Chapter 36 Organizer

Refer to pages 4T-5T of the Teacher Guide for an explanation of the National Science Education Standards correlations.

Section	Objectives	Activities/Features
Section 36.1 **The Nervous System** National Science Education Standards UCP.1-3, UCP.5; A.1; B.1, B.3; C.1, C.5, C.6 (2 sessions, 1 block)	1. **Analyze** how nerve impulses travel within the nervous system. 2. **Recognize** the functions of the major parts of the nervous system. 3. **Compare** voluntary responses and involuntary responses.	**Focus On** Evolution of the Brain, p. 978 **MiniLab 36-1:** Distractions and Reaction Time, p. 980 **BioTechnology:** Scanning the Mind, p. 998
Section 36.2 **The Senses** National Science Education Standards UCP.1-3, UCP.5; C.1, C.5, C.6 (1 session)	4. **Define** the role of the senses in the human nervous system. 5. **Recognize** how senses detect chemical, light, and mechanical stimulation. 6. **Identify** ways in which the senses work together to gather information.	**Inside Story:** The Eye, p. 985 **Problem-Solving Lab 36-1,** p. 986
Section 36.3 **The Effects of Drugs** National Science Education Standards UCP.1, UCP.2; A.1, A.2; C.6; E.1, E.2; F.1, F.5, F.6; G.1, G.2 (2 sessions, ½ block)	7. **Recognize** the medicinal uses of drugs. 8. **Identify** the different classes of drugs. 9. **Interpret** the effect of drug misuse and abuse on the body.	**Problem-Solving Lab 36-2,** p. 989 **Careers in Biology:** Pharmacist, p. 990 **MiniLab 36-2:** Interpret a Drug Label, p. 991 **Design Your Own BioLab:** What drugs affect the heart rate of *Daphnia?* p. 996

Need Materials? Contact Carolina Biological Supply Company at 1-800-334-5551 or at **http://www.carolina.com**

MATERIALS LIST

BioLab

p. 996 microscope, microscope slides, dropper, aged tap water, *Daphnia* culture, dilute solutions of coffee, tea, cola, ethyl alcohol, tobacco, and cough medicine

MiniLabs

p. 980 meterstick, paper, pencil
p. 991 paper, pencil

Alternative Lab

p. 980 paper clips, metric ruler, paper, pencil

Quick Demos

p. 975 telephone cable
p. 981 rubber hammer
p. 984 tape recording of common sounds
p. 990 samples of non prescription drugs

Key to Teaching Strategies

- L1 Level 1 activities should be appropriate for students with learning difficulties.
- L2 Level 2 activities should be within the ability range of all students.
- L3 Level 3 activities are designed for above-average students.
- ELL ELL activities should be within the ability range of English Language Learners.
- COOP LEARN Cooperative Learning activities are designed for small group work.
- P These strategies represent student products that can be placed into a best-work portfolio.
- These strategies are useful in a block scheduling format.

The Nervous System

Teacher Classroom Resources

Section	Reproducible Masters	Transparencies
Section 36.1 **The Nervous System**	**Reinforcement and Study Guide,** pp. 159-160 L2 **Critical Thinking/Problem Solving,** p. 36 L3 **BioLab and MiniLab Worksheets,** p. 159 L2 **Laboratory Manual,** pp. 261-264 L2 **Content Mastery,** pp. 177-178, 180 L1	**Section Focus Transparency 87** L1 ELL **Basic Concepts Transparency 67** L2 ELL
Section 36.2 **The Senses**	**Reinforcement and Study Guide,** p. 161 L2 **Concept Mapping,** p. 36 L3 ELL **Laboratory Manual,** pp. 265-268 L2 **Content Mastery,** pp. 177, 179-180 L1 **Tech Prep Applications,** pp. 47-48 L2	**Section Focus Transparency 88** L1 ELL **Basic Concepts Transparency 68** L2 ELL **Basic Concepts Transparency 69** L2 ELL **Reteaching Skills Transparency 52** L1 ELL **Reteaching Skills Transparency 53** L1 ELL
Section 36.3 **The Effects of Drugs**	**Reinforcement and Study Guide,** p. 162 L2 **BioLab and MiniLab Worksheets,** pp. 160-162 L2 **Content Mastery,** pp. 177, 180 L1 **Tech Prep Applications,** pp. 49-50 L2	**Section Focus Transparency 89** L1 ELL

Assessment Resources

Chapter Assessment, pp. 211-216
MindJogger Videoquizzes
Performance Assessment in the Biology Classroom
Alternate Assessment in the Science Classroom
Computer Test Bank
BDOL Interactive CD-ROM, Chapter 36 quiz

Additional Resources

Spanish Resources ELL
English/Spanish Audiocassettes ELL
Cooperative Learning in the Science Classroom COOP LEARN
Lesson Plans/Block Scheduling

NATIONAL GEOGRAPHIC Teacher's Corner

Products Available From Glencoe
To order the following products, call Glencoe at 1-800-334-7344:
CD-ROM
NGS PictureShow: Human Body 1
Curriculum Kit
GeoKit: Human Body 2
Transparency Set
NGS PicturePack: Human Body 1
Videodisc
STV: Human Body

Products Available From National Geographic Society
To order the following products, call National Geographic Society at 1-800-368-2728:
Videos
Incredible Human Machine
Nervous System (Human Body Series)

GLENCOE TECHNOLOGY

The following multimedia resources are available from Glencoe.

Biology: The Dynamics of Life
CD-ROM ELL
BioQuest: *Body Systems*
Animation: *Impulse Transmission in a Motor Neuron*
Animation: *Impulse Transmission Across a Synapse*
Animation: *The Sense of Sight*
Animation: *The Sense of Hearing*
Videodisc Program
Impulse Transmission
Impulse Transmission: *Synapse*
Sense of Sight

Chapter 36

Getting Started Demo

Create a loud noise by slamming a book on your desk. Use student reaction to begin a discussion of how the nervous system reacts to environmental stimuli, including loud noises.

Theme Development

The major theme in this chapter is **systems and interactions**. Stress that the nervous system receives information from all body systems and responds in order to maintain homeostasis in the body.

0:00 Out of Time?

If time does not permit teaching the entire chapter, use the BioDigest at the end of the unit as an overview.

Internet Address Book

internNET CONNECTION Note Internet addresses that you find useful in the space below for quick reference.

_____

_____

_____

_____

_____

Chapter

36 The Nervous System

What You'll Learn

- You will relate the structure of a nerve cell to the transmission of a nerve signal.
- You will identify the senses and their signal pathways.
- You will compare and contrast various types of drugs and their effects on the nervous system.

Why It's Important

The nervous system helps you perceive and react to the world around you. By understanding how drugs—both legal and illegal—affect the function of the nervous system, you will discover their role in treating medical disorders, and the danger they pose if misused.

Getting Started

Swapping Colors

Draw a picture of a green tree with red dots all over it. Stare at the drawing for one full minute. Then look at a sheet of white paper. *What do you see?*

internNET CONNECTION To find out more about the nervous system, visit the Glencoe Science Web Site. **www.glencoe.com/sec/science**

Magnification: 5550×

When nerve cells (inset) in your eyes detect something scary, they relay a message to your brain, which, in turn, tells your muscles to tense up and your heart to beat faster.

Multiple Learning Styles

Look for the following logos for strategies that emphasize different learning modalities.

Kinesthetic Portfolio, p. 975; Quick Demo, p. 981; Project, p. 983

Visual-Spatial Meeting Individual Needs, pp. 974, 988; Reinforcement, p. 975; Display, p. 984; Portfolio, p. 985; Check for Understandning, p. 987

Interpersonal Biology Journal, p. 994

Intrapersonal Enrichment, p. 994; Concept Development, p. 994

Linguistic Biology Journal, pp. 974, 976, 977, 984, 990, 992; Enrichment, pp. 976, 977; Tech Prep, p. 976; Project, p. 977; Portfolio, p. 993; Check for Understanding, p. 994; Reteach, p. 994

Auditory-Musical Quick Demo, p. 984

Section

36.1 The Nervous System

What do you use the telephone for? To communicate with a friend in another location. You may know that your message is transmitted as an electrical impulse across the telephone wires. Would it surprise you to know that a similar electrical impulse travels through your body, helping some parts to communicate with others?

Like telephone wires between homes, nerve cells relay messages within the human body.

Section Preview

Objectives

Analyze how nerve impulses travel within the nervous system.

Recognize the functions of the major parts of the nervous system.

Compare voluntary responses and involuntary responses.

Vocabulary

neuron
dendrite
axon
synapse
neurotransmitter
central nervous system
peripheral nervous system
cerebrum
cerebellum
medulla oblongata
somatic nervous system
reflex
autonomic nervous system
sympathetic nervous system
parasympathetic nervous system

Neurons: Basic Units of the Nervous System

The basic unit of structure and function in the nervous system is the neuron, or nerve cell. **Neurons** (NYU ronz) conduct impulses throughout the nervous system. As shown in ***Figure 36.1***, a neuron is a long cell that consists of three regions: a cell body, dendrites, and an axon.

Dendrites (DEN drites) are branchlike extensions of the neuron that receive impulses and carry them toward the cell body. The **axon** is a single extension of the neuron that carries impulses away from the cell body and toward other neurons, muscles, or glands.

Neurons fall into three categories: sensory neurons, motor neurons, and interneurons. Sensory neurons carry impulses from the body to the spinal cord and brain. Interneurons are found within the brain and spinal cord. They process incoming impulses and pass response impulses on to motor neurons. Motor neurons carry the response impulses away from the brain and spinal cord to a muscle or gland.

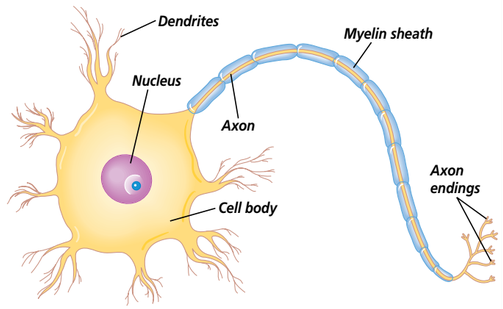


Figure 36.1
Dendrites and axons are extensions that branch out from the cell body of a neuron.

Assessment Planner

Portfolio Assessment
- **Portfolio, TWE,** pp. 975, 985, 993
- **Alternative Lab, TWE,** pp. 980-981
- **Problem-Solving Lab, TWE,** p. 986

Performance Assessment
- **MiniLab, SE,** pp. 980, 991
- **BioLab, SE,** pp. 996-997
- **Alternative Lab, TWE,** pp. 980-981
- **Assessment, TWE,** p. 977
- **MiniLab, TWE,** p. 991
- **BioLab, TWE,** pp. 996-997

Knowledge Assessment
- **Section Assessment, SE,** pp. 982, 987, 995
- **Chapter Assessment, SE,** pp. 999-1001
- **Assessment, TWE,** pp. 984, 987, 995
- **Problem-Solving Lab, TWE,** p. 989

Skill Assessment
- **Assessment, TWE,** pp. 982, 992
- **MiniLab, TWE,** p. 980

Prepare

Key Concepts

The method by which impulses travel in the nervous system—including electrical transmission along the neuron and chemical transmission at the synapse—are covered in this section. The organization and function of the major parts of the nervous system are discussed.

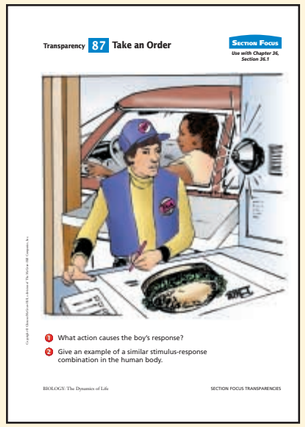
Planning

- Obtain a piece of cable for the first Quick Demo.
- Collect enough metersticks for student use in MiniLab 36-1.
- Acquire a rubber hammer for the second Quick Demo.

1 Focus

Bellringer

Before presenting the lesson, display **Section Focus Transparency 87** on the overhead projector and have students answer the accompanying questions. L1 ELL



2 Teach

Visual Learning

Figure 36.2 Spend a few minutes reviewing the sequence of events involved in the nervous system's response to a stimulus. Ask students what path the nervous system would take to turn the head in response to a sound such as a honking car horn. *The path would be the same except for the initial receptors, which would be located in the ear rather than in the skin.*

Visual Learning

Figure 36.3 Ask: What effect does the Na^+/K^+ pump have on the charge of the normal resting neuron? *It maintains a positive charge on the outside of the membrane and a negative charge within the membrane of a resting neuron.*

GLENCOE TECHNOLOGY

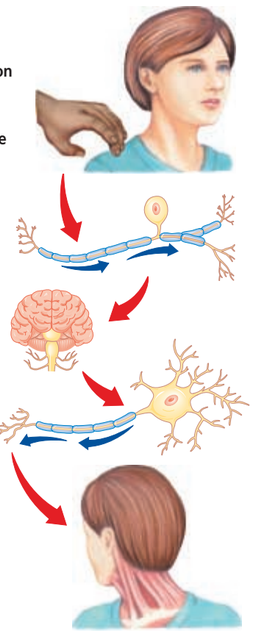
CD-ROM
Biology: The Dynamics of Life
BioQuest: *Body Systems*
Discs 1-5

VIDEODISC
Biology: The Dynamics of Life
Impulse Transmission: Neuron
(Ch. 37)
Disc 2, Side 1, 1 min. 24 sec.

Resource Manager

Section Focus Transparency 87 and Master L1 ELL
Critical Thinking/Problem Solving, p. 36 L3

Figure 36.2
The nervous system sorts and interprets incoming information before directing a response.



A Receptors in the skin sense a tap or other stimulus.

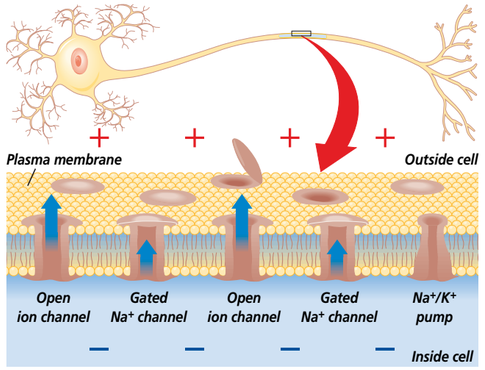
B Sensory neurons transmit the touch message.

C The message is interpreted. A response is sent to the motor neurons.

D Motor neurons transmit a response message to the shoulder muscles.

E The neck muscles are activated, causing the head to turn.

Figure 36.3
The membrane of a neuron contains open as well as gated channels that allow movement of sodium (Na^+) and potassium (K^+) ions into and out of the cell.



