Guided Tour

A Sound Learning System

Anatomy and Physiology is designed to help you learn in a systematic fashion. Simple facts are the building blocks for developing explanations of more complex concepts. The text discussion is presented within a supporting framework of learning aids that help organize studying, reinforce learning, and promote problem-solving skills.

Chapter Introduction

Each chapter opens with a detailed photomicrograph that ties in with the chapter topic. The opening paragraphs introduce the topic and end with a brief overview of the major section divisions of the chapter.

Color enhanced scanning electron micrograph of podocytes wrapped around the glomerular capillaries.

CHAPTER 26

Urinary System

The kidneys make up the body's main purification system. They control the composition of blood by removing waste products, many of which are toxic, and conserving useful substances. The kidneys help control blood volume, and consequently play a role in regulating blood pressure. The kidneys also play an essential role in regulation of blood pH. Approximately one-third of one kidney is all that's needed to maintain homeostasis. Even after extensive damage, the kidneys can still perform their life-sustaining function. If the kidneys are damaged further, however, death results unless specialized medical treatment is administered.

The **urinary system** consists of two kidneys; a single, midline urinary bladder; two ureters, which carry urine from the kidneys to the urinary bladder; and a single urethra, which carries urine from the bladder to the outside of the body (figure 26.1).

This chapter explains the *functions of the urinary system* (p. 966), *kidney anatomy and histology* (p. 966), *anatomy and histology of the ureters and urinary bladder* (p. 973), *urine production* (p. 974), *regulation of urine concentration and volume* (p. 990), *clearance and tubular maximum* (p. 993), *and urine movement* (p. 994). We conclude the chapter with a look at the *effects of aging on the kidneys* (p. 996).

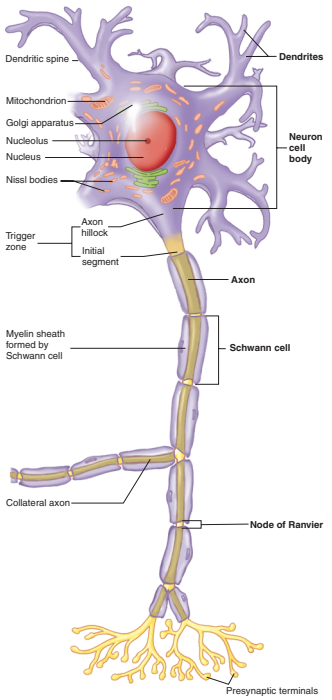


Figure 11.4 Neuron
Structural features of a neuron include a cell body and two types of cell processes: dendrites and an axon.

PREDICT 1
Predict the effect on the part of a severed axon that's no longer connected to its neuron cell body. Explain your prediction.

Dendrites

Dendrites are short, often highly branched cytoplasmic extensions that are tapered from their bases at the neuron cell body to their tips (see figure 11.4). Many dendrite surfaces have small extensions called **dendritic spines,** where axons of other neurons form synapses with the dendrites. Dendrites are the input part of the neuron. When stimulated, they generate small electric currents that are conducted to the neuron cell body.

Axons

In most neurons, a single axon arises from a cone-shaped area of the neuron cell body called the **axon hillock.** The beginning of the axon is called the **initial segment.** An axon can remain as a single structure or can branch to form collateral axons or side branches (see figure 11.4). Each axon has a constant diameter, but it can vary in length from a few millimeters to more than 1 meter. The cytoplasm of the axon is sometimes called **axoplasm,** and its plasma membrane is called the **axolemma** (*lemma* is Greek, meaning husk or sheath). Axons terminate by branching to form small extensions with enlarged ends called **presynaptic terminals,** or **terminal boutons** (boo-tonz′; buttons). Numerous small vesicles containing neurotransmitters are present in the presynaptic terminals. **Neurotransmitters** are chemicals released from the presynaptic terminal that cross the synapse to stimulate or inhibit the postsynaptic cell. Functionally, action potentials are generated at the **trigger zone,** which consists of the axon hillock and the part of the axon nearest to the cell body. Action potentials are conducted along the axon to the presynaptic terminal, where they stimulate the release of neurotransmitters.

Axon transport mechanisms can move cytoskeletal proteins (see chapter 3), organelles such as mitochondria, and vesicles containing neurohormones to be secreted (see chapter 17) down the axon to the presynaptic terminals. In addition, damaged organelles, recycled plasma membrane, and substances taken in by endocytosis can be transported up the axon to the neuron cell body. The movement of materials within the axon is necessary for its normal function, but it also provides a way for infectious agents and harmful substances to be transported from the periphery to the CNS. For example, rabies and herpes viruses enter the axon endings of damaged skin and are transported to the CNS.

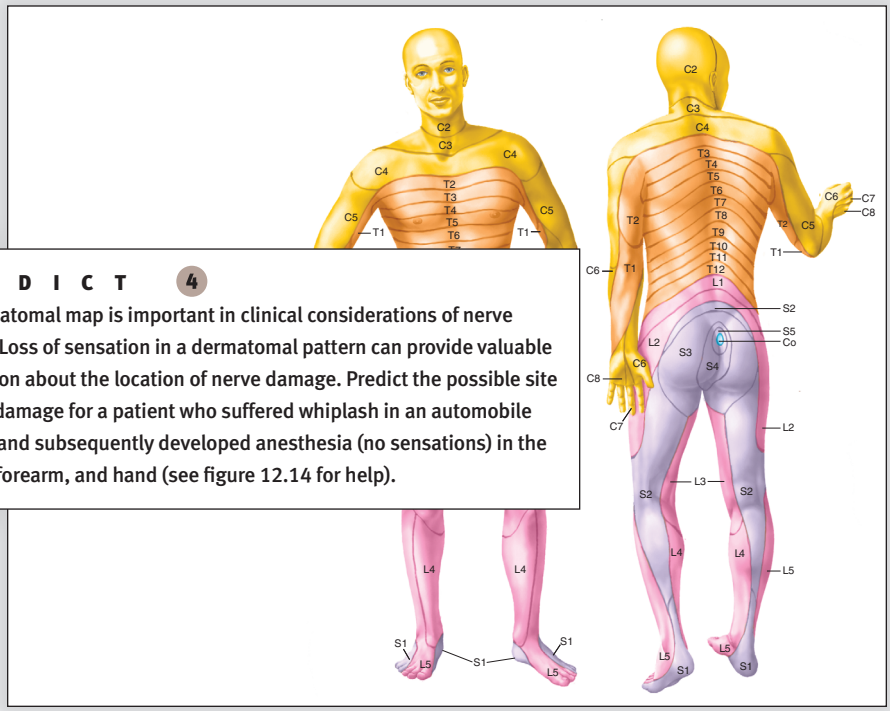
9. Compare the functions of neuroglia and neurons.
10. Describe and give the function of a neuron cell body, dendrite, and axon.
11. Define trigger zone, presynaptic terminal, and neurotransmitter.

Section Review

Review questions at the end of each section prompt you to test your understanding of key concepts. Use them as a self-test to determine whether you have a sufficient grasp of the information before proceeding with the next section.

Predict Questions

These innovative critical thinking exercises encourage you to become an active learner as you read. Predict questions challenge you to use your understanding of new concepts to solve a problem. Answers to Predict questions are given at the end of each chapter, allowing you to evaluate your response and discover the logic used to arrive at the correct answer.



P R E D I C T 4

The dermatomal map is important in clinical considerations of nerve damage. Loss of sensation in a dermatomal pattern can provide valuable information about the location of nerve damage. Predict the possible site of nerve damage for a patient who suffered whiplash in an automobile accident and subsequently developed anesthesia (no sensations) in the left arm, forearm, and hand (see figure 12.14 for help).

