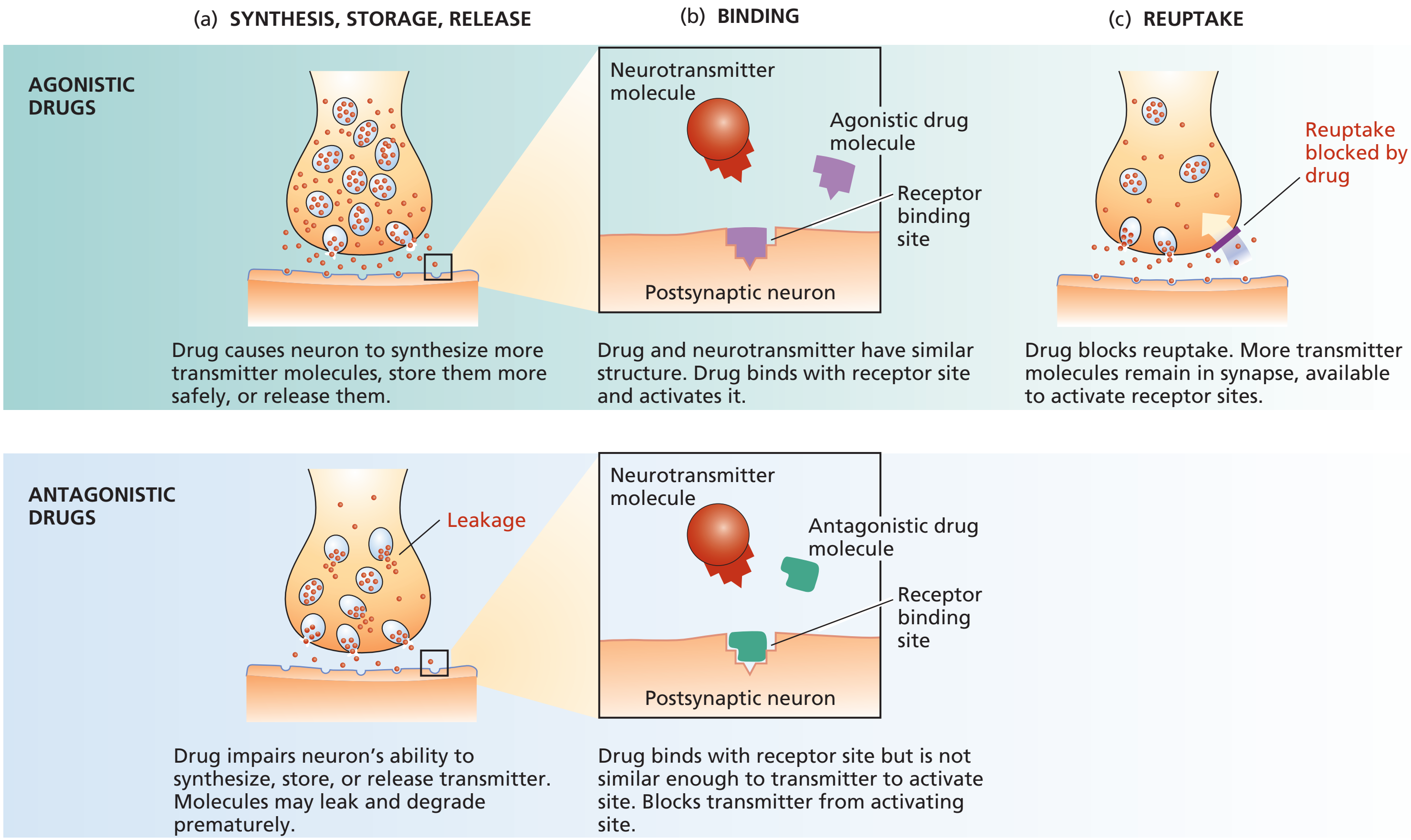


Figure 6.21

How drugs affect neurotransmitters. (*top*) Agonistic drugs increase the activity of a neurotransmitter. (*bottom*) Antagonistic drugs decrease the activity of a neurotransmitter.

How Drugs Inhibit Synaptic Transmission

An **antagonist** *is a drug that inhibits or decreases the action of a neurotransmitter*. As Figure 6.21 shows, an antagonist may

- reduce a neuron's ability to synthesize, store, or release neurotransmitters; or
- prevent a neurotransmitter from binding with the postsynaptic neuron, such as by fitting into and blocking the receptor sites on the postsynaptic neuron.

Consider the action of drugs called *antipsychotics* used to treat *schizophrenia*, a severe psychological disorder whose symptoms may include hallucinations (e.g., hearing voices) and delusions (clearly false beliefs, such as believing you are Joan of Arc). These symptoms are often associated with overactivity of the dopamine system. To restore dopamine activity to more normal levels, pharmaceutical companies have developed drugs with a molecular structure similar to dopamine, but not too similar. Returning to the lock-and-key analogy, imagine finding a key that fits into a lock but won't turn. The key's shape is close enough to the real key to get in but not to open the lock. Similarly, antipsychotic drugs fit into dopamine receptor sites but not well enough to stimulate them. While they occupy the sites, dopamine released by presynaptic neurons is blocked and cannot get in, and the schizophrenic symptoms usually decrease.

Drug Tolerance and Dependence

When a drug is used repeatedly, the intensity of effects produced by the same dosage level may decrease over time. This *decreasing responsivity to a drug is called* **tolerance.** As it develops, the person must take increasingly larger doses to achieve the same physical and psychological effects. Tolerance stems from the body's attempt to maintain a state of optimal physiological balance, called *homeostasis*. If a drug changes bodily functioning in a certain way, say by increasing heart rate, the brain tries to restore balance by producing **compensatory responses,** *which are reactions opposite to that of the drug* (e.g., reactions that decrease heart rate).

What happens when drug tolerance develops and the person suddenly stops using the drug? The body's compensatory responses may continue and, no longer balanced out by the drug's effects, the person can experience strong reactions

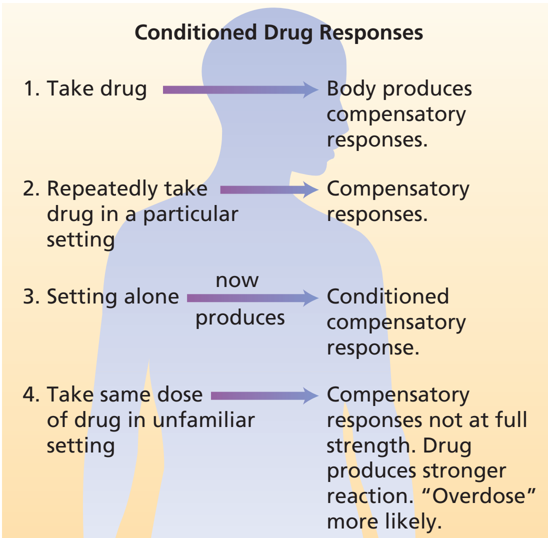


Figure 6.22

Conditioned drug responses and overdose.
Environmental stimuli that are repeatedly paired with the use of a drug can eventually trigger compensatory responses on their own. If the same drug dose is now taken in a new setting, compensatory responses will not be at full strength, thereby increasing the risk of an "overdose" reaction.

opposite to those produced by the drug. This *occurrence of compensatory responses after discontinued drug use is known as* **withdrawal.** For example, in the absence of alcohol's sedating and relaxing effects, a chronic drinker may experience anxiety and hypertension.

Learning, Drug Tolerance, and Overdose

Tolerance for various drugs depends partly on the familiarity of the drug setting. Figure 6.22 illustrates how environmental stimuli associated with repeated drug use begin to elicit compensatory responses through a learning process called *classical conditioning*. As drug use continues, the physical setting triggers progressively stronger compensatory responses, increasing the user's tolerance. This helps explain why drug addicts often experience cravings when they enter a setting associated with drug use. The environmental stimuli trigger compensatory responses that, without drugs to mask their effect, cause the user to feel withdrawal symptoms (Bradizza & Stasiewkz, 2009).

