

# Glossary | Index

Page numbers followed by *t* or *f* indicate tables and figures respectively. Key terms in the text are defined here.

## A

**A band** one of the transverse bands making up repeated striations of cardiac and skeletal muscle; region of aligned myosin-containing thick filaments, 259*f*, 260–61, 261*f*

**abducens nerve (cranial nerve VI)**, 177*t*

**ABO blood groups**, 681–82, 682*t*

**abortifacients**, 647

**abortion** spontaneous or clinically induced death of an embryo or fetus after implantation, 647

**abscess**, 707

**absolute refractory period** time during which an excitable membrane cannot generate an action potential in response to any stimulus, 153–54, 154*f*, 380

**absorption** movement of materials across an epithelial layer from body cavity or compartment toward the blood capillary, 404, 534*f*, 535*f*

**gastrointestinal**, 533, 535*t*, 553–58

**absorptive state** period during which nutrients enter bloodstream from gastrointestinal tract, 573

endocrine and neural control of, 578–84, 579*f*

nutrient metabolism in, 573–76, 573*f*, 576*t*

**accessory digestive organs**, 532

**accessory nerve (cranial nerve XI)**, 177*t*

**accessory reproductive organs** ducts through which sperm or egg is transported, or glands emptying into such a duct (in the female, the breasts are usually included), 612, 620

**acclimatization** (ah-climb-ah-tih-ZAY-shun) environmentally induced improvement in functioning of a physiological system with no change in genetic endowment, 12–13, 596

**accommodation** adjustment of eye for viewing various distances by changing shape of lens, 208

**acetylcholine (ACh)** (uh-CEE-tul-KOH-leen) a neurotransmitter released by pre- and postganglionic parasympathetic neurons, preganglionic sympathetic neurons, somatic neurons, and some CNS neurons, 165*t*, 166, 180–81, 181*t*

in Alzheimer's disease, 166

drugs or diseases disrupting function of, 165, 264–65

in myasthenia gravis, 284–85

in skeletal muscle contraction, 262–65, 264*f*

in sleep-wake cycle, 239

**acetylcholine receptors**, 166, 178, 180, 180*f*

**acetylcholinesterase** (ass-ih-teel-koh-lin-ES-ter-ase) enzyme that breaks down acetylcholine into acetic acid and choline, 166, 264–65

**acetylcholinesterase inhibitors**, 284

**acetyl coenzyme A (acetyl CoA)** (ASS-ih-teel koh-EN-zime A) metabolic intermediate that

transfers acetyl groups to Krebs cycle and various synthetic pathways, 80–82, 81*f*

**acid(s)** molecules capable of releasing a hydrogen ion; solutions having an H<sup>+</sup> concentration greater than that of pure water (that is, pH less than 7), 29, 520–21. *See also* strong acids; weak acids

**acid-base balance**, 520–24, 524*t*

**acidic solutions** any solutions with a pH less than 7.0, 29

**acidity** concentration of free, unbound hydrogen ion in a solution; the higher the H<sup>+</sup> concentration, the greater the acidity, 29

**acidosis**, 476, 520, 523–24, 524*t*

**acini** (ASS-uh-nye) grapelike clusters of secretory lobules (groups of acinar cells) in the exocrine pancreas; secrete digestive enzymes into the pancreatic duct, 548

**acquired immune deficiency syndrome (AIDS)**, 680, 680*f*

**acquired reflexes** behaviors that appear to be stereotypical and automatic but that in fact result from considerable conscious effort to be learned; also called *learned reflexes*, 10

**acromegaly**, 357–59, 357*f*

**acrosome** (AK-roh-sohm) cytoplasmic vesicle containing digestive enzymes and located at head of a sperm, 616, 616*f*

**acrosome reaction** process that occurs in the sperm after it binds to the zona pellucida of the egg, exposing acrosomal enzymes, 636

**actin** protein that forms the thin filaments that contribute to muscle action, 259*f*, 260, 260*f*, 265–66, 265*f*–66*f*. *See also* actin filaments

**actin filaments** polymers of G-actin that form part of the cell cytoskeleton and are part of the contractile apparatus of muscle cells; also called *microfilaments*, 47*f*, 55, 55*f*

**action potential(s)** electrical signals propagated by neurons and muscle cells; all-or-none depolarizations of membrane polarity; have a threshold and refractory period and are conducted without decrement, 149*t*, 150–56, 151*f*–53*f*

in cardiac muscle contraction, 293–94, 294*f*, 375–78, 376*f*–77*f*

graded potentials *versus*, 150, 157*t*

myelination and, 155–56, 156*f*

in neurotransmitter release, 159–60

refractory periods in, 153–54, 154*f*

saltatory conduction of, 156, 156*f*

in skeletal muscle contraction, 262–69, 264*f*–66*f*

in smooth muscle contraction, 290–91, 291*f*

**action potential propagation** the movement of an action potential along an axon; in myelinated axons, it occurs via saltatory conduction, 154–56, 155*f*–56*f*

**activated macrophages** macrophages whose killing ability has been enhanced by cytokines, particularly IL-2 and interferon-gamma, 677, 677*f*

**activation energy** energy necessary to disrupt existing chemical bonds during a chemical reaction, 72

**active hyperemia** (hy-per-EE-me-ah) increased blood flow through a tissue associated with increased metabolic activity, 396–97, 396*f*

**active immunity** resistance to reinfection acquired by contact with microorganisms, their toxins, or other antigenic material; *compare* passive immunity, 675

**active site** region of enzyme to which substrate binds, 73–74

**active transport** energy-requiring system that uses transporters to move ions or molecules across a membrane against an electrochemical difference, 102–5, 102*f*–4*f*, 112–13, 112*f*–13*f*. *See also* primary active transport; secondary active transport

**active zones** regions within an axon terminal where neurotransmitter vesicles are clustered prior to secretion, 159

**acuity** sharpness or keenness of perception, 193, 194*f*

**acupuncture**, 203

**acute phase proteins** proteins secreted by liver during systemic response to injury or infection, 679

**acute phase response** response of tissues or organs distant from site of infection or immune response, 677–79, 678*f*

**adaptation** (evolution) a biological characteristic that favors survival in a particular environment; (neural) decrease in action potential frequency in a neuron despite constant stimulus, 12–13, 192, 192*f*, 211

**adaptive immune responses** the specific responses of the cells of the immune system to a particular pathogen; subsequent responses to the same pathogen are amplified, 655–56, 664–77

**Addison's disease**, 346

**adenine** one of the four bases making up DNA; also a breakdown product of ATP used as a neurotransmitter, 38–39, 38*f*, 39*f*, 57–58

**adenoids** lymphoid tissue; also known as *pharyngeal tonsils*, 665–66

**adenosine** a nucleoside composed of adenine bound to a ribose sugar; building block for ATP; neurotransmitter in CNS, 170

**adenosine diphosphate (ADP)**, 78, 78*f*, 275–76, 275*f*

**adenosine triphosphate (ATP)** nucleotide that transfers energy from metabolism to cell functions during its breakdown to ADP and release of Pi, 77–83

conversion to cAMP, 126, 126*f*

feedback regulation of, 8

as neurotransmitter, 170

production of

in carbohydrate metabolism, 83–84, 84*f*

in fat metabolism, 86–87, 86f  
in glycolysis, 78–80, 79f, 80f, 83–84, 84f, 275f, 276  
in Krebs cycle, 80–84, 80f, 81f, 82t, 84f  
in mitochondria, 52  
in oxidative phosphorylation, 82–84, 83f, 84f, 84t  
in skeletal muscle, 275–76, 275f  
in skeletal muscle contraction, 268–69, 268f, 269t, 275–76, 275f  
in smooth muscle contraction, 288–289  
structure of, 77–78, 78f

**adenyl cyclase** (ad-DEN-ah-lil SYE-klase)  
enzyme that catalyzes transformation of ATP to cyclic AMP, 126, 126f

**adequate stimulus** the modality of stimulus to which a particular sensory receptor is most sensitive, 190, 192

**adipocytes** (ad-DIP-oh-sites) cells specialized for triglyceride synthesis and storage; fat cells, 86, 574

**adipose tissue** (AD-ah-poze) tissue composed largely of fat-storing cells, 86, 322f, 595

**adrenal cortex** (ah-DREE-nal KORE-tex)  
endocrine gland that forms outer layers of each adrenal gland; secretes steroid hormones—mainly cortisol, aldosterone, and androgens; *compare* adrenal medulla, 322f, 323, 325–26, 326f

**adrenal gland** one of a pair of endocrine glands above each kidney; each gland consists of outer *adrenal cortex* and inner *adrenal medulla*, 322f, 323

**adrenal hormones**, 322f

**adrenal insufficiency**, 346

**adrenal medulla** (meh-DUL-ah or meh-DOOL-ah) endocrine gland that forms inner core of each adrenal gland; secretes amine hormones, mainly epinephrine; *compare* adrenal cortex, 180f, 181, 322f, 323

**adrenergic** (ad-ren-ER-jik) pertaining to norepinephrine or epinephrine;  
compound that acts like norepinephrine or epinephrine, 167

**adrenergic receptors**, 167, 180–81

**adrenocorticotrophic hormone** (ACTH) (ad-ren oh-kor-tih-koh-TROH-pik) polypeptide hormone secreted by anterior pituitary gland; stimulates adrenal cortex to secrete cortisol; also called *corticotropin*, 322f, 335–39, 337f–38f, 344–46, 344f

**aerobic** (air-OH-bik) requiring oxygen, 80

**aerobic metabolism**, 80–82

**afferent arteriole** vessel in kidney that carries blood from artery to renal corpuscle, 490, 491f, 493, 494f

**afferent division (of the peripheral nervous system)** neurons in the peripheral nervous system that project to the central nervous system, 172f, 176

**afferent input, local**, 304–8

**afferent neurons** neurons that carry information from sensory receptors at their peripheral endings to CNS; cell body lies outside CNS, 138–139, 140f, 140t

**afferent pathway** component of reflex arc that transmits information from receptor to integrating center, 10–11, 10f, 11f

**affinity** strength with which ligand binds to its binding site, 68–69, 68f, 69f

**affinity of receptors**, 119, 121f, 121t

**afterhyperpolarization** decrease in membrane potential in neurons at the end of the action potential due to opened voltage-gated  $K^+$  channels, 152

**afterload** load (related to aortic pressure) against which the heart contracts to eject blood, 386, 387–88

**age-related macular degeneration (AMD)**, 216

**agonists** (AG-ah-nists) chemical messengers that bind to receptor and trigger cell's response; often refer to drugs that mimic action of chemical normally in the body, 121t, 122, 164

**AIDS**, 680, 680f

**airway resistance**, 456–57

**airways** tubes through which air flows between external environment and lung alveoli, 446–47, 446f–47f

**akinesia**, 310

**albumins** (al-BU-minz or AL-bu-minz) most abundant plasma proteins, 364

**aldosterone** (al-doh-STEER-own or al-DOS-stir-own) mineralocorticoid steroid hormone secreted by adrenal cortex; regulates electrolyte balance, 322f, 325, 325f, 326f, 347  
and heart failure, 518  
and potassium regulation, 516, 517f  
and sodium regulation, 511–13, 511f

**alimentary canal** the tube of the digestive system consisting of structures from the mouth to the anus, 532–33, 532f

**alkaline solutions** any solutions having  $H^+$  concentration lower than that of pure water (that is, having a pH greater than 7), 29

**alkalosis**, 476, 520, 523–24, 524t

**allergens**, 683

**allergy**, 683–84

**all-or-none** pertaining to event that occurs maximally or not at all, 153

**allosteric modulation** (al-low-STAIR-ik or al-low-STEER-ik) in the case of a protein with binding sites for two different ligands, the binding of one ligand alters the binding characteristics of the protein for the other ligand, 69–71, 70f

**allosteric proteins** proteins whose binding site characteristics are subject to allosteric modulation, 70

**alpha-adrenergic receptors (alpha-adrenoceptors)** subtype of plasma membrane receptors for epinephrine and norepinephrine; *compare* beta-adrenergic receptors, 167

**alpha cells**, 580

**alpha-gamma coactivation** simultaneous firing of action potentials along alpha motor neurons to extrafusal fibers of a muscle and along gamma motor neurons to the contractile ends of intrafusal fibers within that muscle, 305, 306f

**alpha helix** coiled regions of proteins or DNA formed by hydrogen bonds, 36, 37f

**$\alpha$ -keto acid** (AL-fuh KEY-toh) molecule formed from amino acid metabolism and containing carbonyl ( $—CO—$ ) and carboxyl ( $—COOH$ ) groups, 576

**alpha motor neurons** somatic efferent neurons, which innervate skeletal muscle, 177, 178t, 262–65, 263f, 279–80, 301–08  
local control of, 304–8, 304f  
lower, 313

in motor control hierarchy, 302–4, 302f  
upper, 313

**alpha rhythm** prominent 8 to 12 Hz oscillation on the electroencephalograms of awake, relaxed adults with their eyes closed, 236, 236f, 237f

**alprazolam**, 169, 239

**altered states of consciousness**, 245–48

**alternative complement pathway** sequence for complement activation that bypasses first steps in classical pathway and is not antibody dependent, 662

**altitude**, 480, 480t

**alveolar cells**, 447–48, 449f

**alveolar dead space** (al-VEE-oh-lar) volume of fresh inspired air that reaches alveoli but does not undergo gas exchange with blood, 460

**alveolar ducts**, 447f, 449f

**alveolar gas pressures**, 462–63, 463f, 463t

**alveolar pressure** ( $P_{alv}$ ) air pressure in pulmonary alveoli, 449–53, 450f, 452f

**alveolar sacs** clusters of alveoli resembling grapes on a vine, 447, 447f

**alveolar ventilation** ( $\dot{V}_A$ ) volume of atmospheric air entering alveoli each minute, 458–60, 460t, 461f

**alveoli** (singular, **alveolus**) (al-vee-OH-lee or al-vee-OH-lye) (lungs) thin-walled, air-filled “outpocketings” from terminal air passageways in lungs; (glands) cell clusters at end of duct in secretory gland, 446, 447–48, 448f, 449f, 645  
air exchange in (ventilation), 449–60  
gas exchange in, 460–65  
matching of ventilation and blood flow in, 464–65, 465f

**Alzheimer's disease**, 166, 249, 685

**amacrine cells** (AM-ah-krin) specialized type of neurons found in the retina of the eye that integrate information between local photoreceptor cells, 210f, 212

**ambiguous genitalia**, 610–11

**amenorrhea**, 585, 633, 651–52, 651f

**amiloride**, 518

**amine hormones** (ah-MEEN) hormones derived from amino acid tyrosine; include thyroid hormones, epinephrine, norepinephrine, and dopamine, 323, 323f

**amines, biogenic**, 165t, 166–68

**amino acids** (ah-MEEN-oh) molecules containing amino group, carboxyl group, and side chain attached to a carbon atom; molecular subunits of protein, 34–35, 35f  
in absorptive state, 576  
essential, 88, 89  
excitatory, 168–169  
metabolism of, 87–88, 87f, 88f, 576  
as neurotransmitters, 165t, 168–69

**amino acid sequences**, 38, 58, 58f

**amino acid side chain** the variable portions of amino acids; may contain acidic or basic charged regions, or may be hydrophobic, 35, 35f

**amino group**  $—NH_2$ ; ionizes to  $—NH_3^+$ , 26

**aminopeptidases** (ah-meen-oh-PEP-tih-dase-is) a family of enzymes located in the intestinal epithelial membrane; break peptide bond at amino end of polypeptide, 554

**amitriptyline**, 246

**amnesia**, 249–50, 253–54

**amniocentesis**, 639–40

**amnion** another term for amniotic sac, 639, 640f

**amniotic cavity** (am-nee-AHT-ik) fluid-filled space surrounding the developing fetus enclosed by amniotic sac, 639–40, 640f

**amniotic fluid** liquid within amniotic cavity that has a composition similar to extracellular fluid, 639–40

**amniotic sac** membrane surrounding fetus in utero, 639, 644f

**AMPA receptors** receptor proteins found in the membrane of some brain neurons, named for their binding to alpha-amino-3 hydroxy-5 methyl-4 isoxazole propionic acid, 168, 168f

**amphetamines**, 244

**amphipathic molecule** (am-fuh-PATH-ik) a molecule containing polar or ionized groups at one end and nonpolar groups at the other, 28, 28f

**ampulla** structure in the wall of the semicircular canals containing hair cells that respond to head movement, 222, 222f, 223f

**amygdala**, 244–45, 245f

**amylase** (AM-ih-lase) enzyme that partially breaks down polysaccharides, 532, 539t, 550t, 553–54

**amyotrophic lateral sclerosis (ALS) disease** characterized by progressive deterioration of alpha motor neurons, 313

**anabolic steroids**, 351, 620–21

**anabolism** (an-AB-oh-lizm) cellular synthesis of organic molecules, 71

**anaerobic** (an-ih-ROH-bik) in the absence of oxygen, 82

**anaerobic metabolism**, 82–83

**analgesia**, 202–3, 204f

**analgesics**, 170

**anal sphincters**, 560

**anaphylaxis**, 684

**anatomical dead space** ( $V_D$ ) space in respiratory tract airways where gas exchange does not occur with blood, 458, 459f

**androgen(s)** (AN-dro-jenz) any hormones with testosterone-like actions, 322f, 325, 326f, 605, 611, 612f, 620–21

**androgen-binding protein (ABP)** synthesized and secreted by Sertoli cell of the testes—binds to and increases local testosterone concentration in fluid in the seminiferous tubule, 617