- *3. What is the pericardium?*
- *4. Describe the parts of the pericardium and their functions.*
- *5. Define pericarditis.*
- *6. Explain the effects of cardiac tamponade on the heart.*

Heart Wall

The heart wall is composed of three layers of tissue: the epicardium, the myocardium, and the endocardium (figure 20.4). The **epicardium** (ep-i-kar′dē-ūm) is a thin serous membrane that constitutes the smooth outer surface of the heart. The epicardium and the visceral pericardium are two names for the same structure. The serous pericardium is called the epicardium when considered a part of the heart and the visceral pericardium when considered a part of the pericardium. The thick middle layer of the heart, the **myocardium** (mī-ō-kar′dē-ūm), is composed of cardiac muscle cells and is responsible for the ability of the heart to contract. The smooth inner surface of the heart chambers is the **endocardium** (en-dō-kar′dē-ūm), which consists of simple squamous epithelium over a layer of connective tissue. The smooth inner surface allows blood to move easily through the heart. The heart valves result from a fold in the endocardium, thus making a double layer of endocardium with connective tissue in between.

The interior surfaces of the atria are mainly flat, but the interior of both auricles and a part of the right atrial wall contain muscular ridges called **musculi pectinati** (pek′ti-nah′tē; hair comb). The musculi pectinati of the right atrium are separated from the larger, smooth portions of the atrial wall by a ridge called the **crista terminalis** (kris′tă ter′mi-nal′is; terminal crest). The interior walls of the ventricles contain larger muscular ridges and columns called **trabeculae** (trā-bek′ū-lē; beams) **carneae** (kar′nē-ē; flesh).

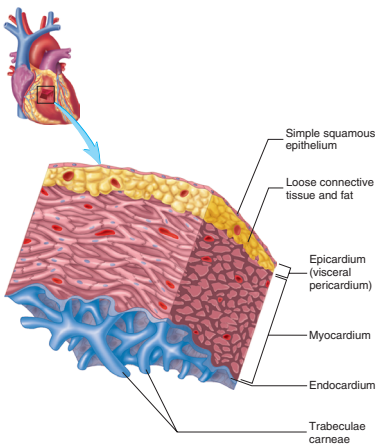


Figure 20.4 Heart Wall
Part of the wall of the heart has been removed to show its structure. The enlarged section illustrates the epicardium, the myocardium, and the endocardium.

- *7. Describe the three layers of the heart, and state their functions.*
- *8. Name the muscular ridges found on the interior of the auricles, and name the ridges and columns found on the interior walls of the ventricles.*

External Anatomy and Coronary Circulation

The heart consists of four chambers: two **atria** (ā′trē-ă; entrance chamber) and two **ventricles** (ven′tri-klz; belly). The thin-walled atria form the superior and posterior parts of the heart, and the thick-walled ventricles form the anterior and inferior portions (figure 20.5). Flaplike **auricles** (aw′ri-klz; ears) are extensions of the atria that can be seen anteriorly between each atrium and ventricle. The entire atrium used to be called the auricle, and some medical personnel still refer to it as such.

Several large veins carry blood to the heart. The **superior vena cava** (vē′nă kā′vă) and the **inferior vena cava** carry blood from the body to the right atrium, and four **pulmonary veins** carry blood from the lungs to the left atrium. In addition, the smaller coronary sinus carries blood from the walls of the heart to the right atrium.

Two arteries, the **aorta** and the **pulmonary trunk,** exit the heart. The aorta carries blood from the left ventricle to the body, and the pulmonary trunk carries blood from the right ventricle to the lungs.

A large **coronary** (kōr′o-năr-ē; circling like a crown) **sulcus** (sool′kŭs; ditch) runs obliquely around the heart, separating the atria from the ventricles. Two more sulci extend inferiorly from the coronary sulcus, indicating the division between the right and left ventricles. The **anterior interventricular sulcus,** or **groove,** is on the anterior surface of the heart, and the **posterior interventricular sulcus,** or **groove,** is on the posterior surface of the heart. In a healthy, intact heart the sulci are covered by fat, and only after this fat is removed can the actual sulci be seen.

The major arteries supplying blood to the tissue of the heart lie within the coronary sulcus and interventricular sulci on the surface of the heart. The **right** and **left coronary arteries** exit the aorta just above the point where the aorta leaves the heart and lie within the coronary sulcus (figure 20.6*a*). The right coronary artery is usually smaller in diameter than the left one, and it doesn't carry as much blood as the left coronary artery.

A major branch of the left coronary artery, called the **anterior interventricular artery,** or the **left anterior descending artery,** extends inferiorly in the anterior interventricular sulcus and supplies blood to most of the anterior part of the heart. The **left marginal artery** branches from the left coronary artery to supply blood to the lateral wall of the left ventricle. The **circumflex** (ser′kŭm-fleks) **artery** branches from the left coronary artery and extends around to the posterior side of the heart in the coronary

Vocabulary Aids

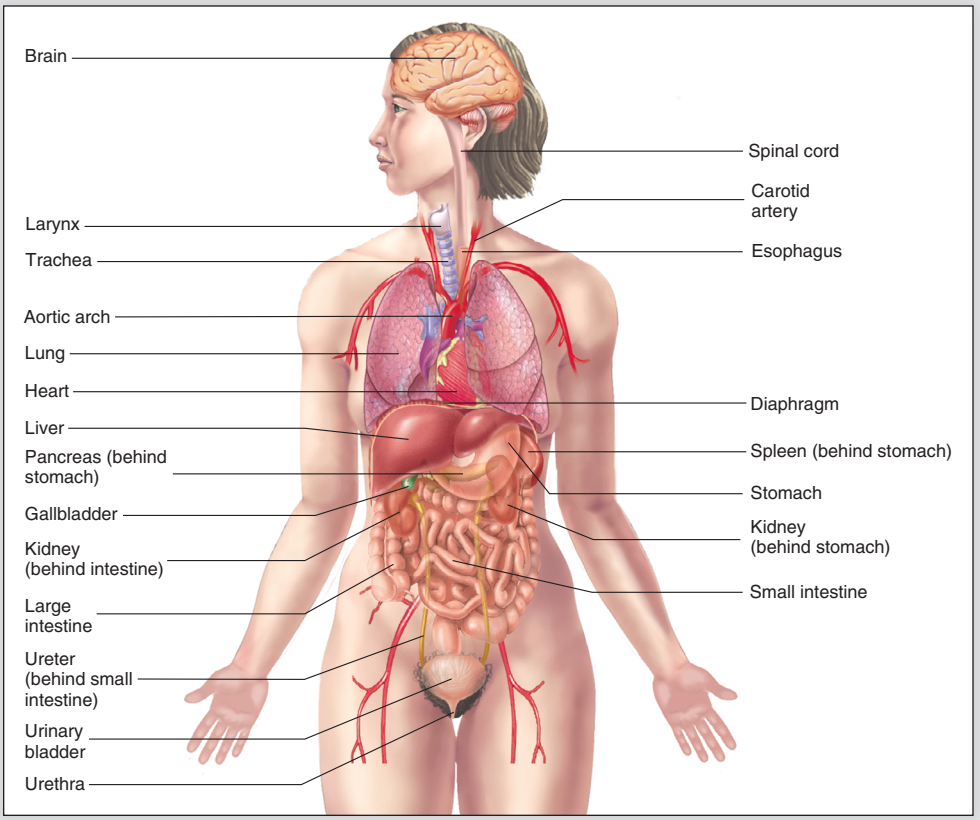
Learning anatomy and physiology is, in many ways, like learning a new language. Mastering the terminology is key to building your knowledge base.