There is a hidden danger in this process, particularly for experienced drug users. Compensatory responses serve a protective function by physiologically countering part of the drug's effects. If a user takes his or her usual high dose in a familiar environment, the body's compensatory responses are at full strength—a combination of compensatory reactions to the drug itself and also to the familiar, conditioned environmental stimuli. But in an *unfamiliar* environment, the conditioned compensatory responses are weaker, and the drug has a stronger physiological net effect than usual (Siegel et al., 2000).

Shepard Siegel (1984) interviewed people addicted to heroin who had experienced near-fatal overdoses. He found that in most cases they had not taken a dose larger than their customary one. Rather, they had injected a normal dose in an unfamiliar environment. Siegel concluded that the addicts were not protected by their usual compensatory responses, resulting in an "overdose" reaction.

Drug Addiction and Dependence

Drug addiction, which is formally called **substance dependence,** *is a maladaptive pattern of substance use that causes a person significant distress or substantially impairs that person's life*. Substance dependence is diagnosed as occurring with *physiological dependence* if drug tolerance or withdrawal symptoms have developed. The term *psychological dependence* is often used to describe situations in which people strongly crave a drug because of its pleasurable effects, even if they are not physiologically dependent. However, this is not a diagnostic term, and some drug experts feel it is misleading. Drug cravings do have a physical basis; they are rooted in patterns of brain activity (Sun & Rebec, 2005).

Misconceptions about Substance Dependence

Many people mistakenly believe that if a drug doesn't produce tolerance or withdrawal, one can't become dependent on it. In reality, neither tolerance nor withdrawal is needed for a diagnosis of substance dependence.

The popular media image of a shaking alcoholic desperately searching for a drink reinforces another misconception, namely that the motivation to avoid or end withdrawal symptoms is the primary cause of addiction. Such physiological dependence contributes powerfully to drug dependence, but consider these points:

- People can become dependent on drugs, such as cocaine, that produce only mild withdrawal (Kampmann et al., 2002). The drug's pleasurable effects—often produced by boosting dopamine activity—play a key role in causing dependence.
- Many drug users who quit and make it through withdrawal eventually start using again, even though they are no longer physiologically dependent.

Table 6.4 **Behavioral Effects of Alcohol**

BAL	Hours to Leave Body	Behavioral Effects
.03	1	Decreased alertness, impaired reaction time in some people
.05	2	Decreased alertness, impaired judgment and reaction time, good feeling, release of inhibitions
.10	4	Severely impaired reaction time, motor function, and judgment; lack of caution
.15	10	Gross intoxication, worsening impairments
.25	?	Extreme sensory and motor impairment, staggering
.30	?	Stuporous but conscious, cannot comprehend immediate environment
.40	?	Lethal in over 50 percent of cases

- Many factors influence drug dependence, including genetic predispositions, religious beliefs, family and peer influences, and cultural norms (Ehlers et al., 2010).

Depressants

Depressants *decrease nervous system activity*. In moderate doses, they reduce tension and anxiety and produce euphoria. In extremely high doses, depressants can slow down vital life processes to the point of death.

Alcohol

Alcohol is the most widely used recreational drug in many cultures. A national survey of American college students found that 69 percent had consumed alcohol within the previous month, with 40 percent binging (five or more drinks at one time) within the previous two weeks (Johnston et al., 2009). Tolerance develops gradually and can lead to physiological dependence.

Alcohol dampens the nervous system by increasing the activity of GABA, the brain's main inhibitory neurotransmitter, and by decreasing the activity of glutamate, a major excitatory neurotransmitter (Kumar et al., 2009). Why, then, if alcohol is a depressant drug, do many people initially seem less inhibited when they drink and report getting a high from alcohol? In part, the weakening of inhibitions occurs because alcohol's neural slowdown depresses the action of inhibitory control centers in the brain. As for the subjective high, alcohol boosts the activity of several neurotransmitters, such as dopamine, that produce feelings of pleasure and euphoria (Tupala & Tiihonen, 2004). At higher doses, however, the brain's control centers become increasingly disrupted, thinking and physical coordination become disorganized, and fatigue may occur as blood alcohol level (BAL) rises (Table 6.4).

The *blood-alcohol level (BAL)* is a measure of alcohol concentration in the body. Elevated BALs impair reaction time, coordination, and decision making and also increase risky behaviors (Figure 6.23). Thirty-nine percent of American and Canadian traffic accident deaths involve alcohol (National Highway Traffic Safety Administration, 2006).

Why do intoxicated people often act in risky ways that they wouldn't when sober? It is not simply a matter of lowered inhibitions. Alcohol

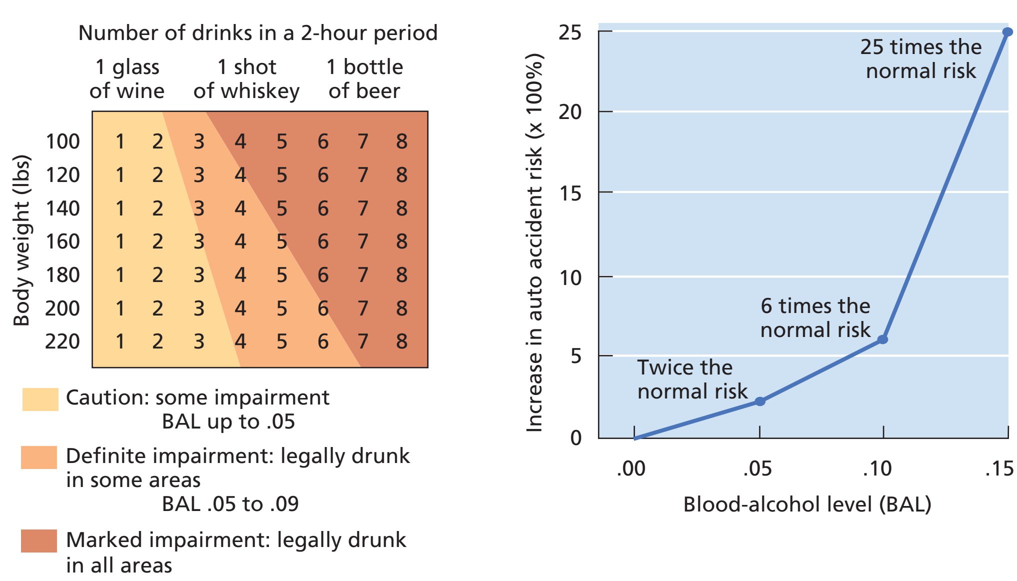


Figure 6.23

Drinking, driving, and accident risk.

At .08 to 0.10 BAL, the legal definition of intoxication in most American states and Canadian provinces, the risk of having an auto accident is about 6 times greater than at 0.00, and the risk climbs to 25 times higher at a BAL of 0.15.

SOURCE: Based on National Safety Council, 1992.

also produces **alcohol myopia,** *shortsighted thinking caused by the inability to pay attention to as much information as when sober* (Davis et al., 2007; Steele & Josephs, 1990). People who drink start to focus only on aspects of the situation (cues) that stand out. In the absence of strong cautionary cues (such as warnings) to inhibit risky behavior, they don't think about long-term consequences of their actions as carefully as when they are sober. Our "Research Close-up" illustrates this effect.

Research Close-up

Drinking and Driving: Decision Making in Altered States

SOURCE: TARA K. MACDONALD, MARK P. ZANNA, and GEOFFREY T. FONG (1995). Decision making in altered states: Effects of alcohol on attitudes toward drinking and driving. *Journal of Personality and Social Psychology, 68,* 973–985.

INTRODUCTION

Most people have negative attitudes about drunk driving and say they would not do it. They realize that the cons (e.g., risk of accident, injury, death, and police arrest) far outweigh the pros (e.g., not having to ask someone for a lift). Why, then, do so many people decide to drive after becoming intoxicated?

Based on alcohol-myopia principles, Tara MacDonald and her colleagues reasoned that when intoxicated people decide whether to drive, they may focus on the pros or the cons but do not have the attentional capacity to focus on both. If a circumstance that favors driving (a *facilitating cue*) is called to the intoxicated person's attention (e.g., "It's only a short distance"), she or he will latch onto it and fail to consider the cons. But in general situations that do not contain facilitating cues, intoxicated people's feelings about driving should remain as negative as when they were sober.