**androgen insensitivity syndrome**, 610

**andropause**, 622

**anemia**, 366, 466, 470

- causes of, 366t
- hemolytic, 690
- iron-deficiency, 365, 366t
- pernicious, 365, 557
- sickle-cell, 38, 41–42, 42f, 366

**anemic hypoxia**, 479

**angina pectoris**, 427, 438–40

**angiogenesis** (an-gee-oh-JEN-ah-sis) the development and growth of new blood vessels; stimulated by angiogenic factors, 399

**angiogenic factors** chemical signals that induce the development and growth of blood vessels, 399

**angiostatin**, 399

**angiotensin I** small polypeptide generated in plasma by the action of the enzyme renin on angiotensinogen; inactive precursor of angiotensin II, 511, 511f

**angiotensin II** hormone formed by action of angiotensin-converting enzyme on angiotensin I;

stimulates aldosterone secretion from adrenal cortex, vascular smooth muscle contraction, and possibly thirst, 322f, 325, 398, 416, 511–13, 511f

**angiotensin-converting enzyme (ACE) enzyme** on capillary endothelial cells that catalyzes removal of two amino acids from angiotensin I to form angiotensin II, 511–12, 511f

**angiotensin-converting enzyme (ACE) inhibitors**, 425t, 512

**angiotensinogen** (an-gee-oh-ten-SIN-oh-gen) plasma protein precursor of angiotensin I; produced by liver, 511, 511f

**anions** (AN-eye-onz) negatively charged ions; *compare* cations, 23

**anorexia nervosa**, 592, 633

**anosmia**, 226

**antagonist** (muscle) muscle whose action opposes intended movement; (drug) molecule that competes with another for a receptor and binds to the receptor but does not trigger the cell's response

- drug, 121–22, 121t, 164
- muscle, 281–82, 282f

**anterior pituitary gland** anterior portion of pituitary gland; synthesizes, stores, and releases ACTH, GH, TSH, PRL, FSH, and LH, 333–38, 333f, 335f

- hypothalamic control of, 334, 336–39, 336f–38f
- stress response of, 344–46

**anterograde** (AN-ter-oh-grayd) movement of a substance or action potential in the forward direction from a neuron's dendrites and/or cell body toward the axon terminal, 138

**anterograde amnesia**, 249–50

**anterograde transport**, 138, 139f

**anterolateral pathway** ascending neural pathway running in the anterolateral column of the spinal cord white matter; conveys information about pain and temperature, 204, 205f

**antibiotics**, 681

**antibodies** (AN-tih-bah-deez) immunoglobulins secreted by plasma cell; combine with type of antigen that stimulated their production; direct attack against antigen or cell bearing it, 666, 668–69

- effects of, 674–75, 674f
- natural, 681
- rate of production, 675, 675f
- secretion of, 674

**antibody-dependent cellular cytotoxicity (ADCC)** killing of target cells by toxic chemicals secreted by NK cells; the target cells are linked to the NK cells by antibodies, 675

**antibody-mediated responses** humoral immune responses mediated by circulating antibodies; major defense against microbes and toxins in the extracellular fluid, 666, 672–76, 672t, 673f

**anticoagulant drugs**, 436–37

**anticoagulation systems**, 435–36, 435f–36f, 436t

**anticodon** (an-tie-KOH-don) three-nucleotide sequence in tRNA able to base-pair with complementary codon in mRNA during protein synthesis, 60, 61f

**antidepressants**, 246

**antidiuretic hormone (ADH)** (an-tye-dye yoor-ET-ik or an-tee-dye-yoor-ET-ik). *See* vasopressin

**antigen** (AN-tih-jen) any molecule that stimulates a specific immune response, 664

**antigen-binding site** one of the two variable “prongs” on an immunoglobulin capable of binding to a specific antigen, 668–69

**antigen presentation** process by which an antigen-presenting cell, such as a macrophage, combines proteolytic fragments of a foreign antigen with host cell class II MHC proteins, which are transported to the host cell's surface, 670–71, 670f, 673f

**antigen-presenting cells (APCs)** cells that present antigen, complexed with MHC proteins on its surface, to T cells, 670, 670f

**antigen recognition**, 672–74

**antihistamines**, 122

**anti-inflammatory drugs**, 457

**anti-Müllerian hormone (AMH)** protein secreted by fetal testes that causes Müllerian ducts to degenerate; formerly known as Müllerian-inhibiting substance (MIS), 607, 608f

**antiport**, 104–5

**antithrombin III** a plasma protein activated by heparin that limits clot formation by inactivating thrombin and other clotting factors, 436

**antrum** (AN-trum) (gastric) lower portion of stomach (that is, region closest to pyloric sphincter); (ovarian) fluid-filled cavity in maturing ovarian follicle

- ovarian, 625
- stomach, 541, 541f

**anus** lowest opening of the digestive tract through which fecal matter is extruded, 532, 532f

**aorta** (a-OR-tah) largest artery in body; carries blood from left ventricle of heart, 368, 368f, 373f

**aortic arch baroreceptor** (a-OR-tik). *See* arterial baroreceptors

**aortic bodies** chemoreceptors located near aortic arch; sensitive to arterial blood  $O_2$  content and  $H^+$  concentration, 473–74, 473f

**aortic stenosis**, 438–40, 439f–40f

**aortic valve** valve between left ventricle of heart and aorta, 372–73, 374f

**aortic valve replacement**, 440

**aphasia**, 251

**apical membrane** the surface of an epithelial cell that faces a lumen, such as that of the intestines; also known as *luminal membrane*, 3f, 4, 111–12, 497f, 498

**apneustic center** (ap-NOOS-tik) area in the lower pons in the brain with input to the medullary inspiratory neurons; helps to terminate inspiration, 472f, 473

**apoptosis** (ay-pop-TOE-sis) programmed cell death that typically occurs during differentiation and development, 142, 367, 625, 626, 664, 672, 677, 680

**appendicitis**, 702–5, 703f

**appendix** small fingerlike projection from cecum of large intestine, 560

**appetite** the psychological desire to eat, 589

**aprosodia**, 251

**aquaporins** (ah-qu-a-PORE-inz) protein membrane channels through which water can diffuse, 105, 505, 505f

**aqueous humor** fluid filling the anterior chamber of the eye, 207, 207f

**arachidonic acid**, 32, 130, 170, 431–32

**N-arachidonoyl ethanolamine (anandamide)** an endocannabinoid neurotransmitter derived



from the membrane phospholipid arachidonic acid, 170

**2-arachidonoylglycerol** an endocannabinoid neurotransmitter derived from the membrane phospholipid arachidonic acid, 170

**arachnoid mater** (ah-RAK-noid) the middle of three membranes (meninges) covering the brain, 181, 183f

**area postrema** a circumventricular organ outside the blood-brain barrier, 562

**Aristotle**, 5

**aromatase** enzyme that converts androgens to estrogens; located predominantly in the ovaries, the placenta, the brain, and adipose tissue, 325, 326f, 611

**arrhythmias**, 384, 427–28, 433, 516

**arterial baroreceptors** neuronal endings sensitive to stretch or distortion produced by arterial blood pressure changes; located in carotid sinus or aortic arch; also called *carotid sinus* and *aortic arch baroreceptor*, 414–17, 414f–16f, 423, 426

**arterial blood pressure**, 392–94, 393f–94f baroreceptors and, 414–17, 414f–16f blood volume and, 417, 417f, 419–20 Cushing’s phenomenon and, 418 mean, 393–94, 394f, 411–18 mean *versus* pulmonary, 412, 414t systemic, regulation of, 411–18, 411f–13f

**arteries** (AHR-ter-eez) thick-walled elastic vessels that carry blood away from heart to arterioles, 371t, 391f, 392–94

**arterioles** (ahr-TEER-ee-ohlz) blood vessels between arteries and capillaries, surrounded by smooth muscle; primary site of vascular resistance, 368, 368f, 371t, 394–99 afferent, 490, 491f, 493, 494f blood-flow distribution by, 394–96, 396f efferent, 490, 491f, 493, 494f radius, major factors affecting, 399f regulation of, 396–98, 396f, 400t structure of, 391f

**arteriosclerosis**, 393

**arthritis**, 345

**artificial pacemaker**, 378

**ascending colon**, 560, 560f

**ascending limb** portion of Henle’s loop of renal tubule leading to distal convoluted tubule, 491f, 493, 494f

**ascending pathways** neural pathways that go to the brain; also called *sensory pathways*, 196–98, 197f

**asphyxia**, 484

**aspiration** inhalation of liquid or a foreign body into the airways, 540

**aspirin**, 131, 437, 596

**association areas**, 197f, 198, 242, 308–9, 309f

**asthma**, 457, 685

**astigmatism**, 209

**astrocyte** a form of glial cell that regulates composition of extracellular fluid around neurons and forms part of the blood-brain barrier, 140–41, 141f

**astrocytoma**, 707

**atelectasis**, 699

**atherosclerosis**, 428–30, 428f, 575, 576, 685

**atmospheric pressure** ( $P_{\text{atm}}$ ) air pressure surrounding the body (760 mmHg at sea level); also called *barometric pressure*, 449–53, 450f

**atom(s)** smallest units of matter that have unique chemical characteristics; have no net charge;

combine to form chemical substances, 21–23, 21f, 21t

**atomic mass** (also called *atomic weight*) value that indicates an atom’s mass relative to mass of other types of atoms based on the assignment of a value of 12 to carbon atom, 22–23

**atomic nucleus** dense region, consisting of protons and neutrons, at center of atom, 21, 21f

**atomic number** number of protons in nucleus of atom, 22

**ATP**. *See* adenosine triphosphate

**ATPase**, 102–3, 103f

**ATP synthase** the enzyme complex present in mitochondria responsible for the synthesis of ATP using the energy of an electrochemical gradient for hydrogen ions, 82–83, 83f

**atresia** degeneration of nondominant follicles in the ovary, 625

**atrial fibrillation**, 384

**atrial natriuretic peptide** (nay-tree-yor-ET-ik) peptide hormone secreted by cardiac atrial cells in response to atrial distension; causes increased renal sodium excretion, 322f, 398, 513, 513f

**atrioventricular (AV) conduction disorder**, 378

**atrioventricular (AV) node** (ay-tree-oh-ven-TRIK-you-lar) region at base of right atrium near interventricular septum, containing specialized cardiac muscle cells through which electrical activity must pass to go from atria to ventricles, 375–76, 375f

**atrioventricular (AV) valves** valves between atrium and ventricle of heart; AV valve on right side of heart is the tricuspid valve, and that on left side is the mitral valve, 372–73, 374f

**atrium** (AY-tree-um) chamber of heart that receives blood from veins and passes it on to ventricle on same side of heart, 368, 371t, 372, 373f

**atrophy**, 280

**atropine**, 166, 264

**attention, selective**, 241–42

**attention-deficit/hyperactivity disorder (ADHD)**, 242

**audition** (aw-DIH-shun) sense of hearing, 216–21, 218f, 221f, 221t

**auditory cortex** region of cerebral cortex that receives inputs from auditory (hearing) pathways, 197, 197f

**auricle**, 217, 218f

**autocrine substances** (AW-toh-crin) chemical messengers secreted into extracellular fluid that act upon the cell that secreted them; *compare* paracrine substances, 11–12, 12f

**autoimmune disease**, 684, 684r, 690–91

**autoimmune thyroiditis**, 342–43

**automatic electronic defibrillators (AEDs)**, 428

**automaticity** (aw-toh-mah-TISS-ih-tee) capable of spontaneous, rhythmic self-excitation, 377–78

**autonomic ganglion** group of neuron cell bodies in the peripheral nervous system, 177, 180f

**autonomic nervous system** (aw-toh-NAHM-ik) component of efferent division of peripheral nervous system that consists of sympathetic and parasympathetic subdivisions; innervates cardiac muscle, smooth muscle, and glands; *compare* somatic nervous system, 176–81, 178t, 179f, 182t

**autoreceptors** receptors on a cell affected by a chemical messenger released from the same cell, 163f, 164

**autoregulation, arteriolar (flow)**, 396f, 397

**autotransfusion**, 419, 419f

**axo-axonic synapse** presynaptic synapse where an axon stimulates the presynaptic terminal of another axon, 163–64, 163f

**axon** (AX-ahn) extension from neuron cell body; propagates action potentials away from cell body, 137–38, 138f growth and development of, 141–42 myelinated, 138, 138f, 141f regeneration of, 142

**axon hillock** the part of a neuron where an axon leaves the cell body; site of action potential origination, 138

**axon terminal** end of axon; forms synaptic or neuroeffector junction with postjunctional cell, 138, 138f

**axonal transport** process involving intracellular filaments by which materials are moved from one end of axon to other, 138, 139f

## B

**bacteria**, 656, 675–76

**baldness, male pattern**, 620

**balloon valvuloplasty**, 440

**baroreceptors** receptors sensitive to pressure and to rate of change in pressure, 414–17. *See also* arterial baroreceptors; intrarenal baroreceptors

**Barr body** sex chromatin nuclear mass formed by the nonfunctional X chromosome in female cell nuclei, 607

**barrier defenses, immune**, 657

**basal cells** cells found within taste buds that can divide and differentiate to replace worn-out taste receptor cells, 224, 225f

**basal ganglia**. *See* basal nuclei

**basal metabolic rate (BMR)** metabolic rate when a person is at mental and physical rest but not sleeping, at comfortable temperature, and has fasted at least 12 h; also called *metabolic cost of living*, 587

**basal nuclei** nuclei deep in cerebral hemispheres that code and relay information associated with control of body movements; specifically, caudate nucleus, globus pallidus, and putamen; also called *basal ganglia*, 174f, 175, 303, 303f, 309–10

**base** (acid-base) any molecule that can combine with  $\text{H}^+$ ; (nucleotide) molecular ring of carbon and nitrogen that, with a phosphate group and a sugar, constitutes a nucleotide acid-base, 29 nucleotide, 38–39, 38f, 57–58

**basement membrane** thin layer of extracellular proteinaceous material upon which epithelial and endothelial cells sit, 3–4, 3f

**base pairing**, 38–39, 39f, 58, 59

**basic electrical rhythm** spontaneous depolarization-repolarization cycles of pacemaker cells in longitudinal smooth muscle layer of stomach and intestines; coordinates repetitive muscular activity of GI tract, 546, 546f

**basilar membrane** (BAS-ih-lar) membrane that separates cochlear duct and scala tympani in inner ear; supports organ of Corti, 218, 218f, 219f

**basolateral membrane** (bay-zo-LAH-ter-al) sides of epithelial cell other than luminal surface; also called *serosal* or *blood side of cell*, 3–4, 3f, 111–12, 498

**basophils** (BAY-zo-fillz) polymorphonuclear granulocytic leukocytes whose granules stain with basic dyes; enter tissues and become mast cells, 364f, 367, 656, 658t

**B cells** (immune system). *See* B lymphocytes

**benign paroxysmal positional vertigo (BPPV)**, 230, 230f

**benzodiazepines**, 169, 239

**Bernard, Claude**, 2, 6

**beta-adrenergic receptor blockers (beta-blockers)**, 121, 425t, 427t

**beta-adrenergic receptors (beta adrenoceptors)** (BAY-ta ad-ren-ER-jik) plasma membrane receptors for epinephrine and norepinephrine; *compare* alpha-adrenergic receptors, 167

**beta-amyloid protein**, 166

**beta cells** also called *B cells*, 580, 581, 582f, 600

**beta-endorphin** putative hormone released from the anterior pituitary gland, believed to play a role in adaptation to stress and pain relief; also acts as a neurotransmitter, 170, 335, 347

**beta-lipotropin** a protein formed from the proopiomelanocortin precursor in the anterior pituitary gland; further processing results in the putative hormone beta-endorphin, 335

**beta oxidation** (ox-ih-DAY-shun) series of reactions that generate hydrogen atoms (for oxidative phosphorylation) from breakdown of fatty acids to acetyl CoA, 86

**beta pleated sheet** a form of secondary protein structure determined by the relative hydrophobicity of amino acid side chains, 36, 37f

**beta rhythm** low, fast EEG oscillations in alert, awake adults who are paying attention to (or thinking hard about) something, 236, 236f, 237f

**bicuspid valve** another term for the left atrioventricular valve, also called the *mitral valve*, 372, 373f, 374f

**bile** fluid secreted by liver into bile canaliculi; contains bicarbonate, bile salts, cholesterol, lecithin, bile pigments, metabolic end products, and certain trace metals, 548, 551–53, 552f

**bile canaliculi** (kan-al-IK-you-lee) small ducts adjacent to liver cells into which bile is secreted, 551

**bile ducts**, 549f

**bile pigments** colored substances, derived from breakdown of heme group of hemoglobin, secreted in bile, 552

**bile salts** a family of steroid molecules produced from cholesterol and secreted in bile by the liver; promote solubilization and digestion of fat in small intestine, 551–53, 552f, 555–5, 555f

**bilirubin** (bil-eh-RUE-bin) yellow substance resulting from heme breakdown; excreted in bile as a bile pigment, 365, 552

**binding site** region of protein to which a specific ligand binds, 66–71, 67f–70f

**binocular vision** visual perception of overlapping fields from the two eyes, 213, 213f

**biogenic amines** (by-oh-JEN-ik ah-MEENZ) neurotransmitters having basic formula R—NH<sub>2</sub>; include dopamine, norepinephrine, epinephrine, serotonin, and histamine, 165t, 166–68