Key terms are set in boldface where they are defined in the chapter, and most terms are included in the glossary at the end of the book. Pronunciation guides are included for difficult words.

Because knowing the original meaning of a term can enhance understanding and retention, derivations of key words are given when they are relevant. Furthermore, a handy list of prefixes, suffixes, and combining forms is printed on the inside back cover as a quick reference to help you identify commonly used word roots. A list of abbreviations used throughout the text is also included.

Instructive Artwork Makes the Difference

A picture is worth a thousand words—especially when you're learning anatomy and physiology. Because words alone cannot convey the nuances of anatomy or the intricacies of physiology, *Anatomy and Physiology* employs a dynamic program of full-color illustrations and photographs that support and further clarify the text explanations. Brilliantly rendered and carefully reviewed for accuracy and consistency, the precisely labeled illustrations and photos provide concrete, visual reinforcement of the topics discussed throughout the text.



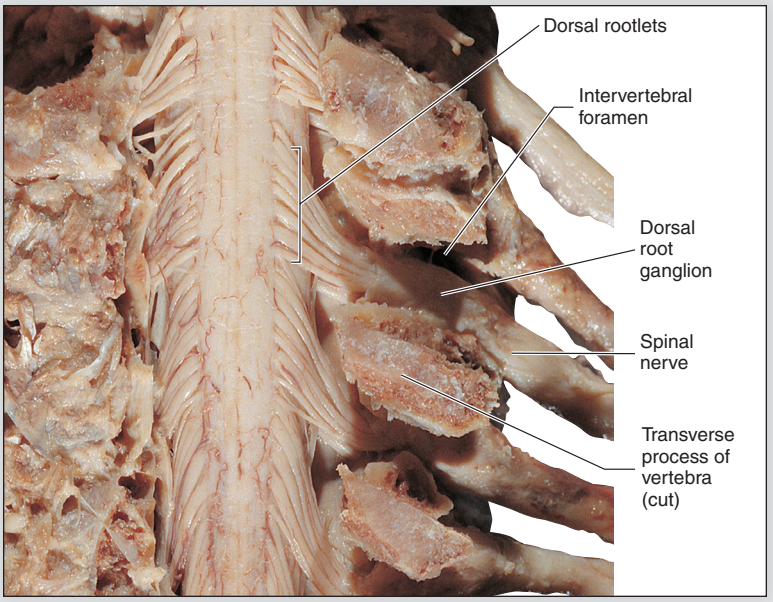
Realistic Anatomical Art

The anatomical figures in Anatomy and Physiology *have been carefully rendered to convey realistic, three-dimensional detail. Richly textured bones and artfully shaded muscles and vessels lend a sense of realism to the figures that helps you envision the appearance of actual structures within in the body.*

The colors used to represent different anatomical structures have been applied consistently throughout the book. This reliable pattern of color consistency helps you easily identify the structures in every figure and promotes continuity between figures.

Atlas-Quality Cadaver Images

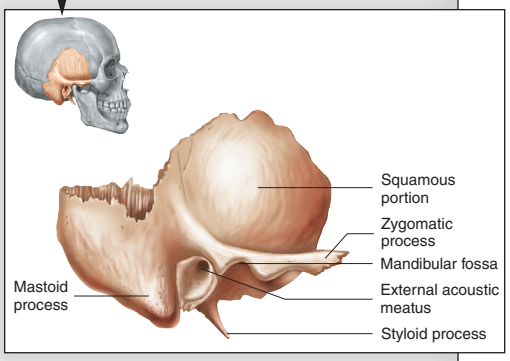
Clearly labeled photos of dissected human cadavers provide detailed views of anatomical structures, capturing the intangible characteristics of actual human anatomy that can be appreciated only when viewed in human specimens.

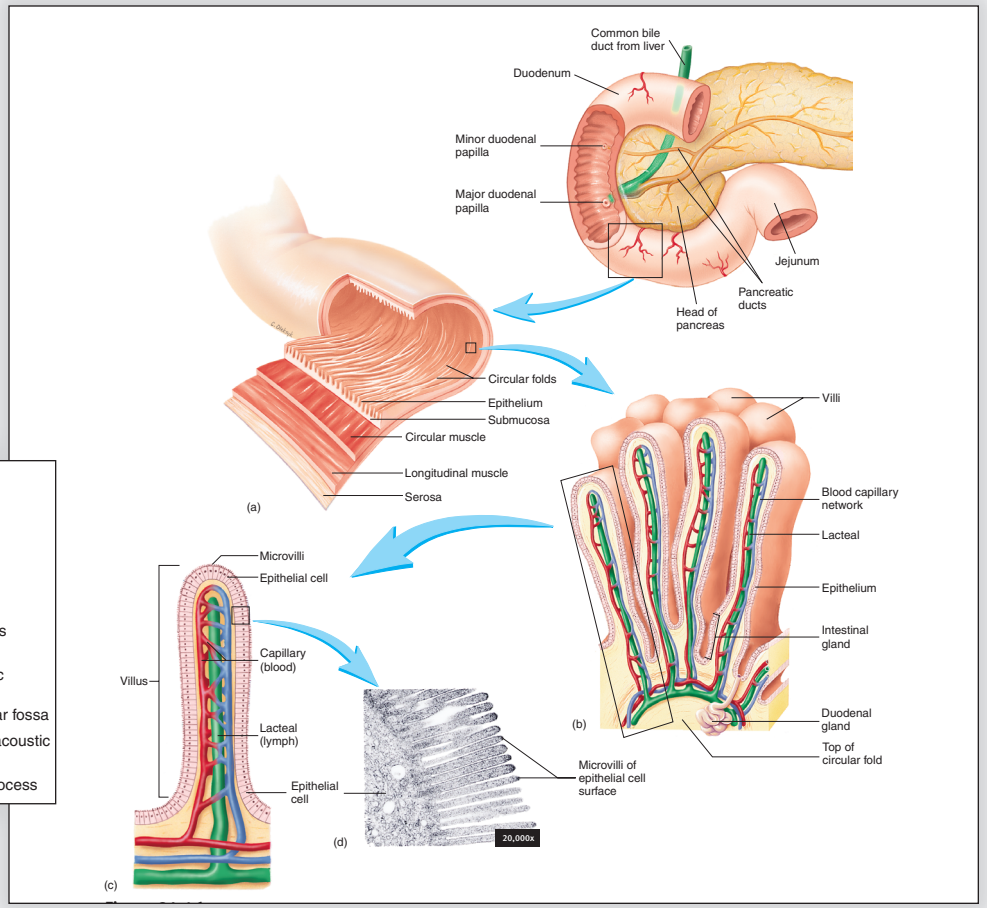


Multi-Level Perspective

Illustrations depicting complex structures or processes combine macroscopic and microscopic views to help you see the relationships between increasingly detailed drawings.

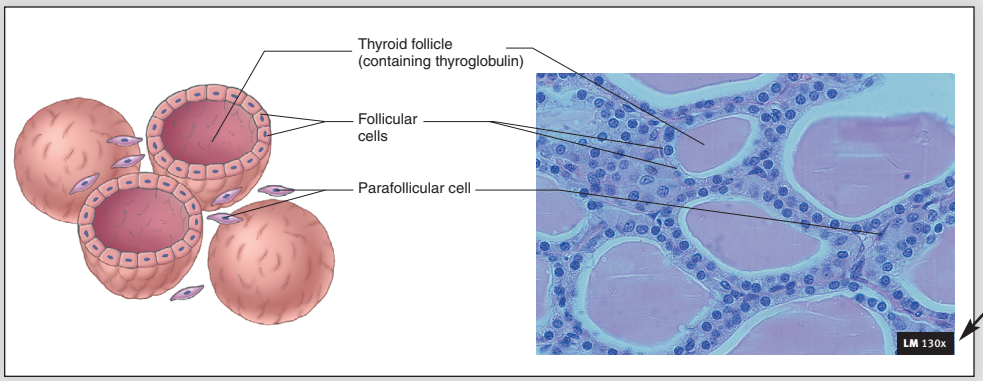
Reference diagrams orient you to the view or plane an illustration represents.





