Module 13

Monica Murphy/Getty Images

Brain Hemisphere Organization and the Biology of Consciousness

Module Learning Objectives

13-1 Explain how split-brain research helps us understand the functions of our two brain hemispheres.

13-2 Explain what is meant by "dual processing," as revealed by today's cognitive neuroscience.

Our Divided Brain

13-1 What do split brains reveal about the functions of our two brain hemispheres?

Our brain's look-alike left and right hemispheres serve differing functions. This *lateralization* is apparent after brain damage. Research collected over more than a century has shown that accidents, strokes, and tumors in the left hemisphere can impair reading, writing, speaking, arithmetic reasoning, and understanding. Similar lesions in the right hemisphere have effects that are less visibly dramatic.

Does this mean that the right hemisphere is just along for the ride—a silent, "subordinate" or "minor" hemisphere? Many believed this was the case until 1960, when researchers found that the "minor" right hemisphere was not so limited after all. The story of this discovery is a fascinating episode in psychology's history.

Splitting the Brain

In 1961, two Los Angeles neurosurgeons, Philip Vogel and Joseph Bogen, speculated that major epileptic seizures were caused by an amplification of abnormal brain activity bouncing back and forth between the two cerebral hemispheres. If so, they wondered, could they put an end to this biological tennis game by severing the **corpus callosum** (see **FIGURE 13.1**)? This wide band of axon fibers connects the two hemispheres and carries messages between them. Vogel and Bogen knew that psychologists Roger Sperry, Ronald Myers, and Michael Gazzaniga had divided the brains of cats and monkeys in this manner, with no serious ill effects.

So the surgeons operated. The result? The seizures all but disappeared. The patients with these **split brains** were surprisingly normal, their personality and intellect hardly affected. Waking from surgery, one even joked that he had a "splitting headache" (Gazzaniga, 1967). By sharing their experiences, these patients have greatly expanded our understanding of interactions between the intact brain's two hemispheres.

corpus callosum [KOR-pus kah-LOW-sum] the large band of neural fibers connecting the two brain hemispheres and carrying messages between them.

split brain a condition resulting from surgery that isolates the brain's two hemispheres by cutting the fibers (mainly those of the corpus callosum) connecting them.

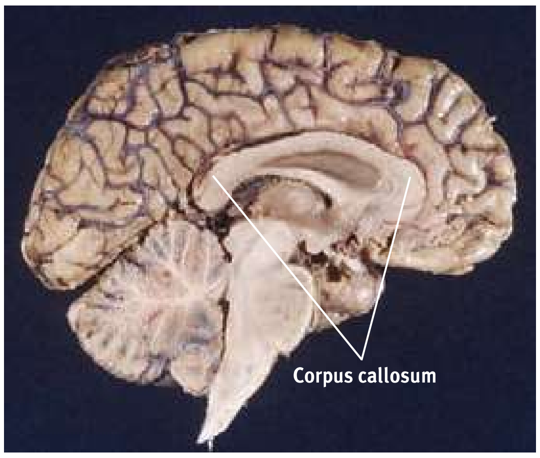


Figure 13.1
The corpus callosum This large band of neural fibers connects the two brain hemispheres. To photograph this half brain, a surgeon separated the hemispheres by cutting through the corpus callosum and lower brain regions.

AP® Exam Tip
The classic split-brain studies are famous in psychology, which means they are likely to show up on the AP® exam.

To appreciate these findings, we need to focus for a minute on the peculiar nature of our visual wiring. As **FIGURE 13.2** illustrates, information from the left half of your field of vision goes to your right hemisphere, and information from the right half of your visual field goes to your left hemisphere, which usually controls speech. (Note, however, that each eye receives sensory information from both the right and left visual fields.) Data received by either hemisphere are quickly transmitted to the other across the corpus callosum. In a person with a severed corpus callosum, this information-sharing does not take place.

Knowing these facts, Sperry and Gazzaniga could send information to a patient's left or right hemisphere. As the person stared at a spot, they flashed a stimulus to its right or left. They could do this with you, too, but in your intact brain, the hemisphere receiving the information would instantly pass the news to the other side. Because the split-brain surgery had cut the communication lines between the hemispheres, the researchers could, with these patients, quiz each hemisphere separately.

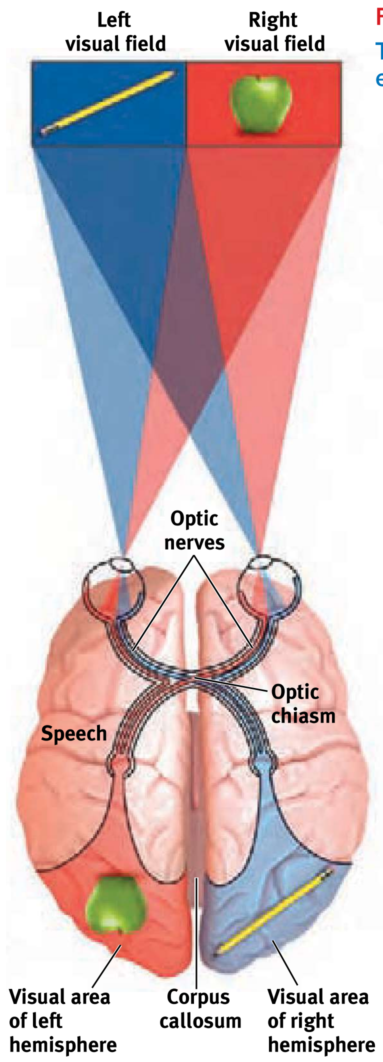
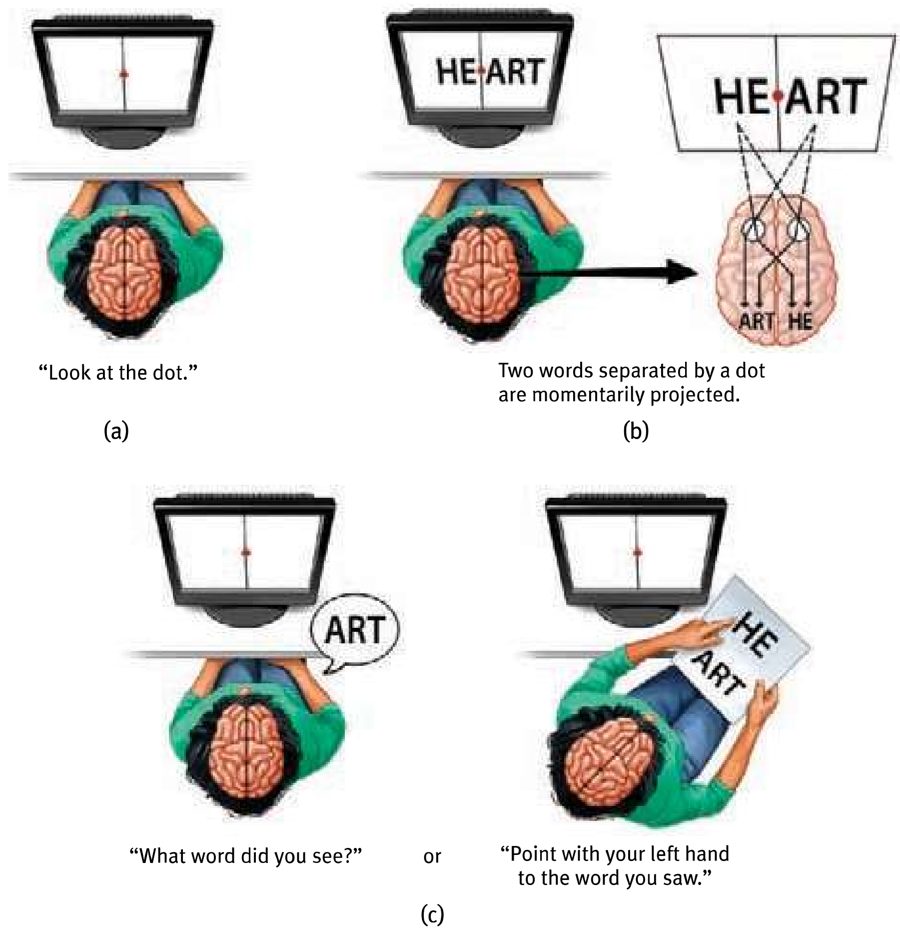


Figure 13.2
The information highway from eye to brain

In an early experiment, Gazzaniga (1967) asked these people to stare at a dot as he flashed HE·ART on a screen (**FIGURE 13.3** on the next page). Thus, HE appeared in their left visual field (which transmits to the right hemisphere) and ART in the right field (which transmits to the left hemisphere). When he then asked them to *say* what they had seen, the patients reported that they had seen ART. But when asked to *point* to the word they had seen, they were startled when their left hand (controlled by the right hemisphere) pointed to HE. Given an opportunity to express itself, each hemisphere reported what it had seen. The right hemisphere (controlling the left hand) intuitively knew what it could not verbally report.

Figure 13.3

Testing the divided brain When an experimenter flashes the word HEART across the visual field, a woman with a split brain reports seeing the portion of the word transmitted to her left hemisphere. However, if asked to indicate with her left hand what she saw, she points to the portion of the word transmitted to her right hemisphere. (From Gazzaniga, 1983.)



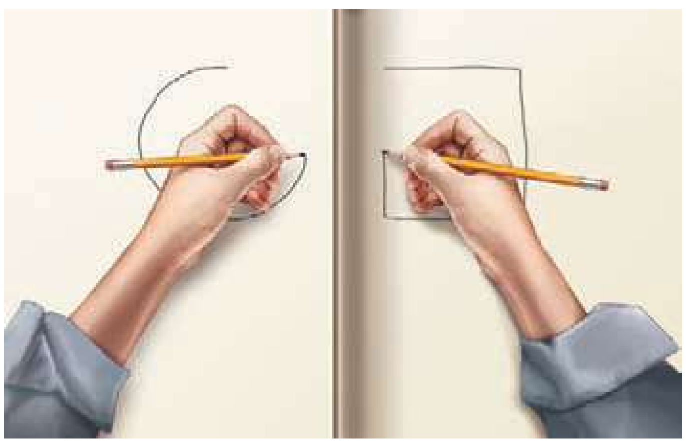
When a picture of a spoon was flashed to their right hemisphere, the patients could not *say* what they had viewed. But when asked to *identify* what they had viewed by feeling an assortment of hidden objects with their left hand, they readily selected the spoon. If the experimenter said, "Correct!" the patient might reply, "What? Correct? How could I possibly pick out the correct object when I don't know what I saw?" It is, of course, the left hemisphere doing the talking here, bewildered by what the nonverbal right hemisphere knows.

"Do not let your left hand know what your right hand is doing."
-Matthew 6:3

A few people who have had split-brain surgery have been for a time bothered by the unruly independence of their left hand, which might unbutton a shirt while the right hand buttoned it, or put grocery store items back on the shelf after the right hand put them in the cart. It was as if each hemisphere was thinking "I've half a mind to wear my green (blue) shirt today." Indeed, said Sperry (1964), split-brain surgery leaves people "with two separate minds." With a split brain, both hemispheres can comprehend and follow an instruction to copy—*simultaneously*—different figures with the left and right hands (Franz et al., 2000; see also **FIGURE 13.4**). (Reading these reports, I fantasize a patient enjoying a solitary game of "rock, paper, scissors"—left versus right hand.)

Figure 13.4

Try this! A person who has undergone split-brain surgery can simultaneously draw two different shapes.



When the "two minds" are at odds, the left hemisphere does mental gymnastics to rationalize reactions it does not understand. If a patient follows an order sent to the right hemisphere ("Walk"), a strange thing happens. Unaware of the order, the left hemisphere doesn't know why the patient begins walking. Yet, when asked why, the patient doesn't say "I don't know." Instead, the interpretive left hemisphere improvises—"I'm going into the house to get a Coke." Gazzaniga (1988), who considers these patients "the most fascinating people on earth," concluded that the conscious left hemisphere is an "interpreter" or press agent that instantly constructs theories to explain our behavior.

Right-Left Differences in the Intact Brain

So, what about the 99.99+ percent of us with undivided brains? Does each of *our* hemispheres also perform distinct functions? Several different types of studies indicate they do. When a person performs a *perceptual* task, for example, brain waves, bloodflow, and glucose consumption reveal increased activity in the *right* hemisphere. When the person speaks or calculates, activity increases in the *left* hemisphere.

A dramatic demonstration of hemispheric specialization happens before some types of brain surgery. To locate the patient's language centers, the surgeon injects a sedative into the neck artery feeding blood to the left hemisphere, which usually controls speech. Before the injection, the patient is lying down, arms in the air, chatting with the doctor. Can you predict what probably happens when the drug puts the left hemisphere to sleep? Within seconds, the person's right arm falls limp. If the left hemisphere is controlling language, the patient will be speechless until the drug wears off. If the drug is injected into the artery to the right hemisphere, the *left* arm will fall limp, but the person will still be able to speak.

