CHAPTER 2

# The Biology of Behavior

## Chapter Preview

Our nervous system plays a vital role in how we think, feel, and act. Neurons, the basic building blocks of the body's circuitry, receive signals through their branching dendrites and cell bodies and transmit electrical impulses down their axons. Chemical messengers called neurotransmitters traverse the tiny synaptic gap between neurons and pass on excitatory or inhibitory messages.

The central nervous system consists of the brain and spinal cord. The peripheral nervous system consists of the somatic nervous system, which directs voluntary movements and reflexes, and the autonomic nervous system, which controls the glands and muscles of our internal organs.

Hormones released by endocrine glands affect other tissues, including the brain. The most influential endocrine gland, the pituitary gland, releases hormones that influence growth, and its secretions also influence the release of hormones by other glands. The nervous system directs endocrine secretions, which then affect the nervous system.

The brain's increasing complexity arises from new brain systems built on top of old. Within the brainstem are the oldest regions, the medulla and the reticular formation. The thalamus sits atop the brainstem and the cerebellum extends from the rear. The limbic system includes the amygdala, the hippocampus, and the hypothalamus. The cerebral cortex, representing the highest level of brain development, is responsible for our most complex functions.

Each hemisphere of the cerebral cortex has four geographical areas: the frontal, parietal, occipital, and temporal lobes. Although small, well-defined regions within these lobes control muscle movement and receive information from the body senses, most of the cortex—its association areas—are free to process other information. Experiments on split-brain patients suggest that, for most people, the left hemisphere is the more verbal and the right hemisphere excels in visual perception. Studies of people with intact brains indicate that each hemisphere makes unique contributions to the integrated functions of the brain.

How do our heredity and our experiences organize and "wire" the brain? Genes provide the blueprints that design both our universal human attributes and our individual traits. Behavior geneticists explore individual differences. By using twin and adoption studies, they assess the heritability of various traits and disorders. Their research indicates that both nature and nurture influence our life courses. We are products of interactions between our genetic predispositions and our surrounding environments.

Evolutionary psychologists focus on what makes us alike as humans. They study how natural selection favored behavioral tendencies that contributed to the survival and spread of our genes.

# Chapter Guide

*Introductory Exercise: Fact or Falsehood?*

The correct answers to Handout 2–1 are as follows: 1. F 2. T 3. T 4. T 5. F 6. F 7. T 8. T 9. F 10. F

2-1. *Explain why psychologists are concerned with human biology.*

Everything psychological is simultaneously biological. We think, feel, and act with our bodies. By studying the links between biology and behavior, ***biological psychologists*** enable us to gain a better understanding of our experiences of sights and sounds, meanings and memories, pain and passion. In the 1800s, Franz Gall invented phrenology, a popular theory that claimed that bumps on the skull reveal our mental abilities and our character traits. Although bumps on the skull reveal nothing about the brain's underlying functions, Gall was accurate in supposing that various brain regions have particular functions.

## Neural Communication

- ▶ Lecture: Multiple Sclerosis and Guillain-Barré Syndrome (p. 90)
- ▶ Exercise: Modeling a Neuron and Using Dominoes to Illustrate the Action Potential (p. 90)
- ▶ PsychSim 5: Neural Messages (p. 90)
- ▶ Worth Video Anthology: *The Neuron: Basic Units of Communication*

At all levels, researchers examine how we take in information and then how we organize, interpret, store, and use it. The information systems of humans and other animals operate similarly. This similarity permits researchers to study relatively simple animals to discover how our neural systems operate.

2-2. *Describe the parts of a neuron, and explain how its impulses are generated.*

A ***neuron*** consists of a cell body and branching fibers: The ***dendrite*** fibers receive information from sensory receptors or other neurons, and the ***axon*** fibers pass that information along to other neurons. The axons of some neurons are encased by a ***myelin sheath,*** which helps speed their impulses.

***Glial cells*** support, nourish, and protect the nerve cells of the nervous system. They may also play a role in learning and thinking.

A neural impulse, or ***action potential,*** fires when the neuron is stimulated by signals from the senses or when triggered by chemical signals from neighboring neurons. The action potential is a brief electrical charge that travels down the axon. Received signals trigger an impulse only if the excitatory signals minus the inhibitory signals exceeds a minimum intensity called the ***threshold.*** The neuron's reaction is an *all-or-none response.* When a neuron is at rest, the fluid interior of the axon carries mostly negatively charged atoms (*ions*), while the fluid outside has mostly positively charged atoms. Then, the first bit of the axon is *depolarized,* and the electrical impulse travels down the axon as channels open, admitting ions with a positive charge. During a resting pause, the neuron pumps the positively charged sodium ions back outside. Then it can fire again.