The authors made two predictions. First, intoxicated and sober people will have equally negative *general attitudes* and intentions toward drinking and driving. Second, intoxicated people will have less negative attitudes and greater intentions toward drinking and driving than sober people in situations that contain a facilitating cue.

RESEARCH DESIGN

Question: If sober people hold negative attitudes toward drinking and driving, then why after becoming intoxicated do they decide to drive? Does focusing on "special circumstances" play a role?

Type of Study: *Experimental*

Independent Variables

- Alcoholic state (intoxicated versus sober)
- Drinking-driving situation (special circumstance versus general situation)

→

Dependent Variables

- Attitude toward "drinking and driving"
- Intention to drive while intoxicated

METHOD

Laboratory Experiment

Fifty-seven male introductory psychology students, all regular drinkers who owned cars, participated. They were randomly assigned to either the sober condition, in which they received no alcohol, or the alcohol condition, in which they received 3 alcoholic drinks within 1 hour (the average BAL was .074 percent, just below the .08 percent legal driving limit in Ontario, Canada).

Participants then completed a drinking-and-driving questionnaire. Some items asked about general attitudes and intentions (e.g., "I will drink and drive the next time that I am out at a party or bar with friends"). Other items contained a facilitating cue, a special circumstance that suggested a possible reason for drinking and driving ("If I had only a short distance to drive home . . . / If my friends tried to persuade me to drink and drive . . . I would drive while intoxicated"). Participants rated each item on a 9-point scale (1 = "strongly disagree"; 9 = "strongly agree").

Party/Bar Diary Study

Fifty-one male and female college students recorded a telephone diary while at a party or bar where they were going to drink alcohol. Some were randomly assigned to record the diary when they first arrived; others, just before they left. Based on participants' descriptions of how much alcohol they had consumed, the researchers estimated their BAL and identified two groups: "sober participants" (average BAL .01) and "intoxicated participants" (average BAL .11).

Continued

RESULTS

The findings from both studies supported the predictions. Sober participants and intoxicated participants both expressed negative general attitudes about drinking and driving and indicated they would not drive when intoxicated. But when the questions presented a special circumstance, intoxicated participants expressed more favorable attitudes and a greater intention to drive than did sober participants.

DISCUSSION

This study nicely illustrates how a person's physiological state (sober versus intoxicated) and an environmental factor (general situation versus special circumstance) interact to influence psychological functioning (attitudes and decision making). However, let's think critically about the results. Was it really narrowed attention—leading to a failure to consider negative consequences—that caused the results? The authors anticipated two alternative explanations. First, perhaps people who drink do not realize how intoxicated they are. Second, perhaps intoxicated people overestimate their driving ability, a belief called *drunken invincibility*. The authors tested and ruled out these explanations. Intoxicated participants believed they were *more* intoxicated than they actually were and also estimated that they would drive *more poorly* than the average person.

Is it possible that the findings were caused by participants' expectations about alcohol rather than its chemical effects? The authors conducted a placebo control experiment in which some participants were convincingly misled to believe they were intoxicated. Results showed that the alcohol-myopia effect occurred only for participants who truly had consumed alcohol. It was not caused by participants' expectations.

What practical value do these findings have? The researchers suggest that a sign saying "Drinking and Driving Kills," or a large photograph of a police officer administering a breathalyzer test, be made highly visible near the exit of a bar. Alcohol myopia should cause intoxicated people to narrow their focus of attention to these *inhibiting cues*, causing them to rethink any decision to drink and drive. In subsequent research, MacDonald and coworkers (2003) found that making strong inhibiting cues salient did indeed lead intoxicated people to behave more cautiously.

Barbiturates and Tranquilizers

Physicians prescribe barbiturates (sleeping pills) and tranquilizers (antianxiety drugs, such as Valium) as sedatives and relaxants. Like alcohol, they depress the nervous system by increasing the activity of the inhibitory neurotransmitter GABA (Grasshoff et al., 2008).

Barbiturates and tranquilizers are widely overused, and tolerance and physiological dependence can occur. As tolerance builds, addicted people may take up to 50 sleeping pills a day. At high doses, barbiturates trigger initial excitation, followed by slurred speech, loss of coordination, depression, and memory impairment. Overdoses may cause unconsciousness, coma, and even death. Users often don't recognize that they have become dependent until they try to stop and experience serious withdrawal symptoms, such as anxiety, insomnia, and possibly seizures.

Stimulants

Stimulants *increase neural firing and arouse the nervous system*. They increase blood pressure, respiration, heart rate, and overall alertness. While they can elevate mood to the point of euphoria, they also can heighten irritability.

Amphetamines

Amphetamines are powerful stimulants prescribed to reduce appetite and fatigue, decrease the need for sleep, and reduce depression. Unfortunately, they are widely overused to boost energy and mood (Ghodse, 2007).

Amphetamines increase dopamine and norepinephrine activity. Tolerance develops, and users may crave their pleasurable effects. Eventually, many heavy users start injecting large quantities, producing a sudden surge of energy and rush of intense pleasure. With frequent injections, they may remain awake for a week, their bodily systems racing at breakneck speed. Injecting amphetamines greatly increases blood pressure and can lead to heart failure and cerebral hemorrhage (stroke); repeated high doses may cause brain damage (Ksir et al., 2008).

There is an inevitable crash when heavy users stop taking the drug. They may sleep for 1 to 2 days, waking up depressed, exhausted, and irritable. This crash occurs because the neurons' norepinephrine and dopamine supplies have become depleted.

Cocaine

Cocaine is a powder derived from the coca plant, which grows mainly in western South America. Usually inhaled or injected, it produces excitation, a sense of increased muscular strength, and euphoria. Cocaine increases the activity of norepinephrine and dopamine by blocking their reuptake.

(a) (b)

Figure 6.24

(a) Until 1903, there was a clear reason why Coca-Cola "relieved fatigue": it contained cocaine, which was then replaced by caffeine. (b) Before it was made illegal, cocaine was found in a variety of medicinal products.

Cocaine was once widely used as a local anesthetic in eye, nose, and throat surgery. Novocain, a synthetic form of cocaine, is still used in dentistry as an anesthetic. Due to its stimulating effects, cocaine found its way into health potions sold to the public, before it was made illegal. In 1885 John Pemberton developed Coca-Cola by mixing cocaine with the kola nut and syrup (Figure 6.24).

In large doses, cocaine can produce vomiting, convulsions, and paranoid delusions (Smith et al., 2009). A depressive crash may occur after a cocaine high. Tolerance develops to many of cocaine's effects, and chronic use has been associated with an increased risk of cognitive impairments and brain damage (Franklin et al., 2002). Crack is a chemically converted form of cocaine that can be smoked, and its effects are faster and more dangerous. Overdoses can cause sudden death from cardiorespiratory arrest.

Ecstasy (MDMA)

Ecstasy, also known as MDMA (methylenedioxymethamphetamine), is artificially synthesized and has a chemical structure that partly resembles both methamphetamine (a stimulant) and mescaline (a hallucinogen). Ecstasy produces feelings of pleasure, elation, empathy, and warmth. In the brain, it primarily increases serotonin functioning, which boosts one's mood but may cause agitation. After the drug wears off, users often feel sluggish and depressed—a rebound effect partly due to serotonin depletion (Travers & Lyvers, 2005). They may have to take increasingly stronger doses to overcome tolerance to Ecstasy.

In experiments with laboratory rats, Ecstasy has produced long-lasting damage to the axons of neurons that release serotonin (Mechan et al., 2002). Human studies suggest a similar possibility (Figure 6.25), but it is not clear whether such damage is permanent (de Win et al., 2008). In the long run, Ecstasy may produce consequences that are anything but pleasurable. Continued use has been associated with impaired memory and sleep difficulties (Indlekofer et al., 2009).