AP® Exam Tip

Notice that David Myers never refers to your left brain or your right brain. You have two brain hemispheres, each with its own responsibilities, *but you only have one brain.* It's very misleading when the media refers to the left brain and the right brain, and this happens frequently.

To the brain, language is language, whether spoken or signed. Just as hearing people usually use the left hemisphere to process speech, deaf people use the left hemisphere to process sign language (Corina et al., 1992; Hickok et al., 2001). Thus, a left-hemisphere stroke disrupts a deaf person's signing, much as it would disrupt a hearing person's speaking. The same brain area is involved in both (Corina, 1998). (For more on how the brain enables language, see Module 36.)

Although the left hemisphere is adept at making quick, literal interpretations of language, the right hemisphere

- *excels in making inferences* (Beeman & Chiarello, 1998; Bowden & Beeman, 1998; Mason & Just, 2004). Primed with the flashed word *foot,* the left hemisphere will be especially quick to recognize the closely associated word *heel.* But if primed with *foot, cry,* and *glass,* the right hemisphere will more quickly recognize another word distantly related to all three *(cut)*. And if given an insight-like problem—"What word goes with *boot, summer,* and *ground?*"—the right hemisphere more quickly than the left recognizes the solution: *camp.* As one patient explained after a right-hemisphere stroke, "I understand words, but I'm missing the subtleties."
- *helps us modulate our speech* to make meaning clear—as when we ask "What's that in the road ahead?" instead of "What's that in the road, a head?" (Heller, 1990).
- *helps orchestrate our sense of self.* People who suffer partial paralysis will sometimes obstinately deny their impairment—strangely claiming they can move a paralyzed limb—if the damage is to the right hemisphere (Berti et al., 2005).

Simply looking at the two hemispheres, so alike to the naked eye, who would suppose they contribute uniquely to the harmony of the whole? Yet a variety of observations—of people with split brains, of people with normal brains, and even of other species' brains—converge beautifully, leaving little doubt that we have unified brains with specialized parts (Hopkins & Cantalupo, 2008; MacNeilage et al., 2009; and see Close-up: Handedness on the next page).

Close-up

Handedness

Nearly 90 percent of us are primarily right-handed (Leask & Beaton, 2007; Medland et al., 2004; Peters et al., 2006). Some 10 percent of us (somewhat more among males, somewhat less among females) are left-handed. (A few people write with their right hand and throw a ball with their left, or vice versa.) Almost all right-handers (96 percent) process speech primarily in the left hemisphere, which tends to be the slightly larger hemisphere (Hopkins, 2006). Left-handers are more diverse. Seven in ten process speech in the left hemisphere, as right-handers do. The rest either process language in the right hemisphere or use both hemispheres.

IS HANDEDNESS INHERITED?

Judging from prehistoric human cave drawings, tools, and hand and arm bones, this veer to the right occurred long ago (Corballis, 1989; MacNeilage et al., 2009). Right-handedness prevails in all human cultures, and even in monkeys and apes. Moreover, it appears prior to culture's impact: More than 9 in 10 fetuses suck the right hand's thumb (Hepper et al., 1990, 2004). Twin studies indicate only a small genetic influence on individual handedness (Vuoksimaa et al., 2009). But the universal prevalence of right-handers in humans and other primates suggests that either genes or some prenatal factors influence handedness.

Most people also kick with their right foot, look through a microscope with their right eye, and (had you noticed?) kiss the right way—with their head tilted right (Güntürkün, 2003).

SO, IS IT ALL RIGHT TO BE LEFT-HANDED?

Judging by our everyday conversation, left-handedness is not all right. To be "coming out of left field" is hardly better than to be "gauche" (derived from the French word for "left"). On the other hand, right-handedness is "right on," which any "righteous," "right-hand man" "in his right mind" usually is.

Left-handers are more numerous than usual among those with reading disabilities, allergies, and migraine headaches (Geschwind & Behan, 1984). But in Iran, where students report which hand they write with when taking the university entrance exam, lefties have outperformed righties in all subjects (Noroozian et al., 2003). Left-handedness is also more common among musicians, mathematicians, professional baseball and cricket players, architects, and artists, including such luminaries as Michelangelo, Leonardo da Vinci, and Picasso.[1] Although left-handers must tolerate elbow jostling at the dinner table, right-handed desks, and awkward scissors, the pros and cons of being a lefty seem roughly equal.

Both photos Mike James/Four Seam Images via AP Images

The rarest of baseball players: an ambidextrous pitcher Using a glove with two thumbs, Minor League New York Yankees pitcher Pat Venditte, shown here in 2012, pitches to right-handed batters with his right hand, then switches to face left-handed batters with his left hand. During his college career at Creighton University, after one switch-hitter switched sides of the plate, Venditte switched pitching arms, which triggered the batter to switch again, and so on. The umpires ultimately ended the comedy routine by applying a little-known rule: A pitcher must declare which arm he will use before throwing his first pitch to a batter (Schwarz, 2007).

[1] Strategic factors explain the higher-than-normal percentage of lefties in sports. For example, it helps a soccer team to have left-footed players on the left side of the field (Wood & Aggleton, 1989). In golf, however, no left-hander won the Masters tournament until Canadian Mike Weir did so in 2003.

The Biology of Consciousness

13-2 What is the "dual processing" being revealed by today's cognitive neuroscience?

consciousness our awareness of ourselves and our environment.

Today's science explores the biology of **consciousness.** Evolutionary psychologists speculate that consciousness must offer a reproductive advantage (Barash, 2006). Consciousness helps us act in our long-term interests (by considering consequences) rather than merely seeking short-term pleasure and avoiding pain. Consciousness also promotes our survival by anticipating how we seem to others and helping us read their minds: "He looks really angry! I'd better run!"

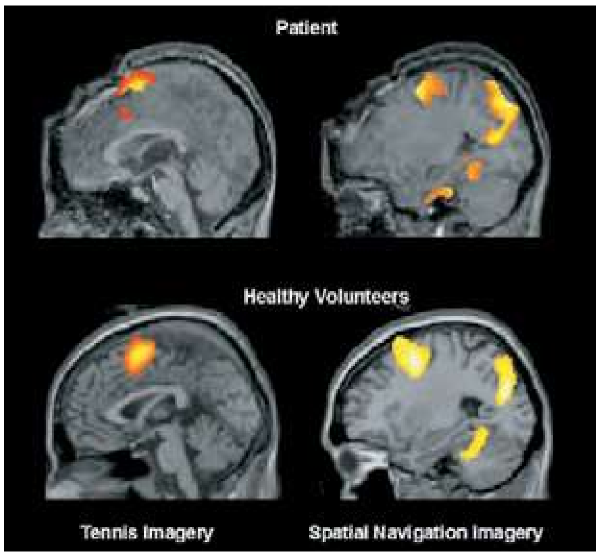
Such explanations still leave us with the "hard problem": How do brain cells jabbering to one another create our awareness of the taste of a taco, the idea of infinity, the feeling of fright? Today's scientists are pursuing answers.

Cognitive Neuroscience

Scientists assume, in the words of neuroscientist Marvin Minsky (1986, p. 287), that "the mind is what the brain does." We just don't know *how* it does it. Even with all the world's chemicals, computer chips, and energy, we still don't have a clue *how* to make a conscious robot. Yet today's **cognitive neuroscience**—the interdisciplinary study of the brain activity linked with our mental processes—is taking the first small step by relating specific brain states to conscious experiences.

cognitive neuroscience the interdisciplinary study of the brain activity linked with cognition (including perception, thinking, memory, and language).

A stunning demonstration of consciousness appeared in brain scans of a noncommunicative patient—a 23-year-old woman who had been in a car accident and showed no outward signs of conscious awareness (Owen et al., 2006). When researchers asked her to *imagine* playing tennis, fMRI scans revealed brain activity in a brain area that normally controls arm and leg movements (**FIGURE 13.5**). Even in a motionless body, the researchers concluded, the brain—and the mind—may still be active. A follow-up study of 22 other "vegetative" patients revealed 3 more who also showed meaningful brain responses to questions (Monti et al., 2010).



Courtesy of Adrian M. Owen, The Brain and Mind Institute, Western University

Figure 13.5
Evidence of awareness? When asked to imagine playing tennis or navigating through her home, a vegetative patient's brain (top) exhibited activity similar to a healthy person's brain (bottom). Researchers wonder if such fMRI scans might enable a "conversation" with some unresponsive patients, by instructing them, for example, to answer *yes* to a question by imagining playing tennis and *no* by imagining walking around their home.

Many cognitive neuroscientists are exploring and mapping the conscious functions of the cortex. Based on your cortical activation patterns, they can now, in limited ways, read your mind (Bor, 2010). They can, for example, tell which of 10 similar objects (hammer, drill, and so forth) you are viewing (Shinkareva et al., 2008).

Despite such advances, much disagreement remains. One view sees conscious experiences as produced by the synchronized activity across the brain (Gaillard et al., 2009; Koch & Greenfield, 2007; Schurger et al., 2010). If a stimulus activates enough brainwide coordinated neural activity—with strong signals in one brain area triggering activity elsewhere—it crosses a threshold for consciousness. A weaker stimulus—perhaps a word flashed too briefly to consciously perceive—may trigger localized visual cortex activity that quickly dies out. A stronger stimulus will engage other brain areas, such as those involved with language, attention, and memory. Such reverberating activity (detected by brain scans) is a telltale sign of conscious awareness. How the synchronized activity produces awareness—how matter makes mind—remains a mystery.

Dual Processing: The Two-Track Mind

Many cognitive neuroscience discoveries tell us of a particular brain region (such as the visual cortex mentioned above) that becomes active with a particular conscious experience. Such findings strike many people as interesting but not mind-blowing. (If everything psychological is simultaneously biological, then our ideas, emotions, and spirituality must all, somehow, be embodied.) What *is* mind-blowing to many of us is the growing evidence that we have, so to speak, two minds, each supported by its own neural equipment.

AP® Exam Tip

Dual processing is another one of those big ideas that shows up in several units. Pay attention!

At any moment, you and I are aware of little more than what's on the screen of our consciousness. But beneath the surface, unconscious information processing occurs simultaneously on many parallel tracks. When we look at a bird flying, we are consciously aware of the result of our cognitive processing ("It's a hummingbird!") but not of our subprocessing of the bird's color, form, movement, and distance. One of the grand ideas of recent cognitive neuroscience is that much of our brain work occurs off stage, out of sight. Perception, memory, thinking, language, and attitudes all operate on two levels—a conscious, deliberate

dual processing the principle that information is often simultaneously processed on separate conscious and unconscious tracks.

"high road" and an unconscious, automatic "low road." Today's researchers call this **dual processing.** We know more than we know we know.

Sometimes science confirms widely held beliefs. Other times, as this next story illustrates, science is stranger than science fiction.

During my sojourns at Scotland's University of St. Andrews, I came to know cognitive neuroscientists David Milner and Melvyn Goodale (2008). When overcome by carbon monoxide, a local woman, whom they call D. F., suffered brain damage that left her unable to recognize and discriminate objects visually. Consciously she could see nothing. Yet she exhibited *blindsight*—she would act as if she could see. Asked to slip a postcard into a vertical or horizontal mail slot, she could do so without error. Although unable to report the width of a block in front of her, she could grasp it with just the right finger-thumb distance. If you were to experience temporary blindness (with magnetic pulses to your brain's primary visual cortex area) this, too, would create blindsight—as you correctly guess the color or orientation of an object that you cannot consciously see (Boyer et al., 2005).

How could this be? Don't we have one visual system? Goodale and Milner knew from animal research that the eye sends information simultaneously to different brain areas, which support different tasks (Weiskrantz, 2009, 2010). Sure enough, a scan of D. F.'s brain activity revealed normal activity in the area concerned with reaching for, grasping, and navigating objects, but damage in the area concerned with consciously recognizing objects. (See another example in **FIGURE 13.6.**)

adapted from: Milner, A. D., & Goodale, M.A. (2006). The Visual Brain in Action: 2nd Edition/ Oxford: Oxford University Press, 297 pp. (paperback 2006)

Figure 13.6
When the blind can "see" In a compelling demonstration of blindsight and the two-track mind, a researcher trails a blindsight patient down a cluttered hallway. Although told the hallway was empty, the patient meandered around all the obstacles without any awareness of them.

So, would the reverse damage lead to the opposite symptoms? Indeed, there are a few such patients—who can see and recognize objects but have difficulty pointing toward or grasping them.

How strangely intricate is this thing we call vision, conclude Goodale and Milner in their aptly titled book, *Sight Unseen.* We may think of our vision as one system controlling our visually guided actions, but it is actually a dual-processing system. A *visual perception track* enables us "to think about the world"—to recognize things and to plan future actions. A *visual action track* guides our moment-to-moment movements.