Combination Art

Drawings are often paired with photographs to enhance visualization of structures.



Histology Micrographs

Light micrographs, as well as scanning and transmission electron micrographs, are used in conjunction with illustrations to present a true picture of anatomy and physiology from the cellular level.

Magnifications are indicated to help you estimate the size of structures shown in the photomicrographs.

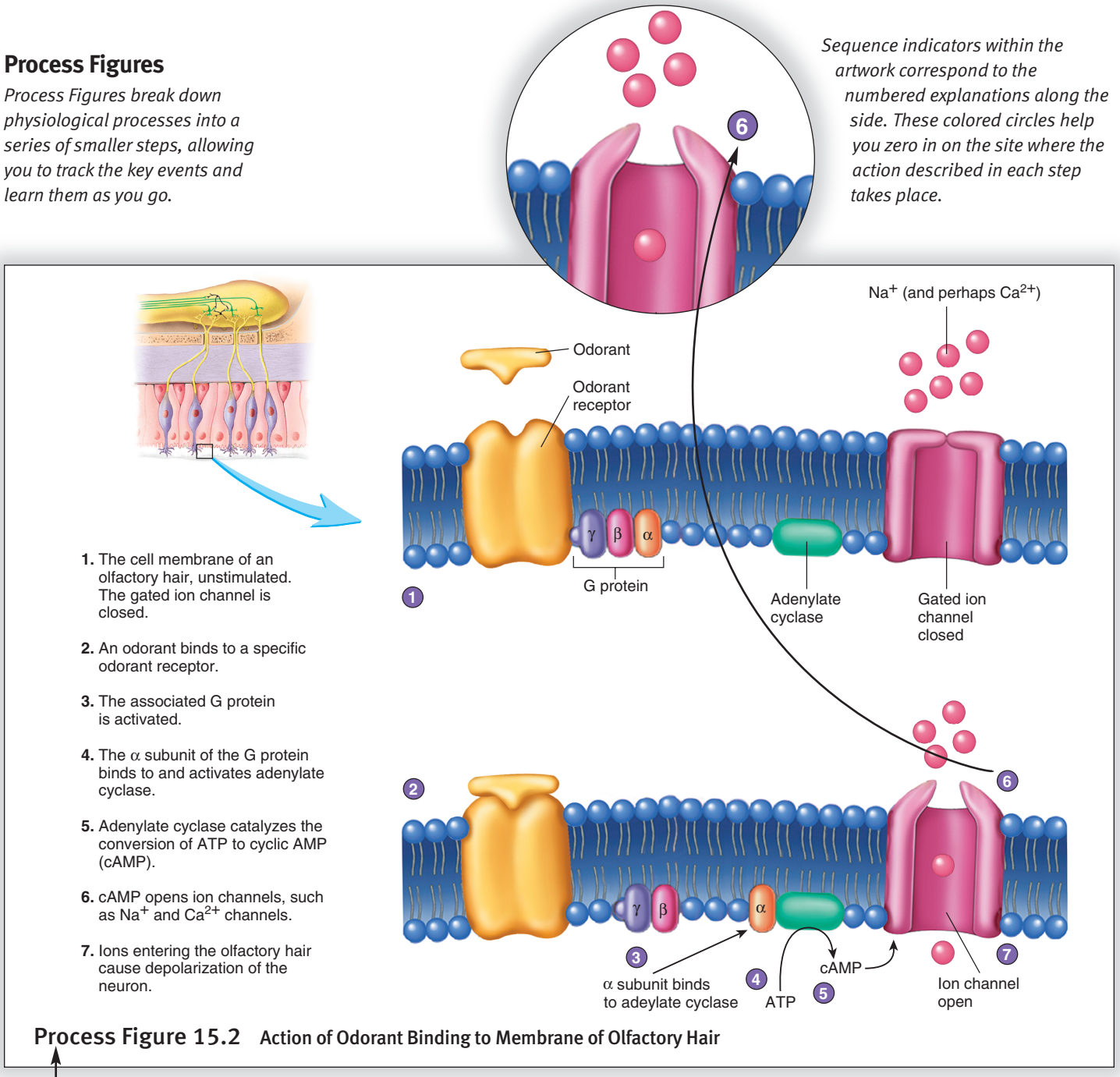
Specialized Figures Clarify Tough Concepts

Studying physiology does not have to be an intimidating task mired in memorization. *Anatomy and Physiology* uses two special types of illustrations to help you not only to learn the steps involved in specific processes, but also to apply this knowledge as you predict outcomes in similar situations. Process Figures organize the key occurrences of physiological processes in an easy-to-follow format. Homeostasis Figures summarize the mechanisms of homeostasis by diagramming the means by which a given system regulates a parameter within a narrow range of values.

Process Figures

Process Figures break down physiological processes into a series of smaller steps, allowing you to track the key events and learn them as you go.

Sequence indicators within the artwork correspond to the numbered explanations along the side. These colored circles help you zero in on the site where the action described in each step takes place.



Process Figure 15.2 Action of Odorant Binding to Membrane of Olfactory Hair

Process Figures and Homeostasis Figures are identified next to the figure number. The accompanying caption provides additional explanation.