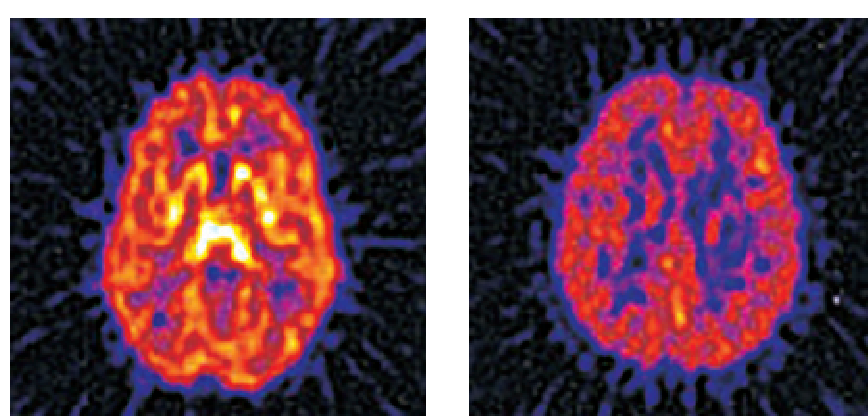


Figure 6.25

Frequent Ecstasy use and the brain.
(*left*) This PET-scan image shows the brain of a person who never used Ecstasy. (*right*) This image shows the brain of a person who used Ecstasy 70 times or more over a period of at least 1.5 years but who stopped using the drug for several weeks before these images were taken. Areas of lighter color indicate a higher density of special proteins (called *transporters*) necessary for normal serotonin reuptake. The darker image of the brain on the right suggests that there is damage to the serotonin reuptake system. Source: McCann et al., 1998.

Opiates

Opium is a product of the opium poppy. *Opium and drugs derived from it, such as morphine, codeine, and heroin, are called* **opiates.** Opiates have two major effects: they provide pain relief and cause mood changes, which may include euphoria. Opiates stimulate receptors normally activated by endorphins, thereby producing pain relief. Opiates also increase dopamine activity, which may be one reason they induce euphoria (Flores et al., 2006).

In medical use, opiates are the most effective agents known for relieving intense pain. Heroin was developed in 1889 by the Bayer company (which today produces aspirin). Initially thought to be a nonaddictive painkiller, heroin is, like other opiates, highly addictive. In the 1920s, it was made illegal in the United States.

Heroin users feel an intense rush within several minutes of an injection, but they often pay a high price for this transient pleasure. High doses may lead to coma, and overdoses can cause death (Morgan et al., 2008).

Hallucinogens

Hallucinogens *are powerful mind-altering drugs that produce hallucinations*. Some derive from natural sources and have been considered sacred in many tribal cultures because of their ability to produce contact with spiritual forces (Figure 6.26). Other hallucinogens, such as LSD (lysergic acid diethylamide, or "acid") and phencyclidine ("angel dust") are synthetic.

Hallucinogens distort sensory experience and can blur the boundaries between reality and fantasy. Users may speak of having mystical experiences and feeling exhilarated. They may also experience violent outbursts, paranoia, and panic and have flashbacks after the "trip" has ended. The mental effects of hallucinogens are unpredictable, which constitutes their greatest danger (Johnson et al., 2008).

LSD is a powerful hallucinogen that causes a flooding of excitation in the nervous system. Tolerance develops rapidly but decreases quickly. It increases the activity of serotonin and dopamine at certain receptor sites, but scientists still do not know precisely how LSD produces its effects (Passie et al., 2008).

Marijuana

Marijuana, a product of the hemp plant (*Cannabis sativa*), is the most widely used and controversial illegal drug in the United States (Figure 6.27). **THC (tetrahydrocannabinol)** *is marijuana's major active ingredient*, and it binds to receptors on neurons throughout the brain. But why does the brain have receptor sites for a foreign substance such as marijuana? The answer is that the brain produces its own THC-like substances called *cannabinoids*. With chronic use, THC may increase GABA activity, which slows down neural activity and produces relaxing effects (Ksir et al., 2008). THC also increases dopamine activity, which may account for some of its pleasurable subjective effects (Maldonado & Rodriguez de Fonseca, 2002).

Misconceptions about Marijuana

One misconception about marijuana is that chronic use causes people to become unmotivated and apathetic, a condition called *amotivational syndrome*. Another misconception is that marijuana causes people to start using more dangerous

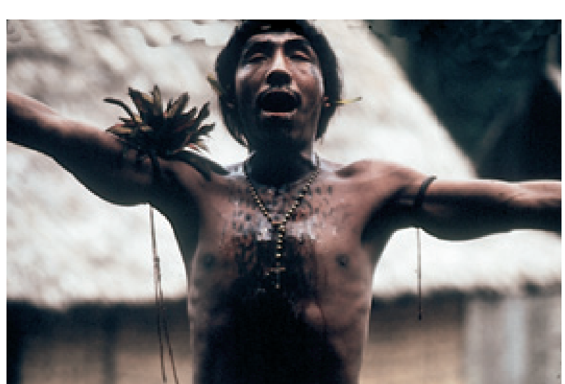


Figure 6.26

In some cultures, hallucinogenic drugs are thought to have spiritual powers. Under the influence of peyote, this Indian shaman prepares to conduct a religious ceremony.

Figure 6.27

Marijuana is illegal in the United States at the federal level, but some jurisdictions have legalized marijuana use for certain medical purposes. Although the U.S. Supreme Court ruled against the medical legalization of marijuana in 2005, the issue remains hotly debated.

drugs. Neither statement is supported by the scientific evidence (Ksir et al., 2008; Rao, 2001). A third misconception is that using marijuana has no significant dangers. In fact, marijuana smoke contains more cancer-causing substances than does tobacco smoke. At high doses, users may experience negative changes in mood, sensory distortions, and feelings of panic and anxiety. While users are high, marijuana can impair their reaction time, thinking, memory, learning, and driving skills (Hall & Degenhardt, 2009).

Another misconception is that users can't become dependent on marijuana. Actually, repeated marijuana use produces tolerance, and at typical doses, some chronic users may experience withdrawal symptoms, such as restlessness. People who use chronically high doses and suddenly stop may experience vomiting, disrupted sleep, and irritability. About 5 to 10 percent of people who use marijuana develop dependence (Anthony, 2006).

From Genes to Culture: Determinants of Drug Effects

Table 6.5 lists some typical drug effects, but as we now discuss and as the Levels of Analysis graphic on the next page summarizes, a user's reaction depends on more than the drug's chemical structure.

Biological Factors

Animal research indicates that genetic factors influence sensitivity and tolerance to drugs' effects (Radcliffe et al., 2009). The most extensive research has focused on alcohol. Rats and mice can be genetically bred to inherit a strong preference for drinking alcohol instead of water. Even in their first exposure to alcohol, these rats show greater tolerance than normal rats.

Among humans, identical twins have a higher concordance rate for alcoholism than do fraternal twins (Lyons et al., 2006). Moreover, people who grow up with alcoholic versus nonalcoholic parents respond differently to drinking alcohol under laboratory conditions. Adults who had alcoholic parents typically display faster hormonal and psychological reactions as blood-alcohol levels rise, but these responses drop off more quickly as blood-alcohol levels decrease (Newlin & Thomson, 1997). Compared with other people, they must drink more alcohol over the course of a few hours to maintain their feeling of intoxication. Overall, many scientists see evidence for a genetic role in determining human responsiveness to alcohol (Kuo et al., 2009).

Psychological Factors

People's beliefs and expectancies can influence drug reactions and drug use (George et al., 2000; Metrik et al., 2009). Experiments show that people may behave as if drunk if they simply think they have consumed alcohol but actually have not. If a person's fellow drinkers are gregarious, he or she

Table **6.5** Effects of Some Major Drugs

Class	Typical Effects	Risks of High Doses and/or Chronic Use
Depressants		
Alcohol	Relaxation, lowered inhibition, impaired physical and psychological functioning	Disorientation, unconsciousness, possible death at extreme doses
Barbiturates, tranquilizers	Reduced tension, impaired reflexes and motor functioning, drowsiness	Shallow breathing, clammy skin, weak and rapid pulse, coma, possible death
Stimulants		
Amphetamines, cocaine, Ecstasy	Increased alertness, pulse, and blood pressure; elevated mood; suppressed appetite; agitation; sleeplessness	Hallucinations, paranoid delusions, convulsions, long-term cognitive impairments, brain damage, possible death
Opiates		
Opium, morphine, codeine, heroin	Euphoria, pain relief, drowsiness, impaired motor and psychological functioning	Shallow breathing, convulsions, coma, possible death
Hallucinogens		
LSD, mescaline, phencyclidine	Hallucinations and visions, distorted time perception, loss of contact with reality, nausea	Psychotic reactions (delusions, paranoia), panic, possible death
Marijuana	Mild euphoria, relaxation, enhanced sensory experiences, increased appetite, impaired memory and reaction time	Fatigue, anxiety, disorientation, sensory distortions, possible psychotic reactions, exposure to carcinogens

may feel it's expected to respond the same way. Personality factors also influence drug reactions and usage. People who have difficulty adjusting to life's demands or whose contact with reality is marginal may be particularly vulnerable to negative drug reactions and addiction (Ray & Ksir, 2004).