**biological rhythms**, 13–14, 13f

**biopsy**, 562

**bipolar cells** neurons that have one input branch and one output branch each, 211–12

**bipolar disorder**, 246–47

**birth**. *See* parturition

**bisphosphonates**, 355

**bitter taste**, 224

**bivalents** paired homologous chromosomes, each with two sister chromatids, that are produced during meiosis, 605, 606f

**bladder** urinary bladder; thick-walled sac composed of smooth muscle; stores urine prior to urination, 489, 490f, 500–1, 500f

**blastocyst** (BLAS-toh-cyst) particular early embryonic stage consisting of ball of developing cells surrounding central cavity, 629f, 638

**block to polyspermy** process that prevents more than one sperm cell from fertilizing an ovum, 636, 637f, 638f

**blood** pressurized contents of the circulatory system composed of a liquid phase (plasma) and cellular phase (red and white blood cells, platelets), 363–72, 371t

carbon dioxide transport in, 470–71, 470f

hormone transport in, 327, 327t

oxygen-carrying capacity of, 466

oxygen transport in, 365, 465–70

**blood-brain barrier** group of anatomical barriers and transport systems in brain capillary endothelium that controls kinds of substances entering brain extracellular space from blood and their rates of entry, 140–41, 184

**blood cells**, 363–67, 364f, 371t. *See also specific types*

**blood coagulation** (koh-ag-you-LAY-shun) blood clotting, 432–35, 433f–35f, 436t

**blood-CSF barrier**, 184

**blood flow**, 367–70, 368f–69f

arterial, 392–94

arteriolar, 394–99

capillary, 367–68, 401–2, 401f–02f

coronary, 374

exercise and, 421–24

matching of ventilation to, 464–65, 465f

regulation of, 396–98, 396f

turbulent, 384–85, 384f

venous, 406–7, 406f–407f

**blood loss**, 419–20

fluid shifts after, 419, 419f, 420t

hypotension with, 414, 414t, 419–20, 419f

prevention of, 431–37

**blood pressure**, 369–70, 369f

arterial, 393–94, 393f–94f

baroreceptors and, 414–17, 414f–16f

blood volume and, 417, 417f, 419–20

Cushing’s phenomenon and, 418

mean, 393–94, 394f, 411–18

mean *versus* pulmonary, 412, 414t

systemic, regulation of, 411–18, 411f–13f

capillary, 403–5, 405f

diastolic, 392–93, 394f

exercise and, 421–24, 422f

hemorrhage and, 414, 414f, 419–20, 419f

high (*See* hypertension)

low (*See* hypotension)

measurement of, 394, 394f

in pregnancy, 642–43

renal function and, 513

sleep apnea and, 484–85

systolic, 392–93, 394f

upright posture and, 420–21, 421f

venous, 406–7, 406f–407f

**blood types**, 681–82, 682t

**blood vessels** tubular structures of various sizes that transport blood throughout the body, 390–407, 391f. *See also specific types*

**B lymphocytes** lymphocytes that, upon activation, proliferate and differentiate into antibody-secreting plasma cells; also called *B cells*, 364f, 367, 657, 658t, 670f

activation of, 672–74

functions of, 666, 668f

origins of, 666, 667f

receptors for, 668–69

**body** (of stomach) middle portion of the stomach; secretes mucus, pepsinogen, and hydrochloric acid, 541, 541f

**body fluid**, 4, 6f

**body fluid compartments**, 4–5, 6f

**body mass index (BMI)** method for assessing degree of obesity; calculated as weight in kilograms divided by square of height in meters, 591

**body movement**, 301–17

hierarchy of control, 302–4, 302f–303f, 303t

local control of, 304–8, 304f

sense of, 200–201, 303

**body temperature**, 593–98

fever and hyperthermia in, 597–98, 597f

heat loss/gain mechanisms in, 593–94, 595f

homeostatic control of, 7–11, 7f, 11f, 594–96, 595f

resetting set points in, 8–9, 596

**body weight**, 589

**bolus** meaning “lump”; refers to mucus-covered ball of chewed food that is swallowed, 533

**bone(s)**

calcium homeostasis in, 352–53

formation of, 353, 353f

growth of, 348, 348f

hormonal influences on, 353, 353t

muscle lever action on, 281–82, 282f–84f

**bone age** an x-ray determination of the degree of bone development; often used in assessing reasons for unusual stature in children, 348

**bone marrow** highly vascular, cellular substance in central cavity of some bones; site of erythrocyte, leukocyte, and platelet synthesis, 364f, 365, 664–66

**bone mass**, 353, 353t

**Botox**, 165

**botulism**, 165, 265

**bound ribosomes**, 47f, 51

**Bowman’s capsule** blind sac at beginning of tubular component of kidney nephron, 490–93, 491f, 492f, 494f

**Bowman’s space** fluid-filled space within Bowman’s capsule into which protein-free fluid filters from the glomerulus, 491

**Boyle’s law** pressure of a fixed amount of gas in a container is inversely proportional to container’s volume, 450, 451f, 453

**bradykinesia**, 310

**bradykinin** (braid-ee-KYE-nin) protein formed by action of the enzyme kallikrein on precursor, 397

**brain**, 172–76, 172f, 173t

arteriolar control in, 400t

motor centers of, 302–3, 303f, 308–12

protective elements associated with, 181–84, 183f  
sexual differentiation of, 611

**brain cancer**, 706–9, 708f

**brain death**, 240–41, 241t

**brain self-stimulation** phenomenon in which animals will press a bar to get electrical stimulation of certain parts of their brains, 243–44, 244f

**brainstem** brain subdivision consisting of medulla oblongata, pons, and midbrain and located between spinal cord and forebrain, 173t, 175–76, 179f  
development of, 172, 173f  
in movement control, 303, 303f, 309–11

**brainstem pathways** descending motor pathways whose cells of origin are in the brainstem, 311–12, 312f

**breathing**. *See* respiration

**breech presentation**, 643

**Broca's area** (BRO-kahz) region of left frontal lobe associated with speech production, 250f, 251

**bronchi** (singular, **bronchus**) (BRON-kye) large-diameter air passages that enter lung; located between trachea and bronchioles, 446–47, 446f, 448f

**bronchioles** (BRON-kee-ohlz) small airways distal to bronchus, 446f, 447, 448f

**bronchitis, chronic**, 458

**bronchodilator drugs**, 457

**brown adipose tissue** type of adipose (fat) tissue found in newborns and in many mammals, with a higher heat-producing capacity than ordinary white fat; may be important in regulating body temperature in extreme conditions, 595

**bruise**, 695

**brush border** small projections (microvilli) of epithelial cells covering the villi of the small intestine; major absorptive surface of the small intestine, 547, 548f

**buffer** weak acid or base that can exist in undissociated (Hbuffer) or dissociated ( $H^+$  + buffer) form, 521

**bulbourethral glands** (bul-bo-you-REETH-ral) paired glands in male that secrete fluid components of semen into the urethra, 615, 615f

**bulimia nervosa**, 592

**bulk flow** movement of fluids or gases from region of higher pressure to one of lower pressure, 97, 367–68, 403–6, 403f, 405f

**bundle branches** pathway composed of cells that rapidly conduct electrical signals down the right and left sides of the interventricular septum; these pathways connect the bundle of His to the Purkinje network, 375f, 376

**bundle of His** (HISS) nerve-like structure composed of modified heart cells that carries electrical impulses from the atrioventricular node down the interventricular septum, 375f, 376

**butterfly rash**, 690, 690f

## C

**C1** the first protein in the classical complement pathway, 661–62, 674–75, 674f

**cadherins** proteins that extend from a cell surface and link up with cadherins from other cells; important in the formation of tissues, 51

**calcitonin** hormone from the thyroid gland that inhibits bone resorption, although physiological role in humans is minimal, 322f, 355

**calcium (calcium ions)**  
in audition, 220, 221f  
in blood coagulation, 433  
in cardiac muscle contraction, 293–94, 294f, 376–80, 376f  
homeostasis of, 14, 352–57, 354f–55f  
imbalances of, 133–34, 283, 355–356  
in neurotransmitter release, 159–60, 160f  
renal regulation of, 517  
as second messenger, 128–29, 129t, 130f, 130t  
in skeletal muscle contraction, 265–69, 265f–66f, 289f  
in skeletal muscle fatigue, 276–77  
in smooth muscle contraction, 288–291, 289f–90f

**calcium channel blockers**, 425t

**caldesmon**, 288–289

**calmodulin** (kal-MADJ-you-lin) intracellular calcium-binding protein that mediates many of calcium's second-messenger functions, 129, 130f

**calmodulin-dependent protein kinases**  
intracellular enzymes that, when activated by calcium and the protein calmodulin, phosphorylate many protein substrates within cells; they are components of many intracellular signaling mechanism, 129, 130f

**calorie** (cal) unit of heat-energy measurement; amount of heat needed to raise temperature of 1 g of water 1° C; *compare* kilocalorie, 72, 587

**calorigenic effect** (kah-lor-ih-JEN-ik) increase in metabolic rate caused by epinephrine or thyroid hormones, 587

**calsequestrin high-capacity** calcium-binding protein that enhances  $Ca^{2+}$  storage in terminal cisternae of striated muscle cells, 261

**calyx** (plural, **calyces**) (KAY-licks) funnel-shaped structure that drains urine into the ureter, 490, 490f

**cAMP (cyclic AMP)**, 126–28, 126f, 127f, 128f, 130t

**cAMP-dependent protein kinase** (KYE-nase) enzyme that is activated by cyclic AMP and then phosphorylates specific proteins, thereby altering their activity; also called *protein kinase A*, 126f, 127–28

**cAMP phosphodiesterase** an enzyme in all cells that converts cAMP into an inactive molecule of AMP, 126–27

**canaliculi** (singular, **canaliculus**) thin canals formed by invagination of the cell membrane bile, 551  
gastric, 541

**cancer**, 620, 676–77, 706–9, 708f

**cannabis** plant genus that produces the psychotropic chemical tetrahydrocannabinol (THC); marijuana, 170

**Cannon, Walter**, 6

**capacitance vessels** compliant blood vessels in which most of the circulating blood volume typically resides (venules and veins), 406

**capacitation** process by which sperm in female reproductive tract gains ability to fertilize egg; also called *sperm capacitation*, 636

**capillaries** the smallest blood vessels; where most exchange of nutrients and wastes occurs with

interstitial fluid, 367–68, 371t, 391f, 399–406, 401f  
blood flow in, 367–68, 401–2, 401f–02f  
bulk flow across, 403–6, 403f, 405f  
diffusion across, 402–3, 403f  
filtration across, 403  
glomerular, 490, 491f, 492f  
hypotension and, 419, 419f  
lymphatic, 407–8, 408f  
osmosis across, 403–4  
peritubular, 491f, 493  
permeability, in inflammation, 659–60  
Starling forces and, 404, 405f

**capillary network**, 400–401, 401f

**capillary pressure**, 403–5, 405f

**capsule**, 490, 490f

**carbaminohemoglobin** (kar-bah-MEEN-oh-HEE-ma-gloh-bin) compound resulting from combination of carbon dioxide and amino groups in hemoglobin, 470

**carbohydrates** organic substances composed of carbon, hydrogen, and oxygen; include mono-, di-, and polysaccharides, 30–31, 30t, 31f  
absorptive state, 573–74  
dietary sources of, 553  
digestion and absorption of, 553–54, 553f  
metabolism of, 78–86, 84f, 573–74

**carbon dioxide**  
and acid-base balance, 520–24, 524t  
concentration, and arterial pressure, 417–18  
and hemoglobin, 468  
partial pressure of  
and gas exchange, 461–62, 462f  
and ventilation control, 475–76, 475f, 477f  
and ventilation during exercise, 477, 478f  
respiratory exchange of, 460–65, 461f  
total-blood, 471  
transport in blood, 470–71, 470f  
ventilation-perfusion inequality and, 479

**carbon dioxide-bicarbonate buffer**, 521

**carbonic acid**, 29

**carbonic anhydrase** (an-HYE-drase) enzyme that catalyzes the reaction  $CO_2 + H_2O \rightleftharpoons H_2CO_3$ , 74, 470–71

**carbon monoxide (CO)**; gas that binds to hemoglobin; decreases blood oxygen-carrying capacity and shifts oxygen-hemoglobin dissociation curve to the left; also acts as an intracellular messenger in neurons, 170, 466f, 469–70, 475

**carbon monoxide hypoxia**, 479

**carboxyl group** (kar-BOX-il) —COOH; ionizes to carboxyl ion ( $-COO^-$ ), 26

**carboxypeptidases** (kar-box-ee-PEP-tih-dase-is) enzymes secreted into small intestine by exocrine pancreas as precursor, procarboxypeptidase; break peptide bond at carboxyl end of protein, 550t, 554

**cardiac angiography**, 388

**cardiac cycle** one contraction-relaxation sequence of heart, 380–85, 381f–82f, 389f

**cardiac inotropic drugs**, 427t

**cardiac muscle** heart muscle, 3, 258, 258f, 293–95, 373  
cellular structure of, 293, 293f, 295t  
contraction of, 293–94, 375–85  
excitation-contraction coupling in, 293–94, 294f, 378–80  
refractory period of, 380, 380f

**cardiac muscle cells**, 2–3



**cardiac output (CO)** blood volume pumped by each ventricle per minute (not total output pumped by both ventricles), 385–88  
 exercise and, 421–24, 421*f*–22*f*, 423*t*, 424*f*  
 and heart failure, 426  
 and mean systemic arterial pressure, 411–14

**cardiogenic shock**, 420

**cardiomyopathy, hypertrophic**, 427

**cardiopulmonary resuscitation (CPR)**, 428

**cardiovascular system** heart, blood, and blood vessels  
 diseases of, 427–30  
 physiology of, 362–440

**carnitine**, 89

**carotid bodies** chemoreceptors near main branching of carotid artery; sensitive to blood O<sub>2</sub> and CO<sub>2</sub> content and H<sup>+</sup> concentration, 473–74, 473*f*

**carotid sinus** region of internal carotid artery just above main carotid branching; location of carotid baroreceptors, 414, 414*f*

**castration**, 620

**catabolism** (kuh-TAB-oh-lizm) cellular breakdown of organic molecules, 71  
 of carbohydrates, 78–84, 84*f*  
 of proteins, 87–88  
 of vitamins, 89

**catalyst** (KAT-ah-list) substance that accelerates chemical reactions but does not itself undergo any net chemical change during the reaction, 72

**cataract**, 216

**catatonia**, 245

**catch-up growth** a period of rapid growth during which a child attains his or her predicted height for a given age after a temporary period of slow growth due to illness or malnourishment, 349

**catecholamines** (kat-eh-COLE-ah-meenz) dopamine, epinephrine, and norepinephrine, all of which have similar chemical structures, 167, 167*f*, 180*f*, 181*t*, 323, 323*f*, 328–29

**catheter**, 702

**cations** (KAT-eye-onz) ions having net positive charge; *compare* anions, 23

**caveolae** (kav-ee-OH-lee) (singular, **caveola**) small invaginations of the plasma membrane that pinch off and form endocytotic vesicles that deliver their contents directly to the cytosol, 111

**C3b** a complement molecule that attaches phagocytes to microbes; also amplifies complement cascade, 661, 662*f*, 674–75, 674*f*

**cecum** (SEE-come) dilated pouch at beginning of large intestine into which the ileum, colon, and appendix open, 559, 560*f*

**celiac disease**, 556

**cell(s)** the functional units of living organisms; four broad classes include epithelial, connective, nervous, and muscle, 2–3  
 eukaryotic, 46  
 membranes of, 46–51 (*See also* plasma membrane)  
 microscopic observation of, 45–46, 45*f*, 46*f*  
 organelles of, 46, 51–56  
 prokaryotic, 46  
 structure of, 45–57, 45*f*, 47*f*  
 volume of, extracellularly osmolarity and, 108–9, 108*f*

**cell body** in cells with long extensions, the part that contains the nucleus, 137, 137*f*

**cell differentiation** process by which unspecialized cells acquire specialized structural and functional properties, 2–3, 2*f*

**cell division**, 2, 2*f*

**cell-mediated immune responses**, 666

**cell organelles** (or-guh-NELZ) membrane-bound compartments, nonmembranous particles, or filaments that perform specialized functions in cell, 46

**cell signaling**, 118–35  
 first messengers in, 123  
 pathways in, 122–31  
 receptors in, 119–22  
 second messengers in, 123

**cell signaling proteins**, 34*t*

**central chemoreceptors** receptors in brainstem medulla oblongata that respond to changes in H<sup>+</sup> concentration of brain extracellular fluid, 474–76, 474*t*

**central command fatigue** muscle fatigue due to failure of appropriate regions of cerebral cortex to excite motor neurons, 277

**central nervous system (CNS)**  
 brain and spinal cord, 137, 172–76, 172*f* (*See also* brain; spinal cord)  
 cells of, 137–43  
 growth and regeneration in, 141–42  
 pathways or tracts of, 172

**central sleep apnea**, 484–85

**central sulcus**, 197, 197*f*, 206*f*

**central thermoreceptors** temperature receptors in hypothalamus, spinal cord, abdominal organ, or other internal location, 594, 595*f*

**centrioles** (SEN-tree-oles) small cytoplasmic bodies, each having nine fused sets of microtubules; participate in nuclear and cell division, 47*f*, 55

**centrosome** region of cell cytoplasm in which microtubule formation and elongation occur, particularly during cell division, 55

**cephalic phase** (seh-FAL-ik) (of gastrointestinal control) initiation of the neural and hormonal reflexes regulating gastrointestinal functions by stimulation of receptors in head, that is, cephalic receptors—sight, smell, taste, and chewing—as well as by emotional states, 537, 544*f*, 544*t*