On rare occasions, the two conflict. Shown the *hollow face illusion,* people will mistakenly perceive the inside of a mask as a protruding face (**FIGURE 13.7**). Yet they will unhesitatingly and accurately reach into the inverted mask to flick off a buglike target stuck on the face (Króliczak et al., 2006). What their conscious mind doesn't know, their hand does.

Figure 13.7
The hollow face illusion We tend to see an illusory protruding face even on an inverted mask (right). Yet research participants will accurately reach for a speck on the face inside the inverted mask, suggesting that our unconscious mind seems to know the truth of the illusion.

David Mack/Science Source

Another patient, who lost all his left visual cortex—leaving him blind to objects presented on the right side of his field of vision—can nevertheless sense the emotion expressed in faces he does not consciously perceive (De Gelder, 2010). The same is true of normally sighted people whose visual cortex has been disabled with magnetic stimulation. This suggests that brain areas below the cortex are processing emotion-related information.

People often have trouble accepting that much of our everyday thinking, feeling, and acting operates outside our conscious awareness (Bargh & Chartrand, 1999). We are understandably biased to believe that our intentions and deliberate choices rule our lives. But consciousness, though enabling us to exert voluntary control and to communicate our mental states to others, is but the tip of the information-processing iceberg. Being intensely focused on an activity (such as reading this module, I'd love to think) increases your total brain activity no more than 5 percent above its baseline rate. And even when you rest, "hubs of dark energy" are whirling inside your head (Raichle, 2010).

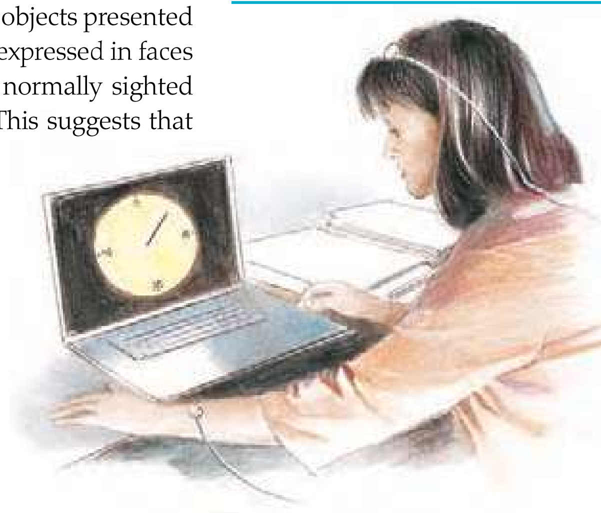


Figure 13.8

Is the brain ahead of the mind? In this study, volunteers watched a computer clock sweep through a full revolution every 2.56 seconds. They noted the time at which they decided to move their wrist. About one-third of a second before that decision, their brain-wave activity jumped, indicating a *readiness potential* to move. Watching a slow-motion replay, the researchers were able to predict when a person was about to decide to move (following which, the wrist did move) (Libet, 1985, 2004). Other researchers, however, question the clock measurement procedure (Miller et al., 2011).

Experiments show that when you move your wrist at will, you consciously experience the decision to move it about 0.2 seconds before the actual movement (Libet, 1985, 2004). No surprise there. But your brain waves jump about 0.35 seconds before you consciously perceive your decision to move (**FIGURE 13.8**)! This readiness potential has enabled researchers (using fMRI brain scans) to predict—with 60 percent accuracy and up to 7 seconds ahead—participants' decisions to press a button with their left or right finger (Soon et al., 2008). The startling conclusion: Consciousness sometimes arrives late to the decision-making party.

Running on automatic pilot allows our consciousness—our mind's CEO—to monitor the whole system and deal with new challenges, while neural assistants automatically take care of routine business. Walking the familiar path to your next class, your feet do the work while your mind rehearses the presentation you're about to give. A skilled tennis player's brain and body respond automatically to an oncoming serve before becoming consciously aware of the ball's trajectory (which takes about three-tenths of a second). Ditto for other skilled athletes, for whom action precedes awareness. *The bottom line:* In everyday life, we mostly function like an automatic point-and-shoot camera, but with a manual (conscious) override.

Our unconscious parallel processing is faster than sequential conscious processing, but both are essential. Sequential processing is skilled at solving new problems, which require our focused attention. Try this: If you are right-handed, you can move your right foot in a smooth counterclockwise circle, and you can write the number 3 repeatedly with your right hand—but probably not at the same time. (Try something equally difficult: Tap a steady beat three times with your left hand while tapping four times with your right hand.) Both tasks require conscious attention, which can be in only one place at a time. If time is nature's way of keeping everything from happening at once, then consciousness is nature's way of keeping us from thinking and doing everything at once.

Before You Move On

► ASK YOURSELF

What are some examples of things you do on "automatic pilot"? What behaviors require your conscious attention?

► TEST YOURSELF

What are the mind's two tracks, and what is "dual processing"?

Answers to the Test Yourself questions can be found in Appendix E at the end of the book.

Module 13 Review

13-1 What do split brains reveal about the functions of our two brain hemispheres?

- *Split-brain* research (experiments on people with a severed *corpus callosum*) has confirmed that in most people, the left hemisphere is the more verbal, and that the right hemisphere excels in visual perception and the recognition of emotion.
- Studies of healthy people with intact brains confirm that each hemisphere makes unique contributions to the integrated functioning of the brain.

13-2 What is the "dual processing" being revealed by today's cognitive neuroscience?

- *Cognitive neuroscientists* and others studying the brain mechanisms underlying consciousness and cognition have discovered that the mind processes information on two separate tracks, one operating at an explicit, conscious level and the other at an implicit, unconscious level. This *dual processing* affects our perception, memory, attitudes, and other cognitions.

Multiple-Choice Questions

1. A split-brain patient has a picture of a dog flashed to his right hemisphere and a cat to his left hemisphere. He will be able to identify the
   a. cat using his right hand.
   b. dog using his right hand.
   c. dog using either hand.
   d. cat using either hand.
   e. cat using his left hand.

2. You are aware that a dog is viciously barking at you, but you are not aware of the type of dog. Later, you are able to describe the type and color of the dog. This ability to process information without conscious awareness best exemplifies which of the following?
   a. Split brain
   b. Blindsight
   c. Consciousness
   d. Cognitive neuroscience
   e. Dual processing

3. Which of the following is most likely to be a function of the left hemisphere?
   a. Speech
   b. Evaluating perceptual tasks
   c. Making inferences
   d. Identifying emotion in other people's faces
   e. Identifying one's sense of self

4. The dual-processing model refers to which of the following ideas?
   a. The right and left hemispheres of the brain both process incoming messages.
   b. Incoming information is processed by both conscious and unconscious tracks.
   c. Each lobe of the brain processes incoming information.
   d. The brain first processes emotional information and then processes analytical information.
   e. The thalamus and hypothalamus work together to analyze incoming sensory information.

Practice FRQs

1. Brain lateralization means that each hemisphere has its own functions. Give an example of both a left hemisphere and a right hemisphere function. Then explain how the two hemispheres communicate with one another.

Answer

1 point: Left hemisphere functions include language, math, and logic.

1 point: Right hemisphere functions include spatial relationships, facial recognition, and patterns.

1 point: The corpus callosum carries information back and forth between the two hemispheres.

2. Because Jerry suffered severe seizures, his neurosurgeon decided to "split his brain." What does this mean? How might a psychologist use people who have had split-brain surgery to determine the location of speech control?

(3 points)

Module 14

Behavior Genetics: Predicting Individual Differences


Michael Tullberg/Getty Images

Module Learning Objectives

14-1 Define *genes*, and describe how behavior geneticists explain our individual differences.

14-2 Identify the potential uses of molecular genetics research.

14-3 Explain what is meant by heritability, and discuss how it relates to individuals and groups.

14-4 Discuss the interaction of heredity and environment.

Behind the story of our human brain—surely the most awesome thing on Earth—is the essence of our universal human attributes and our individual traits. What makes you *you?* In important ways, we are each unique. We look different. We sound different. We have varying personalities, interests, and cultural and family backgrounds.

We are also the leaves of one tree. Our human family shares not only a common biological heritage—cut us and we bleed—but also common behavioral tendencies. Our shared brain architecture predisposes us to sense the world, develop language, and feel hunger through identical mechanisms. Whether we live in the Arctic or the tropics, we prefer sweet tastes to sour. We divide the color spectrum into similar colors. And we feel drawn to behaviors that produce and protect offspring.

Our kinship appears in our social behaviors as well. Whether named Wong, Nkomo, Smith, or Gonzales, we start fearing strangers at about eight months, and as adults we prefer the company of those with attitudes and attributes similar to our own. Coming from different parts of the globe, we know how to read one another's smiles and frowns. As members of one species, we affiliate, conform, return favors, punish offenses, organize hierarchies of status, and grieve a child's death. A visitor from outer space could drop in anywhere and find humans dancing and feasting, singing and worshipping, playing sports and games, laughing and crying, living in families and forming groups. Taken together, such universal behaviors define our human nature.

What causes our striking diversity, and also our shared human nature? How much are human differences shaped by our differing genes? And how much by our *environment*—by every external influence, from maternal nutrition while in the womb to social support while nearing the tomb? To what extent are we formed by our upbringing? By our culture? By our current circumstances? By people's reactions to our genetic dispositions? This module and the next begin to tell the complex story of how our genes (nature) and environments (nurture) define us.


Courtesy of Kevin Feyen

The nurture of nature Parents everywhere wonder: Will my baby grow up to be peaceful or aggressive? Homely or attractive? Successful or struggling at every step? What comes built in, and what is nurtured—and how? Research reveals that nature and nurture together shape our development—every step of the way.

behavior genetics the study of the relative power and limits of genetic and environmental influences on behavior.

environment every external influence, from prenatal nutrition to the people and things around us.

chromosomes threadlike structures made of DNA molecules that contain the genes.

DNA *(deoxyribonucleic acid)* a complex molecule containing the genetic information that makes up the chromosomes.

genes the biochemical units of heredity that make up the chromosomes; segments of DNA capable of synthesizing proteins.

genome the complete instructions for making an organism, consisting of all the genetic material in that organism's chromosomes.

Genes: Our Codes for Life

14-1 What are genes, and how do behavior geneticists explain our individual differences?

If Jaden Agassi, son of tennis stars Andre Agassi and Steffi Graf, grows up to be a tennis star, should we attribute his superior talent to his Grand Slam genes? To his growing up in a tennis-rich environment? To high expectations? Such questions intrigue **behavior geneticists,** who study our differences and weigh the effects and interplay of heredity and **environment.**

Barely more than a century ago, few would have guessed that every cell nucleus in your body contains the genetic master code for your entire body. It's as if every room in Dubai's Burj Khalifa (the world's tallest building) had a book containing the architect's plans for the entire structure. The plans for your own book of life run to 46 chapters—23 donated by your mother's egg and 23 by your father's sperm. Each of these 46 chapters, called a **chromosome,** is composed of a coiled chain of the molecule **DNA** *(deoxyribonucleic acid).* **Genes,** small segments of the giant DNA molecules, form the words of those chapters (**FIGURE 14.1**). All told, you have 20,000 to 25,000 genes. Genes can be either active *(expressed)* or inactive. Environmental events "turn on" genes, rather like hot water enabling a tea bag to express its flavor. When turned on, genes provide the code for creating *protein molecules,* our body's building blocks.

Genetically speaking, every other human is nearly your identical twin. Human **genome** researchers have discovered the common sequence within human DNA. It is this shared genetic profile that makes us humans, rather than chimpanzees or tulips.

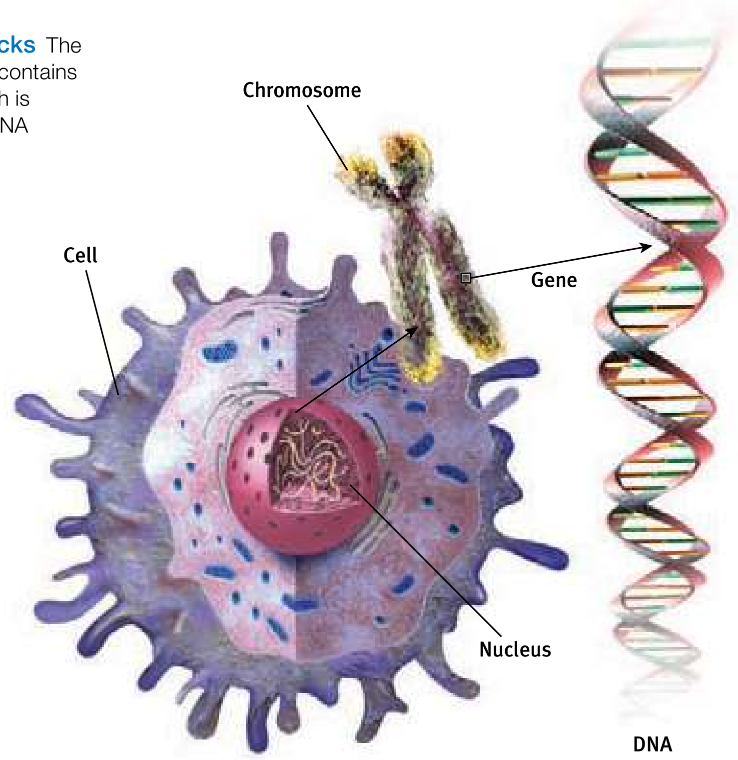
Actually, we aren't all that different from our chimpanzee cousins; with them we share about 96 percent of our DNA sequence (Mikkelsen et al., 2005). At "functionally important" DNA sites, reported one molecular genetics team, the human-chimpanzee DNA similarity is 99.4 percent (Wildman et al., 2003). Yet that wee difference matters. Despite

"Your DNA and mine are 99.9 percent the same. . . . At the DNA level, we are clearly all part of one big worldwide family." -Francis Collins, Human Genome Project director, 2007

"Thanks for almost everything, Dad."