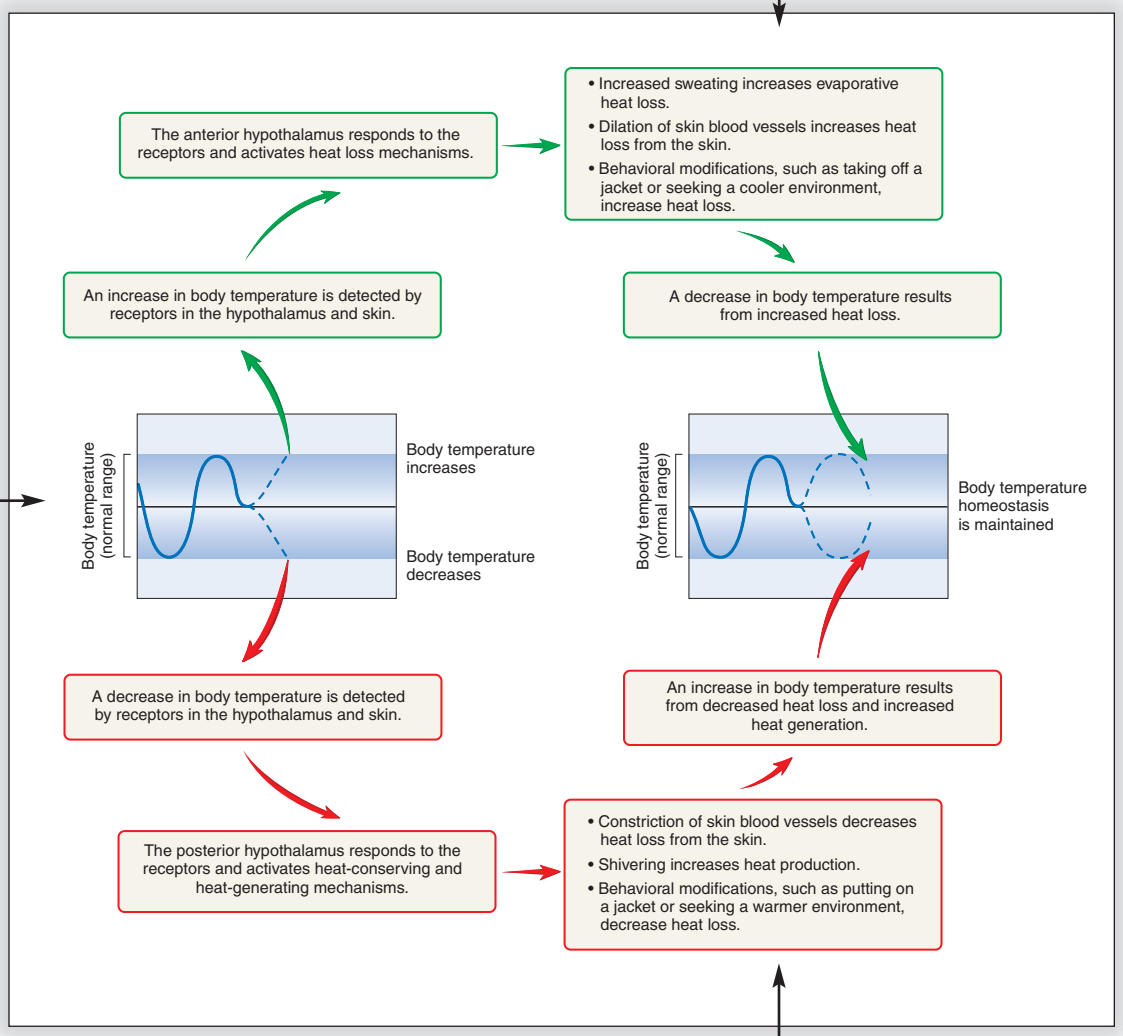
Homeostasis Figures

These specialized flowcharts diagram the mechanisms that body systems employ to maintain homeostasis.

Changes caused by an increase of a variable outside its normal range are shown in the green boxes across the top.

The normal range for a given value is represented by the graphs in the center of each figure.

Start with the graph on the left side of the figure and follow the green arrows to learn about the chain of events triggered by an increase in the variable, or the red arrows for events resulting from a decrease in the variable.



Changes caused by a decrease of a variable outside its normal range are shown in the red boxes across the bottom.

Clinical Content Puts Knowledge into Practice

Anatomy and Physiology provides clinical examples to illustrate the application of basic knowledge in an interesting and relevant clinical context. Exposure to clinical information is especially beneficial if you are planning on using your knowledge of anatomy and physiology in a health-related career.

Description of Selected Joints

It's impossible in a limited space to describe all the joints of the body; therefore, we describe only selected joints in this chapter, and they have been chosen because of their representative structure, important function, or clinical significance.

Temporomandibular Joint

The mandible articulates with the temporal bone to form the **temporomandibular joint (TMJ).** The mandibular condyle fits into the mandibular fossa of the temporal bone. A fibrocartilage articular disk is located between the mandible and the temporal bone, dividing the joint into superior and inferior cavities (figure 8.27). The joint is surrounded by a fibrous capsule to which the articular disk is attached at its margin, and is strengthened by lateral and accessory ligaments.

The temporomandibular joint is a combination plane and ellipsoid joint, with the ellipsoid portion predominating. Depression of the mandible to open the mouth involves an anterior gliding motion of the mandibular condyle and articular disk relative to the temporal bone, which is about the same motion that occurs in protraction of the mandible; it is followed by a hinge motion that occurs between the articular disk and the mandibular head. The mandibular condyle is also capable of slight mediolateral movement, allowing excursion of the mandible.

TMJ Disorders

TMJ disorders are a group of conditions that cause most chronic orofacial pain. The conditions include joint noise; pain in the muscles, joint, or face; headache; and reduction in the range of joint movement. TMJ pain is often felt as referred pain in the ear. Patients may go to a physician complaining of an earache and are then referred to a dentist. As many as 65%–75% of people between ages 20 and 40 experience some of these symptoms. Symptoms appear to affect men and women about equally, but only about 10% of the symptoms are severe enough to cause people to seek medical attention. Women experience severe pain eight times more often than do men.

TMJ disorders are classified as those involving the joint, with or without pain; those involving only muscle pain; or those involving both the joint disorder and muscle pain. TMJ disorders are also classified as acute or chronic. Acute cases are usually self-limiting and have an identifiable cause. Chronic cases are not self-limiting, may be permanent, and often have no apparent cause. Chronic TMJ disorders are not easily treated, and chronic TMJ pain has much in common with other types of chronic pain. Whereas some people learn to live with the pain, others may experience psychologic problems, such as a sense of helplessness and hopelessness, high tension, and loss of sleep and appetite. Drug dependency may occur if strong drugs are used to control the pain; and relationships, lifestyle, vocation, and social interactions may be disrupted. Many of these problems may make the pain worse through positive feedback. Treatment includes teaching the patient to reduce jaw movements that aggravate the problem and to reduce stress and anxiety. Physical therapy may help to relax the muscles and restore function. Analgesic and antiinflammatory drugs may be used, and oral splints may be helpful, especially at night.

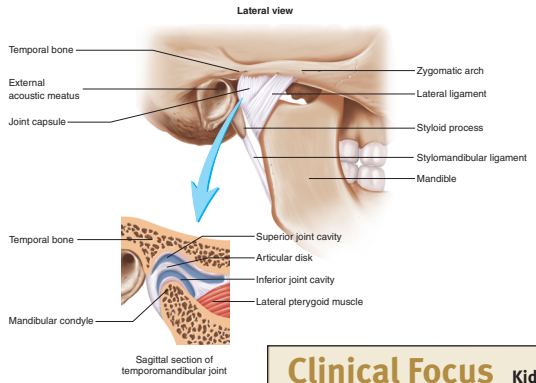


Figure 8.27 Right Temporomandibular Joint, Lateral View

Clinical Topics

Interesting clinical sidebars reinforce or expand upon the facts and concepts discussed within the narrative. Once you have learned a concept, applying that information in a clinical context shows you how your new knowledge can be put into practice.

Clinical Focus

These in-depth boxed essays explore relevant topics of clinical interest. Subjects covered include pathologies, current research, sports medicine, exercise physiology, and pharmacology.

Clinical Focus Kidney Dialysis

The artificial kidney (renal dialysis machine) is a machine used to treat patients suffering from renal failure. The use of this machine often allows people with severe acute renal failure to recover without developing the side effects of renal failure, and the machine can substitute for the kidneys for long periods in people suffering from chronic renal failure.

Renal dialysis allows blood to flow though tubes made of a selectively permeable membrane. On the outside of the dialysis tubes is a fluid that contains the same concentration of solutes as the plasma, except for the metabolic waste products. As a consequence, a diffusion gradient exists for the metabolic waste products from the blood to the dialysis fluid. The dialysis membrane has pores that are too small to allow plasma proteins to pass through them. For smaller solutes, the dialysis fluid contains the same beneficial solutes as the plasma, so the net movement of these substances is zero. In contrast, the dialysis fluid contains no metabolic waste products, so metabolic waste products diffuse rapidly from the blood into the dialysis fluid.

Blood usually is taken from an artery, passed through tubes of the dialysis machine, and then returned to a vein. The rate of blood flow is normally several hundred milliliters per minute, and the total surface area of exchange in the machine is close to 10,000–20,000 cm^2 (figure A). Kidney dialysis is not convenient for those suffering from kidney failure, and it can be emotionally difficult. Clearly, kidney dialysis is not a good substitute for healthy kidneys.