**cerebellar disease**, 311

**cerebellum** (ser-ah-BEL-um) brain subdivision lying behind forebrain and above brainstem; plays important role in skeletal muscle control  
 development of, 172, 173*f*  
 movement control, 173*t*, 175  
 in movement control, 303, 303*f*, 311

**cerebral cortex** (SER-ah-brul or sah-REE-brul) cellular layer covering the cerebrum, 173, 174–75, 174*f*  
 in emotion, 244  
 in movement control, 303, 303*f*, 308–12, 309*f*–10*f*

**cerebral hemispheres** left and right halves of the cerebral cortex, 173, 174*f*, 250–51, 250*f*–51*f*

**cerebral ventricles** four interconnected spaces in the brain; filled with cerebrospinal fluid, 172, 174*f*, 183*f*

**cerebrospinal fluid (CSF)** (sah-ree-broh-SPY-nal) fluid that fills cerebral ventricles and the subarachnoid space surrounding brain and spinal cord, 181, 183, 183*f*

**cerebrum** (SER-ah-brum or sah-REE-brum) part of the brain that, with diencephalon forms the forebrain, 172, 173*f*, 173*t*, 174*f*

**cervical nerves**, 176–77, 178*f*

**cervix** (SIR-vix) lower portion of uterus; cervical opening connects uterine and vaginal lumens, 623, 623*f*  
 anatomy of, 623, 624*f*  
 parturition and, 643–45, 644*f*, 645*f*

**cesarean section**, 643

**CF transmembrane conductance regulator (CFTR)** epithelial chloride channel; mutations in the *CFTR* gene can cause cystic fibrosis, 447, 449, 550*f*

**cGMP-dependent protein kinase** (KYE-nase) enzyme that is activated by cyclic GMP and then phosphorylates specific proteins, thereby altering their activity, 125

**cGMP phosphodiesterase** an enzyme in cells that converts cGMP into GMP, 210–11, 211*f*

**cGMP-phosphodiesterase type 5 (PDE5) inhibitors**, 618

**channel gating** process of opening and closing ion channels, 100, 100*f*

**chemical bonds**, 23–25, 24*f*, 26*f*

**chemical element** specific type of atom, 21–23, 21*t*, 23*t*

**chemical equilibrium** state when rates of forward and reverse components of a chemical reaction are equal, and no net change in reactant or product concentration occurs, 72–73

**chemical messengers** *See also specific types*  
 intracellular, 11–12, 12*f*  
 lipid-soluble, 122–23, 123*f*  
 receptor, 119–22  
 second, 123, 126–29, 130*t*  
 water-soluble, 123–26, 124*f*

**chemical reactions**, 71–77, 73*t*. *See also specific reactions*

**chemical senses**, 224–26

**chemical specificity**. *See* specificity

**chemical substances**  
 balance in body, 14, 14*f*  
 pool of, 14

**chemical synapse** (SIN-aps) synapse at which neurotransmitters released by one neuron diffuse across an extracellular gap to influence a second neuron's activity, 159–65. *See also* neurotransmitters

**chemiosmosis** the mechanism by which ATP is formed during oxidative phosphorylation; the movement of protons across mitochondrial inner membranes is coupled with ATP production, 82–83

**chemoattractants** any mediators that cause chemotaxis; also called *chemotaxins*, 660

**chemokines** any cytokines that function as chemoattractants, 659*t*, 660, 660*t*

**chemoreceptors** afferent neuron endings (or cells associated with them) sensitive to concentrations of specific chemicals, 191, 473–76, 473*f*, 474*t*

**chemotaxins** (kee-moh-TAX-inz). *See* chemoattractants

**chemotaxis** (kee-moh-TAX-iss) movement of cells, particularly phagocytes, in a specific direction in response to a chemical stimulus, 660, 663*f*

**chewing**, 539

**chief cells** gastric gland cells that secrete pepsinogen, precursor of pepsin, 541, 542*f*

**chloride ions, in resting membrane potential**, 144–49

**chlorpromazine**, 244

**cholecalciferol**, 354  
**cholecystectomy**, 564  
**cholecystokinin (CCK)** (koh-lee-sis-toh-KYE-nin) peptide hormone secreted by duodenum that regulates gastric motility and secretion, gallbladder contraction, and pancreatic enzyme secretion; possible satiety signal, 322*f*, 537, 550, 551*f*, 553  
**cholera**, 565  
**cholesterol** particular steroid molecule; precursor of steroid hormones and bile salts and a component of plasma membranes, 325*f*, 574*f*, 575–76, 575*f*  
 bile synthesis from, 551–53  
 in plasma membrane, 47–49, 49*f*  
 steroid synthesis from, 324, 326*f*, 611, 612*f*  
**cholesterol-lowering drugs**, 429  
**choline**, 89  
**cholinergic** (koh-lin-ER-jik) pertaining to acetylcholine; a compound that acts like acetylcholine or a neuron that contains acetylcholine, 166  
**cholinergic neurons**, 166  
**chondrocytes** (KON-droh-sites) cell types that form new cartilage, 348  
**chordae tendineae** (KORE-day TEN-den-ay) strong, fibrous cords that connect papillary muscles to the edges of atrioventricular valves; they prevent backward flow of blood during ventricular systole, 372, 373*f*  
**chorion** outermost fetal membrane derived from trophoblast cells; becomes part of the placenta, 638, 640*f*  
**chorionic villi** fingerlike projections of the trophoblast cells extending from the chorion into the endometrium of the uterus, 638, 640*f*  
**chorionic villus sampling**, 640  
**choroid** (KORE-oyd) pigmented layer of eye that lies next to retina, 206, 207*f*, 209–10  
**choroid plexus** highly vascular epithelial structure lining portions of cerebral ventricles; responsible for much of cerebrospinal fluid formation, 181, 183*f*  
**chromatin** (KROM-ih-tin) combination of DNA and nuclear proteins; principal component of chromosomes, 51, 52*t*  
**chromophore** retinal light-sensitive component of a photopigment, 210  
**chromosomes** strands of DNA formed from condensed chromatin, containing all the genes that code for the proteins found in the body, 51, 57–58, 605–7, 606*f*  
**chronic bronchitis**, 458  
**chronic inflammatory disease**, 685  
**chronic obstructive pulmonary disease (COPD)**, 458  
**chronotropic** factors that alter heart rate, 385  
**chylomicrons** (kye-loh-MYE-kronz) small droplets consisting of lipids and protein released from intestinal epithelial cells into the lacteals during fat absorption, 556, 556*f*, 574, 574*f*  
**chyme** (kyme) solution of partially digested food in stomach and intestinal lumens, 533  
**chymotrypsin** enzyme secreted by exocrine pancreas; breaks certain peptide bonds in proteins and polypeptides, 550*t*, 554  
**Cialis**, 398, 618  
**cilia** (SIL-ee-ah) hairlike projections from specialized epithelial cells that sweep back and

forth in a synchronized way to propel material along epithelial surface, 56  
**ciliary muscle** involved in movement and shape of the lens during accommodation, 206, 207*f*, 208, 208*f*  
**ciliopathies**, 56  
**cimetidine**, 562  
**circadian rhythm** (sir-KAY-dee-an) occurring in an approximately 24 h cycle, 13–14, 13*f*, 238, 593*f*  
**circular folds**, 547, 547*f*  
**circular muscle**, 536*f*, 546, 560  
**circulation**, 368–69, 368*f*–69*f*  
**circulatory system** (SIRK-you-la-tor-ee) the heart and system of vessels that deliver blood to all parts of the body, 5*t*, 363–71, 371*t*  
**citric acid cycle**. *See* Krebs cycle  
**clasp-knife phenomenon**, 313  
**classical complement pathway** antibody-dependent system for activating complement; begins with complement molecule C1, 662, 674–75, 674*f*  
**class I MHC proteins** form complexes with antigens on all cells except erythrocytes; required for T-cell recognition, 670, 670*t*, 676, 676*f*  
**class II MHC proteins** form complexes with antigens on surface of macrophages, B lymphocytes, and dendritic cells; required for T-cell recognition, 670, 670*t*, 673*f*, 676, 676*f*  
**clathrin** a cytosolic protein that binds to regions of the plasma membrane and helps initiate receptor-mediated endocytosis, 110  
**clathrin-coated pit** aggregation of ligand-bound receptors on a cell membrane that pinches off and is internalized into the cell, 110  
**clearance** volume of plasma from which a particular substance has been completely removed in a given time, 499–500, 500*f*  
**cleavage** mitotic cell division, 629*f*, 637  
**clitoris** (KLIT-or-iss) small body of erectile tissue in female external genitalia; homologous to penis, 624, 624*f*, 634  
**clonal deletion** destruction by apoptosis in the thymus of those T cells that have receptors capable of binding to self proteins, 672  
**clonal expansion** lymphocyte cell divisions initiated by binding of an antigen to a lymphocyte cell membrane receptor, 664  
**clonal inactivation** process occurring in the periphery (that is, not in the thymus) that causes potentially self-reacting T cells to become nonresponsive, 672  
**clone** one of a set of genetically identical molecules, cells, or organisms, 615–16, 616*f*  
**closed ion channels**, 100, 100*f*  
**Clostridium botulinum**, 165  
**Clostridium tetani**, 165, 316–317, 317*f*  
**clot** solid phase of blood formed from platelets, trapped blood cells, and a polymer of the protein fibrin, 432–33  
**clotting** phase transition of blood from a liquid cell suspension into a solid, gel-like mass, 432–35, 433*f*  
**clotting factors**, 432–34, 434*f*, 434*t*  
**cocaine**, 247  
**coccygeal nerves**, 176–77, 178*f*  
**cochlea** (KOK-lee-ah) inner ear; fluid-filled spiral-shaped compartment that contains cochlear duct, 218–20, 218*f*, 219*f*

**cochlear duct** (KOK-lee-er) fluid-filled membranous tube that extends length of inner ear, dividing it into compartments; contains organ of Corti, 218–20, 218*f*, 219*f*  
**cochlear implants**, 220  
**codeine**, 170  
**coding** process by which neural signals from sensory receptors are converted into action potentials in the CNS, 192–96  
**codon** (KOH-don) three-base sequence in mRNA that determines the position of a specific amino acid during protein synthesis or that designates the end of the coded sequence of a protein, 59, 59*f*  
**coenzyme** (koh-EN-zime) organic cofactor; generally serves as a carrier that transfers atoms or small molecular fragments from one reaction to another; is not consumed in the reaction and can be reused, 74  
**coenzyme A (CoA)**, 80–82, 81*f*, 86  
**cofactors** organic or inorganic substances that bind to a specific region of an enzyme and are necessary for the enzyme's activity, 74  
**cold acclimatization**, 596  
**cold intolerance**, 343  
**colipase** protein secreted by pancreas that binds lipase, bringing it in contact with lipid droplets in the small intestine, 555, 556*f*  
**collagen fibers** (KOLL-ah-jen) strong, fibrous proteins that function as extracellular structural elements in connective tissue, 4  
**collaterals** branches of a neuron axon, 138  
**collecting-duct system** portion of renal tubules between distal convoluted tubules and renal pelvis; comprises *cortical collecting duct* and *medullary collecting duct*, 491*f*, 493  
**colloid** (KOLL-oid) large molecule, mainly protein, to which capillaries are relatively impermeable; also, part of the inner structure of the thyroid gland, 339–41, 340*f*, 404  
**colon** (KOH-lun) a portion of the large intestine, specifically the part extending from cecum to rectum, 560, 560*f*  
**colonoscopy**, 562  
**colony-stimulating factors (CSFs)**, 367*t*  
**color blindness**, 214–15  
**color vision**, 214–15, 214*f*, 215*f*  
**colostrum** watery, protein-rich liquid secreted by mother's breasts for first 24 to 48 hours after delivery of baby, 646–47  
**coma**, 240  
**commissure** (KOM-ih-shur) bundle of axons linking right and left halves of the brain, 172  
**common bile duct** carries bile from gallbladder to small intestine, 549*f*  
**compartments**, body fluid, 4–5, 6*f*  
**compensatory endocytosis**, 111  
**competition** ability of similar molecules to combine with the same binding site or receptor, 69, 119–21, 121*f*, 121*t*  
**competitive antagonist**, 121–22  
**complement** (KOM-plih-ment) one of a group of plasma proteins that, upon activation, kills microbes directly and facilitates the inflammatory process, including phagocytosis, 660*t*, 661–62, 662*f*, 663*f*, 674–75, 674*f*  
**compliance** stretchability, 392  
 arterial, 392–93  
 lung, 453–56, 456*f*–57*f*  
**compound**, 23



**computed tomography (CT)**, 703, 703*f*  
**concentration** amount of solute per unit volume of solution, 28–29  
**concentric contraction** muscle activity that involves shortening of muscle length, 269  
**conceptus** collective term for the fertilized egg and everything derived from it, 637  
**concussion**, 253–54  
**conducting system** network of cardiac muscle fibers specialized to conduct electrical activity between different areas of heart, 373, 375–78, 375*f*  
**conducting zone** air passages that extend from top of trachea to beginning of respiratory bronchioles and have walls too thick for gas exchange between air and blood, 446*f*, 447  
**conduction** (heat) transfer of thermal energy during collisions of adjacent molecules, 593–94, 595–96  
**cones** members of one of two retinal receptor types for photic energy; give rise to color vision, 209–11, 214–15, 214*f*  
**conformation** three-dimensional shape of a molecule, 36–38  
**congenital** existing at birth; usually referring to a birth defect, 640  
**congenital adrenal hyperplasia (CAH)**, 325, 610, 612*f*  
**congenital hypothyroidism**, 342  
**connective tissue** one of the four major categories of tissues in the body; major component of extracellular matrices, cartilage, and bone, 2*f*, 3, 4  
**connective-tissue cells** cells specialized to form extracellular elements that connect, anchor, and support body structures, 2, 2*f*, 4  
**connexins**, 643  
**conscious experiences** things of which a person is aware; thoughts, feelings, perceptions, ideas, and reasoning during any state of consciousness, 235, 241–43, 242*f*  
**consciousness**, 234–43  
     altered states of, 245–48  
     brain death, 240–41, 241*t*  
     states of, 235–41, 237*f*, 239*f*  
**consolidation** process by which short-term memories are converted into long-term memories, 249  
**constipation**, 564  
**continuous positive airway pressure (CPAP)**, 484–85, 485*f*  
**contraceptives**, 647–48, 648*t*  
**contractility** (kon-trak-TIL-ity) force of heart contraction that is independent of sarcomere length, 386–87, 387*f*  
**contraction** operation of the force-generating process in a muscle  
     cardiac, 293–94  
     skeletal muscle, 262–75  
     smooth muscle, 288–93  
**contraction time** time between beginning of force development and peak twitch tension by the muscle, 270  
**contralateral** on the opposite side of the body, 307  
**convection** (kon-VEK-shun) process by which a fluid or gas next to a warm body is heated by conduction, moves away, and is replaced by colder fluid or gas that in turn follows the same cycle, 594

**convergence** (neuronal) many presynaptic neurons synapsing upon one postsynaptic neuron, 158, 158*f*  
**convulsions (seizures)**, 235–36, 236*f*, 706  
**cooperativity** interaction between functional binding sites in a multimeric protein, 70  
**COPD (chronic obstructive pulmonary disease)**, 458  
**core body temperature** temperature of inner body, 593  
**cornea** (KOR-nee-ah) transparent structure covering front of eye; forms part of eye's optical system and helps focus an object's image on retina, 206–9, 207*f*, 208*f*  
**coronary arteries** vessels delivering oxygenated blood to the muscular walls of the heart, 374  
**coronary artery bypass grafting**, 429  
**coronary artery disease**, 427–30, 428*f*  
**coronary balloon angioplasty**, 428*f*, 429  
**coronary blood flow** blood flow to heart muscle, 374  
**coronary stents**, 428*f*, 429  
**coronary thrombosis**, 429  
**corpus callosum** (KOR-pus kal-LOH-sum) wide band of axons connecting the two cerebral hemispheres; a brain commissure, 174, 174*f*  
**corpus luteum** (KOR-pus LOO-tee-um) ovarian structure formed from the follicle after ovulation; secretes estrogen and progesterone, 626, 626*f*, 627*f*, 641–42  
**cortical (nephron)** functional unit of the kidney contained in the renal cortex and with a small (or no) loop of Henle, 4, 490–93, 491*f*  
**cortical association areas** regions of cerebral cortex that receive input from various sensory types, memory stores, and so on, and perform further perceptual processing, 197*f*, 198, 242  
**cortical collecting duct** primary site of sodium ion reabsorption at the distal end of a nephron, 491*f*, 493  
**cortical reaction** release of factors by the ovum that hardens the zona pellucida, 636, 637*f*  
**corticobulbar pathway** (kor-tih-koh-BUL-bar) descending pathway having its neuron cell bodies in cerebral cortex; its axons pass without synapsing to region of brainstem motor neurons, 312  
**corticospinal pathways** descending pathways having their neuron cell bodies in cerebral cortex; their axons pass without synapsing to region of spinal motor neurons; also called *pyramidal tracts*; *compare* brainstem pathways, corticobulbar pathway, 311–12, 312*f*  
**corticotropin-releasing hormone (CRH)** (kor-tih-koh-TROH-pin) hypophysiotropic peptide hormone that stimulates ACTH (corticotropin) secretion by anterior pituitary gland, 336–38, 344*f*  
**cortisol** (KOR-tih-sol) main glucocorticoid steroid hormone secreted by adrenal cortex; regulates various aspects of organic metabolism, 322*f*, 325, 325*f*, 344–46, 344*f*  
     in growth and development, 351, 351*t*  
     imbalances of, 346–47  
     in organic metabolism, 583–84, 584*t*  
     in stress response, 344–46, 345*t*  
**costameres** clusters of structural proteins linking Z disks of sarcomeres to the sarcolemma of striated muscle cells, 283–84, 284*f*