Figure 14.1

The human building blocks The nucleus of every human cell contains chromosomes, each of which is made up of two strands of DNA connected in a double helix.



some remarkable abilities, chimpanzees grunt. Shakespeare intricately wove 17,677 words to form his literary masterpieces.

Small differences matter among chimpanzees, too. Two species, common chimpanzees and bonobos, differ by much less than 1 percent of their genomes, yet they display markedly differing behaviors. Chimpanzees are aggressive and male dominated. Bonobos are peaceable and female led.

Geneticists and psychologists are interested in the occasional variations found at particular gene sites in human DNA. Slight person-to-person variations from the common pattern give clues to our uniqueness—why one person has a disease that another does not, why one person is short and another tall, why one is outgoing and another shy.

Most of our traits are influenced by many genes. How tall you are, for example, reflects the size of your face, vertebrae, leg bones, and so forth—each of which may be influenced by different genes interacting with your environment. Complex traits such as intelligence, happiness, and aggressiveness are similarly influenced by groups of genes. Thus our genetic predispositions—our genetically influenced traits—help explain both our shared human nature and our human diversity.

"We share half our genes with the banana." -Evolutionary biologist Robert May, president of Britain's Royal Society, 2001

Twin and Adoption Studies

To scientifically tease apart the influences of environment and heredity, behavior geneticists would need to design two types of experiments. The first would control the home environment while varying heredity. The second would control heredity while varying the home environment. Such experiments with human infants would be unethical, but happily for our purposes, nature has done this work for us.

identical twins *(monozygotic twins)* twins who develop from a single fertilized egg that splits in two, creating two genetically identical organisms.

fraternal twins *(dizygotic twins)* twins who develop from separate fertilized eggs. They are genetically no closer than brothers and sisters, but they share a fetal environment.

Identical Versus Fraternal Twins

Identical *(monozygotic)* **twins** develop from a single fertilized egg that splits in two. Thus they are *genetically* identical—nature's own human clones (**FIGURE 14.2**). Indeed, they are clones who share not only the same genes but the same conception and uterus, and usually the same birth date and cultural history. Two slight qualifications:

- Although identical twins have the same genes, they don't always have the same *number of copies* of those genes. That helps explain why one twin may be more at risk for certain illnesses (Bruder et al., 2008).
- Most identical twins share a placenta during prenatal development, but one of every three sets has two separate placentas. One twin's placenta may provide slightly better nourishment, which may contribute to identical twin differences (Davis et al., 1995; Phelps et al., 1997; Sokol et al., 1995).

Fraternal *(dizygotic)* **twins** develop from separate fertilized eggs. As womb-mates, they share a fetal environment, but they are genetically no more similar than ordinary brothers and sisters.

Shared genes can translate into shared experiences. A person whose identical twin has Alzheimer's disease, for example, has a 60 percent risk of getting the disease; if the affected twin is fraternal, the risk is 30 percent (Plomin et al., 1997). To study the effects of genes and environments, hundreds of researchers have studied some 800,000 identical and fraternal twin pairs (Johnson et al., 2009).

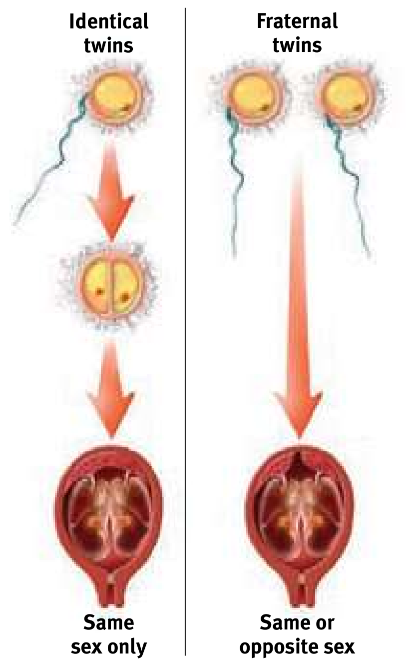


Figure 14.2
Same fertilized egg, same genes; different eggs, different genes Identical twins develop from a single fertilized egg, fraternal twins from two.

Ethel Wolvitz/The Image Works

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Belinda Images/SuperStock

More twins Curiously, twinning rates vary by race. The rate among Caucasians is roughly twice that of Asians and half that of Africans. In Africa and Asia, most twins are identical. In Western countries, most twins are fraternal, and fraternal twins are increasing with the use of fertility drugs (Hall, 2003; Steinhauer, 1999).

Are identical twins, being genetic clones of each other, also behaviorally more similar than fraternal twins? Studies of thousands of twin pairs in Sweden, Finland, and Australia find that on both extraversion (outgoingness) and neuroticism (emotional instability), identical twins are much more similar than fraternal twins. If genes influence traits such as emotional instability, might they also influence the social effects of such traits? To find out, researchers studied divorce rates among 1500 same-sex, middle-aged twin pairs (McGue & Lykken, 1992). Their result: If you have a fraternal twin who has divorced, the odds of your divorcing are 1.6 times greater than if you have a not-divorced twin. If you have an identical twin who has divorced, the odds of your divorcing are 5.5 times greater. From such data, the researchers estimate that people's differing divorce risks are about 50 percent attributable to genetic factors.

Identical twins, more than fraternal twins, also report being treated alike. So, do their experiences rather than their genes account for their similarity? *No*. Studies have shown that identical twins whose parents treated them alike were not psychologically more alike than identical twins who were treated less similarly (Loehlin & Nichols, 1976). In explaining individual differences, genes matter.

Separated Twins

Imagine the following science fiction experiment: A mad scientist decides to separate identical twins at birth, then rear them in differing environments. Better yet, consider a *true* story:

On a chilly February morning in 1979, some time after divorcing his first wife, Linda, Jim Lewis awoke in his modest home next to his second wife, Betty. Determined that this marriage would work, Jim made a habit of leaving love notes to Betty around the house. As he lay in bed he thought about others he had loved, including his son, James Alan, and his faithful dog, Toy.

Jim was looking forward to spending part of the day in his basement woodworking shop, where he had put in many happy hours building furniture, picture frames, and other items, including a white bench now circling a tree in his front yard. Jim also liked to spend free time driving his Chevy, watching stock-car racing, and drinking Miller Lite beer.

Jim was basically healthy, except for occasional half-day migraine headaches and blood pressure that was a little high, perhaps related to his chain-smoking habit. He had become overweight a while back but had shed some of the pounds. Having undergone a vasectomy, he was done having children.

What was extraordinary about Jim Lewis, however, was that at that same moment (I am not making this up) there existed another man—also named Jim—for whom all these things (right down to the dog's name) were also true.[1] This other Jim—Jim Springer—just happened, 38 years earlier, to have been his fetal partner. Thirty-seven days after their birth, these genetically identical twins were separated, adopted by blue-collar families, and reared with no contact or knowledge of each other's whereabouts until the day Jim Lewis received a call from his genetic clone (who, having been told he had a twin, set out to find him).

FYI

Sweden has the world's largest national twin registry—140,000 living and dead twin pairs—which forms part of a massive registry of 600,000 twins currently being sampled in the world's largest twin study (Wheelwright, 2004; www.genomeutwin.org).

FYI

Twins Lorraine and Levinia Christmas, driving to deliver Christmas presents to each other near Flitcham, England, collided (Shepherd, 1997).

"In some domains it looks as though our identical twins reared apart are . . . just as similar as identical twins reared together. Now that's an amazing finding and I can assure you none of us would have expected that degree of similarity."
-Thomas Bouchard (1981)

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[1] Actually, this description of the two Jims errs in one respect: Jim Lewis named his son James Alan. Jim Springer named his James Allan.

One month later, the brothers became the first twin pair tested by University of Minnesota psychologist Thomas Bouchard and his colleagues, beginning a study of separated twins that extends to the present (Holden, 1980a,b; Wright, 1998). Their voice intonations and inflections were so similar that, hearing a playback of an earlier interview, Jim Springer guessed "That's me." Wrong—it was his brother. Given tests measuring their personality, intelligence, heart rate, and brain waves, the Jim twins—despite 38 years of separation—were virtually as alike as the same person tested twice. Both married women named Dorothy Jane Scheckelburger. Okay, the last item is a joke. But as Judith Rich Harris (2006) notes, it is hardly weirder than some other reported similarities.

Aided by publicity in magazine and newspaper stories, Bouchard (2009) and his colleagues located and studied 74 pairs of identical twins reared apart. They continued to find similarities not only of tastes and physical attributes but also of personality (characteristic patterns of thinking, feeling, and acting), abilities, attitudes, interests, and even fears.

In Sweden, Nancy Pedersen and her co-workers (1988) identified 99 separated identical twin pairs and more than 200 separated fraternal twin pairs. Compared with equivalent samples of identical twins reared together, the separated identical twins had somewhat less identical personalities. Still, separated twins were more alike if genetically identical than if fraternal. And separation shortly after birth (rather than, say, at age 8) did not amplify their personality differences.

Stories of startling twin similarities do not impress Bouchard's critics, who remind us that "the plural of *anecdote* is not *data.*" They contend that if any two strangers were to spend hours comparing their behaviors and life histories, they would probably discover many coincidental similarities. If researchers created a control group of biologically unrelated pairs of the same age, sex, and ethnicity, who had not grown up together but who were as similar to one another in economic and cultural background as are many of the separated twin pairs, wouldn't these pairs also exhibit striking similarities (Joseph, 2001)? Bouchard replies that separated fraternal twins do not exhibit similarities comparable to those of separated identical twins.

Even the more impressive data from personality assessments are clouded by the reunion of many of the separated twins some years before they were tested. Moreover, identical twins share an appearance, and the responses it evokes. Adoption agencies also tend to place separated twins in similar homes. Despite these criticisms, the striking twin-study results helped shift scientific thinking toward a greater appreciation of genetic influences.

FYI

Bouchard's famous twin research was, appropriately enough, conducted in Minneapolis, the "Twin City" (with St. Paul), and home to the Minnesota Twins baseball team.

FYI

Coincidences are not unique to twins. Patricia Kern of Colorado was born March 13, 1941, and named Patricia Ann Campbell. Patricia DiBiasi of Oregon also was born March 13, 1941, and named Patricia Ann Campbell. Both had fathers named Robert, worked as bookkeepers, and at the time of this comparison had children ages 21 and 19. Both studied cosmetology, enjoyed oil painting as a hobby, and married military men, within 11 days of each other. They are not genetically related. (From an AP report, May 2, 1983.)

St. Bonaventure University

The twin friars Julian and Adrian Reister—two "quiet, gentle souls"—both died of heart failure, at age 92, on the same day in 2011.

Biological Versus Adoptive Relatives

For behavior geneticists, nature's second real-life experiment—adoption—creates two groups: *genetic relatives* (biological parents and siblings) and *environmental relatives* (adoptive parents and siblings). For any given trait, we can therefore ask whether adopted children are more like their biological parents, who contributed their genes, or their adoptive parents, who contribute a home environment. While sharing that home environment, do adopted siblings also come to share traits?

The stunning finding from studies of hundreds of adoptive families is that people who grow up together, whether biologically related or not, do not much resemble one another in personality (McGue & Bouchard, 1998; Plomin, 2011; Rowe, 1990). In traits such as extraversion and agreeableness, adoptees are more similar to their biological parents than to their caregiving adoptive parents.

"We carry to our graves the essence of the zygote that was first us." -Mary Pipher, *Seeking Peace: Chronicles of the Worst Buddhist in the World*, 2009

The finding is important enough to bear repeating: *The environment shared by a family's children has virtually no discernible impact on their personalities.* Two adopted children reared in the same home are no more likely to share personality traits with each other than with the child down the block. Heredity shapes other primates' personalities, too. Macaque monkeys raised by foster mothers exhibit social behaviors that resemble their biological, rather than foster, mothers (Maestripieri, 2003). Add all this to the similarity of identical twins, whether they grow up together or apart, and the effect of a shared rearing environment seems shockingly modest.