Environmental Factors

The setting in which a drug is taken can influence a user's reactions. As noted earlier, merely being in a familiar drug-use setting can trigger compensatory physiological responses and cravings. The behavior of other people who are sharing the drug experience provides cues for how to respond, and a hostile environment may increase the chances of a bad trip with drugs such as LSD (Palfai & Jankiewicz, 1991).

Cultural learning also affects how people respond to a drug (Bloomfield et al., 2002). In many Western cultures, increased aggressiveness and sexual promiscuity are commonly associated with drunken excess. In contrast, members of the Camba culture of Bolivia customarily drink large quantities of a 178-proof beverage, remaining cordial and nonaggressive between episodes of passing out. In the 1700s, Tahitians introduced to alcohol by European sailors reacted at first with pleasant relaxation when intoxicated, but after witnessing the violent aggressiveness exhibited

Levels of Analysis

Drug-Induced States

Drug-induced states involve an interplay of biological, psychological, and environmental factors. Let's summarize some of these factors.

BIOLOGICAL LEVEL

- Drugs increase or decrease the activity of particular neurotransmitter systems.
- The body produces compensatory responses to counteract a drug's effect, possibly leading to tolerance.
- Withdrawal symptoms occur when drug use stops, but the body's compensatory responses continue.
- Genetic factors influence biological reactivity to specific drugs.

ENVIRONMENTAL LEVEL

- Cultural norms and experiences can shape users' drug attitudes and expectations.
- Repeated drug use in a particular setting can produce conditioned compensatory stimuli.
- The social context and behavior of other drug users who are present can affect how a person responds to a drug.

PSYCHOLOGICAL LEVEL

- Drugs can alter numerous aspects of psychological functioning, including mood, memory, attention, decision making, social inhibitions, and pain awareness.
- Users' attitudes and expectations about drugs can influence their psychological reactions to a drug.
- A user's level of personal adjustment can influence the likelihood of a negative drug reaction.

Suppose a person consumes enough alcoholic drinks within 30 minutes to reach a blood-alcohol level of .08. In one case, suppose all the drinks are the same: all beers or all the same kind of wine. In another case, suppose each drink is different: beer, red wine, and tequila. Would you expect the person to feel equally intoxicated in both cases?

by drunken sailors, they too began behaving aggressively (MacAndrew & Edgerton, 1969).

Cultural factors also affect drug consumption. Traditionally, members of the Navajo tribe do not consider drinking any amount of alcohol to be normal, whereas drinking wine or beer is central to social life in some European countries (Tanaka-Matsumi & Draguns, 1997). In some cultures, hallucinogenic drugs are feared and outlawed, whereas in others they are used in medicinal or religious contexts to seek advice from spirits (Dalgarno, 2009).

test yourself — **Drug-Induced States**

True or false?

1. Agonists are drugs that increase neurotransmitter activity.
2. Compensatory bodily responses to a drug produce tolerance.
3. Drug dependence can occur only with withdrawal symptoms.
4. Alcohol myopia is the principle that intoxication causes attention to narrow.
5. Amphetamines increase dopamine and norepinephrine activity.
6. Cocaine is classified as an opiate drug.

ANSWERS: 1-true, 2-true, 3-false, 4-true, 5-true, 6-false

HYPNOSIS

In 18th-century Vienna, physician Anton Mesmer gained fame for using magnetized objects to cure patients. He claimed that illness was caused by blockages of an invisible bodily fluid and that his technique of "animal magnetism" (later named *mesmerism* in his honor) would restore the fluid's normal flow. A scientific commission discredited mesmerism, but its use continued. Decades later, Scottish surgeon James Braid investigated the fact that mesmerized patients often went into a trance in which they seemed oblivious to their surroundings. Braid concluded that mesmerism was a state of "nervous sleep" produced by concentrated attention, and he renamed it *hypnosis*, after Hypnos, the Greek god of sleep.

The Scientific Study of Hypnosis

Hypnosis *is a procedure in which "one person (the subject) is guided by another (the hypnotist) to respond to suggestions for changes in subjective experience, alterations in perception, sensation, emotion, thought or behavior"* (APA, 2005, para. 1). Hypnosis draws great interest because some mental health practitioners use it as an aid in conducting therapy. Basic scientists explore whether hypnosis produces a unique state of consciousness and put its claims to rigorous test.

Hypnotic induction is a process that creates a context for hypnosis. A hypnotist may ask the subject to sit down and gaze at an object on the wall, and then, in a quiet voice, suggest that the subject's eyes are becoming heavy. The goal is to relax the subject and increase her or his concentration.

Contrary to popular belief, people cannot be hypnotized against their will. Even when people want to be hypnotized, they differ in how susceptible (i.e., responsive) they are to hypnotic suggestions. **Hypnotic susceptibility scales** *contain a standard series of pass-fail suggestions that are read to a subject after a hypnotic induction* (Table 6.6). The subject's score is based on the number of passes. Across many cultures, about 5 percent of subjects respond to few or none of the suggestions, 10 percent pass all or nearly all of the items, and the rest fall in between (Sanchez-Armass & Barabasz, 2005).

Hypnotic Behaviors and Experiences

Does hypnosis alter people's psychological functioning and behavior? Let's examine some claims.

Involuntary Control and Behaving against One's Will

Hypnotized people *subjectively experience* their actions to be involuntary (Kirsch, 2001). For example, look at the second item in Table 6.6. To hypnotized subjects, it really feels like their hands are being pushed apart by a mysterious force, Table **6.6** **Sample Test Items from the Stanford Hypnotic Susceptibility Scale, Form C**

Item	Suggested Behavior	Criterion for Passing
Lowering Arm	Right arm is held out; subject is told arm will become heavy and drop	Arm is lowered by 6 inches in 10 seconds
Moving Hands Apart	With hands extended and close together, subject is asked to imagine a force pushing them apart	Hands are 6 or more inches apart in 10 seconds
Mosquito Hallucination	It is suggested that a mosquito is buzzing nearby and lands on subject	Any grimace or acknowledgment of mosquito
Posthypnotic Amnesia	Subject is awakened and asked to recall suggestions after being told under hypnosis that he or she will not remember the suggestions	Three or fewer items recalled before subject is told, "Now you can remember everything."

Source: Based on Wertzenhoffer & Hilgard, 1962.

rather than by their conscious control. If this is so, then can a hypnotist make people perform acts that are harmful to themselves or others? In a classic experiment, Martin Orne and Frederick Evans (1965) found that hypnotized subjects could be induced to dip their hands briefly in a foaming solution they were told was acid and then to throw the "acid" in another person's face. This might appear to be a striking example of the power of hypnosis to get people to act against their will. However, Orne and Evans tested a control group of subjects who were asked to simply pretend that they were hypnotized. These subjects were just as likely as hypnotized subjects to put their hands in the "acid" and throw it at someone.

Hypnosis does not involve a unique power to get people to behave against their will (Wagstaff, 2008). A legitimate authority figure can induce people to commit out-of-character and dangerous acts whether they are hypnotized or not.

Amazing Feats

Have you seen or heard about stage hypnotists who get an audience member to perform an amazing physical feat, such as the "human plank" (Figure 6.28)? A subject, usually male, is hypnotized and lies outstretched between two chairs. He is told that his body is rigid and then, amazingly, another person successfully stands on the subject's legs and chest.