**costimulus** nonspecific interactions between proteins on the surface of antigen-presenting cells and helper T cells; required for T-cell activation, 671  
**cotransmitter** chemical messenger released with a neurotransmitter from synapse or neuroeffector junction, 159  
**cotransport** form of secondary active transport in which net movement of actively transported substance and “downhill” movement of molecule supplying the energy are in the same direction, 104–5, 104*f*  
**cough reflex**, 478  
**countercurrent multiplier system** mechanism associated with loops of Henle that creates a region having high interstitial fluid osmolarity in renal medulla, 506–8, 507*f*  
**countertransport** form of secondary active transport in which net movement of actively transported molecule is in direction opposite “downhill” movement of molecule supplying the energy, 104–5, 104*f*  
**covalent bond** (koh-VAY-lent) chemical bond between two atoms in which each atom shares one of its electrons with the other, 23–25, 24*f*, 25*t*  
**covalent modulation** alteration of a protein's shape, and therefore its function, by the covalent binding of various chemical groups to it, 70–71, 70*f*  
**C-peptide**, 324, 324*f*  
**cramps**, 283, 313  
**cranial nerves** 24 peripheral nerves (12 pairs) that join brainstem or forebrain with structures outside CNS, 176, 177*t*  
**craniotomy**, 707  
**C-reactive protein** an acute phase protein that functions as a nonspecific opsonin, 662  
**creatine phosphate (CP)** (KREE-ah-tin) molecule that transfers phosphate and energy to ADP to generate ATP, 275–76, 275*f*  
**creatinine** (kree-AT-ih-nin) waste product derived from muscle creatine, 489, 690  
**creatinine clearance ( $C_{Cr}$ )** plasma volume from which creatinine is removed by the kidneys per unit time; approximates glomerular filtration rate, 500  
**cristae** (mitochondrial) the inner membrane of mitochondria, which may assume sheetlike or tubular appearances; site containing cytochrome P450 enzymes involved in steroid hormone production, 53, 54*f*  
**Crohn's disease**, 568–69  
**cross-bridge(s)** in muscle, myosin projections extending from thick filaments and capable of exerting force on thin filaments, causing the filaments to slide past each other  
     in skeletal muscle contraction, 260, 260*f*, 262, 265–69, 265*f*–68*f*, 289*f*  
     in smooth muscle contraction, 288–91, 289*f*–90*f*  
**cross-bridge cycle** sequence of events between binding of a cross-bridge to actin, its release, and reattachment during muscle contraction, 267–69, 268*f*, 288–289  
**crossed-extensor reflex** increased activation of extensor muscles contralateral to limb flexion, 307–8, 308*f*  
**crossing-over** process in which segments of maternal and paternal chromosomes exchange with each other during chromosomal pairing in meiosis, 605, 606*f*

**cross-matching**, 682  
**cross-tolerance**, 247  
**cryptorchidism**, 607, 610  
**crystalloids** low-molecular-weight solutes in plasma, 404  
**cumulus oophorous** layers of granulosa cells that surround the egg within the dominant follicle, 625  
**cupula** a gelatinous mass within the semicircular canals that contains stereocilia and responds to head movement, 222, 222f, 223f  
**curare**, 264  
**current** movement of electrical charge; in biological systems, this is achieved by ion movement, 143  
**Cushing's disease**, 346–47  
**Cushing's phenomenon**, 418  
**Cushing's syndrome**, 346–47, 346f  
**cusp** a flap or “leaflet” of a heart valve, 372–73  
**cyclic AMP (cAMP)** cyclic 39,59-adenosine monophosphate; cyclic nucleotide that serves as a second messenger for many “first” chemical messengers, 126–28, 127f, 128f, 130t  
**cyclic endoperoxides** eicosanoids formed from arachidonic acid by cyclooxygenase, 130–31, 131f  
**cyclic GMP (cGMP)** cyclic 39,59-guanosine monophosphate; cyclic nucleotide that acts as second messenger in some cells, 125, 130t, 210–11, 211f  
**cyclooxygenase (COX)** (sy-e-klo-OX-ah-jen-ase) enzyme that acts on arachidonic acid and initiates production of cyclic endoperoxides, prostaglandins, and thromboxanes, 130, 131f, 437  
**cyclosporine**, 569, 681  
**cystic fibrosis (CF)**, 447, 549  
**cytochromes** (SYE-toe-kromz) enzymes that couple energy to ATP formation during oxidative phosphorylation, 82  
**cytokines** (SYE-toh-kinz) general term for protein extracellular messengers that regulate immune responses; secreted by macrophages, monocytes, lymphocytes, neutrophils, and several nonimmune cell types, 657–59, 659t, 660t  
**cytoplasm** (SYE-toh-plasm) region of cell interior outside the nucleus, 46, 47f  
**cytosine (C)** (SYE-toh-seen) pyrimidine base in DNA and RNA, 38–39, 38f, 39f, 57–58  
**cytoskeleton** cytoplasmic filamentous network associated with cell shape and movement, 55–56, 55f  
**cytosol** (SYE-toh-sol) intracellular fluid that surrounds cell organelles and nucleus, 46  
**cytotoxic hypersensitivity**, 682–83, 683t  
**cytotoxic T cells** (SYE-toh-TOX-ik) T lymphocytes that, upon activation by specific antigen, directly attack a cell bearing that type of antigen and destroy it; major killers of virus-infected and cancer cells, 658t, 666, 668f, 671, 671f, 676–77, 676f

## D

**Dalton's law** pressure exerted by each gas in a mixture of gases is independent of the pressure exerted by the other gases, 461  
**dantrolene**, 297  
**dark adaptation** process by which photoreceptors in the retina adjust to darkness, 211

**daytime somnolence**, 484  
**dead space**, 458, 459f  
**death, brain**, 240–41, 241t  
**decibel**, 220, 221t  
**declarative memory** memories of facts and events, 248–50, 249f  
**decremental** decreasing in amplitude, 150  
**deep brain stimulation**, 311  
**deep vein thrombosis**, 700  
**defecation** (def-ih-KAY-shun) expulsion of feces from rectum, 560–61  
**defecation reflex** urge to extrude feces caused by sudden distension of the walls of the rectum, 564  
**defense proteins**, 34t  
**defensins** (dee-FENS-ins) small peptides released by immune cells involved in destroying bacteria, fungi, and some viruses, 367  
**defibrillation**, 428  
**dehydration** type of chemical reaction in which two smaller molecules, such as amino acids, are joined to form a larger molecule; a single molecule of water is lost in the process, 27–28  
**dehydroepiandrosterone (DHEA)**, 325–26, 326f, 351, 611, 612f  
**delayed hypersensitivity**, 683, 683t  
**delta rhythm** slow-wave, high-amplitude EEG waves associated with the deepest stages of slow-wave sleep, 236, 237f  
**dendrites** (DEN-drites) highly branched extensions of neuron cell body; receive synaptic input from other neurons, 137, 137f  
**dendritic cells** immune cells with phagocytic and antigen-presenting properties, 656, 658t  
**dendritic spines** small protrusions from dendrites that receive synapses from axons, 137  
**denervation atrophy**, 280  
**dense bodies** cytoplasmic structures to which thin filaments of a smooth muscle fiber are anchored, 288, 288f  
**deoxyhemoglobin (Hb)** (dee-ox-see-HEE-mohgloh-bin) hemoglobin not combined with oxygen; reduced hemoglobin, 471  
**deoxyribonuclease**, 550t  
**deoxyribonucleic acid (DNA)** (dee-ox-see-rye boh-noo-KLAY-ik) nucleic acid that stores and transmits genetic information; consists of double strand of nucleotide subunits that contain deoxyribose, 38–39, 38f, 57–58  
 structure of, 38–39, 39f, 57–58  
 transcription from, 57–60, 57f, 59f, 60f, 62t, 63  
**deoxyribose** a ribose molecule with a single hydroxyl group removed; a component of DNA, 38  
**depolarized** membrane potential value changed toward zero so that cell interior becomes less negative than resting level, 149–53, 149f–53f, 159–60, 160f  
**depression/depressive disorder**, 246  
**descending colon**, 560, 560f  
**descending limb** (of Henle's loop) segment of renal tubule into which proximal tubule drains, 491f, 493  
**descending pathways** neural pathways that go from the brain down to the spinal cord, 302–3, 302f, 311–12, 312f  
**desensitization, receptor**, 164  
**desipramine**, 246  
**desmosomes** (DEZ-moh-sohmz) junctions that hold two cells together; consist of plasma

membranes of adjacent cells linked by fibers, yet separated by a 20 nm extracellular space filled with a cementing substance, 49–51, 50f  
**detrusor muscle** (duh-TRUSS-or) the smooth muscle that forms the wall of the urinary bladder, 500  
**diabetes insipidus**, 506  
**diabetes mellitus**, 599–601  
 renal function in, 498, 525–27  
 type 1, 599–600, 600f, 684  
 type 2, 331, 599–601  
**diabetic ketoacidosis**, 599, 600f  
**diabetic nephropathy**, 498, 525–27  
**diacylglycerol (DAG)** (dye-ace-ul-GLIS-er-ol) second messenger that activates protein kinase C, which then phosphorylates a large number of other proteins, 128, 129f, 130t  
**dialysis**, 526–27, 527f  
**diapedesis** (dye-app-uh-DEE-suhs) passage of leukocytes out of the blood and into the surrounding tissue, 660  
**diaphragm** (DYE-ah-fram) dome-shaped skeletal muscle sheet that separates the abdominal and thoracic cavities; principal muscle of respiration, 446f, 449, 453–55, 455f, 539f  
**diarrhea**, 565, 568–69  
**diastole** (dye-ASS-toh-lee) period of cardiac cycle when ventricles are relaxing, 380–84, 381f–82f  
**diastolic dysfunction**, 426  
**diastolic pressure (DP)** (dye-ah-STAL-ik) minimum blood pressure during cardiac cycle, 392–93, 394f  
**diazepam**, 169, 239  
**dicotic notch** deflection of the arterial pressure wave associated with closing of the semilunar valve, 382f, 383  
**diencephalon** (dye-en-SEF-ah-lon) core of anterior part of brain; lies beneath cerebral hemispheres and contains *thalamus* and *hypothalamus*, 172, 173f, 173t, 174f, 175  
**dietary fiber** nondigestible carbohydrates consumed in food, 553  
**dietary recommendations**, 592, 592t  
**diet-induced thermogenesis** the creation of heat within the body following a meal, particularly one rich in protein; at least part of the heat is generated secondarily to the increased activity of the gastrointestinal tract, 588  
**diffuse interstitial fibrosis**, 464  
**diffusion**, 96–100, 97f, 98f, 105t  
 capillary, 402–3, 403f  
 facilitated, 101–2  
 gases in liquid, 461–62  
 simple, 96, 96f  
 tubular reabsorption by, 497–98  
**diffusion equilibrium** state during which diffusion fluxes in opposite directions are equal; that is, the net flux equals zero, 96  
**diffusion impairment**, 479t  
**digestion** process of breaking down large particles and high-molecular-weight substances into small molecules, 532–33, 533f, 534f, 535t, 553–58, 553f–57f  
**digestive system** the gastrointestinal tract and its accessory organs, 5t, 531–69  
 anatomy of, 532–33, 532f  
 functions of, 531, 532–33, 535t (*See also* digestion)  
 pathophysiology of, 561–65  
 regulation of, 536–38, 537f

**digitalis**, 427*t*

**dihydropyridine (DHP) receptor** (dye-hydro-PEER-a-deen) nonconducting calcium channels in the T-tubule membranes of skeletal muscle cells, which act as voltage sensors in excitation-contraction coupling, 267, 607

**dihydrotestosterone (DHT)** (dye-hy-droh-tes-TOS-ter-own) steroid formed by enzyme-mediated alteration of testosterone; active form of testosterone in certain of its target cells, 605, 620

**1,25-dihydroxyvitamin D [1,25-(OH)<sub>2</sub>D]**

(1-25-dye-hy-DROX-ee-vie-tah-min DEE) hormone that is formed by kidneys and is the active form of vitamin D, 322*f*, 354–55, 355*f*, 489

**diiodotyrosine (DIT)** a doubly iodinated tyrosine molecule that is an intermediate in the formation of thyroid hormones, 340*f*, 341

**Dilantin**, 709

**2,3-diphosphoglycerate (DPG)** (2-3-dye-fos-foh-GLISS-er-ate) substance produced by erythrocytes during glycolysis; binds reversibly to hemoglobin, causing it to release oxygen, 468, 469*f*, 480*t*

**diplopia**, 695

**disaccharides** (dye-SAK-er-eyedz) carbohydrate molecules composed of two monosaccharides, 31, 31*f*

**discs** layers of membranes in outer segment of photoreceptor; contain photopigments, 209

**distal convoluted tubule** portion of kidney tubule between loop of Henle and collecting-duct system, 491*f*, 493

**disulfide bonds** R—S—S—R bonds in a protein, 36

**disuse atrophy**, 280

**diuresis** (dye-uh-REE-sis) increased urine excretion, 506

**diuretics**, 425, 425*t*, 427*t*, 517–18

**divergence** (dye-VER-gence) (neuronal) one presynaptic neuron synapsing upon many postsynaptic, 158, 158*f*

**dizziness**, 229–30

**DNA**. *See* deoxyribonucleic acid

**dominant follicle** most mature developing follicle in the ovary from which the mature egg is ovulated, 625

**dopamine (DA)** (DOPE-ah-meen) biogenic amine (catecholamine) neurotransmitter and hormone; precursor of epinephrine and norepinephrine, 167, 167*f*, 323, 323*f*, 646  
in motivation, 243–44  
in Parkinson's disease, 311  
in prolactin regulation, 337  
in substance use/dependence, 247

**dorsal column pathway** ascending pathway for somatosensory information; runs through dorsal area of spinal white matter, 204, 205*f*

**dorsal horns** regions of gray matter in the spinal cord that receive sensory input and connect with motor neurons in ventral horn, 176, 176*f*

**dorsal respiratory group (DRG)** neurons in the medullary respiratory center that fire during inspiration, 472–73, 472*f*

**dorsal root ganglia** groups of sensory neuron cell bodies that have axons projecting to the dorsal horn of the spinal cord, 176, 176*f*, 178*f*

**dorsal roots** groups of afferent neurons that enter dorsal region of spinal cord, 176, 176*f*

**double helix of DNA**, 38–39, 39*f*, 57–58

**down-regulation** decrease in number of target-cell receptors for a given messenger in response to a chronic high concentration of that messenger; *compare* up-regulation, 121*t*, 122, 164, 328

**Down syndrome**, 640

**doxepin**, 246

**dromotropic** factors that change the speed of electrical conduction in the AV node of the heart, 385

**drug abuse (substance dependence)**, 247, 248*t*

**dual innervation** (in-ner-VAY-shun) innervation of an organ or gland by both sympathetic and parasympathetic neurons, 181

**Duchenne muscular dystrophy**, 284, 284*f*

**duodenal ulcers**, 561–62, 563*f*

**duodenum** (doo-oh-DEE-num or doo-ODD-en-um) first portion of small intestine (between stomach and jejunum), 533, 546, 548, 549*f*, 553

**dup sound of heart**, 384

**dura mater** thick, outermost membrane (meninges) covering the brain, 181, 183*f*

**dynamic constancy** a way of describing homeostasis that includes the idea that a variable such as blood glucose may vary in the short term but is stable and predictable when averaged over the long term, 7

**dyneins** (DYE-neenz) motor proteins that use the energy from ATP to transport attached cellular cargo molecules along microtubules, 138, 139*f*

**dynorphins** (dye-NOR-finz) endogenous opioid peptides that act as neuromodulators in the brain, 170

**dysmenorrhea**, 631

**dyspnea**, 479, 690

**dystrophin** protein in muscle cells that links actin to proteins embedded in sarcolemma; stabilizes muscle cells during contractions, 284

## E

**ear(s)**

anatomy of, 218*f*  
auditory function of, 216–21  
sound transmission in, 217–20  
vestibular function of, 221–24

**eating disorders**, 592, 633

**eccentric contraction** muscle activity that is accompanied by lengthening of the muscle generally by an external load that exceeds muscle force, 269, 281

**ECG (electrocardiogram)**, 378, 378*f*–80*f*, 379*t*

**ECG leads** combinations of a reference electrode (designated negative) and a recording electrode (designated positive); each combination is placed on the surface of the body and provides a “view” of the electrical activity of the heart, 378, 379*f*, 379*t*

**echocardiography**, 388

**eclampsia**, 642–43

**ectopic pacemakers**, 378

**ectopic pregnancies**, 637

**eczema** persistent inflammatory skin condition resulting in swelling and itching, 204

**edema**, 405–6

**edema, pulmonary**, 426–27, 464, 480, 704

**EEG**, 235–37, 236*f*–37*f*

**EEG arousal** transformation of EEG pattern from alpha to beta rhythm during increased levels of attention, 236

**effector** (ee-FECK-tor) cell or cell collection whose change in activity constitutes the response in a control system, 10, 10*f*, 11*f*