"Mom may be holding a full house while Dad has a straight flush, yet when Junior gets a random half of each of their cards his poker hand may be a loser." -David Lykken (2001)

What we have here is perhaps "the most important puzzle in the history of psychology," contended Steven Pinker (2002): *Why are children in the same family so different?* Why does shared family environment have so little effect on children's personalities? Is it because each sibling experiences unique peer influences and life events? Because sibling relationships ricochet off each other, amplifying their differences? Because siblings—despite sharing half their genes—have very different combinations of genes and may evoke very different kinds of parenting? Such questions fuel behavior geneticists' curiosity.

The minimal shared-environment effect does not mean that adoptive parenting is a fruitless venture. The genetic leash may limit the family environment's influence on personality, but parents do influence their children's attitudes, values, manners, faith, and politics (Reifman & Cleveland, 2007). A pair of adopted children or identical twins *will,* especially during adolescence, have more similar religious beliefs if reared together (Koenig et al., 2005). Parenting matters!

FYI

The greater uniformity of adoptive homes—mostly healthy, nurturing homes—helps explain the lack of striking differences when comparing child outcomes of different adoptive homes (Stoolmiller, 1999).

Moreover, in adoptive homes, child neglect and abuse and even parental divorce are rare. (Adoptive parents are carefully screened; natural parents are not.) So it is not surprising that, despite a somewhat greater risk of psychological disorder, most adopted children thrive, especially when adopted as infants (Loehlin et al., 2007; van IJzendoorn & Juffer, 2006; Wierzbicki, 1993). Seven in eight report feeling strongly attached to one or both adoptive parents. As children of self-giving parents, they grow up to be more self-giving and altruistic than average (Sharma et al., 1998). Many score higher than their biological parents on intelligence tests, and most grow into happier and more stable adults. In one Swedish study, infant adoptees grew up with fewer problems than were experienced by children whose biological mothers had initially registered them for adoption but then decided to raise the children themselves (Bohman & Sigvardsson, 1990). Regardless of personality differences between parents and their adoptees, most children benefit from adoption.

LUIS ACOSTA/AFP/Getty Images

Nature or nurture or both? When talent runs in families, as with the Williams sisters for tennis, how do heredity and environment together do their work?

The New Frontier: Molecular Genetics

14-2 What is the promise of molecular genetics research?

Behavior geneticists have progressed beyond asking, "Do genes influence behavior?" The new frontier of behavior-genetics research draws on "bottom-up" **molecular genetics** as it seeks to identify *specific genes* influencing behavior.

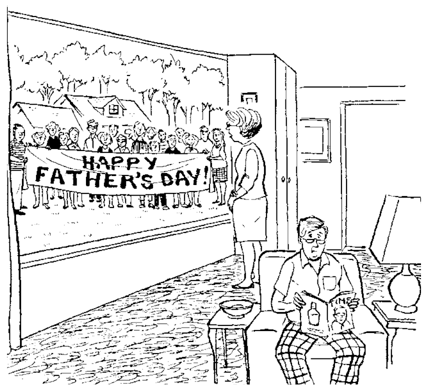
molecular genetics the subfield of biology that studies the molecular structure and function of genes.

As we have already seen, most human traits are influenced by teams of genes. For example, twin and adoption studies tell us that heredity influences body weight, but there is no single "obesity gene." More likely, some genes influence how quickly the stomach tells the brain, "I'm full." Others might dictate how much fuel the muscles need, how many calories are burned off by fidgeting, and how efficiently the body converts extra calories into fat (Vogel, 1999). Given that genes typically are not solo players, a goal of *molecular behavior genetics* is to find some of the many genes that together orchestrate traits such as body weight, sexual orientation, and extraversion (Holden, 2008; Tsankova et al., 2007).

Genetic tests can now reveal at-risk populations for many dozens of diseases. The search continues in labs worldwide, where molecular geneticists are teaming with psychologists to pinpoint genes that put people at risk for such genetically influenced disorders as learning disorder, depression, schizophrenia, and alcohol use disorder. (In Module 67, for example, we will take note of a worldwide research effort to sleuth the genes that make people vulnerable to the emotional swings of bipolar disorder, formerly called manic-depressive disorder.) To tease out the implicated genes, molecular behavior geneticists find families that have had the disorder across several generations. They draw blood or take cheek swabs from both affected and unaffected family members. Then they examine their DNA, looking for differences. "The most powerful potential for DNA," note Robert Plomin and John Crabbe (2000), "is to predict risk so that steps can be taken to prevent problems before they happen."

Aided by inexpensive DNA-scanning techniques, medical personnel are becoming able to give would-be parents a readout on how their fetus' genes differ from the normal pattern and what this might mean. With this benefit come risks. Might labeling a fetus "at risk for a learning disorder" lead to discrimination? Prenatal screening poses ethical dilemmas. In China and India, where boys are highly valued, testing for an offspring's sex has enabled selective abortions resulting in millions—yes, millions—of "missing women."

Assuming it were possible, should prospective parents take their eggs and sperm to a genetics lab for screening before combining them to produce an embryo? Should we enable parents to screen their fertilized eggs for health—and for brains or beauty? Progress is a double-edged sword, raising both hopeful possibilities and difficult problems. By selecting out certain traits, we may deprive ourselves of future Handels and van Goghs, Churchills and Lincolns, Tolstoys and Dickinsons—troubled people all.



"I thought that sperm-bank donors remained anonymous."

Heritability

14-3 What is heritability, and how does it relate to individuals and groups?

Using twin and adoption studies, behavior geneticists can mathematically estimate the **heritability** of a trait—the extent to which variation among individuals can be attributed to their differing genes. As Modules 63 and 64 will emphasize, if the heritability of intelligence is, say, 50 percent, this does *not* mean that *your* intelligence is 50 percent genetic. (The heritability of height is 90 percent, but this does not mean that a 60-inch-tall woman can credit

heritability the proportion of variation among individuals that we can attribute to genes. The heritability of a trait may vary, depending on the range of populations and environments studied.

AP® Exam Tip

Heritability is likely to show up on the AP® exam because it's confusing. The key thing to remember is that heritability refers to variation within a group. It does not refer to the impact of nature on an individual. Be clear on both what it is and what it isn't.

her genes for 54 inches and her environment for the other 6 inches.) Rather, it means that genetic influence explains 50 percent of the observed *variation among people.* This point is so often misunderstood that I repeat: We can never say what percentage of an *individual's* personality or intelligence is inherited. It makes no sense to say that your personality is due *x* percent to your heredity and *y* percent to your environment. Heritability refers instead to the extent to which *differences among people* are attributable to genes.

Even this conclusion must be qualified, because heritability can vary from study to study. Consider humorist Mark Twain's (1835–1910) fantasy of raising boys in barrels to age 12, feeding them through a hole. If we were to follow his suggestion, the boys would all emerge with lower-than-normal intelligence scores at age 12. Yet, given their equal environments, their test score differences could be explained only by their heredity. In this case, heritability—differences due to genes—would be near 100 percent.

As environments become more similar, heredity as a source of differences necessarily becomes more important. If all schools were of uniform quality, all families equally loving, and all neighborhoods equally healthy, then heritability would *increase* (because differences due to environment would *decrease*). At the other extreme, if all people had similar heredities but were raised in drastically different environments (some in barrels, some in luxury homes), heritability would be much lower.

"The title of my science project is 'My Little Brother: Nature or Nurture.'"

Can we extend this thinking to differences between groups? If genetic influences help explain individual diversity in traits such as aggressiveness, for example, can the same be said of group differences between men and women, or between people of different races? Not necessarily. Individual differences in height and weight, for example, are highly heritable; yet nutritional rather than genetic influences explain why, as a group, today's adults are taller and heavier than those of a century ago. The two groups differ, but not because human genes have changed in a mere century's eyeblink of time. Although height is 90 percent heritable, South Koreans, with their better diets, average six inches taller than North Koreans, who come from the same genetic stock (Johnson et al., 2009).

As with height and weight, so with personality and intelligence scores: Heritable individual differences need not imply heritable group differences. If some individuals are genetically disposed to be more aggressive than others, that needn't explain why some groups are more aggressive than others. Putting people in a new social context can change their aggressiveness. Today's peaceful Scandinavians carry many genes inherited from their Viking warrior ancestors.

Gene-Environment Interaction

14-4 How do heredity and environment work together?

Among our similarities, the most important—the behavioral hallmark of our species—is our enormous adaptive capacity. Some human traits, such as having two eyes, develop the same in virtually every environment. But other traits are expressed only in particular environments. Go barefoot for a summer and you will develop toughened, callused feet—a biological adaptation to friction. Meanwhile, your shod neighbor will remain a tenderfoot. The difference between the two of you is, of course, an effect of environment. But it is also the product of a biological mechanism—adaptation. Our shared biology enables our developed diversity (Buss, 1991).

"Men's natures are alike; it is their habits that carry them far apart."
-Confucius, *Analects*, 500 B.C.E.

An analogy may help: Genes and environment—nature and nurture—work together like two hands clapping. Genes are *self-regulating.* Rather than acting as blueprints that lead to the same result no matter the context, genes react. An African butterfly that is green in summer turns brown in fall, thanks to a temperature-controlled genetic switch. The genes that produce brown in one situation produce green in another. So, too, people with identical genes but differing experiences will have similar but not identical minds. One twin may fall in love with someone quite different from the co-twin's love.

Asking whether our personality is more a product of our genes or our environment is like asking whether the area of a field is more the result of its length or its width. We could, however, ask whether the differing areas of various fields are more the result of *differences* in their length or their width, and also whether person-to-person personality differences are influenced more by nature or nurture.


Dim154/Shutterstock

"Heredity deals the cards; environment plays the hand."
-Psychologist Charles L. Brewer (1990)

To say that genes and experience are *both* important is true. But more precisely, they **interact.** Imagine two babies, one genetically predisposed to be attractive, sociable, and easygoing, the other less so. Assume further that the first baby attracts more affectionate and stimulating care and so develops into a warmer and more outgoing person. As the two children grow older, the more naturally outgoing child more often seeks activities and friends that encourage further social confidence.

interaction the interplay that occurs when the effect of one factor (such as environment) depends on another factor (such as heredity).

epigenetics the study of environmental influences on gene expression that occur without a DNA change.

What has caused their resulting personality differences? Neither heredity nor experience dances alone. Environments trigger gene activity. And our genetically influenced traits *evoke* significant responses in others. Thus, a child's impulsivity and aggression may evoke an angry response from a teacher who reacts warmly to the child's model classmates. Parents, too, may treat their own children differently; one child elicits punishment, another does not. In such cases, the child's nature and the parents' nurture interact. Neither operates apart from the other. Gene and scene dance together.

Evocative interactions may help explain why identical twins reared in different families recall their parents' warmth as remarkably similar—almost as similar as if they had had the same parents (Plomin et al., 1988, 1991, 1994). Fraternal twins have more differing recollections of their early family life—even if reared in the same family! "Children experience us as different parents, depending on their own qualities," noted Sandra Scarr (1990). Moreover, a selection effect may be at work. As we grow older, we select environments well suited to our natures.

Recall that genes can be either active (expressed, as the hot water activates the tea bag) or inactive. A new field, **epigenetics** (meaning "in addition to" or "above and beyond" genetics), is studying the molecular mechanisms by which environments trigger genetic expression. Although genes have the potential to influence development, environmental triggers can switch them on or off, much as your computer's software directs your printer. One such *epigenetic mark* is an organic methyl molecule attached to part of a DNA strand (**FIGURE 14.3**). It instructs the cell to ignore any gene present in that DNA segment, thereby preventing the DNA from producing the proteins coded by that gene.

Environmental factors such as diet, drugs, and stress can affect the epigenetic molecules that regulate gene expression. In one experiment, infant rats deprived of their mothers' normal licking had more molecules that blocked

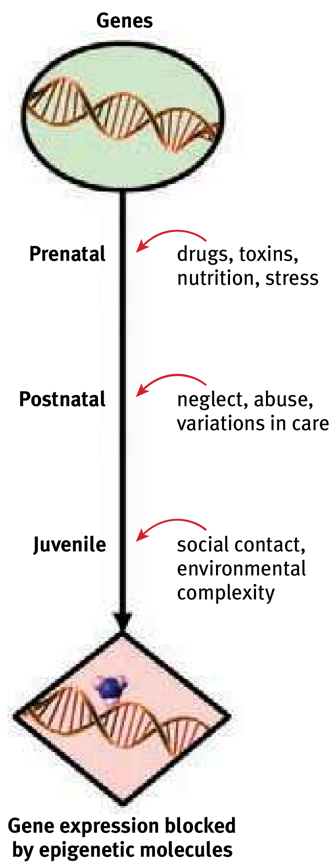


Figure 14.3
Epigenetics influences gene expression Life experiences beginning in the womb lay down *epigenetic marks*—often organic methyl molecules—that can block the expression of any gene in the associated DNA segment (from Champagne, 2010).