Relaying an impulse

Suppose you're in a crowded, noisy store and you feel a tap on your shoulder. Turning your head, you see the smiling face of a good friend. How did the shoulder tap get your attention? The touch stimulated sensory receptors located in the skin of your shoulder to produce an impulse. The sensory impulse was carried to the spinal cord and then up to your brain. From your brain, an impulse was sent out to your motor neurons, which then transmitted the impulse to muscles in your neck. Your neck muscles then turned your head. ***Figure 36.2*** shows how a stimulus, such as a tap on the shoulder, is transmitted through your nervous system.

A neuron at rest

First, let's look at a resting neuron—one that is not transmitting an impulse. You have learned that the plasma membrane controls the concentration of ions inside a cell. Because the plasma membrane of a neuron is more permeable to potassium ions (K^+) than it is to sodium ions (Na^+), more potassium ions exist within the cell membrane than outside it. Similarly, more sodium ions exist outside the cell membrane than within it.

The neuron membrane also contains an active transport system, called the sodium/potassium (Na^+/K^+) pump, which uses ATP to pump three sodium ions out of the cell for every two potassium ions it pumps in. As you can see in ***Figure 36.3,*** the action of the pump increases the concentration of positive charges on the outside of the membrane. In addition, the presence of many negatively charged proteins and organic phosphates means that the inside of the membrane is more negatively charged than the outside. Under these conditions, which exist when the cell is at rest, the plasma membrane is said to be polarized. A polarized membrane has the potential to transmit an impulse.

How an impulse is transmitted

When a stimulus excites a neuron, gated sodium channels in the membrane open up and sodium ions rush into the cell. As the positive sodium ions build up inside the membrane, the inside of the cell becomes more positively charged than the outside. This change in charge, called depolarization, moves like a wave down the length of the axon, as seen in ***Figure 36.4.*** As the wave passes, gated channels and the Na^+/K^+ pump act to return the neuron to its resting state, with the inside of the cell negatively charged and the outside positively charged.

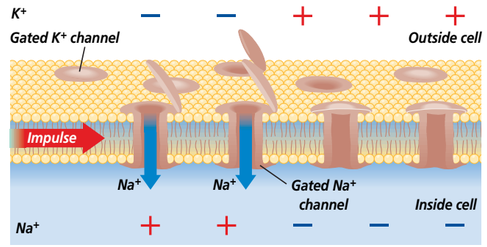
An impulse can move down the complete length of an axon only when stimulation of the neuron is strong enough. If the threshold level—the level at which depolarization occurs—is not reached, the impulse quickly dies out.

White matter and gray matter

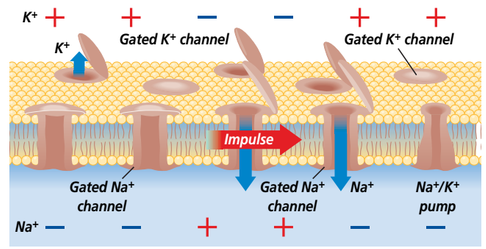
Most axons are surrounded by a white covering of cells called the myelin sheath. Like the plastic coating on an electric wire, the myelin sheath tightly insulates the axon, hindering the movement of ions across its plasma membrane. The ions move quickly down the axon until they reach a gap in the sheath. At this point, the ions pass through the plasma membrane of the nerve cell and depolarization occurs. As a result, the impulse jumps from gap to gap, greatly increasing the speed at which it travels.

CD-ROM
View an animation of nerve depolarization in the Presentation Builder of the Interactive CD-ROM.

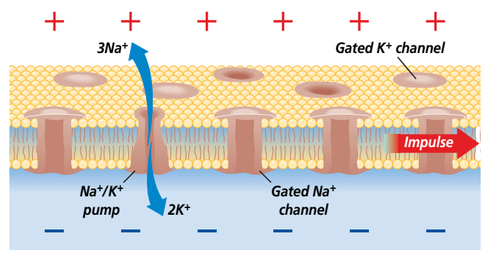
Figure 36.4
A wave of depolarization moves down the axon of a neuron.



A Gated sodium channels open, allowing sodium ions to enter and make the inside of the cell positively charged and the outside negatively charged.



B As the impulse passes, gated sodium channels close, stopping the influx of sodium ions. Gated potassium channels open, letting potassium ions out of the cell. This action repolarizes the cell.



C As gated potassium channels close, the Na^+/K^+ pump restores the ion distribution.

Reinforcement

Visual-Spatial Have students draw neurons similar to Figures 36.3 and 36.4, label the parts, and use arrows to show the pathway of the nerve impulse. L1 ELL

Quick Demo

To demonstrate what a nerve is like, show students the end of a cable, such as a telephone cable. Compare each wire to an axon and the individual wire wrappings to myelin sheaths. Explain that the whole cable represents a nerve.

GLENCOE TECHNOLOGY

CD-ROM
Biology: The Dynamics of Life
Animation: *Impulse Transmission in a Motor Neuron,* Disc 5

TECHPREP

Exploring Nursing

Have students interested in nursing contact a local hospital and arrange to shadow a nurse for an afternoon to find out more about what these professionals do. L2

BIOLOGY JOURNAL

Nerve Analogy

Linguistic Have students write a paragraph that explains how a nerve is similar to a wire going from a controlling switch (stimulus) to a light bulb (effector). L2

MEETING INDIVIDUAL NEEDS

Gifted

Visual-Spatial Have gifted students prepare a labeled dissection of a sheep brain. They should prepare whole brains and half brains, labeling areas discussed in Chapter 36. Brains for this activity can be ordered from biological supply houses. L3

Portfolio

Using a Model

Kinesthetic Ask students to obtain a small cable of wires, such as that used in the Quick Demo above. Have them mount the cable on a sheet of paper and draw a nerve beside it. Ask the students to write a paragraph that compares and contrasts the nerve and the cable. *Similarities include the following: Both carry messages, connect two things, contain a bundle of "wires," and have a covering. Differences include the following: The nerve is alive, made of cells, and can repair itself to a degree.* L2 ELL P

Activity

Have students take a right/left hemispheric mode indicator test to assess their personal approach to learning. Indicator tests are available from EXCEL INC, 200 W. Station St., Barrington, IL 60010. L2

Visual Learning

Figure 36.5 Draw attention to the illustration as you discuss the transmission of an impulse across a synapse.

Enrichment

Linguistic Have interested students read "Wide Hats and Narrow Minds" (from Stephen Jay Gould's *The Panda's Thumb*), which looks at the topic of brain size versus intelligence. L3

GLENCOE TECHNOLOGY

VIDEODISC
The Infinite Voyage
Fires of the Mind
Synaptic Development (Ch. 5)
5 min. 30 sec.

Biology: The Dynamics of Life
Impulse Transmission: Synapse (Ch. 38)
Disc 2, Side 1, 38 sec.

CD-ROM
Biology: The Dynamics of Life
Animation: *Impulse Transmission Across a Synapse*
Disc 5

The myelin sheath gives axons a white appearance. In the brain and spinal cord, masses of myelinated axons make up what is called "white matter." Has anyone ever told you to "use your gray matter"? They were actually referring to a specific part of your brain. The absence of myelin in masses of neurons accounts for the grayish color of "gray matter" in the brain.

WORD Origin

synapse
From the Greek word *synapsis*, meaning "union or joining." A synapse is a junction that connects two neurons.

Connections between neurons

Although neurons lie end to end—axons to dendrites—they don't actually touch. A tiny space lies between one neuron's axon and another neuron's dendrites. This junction between neurons is called a **synapse.** Impulses traveling to and from the brain must move across the synaptic space that separates the axon and dendrites. How do they make this leap?

As an impulse reaches the end of an axon, calcium channels open, allowing calcium to enter the end of the axon. As shown in ***Figure 36.5,*** the calcium causes vesicles in the axon to fuse with the plasma membrane, releasing their chemicals into the synaptic space by exocytosis. These chemicals, called **neurotransmitters,** diffuse across the space to the dendrites of the next neuron. As the neurotransmitters reach the dendrites, they signal receptor sites to open the ion channels. These open channels change the polarity in the neuron, initiating a new impulse. Enzymes in the synapse typically break down the neurotransmitters shortly after transmission, preventing the continual firing of impulses.

CD-ROM
View an animation of the synapse in the Presentation Builder of the Interactive CD-ROM.

The Central Nervous System

When you make a call to a friend, your call travels through wires to a control center where it is switched over to wires that connect with your friend's telephone. In the same manner, an impulse traveling through neurons in your body usually reaches the control center of the nervous system—your brain—before being rerouted. The brain and the spinal cord together make up the **central nervous system,** which coordinates all your body's activities.

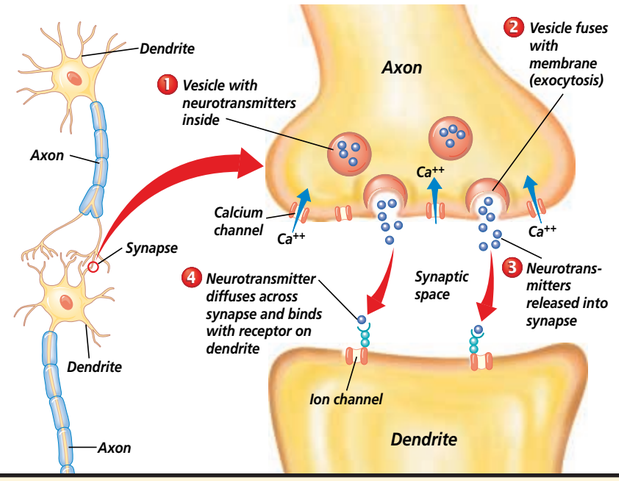


Figure 36.5
Neurotransmitters are released into the synaptic space by the axon. When the neurotransmitters bind to receptors on the dendrites of the next neuron, the ion channels open, changing the polarity of the dendrites. In this way, nerve impulses move from neuron to neuron.

Two systems work together

Another division of your nervous system, called the **peripheral nervous system** (puh RIHF rul), is made up of all the nerves that carry messages to and from the central nervous system. It is similar to the telephone wires that run between a phone system's control center and the phones in individual homes. Together, the central nervous system (CNS) and the peripheral nervous system (PNS), shown in ***Figure 36.6,*** respond to stimuli from the external environment.

Anatomy of the brain

The brain is the control center of the entire nervous system. For descriptive purposes, it is useful to divide the brain into three main sections: the cerebrum, the cerebellum, and the brain stem.

The **cerebrum** (suh REE brum) is divided into two halves, called hemispheres, that are connected by bundles of nerves. Your conscious activities, intelligence, memory, language, skeletal muscle movements, and senses are all controlled by the cerebrum. The outer surface of the cerebrum, called the cerebral cortex, is made up of gray matter. The cerebral cortex contains countless folds and grooves that increase its total surface area. This increase in surface area played an important role in the evolution of human intelligence as greater surface area allowed more and more complex thought processes.

The **cerebellum** (ser uh BEL um), located at the back of your brain, controls your balance, posture, and coordination. If the cerebellum is injured, your movements become jerky.

The brain stem is made up of the medulla oblongata, the pons, and the midbrain. The **medulla oblongata** (muh DUL uh • ahb long GAHT uh) is the part of the brain that controls involuntary activities such as breathing and heart rate. The pons and midbrain act as pathways connecting various parts of the brain with each other. Find out more about how the brain evolved by reading *Focus On Evolution of the Brain.* For the latest on technological advances in brain imaging, check out the *BioTechnology* section at the end of the chapter.

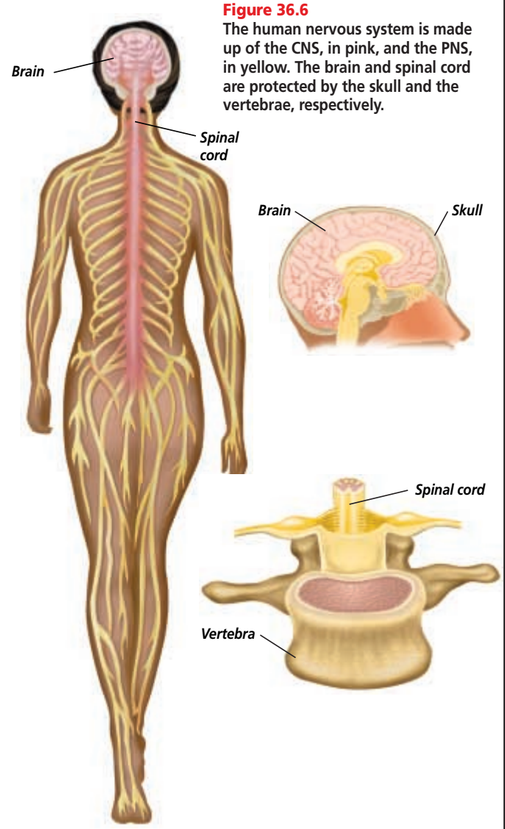


Figure 36.6
The human nervous system is made up of the CNS, in pink, and the PNS, in yellow. The brain and spinal cord are protected by the skull and the vertebrae, respectively.

Enrichment

Linguistic The Chinese have used acupuncture as a complete system of medicine for thousands of years. The procedure involves inserting long, thin needles into specific areas of the patient's body. Electrical impulses are then sent down the length of the needles. Acupuncture is used to relieve pain, cure cancer, and everything in between. It is also currently being used in China as a form of anesthesia for patients undergoing surgery.

Have students research and report on ancient methods of acupuncture. How did the methods used then differ from those used today? *The needles used to be turned to achieve the desired effect. Now electrical impulses are used instead.* L3

Assessment

Performance Assessment in the Biology Classroom, p. 49, *Preparing and Teaching a Lesson About the Nervous System.* Have students carry out this activity to demonstrate their knowledge of the structure and function of the nervous system. L2

NATIONAL GEOGRAPHIC

VIDEODISC
STV: Human Body Vol. 2
Nervous System
Unit 2, Side 2, 1 min. 59 sec.
The Brain and Its Parts

Resource Manager
Basic Concepts Transparency 66 and Master L2 ELL

TECHPREP

Exploring Medicine

Linguistic Have students interested in medicine interview a doctor to find out what type of preparation they need for medical school. L2

BIOLOGY JOURNAL

Spinal Cord Injuries

Linguistic Have students research the latest treatments for spinal cord injuries and the progress scientists have made in stimulating nerve cells to repair themselves. They should include a copy of their reports in their journals. L3

BIOLOGY JOURNAL

Involuntary Actions

Linguistic Ask students to list activities their bodies do without conscious thought. To get them started, have them consider what their bodies do while they are asleep. L1

PROJECT

Neuroscience Research

Linguistic Have students research and prepare a report, a visual device, or an audiovisual presentation on one of the following topics: sleep, split brain experiments, dementia, Alzheimer's disease, retrograde amnesia, or Penfield maps of the brain. Have students present their findings to the class. L2

Focus On

Evolution of the Brain

Purpose

Students will explore the evolution of the brain by comparing the brains of different animals. They will also learn about brain structure and function.