**efferent arteriole** renal vessel that conveys blood from glomerulus to peritubular capillaries, 490, 491*f*, 493, 494*f*

**efferent division (of the peripheral nervous system)** neurons in the peripheral nervous system that project out of the central nervous system, 172*f*, 176

**efferent neurons** neurons that carry information away from CNS, 138–39, 140*f*, 140*t*

**efferent pathway** component of reflex arc that transmits information from integrating center to effector, 10–11, 10*f*, 11*f*

**egg** female germ cell at any of its stages of development, 623

**egg transport**, 636

**eicosanoids** (eye-KOH-sah-noidz) general term for modified fatty acids that are products of arachidonic acid metabolism (cyclic endoperoxides, prostaglandins, thromboxanes, and leukotrienes); function as paracrine or autocrine substances, 32, 129–31, 131*f*, 660*t*

**ejaculation** (ee-jak-you-LAY-shun) discharge of semen from penis, 617, 618–19, 636

**ejaculatory ducts** (ee-JAK-you-lah-tory) continuation of vas deferens after it is joined by seminal vesicle duct; join urethra in prostate gland, 615, 615*f*

**ejection fraction (EF)** the ratio of stroke volume to end-diastolic volume;  $EF = SV/EDV$ , 387

**elastase**, 550*t*

**elastic recoil** tendency of an elastic structure to oppose stretching or distortion, 451–52

**elastin fibers** proteins with elastic or springlike properties; found in large arteries and in the airways, 4

**Elavil (amitriptyline)**, 246

**electrical potential (*E*)** (or electrical potential difference). *See* potential

**electrical synapses** (SIN-aps-ez) synapses at which local currents resulting from electrical activity flow between two neurons through gap junctions joining them, 158–59, 159*f*

**electricity, basic principles of**, 143–44, 144*f*

**electrocardiogram (ECG, also abbreviated EKG)** (ee-lek-troh-KARD-ee-oh-gram) recording at skin surface of the electrical currents generated by cardiac muscle action potentials, 378, 378*f*–80*f*, 379*t*

**electrochemical gradient** the driving force across a plasma membrane that dictates whether an ion will move into or out of a cell; established by both the concentration difference and the electrical charge difference between the cytosolic and extracellular surfaces of the membrane, 99, 102, 103–5, 104*f*, 151–53

**electroconvulsive therapy (ECT)**, 246

**electroencephalogram (EEG)** (eh-lek-troh-en-SEF-ah-loh-gram) recording of brain electrical activity from scalp, 235–37, 236*f*–37*f*

**electrogenic pump** (elec-troh-JEN-ik) active-transport system that directly separates electrical charge, thereby producing a potential difference, 148

**electrolytes** (ee-LEK-troh-lites) substances that dissociate into ions when in aqueous solution, 23

**electromagnetic spectrum**, 205, 206*f*



**electron(s)** (ee-LEK-tronz) subatomic particles, each of which carries one unit of negative charge, 21–22, 21*f*  
 sharing of (covalent bonding), 23–25, 24*f*  
 transfer of (ionic bonding), 25, 25*f*  
**electronegativity** measure of an atom's ability to attract electrons in a covalent bond, 24  
**electron microscopy**, of cells, 45–46, 45*f*, 46*f*  
**electron-transport chain** a series of metal-containing proteins within mitochondria that participate in the flow of electrons from proteins to molecular oxygen; they are key components of the energy-producing processes in all cells, 82–83, 83*f*  
**element**. *See* chemical element  
**elephantiasis**, 408, 409*f*  
**elimination** removal of certain metabolic waste products from the body via the digestive system, 534, 534*f*  
**embolism**, 430, 479, 699–702, 700*f*  
**embolus**, 430  
**embryo** (EM-bree-oh) organism during early stages of development; in human beings, the first 2 months of intrauterine life, 638  
**emesis (vomiting)**, 562  
**emetics**, 562  
**emission** (ee-MISH-un) movement of male genital duct contents into urethra prior to ejaculation, 619  
**emotion**, 244–45, 245*f*  
**emotional behavior** outward expression and display of inner emotions, 244  
**emphysema**, 479–80  
**emulsification** (eh-mul-suh-fah-KAY-shun) division of large lipid droplets into very small droplets that are prevented from coalescing through the action of amphipathic substances, 555–56, 555*f*  
**end-diastolic volume (EDV)** (dye-ah-STAH-lik) amount of blood in ventricle just prior to systole, 382*f*, 383, 386–87, 387*f*  
**endocannabinoids** a class of lipid neurotransmitter derived from membrane phospholipids, 170  
**endocrine glands** (EN-doh-krin) group of epithelial cells that secrete into the extracellular space hormones that then diffuse into bloodstream; also called *ductless glands*, 321–23, 321*f*  
**endocrine system** all the body's hormone-secreting glands, 5*t*, 321–59  
 components and hormones of, 321, 321*f*–22*f*  
 disorders of, 330–31  
 reproductive control by, 611–13  
 stress response of, 344–47  
**endocytosis** (en-doh-sye-TOH-sis) process in which plasma membrane folds into the cell forming small pockets that pinch off to produce intracellular, membrane-bound vesicles, 109–11, 109*f*–10*f*. *See also* phagocytosis  
**endogenous opioids** (en-DAHJ-en-us OH-peeoidz) certain neuropeptides—endorphin, dynorphin, and enkephalin, 170, 203, 204*f*  
**endogenous pyrogen (EP)** (en-DAHJ-en-us PY-roh-jen) any of the cytokines (including interleukin 1 and interleukin 6) that act physiologically in the brain to cause fever, 596–97  
**endolymph** extracellular fluid found in the cochlea and vestibular apparatus, 218, 221

**endometrium** (en-doh-MEE-tree-um) glandular epithelium lining uterine cavity, 631–32, 631*f*  
**endoperoxides**, 130–31, 131*f*  
**endoplasmic reticulum** (en-doh-PLAS-mik reh-TIK-you-lum) cell organelle that consists of interconnected network of membrane-bound branched tubules and flattened sacs; two types are distinguished: rough, with ribosomes attached, and smooth, which is smooth-surfaced (does not contain ribosomes), 47*f*, 51–52, 53*f*, 64–65, 65*f*  
**endoscopy**, 562, 563*f*  
**endosomes** (EN-doh-sohmz) intracellular vesicles that transport molecules between Golgi apparatus, lysosomes, and plasma membrane, 47*f*, 52  
**endothelial cells**. *See* endothelium  
**endothelin-1 (ET-1)** (en-doh-THÉE-lin) one member of a family of peptides secreted by many tissues that can act as a paracrine or hormonal signal; one major action is vasoconstriction, 399  
**endothelium** (en-doh-THÉE-lee-um) thin layer of cells that lines heart cavities and blood vessels, 372, 390–91, 392*t*, 399  
 anticlotting roles of, 436, 436*t*  
**endothelium-derived relaxing factor (EDRF)** nitric oxide secreted by vascular endothelium, it relaxes vascular smooth muscle and causes arteriolar dilation, 399  
**endotherms** animals that generate their own internal body heat without having to rely on the environment, 593  
**end-plate potential (EPP)** depolarization of motor end plate of skeletal muscle fiber in response to acetylcholine; initiates action potential in muscle plasma membrane, 263  
**end-product inhibition** inhibition of a metabolic pathway by final product's action upon allosteric site on an enzyme (usually the rate-limiting enzyme) in the pathway, 76, 76*f*  
**end-systolic volume (ESV)** (sis-TAH-lik) amount of blood remaining in ventricle after ejection, 382*f*, 383  
**energy expenditure**, 587–92  
 general principles of, 587–89  
 muscle activity and, 588, 588*f*  
 total, 587  
**energy homeostasis**, in exercise and stress, 584–85, 585*f*  
**energy stores**, total-body, 589  
**energy transfer**  
 in glycolysis, 78–80, 79*f*, 80*f*  
 in Krebs cycle, 78, 80–82, 80*f*, 81*f*, 82*t*  
 in metabolic pathways, 77–90  
 in oxidative phosphorylation, 78, 82–84, 83*f*, 84*f*, 84*t*  
**enkephalins** (en-KEF-ah-linz) peptide neurotransmitters at some synapses activated by opiate drugs; endogenous opioids, 170  
**enteric nervous system** (en-TAIR-ik) neural network residing in and innervating walls of gastrointestinal tract, 177, 536–37  
**enterochromaffin-like (ECL) cells** histamine-secreting cells of the stomach, 542, 542*f*  
**enteroendocrine cell** cell located in the gastric gland in the stomach and in the wall of the small intestine; these cells secrete hormones that control digestion and related processes, 535  
**enterogastric reflex**, 546, 546*f*

**enterogastrones** (en-ter-oh-GAS-trones) collective term for hormones released by intestinal tract; inhibit stomach activity, 544  
**enterohepatic circulation** (en-ter-oh-hih-PAT-ik) reabsorption of bile salts (and other substances) from intestines, passage to liver (via hepatic portal vein), and secretion back to intestines (via bile), 551, 552*f*  
**enterokinase** (en-ter-oh-KYE-nase) enzyme in luminal plasma membrane of intestinal epithelial cells; converts pancreatic trypsinogen to trypsin, 549, 550*f*  
**entrainment** (en-TRAIN-ment) adjusting biological rhythm to environmental cues, 13  
**enzyme(s)** (EN-zymz) protein catalysts that accelerate specific chemical reactions but do not themselves undergo net chemical change during the reaction, 8, 8*f*, 34*t*, 73–77, 74*f*–76*f*  
**enzyme activity** rate at which enzyme converts reactant to product; may be measure of the properties of enzyme's active site as altered by allosteric or covalent modulation; affects rate of enzyme-mediated reaction, 75–76, 75*f*  
**eosinophils** (ee-oh-SIN-oh-filz) polymorphonuclear granulocytic leukocytes whose granules take up red dye eosin; involved in parasite destruction and allergic responses, 364*f*, 367, 656, 658*t*  
**ependymal cells** (ep-END-ih-mel) types of glial cells that line internal cavities of the brain and produce cerebrospinal fluid, 141, 141*f*  
**epicardium** (epp-ee-KAR-dee-um) layer of connective tissue closely affixed to outer surface of the heart, 372, 373*f*  
**epididymis** (ep-ih-DID-ih-mus) portion of male reproductive duct system located between seminiferous tubules and vas deferens, 614, 615*f*  
**epidural hematoma**, 254, 254*f*  
**epigenetics (epigenetic programming)** heritable modification of gene expression without an alteration of the genetic code, 611  
**epiglottis** (ep-ih-GLOT-iss) thin cartilage flap that folds down, covering trachea, during swallowing, 540, 540*f*  
**epileptic seizure**, 235–36, 236*f*, 706–9  
**epinephrine** (ep-ih-NEF-rin) amine hormone secreted by adrenal medulla and involved in regulation of organic metabolism; a biogenic amine (catecholamine) neurotransmitter; also called *adrenaline*, 167, 167*f*, 180*f*, 181*t*, 322*f*, 323, 323*f*  
 blood flow control by, 398, 398*f*, 399*f*  
 metabolic effects of, 583, 584*t*, 588  
 stress response of, 347, 347*t*  
**epiphyseal closure** (ep-ih-FIZ-ee-al) conversion of epiphyseal growth plate to bone, 348  
**epiphyseal growth plate** actively proliferating cartilage near bone ends; region of bone growth, 348, 348*f*  
**epiphyses** (eh-PIF-ih-sis) ends of long bone, 348, 348*f*  
**epithalamus** a small portion of the dorsal posterior diencephalon containing the pineal gland, 175  
**epithelial cells** (ep-ih-THÉE-lee-al) cells at surface of body or hollow organ; specialized to secrete or absorb ions and organic molecules; with other epithelial cells form an epithelium, 2, 2*f*, 3–4, 3*f*

**epithelial tissue** one of the four major tissue types in the body, comprised of aggregates of epithelial cells, 2*f*, 3–4, 3*f*

**epithelial transport**, 111–13, 111*f*–13*f*

**epithelium** (ep-ih-THEE-lee-um) tissue that covers all body surfaces, lines all body cavities, and forms most glands, 2*f*, 3–4, 3*f*

**epitopes** (EP-ih-tope) antigenic portions of a molecule complexed to the MHC protein and presented to the T cell; also called *antigenic determinants*, 670

**eplerenone**, 512, 518

**Epley maneuver**, 230, 230*f*

**equilibrium** (ee-quah-LIB-ree-um) no net change occurs in a system; requires no energy, 7

**equilibrium potential** voltage gradient across a membrane that is equal in force but opposite in direction to concentration force affecting a given ion species, 146–47, 149*t*

**erectile dysfunction**, 618

**erection** penis or clitoris becoming stiff due to vascular congestion, 618, 618*f*

**ergocalciferol**, 354

**erythrocytes** (eh-RITH-roh-sites) red blood cells, 363, 364*f*–65*f*, 365–66

**erythromycin**, 681

**erythropoiesis** (eh-rith-roh-poy-EE-sis) erythrocyte production, 366

**erythropoietin** (eh-rith-roh-POY-ih-tin) peptide hormone secreted mainly by kidney cells; stimulates red blood cell production; one of the hematopoietic growth factors, 322*f*, 366, 366*f*, 367, 367*t*, 480*t*, 489

**escitalopram**, 246

**Eskalith (lithium)**, 246–47

**esophageal sphincters**, 540–41, 540*f*, 541*f*

**esophagus** (eh-SOF-uh-gus) portion of digestive tract that connects throat (pharynx) and stomach, 446, 532, 532*f*, 538–41, 539*f*, 540*f*, 561*t*

**essential amino acids** amino acids that cannot be formed by the body at all (or at a rate adequate to meet metabolic requirements) and so must be obtained from diet, 88, 89

**essential nutrients** substances required for normal or optimal body function but synthesized by the body either not at all or in amounts inadequate to prevent disease, 89–90, 90*t*

**estradiol** (es-tra-DYE-ol) steroid hormone of estrogen family; major female sex hormone, 322*f*, 325–26, 325*f*, 326*f*, 605, 612, 612*f*, 620, 627

**estriol** (ES-tree-ol) estrogen present in pregnancy; produced primarily by the placenta, 611

**estrogen(s)** (ES-troh-jenz) steroid hormones that have effects similar to estradiol on female reproductive tract, 322*f*, 325–26, 605, 611–12, 612*f*  
effects of, 632, 633*t*  
in growth and development, 351, 351*t*  
in menstrual cycle, 627–33, 627*f*, 628*t*, 629*f*, 632*t*  
in pregnancy, 641–42, 641*f*

**estrogen priming** increase in responsiveness to progesterone caused by prior exposure to estrogen (e.g., in the uterus), 632

**estrone** estrogen that is less prominent than estradiol, 611, 612*f*, 627

**eukaryotic cells** cells containing a membrane-enclosed nucleus with genetic material; plant and animal cells, 46

**eustachian tube** (yoo-STAY-shee-an) duct connecting the middle ear with the nasopharynx, 217, 218*f*

**evaporation** the loss of body water by perspiration, resulting in cooling, 594, 596

**excitability** ability to produce electrical signals, 149

**excitable membranes** membranes capable of producing action potentials, 149

**excitation-contraction coupling** in muscle fibers, mechanism linking plasma membrane stimulation with cross-bridge force generation, 265–66  
in cardiac muscle, 293–94, 294*f*, 378–80  
in skeletal muscle, 265–67, 265*f*–66*f*  
in smooth muscle, 290

**excitatory amino acids** amino acids that act as excitatory (depolarizing) neurotransmitters in the nervous system, 168–169

**excitatory postsynaptic potential (EPSP)** (post-sin-NAP-tic) depolarizing graded potential in postsynaptic neuron in response to activation of excitatory synapse, 161–63, 161*f*–62*f*

**excitatory synapse** (SIN-aps) synapse that, when activated, increases likelihood that postsynaptic neuron will undergo action potentials or increases frequency of existing action potentials, 158, 160–63, 163*f*

**excitotoxicity** (eggs-SYE-toe-tocks-ih-city) spreading damage to brain cells due to release of glutamate from ruptured neurons, 169

**exercise**  
cardiovascular effects of, 421–24, 421*f*–22*f*, 423*t*, 424*f*, 429  
energy homeostasis in, 584–85, 585*f*  
heat production in, 597, 597*f*  
metabolic effects of, 584–85, 585*f*, 588, 588*f*  
muscle adaptation in, 280–81  
ventilation during, 477, 478*f*

**exercise-associated hyponatremia (EAH)**, 114–15, 115*f*

**exercise-associated thermogenesis (EAT)** the increase in heat production in the body due to sports-like activities, 588

**exercise-induced amenorrhea**, 585

**exocrine gland** (EX-oh-krin) cluster of epithelial cells specialized for secretion and having ducts that lead to an epithelial surface, 321, 321*f*

**exocytosis** (ex-oh-sye-TOE-sis) process in which intracellular vesicle fuses with plasma membrane, the vesicle opens, and its contents are liberated into the extracellular fluid, 109, 109*f*, 111

**exons** (EX-onz) DNA gene regions containing code words for a part of the amino acid sequence of a protein, 59, 60*f*

**exophthalmos**, 695, 696*f*

**expiration** (ex-pur-AY-shun) movement of air out of lungs, 446, 453, 454*f*–55*f*

**expiratory reserve volume (ERV)** (ex-PYE-ruh-tor-ee) volume of air that can be exhaled by maximal contraction of expiratory muscles after normal resting expiration, 458, 459*f*