Similarly, hypnosis can have striking physiological effects. Consider another classic experiment involving 13 people who were strongly allergic to the toxic leaves of a certain tree (Ikemi & Nakagawa, 1962). Five of them were hypnotized, blindfolded, and told that a leaf from a harmless tree to which they were not allergic was touching one of their arms. In fact, the leaf really was toxic, but 4 out of the 5 hypnotized people had no allergic reaction. Next, the other arm of each hypnotized person was rubbed with a leaf from a harmless tree, but he or she was falsely told that the leaf was toxic. All 5 people responded to the harmless leaf with allergic reactions.

Should we attribute the human-plank feat and the unusual responses of the allergic people to unique powers of hypnosis? Here is where a healthy dose of critical thinking is important.

Figure 6.28

The human-plank demonstration, a favorite of stage hypnotists, seems to demonstrate the power of hypnosis. Are you convinced?

thinking **critically**

HYPNOSIS AND AMAZING FEATS

In the case of the human plank and in the allergy experiment, what additional evidence do you need to determine whether these amazing feats and responses really are caused by hypnosis? How could you gather this evidence? Think about it, then see page 212.

Pain Tolerance

Scottish surgeon James Esdaile performed more than 300 major operations in the mid-1800s using hypnosis as the sole anesthetic (Figure 6.29). Experiments confirm that hypnosis often increases pain tolerance and that this is not due merely to a placebo effect (Milling, 2008). For patients who experience chronic pain, hypnosis can produce relief that lasts for months or even years

Figure 6.29

This patient is having her appendix removed with hypnosis as the sole anesthetic. Her verbal reports that she feels no pain are being recorded.

(Patterson, 2004). Brain-imaging research reveals that hypnosis modifies neural activity in brain areas that process painful stimuli, but nonhypnotic techniques, such as mental imagery and performing distracting cognitive tasks, also alter neural functioning and reduce pain (Petrovic & Ingvar, 2002).

We do not know exactly how hypnosis produces its painkilling effects, although the positive expectancies it creates for pain reduction play some role (Milling, 2008). It also may influence the release of endorphins, distract patients from their pain, or somehow help them separate the pain from conscious experience (Barber, 1998).

Hypnotic Amnesia

You may have seen TV shows or movies in which hypnotized people are given a suggestion that they will not remember something (such as a familiar person's name), either during the session itself (*hypnotic amnesia*) or after coming out of hypnosis (*posthypnotic amnesia*). A reversal cue also is given, such as a phrase ("You will now remember everything") that ends the amnesia once the person hears it. Is this Hollywood fiction?

Research indicates that about 25 percent of hypnotized college students can be led to experience amnesia (Kirsch, 2001). Although researchers agree that hypnotic and posthypnotic amnesias occur, they debate the causes. Some believe it results from voluntary attempts to avoid thinking about certain information, and others believe it is caused by an altered state of consciousness that weakens normal memory systems (Kihlstrom, 2007; Spanos, 1996).

In contrast to hypnotic amnesia, can hypnosis enhance memory? Let's examine whether this is myth or reality.

Myth or Reality? Hypnosis Uncovers Eyewitnesses' Hidden Memories

In a 2007 episode of the popular TV show *Mythbusters,* one of the show's hosts, Adam Savage, noted: "There is one [hypnosis myth] I've always wanted to try. Well, it's that you can remember more material under hypnosis than under normal circumstances. Like the police could put you under hypnosis and you'd remember all sorts of things about a crime you witnessed that you had no conscious memory of witnessing." As the show's narrator added, "it's one of the most pervasive myths associated with hypnosis. But can going under really unleash a vast resource of hidden memories?" (2007, April 11, episode 76).

Many people believe hypnosis can do just that. Psychologist Joseph Green and his colleagues, for example, found that college students in Australia, Germany, Iran, and the United States endorsed the view that hypnosis "can make subjects remember things that they could not normally remember" (2006, p. 271). In the popular media, from science-fiction TV shows like *Star Trek: The Next Generation,* to modern crime dramas like *The Mentalist,* hypnosis has been portrayed as a technique for uncovering hidden memories. And some real-life cases seem to back it up.

In a bizarre mass kidnapping, later dramatized in a book and television movie, a school bus from Chowchilla, California, carrying 26 children and its driver disappeared from a country road in 1976. The victims, buried underground in an abandoned moving van by three kidnappers, escaped 16 hours later. Afterward, a police expert hypnotized the bus driver and asked him to recall the ordeal. The driver formed a vivid image of the kidnappers' white van and could "read" all but one digit on the van's license plate. This information allowed the authorities to track down the kidnappers.

On *Mythbusters,* three employees witnessed a staged altercation between two men and later recalled more details of the event while hypnotized than when not hypnotized. The show's conclusion about hypnosis as a forensic memory aid: "confirmed." But unfortunately,

Continued

their hypnosis test was flawed. Aside from testing only three people, the participants were told ahead of time about the memory hypothesis being tested. Memory while under hypnosis was always tested second, after the three had first tried to recall the events while not hypnotized. Perhaps their better memory resulted merely from a second attempt at recalling the events, not from hypnosis. Further, the first memory test was solely by written questionnaire. For the second test, the hypnotist verbally presented the questions. In short, the hypnosis test was entertaining, but not solid science.

Despite some success stories like the Chowchilla case, there are also real-life failures of forensic hypnosis. The most rigorous testing, performed in controlled experiments, has revealed overall that hypnosis does not reliably improve memory (Lynn et al., 2009; Whitehouse et al., 2009). In some experiments, participants watched videotapes of simulated bank robberies or other crimes. Next, while hypnotized or not, they were questioned by researchers, or even by actual police investigators or criminal lawyers. Hypnotized people displayed better recall than unhypnotized people in some studies but no better recall in others. In still other experiments, hypnotized participants performed more poorly than unhypnotized controls. They recalled more information, but much of that extra recall was inaccurate and, to make matters worse, the fact that they recalled these memories under hypnosis may have convinced people that their memories must have been accurate (Burgess & Kirsch, 1999; Wagstaff et al., 2008).

A related concern is that some memories recalled under hypnosis may be *pseudomemories*, false memories *created* during hypnosis by statements or leading suggestions made by the forensic examiner (Lynn et al., 2009). In some experiments, hypnotized and nonhypnotized subjects were intentionally exposed to false information about an event (e.g., about a bank robbery). Later, after the hypnotized subjects had been brought out of hypnosis, all participants were questioned. Highly suggestible people who had been hypnotized were more likely to report the false information as being a true memory (Sheehan et al., 1992; Wagstaff, 2009).

So, is the claim that forensic hypnosis uncovers hidden memories a myth or reality? Unlike *Mythbusters*, we view the claim as mostly "busted," due to the unreliable effects of hypnosis on eyewitness memory. Efforts by psychologists and others are under way, however, to examine whether hypnotic induction instructions can be modified, or specific elements of the hypnosis procedure (e.g., just closing one's eyes) can be used, to improve the overall accuracy of memories recalled in forensic interviews (Wagstaff et al., 2008; Whitehouse et al., 2009)

Many North American courts have banned or limited testimony obtained under hypnosis (Patry et al., 2009; Wagstaff, 2009). A chief concern is that the increased suggestibility of hypnotized eyewitnesses makes them particularly susceptible to memory distortion caused by leading questions, and they may honestly come to believe facts that never occurred (Scoboria et al., 2002). Similarly, if a therapist uses hypnosis to help patients recall long-forgotten memories of sexual abuse, what shall we conclude? Are the horrible memories real, or are they pseudomemories created during therapy? We explore this issue in Chapter 8.

Theories of Hypnosis

Hypnos may have been the Greek god of sleep, but studies of brain physiology reveal that hypnosis definitely *is not* sleep. What is hypnosis, and how does it produce its effects?

Dissociation Theories

Several researchers propose **dissociation theories** *that view hypnosis as an altered state involving a division (dissociation) of consciousness* (Kihlstrom, 2007). Ernest Hilgard (1994) proposed that hypnosis creates a division of awareness in which the person simultaneously experiences two streams of consciousness that are cut off from one another. One stream responds to the hypnotist's suggestions, while the second stream—the part of consciousness that monitors behavior—remains in the background but is aware of everything that goes on. Hilgard refers to this second part of consciousness as the *hidden observer*.