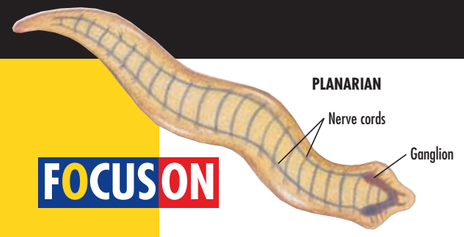
Background

Functionally, the human brain can be divided into the lobes of the cerebrum (including the cerebral cortex), the cerebellum, and the brain stem—pons, midbrain, and medulla oblongata.

Over the course of human evolution, the human brain has tripled in size. Scientists surmise that the increase in brain size accompanied the developed use of tools and other skills that enabled our ancestors to live in a greater variety of habitats.

Teaching Strategies

- Have students in groups draw a large outline of the brain on a piece of poster paper. Have them cut out magazine pictures that relate to the specializations of the brain and glue them on their outline. For instance, they could cut out eyes and place them in the occipital lobe to indicate that is where vision is interpreted.
- Have students make scale models of the cerebrums in the different animals shown. Then have them compare the size of the cerebrum with the size of the animal. Which animal has the largest cerebrum for its body size? Which has the smallest?



FOCUS ON

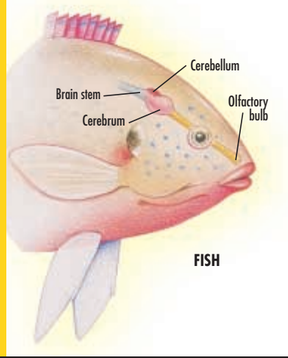
Evolution of the Brain

As animals have evolved over hundreds of millions of years, there has been a tendency toward ever-increasing complexity in the nervous system, and especially, in the brain. Brains had their beginnings as relatively simple bundles of nerve cells. But over time, the brains of vertebrate animals have become more complex and specialized. Humans possess the most complex brain in the animal kingdom, a remarkable organ that enables us to reason, wonder, and dream.

THE EVOLVING BRAIN

Jumping ahead millions of years to when the vertebrates emerged, the five brains shown here illustrate how evolution has transformed a simple ganglion to a complex brain. As the brain evolved, areas that control senses, behavior, and coordination became predominant.

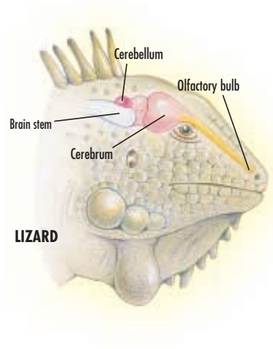
Notice that in humans the brain is proportionally much larger than it is in many other vertebrates and that the area dedicated to thinking, the cerebrum, covers and dominates everything else.



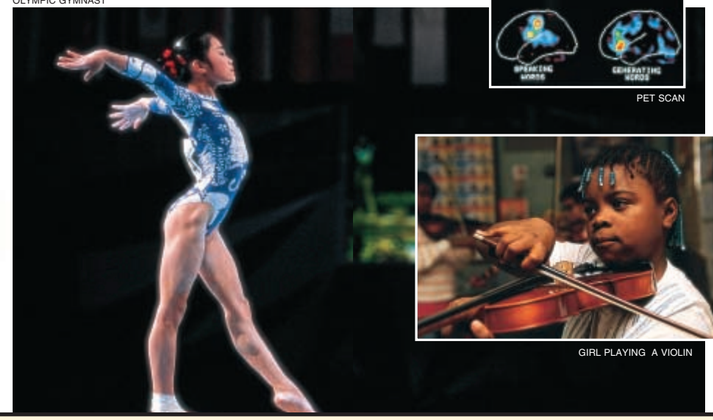
FISH

THE SIMPLEST BRAIN

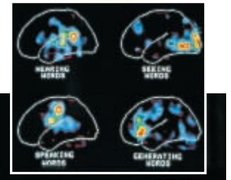
Flatworms are the simplest animals that have an identifiable brain. A planarian, for example, has a mass of nerve tissue called a ganglion that lies beneath each eyespot. Extending back from these ganglia are long nerve cords that run the length of the body. Between the cords are cross connections that make the planarian nervous system look like a ladder.



LIZARD

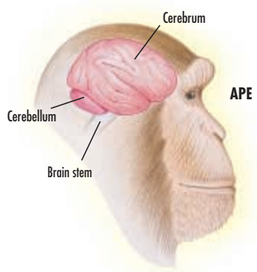


OLYMPIC GYMNAST

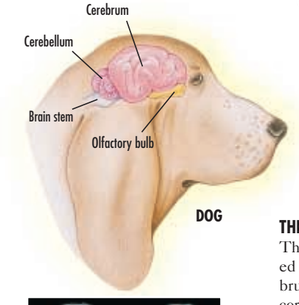


PET SCAN

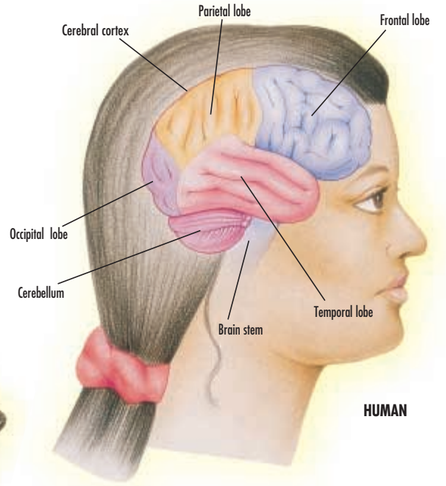
GIRL PLAYING A VIOLIN



APE



DOG



HUMAN

THE HUMAN BRAIN

The largest part of the human brain is the cerebrum. The cerebrum is divided into two hemispheres, left and right. But the feature that makes the cerebrum unique is an outer, folded layer less than 5 mm thick—the cerebral cortex. Because of the cortex, you can remember, reason, organize, communicate, understand, and create.

When you watch an Olympic gymnast perform on the balance beam, you are witnessing the work of a well-trained cerebellum. It is here that muscles are coordinated and the memories of physical skills are stored.

The brain stem consists of the medulla, pons, and midbrain. The brain stem regulates breathing, heart rate, circulation, and other vital body processes.

COMPLEX COORDINATION

The cerebral cortex may look like a uniform mass of nerve tissue. But different areas of the cortex receive and process different types of sensory, motor, and integrative nerve impulses. Using a technological tool known as a PET (positron emission tomography) scan (above left), scientists can pinpoint areas of increased metabolic activity in the brain. In so doing they can identify specific regions of the cortex that are involved in complex behaviors such as playing—from memory—a musical composition on the violin.

EXPANDING Your View

1. **THINKING CRITICALLY** Fish, reptiles, and dogs rely far more on their sense of smell to monitor their environments than humans do. How do the brain structures of these different animals reflect this fact?
2. **JOURNAL WRITING** In your journal, record your predictions about how a person's behavior might be affected by an injury to the cerebellum.

GLENCOE TECHNOLOGY

VIDEODISC

The Infinite Voyage

Fires of the Mind, The Brain and Memory (Ch. 6), 6 min.

The Brain: Understanding Left and Right (Ch. 8), 6 min.

The Brain and Defining Our Talents (Ch. 9) 9 min. 30 sec.

GLENCOE TECHNOLOGY

VIDEODISC

The Infinite Voyage *Unseen Worlds*

Magnetic Resonance Imaging: MRI a Medical Breakthrough (Ch. 6) 2 min. 30 sec.

Unseen Worlds

Brain Tumor Surgery: Made Possible by MRI (Ch. 7) 2 min. 30 sec.

Enrichment

Have students research the work of evolutionary biologists such as Niles Eldridge and Stephen Jay Gould. What facts are they able to base their work on? How much do they have to infer from fossil and other records?

Visual Learning

Visual-Spatial Display models or posters of various vertebrate brains. Point out the differences among the brains. L1

Tying to Previous Knowledge

Review the evolutionary sequence of the various phyla, paying special attention to the evolutionary tree of the vertebrates.

Answers to Expanding Your View

1. The percentage of brain devoted to the sense of smell is much larger in these animals than in the human brain.
2. The cerebellum coordinates physical skills, such as walking. Damage to this area of the brain could cause a person to have jerky, uncoordinated movements.

Going Further

Students interested in the evolution and function of the brain can read *Dragons of Eden*, by Carl Sagan.

Resource Manager

BioLab and MiniLab Worksheets, p. 159 L2

MiniLab 36-1

Purpose
Students investigate how a distracting stimulus affects reaction time.

Process Skills
observe and infer, compare and contrast, recognize cause and effect, collect and organize data, interpret data, experiment, analyze

Teaching Strategies
- If students find counting backwards awkward, have them whistle or sing a song as another kind of distraction.

Expected Results
A distraction should increase reaction time.

Analysis
1. As students learn to anticipate the drop, their reaction time should improve.
2. The distraction probably increased their reaction time.
3. Answers may include being tired, sick, hungry, or otherwise preoccupied.

Assessment
Skill Have students describe the sequence of events involved in their response to the falling meterstick. They should identify the stimulus (seeing the falling stick), the path of the impulse in their bodies, and the effect (grabbing the stick). Use the Performance Task Assessment List for Events Chain in **PASC,** p. 91. L2

The Peripheral Nervous System

Remember that the peripheral nervous system carries impulses between the body and the central nervous system. For example, when a stimulus is picked up by receptors in your skin, it initiates an impulse in the sensory neurons. The impulse is carried to the CNS. There, the impulse transfers to motor neurons that carry the impulse to a muscle.

The peripheral nervous system can be separated into two divisions—the somatic nervous system and the autonomic nervous system.

The somatic nervous system

The **somatic nervous system** is made up of 12 pairs of cranial nerves from the brain, 31 pairs of spinal nerves from the spinal cord, and all of their branches. These nerves are actually bundles of neuron axons bound together by connective tissue. The cell bodies of the neurons are found in clusters along the spinal column. Most nerves contain both sensory and motor axons.

The nerves of the somatic system relay information mainly between your skin, the CNS, and skeletal muscles. This pathway is voluntary, meaning that you can decide whether or not to move body parts under the control of this system. Try the *MiniLab* on this page to find out how distractions can affect the time it takes you to respond to a stimulus.

Reflexes in the somatic system

Sometimes a stimulus results in an automatic, unconscious response within the somatic system. When you touch something hot, you automatically jerk your hand away. Such an action is a **reflex,** an automatic response to a stimulus. Rather than proceeding to the brain for interpretation, a reflex impulse travels to the spinal column where it is sent directly back out to a muscle. The brain becomes aware of the reflex only after it occurs. ***Figure 36.7*** on the next page shows the shortened route of a reflex impulse.

The autonomic nervous system

Imagine that you are spending the night alone in a creepy old house. Suddenly, a creak comes from the attic and you think you hear footsteps. Your heart begins to pound. Your breathing becomes rapid. Your thoughts race wildly as you try to figure out what to do—stay and confront the unknown, or run out of the house!

Your internal reactions to this scary situation are being controlled by your autonomic nervous system. The **autonomic nervous system** carries impulses from the CNS to internal organs. These impulses produce responses that are involuntary, or not under conscious control.

There are two divisions of the autonomic nervous system—the **sympathetic nervous system** and the parasympathetic nervous system. The sympathetic nervous system controls many internal functions during times of stress. When you are frightened, the sympathetic nervous system causes the release of a hormone that results in the fight-or-flight response you learned about earlier, as shown in ***Figure 36.8.***

The **parasympathetic nervous system** on the other hand, controls many of the body's internal functions when it is at rest. It is in control when you are relaxing on a warm summer day after a picnic or reading quietly in your room. Both the sympathetic and parasympathetic systems send signals to the same internal organs. The resulting activity of the organ depends on the intensities of the opposing signals.

MiniLab 36-1 Experimenting

Distractions and Reaction Time
Have you ever tried to read while someone is talking to you? What effect does such a distracting stimulus have on your reaction time?

Procedure
1. Work with a partner. Sit facing your partner as he or she stands.
2. Have your partner hold the top of a meterstick above your hand. Hold your thumb and index finger about 2.5 cm away from either side of the lower end of the meterstick without touching it.
3. Tell your partner to drop the meterstick straight down between your fingers.
4. Catch the meterstick between your thumb and finger as soon as it begins to fall. Measure how far it falls before you catch it. Practice several times.
5. Run ten trials, recording the number of centimeters the meterstick drops each time. Average the results.
6. Repeat the experiment, this time counting backwards from 100 by fives (100, 95, 90, . . .) as you wait for your partner to release the meterstick.

Analysis
1. Did your reaction time improve with practice? Explain.
2. How was your reaction time affected by the distraction (counting backward)?
3. What other factors, besides distractions, would increase reaction time?

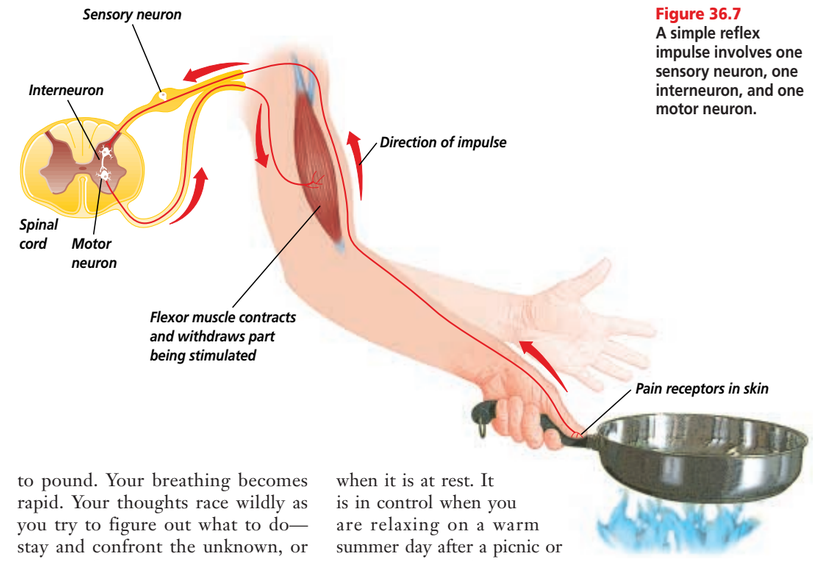


Figure 36.7
A simple reflex impulse involves one sensory neuron, one interneuron, and one motor neuron.