**explicit memory**, 248

**extension** straightening a joint, 281–82, 282*f*

**external anal sphincter** ring of skeletal muscle around lower end of rectum, 560

**external auditory canal** outer canal of the ear between the pinna and the tympanic membrane, 217, 218*f*

**external environment** environment surrounding external surface of an organism, 6–14

**external genitalia**  
ambiguous, 610–11  
differentiation of, 607–11, 609*f*  
female, 624, 624*f*

**external urethral sphincter** ring of skeletal muscle that surrounds the urethra at base of bladder, 500

**external work** movement of external objects by skeletal muscle contraction, 587

**extracellular fluid** fluid outside cell; interstitial composition of, 105*t*  
distribution of, 403–6, 403*f*, 405*f*  
fluid and plasma, 4  
movement between intracellular fluid and, 95–117 (*See also specific mechanisms*)  
osmolarity of, 108–9

**extracellular matrix** (MAY-trix) a complex consisting of a mixture of proteins (and, in some cases, minerals) interspersed with extracellular fluid, 4

**extrafusal fibers** primary muscle fibers in skeletal muscle, as opposed to modified (intrafusal) fibers in muscle spindle, 305, 305*f*, 306*f*, 307

**extrapyramidal system.** *See* brainstem pathways

**extrinsic controls**, of arteriolar blood flow, 397–98

**extrinsic pathway** formation of fibrin clots by pathway using tissue factor on cells in interstitium; once activated, it also recruits the intrinsic clotting pathway beyond factor XII, 434–35, 434*f*

**eye(s)**, 205–16  
anatomy of, 206–7, 207*f*  
common diseases of, 216  
movement of, 215–16, 215*f*

**eye muscles**, 215*f*, 216

## F

**facial nerve (cranial nerve VII)**, 177*t*

**facilitated diffusion** (fah-SIL-ih-tay-ted) system using a transporter to move molecules from high to low concentration across a membrane; energy not required, 101–2

**F-actin** the polymerized form of actin found in actin filaments, 55

**FAD** flavin adenine dinucleotide, a coenzyme derived from the B-vitamin riboflavin that participates in transfer of hydrogen atoms during metabolism, 74, 81–83

**fallopian tubes** tubes that carry eggs from ovary to uterus, 623, 623*f*, 624*f*, 636

**familial hypercholesterolemia**, 576

**familial renal glucosuria**, 499

**farsightedness**, 209, 209*f*

**fast fibers** skeletal muscle fibers that contain myosin having high ATPase activity, 277–78, 277*f*, 278*f*, 279*t*

**fast-glycolytic fibers** skeletal muscle fibers that have high intrinsic contraction speed and abundant capacity for production of ATP by anaerobic glycolysis, 277–78, 277*f*, 278*f*, 279*t*

**fasting hypoglycemia**, 584

**fast-oxidative-glycolytic fibers** skeletal muscle fibers that have high intrinsic contraction speed and abundant capacity for production of ATP

by aerobic oxidative phosphorylation, 277–78, 277f, 278f, 279t

**fat(s)**  
digestion and absorption of, 554–56, 555f–56f  
metabolism of, 86–87, 86f, 574–76  
utilization (glucose sparing), 578

**fat-soluble vitamins.** *See* vitamin(s)

**fatty acid** carbon chain with carboxyl group at one end through which chain can be linked to glycerol to form triglyceride, 31–34, 33f, 574–75. *See also* polyunsaturated fatty acid; saturated fatty acid; unsaturated fatty acids

**Fc** “stem” part of antibody, 668

**feces** (FEE-sees) material expelled from large intestine during defecation, 534, 560

**feedback**, 8–9  
hormonal, 337–38, 338f  
negative, 8, 8f, 10–11, 10f, 11f, 337–38, 338f  
positive, 8, 9f

**feedforward** aspect of some control systems that allows system to anticipate changes in a regulated variable, 9

**female external genitalia** mons pubis, labia majora, labia minora, clitoris, outer vagina, and its glands, 624, 624f

**female internal genitalia** (jen-ih-TALE-ee-ah) ovaries, uterine tubes, uterus, and vagina, 623, 624f

**female reproductive system**, 623–48  
aging and, 634  
anatomy of, 623–24, 624f  
physiology of, 624–48  
puberty in, 633–34

**female sexual response**, 634

**feminization**, 610

**ferritin** (FERR-ih-tin) iron-binding protein that stores iron in body, 365, 557

**fertilization** union of sperm and egg, 636–37, 637f, 638f

**fetal hemoglobin** oxygen-carrying molecule with high oxygen affinity, 469, 469f

**fetus** (FEE-tus) human being from third month of intrauterine life until birth, 638

**fever**, 8–9, 596–97, 597f, 677–78, 704

**fibers.** *See* muscle fiber

**fibrin** (FYE-brin) protein polymer resulting from enzymatic cleavage of fibrinogen; can turn blood into gel (clot), 432–33, 433f

**fibrinogen** (fye-BRIN-oh-jen) plasma protein precursor of fibrin, 364, 431, 432

**fibrinolytic system** (fye-brin-oh-LIT-ik) cascade of plasma enzymes that breaks down clots; also called *thrombolytic system*, 436, 436f

**Fick’s first law of diffusion** describes the rate of diffusion of a solute as a function of concentration gradient, area across which the solute diffuses, and other factors, 98

**fight-or-flight response** activation of sympathetic nervous system during stress, 181, 347

**filtered load** amount of any substance filtered from renal glomerular capillaries into Bowman’s capsule, 497

**fimbriae** (FIM-bree-ay) openings of the fallopian tubes; they have fingerlike projections lined with ciliated epithelium through which the ovulated eggs pass into the fallopian tubes, 623, 624f

**first messengers** extracellular chemical messengers such as hormones, 123, 124f

**first polar body** non-functional structure containing one of the two nuclei resulting from the first meiotic division of a primary oocyte in the ovary, 606, 606f

**5- $\alpha$ -reductase** intracellular enzyme that converts testosterone to dihydrotestosterone, 612f

**5- $\alpha$ -reductase inhibitors**, 611

**flaccid**, 313

**flatus** (FLAY-tus) intestinal gas expelled through anus, 560

**flexion** (FLEK-shun) bending a joint, 281–82, 282f

**flow autoregulation** ability of individual arterioles to alter their resistance in response to changing blood pressure so that relatively constant blood flow is maintained, 396f, 397

**fluid endocytosis** invagination of a plasma membrane by which a cell can engulf extracellular fluid, 109, 110f

**fluid-mosaic model** (moh-ZAY-ik) cell membrane structure consists of proteins embedded in bimolecular lipid that has the physical properties of a fluid, allowing membrane proteins to move laterally within it, 49, 49f

**fluoxetine**, 246

**flux** rate of flow of a substance (such as a solute in water) through a unit of surface area in a unit of time, 96–97, 98f. *See also* net flux

**folic acid** (FOH-lik) vitamin of B-complex group; essential for formation of nucleotide thiamine, 365–66

**follicles** (FOL-ih-kels) eggs and their encasing follicular, granulosa, and theca cells at all stages prior to ovulation; also called *ovarian follicles*, 625–27, 626f

**follicle-stimulating hormone (FSH)** glycoprotein hormone secreted by anterior pituitary gland in males and females that acts on gonads; a gonadotropin, 322f, 335–37, 335f, 337f–38f, 612–13, 613f  
in female physiology, 627–31, 627f, 641  
in male physiology, 619–20, 619f

**follicular phase** (fuh-LIK-you-lar) that portion of menstrual cycle during which follicle and egg develop to maturity prior to ovulation, 626, 626f, 627f, 627f–29f, 628–9

**food intake**, control of, 589–91, 590f

**forced expiratory volume in 1 sec (FEV1)**, 458

**forebrain** large, anterior brain subdivision consisting of right and left cerebral hemispheres (the cerebrum) and diencephalon, 172, 173–75, 173f, 173t

**formed elements** solid phase of blood, including cells (erythrocytes and leukocytes) and cell fragments (platelets), 363–67, 371t

**fovea centralis** (FOH-vee-ah) area near center of retina where cones are most concentrated; gives rise to most acute vision, 207, 207f, 215–16

**Frank-Starling mechanism** the relationship between stroke volume and end-diastolic volume such that stroke volume increases as end-diastolic volume increases; also called *Starling’s law of the heart*, 386–87, 426, 426f

**fraternal (dizygotic) twins** twins that occur when two eggs are fertilized, 626

**free radical** atom that has an unpaired electron in its outermost orbital; molecule containing such an atom, 26–27

**free ribosomes**, 47f, 51

**free-running rhythm** cyclical activity driven by biological clock in absence of environmental cues, 13

**frequency** number of times an event occurs per unit time  
sound, 216, 217f  
wavelength, 205, 206f

**frequency-tension relation**, 272–73, 272f

**frontal lobe** region of anterior cerebral cortex where motor areas, Broca’s speech center, and some association cortex are located, 173f, 174, 175f

**frontal lobe association area**, 197f

**fructose**, 573

**F-type channels (hyperpolarization-activated cyclic nucleotide-gated [HCN] channels)**, the “funny” sodium-conducting channels mainly responsible for the inward flow of positive current in autorhythmic cardiac cells, 377

**functional residual capacity (FRC)** lung volume after relaxed expiration, 458, 459f

**functional site** binding site on allosteric protein that, when activated, carries out protein’s physiological function; also called *active site*, 70, 70f

**functional units** small structures within an organ that act similarly to carry out an organ’s function; for example, nephrons are the functional units of the kidneys, 4

**fundus** upper portion of the stomach; secretes mucus, pepsinogen, and hydrochloric acid, 541, 541f

**furosemide**, 221, 518

**fused tetanus** (TET-ah-nuss) skeletal muscle activation in which action potential frequency is sufficiently high to cause a smooth, sustained, maximal strength contraction, 273, 273f

**fused-vesicle channels** endocytotic or exocytotic vesicles that have fused to form continuous water-filled channels through capillary endothelial cells, 400, 401f

## G

**GABA (gamma-aminobutyric acid)** an amino acid neurotransmitter commonly occurring at inhibitory synapses in the central nervous system, 169, 239

**G-actin** a monomer of actin that polymerizes to form F-actin, that makes up actin filaments, 55

**galactorrhea**, 651–52, 651f

**galactose**, 30f, 573

**gallbladder** small sac under the liver; concentrates bile and stores it between meals; contraction of gallbladder ejects bile, which eventually flows into small intestine, 532, 532f, 538t, 548, 553, 561t

**gallstones**, 562–63

**gametes** (GAM-eets) germ cells or reproductive cells; sperm in male and eggs in female, 605

**gametogenesis** (gah-mee-toh-JEN-ih-sis) gamete production, 605–7, 606f

**gamma globulin** immunoglobulin G (IgG), most abundant class of plasma antibodies, 674

**gamma motor neurons** small motor neurons that control intrafusal muscle fibers in muscle spindles, 305, 306f



**gamma rhythm** high-frequency (30–100 Hz) pattern detected on electroencephalogram associated with processing sensory inputs and other specific cognitive tasks, 236

**ganglion** (GANG-lee-on) (plural, *ganglia*) generally reserved for cluster of neuron cell bodies outside CNS, 172

**ganglion cells** retinal neurons that are postsynaptic to bipolar cells; axons of ganglion cells form optic nerves, 211–14, 212f–13f

**gap junction** protein channels linking cytosol of adjacent cells; allows ions and small molecules to flow between cytosols of the connected cells, 12, 50f, 51, 292, 292f

**gas(es)**  
flatus, 560  
as neurotransmitters, 165t, 170  
partial pressures of, 461–62, 466–67, 473–76

**gas exchange**, 460–65, 461f, 461f–62f, 463t

**gastric** (GAS-trik) pertaining to the stomach, 533

**gastric emptying**, 545–57

**gastric phase** (of gastrointestinal control) initiation of neural and hormonal gastrointestinal reflexes by stimulation of stomach wall, 537, 544f, 544t

**gastric ulcers**, 561–62, 563f

**gastrin** (GAS-trin) peptide hormone secreted by antral region of stomach; stimulates gastric acid secretion, 322f, 537, 538t, 542, 543f

**gastritis**, 562

**gastroesophageal reflux**, 541

**gastrointestinal hormones**, 322f, 537, 538t, 589–90

**gastrointestinal (GI) tract** mouth, pharynx, esophagus, stomach, small and large intestines, and anus  
anatomy of, 532–33, 532f  
digestion and absorption in, 547–59  
functions of, 532–33, 535t  
pathophysiology of, 561–65  
regulation of, 536–38, 537f  
wall structure of, 535, 536f

**gaze**, 215–16, 215f

**gene** unit of hereditary information; portion of DNA containing information required to determine a protein's amino acid sequence, 57

**gene expression**, 34t

**gene regulation**, 63, 63f

**genetic code**, 57–58, 58f

**genitalia**  
ambiguous, 610–11  
differentiation of, 607–11, 609f  
female, 624, 624f

**genome** complete set of an organism's genes, 57

**genotype** the set of alleles present in an individual; determines genetic sex (XX, female; XY, male), 607

**germ cells** cells that give rise to male or female gametes (sperm and eggs), 605

**gestation** (jess-TAY-shun) length of time of intrauterine fetal development (usually about 9 months in humans), 614

**GFR**. *See* glomerular filtration rate

**ghrelin** (GREH-lin) hormone released from cells of the stomach; stimulates hunger, 590–91

**gigantism**, 357–59, 357f

**glands**. *See* endocrine glands; exocrine gland

**glaucoma**, 216

**glial cells** (GLEE-al) nonneuronal cells in CNS; help regulate extracellular environment of CNS; also called *neuroglia*, 137, 140–41

**glioblastoma multiforme**, 706–9, 708f

**globin** (GLOH-bin) collective term for the four polypeptide chains of the hemoglobin molecule, 465, 466f

**globulins** (GLOB-you-linz) proteins found in blood plasma, 364

**glomerular capillaries** very small blood vessels within the glomerulus of the kidney through which plasma is filtered, 490, 491f, 492f

**glomerular filtrate** ultrafiltrate of plasma produced in the glomerulus that is usually free of cells and large proteins, 493

**glomerular filtration** process by which components of plasma in the glomerular capillary are passed to the Bowman's space of the glomerulus; process is governed by net glomerular filtration pressure, 492f, 493–95, 494f–95f

**glomerular filtration rate (GFR)** volume of fluid filtered from renal glomerular capillaries into Bowman's capsule per unit time, 496–97, 496f, 510–11, 510f

**glomerulus** (gloh-MER-you-lus) tuft of glomerular capillaries at beginning of kidney nephron, 490–93, 491f, 494f

**glossopharyngeal nerve (cranial nerve IX)**, 177t

**glottis** opening between vocal cords through which air passes, and surrounding area, 540, 540f

**glucagon-like peptide 1 (GLP-1)** an incretin hormone secreted by cells of the small intestine following a meal; enhances the insulin response to glucose, 578

**glucagon** (GLOO-kah-gahn) peptide hormone secreted by alpha cells of pancreatic islets of Langerhans; leads to rise in plasma glucose, 322f, 347, 582–83, 582f, 584t

**glucocorticoids** (gloo-koh-KOR-tih-koidz) steroid hormones produced by adrenal cortex and having major effects on nutrient metabolism and the body's response to stress, 325  
in postabsorptive state, 576–78

**gluconeogenesis** (gloo-koh-nee-oh-JEN-ih-sis) formation of glucose by the liver or kidneys from pyruvate, lactate, glycerol, or amino acids, 85–86, 85f, 578, 584t

**glucose** major monosaccharide in the body; a six-carbon sugar,  $C_6H_{12}O_6$ ; also called *blood sugar*, 30–31, 30f  
in absorptive state, 573–74  
blood concentrations of, 6–7, 6f, 584, 599–601  
in exercise and stress, 584–85, 585f  
filtration and reabsorption of, 498, 498f  
glucagon and, 583  
insulin and, 580–84  
metabolism of, 76, 78–80, 79f–80f, 83–84, 84f, 573–74  
storage of, 84–85  
synthesis of, 85–86, 85f

**glucose-counterregulatory controls** neural or hormonal factors that oppose insulin's actions; include glucagon, epinephrine, sympathetic nerves to liver and adipose tissue, cortisol, and growth hormone, 582, 584t

**glucose-dependent insulinotropic peptide (GIP)** intestinal hormone; stimulates insulin secretion in response to glucose and fat in small intestine, 537, 538t, 582

**glucose sparing** switch from glucose to fat utilization by most cells during postabsorptive state, 578

**glucose transporters**, 580–81

**glucosuria**, 498, 499

**glutamate** (GLU-tah-mate) anion formed from the amino acid glutamic acid; a major excitatory CNS neurotransmitter, 168–169

**gluten** a collective term for several proteins found in wheat and other foods; some individuals develop autoimmunity to these proteins, 556

**glycerol** (GLISS-er-ol) three-carbon carbohydrate; forms backbone of triglyceride, 32

**glycerol 3-phosphate** three-carbon molecule that combines with fatty acids to form triglyceride, 87, 574

**glycine** (GLYE-seen) an amino acid; a neurotransmitter at some inhibitory synapses in CNS, 169

**glycocalyx** (glye-koh-KAY-lix) fuzzy coating on extracellular surface of plasma membrane; consists of short, branched carbohydrate chains, 49

**glycogen** (GLYE-koh-jen) highly branched polysaccharide composed of glucose subunits; major carbohydrate storage form in body, 31, 32f, 84–85, 85f

**glycogenolysis** (glye-koh-jen-NOL-ih-sis) glycogen breakdown to glucose, 85, 577, 584t

**glycogen phosphorylase** intracellular enzyme required to begin the process of breaking down glycogen into glucose; inhibited by insulin, 581