- ▶ Exercises: Neural Transmission (p. 91); Crossing the Synaptic Gap (p. 91); Reaction-Time Measure of Neural Transmission and Mental Processes (p. 92)
- ▶ Worth Video Anthology*: Neural Communication; Neural Communication: Impulse Transmission Across the Synapse*

2-3. *Describe how nerve cells communicate with other nerve cells.*

When electrical impulses reach the axon terminal, they stimulate the release of chemical messengers called ***neurotransmitters*** that cross the junction between neurons called the ***synapse.*** After these molecules traverse the tiny *synaptic gap* (*cleft*) between neurons, they bind to receptor sites on neighboring neurons, thus passing on their excitatory or inhibitory messages. The sending neuron, in a process called *reuptake,* normally absorbs the excess neurotransmitter molecules in the synaptic gap.

- ▶ Lecture: Endorphins (p. 93)
- ▶ Lecture/Feature Film: Parkinson's Disease and *Awakenings* (p. 93)
- ▶ Worth Video Anthology: *Chemically Induced Hallucinations: Studies of Anesthetic Drugs; The Runner's High; Parkinson's Disease: A Case Study; Treating Parkinson's Disease: Deep Brain Electrode Implantation*

2-4. *Describe how neurotransmitters influence behavior.*

Different neurotransmitters have different effects on behavior and emotion. For example, the neurotransmitter *acetylcholine (ACh)* plays a crucial role in learning and memory. Found at every junction between a motor neuron and skeletal muscle, ACh causes the muscle to contract. The brain's ***endorphins,*** natural opiates released in response to pain and vigorous exercise, explain the "runner's high" and the indifference to pain in some severely injured people.

When the brain is flooded with opiate drugs such as heroin and morphine, it may stop producing its own natural opiates, and withdrawal of these drugs may result in intense discomfort until the brain resumes production of its natural opiates.

## The Nervous System

- ▶ Lectures: Lou Gehrig's Disease (p. 94); The Autonomic Nervous System and Sexual Functioning (p. 95)
- ▶ Exercise/Critical Thinking Break: Drug Effects and the Nervous System (p. 95)
- ▶ Worth Video Anthology: *The Central Nervous System: Spotlight on the Brain*

2-5. *Describe the functions of the nervous system's main divisions, and identify the three main types of neurons.*

Neurons communicating with other neurons form our body's primary system, the ***nervous system.*** The brain and spinal cord form the ***central nervous system (CNS).*** The ***peripheral nervous system (PNS)*** links the central nervous system with the body's sense receptors, muscles, and glands. The axons carrying this PNS information are bundled into the electrical cables we know as ***nerves.***

***Sensory (afferent) neurons*** send information from the body's tissues and sensory organs inward to the brain and spinal cord, which process the information. ***Motor (efferent) neurons*** carry outgoing information from the central nervous system to the body's tissues. ***Interneurons*** in the central nervous system communicate internally and intervene between the sensory inputs and the motor outputs.

The ***somatic nervous system*** of the peripheral nervous system enables voluntary control of our skeletal muscles. The ***autonomic nervous system*** of the peripheral nervous system is a dual self-regulating system that influences the glands and muscles of our internal organs. The ***sympathetic nervous system*** arouses; the ***parasympathetic nervous system*** calms.

The brain's neurons cluster into work groups called *neural networks.* This enables neurons to have short, fast connections with other neurons.

***Reflexes,*** which are simple, automatic responses to stimuli, illustrate the spinal cord's work. A simple reflex pathway is composed of a single sensory neuron and a single motor neuron, which often communicate through an interneuron. For example, when our fingers touch a candle's flame, information from the skin receptors travels inward via a sensory neuron to a spinal cord interneuron, which sends a signal outward to the arm muscles via a motor neuron. Because this reflex involves only the spinal cord, we jerk our hand away before the brain creates an experience of pain.