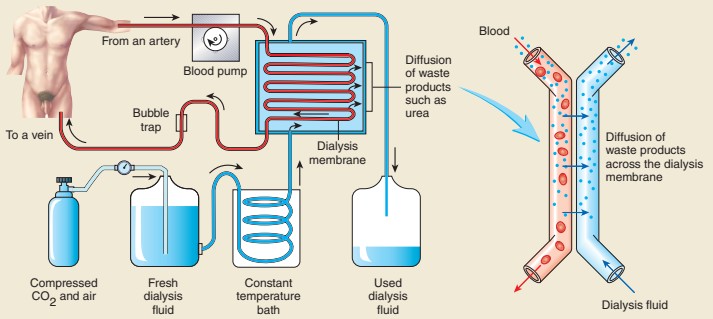


Figure A Kidney Dialysis

During kidney dialysis blood flows through a system of tubes composed of a selectively permeable membrane. Dialysis fluid, the composition of which is similar to that of blood, except that the concentration of waste products is very low, flows in the opposite direction on the outside of the dialysis tubes. Consequently, waste products such as urea diffuse from the blood into the dialysis fluid. Other substances such as sodium, potassium, and glucose do not rapidly diffuse from the blood into the dialysis fluid because there is no concentration gradient for these substances between the blood and the dialysis fluid.

Systems Pathology

These boxes explore a specific disorder or condition related to a particular body system. Presented in a simplified case study format, each Systems Pathology box begins with a patient history followed by background information about the featured topic.

Systems Pathology
Stroke

Mr. S, who is approaching middle age, is somewhat overweight and has high blood pressure. He was seated on the edge of his couch, at least most of the time, when he was not jumping to his feet and shouting at the referees for an obviously bad call. He was surrounded by empty pizza boxes, bowls of chips and salsa, empty beer cans, and full ashtrays. As Mr. S cheered on his favorite team in a hotly contested big game, which they would be winning easily if it weren't for the lousy officiating, he noticed that he felt drowsy and that the television screen seemed blurry. He began to feel dizzy. As he tried to stand up, he suddenly vomited and collapsed to the floor, unconscious.

Mr. S was rushed to the local hospital, where the following signs and symptoms were observed. He exhibited weakness in his limbs, especially on the right, and ataxia (inability to walk). He had loss of pain and temperature sensation in his right lower limb and loss of all sensation in the left side of his face. The dizziness persisted and he appeared disoriented and lacked attentiveness. He also exhibited dysphagia (the inability to swallow) and hoarseness. He had nystagmus (rhythmic oscillation of the eyes). His pupils were slightly dilated, his respiration was short and shallow, and his pulse rate and blood pressure were elevated.

Background Information

Mr. S suffered a "stroke," also referred to as a cerebrovascular accident (CVA). The term *stroke* describes a heterogeneous group of conditions involving death of brain tissue resulting from disruption of its vascular supply. Two types of stroke exist: **hemorrhagic stroke,** which results from bleeding of arteries supplying brain tissue, and **ischemic stroke,** which results from blockage of arteries supplying brain tissue (figure B). The blockage in ischemic stroke can result from a thrombus (a clot that develops in place within an artery) or an embolism (a plug, composed of a detached th
globule or gas bubble, tha
Mr. S was at high risk for
middle age, was overweig
under stress, and had a pc
The combination of n
limbs, and sensory loss, se

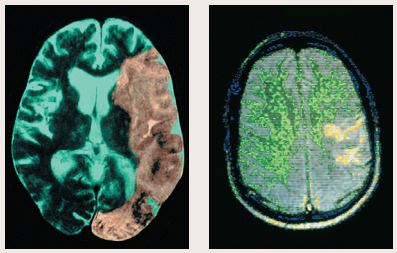


Figure B Images of a Stroke
(*a*) MRI (magnetic resonance imaging) of a massive stroke in the left side (the viewer's right) of the brain. (*b*) Colorized NMR (nuclear magnetic resonance) showing disruption of blood flow to the left side (the viewer's right) of the brain (*yellow*). This disruption could cause a stroke.

A System Interactions table at the end of every box summarizes how the condition impacts each body system.

System Interactions Effect of Stroke on Other Systems

System	Interactions
Integumentary	Decubitus ulcers (bedsores) from immobility; loss of motor function following a stroke leads to immobility.
Skeletal	Loss of bone mass, if muscles are dysfunctional for a prolonged time; in the absence of muscular activity, the bones to which those muscle are attached begin to be resorbed by osteoclasts.
Muscular	Major area of effect; absence of stimulation due to damaged pathways or neurons leads to decreased motor function and may result in muscle atrophy.
Endocrine	Strokes in other parts of the brain could involve the hypothalamus, pineal body, or pituitary gland functions.
Cardiovascular	Risks: Phlebothrombosis (blood clot in a vein) can occur from inactivity. Edema around the brain could apply pressure to the cardioregulatory and vasomotor centers of the brain. This pressure could stimulate these centers, which would result in elevated blood pressure, and congestive heart failure could result. If the cardioregulatory center in the brain is damaged, death may occur rapidly. Bleeding is due to the use of anticoagulants. Hypotension results from use of antihypertensives.
Respiratory	Pneumonia from aspiration of the vomitus or hypoventilation results from decreased function in the respiratory center. If the respiratory center is severely damaged, death may occur rapidly.
Digestive	Vomiting, dysphagia (difficulty swallowing); hypovolemia (decreased blood volume) result from decreased fluid intake; occurs because of dysphagia; may be a loss of bowel control.
Urinary	Control of the micturition reflex may be inhibited. Urinary tract infection results from catheter implantation or from urinary bladder distension.
Reproductive	Loss of libido; innervation of the reproductive organs is often affected.

in his right lower limb and loss of all sensation in the left side of his face; along with the ataxia, dizziness, nystagmus, and hoarseness, suggest that the stroke affected the brainstem and cerebellum. Blockage of the vertebral artery, a major artery supplying the brain, or its branches can result in what is called a lateral medullary infarction (an area of dead tissue resulting from a loss of blood supply to an area). Damage to the descending motor pathways in that area, above the medullary decussation, results in muscle weakness. Damage to ascending pathways can result in loss of pain and temperature sensation (or other sensory modalities depending on the affected tract). Damage to cranial nerve nuclei results in the loss of pain and temperature sensation in the face, dizziness, blurred vision, nystagmus, vomiting, and hoarseness. These signs and symptoms are not observed unless the lesion is in the brainstem, where these nuclei are located. Some damage to the cerebellum, also supplied by branches of the vertebral artery, can account for the ataxia.