Suppose a hypnotized subject is given a suggestion that she will not feel pain. Her arm is lowered into a tub of ice-cold water for 45 seconds, and every few seconds she reports the amount of pain. In contrast to nonhypnotized subjects, who find this experience moderately painful, she probably will report feeling little pain. But suppose the procedure is done differently. Before lowering the subject's arm, the hypnotist says, "Perhaps there is another part of you that is more aware than your hypnotized part. If so, would that part of you report the amount of pain." In this case, the subject's other stream of consciousness, the hidden observer, will report a higher level of pain (Figure 6.30).

For Hilgard, this dissociation explained why behaviors that occur under hypnosis seem involuntary or automatic. Given the suggestion that "your arm will start to feel lighter and will begin to rise," the subject intentionally raises his or her arm, but only the hidden observer is aware of this. The main stream of consciousness that responds to the command is blocked from this awareness and perceives that the arm is rising all by itself.

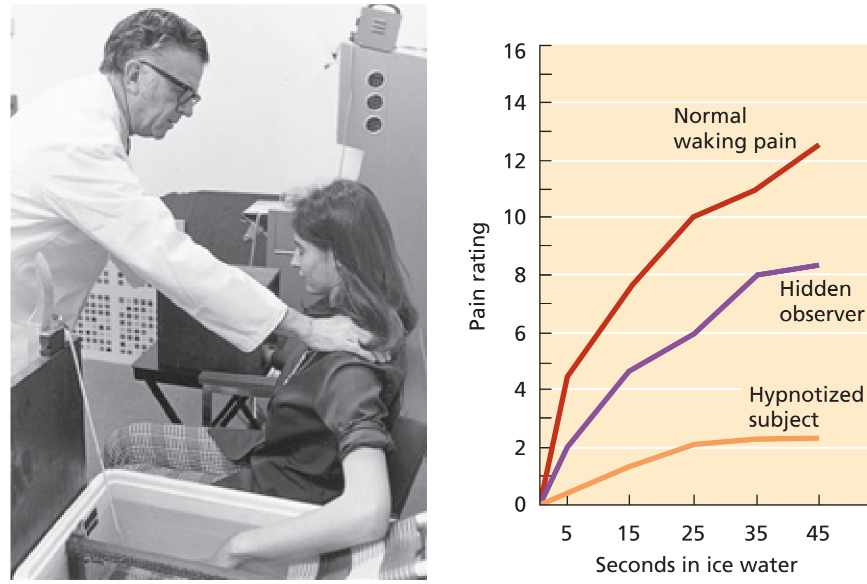
Social-Cognitive Theories

To other theorists, hypnosis does not represent a special state of dissociated consciousness

(Dienes et al., 2009). Instead, **social-cognitive theories** *propose that hypnotic experiences result from expectations of people who are motivated to take on the role of being hypnotized* (Kirsch, 2001; Spanos, 1996). Most people believe that hypnosis involves a trancelike state and responsiveness to suggestions. People motivated to conform to this role develop a readiness to respond to the hypnotist's suggestions and to perceive hypnotic experiences as real and involuntary.

In a classic study, Martin Orne (1959) illustrated the importance of expectations about hypnosis. During a classroom demonstration, college students were told that hypnotized people frequently exhibit spontaneous stiffening of the muscles in the dominant hand. (Actually, this rarely occurs.) An accomplice of the lecturer pretended to be hypnotized and, sure enough, he "spontaneously" exhibited hand stiffness. When students who had seen the demonstration were later hypnotized, 55 percent of them exhibited stiffening of the hand without any suggestion from the hypnotist. Control-group participants saw a demonstration that did not mention or display hand stiffening. Not one of these students exhibited hand stiffening when they were hypnotized.

Does social-cognitive theory imply that hypnotized people are faking or playacting? Not at all. Role theorists emphasize that when people immerse themselves in the hypnotic role, their responses are completely real and may indeed represent altered experiences (Kirsch, 2001). Our expectations strongly influence how the brain organizes sensory information. Often we literally see what we expect to see. According to social-cognitive theory, many effects of hypnosis represent an extension of this principle. The hypnotized subject whose arm automatically rises in response to a suggestion genuinely perceives the behavior to be involuntary because this is what the subject expects and because attention is focused externally on the hypnotist and the hypnotic suggestion.



(a) (b)

Figure 6.30

Hypnosis and the hidden observer.
(a) This hypnotized woman's hand is immersed in painfully cold ice water. Placing his hand on her shoulder, Ernest Hilgard contacts her dissociated hidden observer. (b) This graph shows pain-intensity ratings given by a woman when she is not hypnotized, when she is under hypnosis, and by her hidden observer in the same hypnotic state. The hidden observer reports more pain than the hypnotized woman but less than the subject when she is not hypnotized. Source: Based on Hilgard, 1977, 1994.

The Hypnotized Brain

Can peering inside the brain reveal the nature of hypnosis? To find out, look at the colored and gray-scale drawings in Figure 6.31. Now:

1. Look at the colored drawing again, form a mental image of it, and try to drain the color out of it. In other words, try to visualize it as if it were a gray-scale figure.
2. Next, look at the gray-scale drawing, form a mental picture of it, and try to add color to it.

Stephen Kosslyn and coworkers (2000) identified 8 people who scored high in hypnotic susceptibility and who reported they could drain away

Figure 6.31

Color perception and the hypnotized brain.
These color and gray-scale drawings are similar to the ones used by Kosslyn and his colleagues (2000).

or add color to their mental images of such drawings. Subjects then performed these tasks while inside a PET scanner. On some trials they were hypnotized, and on other trials they were not.

The PET scans revealed that whether subjects were hypnotized or not, an area in the right hemisphere that processes color information was more active when subjects visualized the gray drawing as having color (Task 2) than when they visualized the color drawing as gray (Task 1). In the left hemisphere, however, visualizing the gray drawing as having color increased brain activation in one particular region only when the subjects were hypnotized. As the researchers noted, "The right hemisphere appeared to respond to imagery per se, whereas the left required the additional boost provided by hypnosis" (Kosslyn et al., 2000, p. 1283).

Other brain-imaging studies reveal that giving hypnotized subjects pain-reducing suggestions not only decreases their subjective reports of pain but also decreases activity in several brain regions that process pain signals (Milling, 2008). These results and other physiological findings suggest an important conclusion: hypnotized people are not faking it but rather are experiencing altered brain activity that matches their verbal reports (Dienes et al., 2009). But does this brain activity reflect a state of dissociation?

Social cognitive theorists argue that these findings don't resolve the issue (Kirsch, 2001). They note that hypnotic experiences are subjectively real, and if hypnosis alters brain activity, this does not contradict the position that people's expectations are what lead them to become hypnotized in the first place. In sum, cognitive neuroscience provides insights into the hypnotized brain, but it will take more research to resolve the debate about hypnosis (Dienes et al., 2009).

test yourself — Hypnosis

True or false?

1. Hypnosis is a state of sleep.
2. Forensic hypnosis reliably improves eyewitness memory.
3. According to social-cognitive theory, hypnotic experiences result from people's expectations and highly motivated role-playing.
4. According to dissociation theory, hypnosis creates two independent streams of consciousness.

ANSWERS: 1-false, 2-false, 3-true, 4-true

Chapter Summary

THE PUZZLE OF CONSCIOUSNESS

- *Consciousness* refers to our moment-to-moment awareness of ourselves and the environment. It is subjective, dynamic, self-reflective, central to our sense of identity, and linked to selective attention. Scientists use self-report, behavioral, and physiological measures to measure states of consciousness.
- Freud viewed the unconscious mind as a reservoir of unacceptable desires and repressed experiences. Cognitive psychologists view it as an information-processing system and distinguish between controlled and automatic processing. Research on visual agnosia, blindsight, and priming reveals that information processed unconsciously can influence people's behavior and emotions.
- Consciousness has adaptive value. It facilitates planning and decision making, helps us cope with novel situations, and lets us override impulsive and automated behaviors. The brain contains at least several separate neural circuits for conscious versus unconscious information processing.
- Global-workspace models propose that the mind consists of separate but interacting information-processing modules. Consciousness arises from the unified activity of multiple modules located in different brain areas.

CIRCADIAN RHYTHMS: OUR DAILY BIOLOGICAL CLOCKS

- Circadian rhythms are 24-hour biological cycles that help regulate bodily processes and influence our alertness.