Figure 36.8
A fight-or-flight response to a rattlesnake will increase heart and breathing rates.

Concept Development
Have students name some of the reflexes an infant has from birth. List these reflexes on the chalkboard. Ask students how these behaviors are different from conscious behaviors such as walking and talking. *Reflexes are not learned behaviors.*

Quick Demo
Kinesthetic Demonstrate the knee-jerk reflex using a rubber hammer. Point out that students did not choose to move their legs—they did so automatically.

3 Assess

Check for Understanding
Make sure students understand that some parts of the nervous system are not under conscious control. Test their understanding by asking students to list body functions that they can and cannot control. Have them identify the part of the brain that controls each function. L2

Resource Manager
Laboratory Manual, pp. 261-264 L2

Alternative Lab

Skin Sensitivity

Purpose
Students design and carry out an experiment to determine the sensitivity of their skin.

Materials
paper clips unfolded in U-shapes, metric ruler

Background
Certain areas of the skin contain sensory neurons that are packed closely together, whereas other areas have neurons scattered up to centimeters apart. When two different stimuli depolarize parts of the same neuron, the brain interprets them as if they were one stimulus.

Procedure
Give students the following directions.
1. Working with a partner, plan ten areas of the skin to test for the distance between sensory neurons.
2. Have your partner close his or her eyes. With the paper clip ends close together, test your partner by gently touching his or her skin with the opened paper clip.
3. Continually spread the two ends of the paper clip farther apart until your partner can feel two points rather than one.
4. Determine the distance between sensory neurons in a certain body area by measuring the distance between the two ends of the paper clip.
5. In a data table, record the distance between sensory neurons in different parts of the body.

Analysis
1. Which areas of the skin did you find most sensitive? Least sensitive? *Responses will vary depending upon the areas tested. Regions of the back and inner arms will be less sensitive than areas of the palms and fingers.*
2. Explain why two stimuli are felt as two points when the ends of the paper clip are moved farther apart. *The two signals are detected by different sensory neurons.*

Assessment
Portfolio Have students include a summary of the lab, the data table, and answers to Analysis questions in their portfolios. Have them also write a paragraph explaining possible advantages of some areas of the skin being more sensitive than others. Use the Performance Task Assessment List for Lab Report in **PASC,** p. 47. L2 P

Reteach

Have students make a table that lists the three major parts of the brain and the functions of each. L2

Extension

Have interested students find out about the function of various neurotransmitters such as dopamine, serotonin, norepinephrine, adenosine, or GABA. L3

Assessment

Skill Prepare a handout showing a resting neuron, a stimulated neuron, and a synapse. Have students label the steps of neurotransmission. L1

4 Close

Discussion

Ask students what would happen if their cerebellum were damaged. For example, could they play a video game? *probably not, because the cerebellum controls coordination*

Resource Manager

Reinforcement and Study Guide, pp. 159-160 L2
Content Mastery, p. 178 L1
Basic Concepts Transparency 67 and Master L2 ELL

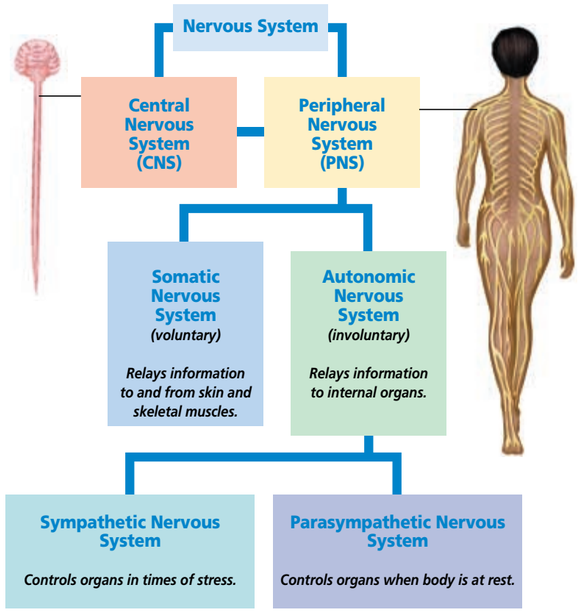


Figure 36.9 Understanding the organization of your nervous system can be made easier by studying the different divisions of the nervous system.

The different divisions and subsystems of your nervous system are summarized in ***Figure 36.9***. Each division plays a key role in communication and control within your body.

Note that the sympathetic and parasympathetic systems are part of the autonomic nervous system. The autonomic and somatic systems are part of the peripheral nervous system. The peripheral nervous system feeds information to the central nervous system.

Section Assessment

Understanding Main Ideas

1. Summarize the charge distribution that exists inside and outside a resting neuron.
2. Outline the functions of the three major parts of the brain.
3. Contrast the functions of the two divisions of the autonomic nervous system.
4. How does the Na^+/K^+ pump affect ion distribution in a neuron?

Thinking Critically

5. Why is it nearly impossible to stop a reflex from taking place?

Skill Review

6. **Sequencing** Sequence the events as a nerve impulse moves from one neuron to another. For more help, refer to *Organizing Information* in the **Skill Handbook.**

Section Assessment

1. The inside of the neuron is more negatively charged than the outside.
2. The cerebrum controls conscious activities, intelligence, memory, language, movement, and the senses. The cerebellum controls balance, posture, and coordination. The medulla oblongata mainly controls involuntary activities.
3. The sympathetic nervous system controls functions in times of stress, while the parasympathetic controls functions while the body is at rest.
4. The pump moves three sodium ions out of the cell for every two potassium ions it pumps into the cell.
5. A reflex is an involuntary action that does not involve conscious control by the brain. You cannot stop it.
6. An impulse reaches the end of an axon, opening calcium channels. This causes vesicles to fuse with the membrane and release their chemicals. These chemicals diffuse across the synaptic space to the dendrites of the next neuron.

Section

36.2 The Senses

SECTION PREVIEW

Objectives

Define the role of the senses in the human nervous system.

Recognize how senses detect chemical, light, and mechanical stimulation.

Identify ways in which the senses work together to gather information.

Vocabulary

taste bud
retina
rods
cones
cochlea
semicircular canals

Picture yourself in a park on a beautiful summer day. Stretching out on the grass, you look up and see white clouds float by against a background of blue. You feel grass tickling your toes and hear a breeze rustling the leaves of the trees. Sipping on a glass of lemonade, you note its tangy odor and sweet flavor. All these sensations are made possible by your senses: sight, touch, hearing, smell, and taste. Senses enable you to interpret your environment.

Magnification: 1040×

Taste buds (inset) respond to different chemical stimuli.

Sensing Chemicals

How are you able to smell and taste the lemonade? Chemical molecules of lemonade contact receptors in your nose and mouth as you sniff and drink the beverage. The receptors for smell are hairlike nerve endings located in the upper portion of your nose, as shown in ***Figure 36.10***. Chemicals acting on these nerve endings initiate impulses in the olfactory nerve, which is connected to your brain. In the brain, this signal is interpreted as a particular odor.

The senses of taste and smell are closely linked. Think about what your sense of taste is like when your nose is stuffed up and you can smell

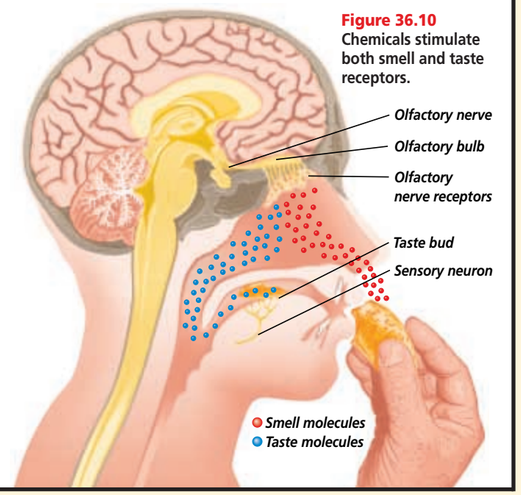


Figure 36.10 Chemicals stimulate both smell and taste receptors.

PROJECT

Modeling the Senses

Kinesthetic Have student groups select and make a model of one of the senses. The model may demonstrate the anatomy or the function of the sense. Have students explain and demonstrate their models to the class. L2 ELL COOP LEARN

GLENCOE TECHNOLOGY

VIDEODISC

The Infinite Voyage *A Taste of Health, Developing Taste* (Ch. 3)
7 min. 30 sec.

Prepare

Key Concepts

The anatomy and physiology of the major senses are presented. The senses that detect chemicals (taste, smell), the sense that detects light (vision), and the senses that detect mechanical stimulation (hearing, touch, and balance) are examined.

Planning

- Make or purchase a tape of common sounds for the first Quick Demo.
- Acquire models of ears, eyes, skin, and nose for the Display.
- Order cow or sheep eyes for the *Inside Story*.

1 Focus

Bellringer

Before presenting the lesson, display **Section Focus Transparency 88** on the overhead projector and have students answer the accompanying questions. L1 ELL

2 Teach

Quick Demo

Auditory-Musical To show how important each sense is, play a tape of various common sounds that students can identify. Discuss the dependence of humans on senses and the adjustments that are made if one sense is lost.

Concept Development

Ask students what kind of information the sense organs keep the body informed of. *They inform the body of changes that occur in the surroundings.* What is the reason for keeping the body informed? *So that it can respond to changes in the environment.*

Enrichment

TECH PREP

Invite an audiologist to speak to the class about sound levels, how they are measured, and damage that may result from high levels. Have the audiologist demonstrate how hearing is tested. L1

Display

Visual-Spatial Obtain display models of the ear, eye, skin, or nose. Have students examine the models as they read about each sense. L1 ELL

Assessment

Knowledge Have students write two questions about the sense of sight. Students should ask these questions of a classmate and then exchange questions with him or her. L2

WORD Origin

retina
From the Latin word *rete*, meaning "net." The retina contains a network of light-sensitive cells.

CD-ROM

View animations of the eye and ear located in the Presentation Builder of the Interactive CD-ROM.

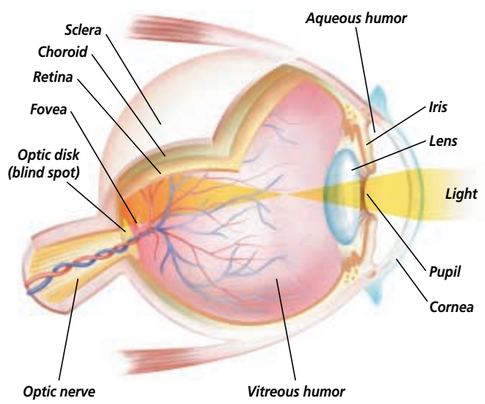
little, if anything. Because much of what you taste depends on your sense of smell, your sense of taste may also be dulled. You taste something when chemicals dissolved in saliva contact sensory receptors on your tongue called **taste buds.** Signals from your taste buds travel to the cerebrum. There, the signal is interpreted, and you notice a particular taste.

Tastes that you experience can be divided into four basic categories: sour, salty, bitter, and sweet. Certain regions of your tongue react more strongly to particular categories. Bitter flavors are most likely to be sensed at the back of the tongue, sour on the sides, and sweet and salty on the tip.

Sensing Light

How are you able to see? Your sense of sight depends on receptors in your eyes that respond to light energy. The **retina,** found at the back of the eye, is a thin layer of tissue made up of light receptors and sensory neurons.

Figure 36.11
A cross section through the human eye shows the path light takes as it enters through the pupil.



Light enters the eye through the pupil and is focused by the lens onto the back of the eye, where it strikes the retina. Follow the pathway of light to the retina in ***Figure 36.11.***

The retina contains two types of light receptor cells—rods and cones. **Rods** are receptor cells adapted for vision in dim light. They help you detect shape and movement. **Cones** are receptor cells adapted for sharp vision in bright light. They also help you detect color.

At the back of the eye, retinal tissue comes together to form the optic nerve, which leads to the brain, where images are interpreted. Can you see as well with one eye as with two? To find out more about how the brain forms a visual image, read the *Inside Story.*

Sensing Mechanical Stimulation

How are you able to hear the leaves rustle and feel the grass as you relax in the park? These senses—hearing and touch—depend on receptors that respond to mechanical stimulation.

Your sense of hearing

Every sound causes the air around it to vibrate. These vibrations travel outward from the source in waves, called sound waves. Sound waves enter your outer ear and travel down to the end of the ear canal, where they strike a membrane called the eardrum and cause it to vibrate. The vibrations then pass to three small bones in the middle ear—the malleus, the incus, and the stapes. As the stapes vibrates, it causes fluid in the **cochlea,** a snail-shaped structure in the inner ear, to move like a wave against the hair cells that line the cochlea's circular walls. Pressed by the fluid, the hairs bend.

INSIDE STORY

The Eye

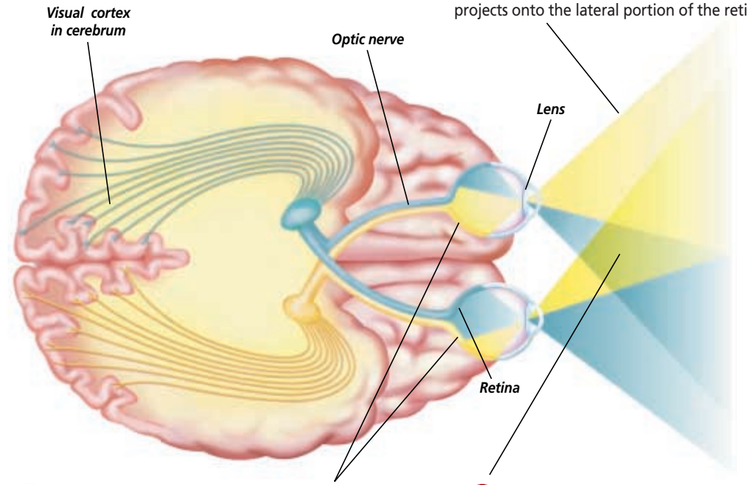
The light energy that reaches your retina is converted into nerve impulses, which are interpreted by your brain, allowing you to see the world around you.

Critical Thinking ***How would a person's vision be affected if his or her rod cells didn't function?***

Rod and cone cells

1 Rod and cone cells Rod cells in the retina are excited by low levels of light. These cells convert light signals into nerve impulses and relay them to the brain. Your brain interprets the information as a black and white picture. Your cone cells respond to bright light. They provide the brain with information about color.

2 Visual field Close one eye. Everything you can see with one eye open is the visual field of that eye. The visual field of each eye can be divided into two parts: a lateral and a medial part. As shown, the lateral half of the visual field projects onto the medial portion of the retina, and the medial half of the visual field projects onto the lateral portion of the retina.