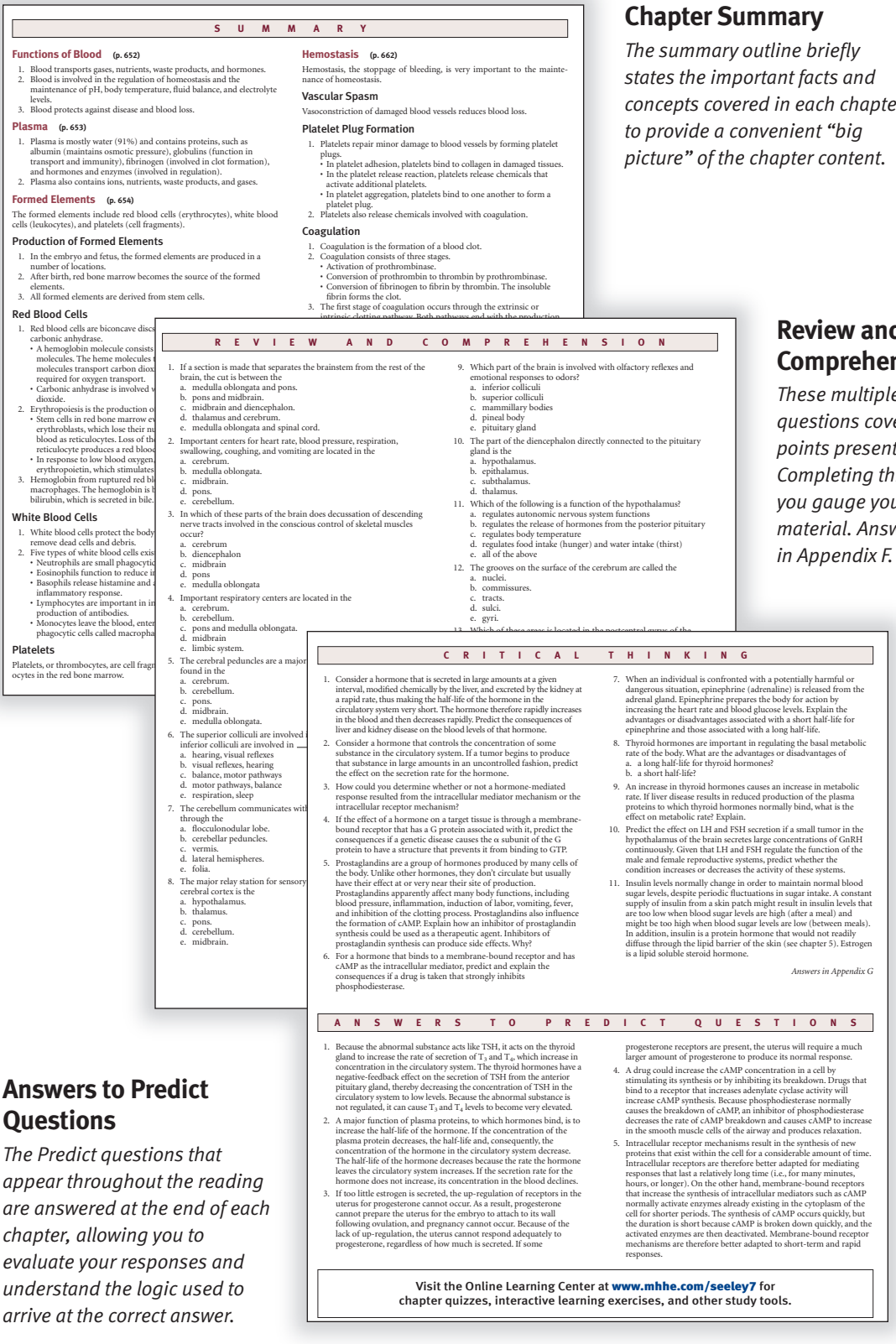
Drowsiness, disorientation, inattentiveness, and loss of consciousness are examples of generalized neurologic response to damage. Seizures may also result from severe neurologic damage. Depression from neurologic damage or from discouragement is also common. Slight dilation of the pupils; short, shallow respiration; and increased pulse rate and blood pressure are all signs of Mr. S's anxiety, not about the outcome of the game but about his current condition and his immediate future. With a loss of consciousness, Mr. S would not remember the last few minutes of what he saw in the game he was watching. People in these circumstances are often worried about how they are going to deal with work tomorrow. They often have no idea that the motor and sensory losses may be permanent, or that they will have a long period of therapy ahead.

PREDICT 9
Given that Mr. S exhibited weakness in his right limbs and loss of pain and temperature sensation in his right lower limb and the left side of his face, state which side of the brainstem was most severely affected by the stroke. Explain your answer.

Every Systems Pathology box includes a Predict question specific to the case study.

Study Features Ensure Success

A carefully devised set of learning aids at the end of each chapter helps you review the chapter content, evaluate your grasp of key concepts, and utilize what you have learned. Reading the chapter summary and completing the practice test and critical thinking exercises will greatly improve your understanding of each chapter and is also a great way to study for exams.



S U M M A R Y

Functions of Blood (p. 652)

1. Blood transports gases, nutrients, waste products, and hormones.
2. Blood is involved in the regulation of homeostasis and the maintenance of pH, body temperature, fluid balance, and electrolyte levels.
3. Blood protects against disease and blood loss.

Plasma (p. 653)

1. Plasma is mostly water (91%) and contains proteins, such as albumin (maintains osmotic pressure), globulins (function in transport and immunity), fibrinogen (involved in clot formation), and hormones and enzymes (involved in regulation).
2. Plasma also contains ions, nutrients, waste products, and gases.

Formed Elements (p. 654)

The formed elements include red blood cells (erythrocytes), white blood cells (leukocytes), and platelets (cell fragments).

Production of Formed Elements

1. In the embryo and fetus, the formed elements are produced in a number of locations.
2. After birth, red bone marrow becomes the source of the formed elements.
3. All formed elements are derived from stem cells.

Red Blood Cells

1. Red blood cells are biconcave discs
   - carbonic anhydrase.
   - A hemoglobin molecule consists
   - molecules. The heme molecules
   - molecules transport carbon diox
   - required for oxygen transport.
   - Carbonic anhydrase is involved
   - dioxide.
2. Erythropoiesis is the production o
   - Stem cells in red bone marrow e
   - erythroblasts, which lose their n
   - blood as reticulocytes. Loss of th
   - reticulocyte produces a red bloo
   - In response to low blood oxygen,
   - erythropoietin, which stimulates
3. Hemoglobin from ruptured red bl
   - macrophages. The hemoglobin is
   - bilirubin, which is secreted in bile.

White Blood Cells

1. White blood cells protect the body
   - remove dead cells and debris.
2. Five types of white blood cells exis
   - Neutrophils are small phagocytic
   - Eosinophils function to reduce i
   - Basophils release histamine and
   - inflammatory response.
   - Lymphocytes are important in i
   - production of antibodies.
   - Monocytes leave the blood, enter
   - phagocytic cells called macropha

Platelets

Platelets, or thrombocytes, are cell fragr
ocytes in the red bone marrow.

Hemostasis (p. 662)

Hemostasis, the stoppage of bleeding, is very important to the maintenance of homeostasis.

Vascular Spasm

Vasoconstriction of damaged blood vessels reduces blood loss.

Platelet Plug Formation

1. Platelets repair minor damage to blood vessels by forming platelet plugs.
   - In platelet adhesion, platelets bind to collagen in damaged tissues.
   - In the platelet release reaction, platelets release chemicals that activate additional platelets.
   - In platelet aggregation, platelets bind to one another to form a platelet plug.
2. Platelets also release chemicals involved with coagulation.

Coagulation

1. Coagulation is the formation of a blood clot.
2. Coagulation consists of three stages.
   - Activation of prothrombinase.
   - Conversion of prothrombin to thrombin by prothrombinase.
   - Conversion of fibrinogen to fibrin by thrombin. The insoluble fibrin forms the clot.
3. The first stage of coagulation occurs through the extrinsic or intrinsic clotting pathway. Both pathways end with the production