The suprachiasmatic nuclei (SCN) are the brain's master circadian clock. Free-running circadian rhythms are about 24.2 hours. The day-night cycle and other environmental factors reset our daily clocks to a 24-hour schedule.
- Circadian rhythms influence our tendency to be a morning or night person. Cultural factors may also play a role.
- In general, our alertness is lowest in the early morning hours. Job performance errors, major industrial accidents, and fatal auto accidents peak during these hours.
- Jet lag, night-shift work, and seasonal affective disorder (SAD) involve circadian disruptions. Treatments include controlling one's exposure to light, taking oral melatonin, and regulating one's daily activity schedule.

SLEEP AND DREAMING

- Sleep has five main stages. Stages 1 and 2 are lighter sleep; stages 3 and 4 are deeper, slow-wave sleep. High physiological arousal and rapid eye movement characterize stage-5 REM sleep. Several brain regions regulate sleep, and genetic, psychological, and environmental factors affect sleep duration and quality.
- Sleep deprivation negatively affects mood and performance.
- The restoration model proposes that we sleep to recover from physical and mental fatigue. Evolutionary/circadian models state that each species developed a sleep-wake cycle that maximized its chance of survival.
- Insomnia, narcolepsy, REM-sleep behavior disorder, sleepwalking, night terrors, and sleep apnea can have serious consequences. Sleepwalking typically occurs during slow-wave sleep, whereas nightmares most often occur during REM sleep. Night terrors create a near-panic state of arousal and typically occur in slow-wave sleep.
- Dreams occur throughout sleep but are most common during REM periods. Our cultural background, current concerns, and recent events influence what we dream about.
- Freud proposed that dreams fulfill unconscious wishes. Cognitive-process dream theories view dreams and waking thoughts as products of the same mental systems. Activation-synthesis theory views dreaming as the brain's attempt to fit a story to random neural activity.

DRUG-INDUCED STATES

- Drugs alter consciousness by modifying neurotransmitter activity. Agonists increase a neurotransmitter system's activity; antagonists decrease it.
- Tolerance develops when the body produces compensatory responses to counteract a drug's effects. When drug use is stopped, compensatory responses continue and produce withdrawal symptoms. Substance dependence is a maladaptive pattern of drug use.
- Depressants, such as alcohol, barbiturates, and tranquilizers, decrease neural activity. Stimulants, such as amphetamines, cocaine, and Ecstasy, increase arousal and boost mood. Repeated use may produce serious negative psychological effects and bodily damage.
- Opiates increase endorphin activity, producing pain relief and mood changes. Opiates are highly addictive. Hallucinogens powerfully distort sensory experience and can blur the line between reality and fantasy.
- Marijuana produces relaxation at low doses but can cause anxiety and sensory distortions at higher doses. It can impair thinking and reflexes.
- A drug's effect depends on its chemical actions, the physical and social setting, cultural norms and learning, and the user's genetic predispositions, expectations, and personality.

HYPNOSIS

- Hypnosis involves an increased receptiveness to suggestions. Hypnotized people experience their actions as involuntary, but hypnosis has no unique power to make people behave against their will or perform amazing feats. Hypnosis increases pain tolerance, as do other psychological techniques.
- Some people can be led to experience hypnotic amnesia and posthypnotic amnesia. The use of hypnosis to improve memory is controversial. Hypnosis increases the risk that people will develop distorted memories about events in response to leading questions.
- Dissociation theories view hypnosis as an altered state of divided consciousness. Social-cognitive theories state that hypnotic experiences occur because people have strong expectations about hypnosis and are highly motivated to enter a hypnotized role.
- Brain imaging reveals that hypnotized people display changes in neural activity consistent with their subjectively reported experiences. This supports the view that hypnosis involves an altered state but doesn't establish whether it is a dissociated state.

KEY TERMS AND CONCEPTS

Each term has been boldfaced and defined in the chapter on the page indicated in parentheses.

activation-synthesis theory (p. 193)
agonist (p. 195)
alcohol myopia (p. 199)
alpha waves (p. 183)
antagonist (p. 196)
automatic (unconscious) processing (p. 177)
beta waves (p. 183)
blindsight (p. 177)
blood-brain barrier (p. 195)

circadian rhythms (p. 180)
cognitive-process dream theories (p. 192)
compensatory responses (p. 196)
consciousness (p. 175)
controlled (conscious) processing (p. 177)
delta waves (p. 184)
depressants (p. 198)
dissociation theories (of hypnosis) (p. 208)
divided attention (p. 177)
evolutionary/circadian sleep models (p. 187)
hallucinogens (p. 202)
hypnosis (p. 205)
hypnotic susceptibility scales (p. 205)
insomnia (p. 188)
melatonin (p. 180)
memory consolidation (p. 188)
narcolepsy (p. 189)
night terrors (p. 190)
opiates (p. 202)
priming (p. 178)
problem-solving dream models (p. 192)
REM sleep (p. 184)
REM-sleep behavior disorder (RBD) (p. 189)
restoration model (p. 187)
seasonal affective disorder (SAD) (p. 181)
selective attention (p. 175)
sleep apnea (p. 190)
slow-wave sleep (p. 184)
social-cognitive theories (of hypnosis) (p. 209)
stimulants (p. 200)
substance dependence (p. 197)
suprachiasmatic nuclei (SCN) (p. 180)
THC (tetrahydrocannabinol) (p. 202)
tolerance (p. 196)
visual agnosia (p. 174)
wish fulfillment (p. 192)
withdrawal (p. 197)

thinking **critically**

EARLY BIRDS, CLIMATE, AND CULTURE (Page 181)

As a critical thinker, keep in mind that correlation does not establish causation. This is a correlational study. The major variables (climate, students' morningness) were not manipulated; they were only measured. The association between climate and morningness might be causal, but we must consider other possible explanations.

First, why might climate affect morningness? The researchers hypothesized that to avoid performing daily activities during the hottest part of the day, people who live in warmer climates adapt to a pattern of rising early in the morning, a finding consistent with a prior study that revealed strong tendencies toward morningness among Brazilians (Benedito-Silva et al., 1989).

Second, as the authors note, these results could be due to factors other than climate. The Netherlands, England, and the United States share a northern-European heritage, and perhaps some aspect of this common background predisposes people toward less morningness. Yet, say the authors, India's cultural traditions are distinct from those of Spain and Colombia, so it's difficult to apply the "common cultural heritage" argument to explain the greater morningness found among students from these countries. If not cultural heritage, perhaps the greater industrialization and summertime use of air-conditioned home and work environments in the Netherlands, England, and the United States reduce the necessity for residents to adapt circadian cycles to local climate conditions. Aware of their study's limitations, the authors suggest that climate may be just one of several factors that contribute to cross-cultural differences in morningness.

HYPNOSIS AND AMAZING FEATS (Page 206)

For any causal claim, as critical thinkers it's important to think about the concept of control groups. You should keep this question in mind: What would have happened anyway, even without this special treatment or intervention? Applied to hypnosis, the key question is whether people can exhibit these same amazing feats when they are not hypnotized. When a stage hypnotist gets someone to perform the human plank, the audience attributes this feat to the hypnotic trance. What the audience doesn't know is that an average man suspended in this manner can support 300 pounds on his chest with little discomfort and no need of a hypnotic trance. Indeed, Figure 6.28 shows The Amazing Kreskin, a professional performer and self-proclaimed "mentalist," standing on someone who is not hypnotized.

As for the allergy experiment, we must ask whether allergic people might show the same reactions if they were not hypnotized. Indeed, the experiment included 8 nonhypnotized control participants (Ikemi & Nakagawa, 1962). When blindfolded and exposed to a toxic leaf but misled to believe that it was harmless, they did not show an allergic response. Conversely, when their arm was rubbed with a harmless leaf but they were falsely told it was toxic, they had an allergic reaction. In short, the nonhypnotized people responded the same way as the hypnotized subjects.

Other research shows that under hypnosis, vision can improve and stomach acidity can increase. However, well-controlled studies show that nonhypnotized subjects can exhibit these same responses (Spanos & Chaves, 1988). As with placebo effects and other mind-body interactions, people's beliefs and expectations can produce real physiological effects.