4 Brain image projections The right half of the retina in each eye is connected to the right side of the visual cortex in the cerebrum. The left half of the retina is similarly connected to the left side of the visual cortex. Thus images entering the eye from the right half of each visual field project to the left half of the brain, and vice versa.

3 Depth perception The visual fields of the eyes partially overlap, each eye seeing about two-thirds of the total field. This overlap allows your brain to judge the depth of your visual field.

INSIDE STORY

Purpose

Students examine the function and structure of rods and cones and the divided projection of the visual field.

Teaching Strategies

- Ask students which cells are most active when they are reading color comics. *cone cells*
- Have students close one eye at a time and note the visual field they see out of each.
- Ask students to explain how they are able to judge depths using both eyes together. L2

Visual Learning

- Dissect a cow or sheep eye. Cow and sheep eyes have a layer on the inner choroid coat that is not present in humans. Explain that this iridescent layer enhances night vision by reflecting some light back into the retina.

Critical Thinking

Because rod cells function in low levels of light, the person would be virtually blind in dimly lit areas.

Resource Manager

Section Focus Transparency 88 and Master L1 ELL
Basic Concepts Transparency 68 and Master L2 ELL
Tech Prep Applications, p. 47 L2

BIOLOGY JOURNAL

Comparing Eyes to Cameras

Linguistic Ask students to write an essay comparing the eye to a camera. They should include references to the lens, the aperture, the body, and the shutter of the camera. Review the function of these camera parts with students. Students should include a copy of the essay in their journals. L3

GLENCOE TECHNOLOGY

CD-ROM
Biology: The Dynamics of Life
Animation: *The Sense of Sight*
Disc 5

Portfolio

Creating a Flowchart

Visual-Spatial Have students use Figures 36.11 and 36.12 to create flowcharts that show the series of events involved in seeing an object or hearing a sound. Encourage students to include the names of the eye, ear, and brain parts involved in these processes. L2 P

GLENCOE TECHNOLOGY

VIDEODISC
Biology: The Dynamics of Life
Sense of Sight (Ch. 39)
Disc 2, Side 1, 30 sec.

Problem-Solving Lab 36-1

Purpose

Students gain practice in determining whether statements are observations or inferences.

Process Skills

acquire information, define operationally, observe and infer, recognize cause and effect, think critically

Teaching Strategies

Refer students to the "Observing and Inferring" section in the Skill Handbook at the back of this text. The entire report can also be accessed on the Internet.

Thinking Critically

1. Student choices must include a specific number. A definition of the word *quantitative* should also be included in their answer.
2. Student choices should not include a specific number. A definition of the word *qualitative* should also be included.
3. Student may cite sentences that include "may be" or "can." A definition of the word *inference* should also be included in their answer.
4. Student answers may include the wearing of protective hearing devices and reducing volume or exposure time.

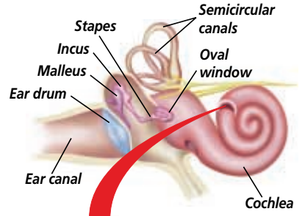
Assessment

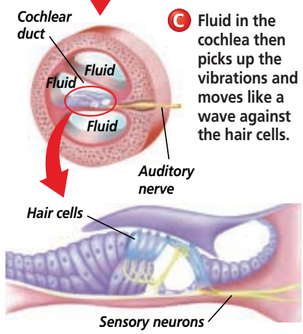
Portfolio Ask students to research the meaning of the term *decibel* and then prepare a poster listing noise-causing agents and their decibel ratings. Have them place the posters in their portfolios. Use the Performance Task Assessment List for Poster in **PASC,** p. 73. L2

Figure 36.12
The internal structure of the human ear is divided into three areas: the outer ear, middle ear, and inner ear. Follow the pathway sound waves take as they move through your ear.

A Sounds waves strike a membrane called the eardrum and cause it to vibrate.

B The vibrations are passed on to three bones in the middle ear–the malleus, the incus, and the stapes.





C Fluid in the cochlea then picks up the vibrations and moves like a wave against the hair cells.

D Impulses travel along the auditory nerve to the sides of the cerebrum, and you hear the sound.

Problem-Solving Lab 36-1

Interpreting and Analyzing

When are loud sounds dangerous to our hearing? Observations may be described as either qualitative or quantitative. A qualitative observation about a woman's height might be that she is tall. A quantitative observation about the same person might be that she is 1.92 m tall.

Analysis

"Hearing loss afflicts approximately 28 million people in the United States. Approximately 10 million of these impairments may be partially attributable to damage from exposure to loud sounds. Sounds that are sufficiently loud to damage sensitive inner ear structures can produce hearing loss that is not reversible. Very loud sounds of short duration, such as an explosion or gunfire, can produce immediate, severe, and permanent loss of hearing. Longer exposure to less intense but still hazardous sounds encountered in the workplace or during leisure activities, exacts a gradual toll on hearing sensitivity, initially without the victim's awareness. Live or recorded high-volume music, lawn-care equipment, and airplanes are examples of potentially hazardous noise."

"Noise and Hearing Loss," NIH Consensus Statement, January 22-24, 1990.

Thinking Critically

1. Choose and record two sentences or phrases from the passage above that provide examples of quantitative observations. Explain your selections.
2. Choose and record two sentences or phrases that provide examples of qualitative observations. Explain your selections.
3. Choose and record one sentence or phrase that provides an example of an inference. Explain your selection.
4. Suggest ways to minimize the type of noise exposure discussed in the last sentence.

The movement of the hairs produces electrical impulses, which travel along the auditory nerve to the sides of the cerebrum, where they are interpreted as sound. Trace the pathway of sound waves in ***Figure 36.12.*** To find out what impact loud sounds have on your hearing, do the *Problem-Solving Lab* on this page.

Your sense of balance

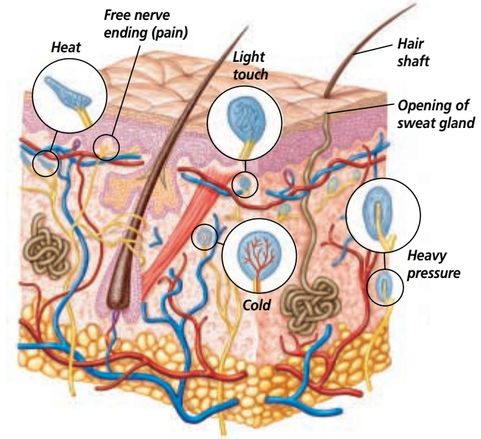
The inner ear also converts information about the position of your head into nerve impulses which travel to your brain, informing it about your body's equilibrium.

Maintaining balance is the function of your **semicircular canals.** Like the cochlea, the semicircular canals are also filled with a thick fluid and lined with hair cells. When you tilt your head, the fluid moves, causing the hairs to bend. This movement stimulates the hair cells to produce impulses. Neurons carry the impulses to the brain, which sends an impulse to stimulate your neck muscles and readjust the position of your head.

Your sense of touch

Like the ear, your skin also responds to mechanical stimulation with receptors that convert the stimulus into a nerve impulse. Receptors in the dermis of the skin respond to changes in temperature, pressure, and pain. It is with the help of these receptors, shown in ***Figure 36.13,*** that your body is able to respond to its external environment.

Although some receptors are found all over your body, those responsible for responding to particular stimuli are usually concentrated within certain areas of your body. For example, receptors that respond to light pressure are numerous in the dermis of your fingertips, eyelids, lips, the tip of your tongue, and the palms of your hands. When these receptors are stimulated, you perceive sensations of light touch.



Receptors that respond to heavier pressure are found inside your joints, in muscle tissue, and in certain organs. They are also abundant on the skin of your palms and fingers and on the soles of your feet. When these receptors are stimulated, you perceive heavy pressure.

Free nerve endings extend into the lower layers of the epidermis. These nerve endings act as pain receptors. You have two other kinds of receptors that respond to temperature. Heat receptors are found deep in the dermis, while cold receptors are found closer to the surface of your skin.

Figure 36.13
Many kinds of receptors are located throughout the dermis of your skin. Some receptors detect gentle touches; others respond to heavy pressure. The sensations of pain, heat, and cold are sensed by other kinds of receptors.

Section Assessment

Understanding Main Ideas

1. Summarize the types of messages the senses receive.
2. When you have a cold, why is it hard to taste food?
3. Explain how your eyes detect light and images.
4. What types of receptors are found in the skin?

Thinking Critically

5. Why might an ear infection lead to problems with balance?

Skill Review

6. **Sequencing** List the sequence of structures through which sound waves pass to reach the auditory nerve. For more help, refer to *Organizing Information* in the **Skill Handbook.**

3 Assess

Check for Understanding

Visual-Spatial Have students label diagrams of the eye, ear, and nose. L2 ELL

Extension

Have students research and report on the causes and treatments of cataracts, glaucoma, or vertigo. L3

Assessment

Knowledge Provide students with a list of sensations (such as pain, pressure, cold, odor, and so on) that can be detected by the body. Have them match each sensation with the sense organ that detects it. L1

4 Close

Discussion

Ask students to identify which of the following professions could be undertaken by someone who has lost the sense of sight: architect, violinist, mathematician, public speaker, professional athlete, accountant, physicist. What special tools (e.g., talking computers) would someone without sight have to use for each of the professions listed?

Resource Manager

Reinforcement and Study Guide, p. 161 L2
Content Mastery, p. 179 L1
Concept Mapping, p. 36 L3 ELL
Basic Concepts Transparency 69 and Master L2 ELL
Reteaching Skills Transparencies 52, 53 and Masters L1 ELL
Laboratory Manual, pp. 265-268 L2

Meeting Individual Needs

Hearing Impaired/Visually Impaired

Students who are hearing or visually impaired may be sensitive during discussions of the senses. Be prepared to answer questions about the causes and possible treatments of hearing or visual impairment.

GLENCOE TECHNOLOGY

CD-ROM Biology: The Dynamics of Life, Animation: *The Sense of Hearing,* Disc 5

VIDEODISC Biology: The Dynamics of Life
Sense of Hearing (Ch. 40)
Disc 2, Side 1, 1 min.

Section Assessment

1. The eyes respond to light. The ears respond to sound. Touch receptors respond to mechanical stimulation. The tongue and nose respond to chemicals.
2. The tasting of food involves both the sense of smell and the sense of taste.
3. Light stimulates the rod or cone cells in the retina, which transmit a signal to the brain by way of the optic nerve.
4. touch, temperature, pressure, and pain
5. Swelling associated with an ear infection could cause fluid in the ear to put pressure on the semicircular canals and cause the hairs in the canals to signal a false sense of balance in the brain.
6. outer ear, eardrum, malleus, incus, and stapes, fluid of cochlea, hairs of cochlea, auditory nerve to the brain

Section 36.3

Prepare

Key Concepts

This section summarizes the medicinal uses of drugs and explains how addictive drugs affect the body. The major classes of misused and abused drugs are discussed.

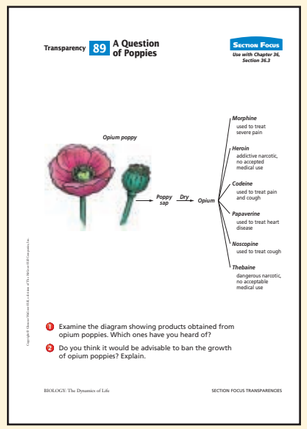
Planning

- Bring in various nonprescription drugs for students to compare in the first Quick Demo.
- Have students bring in magazines for the third Biology Journal activity.
- Order *Daphnia* and purchase coffee, tea, cola, unfiltered cigarettes, and cough syrup with dextromethorphen hydrobromide for the BioLab.

1 Focus

Bellringer

Before presenting the lesson, display **Section Focus Transparency 89** on the overhead projector and have students answer the accompanying questions. L1 ELL


Transparency 89 A Question of Poppies

Section Focus
Use with Chapter 36, Section 36.3

Opium poppy

Poppy sap — Dry — Opium

- Morphine: used to treat severe pain
- Heroin: addictive narcotic, no accepted medical use
- Codeine: used to treat pain and cough
- Papaverine: used to treat heart disease
- Nicotine: used to treat cough
- Thebaine: dangerous narcotic, no acceptable medical use

1. Examine the diagram showing products obtained from opium poppies. Which ones have you heard of?
2. Do you think it would be advisable to ban the growth of opium poppies? Explain.

BIOLOGY: The Dynamics of Life — SECTION FOCUS TRANSPARENCIES

SECTION PREVIEW

Objectives

Recognize the medicinal uses of drugs.

Identify the different classes of drugs.

Interpret the effect of drug misuse and abuse on the body.

Vocabulary

drug
narcotic
stimulant
depressant
addiction
tolerance
withdrawal
hallucinogen

Section

36.3 The Effects of Drugs

Nerves frazzled? Feeling tense? For a person trying to quit a smoking habit, the desire for a cigarette is almost overpowering. Without the person realizing it, an occasional cigarette has grown into a pack-a-day habit. The body now cries out for nicotine. Why do people start smoking even though nicotine is so addictive?

Cigarettes, made from tobacco leaves (top), contain the addictive drug nicotine.

Drugs Act on the Body

You probably hear the word *drug* used often, maybe even every day. A **drug** is a chemical that affects the body's functions. Most drugs interact with receptor sites on cells, probably the same ones used by neurotransmitters of the nervous system or hormones of the endocrine system. Some drugs increase the rate at which neurotransmitters are synthesized and released, or slow the rate at which they are broken down, as illustrated in ***Figure 36.14***. Other drugs interfere with a neurotransmitter's ability to interact with its receptor. Explore how these different drugs work on neurotransmitters by doing the *Problem-Solving Lab* on the next page.

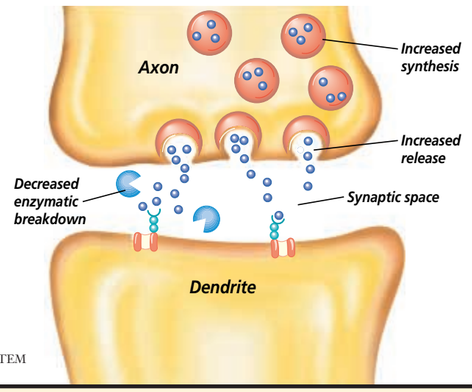


Figure 36.14
Drugs can increase neurotransmitter levels in the synapse by stimulating their synthesis, increasing their release, or by slowing their breakdown by enzymes.

Medicinal Uses of Drugs

A medicine is a drug that, when taken into the body, helps prevent, cure, or relieve a medical problem. Some of the many kinds of medicines used to relieve medical conditions are discussed below.