R E V I E W A N D C O M P R E H E N S I O N

1. If a section is made that separates the brainstem from the rest of the brain, the cut is between the
   a. medulla oblongata and pons.
   b. pons and midbrain.
   c. midbrain and diencephalon.
   d. thalamus and cerebrum.
   e. medulla oblongata and spinal cord.
2. Important centers for heart rate, blood pressure, respiration, swallowing, coughing, and vomiting are located in the
   a. cerebrum.
   b. medulla oblongata.
   c. midbrain.
   d. pons.
   e. cerebellum.
3. In which of these parts of the brain does decussation of descending nerve tracts involved in the conscious control of skeletal muscles occur?
   a. cerebrum
   b. diencephalon
   c. midbrain
   d. pons
   e. medulla oblongata
4. Important respiratory centers are located in the
   a. cerebrum.
   b. cerebellum.
   c. pons and medulla oblongata.
   d. midbrain
   e. limbic system.
5. The cerebral peduncles are a major
   found in the
   a. cerebrum.
   b. cerebellum.
   c. pons.
   d. midbrain.
   e. medulla oblongata.
6. The superior colliculi are involved
   inferior colliculi are involved in
   a. hearing, visual reflexes
   b. visual reflexes, hearing
   c. balance, motor pathways
   d. motor pathways, balance
   e. respiration, sleep
7. The cerebellum communicates wit
   through the
   a. flocculonodular lobe.
   b. cerebellar peduncles.
   c. vermis.
   d. lateral hemispheres.
   e. folia.
8. The major relay station for sensory
   cerebral cortex is the
   a. hypothalamus.
   b. thalamus.
   c. pons.
   d. cerebellum.
   e. midbrain.
9. Which part of the brain is involved with olfactory reflexes and emotional responses to odors?
   a. inferior colliculi
   b. superior colliculi
   c. mammillary bodies
   d. pineal body
   e. pituitary gland
10. The part of the diencephalon directly connected to the pituitary gland is the
    a. hypothalamus.
    b. epithalamus.
    c. subthalamus.
    d. thalamus.
11. Which of the following is a function of the hypothalamus?
    a. regulates autonomic nervous system functions
    b. regulates the release of hormones from the posterior pituitary
    c. regulates body temperature
    d. regulates food intake (hunger) and water intake (thirst)
    e. all of the above
12. The grooves on the surface of the cerebrum are called the
    a. nuclei.
    b. commissures.
    c. tracts.
    d. sulci.
    e. gyri.

C R I T I C A L T H I N K I N G

1. Consider a hormone that is secreted in large amounts at a given interval, modified chemically by the liver, and excreted by the kidney at a rapid rate, thus making the half-life of the hormone in the circulatory system very short. The hormone therefore rapidly increases in the blood and then decreases rapidly. Predict the consequences of liver and kidney disease on the blood levels of that hormone.
2. Consider a hormone that controls the concentration of some substance in the circulatory system. If a tumor begins to produce that substance in large amounts in an uncontrolled fashion, predict the effect on the secretion rate for the hormone.
3. How could you determine whether or not a hormone-mediated response resulted from the intracellular mediator mechanism or the intracellular receptor mechanism?
4. If the effect of a hormone on a target tissue is through a membrane-bound receptor that has a G protein associated with it, predict the consequences if a genetic disease causes the α subunit of the G protein to have a structure that prevents it from binding to GTP.
5. Prostaglandins are a group of hormones produced by many cells of the body. Unlike other hormones, they don't circulate but usually have their effect at or very near their site of production. Prostaglandins apparently affect many body functions, including blood pressure, inflammation, induction of labor, vomiting, fever, and inhibition of the clotting process. Prostaglandins also influence the formation of cAMP. Explain how an inhibitor of prostaglandin synthesis could be used as a therapeutic agent. Inhibitors of prostaglandin synthesis can produce side effects. Why?
6. For a hormone that binds to a membrane-bound receptor and has cAMP as the intracellular mediator, predict and explain the consequences if a drug is taken that strongly inhibits phosphodiesterase.
7. When an individual is confronted with a potentially harmful or dangerous situation, epinephrine (adrenaline) is released from the adrenal gland. Epinephrine prepares the body for action by increasing the heart rate and blood glucose levels. Explain the advantages or disadvantages associated with a short half-life for epinephrine and those associated with a long half-life.
8. Thyroid hormones are important in regulating the basal metabolic rate of the body. What are the advantages or disadvantages of
   a. a long half-life for thyroid hormones?
   b. a short half-life?
9. An increase in thyroid hormones causes an increase in metabolic rate. If liver disease results in reduced production of the plasma proteins to which thyroid hormones normally bind, what is the effect on metabolic rate? Explain.
10. Predict the effect on LH and FSH secretion if a small tumor in the hypothalamus of the brain secretes large concentrations of GnRH continuously. Given that LH and FSH regulate the function of the male and female reproductive systems, predict whether the condition increases or decreases the activity of these systems.
11. Insulin levels normally change in order to maintain normal blood sugar levels, despite periodic fluctuations in sugar intake. A constant supply of insulin from a skin patch might result in insulin levels that are too low when blood sugar levels are high (after a meal) and might be too high when blood sugar levels are low (between meals). In addition, insulin is a protein hormone that would not readily diffuse through the lipid barrier of the skin (see chapter 5). Estrogen is a lipid soluble steroid hormone.

Answers in Appendix G

A N S W E R S T O P R E D I C T Q U E S T I O N S

1. Because the abnormal substance acts like TSH, it acts on the thyroid gland to increase the rate of secretion of T_3 and T_4, which increase in concentration in the circulatory system. The thyroid hormones have a negative-feedback effect on the secretion of TSH from the anterior pituitary gland, thereby decreasing the concentration of TSH in the circulatory system to low levels. Because the abnormal substance is not regulated, it can cause T_3 and T_4 levels to become very elevated.
2. A major function of plasma proteins, to which hormones bind, is to increase the half-life of the hormone. If the concentration of the plasma protein decreases, the half-life and, consequently, the concentration of the hormone in the circulatory system decrease. The half-life of the hormone decreases because the rate the hormone leaves the circulatory system increases. If the secretion rate for the hormone does not increase, its concentration in the blood declines.
3. If too little estrogen is secreted, the up-regulation of receptors in the uterus for progesterone cannot occur. As a result, progesterone cannot prepare the uterus for the embryo to attach to its wall following ovulation, and pregnancy cannot occur. Because of the lack of up-regulation, the uterus cannot respond adequately to progesterone, regardless of how much is secreted. If some progesterone receptors are present, the uterus will require a much larger amount of progesterone to produce its normal response.
4. A drug could increase the cAMP concentration in a cell by stimulating its synthesis or by inhibiting its breakdown. Drugs that bind to a receptor that increases adenylate cyclase activity will increase cAMP synthesis. Because phosphodiesterase normally causes the breakdown of cAMP, an inhibitor of phosphodiesterase decreases the rate of cAMP breakdown and causes cAMP to increase in the smooth muscle cells of the airway and produces relaxation.
5. Intracellular receptor mechanisms result in the synthesis of new proteins that exist within the cell for a considerable amount of time. Intracellular receptors are therefore better adapted for mediating responses that last a relatively long time (i.e., for many minutes, hours, or longer). On the other hand, membrane-bound receptors that increase the synthesis of intracellular mediators such as cAMP normally activate enzymes already existing in the cytoplasm of the cell for shorter periods. The synthesis of cAMP occurs quickly, but the duration is short because cAMP is broken down quickly, and the activated enzymes are then deactivated. Membrane-bound receptor mechanisms are therefore better adapted to short-term and rapid responses.

Visit the Online Learning Center at www.mhhe.com/seeley7 for chapter quizzes, interactive learning exercises, and other study tools.

Chapter Summary

The summary outline briefly states the important facts and concepts covered in each chapter to provide a convenient "big picture" of the chapter content.

Review and Comprehension

These multiple-choice practice questions cover all of the main points presented in the chapter. Completing this self-test helps you gauge your mastery of the material. Answers are provided in Appendix F.

Critical Thinking

These innovative exercises encourage you to apply chapter concepts to solve a problem. Answering these questions helps build your working knowledge of anatomy and physiology while developing reasoning skills. Answers are provided in Appendix G.

Answers to Predict Questions

The Predict questions that appear throughout the reading are answered at the end of each chapter, allowing you to evaluate your responses and understand the logic used to arrive at the correct answer.