Gene-environment interaction Biological appearances have social consequences. People respond differently to recording artist Nicki Minaj and concert violinist Hilary Hahn.

FilmMagic/Getty Images

Saverkin Alexsander/TAR-TASS/Landov

access to the "on" switch for developing the brain's stress hormone receptors. When stressed, the animals had more free-floating stress hormones and were more stressed out (Champagne et al., 2003; Champagne & Mashoodh, 2009). Child abuse may similarly affect its victims. Humans who have committed suicide exhibit the same epigenetic effect if they had suffered a history of child abuse (McGowan et al., 2009). Researchers now wonder if epigenetics might help solve some scientific mysteries, such as why only one member of an identical twin pair may develop a genetically influenced mental disorder, and how experience leaves its fingerprints in our brains.

So, from conception onward, we are the product of a cascade of interactions between our genetic predispositions and our surrounding environments (McGue, 2010). Our genes affect how people react to and influence us. Biological appearances have social consequences. So, forget nature *versus* nurture; think nature *via* nurture.

Before You Move On

► ASK YOURSELF

Would you want genetic tests on your unborn offspring? What would you do if you knew your child would be destined for hemophilia (a medical condition that interferes with blood clotting)? A specific learning disorder? A high risk of depression? Do you think society would benefit or lose if such embryos were aborted?

► TEST YOURSELF

What is *heritability*?

Answers to the Test Yourself questions can be found in Appendix E at the end of the book.

Module 14 Review

14-1 What are genes, and how do behavior geneticists explain our individual differences?

- *Genes* are the biochemical units of heredity that make up *chromosomes,* the threadlike coils of *DNA.*
- When genes are "turned on" (expressed), they provide the code for creating the proteins that form our body's building blocks.
- Most human traits are influenced by many genes acting together.
- *Behavior geneticists* seek to quantify genetic and *environmental* influences on our traits, in part through studies of *identical* (monozygotic) *twins, fraternal* (dizygotic) *twins,* and adoptive families.
- Shared family environments have little effect on personality, and the stability of personality suggests a genetic predisposition.

14-2 What is the promise of molecular genetics research?

- *Molecular geneticists* study the molecular structure and function of genes, including those that affect behavior.
- Psychologists and molecular geneticists are cooperating to identify specific genes—or more often, teams of genes—that put people at risk for disorders.

14-3 What is heritability, and how does it relate to individuals and groups?

- *Heritability* describes the extent to which variation among members of a group can be attributed to genes.
- Heritable individual differences (in traits such as height or intelligence) do not necessarily imply heritable group differences. Genes mostly explain why some people are taller than others, but not why people are taller today than they were a century ago.

14-4 How do heredity and environment work together?

- Our genetic predispositions and our surrounding environments *interact.* Environments can trigger gene activity, and genetically influenced traits can evoke responses from others.
- The field of *epigenetics* studies the influences on gene expression that occur without changes in DNA.

Multiple-Choice Questions

1. Human genome (DNA) researchers have discovered that

a. chimpanzees are completely different than humans, sharing a small DNA sequence percentage.
b. the occasional variations found at particular gene sites in human DNA are of no interest to science.
c. many genes do not influence most of our traits.
d. nearly every other human is your genetically identical twin.
e. genetic predispositions do not help explain our shared human nature and our human diversity.

2. One reason that identical twins might show slight differences at birth is

a. they did not develop from a single fertilized egg.
b. one twin's placenta may have provided slightly better nourishment.
c. they develop from different sperm.
d. one twin gestated much longer in the uterus than the other.
e. their relative positions in the uterus.

3. Generally speaking, heritability is the extent to which

a. differences among people are accounted for by genes.
b. an individual's specific traits are due to genes or the environment.
c. differences among people are due to the environment.
d. differences among people are due to their cultural heritage.
e. an individual's height is related to the height of his or her parents.

4. Which of the following is most closely associated with the idea of epigenetics?

a. Eye color
b. Gene display based on environmental factors
c. IQ as a function of educational experiences
d. Height at birth
e. Shoe size

5. Which of the following is an example of gene-environment interaction?

a. Yeh Lin experiences flushing syndrome, which mostly occurs in those of Asian heritage.
b. Alfonso gets food poisoning from eating undercooked meat.
c. Ted gets diabetes, which runs in his family, because he eats too much sugary food.
d. Samantha has a food allergy to shellfish.
e. Jordan has an autoimmune disorder that causes him to lose hair.

Practice FRQs

1. Explain the two positions in the nature–nurture debate.

Answer (2 points)

1 point: Nature refers to the contributions of heredity and inborn, biologically determined aspects of behavior and mental processes.

1 point: Nurture refers to the contributions of environment and the way individuals are raised.

2. What does it mean to say that the heritability of height is 90 percent? What does that tell us about the contribution of genetics to any one person's height?

(2 points)

Module 15

Evolutionary Psychology: Understanding Human Nature


Chris Johnson/Dreamstime.com

Module Learning Objectives

15-1 Describe evolutionary psychologists' use of natural selection to explain behavior tendencies.

15-2 Discuss evolutionary explanations for gender differences in sexuality and mating preferences.

15-3 Summarize the key criticisms of evolutionary psychology, and describe how evolutionary psychologists respond.

15-4 Describe the biopsychosocial approach to individual development.

15-1 How do evolutionary psychologists use natural selection to explain behavior tendencies?

Behavior geneticists explore the genetic and environmental roots of human differences. **Evolutionary psychologists** instead focus mostly on what makes us so much alike. They use Charles Darwin's principle of natural selection to understand the roots of behavior and mental processes. Richard Dawkins (2007) calls **natural selection** "arguably the most momentous idea ever to occur to a human mind." The idea, simplified, is this:

- Organisms' varied offspring compete for survival.
- Certain biological and behavioral variations increase organisms' reproductive and survival chances in their particular environment.
- Offspring that survive are more likely to pass their genes to ensuing generations.
- Thus, over time, population characteristics may change.

To see these principles at work, let's consider a straightforward example in foxes.

evolutionary psychology the study of the evolution of behavior and the mind, using principles of natural selection.

natural selection the principle that, among the range of inherited trait variations, those contributing to reproduction and survival will most likely be passed on to succeeding generations.

Natural Selection and Adaptation

A fox is a wild and wary animal. If you capture a fox and try to befriend it, be careful. Stick your hand in the cage and, if the timid fox cannot flee, it may snack on your fingers. Russian scientist Dmitry Belyaev wondered how our human ancestors had domesticated dogs from their equally wild wolf forebears. Might he, within a comparatively short stretch of time, accomplish a similar feat by transforming the fearful fox into a friendly fox?


Eric Isselée/Shutterstock

To find out, Belyaev set to work with 30 male and 100 female foxes. From their offspring he selected and mated the tamest 5 percent of males and 20 percent of females. (He measured tameness by the foxes' responses to attempts to feed, handle, and stroke them.) Over more than 30 generations of foxes, Belyaev and his successor, Lyudmila Trut, repeated that simple procedure. Forty years and 45,000 foxes later, they had a new breed of foxes that, in Trut's (1999) words, are "docile, eager to please, and unmistakably domesticated. . . . Before our eyes, 'the Beast' has turned into 'beauty,' as the aggressive behavior of our herd's wild [ancestors] entirely disappeared." So friendly and eager for human contact are they, so inclined to whimper to attract attention and to lick people like affectionate dogs, that the cash-strapped institute seized on a way to raise funds—marketing its foxes to people as house pets.

Over time, traits that are *selected* confer a reproductive advantage on an individual or a species and will prevail. Animal breeding experiments manipulate genetic selection and show its powers. Dog breeders have given us sheepdogs that herd, retrievers that retrieve, trackers that track, and pointers that point (Plomin et al., 1997). Psychologists, too, have bred animals to be serene or reactive, quick learners or slow.

mutation a random error in gene replication that leads to a change.

Does the same process work with naturally occurring selection? Does natural selection explain our human tendencies? Nature has indeed selected advantageous variations from the new gene combinations produced at each human conception and the **mutations** (random errors in gene replication) that sometimes result. But the tight genetic leash that predisposes a dog's retrieving, a cat's pouncing, or an ant's nest building is looser on humans. The genes selected during our ancestral history provide more than a long leash; they endow us with a great capacity to learn and therefore to *adapt* to life in varied environments, from the tundra to the jungle. Genes and experience together wire the brain. Our adaptive flexibility in responding to different environments contributes to our *fitness*—our ability to survive and reproduce.

Evolutionary Success Helps Explain Similarities

Although our person-to-person differences grab attention, we humans are also strikingly alike. As brothers and sisters in one great human family, we all wake and sleep, think and speak, hunger and thirst. We smile when happy and favor what's familiar more than what is foreign. We return favors, fear snakes, grieve death, and, as social animals, have a need to belong. Beneath our differing skin, we all are kin. Evolutionary psychologist Steven Pinker (2002, p. 73) has noted that it is no wonder our emotions, drives, and reasoning "have a common logic across cultures": Our shared human traits "were shaped by natural selection acting over the course of human evolution."

Our Genetic Legacy

Our behavioral and biological similarities arise from our shared human *genome,* our common genetic profile. No more than 5 percent of the genetic differences among humans arise from population group differences. Some 95 percent of genetic variation exists *within* populations (Rosenberg et al., 2002). The typical genetic difference between two Icelandic villagers or between two Kenyans is much greater than the *average* difference between the two groups. Thus, if after a worldwide catastrophe only Icelanders or Kenyans survived, the human species would suffer only "a trivial reduction" in its genetic diversity (Lewontin, 1982).

And how did we develop this shared human genome? At the dawn of human history, our ancestors faced certain questions: Who is my ally, who my foe? What food should I eat? With whom should I mate? Some individuals answered those questions more successfully than others. For example, women who experienced nausea in the critical first three months of pregnancy were predisposed to avoid certain bitter, strongly flavored, and novel foods. Avoiding such foods has survival value, since they are the very foods most often toxic to embryonic development (Schmitt & Pilcher, 2004). Early humans disposed to eat nourishing rather than poisonous foods survived to contribute their genes to later generations. Those who deemed leopards "nice to pet" often did not.

Similarly successful were those whose mating helped them produce and nurture offspring. Over generations, the genes of individuals not so disposed tended to be lost from the human gene pool. As success-enhancing genes continued to be selected, behavioral tendencies and thinking and learning capacities emerged that prepared our Stone Age ancestors to survive, reproduce, and send their genes into the future, and into you.

Across our cultural differences, we even share "a universal moral grammar," notes evolutionary psychologist Marc Hauser (2006, 2009). Men and women, young and old, liberal and conservative, living in Sydney or Seoul, all respond negatively when asked, "If a lethal gas is leaking into a vent and is headed toward a room with seven people, is it okay to push someone into the vent—saving the seven but killing the one?" And they all respond more approvingly when asked if it's okay to allow someone to fall into the vent, again sacrificing one life but saving seven. Our shared moral instincts survive from a distant past where we lived in small groups in which direct harm-doing was punished, argues Hauser. For all such universal human tendencies, from our intense need to give parental care to our shared fears and lusts, evolutionary theory proposes a one-stop shopping explanation (Schloss, 2009).

As inheritors of this prehistoric genetic legacy, we are predisposed to behave in ways that promoted our ancestors' surviving and reproducing. But in some ways, we are biologically prepared for a world that no longer exists. We love the taste of sweets and fats, which prepared our ancestors to survive famines, and we heed their call from school cafeterias, fast-food outlets, and vending machines. With famine now rare in Western cultures, obesity is truly a growing problem. Our natural dispositions, rooted deep in history, are mismatched with today's junk-food environment and today's threats such as climate change (Colarelli & Dettman, 2003).

FYI

Despite high infant mortality and rampant disease in past millennia, not one of your countless ancestors died childless.

Evolutionary Psychology Today

Darwin's theory of evolution has been an organizing principle for biology for a long time. Jared Diamond (2001) noted, "Virtually no contemporary scientists believe that Darwin was basically wrong." Today, Darwin's theory lives on in the *second Darwinian revolution:* the application of evolutionary principles to psychology. In concluding *On the Origin of Species,* Darwin anticipated this, foreseeing "open fields for far more important researches. Psychology will be based on a new foundation" (1859, p. 346).

In modules to come, we'll address questions that intrigue evolutionary psychologists, such as why infants start to fear strangers about the time they become mobile. Why are biological fathers so much less likely than unrelated boyfriends to abuse and murder the children with whom they share a home? Why do so many more people have phobias about spiders, snakes, and heights than about more dangerous threats, such as guns and electricity? And why do we fear air travel so much more than driving?

To see how evolutionary psychologists think and reason, let's pause now to explore their answers to these two questions: How are men and women alike? How and why does men's and women's sexuality differ?