Relieving pain

Headache, muscle ache, cramps—all are common pain sensations. You just studied how pain receptors in your body send signals to your brain. Medicines that relieve pain manipulate either the receptors that initiate the impulses or the central nervous system that receives them.

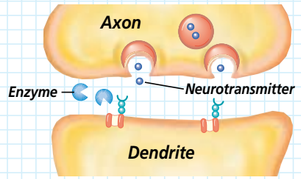
Pain relievers that do not cause a loss of consciousness are called analgesics. Some analgesics, like aspirin, work by inhibiting receptors at the site of pain from producing nerve impulses. Analgesics that work on the central nervous system are called **narcotics.** Many narcotics are made from the opium poppy flower, shown in ***Figure 36.15.*** Opiates, as they are called, can be useful in controlled medical therapy because only these drugs are able to relieve severe pain.

Problem-Solving Lab 36-2 — Formulating Models

How do different drugs affect the levels of neurotransmitters in synapses? Drugs can act on neurotransmitters in a number of different ways. For example, they may speed up the reabsorption of a neurotransmitter back into the dendrite end of a neuron. Or, they may block the release of the neurotransmitter from the axon end of a neuron. They may also prevent the breakdown of the neurotransmitter by blocking the enzyme responsible for this action.

Analysis

Examine the diagram shown here, which illustrates how neurotransmitters work.



Thinking Critically

1. Design three different drugs:
   a. One that will block the enzyme from breaking down the neurotransmitter.
   b. One that will prevent the neurotransmitter from reaching the receptor site on the dendrite.
   c. One that will block the release of the neurotransmitter from the axon.
2. Draw three separate figures to show how each of your drugs works.
3. Predict the effects of each drug on the body. Explain your answer.

Figure 36.15
Sticky sap from the fruit of an opium poppy is used to make drugs called opiates.

Problem-Solving Lab 36-2

Purpose

Students design drugs that will interfere with the action of neurotransmitters.

Process Skills

apply concepts, formulate models, hypothesize, interpret scientific illustrations, predict, recognize cause and effect, think critically

Teaching Strategies

- Review the nature of the synapse and how neurotransmitters work normally.
- Encourage students to consider the shapes of the neurotransmitter molecules, enzymes, and binding sites when designing their blockers.
- Allow students to work in small groups.

Thinking Critically

1. Student models will vary. Make sure that each one produces the effect described.
2. Student figures should indicate how each of their drugs works.
3. (a) Message will be transmitted for a longer period of time than normal; (b) Message will not be received by dendrite; (c) Message will not be delivered to dendrite.

Assessment

Knowledge Ask students to make a diagram showing some type of neurotransmitter blockage. Ask them to interpret the drawing. Use the Performance Task Assessment List for Scientific Drawing in **PASC,** p. 55. L2

Meeting Individual Needs

English Language Learners

Visual-Spatial Have students with limited English proficiency make a poster that summarizes the effects on different body systems of one drug that is misused or abused. Have students combine their posters to create a bulletin board display. L1 ELL

Resource Manager

Section Focus Transparency 89 and Master L1 ELL

Internet Address Book

internet CONNECTION Note Internet addresses that you find useful in the space below for quick reference.

GLENCOE TECHNOLOGY

VIDEODISC

The Infinite Voyage *Prisoners of the Brain: Neurotransmitters and the Chemical Basis of Mental Illness* (Ch. 3), 3 min.

Dopamine and Antipsychotic Drugs (Ch. 4), 7 min.

Using PCP to Study Schizophrenia (Ch. 5), 7 min. 30 sec.

Careers in Biology

Career Path

Courses in high school: chemistry, biology, and other advanced science and mathematics courses

College: for most states, a five-year bachelor's degree in pharmacy plus an internship; for some states, a six-year doctoral program

Career Issue

Ask students whether pharmacists should ever contradict information that doctors have given their patients. Remind the class that the training pharmacists receive about the function of the human body is not as thorough as the training doctors receive.

For More Information

For more information about becoming a pharmacist, students can contact the American Pharmaceutical Association at the following address:

American Pharmaceutical Association
2215 Constitution Avenue, NW
Washington, DC 20037

Quick Demo

Bring various nonprescription drugs (such as aspirin, cough syrup, antacids, and so on) to hold up for the class. Compare such things as price, type of drug, type of packaging, and purpose of the drug.

Resource Manager

BioLab and MiniLab Worksheets, p. 160 L2

Careers in Biology

Pharmacist

Would you like to help people get well, but can't stand the sight of blood? Then consider a career as a pharmacist.

Skills for the Job

Pharmacists read prescriptions written by doctors and other health professionals and carefully prepare containers with the correct medicine. (Few pharmacists still mix the medicine themselves; that is done by the drug manufacturer.) Pharmacists must know how drugs interact and guide people in avoiding harmful combinations. They also help customers select over-the-counter medicines. Besides drugstores, pharmacists work in hospitals and nursing homes, and for drug companies and government agencies. To become a pharmacist, you must complete a five-year bachelor's degree in pharmacy. You must also pass a state examination.

*inter*NET CONNECTION For more careers in related fields, be sure to check the Glencoe Science Web Site.
www.glencoe.com/sec/science

Word Origin

cardiovascular
From the Greek words *kardia*, meaning "the heart," and *vasculum*, meaning "small vessel." Cardiovascular drugs treat problems associated with blood vessels of the heart.

Treating circulatory problems

Many drugs have been developed to treat heart and circulatory problems such as high blood pressure. These medicines are called cardiovascular drugs. In addition to treating high blood pressure, cardiovascular drugs may be used to normalize an irregular heartbeat, increase the heart's pumping capacity, or enlarge small blood vessels. Discover how various types of drugs can affect heart rate by doing the *BioLab* at the end of this chapter.

Treating nervous disorders

Several kinds of medicines are used to help relieve symptoms of nervous system problems. Among these medicines are stimulants and depressants.

Drugs that increase the activity of the central and sympathetic nervous systems are called **stimulants.** Amphetamines (am FET uh meenz) are synthetic stimulants that increase the output of CNS neurotransmitters. Amphetamines are seldom prescribed because they can lead to dependence, which you'll read more about later in this chapter. However, because they increase wakefulness and alertness, amphetamines are sometimes used to treat patients with sleep disorders.

Drugs that lower, or depress, the activity of the nervous system are called **depressants,** or sedatives. The primary medicinal uses of depressants are to encourage calmness and produce sleep. For some people, the symptoms of anxiety are so extreme that they interfere with the person's ability to function effectively. By slowing down the activities of the CNS, a depressant can temporarily relieve some of this anxiety.

The Misuse and Abuse of Drugs

The misuse or abuse of drugs can cause serious health problems—even death. Drug misuse occurs when a medicine is taken for an unintended use. For example, giving your prescription medicine to someone else, not following the prescribed dosage by taking too much or too little, and mixing medicines, are all instances of drug misuse. You must pay careful attention to the specific instructions given on the label of a drug you are taking. The *MiniLab* on the next page shows you how to analyze such a label.

Drug abuse is the inappropriate self-administration of a drug for nonmedical purposes. Drug abuse may involve use of an illegal drug, such as cocaine; use of an illegally obtained medicine, such as someone else's prescribed drugs; or excessive use of a legal drug, such as alcohol or nicotine. Drugs abused in this way can have powerful effects on the nervous system and other systems of the body, as described in ***Figure 36.16***.

Addiction to drugs

When a person believes he or she needs a drug in order to feel good or function normally, that person is psychologically dependent on the drug. When a person's body develops a chemical need for the drug in order to function normally, the person is physiologically dependent. Psychological and physiological dependence are both forms of **addiction.**

Tolerance and withdrawal

When a drug user experiences tolerance or withdrawal to a frequently used drug, that person is addicted to the drug. **Tolerance** occurs when a person needs larger or more frequent doses of a drug to achieve the same effect. The dosage increases are necessary because the body becomes less responsive to the drug. **Withdrawal** occurs when the person stops taking the drug and actually becomes ill.

Figure 36.16
The use of anabolic steroids without careful guidance from a physician is illegal. Some dangerous side effects of steroid abuse include cardiovascular disease, kidney damage, and cancer.

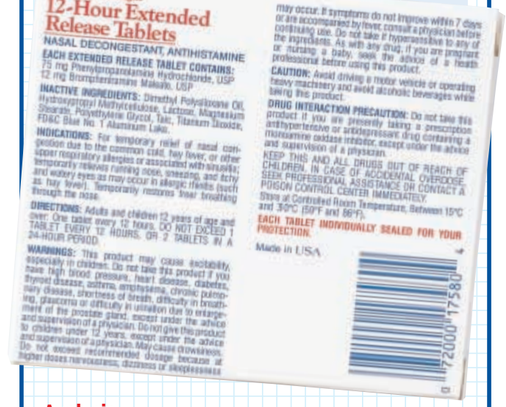
MiniLab 36-2 Analyzing Information

Interpret a Drug Label One common misuse of drugs is not following the instructions that accompany them. Over-the-counter medicines can be harmful—even fatal—if they are not used as directed. The Food and Drug Administration requires that certain information about a drug be provided on its label to help the consumer use the medicine properly and safely.

Procedure

1. The photograph below shows a label from an over-the-counter drug. Read it carefully.
2. Make a data table like the one shown. Then fill in the table using information on the label.

Information from a drug label				
People with these conditions should avoid this drug	Possible side effects	This drug should not be taken with these medicines	Symptoms this drug will relieve	Correct dosage



Analysis

1. What is a side effect? What side effects are caused by this drug?
2. Why should a person never take more than the recommended dosage?
3. How are over-the-counter drugs different from prescription drugs?

Biology Journal

Animal Testing of Medicines

Linguistic Animals are used to test certain drugs. Some people believe that using animals is unnecessary. Ask students to do some research and then write an editorial for the student or local newspaper. Have them include a copy in their journals. L2

Glencoe Technology

VIDEODISC
The Infinite Voyage
Prisoners of the Brain: Understanding Addiction
(Ch. 8), 4 min.
Dopamine and the Craving of Narcotics
(Ch. 9), 5 min.

Cultural Diversity

Solomon Carter Fuller

Students may obtain a more thorough understanding of brain function by learning about common neuropathologies, such as Alzheimer's disease. During your discussions, emphasize the work of African American psychiatrist and researcher, Solomon Carter Fuller (1872–1953).

Fuller taught pathology, neurology, and psychiatry at Boston University for nearly 40 years. He was best known for expanding our medical knowledge in the fields of neuropathology and psychiatry. His research on degenerative diseases of the brain—including Alzheimer's disease—was considered pioneering work. In 1913, Fuller became the editor of the *Westborough State Hospital Papers,* an influential publication specializing in mental diseases.

MiniLab 36-2

Purpose
Students study information found on the labels of over-the-counter drugs.

Process Skills
observe and infer, analyze

Teaching Strategies
■ Have students look at the package labels of other over-the-counter drugs.

Expected Results
Student tables should show the following information: among others, children under 12 years, people with high blood pressure, heart disease, diabetes, thyroid disease, asthma, or emphysema should avoid this drug; drowsiness is a possible side effect; should not be taken with antihypertensive or antidepressant drugs; will relieve nasal congestion associated with the common cold, hay fever, or sinusitis; the correct dosage is one tablet every 12 hours.

Analysis

1. A side effect is any effect of the drug other than the one it is designed to produce. Side effects of this drug include drowsiness.
2. The recommended dosage is the one that has been tested and proven to be safe. Over-the-counter medicines are potentially harmful if not used as directed.
3. Over-the-counter drugs are available without a doctor's prescription. They are not as strong as prescription medicines.

Assessment

Performance Ask students to repeat the MiniLab for other drug labels and include the tables in their portfolios. Use the Performance Task Assessment List for Carrying Out a Strategy and Collecting Data in **PASC,** p. 25. L2 ELL

Assessment

Skill Have students make a table of commonly abused drugs, summarizing their effects on the body and the symptoms associated with their withdrawal. L2

Enrichment

Researchers speculate that animals have learned to medicate themselves by feeding on certain plants. Zoopharmacognosy is the study of the use of medicinal plants by wild animals. This growing area of research involves observing wild animals (including chimpanzees and bears) as they eat plants known to have medicinal properties and noting the results.

In 1989, a primatologist from Kyoto University observed a lethargic chimpanzee that had diarrhea and discolored urine chewing on the bark and leaves of a plant called *Vernonia amygdalina*. The primatologist knew that the plant contained antibiotic and antiparasitic compounds. The day after eating the plant, the chimp had recovered fully.

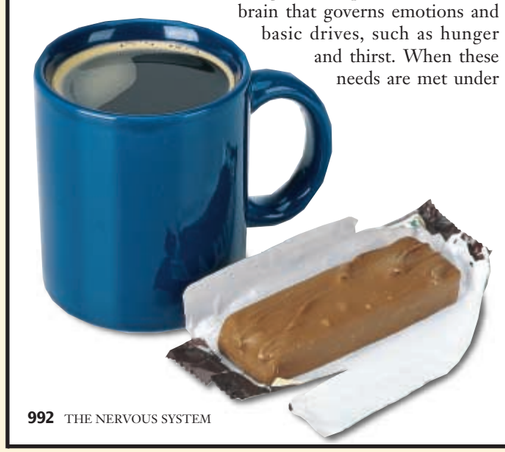
Have students research ways in which their own pets use plants as medicine. Why do they think dogs and cats sometimes eat grass? L3

DESIGN YOUR OWN BioLab

The BioLab at the end of the chapter can be used at this point in the lesson.

Figure 36.17
Babies born addicted to crack cocaine are usually low in birth weight, continually irritable, and may shake constantly.

Figure 36.18
Caffeine can trigger a condition called tachycardia, when the heart beats more than 100 times per minute.



Classes of Commonly Abused Drugs

Each class of drug produces its own special effect on the body, and its own particular symptoms of withdrawal.

Stimulants: Cocaine, amphetamines, caffeine, and nicotine

You already know that stimulants increase the activity of the central nervous system and the sympathetic nervous system. Increased CNS stimulation can result in mild elevation of alertness, increased nervousness, anxiety, or even convulsions.

Cocaine stimulates the CNS by working on the part of the inner brain that governs emotions and basic drives, such as hunger and thirst. When these needs are met under normal circumstances, neurotransmitters—such as dopamine—are released to reward centers and the person experiences pleasure. Cocaine artificially increases levels of these neurotransmitters in the brain. As a result, false messages are sent to reward centers indicating that a basic drive has been satisfied. The user quickly feels a euphoric high called a rush. This sense of intense pleasure and satisfaction cannot be maintained, however, and soon the effects of the drug change. Physical hyperactivity follows, and the user is unable to sit still. Often, anxiety and depression set in.