## The Endocrine System

- ▶ Lectures: The Endocrine System (p. 96); Oxytocin: The Hormone of Love, Bonding, and Generosity? (p. 96)

2-6. *Describe how the endocrine system transmits information and how it interacts with the nervous system.*

The ***endocrine system's*** glands secrete ***hormones,*** chemical messengers produced in one tissue that travel through the bloodstream and affect other tissues, including the brain. Compared with the speed at which messages move through the nervous system, endocrine messages move more slowly, but their effects usually last longer. The endocrine system's hormones influence many aspects of our lives, including growth, reproduction, metabolism, and mood, keeping everything in balance while responding to stress, exertion, and internal thoughts. In a moment of danger, the ***adrenal glands*** release the hormones *epinephrine* and *norepinephrine,* which increase heart rate, blood pressure, and blood sugar, providing us with increased energy. The ***pituitary gland*** is the endocrine system's most influential gland. Under the influence of the brain's hypothalamus, the pituitary's secretions influence growth and the release of hormones by other endocrine glands. These may in turn influence both the brain and behavior and thus reveal the intimate connection of the nervous and endocrine systems.

## The Brain

- ▶ Lectures: Neuroimaging Techniques (p. 97); A Neurosociety and Your Brain on Politics (p. 98); Assessing Awareness in Brain-Injured Patients (p. 98); Brain Puzzles, Models, and Molds (p. 100)
- ▶ Exercises: Building a Play-Doh Brain (p. 99); A Portable Brain Model (p. 99); Mastering Brain Structure (p. 101); Case Studies in Neuroanatomy (p. 101)
- ▶ Exercise/Lecture Break: Neuropsychology of Zombies (p. 102)
- ▶ Project: The Human Brain Coloring Book (p. 102)
- ▶ PsychSim 5: Brain and Behavior (p. 102)
- ▶ Worth Video Anthology: *Neuroimaging: Assessing What's Cool; Brain Imaging; Understanding Neuroscience Methods: ERP; Mapping the Brain Through Electrical Stimulation; Activity, Exercise, and the Brain*

2-7. *Describe how neuroscientists study the brain's connections to behavior and mind.*

The oldest method of studying the brain involved observing the effects of brain diseases and injuries. Powerful new techniques now reveal brain structures and activities in the living brain. By surgically ***lesioning*** and electrically stimulating specific brain areas, by recording electrical activity on the brain's surface ***(electroencephalogram [EEG]),*** and by looking inside the living brain to see its activity (***PET, MRI,*** and ***fMRI***), neuroscientists examine the connections between brain, mind, and behavior.

- ▶ Lecture: Why Can't We Tickle Ourselves? (p. 103)
- ▶ Exercise: Individual Differences in Physiological Functioning and Behavior (p. 104)
- ▶ Worth Video Anthology: *Brain Structures*

2-8. *Identify the components of the brainstem, and describe the functions of the brainstem, thalamus, and cerebellum.*

The ***brainstem,*** the brain's oldest and innermost region, is responsible for automatic survival functions. It includes the ***medulla,*** which controls heartbeat and breathing, and the *pons,* which helps coordinate movements. Atop the brainstem is the ***thalamus,*** the brain's sensory router. It receives information from all the senses, except smell, and sends it to the higher brain regions that deal with seeing, hearing, tasting, and touching. The ***reticular formation,*** which plays an important role in controlling arousal, lies inside the brainstem and extends right up through the thalamus. The ***cerebellum,*** attached to the rear of the brainstem, coordinates movement output and balance and helps process sensory information. It also enables one type of nonverbal learning and memory and helps us judge time, modulate our emotions, and discriminate sounds and textures.

- ▶ Worth Video Anthology: *The Brain's Reward Center; Self-Stimulation in Rats; Compulsive Gambling and the Brain's Pleasure Center*

2-9. *Describe the structures and functions of the limbic system.*

The ***limbic system*** has been linked primarily to memory, emotions, and drives. For example, one of its neural centers, the *hippocampus,* processes conscious memory. Another, the ***amygdala,*** influences aggression and fear. A third, the ***hypothalamus,*** has been linked to various bodily maintenance functions and to pleasurable rewards (other reward centers include the *nucleus accumbens*). The hormones of the hypothalamus influence the pituitary gland, and thus it provides a major link between the nervous and endocrine systems.

- ▶ Lectures: The Case of Clive Wearing (p. 103) ; Einstein's Brain and Genius (p. 105); Kim Peek's Brain (p. 106)
- ▶ Exercises: Neuroscience and Moral Judgments (p. 104); The Sensory Homunculus (p. 106)
- ▶ Worth Video Anthology: *Brain and Behavior: Phineas Gage Revisited; Planning, Life Goals, and the Frontal Lobe*

2-10. *Describe the functions of the various regions of the cerebral cortex.*

The ***cerebral cortex,*** a thin surface layer of interconnected neural cells, is our body's ultimate control and information-processing center. The ***frontal lobes,*** just behind the forehead, are involved in speaking, muscle movements, and planning and making judgments. The ***parietal lobes,*** at the top of head and toward the rear, receive sensory input for touch and body position. The ***occipital lobes,*** at the back of the head, include visual areas. The ***temporal lobes,*** just above the ears, include auditory areas. Each lobe performs many functions and interacts with other areas of the cortex.