FYI

Those who are troubled by an apparent conflict between scientific and religious accounts of human origins may find it helpful to recall from Module 2 that different perspectives of life can be complementary. For example, the scientific account attempts to tell us *when* and *how;* religious creation stories usually aim to tell about an ultimate *who* and *why.* As Galileo explained to the Grand Duchess Christina, "The Bible teaches how to go to heaven, not how the heavens go."

An Evolutionary Explanation of Human Sexuality

15-2 How might an evolutionary psychologist explain gender differences in sexuality and mating preferences?

Having faced many similar challenges throughout history, men and women have adapted in similar ways. Whether male or female, we eat the same foods, avoid the same predators, and perceive, learn, and remember similarly. It is only in those domains where we have faced differing adaptive challenges—most obviously in behaviors related to reproduction—that we differ, say evolutionary psychologists.

What evolutionary psychologists study Each word's size in this "word cloud" shows how frequently it has appeared in evolutionary psychology article titles. (Derived by Gregory Webster, Peter Jonason, and Tatiana Schember [2009] from all articles published in *Evolution and Human Behavior* between 1979 and 2008.)

Webster, G. D., Jonason, P. K., & Schember, T. O. (2009). Hot topics and popular papers in evolutionary psychology: Analyses of title words and citation counts in *Evolution and Human Behavior*, 1979–2008. *Evolutionary Psychology, 7*, 348–362.

Gender Differences in Sexuality

And differ we do. Consider men's and women's sex drives. Who thinks more about sex? Masturbates more often? Initiates more sex? Views more pornography? The answers worldwide: *men, men, men,* and *men* (Baumeister et al., 2001; Lippa, 2009; Petersen & Hyde, 2009). No surprise, then, that in one BBC survey of more than 200,000 people in 53 nations, men everywhere more strongly agreed that "I have a strong sex drive" and "It doesn't take much to get me sexually excited" (Lippa, 2008).

Indeed, "with few exceptions anywhere in the world," reported cross-cultural psychologist Marshall Segall and his colleagues (1990, p. 244), "males are more likely than females to initiate sexual activity."

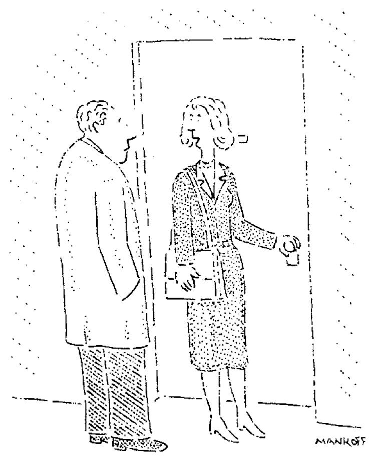
Men also have a lower threshold for perceiving warm responses as a sexual come-on. In study after study, men more often than women attribute a woman's friendliness to sexual interest (Abbey, 1987; Johnson et al., 1991). Misattributing women's cordiality as a come-on helps explain—but does not excuse—men's greater sexual assertiveness (Kolivas & Gross, 2007). The unfortunate results can range from sexual harassment to date rape.

Natural Selection and Mating Preferences

Evolutionary psychologists use natural selection to explain why—worldwide—women's approach to sex is usually more relational, and men's more recreational (Schmitt, 2005, 2007). The explanation goes like this: While a woman usually incubates and nurses one infant at a time, a male can spread his genes through other females. Our natural yearnings are our genes' way of reproducing themselves. In our ancestral history, women most often sent their genes into the future by pairing wisely, men by pairing widely. "Humans are living fossils—collections of mechanisms produced by prior selection pressures," said evolutionary psychologist David Buss (1995).

And what do heterosexual men and women find attractive in a mate? Some desired traits, such as a woman's youthful appearance, cross place and time (Buss, 1994). Evolutionary psychologists say that men who were drawn to healthy, fertile-appearing women—women with smooth skin and a youthful shape suggesting many childbearing years to come—stood a better chance of sending their genes into the future. And sure enough, men feel most attracted to women whose waists (thanks to their genes or their surgeons) are roughly a third narrower than their hips—a sign of future fertility (Perilloux et al., 2010). Moreover, just as evolutionary psychology predicts, men are most attracted to women whose ages in the ancestral past (when ovulation began later than today) would be associated with peak fertility (Kenrick et al., 2009). Thus, teen boys are most excited by a woman several years older than themselves, mid-twenties men prefer women around their own age, and older men prefer younger women. This pattern consistently appears across European singles ads, Indian marital ads, and marriage records from North and South America, Africa, and the Philippines (Singh, 1993; Singh & Randall, 2007).

Women, in turn, prefer stick-around dads over likely cads. They are attracted to men who seem mature, dominant, bold, and affluent, with a potential for long-term mating and investment in their joint offspring (Gangestad & Simpson, 2000; Singh, 1995). In one study of hundreds of Welsh pedestrians, men rated a woman as equally attractive whether pictured at a wheel of a humble Ford Fiesta or a swanky Bentley. Women, however, found the man more attractive if he was in the luxury car (Dunn & Searle, 2010). In another experiment, women skillfully discerned which men most liked looking at baby pictures, and they rated those men higher as potential long-term mates (Roney et al., 2006). From an evolutionary perspective, such attributes connote a man's capacity to support and protect a family (Buss, 1996, 2009; Geary, 1998).



"I had a nice time, Steve. Would you like to come in, settle down, and raise a family?"

There is a principle at work here, say evolutionary psychologists: Nature selects behaviors that increase the likelihood of sending one's genes into the future. As mobile gene machines, we are designed to prefer whatever worked for our ancestors in their environments. They were predisposed to act in ways that would produce grandchildren—had they not been, we wouldn't be here. And as carriers of their genetic legacy, we are similarly predisposed.

Without disputing nature's selection of traits that enhance gene survival, critics see some problems with this explanation of our mating preferences. They believe that the evolutionary perspective overlooks some important influences on human sexuality (see Thinking Critically About: The Evolutionary Perspective on Human Sexuality).

Thinking Critically About

The Evolutionary Perspective on Human Sexuality

15-3 What are the key criticisms of evolutionary psychology, and how do evolutionary psychologists respond?

Evolutionary psychology, say some critics, starts with an effect (such as the gender sexuality difference) and works backward to propose an explanation. They invite us to imagine a different result and reason backward. If men were uniformly loyal to their mates, might we not reason that the children of these committed, supportive fathers would more often survive to perpetuate their genes? Might not men also be better off bonded to one woman—both to increase their odds of impregnation and to keep her from the advances of competing men? Might not a ritualized bond—a marriage—also spare women from chronic male harassment? Such suggestions are, in fact, evolutionary explanations for why humans tend to pair off monogamously (Gray & Anderson, 2010). One can hardly lose at hindsight explanation, which is, said paleontologist Stephen Jay Gould (1997), mere "speculation [and] guesswork in the cocktail party mode."

Some also worry about the social consequences of evolutionary psychology. Does it suggest a genetic determinism that strikes at the heart of progressive efforts to remake society (Rose, 1999)? Does it undercut moral responsibility (Buller, 2005, 2009)? Could it be used to rationalize "high-status men marrying a series of young, fertile women" (Looy, 2001)?

Others argue that evolutionary explanations blur the line between genetic legacy and social-cultural tradition. Show Alice Eagly and Wendy Wood (1999; Eagly, 2009) a culture with gender inequality—where men are providers and women are homemakers—and they will show you a culture where men strongly desire youth and domestic skill in their potential mates, and where women seek status and earning potential in their mates. Show Eagly and Wood a culture with gender equality, and they will show you a culture with smaller gender differences in mate preferences.

Much of who we are is *not* hard-wired, agree evolutionary psychologists. "Evolution forcefully rejects a genetic determinism," insists one research team (Confer et al., 2010). Evolutionary psychologists reassure us that men and women, having faced similar adaptive problems, are far more alike than different, and that humans have a great capacity for learning and social progress. Indeed, natural selection has prepared us to flexibly adjust and respond to varied environments, to adapt and survive, whether we live in igloos or tree houses. Further, they agree that cultures vary, cultures change, and cultural expectations can bend the genders. If socialized to value lifelong commitment, men may sexually bond with one partner; if socialized to accept casual sex, women may willingly have sex with many partners.

Evolutionary psychologists acknowledge struggling to explain some traits and behaviors such as same-sex attraction and suicide (Confer et al., 2010). But they also point to the explanatory and predictive power of evolutionary principles. Evolutionary psychologists predict, and have confirmed, that we tend to favor others to the extent that they share our genes or can later return our favors. They predict, and have confirmed, that human memory should be well-suited to retaining survival-relevant information (such as food locations, for which females exhibit superiority). They predict, and have confirmed, various other male and female mating strategies.

Evolutionary psychologists also remind us that the study of how we came to be need not dictate how we ought to be. Understanding our propensities sometimes helps us overcome them.

> "It is dangerous to show a man too clearly how much he resembles the beast, without at the same time showing him his greatness. It is also dangerous to allow him too clear a vision of his greatness without his baseness. It is even more dangerous to leave him in ignorance of both." -Blaise Pascal, Pensées, 1659

Before You Move On

► ASK YOURSELF

Whose reasoning do you find most persuasive—that of evolutionary psychologists or their critics? Why?

► TEST YOURSELF

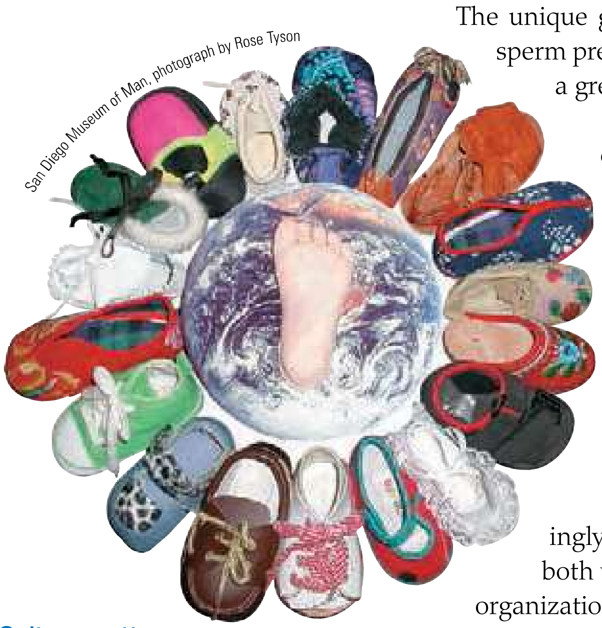
What are the three main criticisms of evolutionary psychology's explanations?

Answers to the Test Yourself questions can be found in Appendix E at the end of the book.

Reflections on Nature and Nurture

15-4 What is included in the biopsychosocial approach to individual development?

"There are trivial truths and great truths," the physicist Niels Bohr reportedly said in reflecting on the paradoxes of science. "The opposite of a trivial truth is plainly false. The opposite of a great truth is also true." It appears true that our ancestral history helped form us as a species. Where there is variation, natural selection, and heredity, there will be evolution. The unique gene combination created when our mother's egg engulfed our father's sperm predisposed both our shared humanity and our individual differences. This is a great truth about human nature. Genes form us.



Culture matters As this exhibit at San Diego's Museum of Man illustrates, children learn their culture. A baby's foot can step into any culture.

But it also is true that our experiences form us. In our families and in our peer relationships, we learn ways of thinking and acting. Differences initiated by our nature may be amplified by our nurture. If genes and hormones predispose males to be more physically aggressive than females, culture may magnify this gender difference through norms that encourage males to be macho and females to be the kinder, gentler sex. If men are encouraged toward roles that demand physical power, and women toward more nurturing roles, each may then exhibit the actions expected of them and find themselves shaped accordingly. Roles remake their players. Presidents in time become more presidential, servants more servile. Gender roles similarly shape us.

But gender roles are converging. Brute strength has become increasingly irrelevant to power and status (think Bill Gates and Hillary Clinton). Thus both women and men are now seen as "fully capable of effectively carrying out organizational roles at all levels," note Wendy Wood and Alice Eagly (2002). And as women's employment in formerly male occupations has increased, gender differences in traditional masculinity or femininity and in what one seeks in a mate have diminished (Twenge, 1997). As the roles we play change over time, we change with them.

* * *

If nature and nurture jointly form us, are we "nothing but" the product of nature and nurture? Are we rigidly determined?

We are the product of nature and nurture (**FIGURE 15.1**), but we are also an open system, as suggested by the biopsychosocial approach (see Module 2). Genes are all pervasive but not all powerful; people may defy their genetic bent to reproduce by electing celibacy. Culture, too, is all pervasive but not all powerful; people may defy peer pressures and do the opposite of the expected. To excuse our failings by blaming our nature and nurture is what philosopher-novelist Jean-Paul Sartre called "bad faith"—attributing responsibility for one's fate to bad genes or bad influences.