Cocaine also disrupts the body's circulatory system by interfering with the sympathetic nervous system. Although initially causing a slowing of the heart rate, it soon produces a great increase in heart rate and a narrowing of blood vessels, known as vasoconstriction. The result is high blood pressure. Heavy use of this drug compromises the immune system and often leads to heart abnormalities. Cocaine affects more than just the people who use it. As ***Figure 36.17*** shows, babies of addicted mothers are sometimes born already dependent on this drug.

As you've already learned, amphetamines are stimulants that increase levels of CNS neurotransmitters. Like cocaine, amphetamines also cause vasoconstriction, a racing heart, and increased blood pressure. Other adverse side effects of amphetamine abuse include irregular heartbeat, chest pain, paranoia, hallucinations, and convulsions.

Not all stimulants are illegal. As shown in ***Figure 36.18,*** one stimulant in particular is as close as the nearest coffee maker or candy machine. Caffeine—a substance found in coffee, cola-flavored drinks, cocoa, and tea—is a CNS stimulant. Its effects include increased alertness and some mood elevation. Caffeine also causes an increase in heart rate and urine production, which can lead to dehydration.

Nicotine, a substance found in tobacco, also is a stimulant. By increasing the release of the hormone epinephrine (adrenaline), nicotine increases heart rate, blood pressure, breathing rate, and stomach acid secretion. Although nicotine is the addictive substance in tobacco, it is only one of about 3000 known chemicals found in cigarettes, many of which are also harmful. Smoking cigarettes is legal for adults. But our ever-increasing knowledge of the effects of smoke not only on the bodies of smokers but on nonsmokers as well has made cigarette smoking an increasingly unaccepted social habit.

Depressants: Alcohol and barbiturates

As you already know, depressants slow down the activities of the CNS. All CNS depressants relieve anxiety, but most also produce noticeable sedation.

One of the most widely abused drugs in the world today is alcohol. Easily produced from various grains and fruits, such as those shown in ***Figure 36.19,*** this depressant is distributed throughout a person's body via the bloodstream.

Unlike other drugs that act on specific receptors, alcohol probably acts on the brain by dissolving through the membranes of neurons. Once inside a neuron, alcohol disrupts important cellular functions. For instance, it appears to block the movement of sodium and calcium ions, which are important in the transmission of impulses and the release of neurotransmitters.

Figure 36.19
Most spirits are made from fermented grains such as wheat, barley, and rye. Wine is made from grapes, and cider from apples.

Tolerance to the effects of alcohol develops as a result of heavy consumption. Addiction to alcohol—alcoholism—can cause the destruction of nerve cells and brain damage. A number of organ diseases are directly attributable to chronic alcohol use. For example, cirrhosis, a hardening of the tissues of the liver, is a common affliction of alcoholics. ***Figure 36.20*** shows another tragic outcome of alcoholism.

Figure 36.20
Alcohol depresses the nervous system, impairing sensory perception and delaying reaction time.

Bioethics

Part of the procedure in getting a drug approved by the Food and Drug Administration (FDA) involves human drug tests. The deaths of five out of 15 participants in National Institute of Health (NIH) drug trial in the summer of 1993 has raised questions as to the safety of these tests. Even though participants sign a consent form, desperately ill patients may be willing to place themselves in inordinately dangerous situations in hopes of helping to find a cure. As a result, researchers question whether these patients can be truly "informed" about the risks involved.

Ask students to research what consenting to drug testing by the FDA involves. Have students present their findings in a written report. L3

BIOLOGY JOURNAL

Cocaine Abuse

Linguistic Have students research the history of a person who has suffered as a result of cocaine abuse. Each student should write a short essay that includes his or her personal feelings about how this drug affected the person. L2

Portfolio

Alcohol in the Body

Linguistic Ask students to write a skit about the travel route of alcohol in the body—from the mouth, into the bloodstream, and to the brain and liver. Have them place the written lines and directions for the skits in their portfolios. L2 P

Enrichment

Intrapersonal Have interested students research how the following toxins affect the nervous system and what they are used for: saxitoxin (from red tide), physostigmine, alpha-bungarotoxin, tetrodotoxin, and diisopropyl fluorophosphate. L3

Concept Development

Intrapersonal Have students find out how computers are allowing pharmacologists to design new drugs. L3

3 Assess

Check for Understanding

Linguistic Have students make a list of stimulants and depressants and write a paragraph about how these substances affect the body. L2

Reteach

Linguistic Have students write a paragraph explaining how nicotine replacement therapy helps smokers to stop smoking. L2

Extension

Have students research information about genetic susceptibility to alcoholism. L2

Barbiturates (bar BIHCH uh ruts) are sedatives and anti-anxiety drugs. When barbiturates are used in excess, the user's respiratory and circulatory systems become depressed. Chronic use results in both tolerance and addiction.

Narcotics: Opiates

Most narcotics are opiates, that is, they are derived from the opium poppy. They act directly on the brain. The most abused narcotic in the United States is heroin. It depresses the CNS, slows breathing, and lowers heart rate. Tolerance develops quickly, and withdrawal from heroin is painful.

Hallucinogens: Natural and synthetic

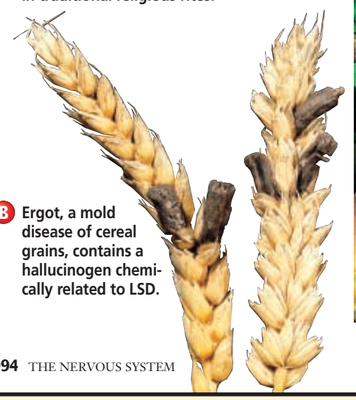
Natural hallucinogens have been known and used for thousands of years, but the abuse of hallucinogenic drugs did not become widespread in the United States until the 1960s, when new synthetic versions became widely available.

Hallucinogens (huh LEWS un uh junz) stimulate the CNS—altering moods, thoughts, and sensory perceptions. Quite simply, the user sees, hears, feels, tastes, or smells things that are not actually there. This disorientation can impair the user's judgement and place him or her in some potentially dangerous situations. Hallucinogens also increase heart rate, blood pressure, respiratory rate, and body temperature, and sometimes cause sweating, salivation, nausea, and vomiting. After large enough doses, convulsions of the body may even occur.

Unlike the hallucinogens shown in ***Figure 36.21,*** LSD—or acid—is a synthetic drug. The mechanism by which LSD produces hallucinations is still debated, but it may involve the blocking of a CNS neurotransmitter.

Figure 36.21
Some hallucinogens are found in nature.

A **Mushrooms of the genus *Psilocybe* contain the CNS hallucinogen psilocybin. These mushrooms are considered sacred by certain Native American tribes, who use them in traditional religious rites.**



B **Ergot, a mold disease of cereal grains, contains a hallucinogen chemically related to LSD.**

Breaking the Habit

Once a person has become addicted to a drug, breaking the habit can be very difficult. Recall that an addiction can involve both physiological and psychological dependencies. Besides the desire to break the addiction, studies have shown that people usually need both medical and psychological therapy—such as counseling—to be successful in their treatment. Support groups such as Alcoholics Anonymous allow addicts to share their experiences in an effort to maintain sobriety. Often, people going through the same recovery are able to offer the best support.

Nicotine replacement therapy

Nicotine replacement therapy is one example of a relatively successful drug treatment approach. People who are trying to break their addiction to tobacco often go through stressful withdrawals when they stop smoking cigarettes. To ease the intensity of the withdrawal symptoms, patients wear adhesive patches that slowly release small amounts of nicotine into their bloodstream, as shown in ***Figure 36.22.*** Alternatively, pieces of nicotine-containing gum are chewed periodically to temporarily relieve cravings.

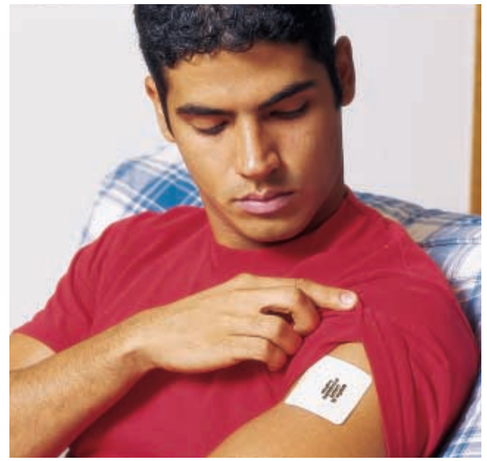


Figure 36.22
To help break an addiction to tobacco, this patient is wearing a patch on his arm that releases small amounts of nicotine directly into his bloodstream.

Nicotine inhalers—similar to asthma inhalers—provide immediate relief. By gradually decreasing the amount of nicotine released by the patches—or the number of gum pieces chewed—cigarette smokers are able to minimize the withdrawal symptoms that often result in a failure to quit.

Section Assessment

Understanding Main Ideas

1. In what ways can drugs be used to treat a cardiovascular problem?
2. What is the difference between aspirin and a narcotic?
3. How does nicotine affect the body?
4. How can drugs affect levels of neurotransmitters between neurons?

Thinking Critically

5. Suggest why a physician but not a pharmacist is legally permitted to write prescriptions.

Skill Review

6. **Comparing and Contrasting** Distinguish between stimulants and depressants, comparing their effects on the body. For more help, refer to *Thinking Critically* in the **Skill Handbook.**

Assessment

Knowledge Have one student name a drug from the chapter and a second student categorize the drug as a stimulant, depressant, narcotic, or hallucinogen. Have a third student list a side effect of the drug. Continue around the class until each student has been involved. L2

4 Close

Discussion

Ask students to discuss the consequences of introducing any type of drug into the body. Bring out that all drugs affect body function. *Some drugs help the body establish and maintain homeostasis while other drugs, those most frequently abused, alter homeostasis.*

Resource Manager

Reinforcement and Study Guide, p. 162 L2
Content Mastery, pp. 177, 180 L1
Tech Prep Applications, p. 49 L2

Biology Journal

Evaluating Advertising

Interpersonal Ask students to cut out cigarette ads from magazines. Post the ads on a bulletin board so all students can view them. In groups, have students discuss who the ads are likely to influence (the targeted audience). Ask students to select one ad and discuss its effectiveness. L2

Section Assessment

1. Drugs are used to normalize an irregular heartbeat, increase the heart's pumping capacity, or enlarge small blood vessels.
2. Aspirin inhibits the production of impulses at the site of pain, while narcotics work on the central nervous system to relieve pain.
3. Nicotine will stimulate the central nervous system, causing an increase in heart rate, blood pressure, and breathing rate.
4. Drugs can increase or decrease the amount of neurotransmitters found between neurons.
5. A physician knows the medical history of the patient and can treat problems that might occur as side effects of the drug.
6. Stimulants increase the activity of the central and sympathetic nervous systems. Depressants decrease the activity of the central nervous system and increase activity of the parasympathetic nervous system. Stimulants can increase alertness, nervousness, anxiety, heart rate, and breathing rate. Depressants do the opposite.

DESIGN YOUR OWN BioLab

Time Allotment
One class period

Process Skills
observe and infer, form a hypothesis, communicate, predict, interpret data, experiment, and analyze

Safety Precautions
Caution students not to drink any of the solutions tested and advise them to wash their hands at the conclusion of the lab.

Preparation

Solutions
- Ethyl alcohol—add 2 mL of ethyl alcohol to 98 mL of distilled water.
- Nicotine—soak an unfiltered cigarette in 100 mL of warm distilled water for one hour; then filter the solution.
- Prepare weak solutions of coffee and tea.
- Dilute cola 1 part water to 1 part cola.
- Cough medicine—add 2 mL of cough medicine to 98 mL of distilled water.

Possible Hypotheses
- Students' hypotheses should categorize each drug according to whether it will increase, decrease, or not affect heart rate. Coffee, tea, cola, tobacco, and possibly cough medicine are stimulants and will increase heart rate. Ethyl alcohol and possibly cough medicine (with dextromethorphen hydrobromide) are depressants and will decrease heart rate.

Plan the Experiment

Teaching Strategies
- Age tap water by leaving it in a beaker overnight.
- Set up a distribution station for all the solutions being tested.
- *Daphnia* that are placed in the aged tap water after being tested with a drug can be reused again later.

Possible Procedures
- Students should measure the resting heart rate of each *Daphnia* before adding several drops of one of the solutions and measuring the heart rate again.

DESIGN YOUR OWN BioLab

What drugs affect the heart rate of *Daphnia*?

Depending on their chemical composition, drugs affect different parts of your body. Stimulants and depressants are drugs that affect the central nervous system and the autonomic nervous system. Stimulants increase the activity of the sympathetic nervous system, which is responsible for the fight-or-flight response. They cause an increase in your breathing rate and in your heart rate. Depressants, on the other hand, decrease the activity of the sympathetic nervous system, reducing your breathing and heart rates.

Preparation

Problem
What legally available drugs are stimulants to the heart? What legal drugs are depressants? Because these drugs are legally available, are they less dangerous?

Hypotheses
Based on what you learned in this chapter, which of the drugs listed under Possible Materials do you think are stimulants? Which are depressants? How will they affect the heart rate in *Daphnia?* Make a hypothesis concerning how each of the drugs listed will affect heart rate.

Objectives
In this BioLab, you will:
- **Measure** the resting heart rate in *Daphnia.*
- **Compare** the resting heart rate with the heart rate when a drug is applied.

Possible Materials
aged tap water
Daphnia culture
dilute solutions of coffee, tea, cola, ethyl alcohol, tobacco, and cough medicine (containing dextromethorphan)
dropper
microscope
microscope slide

Safety Precautions
Do not drink any of the solutions used in this lab. Always wear goggles in the lab. Use caution when working with a microscope, microscope slides, and glassware.

Skill Handbook
Use the **Skill Handbook** if you need additional help with this lab.

Plan the Experiment

1. Using a dropper, place a single *Daphnia* crustacean on a slide.
2. Observe the animal on low power and find its heart.
3. Design an experiment to measure the effect on heart rate of four of the drug-containing substances in the Possible Materials list.
4. Design and construct a data table for recording your data.