The ***motor cortex,*** an arch-shaped region at the rear of the frontal lobes, controls voluntary muscle movements on the opposite side of the body. Body parts requiring the most precise control occupy the greatest amount of cortical space. Researchers are testing whether a device implanted in the motor cortex might help severely paralyzed people to control behavior with their mind. The ***sensory cortex,*** a region at the front of the parietal lobes, registers and processes body sensations. The most sensitive body parts require the largest amount of space in the sensory cortex.

The ***association areas*** are not involved in primary motor or sensory functions. Rather, they integrate and act on information processed by the sensory areas and link it with stored memories. They are involved in higher mental functions, such as learning, remembering, thinking, and speaking. Association areas are found in all four lobes. Complex human abilities, such as memory and language, result from the intricate coordination of many brain areas.

- ▶ Lecture: Hemispherectomy (p. 107)
- ▶ Worth Video Anthology: *Language and Brain Plasticity; Rewiring the Brain; Brain Plasticity: Rewiring the Visual Cortex; Achieving Hemispheric Balance: Improving Sports Performance*

2-11. *Discuss the brain's ability to reorganize itself, and define* neurogenesis.

Research indicates that some neural tissue can reorganize in response to damage. When one brain area is damaged, others may in time take over some of its function. For example, if you lose a finger, the sensory cortex that received its input will begin to receive input from the adjacent fingers, which become more sensitive. Our brains are most ***plastic*** when we are young children. Evidence reveals that adult humans can also generate new brain cells. This process, known as ***neurogenesis,*** has been found in adult mice, birds, monkeys, and humans. Also, master stem cells that can develop into any kind of brain cell have been found in the human embryo.

- ▶ Lectures: The Wada Sodium Amobarbital Test (p. 109); The Right Brain Movement (p. 112)
- ▶ Exercise: Behavioral Effects of the Split-Brain Operation (p. 108)
- ▶ Exercise/Project: The Wagner Preference Inventory (p. 108)
- ▶ Project/Exercise: Hemispheric Specialization (p. 109)
- ▶ Worth Video Anthology: *The Split Brain: Lessons on Language, Vision, and Free Will; The Split Brain: Lessons on Cognition and the Cerebral Hemispheres*
- ▶ PsychSim 5: Hemispheric Specialization (p. 108)

2-12. *Explain how split-brain research helps us understand the functions of our left and right hemispheres.*

A ***split brain*** is one in which the ***corpus callosum,*** the wide band of axon fibers that connects the two brain hemispheres, has been severed. Experiments on split-brain patients have refined our knowledge of each hemisphere's special functions (called *lateralization*). In the laboratory, investigators ask a split-brain patient to look at a designated spot, then send information to either the left or right hemisphere (by flashing it to the right or left visual field). Quizzing each hemisphere separately, the researchers have confirmed that for most people, the left hemisphere is the more verbal and the right hemisphere excels in perceptual tasks. Studies of people with intact brains have confirmed that the right and left hemispheres each make unique contributions. For example, the left hemisphere makes quick, literal interpretations of language, and the right hemisphere helps us modulate our speech to make meaning clear.

## Behavior Genetics: Predicting Individual Differences

- ▶ Lectures: The Origins of Blue Eyes (p. 188); The Genetic Revolution (p. 189)
- ▶ Exercise: Genetic Factors (p. 187)
- ▶ Exercise/Lecture Break: Biology Is More Than Just Genes (p. 190)
- ▶ Exercise/Project: Genetic Influences (p. 189)
- ▶ Worth Video Anthology: *Behavior Genetics; Ethics in Human Research: Violating One's Privacy*

2-13. *Define* genes, *and describe how behavior geneticists explain our individual differences.*

***Behavior geneticists*** study our differences and aim to determine the relative importance of heredity and environment on behavior. ***Environment*** includes every nongenetic influence, from prenatal nutrition to the people and things around us.