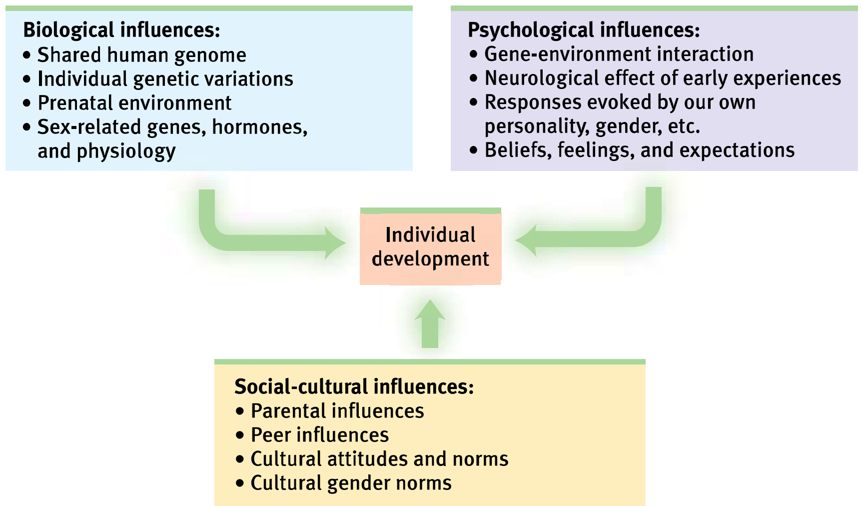


Figure 15.1
The biopsychosocial approach to individual development

In reality, we are both the creatures and the creators of our worlds. We are—it is a great truth—the products of our genes and environments. Nevertheless (another great truth), the stream of causation that shapes the future runs through our present choices. Our decisions today design our environments tomorrow. Mind matters. The human environment is not like the weather—something that just happens. We are its architects. Our hopes, goals, and expectations influence our future. And that is what enables cultures to vary and to change so quickly.

* * *

I know from my mail and from public opinion surveys that some readers feel troubled by the naturalism and evolutionism of contemporary science. Readers from other nations bear with me, but in the United States there is a wide gulf between scientific and lay thinking about evolution. "The idea that human minds are the product of evolution is . . . unassailable fact," declared a 2007 editorial in *Nature,* a leading science magazine. That sentiment concurs with a 2006 statement of "evidence-based facts" about evolution jointly issued by the national science academies of 66 nations (IAP, 2006). In *The Language of God,* Human Genome Project director Francis Collins (2006, pp. 141, 146), a self-described evangelical Christian, compiles the "utterly compelling" evidence that leads him to conclude that Darwin's big idea is "unquestionably correct." Yet Gallup reports that half of U.S. adults do not believe in evolution's role in "how human beings came to exist on Earth" (Newport, 2007). Many of those who dispute the scientific story worry that a science of behavior (and evolutionary science in particular) will destroy our sense of the beauty, mystery, and spiritual significance of the human creature. For those concerned, I offer some reassuring thoughts.

"Let's hope that it's not true; but if it is true, let's hope that it doesn't become widely known." -Lady Ashley, commenting on Darwin's theory

When Isaac Newton explained the rainbow in terms of light of differing wavelengths, the poet Keats feared that Newton had destroyed the rainbow's mysterious beauty. Yet, noted Richard Dawkins (1998) in *Unweaving the Rainbow,* Newton's analysis led to an even deeper mystery—Einstein's theory of special relativity. Moreover, nothing about Newton's optics need diminish our appreciation for the dramatic elegance of a rainbow arching across a brightening sky.


Tetyana Kochneva | Dreamstime.com

> "Is it not stirring to understand how the world actually works—that white light is made of colors, that color measures light waves, that transparent air reflects light . . . ? It does no harm to the romance of the sunset to know a little about it." -Carl Sagan, *Skies of Other Worlds*, 1988

When Galileo assembled evidence that the Earth revolved around the Sun, not vice versa, he did not offer irrefutable proof for his theory. Rather, he offered a coherent explanation for a variety of observations, such as the changing shadows cast by the Moon's mountains. His explanation eventually won the day because it described and explained things in a way that made sense, that hung together. Darwin's theory of evolution likewise is a coherent view of natural history. It offers an organizing principle that unifies various observations.

Collins is not the only person of faith to find the scientific idea of human origins congenial with his spirituality. In the fifth century, St. Augustine (quoted by Wilford, 1999) wrote, "The universe was brought into being in a less than fully formed state, but was gifted with the capacity to transform itself from unformed matter into a truly marvelous array of structures and life forms." Some 1600 years later, Pope John Paul II in 1996 welcomed a science-religion dialogue, finding it noteworthy that evolutionary theory "has been progressively accepted by researchers, following a series of discoveries in various fields of knowledge."

Meanwhile, many people of science are awestruck at the emerging understanding of the universe and the human creature. It boggles the mind—the entire universe popping out of a point some 14 billion years ago, and instantly inflating to cosmological size. Had the energy of this Big Bang been the tiniest bit less, the universe would have collapsed back on itself. Had it been the tiniest bit more, the result would have been a soup too thin to support life. Astronomer Sir Martin Rees has described *Just Six Numbers* (1999), any one of which, if changed ever so slightly, would produce a cosmos in which life could not exist. Had gravity been a tad bit stronger or weaker, or had the weight of a carbon proton been a wee bit different, our universe just wouldn't have worked.

What caused this almost-too-good-to-be-true, finely tuned universe? Why is there something rather than nothing? How did it come to be, in the words of Harvard-Smithsonian astrophysicist Owen Gingerich (1999), "so extraordinarily right, that it seemed the universe had been expressly designed to produce intelligent, sentient beings"? Is there a benevolent superintelligence behind it all? Have there instead been an infinite number of universes born and we just happen to be the lucky inhabitants of one that, by chance, was exquisitely fine-tuned to give birth to us? Or does that idea violate *Occam's razor,* the principle that we should prefer the simplest of competing explanations? On such matters, a humble, awed, scientific silence is appropriate, suggested philosopher Ludwig Wittgenstein: "Whereof one cannot speak, thereof one must be silent" (1922, p. 189).

Rather than fearing science, we can welcome its enlarging our understanding and awakening our sense of awe. In *The Fragile Species,* Lewis Thomas (1992) described his utter amazement that the Earth in time gave rise to bacteria and eventually to Bach's Mass in B Minor. In a short 4 billion years, life on Earth has come from nothing to structures as complex as a 6-billion-unit strand of DNA and the incomprehensible intricacy of the human brain. Atoms no different from those in a rock somehow formed dynamic entities that became conscious. Nature, says cosmologist Paul Davies (2007), seems cunningly and ingeniously devised to produce extraordinary, self-replicating, information-processing systems—us. Although we appear to have been created from dust, over eons of time, the end result is a priceless creature, one rich with potential beyond our imagining.

> "The causes of life's history [cannot] resolve the riddle of life's meaning." -Stephen Jay Gould, *Rocks of Ages: Science and Religion in the Fullness of Life*, 1999

Before You Move On

► ASK YOURSELF

How have your heredity and your environment influenced who you are today? Can you recall an important time when you determined your own fate in a way that was at odds with pressure you felt from either your heredity or your environment?

► TEST YOURSELF

How does the biopsychosocial approach explain our individual development?

Answers to the Test Yourself questions can be found in Appendix E at the end of the book.

* * *

In this unit we have glimpsed an overriding principle: Everything psychological is simultaneously biological. We have focused on how our thoughts, feelings, and actions arise from our specialized yet integrated brain. In modules to come, we will further explore the significance of the biological revolution in psychology.

From nineteenth-century phrenology to today's neuroscience, we have come a long way. Yet what is unknown still dwarfs what is known. We can describe the brain. We can learn the functions of its parts. We can study how the parts communicate. But how do we get mind out of meat? How does the electrochemical whir in a hunk of tissue the size of a head of lettuce give rise to elation, a creative idea, or that memory of Grandmother?

Much as gas and air can give rise to something different—fire—so also, believed Roger Sperry, does the complex human brain give rise to something different: *consciousness.* The mind, he argued, emerges from the brain's dance of ions, yet is not reducible to it. Cells cannot be fully explained by the actions of atoms, nor minds by the activity of cells. Psychology is rooted in biology, which is rooted in chemistry, which is rooted in physics. Yet psychology is more than applied physics. As Jerome Kagan (1998) reminded us, the meaning of the Gettysburg Address is not reducible to neural activity. Communication is more than air flowing over our vocal cords. Morality and responsibility become possible when we understand the mind as a "holistic system," said Sperry (1992) (**FIGURE 15.2**). We are not mere jabbering robots.

The mind seeking to understand the brain—that is indeed among the ultimate scientific challenges. And so it will always be. To paraphrase cosmologist John Barrow, a brain simple enough to be understood is too simple to produce a mind able to understand it.

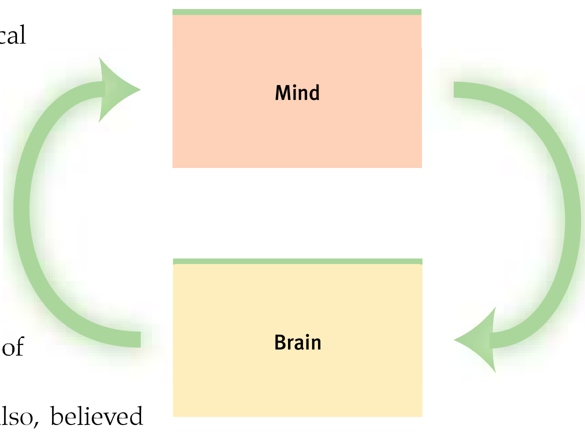


Figure 15.2
Mind and brain as holistic system In Roger Sperry's view, the brain creates and controls the emergent mind, which in turn influences the brain. (Think vividly about biting into a lemon and you may salivate.)

Module 15 Review

15-1 How do evolutionary psychologists use natural selection to explain behavior tendencies?

- *Evolutionary psychologists* seek to understand how our traits and behavior tendencies are shaped by *natural selection,* as genetic variations increasing the odds of reproducing and surviving are most likely to be passed on to future generations.
- Some genetic variations arise from *mutations* (random errors in gene replication), others from new gene combinations at conception.
- Humans share a genetic legacy and are predisposed to behave in ways that promoted our ancestors' surviving and reproducing.
- Charles Darwin's theory of evolution is an organizing principle in biology. He anticipated today's application of evolutionary principles in psychology.

15-2 How might an evolutionary psychologist explain gender differences in sexuality and mating preferences?

- Men tend to have a recreational view of sexual activity; women tend to have a relational view.
- Evolutionary psychologists reason that men's attraction to multiple healthy, fertile-appearing partners increases their chances of spreading their genes widely.
- Because women incubate and nurse babies, they increase their own and their children's chances of survival by searching for mates with the potential for long-term investment in their joint offspring.

15-3 What are the key criticisms of evolutionary psychology, and how do evolutionary psychologists respond?

- Critics argue that evolutionary psychologists (1) start with an effect and work backward to an explanation, (2) do not recognize social and cultural influences, and (3) absolve people from taking responsibility for their sexual behavior.
- Evolutionary psychologists respond that understanding our predispositions can help us overcome them. They also cite the value of testable predictions based on evolutionary principles, as well as the coherence and explanatory power of those principles.

15-4 What is included in the biopsychosocial approach to individual development?

- Individual development results from the interaction of biological, psychological, and social-cultural influences.
- Biological influences include our shared human *genome*; individual variations; prenatal environment; and sex-related genes, hormones, and physiology.
- Psychological influences include gene-environment interactions; the effect of early experiences on neural networks; responses evoked by our own characteristics, such as gender and personality; and personal beliefs, feelings, and expectations.
- Social-cultural influences include parental and peer influences; cultural traditions and values; and cultural gender norms.

Multiple-Choice Questions

1. Which of the following refers to an effect of life experience that leaves a molecular mark that affects gene expression?

a. Epigenetics
b. Adaptation
c. Evolution
d. Natural selection
e. Universal moral grammar

2. Which of the following best describes genetic mutation?

a. Random errors in gene replication
b. The study of the mind's evolution
c. The study of behavioral evolution
d. Passing on successful, inherited traits
e. Survival of the genetically successful

3. Which of the following is true regarding the initiation of sexual activity?

a. Men are more likely to initiate sexual activity than women.
b. Women are more likely to initiate sexual activity than men.
c. The initiation of sexual activity for both men and women correlates with how many television sitcoms they viewed as children.
d. Men and women are equally likely to initiate sexual activity.
e. Who initiates sexual activity is largely determined by culture.

Practice FRQs

1. Explain four of the important ideas behind natural selection.

Answer

1 point: Organisms' varied offspring compete for survival.

1 point: Certain biological and behavioral variations increase an organism's reproductive and survival chances in a particular environment.

1 point: Offspring that survive are more likely to pass their genes to ensuing generations.

1 point: Over time, population characteristics may change.

2. Explain the three major influences on individual development, according to the biopsychosocial approach.

(3 points)