Check the Plan
1. Be sure to consider what you will use as a control.
2. Plan to add two drops of a drug-containing substance directly to the slide.
3. When you are finished testing one drug, you will need to flush the used *Daphnia* with the solution into a beaker of aged tap water provided by your teacher. Plan to use a new *Daphnia* for each substance tested.
4. ***Make sure your teacher has approved your experimental plan before you proceed further.***
5. Carry out your experiment. **CAUTION:** ***Wash your hands with soap and water immediately after making observations.***


Magnification: 30×

Analyze and Conclude

1. **Making Inferences** Which drugs are stimulants? Which are depressants?
2. **Checking Your Hypotheses** Compare your predicted results with the experimental data. Explain whether or not your data support your hypotheses regarding the drugs' effects.
3. **Drawing Conclusions** How do the drugs affect the heart rate of this animal?
4. **Analyzing the Procedure** How would you alter your experiment if you did it again?

Going Further
Changing Variables Many other over-the-counter drugs are available. You may wish to test their effect on the heart rate of *Daphnia*.

internet CONNECTION To find out more about drug effects, visit the Glencoe Science Web Site.
www.glencoe.com/sec/science

Data and Observations

Drug	Heart rate/min
No drug	240
Coffee	270
Cola	270
Tea	260
Ethyl alcohol	215
Tobacco	300
Cough medicine	heart rate varies with brand

Resource Manager
BioLab and MiniLab Worksheets, p. 161-162 L2

DESIGN YOUR OWN BioLab

Analyze and Conclude

1. Stimulants are coffee, tea, cola, and tobacco. Cough medicine may also be listed. Depressants are ethyl alcohol and cough medicine if it contains dextromethorphen hydrobromide.
2. Some students' hypotheses will be confirmed by their data; others' will be rejected.
3. Stimulants speed up the animal's heart rate. Depressants slow the heart rate.
4. Answers will vary.

Error Analysis
Advise students they must have only a small amount of water on each slide with their *Daphnia*. If they have too much water, it will dilute the solutions tested.

Assessment
Performance Have students each prepare a laboratory report that includes the experimental plan, the data table, and the answers to Analyze and Conclude, to be placed in their journals. Use the Performance Task Assessment List for Lab Report in **PASC,** p. 47. L2

Going Further
Have students compare the effects of four over-the-counter cough medicines on the heart rate of *Daphnia*. They should carefully make equal dilutions of each medicine after determining the concentration of the active drug in each (listed on the package). Tablet cough medications list milligrams of medication in each tablet. L2

BIO Technology

Purpose

Students learn how radioactive isotopes are used in positron emission tomography (PET).

Background

- To make use of PET scanners, patients are injected with short-lived radioisotopes such as C-11, N-13, or O-15. As the radioisotope circulates through the body, it emits positively charged particles called *positrons*. The positrons collide with electrons in body tissues, causing the release of gamma rays that are detected by PET receptors.

Teaching Strategies

- Pet scanners can be used to measure activities that involve circulation of chemicals or chemical reactions in the body. Ask students to list some body activities that doctors might be able to monitor with PET scanners.

Investigating the Technology

Thinking Critically Any place where blood flows and metabolic activities occur. Students may mention different organ systems.

Going Further

Students can find out how PET scans are used to distinguish between the two types of breast tumor: those that have estrogen receptors and those that do not have estrogen receptors.

BIO Technology

Scanning the Mind

Advancements in medical technology have led to instruments—such as X-ray and magnetic resonance imaging (MRI) machines—that can examine the human body in a noninvasive way. Recently, another technology has been added to the medical toolbox—positron emission tomography (PET). This instrument is unique in that it allows a physician to view internal body tissues while they carry out their normal daily functions.

PET scanners are excellent tools for studying the human brain. By monitoring either the blood flow to an area or the amount of glucose being metabolized there, doctors are able to pinpoint active sections of the brain.

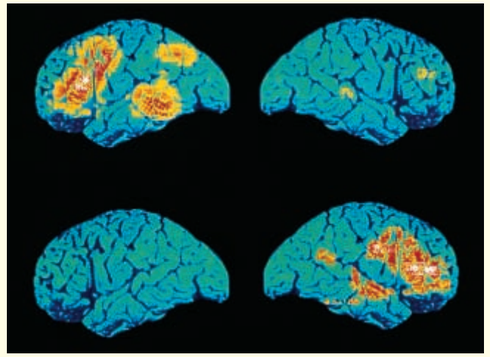
Here's how it works: The patient is injected with a compound containing radioactive isotopes. Because these isotopes emit detectable radiation, they can be tracked by the sensitive PET scanner. Computers create a picture of brain activity by converting the energy emitted from the radioisotopes into a colorful map. The image indicates the location of an activity, such as glucose utilization, and its relative intensity in various regions.

Applications for the Future

PET scanners are important in brain research, including the detection and diagnosis of brain tumors, the evaluation of damage due to stroke, and the mapping of brain functions.

PET scans can also be used to see how learning takes place in the brain. The images on this page show activity in the left and right brains of two different people. Each person was given a list of nouns and asked to visualize them. The unpracticed brain (top) had no previous experience with this exercise and thus was forced to engage in a high level of brain activity to perform the task. The practiced brain (bottom), by comparison, was able to picture the words with much less brain activity. Biologists can discover functions of different parts of the brain and their roles in learning.

PET scans are also proving useful in the study of drug and alcohol addiction. Addicts can be given the addictive drug and then asked questions about their physical and emotional status while the scanner records metabolic activity in the brain. Researchers hope that information gained from the study of drug addiction will provide help in diagnosing and treating manic-depressive psychosis and schizophrenia.



PET scans

Investigating the Technology

Thinking Critically What other body systems might be examined with the aid of a PET scanner?

*inter*NET CONNECTION To find out more about PET scans, visit the Glencoe Science Web Site.
www.glencoe.com/sec/science

GLENCOE TECHNOLOGY

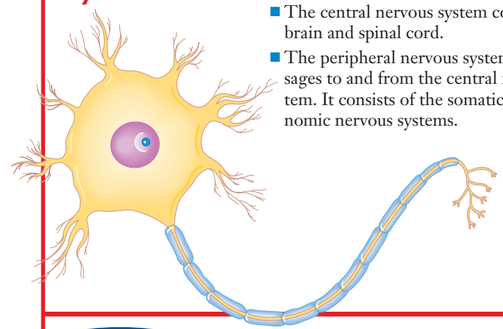
VIDEODISC
The Infinite Voyage
Fires of the Mind: Positron Emission Tomography (PET) (Ch. 4)
3 min.

Chapter 36 Assessment

SUMMARY

Section 36.1

The Nervous System



Main Ideas

- The neuron is the basic structural unit of the nervous system. Impulses move along a neuron in a wave of changing charges.
- The central nervous system consists of the brain and spinal cord.
- The peripheral nervous system relays messages to and from the central nervous system. It consists of the somatic and autonomic nervous systems.

Vocabulary

autonomic nervous system (p. 981)
axon (p. 973)
central nervous system (p. 976)
cerebellum (p. 977)
cerebrum (p. 977)
dendrite (p. 973)
medulla oblongata (p. 977)
neuron (p. 973)
neurotransmitter (p. 976)
parasympathetic nervous system (p. 981)
peripheral nervous system (p. 977)
reflex (p. 980)
somatic nervous system (p. 980)
sympathetic nervous system (p. 981)
synapse (p. 976)

Section 36.2

The Senses

Main Ideas

- Taste and smell are senses that respond to chemical stimulation.
- Sight is a sense that responds to light stimulation.
- Hearing, balance, and touch are senses that respond to mechanical stimulation.

Vocabulary

cochlea (p. 984)
cones (p. 984)
retina (p. 984)
rods (p. 984)
semicircular canals (p. 987)
taste bud (p. 984)

Section 36.3

The Effects of Drugs

Main Ideas

- Drugs act on the body's nervous system.
- Some medicinal uses of drugs include relieving pain and treating cardiovascular problems and nervous disorders.
- The misuse of drugs involves taking a medicine for an unintended use. Drug abuse involves using a drug for a nonmedical purpose.
- Addictions can be broken with the aid of counseling and drug therapy.

Vocabulary

addiction (p. 991)
depressant (p. 990)
drug (p. 988)
hallucinogen (p. 994)
narcotic (p. 989)
stimulant (p. 990)
tolerance (p. 991)
withdrawal (p. 991)

GLENCOE TECHNOLOGY

VIDEOTAPE
MindJogger Videoquizzes
Chapter 36: *The Nervous System*
Have students work in groups as they play the videoquiz game to review key chapter concepts.

Resource Manager

Chapter Assessment, pp. 211-216
MindJogger Videoquizzes
Computer Test Bank
BDOL Interactive CD-ROM, Chapter 36 quiz

Main Ideas

Summary statements can be used by students to review the major concepts of the chapter.

Using the Vocabulary

To reinforce chapter vocabulary, use the Content Mastery Booklet and the activities in the Interactive Tutor for Biology: The Dynamics of Life on the Glencoe Science Web Site.
www.glencoe.com/sec/science

THE PRINCETON REVIEW

All Chapter Assessment questions and answers have been validated for accuracy and suitability by The Princeton Review.

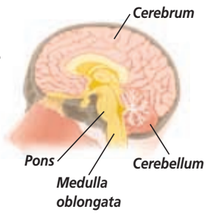
Understanding Main Ideas

1. b
2. d
3. cerebellum
4. c
5. semicircular canals
6. c
7. a
8. b
9. c
10. a
11. neuron
12. axons, myelin
13. sodium
14. central, brain
15. axon, away from
16. synaptic space
17. neurotransmitters
18. addiction, drug
19. taste buds, brain
20. depressant, central nervous system

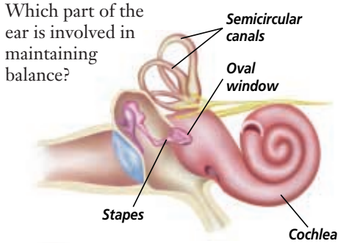
Chapter 36 Assessment

Understanding Main Ideas

1. Which of the following is NOT part of the brain?
   a. cerebrum **c.** cerebellum
   b. cochlea **d.** pons
2. Which of the following is NOT a type of neuron?
   a. interneuron **c.** motor neuron
   b. sensory neuron **d.** stimulus neuron
3. Which portion of the brain controls balance, posture, and coordination?



4. Which vision cells allow humans to see color?
   a. thalamic cells **c.** cone cells
   b. rod cells **d.** cortex cells
5. Which part of the ear is involved in maintaining balance?



6. Which drug type relieves pain by inhibiting receptors at the site of pain?
   a. stimulants **c.** aspirin
   b. depressants **d.** narcotics
7. What type of drug is nicotine?
   a. stimulant **c.** analgesic
   b. depressant **d.** hallucinogen
8. Which of these is NOT a type of receptor found in the dermis of the skin?
   a. pain **c.** pressure
   b. light **d.** temperature
9. Which of the following drugs depresses the activities of the CNS?
   a. cocaine **c.** alcohol
   b. aspirin **d.** opiate
10. Which type of neuron carries impulses toward the brain?
    a. sensory **c.** association
    b. motor **d.** none of the above
11. The basic unit of structure and function in the nervous system is the _____, or nerve cell.
12. Most _____ are surrounded by a white covering called the _____ sheath.
13. When a stimulus excites a neuron, _____ ions rush into the cell.
14. The _____ nervous system is made up of the spinal cord and the _____.
15. A(n) _____ is a single extension of a neuron that carries messages _____ the cell body.
16. A _____ is the region between one neuron's axon and another neuron's dendrites.
17. Chemicals called _____ diffuse across synapses and stimulate neurons.
18. A(n) _____ is a psychological or physiological dependence on a _____.
19. The _____ on the tongue contain sensory receptors that send taste signals to the _____.
20. Alcohol is a _____ that slows the activities of the _____.

Test-Taking Tip

THE PRINCETON REVIEW

Don't Be Afraid to Ask for Help

Ask for advice on things you don't understand. If you're practicing for a test and you find yourself stuck, unable to understand why you got a question wrong, or unable to do it in the first place, ask for help.

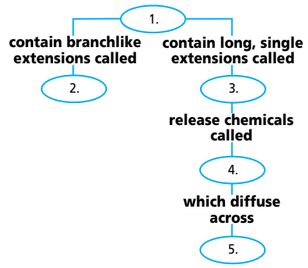
Chapter 36 Assessment

Applying Main Ideas

21. You are making a ferry crossing during rough weather and the horizon seems to be moving up and down as you hold on to the railing. You begin to feel seasick. Explain what is going on inside your body that might be causing this sensation.
22. Tetrodotoxin, a chemical produced by the puffer fish, blocks sodium channels. How does this toxin help the fish capture its prey?
23. Explain how alcohol disrupts the normal functions of a neuron.

Thinking Critically

24. **Observing and Inferring** A medicine has this precaution on its label: "Avoid driving a motor vehicle while taking this medicine as it may cause drowsiness." What type of drug does this medicine contain? Explain.
25. **Concept Mapping** Complete the concept map by using the following vocabulary terms: neurons, neurotransmitters, axons, dendrites, synapses.



CD-ROM

For additional review, use the assessment options for this chapter found on the ***Biology: The Dynamics of Life Interactive CD-ROM*** and on the Glencoe Science Web Site.
www.glencoe.com/sec/science

Assessing Knowledge & Skills

As a part of his job in building a new highway, a construction worker is planning to light a fuse hooked to some TNT to blast out a portion of rock.

Comparing and Contrasting Use the illustration above to answer the following questions.

1. How does the steady burning of the fuse resemble the depolarization of a neuron?
   a. Both involve sodium channels.
   b. Both are under voluntary control.
   c. Both are self-propagating.
   d. Both involve the combustion of oxygen.
2. How do a neuron and the fuse compare in terms of repeated use?
   a. Neither the fuse nor the neuron can be used repeatedly.
   b. The fuse can be used over and over, but the neuron must regrow before being reused.
   c. The neuron can be used after recovery, but the fuse is consumed and cannot be reused.
   d. Both the neuron and the fuse can be used repeatedly.
3. **Applying Concepts** In what ways is the movement of an impulse down an axon similar to the movement of an electric current in a wire?

Chapter 36 Assessment

Applying Main Ideas

21. Your body is constantly moving up, down, and sideways. As a result, your semicircular canals are over-stimulated and you feel seasick.
22. Because the prey cannot transport sodium across its membranes in order to relay an impulse to move, it is effectively paralyzed.
23. Alcohol blocks the movement of sodium and calcium ions, which are responsible for transmitting impulses.

Thinking Critically

24. The medicine may contain a depressant or mild narcotic.
25. 1. Neurons; 2. Dendrites; 3. Axons; 4. Neurotransmitters; 5. Synapses

Assessing Knowledge & Skills

1. c
2. c
3. Both are due to the flow of charged particles. The electrical current is due to the flow of electrons, whereas the impulse is due to the flow of charged ions.

Internet Address Book

internet CONNECTION

Note Internet addresses that you find useful in the space below for quick reference.