Every cell nucleus contains the genetic master code for the body. Within each cell are 46 chromosomes, with 23 donated by each parent. Each ***chromosome*** is composed of a coiled chain of a molecule, called ***DNA** (deoxyribonucleic acid).* ***Genes*** are DNA segments that, when "turned on" (active or expressed), provide the code for the production of *protein molecules*. By directing the manufacture of proteins, the approximately 20,000 to 25,000 genes that compose the human body determine our development. Variations at particular gene sites in the DNA define each person's uniqueness. Human traits are influenced by many genes interacting with the environment.

- ▶ Lectures: The Minnesota Twin Study; (p. 190); "Mom Always Liked You Best" (p. 192)
- ▶ Exercise: Striking Similarities (p. 190)
- ▶ Worth Video Anthology: *Nature Versus Nurture: Growing up Apart; 100-Years-Old and Counting: Psychological and Biological Factors*

Comparisons of ***identical twins,*** who are genetic clones, and ***fraternal twins,*** who develop from separate eggs, help behavior geneticists tease apart the effects of heredity and environment. On both extraversion and neuroticism, identical twins are much more similar than fraternal twins. The discovery that identical twins separated at birth show remarkable similarities also suggests genetic influence. Indeed, separated fraternal twins do not exhibit similarities comparable to those of separated identical twins. However, shared genes can translate into shared experiences.

Adoption studies enable comparisons with both genetic and environmental relatives. Adoptees' traits bear more similarities to their biological parents than to their caregiving adoptive parents. Nonetheless, the latter do influence their children's attitudes, values, manners, faith, and politics. Clearly, nature and nurture shape one's developing personality.

- ▶ Lectures: Nature and Nurture (p. 194); Gene-Environment Correlation (p. 195); Epigenetics (p. 196)
- ▶ Feature Film: *Fly Away Home* and Imprinting (p. 195)
- ▶ Worth Video Anthology *The Nature–Nurture Issue*

2-14. *Discuss the interaction of heredity and environment.*

Our genes affect how our environment reacts to and influences us. Nature enables nurture. Because of human adaptability, most psychologically interesting traits are expressed in particular environments. In other words, genes are self-regulating; they can react differently in different environments.

We are all the products of ***interactions*** between our genetic predispositions and our surrounding environments. For example, a baby who is genetically predisposed to be social and easygoing may, in contrast to one who is less so, attract more affectionate and stimulating care and thus develop into a warmer and more outgoing person. A new field, ***epigenetics,*** is studing the molecular mechanisms by which environments trigger genetic expression.

## Evolutionary Psychology: Understanding Human Nature


- Lectures: Evolutionary Psychology (p. 197); Misunderstanding Evolutionary Theory and Psychology (p. 197)
- Exercises: Evolutionary Psychology (p. 198); Darwinian Grandparenting (p. 198)
- Project/Critical Thinking Break: Thinking Like an Evolutionary Psychologist (p. 199)
- PsychSim 5: Mind-Reading Monkeys (p. 199)
- Worth Video Anthology: *Evolutionary Psychology*


2-15. *Describe evolutionary psychologists' use of natural selection to explain behavior tendencies.*

***Evolutionary psychologists*** focus on what makes us so much alike as humans. They study how natural selection has shaped our universal behavioral tendencies.

***Natural selection*** is the principle that, among the range of inherited trait variations, those that lead to increased reproduction and survival will most likely be passed on to succeeding generations. Nature selects beneficial variations from among the ***mutations*** (random errors in gene replication) and the new gene combinations produced at each human conception. During human ancestry, genes that enable today's capacity to learn and *adapt* had survival value. Similarly, we love the taste of fats and sweets, which once were hard to come by but which prepared our ancestors to survive famines. This particular natural disposition is mismatched with today's junk-food environment.

## HANDOUT 2–1

# Fact or Falsehood?

**T F** 1. Neural impulses travel through the human body at the same speed that electricity travels through a wire.

**T F** 2. The human brain produces its own natural opiates that elevate mood and ease pain.

**T F** 3. Electrically stimulating a cat's brain at a certain point can cause the animal to cower in terror in the presence of a small mouse.

**T F** 4. Both animals and humans seem to have reward centers located in the brain.

**T F** 5. We ordinarily use only 10 percent of our brains.

**T F** 6. Adult humans cannot generate new brain cells.

**T F** 7. Some people have had the hemispheres of their brains split with no apparent ill effect.

**T F** 8. Hearing people usually use the left hemisphere of the brain to process language, and deaf people usually use the left hemisphere to process sign language.

**T F** 9. Even complex human traits are determined by a single gene.

**T F** 10. Adoptees' traits such as extraversion and agreeableness bear more similarities to their adoptive parents than to their biological parents.