**glycogen synthase** intracellular enzyme required to synthesize glycogen; stimulated by insulin, 581

**glycolysis** (glye-KOL-ih-sis) metabolic pathway that breaks down glucose to two molecules of pyruvate (aerobically) or two molecules of lactate (anaerobically), 78–80, 79f–80f, 83–84, 84f, 275f, 276

**glycolytic fibers** skeletal muscle fibers that have a high concentration of glycolytic enzymes and large glycogen stores; white muscle fibers, 277, 277f, 279t

**glycoproteins** proteins containing covalently linked carbohydrates, 36

**goblet cells**, 547, 547f

**goiter**, 341, 342, 342f, 696, 696f

**Goldman-Hodgkin-Katz (GHK) equation** calculation for membrane potential when a membrane is permeable to more than one ion, 147

**Golgi apparatus** (GOAL-gee) cell organelle consisting of flattened membranous sacs; usually near nucleus; processes newly synthesized proteins for secretion or distribution to other organelles, 47f, 52, 54f, 65, 65f

**Golgi tendon organs** tension-sensitive mechanoreceptor endings of afferent neuron; wrapped around collagen bundles in tendon, 200–201, 307, 307f

**gonad(s)** (GOH-nadz) gamete-and steroid-producing reproductive organs; testes in male and ovaries in female, 324, 605, 607, 608f

**gonadal steroids** hormones synthesized in the testes (testosterone) and ovaries (estrogen and progesterone), 325–26, 326f, 605, 627

**gonadotropic hormones**. *See* gonadotropins

**gonadotropin-releasing hormone (GnRH)** hypophysiotropic hormone that stimulates LH and FSH secretion by anterior pituitary gland in males and females, 337, 337f–38f, 612–13, 613f in female physiology, 633–34, 641 in male physiology, 619–20, 619f

**gonadotropins** glycoprotein hormones secreted by anterior pituitary gland (LH, FSH) and placenta (hCG) that influence gonadal function, 335–37, 335*f*, 337*f*–38*f* in female physiology, 627–31, 627*f* in male physiology, 619–20, 619*f*

**G protein(s)** proteins from a family of regulatory proteins that reversibly binds guanosine nucleotides; plasma membrane G proteins interact with membrane ion channels or enzymes, 125

**G-protein-coupled receptors** cell membrane proteins that bind an extracellular signal and then activate an associated G protein, leading to activation of another protein such as adenylyl cyclase, 125–26

**graafian follicle** (GRAF-ee-un) mature follicle just before ovulation, 625

**graded potentials** membrane potential changes of variable amplitude and duration that are conducted decrementally; have no threshold or refractory period, 149–50, 149*t*, 150*f*–51*f*, 157*t*, 190–91, 191*f*, 235–37

**graft rejection**, 681

**gram atomic mass** amount of element in grams equal to the numerical value of its atomic weight, 22–23

**granulocyte colony-stimulating factor** (G-CSF), 367

**granulosa cells** (gran-you-LOH-sah) cells that contribute to the layers surrounding egg and antrum in ovarian follicle; secrete estrogen, inhibin, and other messengers, 625, 626*f*, 628–30

**Graves' disease**, 343, 697–98

**gray matter** area of brain and spinal cord that appears gray in unstained specimens and consists mainly of cell bodies and unmyelinated portions of neurons, 173, 174*f*, 176, 176*f*

**growth and development**  
bone, 348, 348*f*  
catch-up, 349  
disorders of, 357–59  
endocrine control of, 342, 348–51, 351*t*  
periods of, 348, 349*f*

**growth cone** tip of developing axon, 141–42

**growth factors**, 349. *See also specific types*

**growth hormone (GH)** peptide hormone secreted by anterior pituitary gland; stimulates insulin-like growth factor 1 release through which it enhances body growth by stimulating protein synthesis, 322*f*, 335, 335*f*  
actions of, 349–51, 350*t*, 351*t*  
control of, 336–37, 337*f*–38*f*, 350, 350*f*  
imbalances of, 357–59, 357*f*  
metabolic effects of, 584, 584*t*  
stress response of, 347

**growth hormone insensitivity syndrome**, 349

**growth hormone-releasing hormone (GHRH)** hypothalamic peptide hormone that stimulates growth hormone secretion by anterior pituitary gland, 336–37, 337*f*–38*f*, 350, 350*t*

**growth plate**, 348, 348*f*

**guanine** (G) (GWAH-neen) purine base in DNA and RNA, 38–39, 38*f*, 39*f*, 57–58

**guanylyl cyclase** (GUAN-ah-lil) enzyme that catalyzes transformation of GTP to cyclic GMP, 125, 210–11, 211*f*

**gustation** (gus-TAY-shun) the sense of taste, 224–25

**gustatory cortex** (GUS-ta-to-ree) region of cerebral cortex receiving primary sensory inputs from the taste buds, 197, 197*f*

**gynecomastia**, 621, 621*f*

**gyrus** (JYE-rus) sinuous raised ridges on the outer surface of the cerebral cortex, 174, 174*f*

**H**

**HAART (highly active anti-retroviral therapy)**, 680

**habituation** (hab-bit-you-A-shun) reversible decrease in response strength upon repeatedly administered stimulation, 241

**hair cells** mechanoreceptor cells in organ of Corti and vestibular apparatus characterized by stereocilia on cell surface  
auditory, 220, 221*f*  
vestibular, 221–24, 223*f*

**harmful immune responses**, 681–85

**Hashimoto's disease**, 343

**head injury**, 253–54

**hearing**. *See* audition

**hearing aids**, 220

**heart** muscular pump that generates blood pressure and flow in the circulatory system, 371*t*, 372–89  
anatomy of, 372–74, 373*f*–74*f*  
automaticity of, 377–78  
circulation through, 368–69, 368*f*, 373–74, 374*f*  
conducting system of, 373, 375–78, 375*f*  
contraction of, 293–94, 375–85  
electrophysiology of, 378, 378*f*–80*f*, 379*t*  
endocrine function of, 322*f*, 399  
Frank-Starling mechanism of, 386–87, 426, 426*f*  
innervation of, 373–74, 374*f*  
refractory period of, 380, 380*f*  
sympathetic regulation of, 386–87, 387*f*, 388*f*, 388*t*

**heart attack**, 427–30

**heartburn**, 541

**heart disease**, 427–30

**heart failure**, 405, 425–27, 426*f*, 427*t*, 438–40, 439*f*–40*f*, 518

**heart murmurs**, 384–85, 384*f*

**heart palpitations**, 695–99

**heart rate** number of heart contractions per minute, 375, 385, 386*f*  
exercise and, 422–23, 423*t*, 424*f*

**heart sounds** noises that result from vibrations due to closure of atrioventricular valves (first heart sound) or pulmonary and aortic valves (second heart sound), 384–85

**heat acclimitization**, 596

**heat exhaustion**, 598

**heat intolerance**, 343

**heat loss or gain**  
control of, 594–96  
mechanisms of, 593–94

**heatstroke**, 17–18, 18*f*, 598

**heavy chains** pairs of large, coiled polypeptides that make up the rod and globular head of a myosin molecule, 260, 260*f*

**Helicobacter pylori**, 562

**helicotrema** outer point in the cochlea where the scala vestibuli and scala tympani meet, 218–19, 218*f*

**helper T cells** T cells that, via secreted cytokines, enhance the activation of B cells and cytotoxic T cells, 658*t*, 666, 668*f*, 670–72, 670*f*, 671*f*, 673*f*

**hematocrit** (heh-MAT-oh-krit) percentage of total blood volume occupied by red blood cells, 363, 363*f*

**hematoma**, 254

**hematopoietic growth factors (HGFs)** (heh-MAT-oh-poi-ET-ik) protein hormones and paracrine agents that stimulate proliferation and differentiation of various types of blood cells, 367, 367*t*

**hematopoietic stem cells**, 364*f*

**heme** (heem) iron-containing organic complex bound to each of the four polypeptide chains of hemoglobin or to cytochromes, 465, 466*f*

**hemispheres, cerebral**, 173, 174*f*, 250–51, 250*f*–51*f*

**hemochromatosis**, 365, 558

**hemodialysis**, 526, 527*f*

**hemodynamics** the factors describing what determines the movement of blood, in particular, pressure, flow, and resistance, 369

**hemoglobin** (HEE-ma-gloh-bin) protein composed of four polypeptide chains, each attached to a heme; located in erythrocytes and transports most blood oxygen, 37, 37*f*, 365, 465–70, 466*f*–69*f*, 471*f*, 471*t*  
abnormal, in sickle-cell disease, 41–42, 42*f*  
fetal, 469, 469*f*

**hemoglobin saturation** percent of hemoglobin that has O<sub>2</sub> or any other gas bound to its iron moiety, 466–70

**hemolytic anemia**, 690

**hemolytic disease of the newborn**, 682

**hemophilia**, 434

**hemorrhage**. *See* blood loss

**hemostasis** (hee-moh-STAY-sis) stopping blood loss from a damaged vessel, 431–37, 432*f*, 435–36, 435*f*–36*f*, 436*t*

**Henry's law** amount of gas dissolved in a liquid is proportional to the partial pressure of gas with which the liquid is in equilibrium, 461–62, 465

**heparin** (HEP-ah-rin) anticlotting agent found on endothelial cell surfaces; binds antithrombin III to tissues; used as an anticoagulant drug, 436, 701–2

**hepatic lobule**, 551, 552*f*

**hepatic portal vein** vein that conveys blood from capillaries in the intestines and portions of the stomach and pancreas to capillaries in the liver, 533, 552*f*, 558

**hepatocytes**, 551, 552*f*

**Hering-Breuer reflex** inflation of the lung stimulates afferent nerves, which inhibit the inspiratory nerves in the medulla and thereby help to terminate inspiration, 473

**heroin**, 184

**hertz (Hz)** (hurts) cycles per second; measure used for wave frequencies, 205, 216

**hexoses** six-carbon sugars, such as glucose, 31

**high-density lipoproteins (HDLs)** lipid-protein aggregates having low proportion of lipid; promote removal of cholesterol from cells, 574*f*, 576

**hilum**, 490

**hindbrain** portion of the brain consisting of the cerebellum, pons, and medulla oblongata, 172, 173*f*, 175

**hippocampus** (hip-oh-KAM-pus) portion of limbic system associated with learning and emotions, 175*f*; 249–50

**histamine** (HISS-tah-meen) inflammatory chemical messenger secreted mainly by mast cells; monoamine neurotransmitter, 542, 543*f*, 657, 660*t*, 683–84

**histones** class of proteins that participate in the packaging of DNA within the nucleus; strands of DNA form coils around the histones, 57

**histotoxic hypoxia**, 479

**HIV/AIDS**, 680, 680*f*

**homeostasis** (home-ee-oh-STAY-sis) relatively stable condition of internal environment that results from regulatory system actions, 5–7, 11–14, 12*f*–14*f*

**homeostatic control systems** (home-ee-oh-STAT-ik) collections of interconnected components that keep a physical or chemical variable of internal environment within predetermined normal ranges of values, 7–11, 7*f*, 9*t*, 11*f*

**homeotherms** animals that maintain a relatively narrow range of body temperature despite changes in ambient temperature, 593

**homocysteine**, 429, 685

**horizontal cells** specialized neurons found in the retina of the eye that integrate information from local photoreceptor cells, 210*f*, 212

**hormone** chemical messenger synthesized by specific endocrine cells in response to certain stimuli and secreted into the blood, which carries it to target cell, 11, 12, 12*f*, 321*f*–22*f*, 323–332, 323*f*. *See also specific hormones*

blood flow (arteriole) regulation by, 398, 398*f*

control of, 329–30, 329*f*–30*f*, 337–38, 338*f*

gastrointestinal, 537, 538*r*, 589–90

hyperresponsiveness of, 330, 331

hypersecretion of, 330, 331

hyporesponsiveness of, 330, 331

hyposecretion of, 330–31

mechanisms of action, 327–29

metabolism and excretion of, 327, 328*f*

permissiveness of, 328, 328*f*

pharmacological effects of, 329

pregnancy, 641–42, 641*f*, 642*t*, 648–50, 649*t*

sex, 605, 611–12, 612*f*, 613*t*, 619–21, 619*f*, 627–34, 648–50, 649*t*

structural classes of, 323–27, 323*f*–26*f*

transport in blood, 327, 327*t*

**hormone receptors**, 327–28

**hormone-sensitive lipase (HSL)** an enzyme present in adipose tissue that acts to break down triglycerides into glycerol and fatty acids, which then enter the circulation; it is inhibited by insulin and stimulated by catecholamines, 583

**hot flashes**, 634

**human chorionic gonadotropin (hCG)** (kor ee-ON-ik go-NAD-oh-troh-pin) glycoprotein hormone secreted by trophoblastic cells of placenta; maintains secretory activity of corpus luteum during first 3 months of pregnancy, 641–42, 641*f*

**human immunodeficiency virus (HIV)**, 680, 680*f*

**human placental lactogen** (plah-SEN-tal LAK-toh-jen) hormone produced by placenta that has effects similar to those of growth hormone and prolactin, 642

**humoral hypercalcemia of malignancy**, 356

**humoral responses**, 666, 672–76, 672*t*, 673*f*

**humours**, 5

**hunger** the biological drive to eat; unlike *appetite*, hunger is a sensation, 589

**hydrocephalus**, 183, 708

**hydrochloric acid** (hy-droh-KLOR-ik) HCl; strong acid secreted into stomach lumen by parietal cells, 29, 541–44, 543*f*–45*f*, 544*t*

**hydrogen bond** weak chemical bond between two molecules or parts of the same molecule in which negative region of one polarized substance is electrostatically attracted to a positively charged region of polarized hydrogen atom in the other, 25, 26*f*

**hydrogen ions**, 29

regulation of, 520–24, 521*t*

respiratory effects of, 476, 476*f*, 477, 477*f*, 478*f*

transport between tissues and lungs, 471, 471*f*

**hydrogen peroxide** H<sub>2</sub>O<sub>2</sub>; chemical produced by phagosome and highly destructive to macromolecules and pathogens, 661

**hydrogen sulfide** a type of gas that sometimes functions as a neurotransmitter, 170

**hydrolysis** (hye-DRAHL-ih-sis) breaking of chemical bond with addition of elements of water (—H and —OH) to the products formed; also called *hydrolytic reaction*, 27

**hydrophilic** (hye-droh-FIL-ik) attracted to, and easily dissolved in, water, 28

**hydrophobic** (hye-droh-FOH-bik) not attracted to, and insoluble in, water, 28

**hydrostatic pressure** (hye-droh-STAT-ik) pressure exerted by fluid, 369, 403–5

**hydroxyapatite** crystals composed primarily of calcium and phosphate deposited in bone matrix (mineralization), 353

**hydroxychloroquine**, 690

**hydroxyl group** (hye-DROX-il) —OH, 24

**hymen** membrane that partially covers the opening to the vagina, 624, 624*f*

**hyperalgesia**, 202

**hypercalcemia** increased plasma calcium concentration, 355–356

**hypercapnia**, 479

**hypercoagulability**, 435

**hyperemia** (hye-per-EE-me-ah) increased blood flow, 396–97, 396*f*

**hyperkalemia**, 516

**hyperopia**, 209, 209*f*

**hyperosmotic** (hye-per-oz-MAH-tik) having total solute concentration greater than normal extracellular fluid, 108–9, 109*t*

**hyperosmotic urine**, 506–8, 507*f*

**hyperparathyroidism**, 355–356

**hyperpolactinemia**, 621–22

**hyperpolarized** membrane potential changed so cell interior becomes more negative than its resting state, 149–53, 149*f*–53*f*

**hyperprolactinemia**, 651–52, 651*f*

**hyperresponsiveness of hormone**, 330, 331

**hypersecretion of hormone**, 330, 331

**hypersensitivity**, 682–84, 683*f*, 683*t*

**hypertension**, 346–47, 424–25

in pregnancy, 642–43

primary, 425

pulmonary, 484

renal, 425, 526

secondary, 425

sleep apnea and, 484–85

treatment of, 425, 425*t*, 518

**hyperthermia**, 597

**hyperthyroidism**, 343, 695–99

**hypertonia**, 313

**hypertonic solutions** (hye-per-TAH-nik) solutions containing a higher concentration of effectively membrane-impermeable solute particles than normal (isotonic) extracellular fluid, 108, 108*f*, 109*t*

**hypertrophic cardiomyopathy**, 427

**hypertrophy** (hye-PER-troh-fee) enlargement of a tissue or organ due to increased cell size rather than increased cell number

skeletal muscle, 259

**hyperventilation**, 463, 476, 476*f*

**hypnic jerks**, 237

**hypocalcemia** decreased blood calcium concentration, 283, 356

**hypocalcemic tetany**, 283, 356

**hypocretins** (high-poe-CREE-tins). *See* orexins

**hypoglossal nerve (cranial nerve XII)**, 177*t*

**hypoglycemia** (hye-poh-gly-SEE-me-ah) low blood glucose (sugar) concentration, 277, 584

**hypogonadism**, 621–22

**hypokalemia**, 516

**hyponatremia**, exercise-associated, 114–15, 115*f*

**hyposmotic** (hye-poh-oz-MAH-tik) having total solute concentration less than that of normal extracellular fluid, 108–9, 109*t*

**hypoparathyroidism**, 356

**hypoperfusion hypoxia**, 479

**hypophysiologic hormones** (hye-poh-fiz ee-oh-TROH-pik) hormones secreted by hypothalamus that control secretion of an anterior pituitary gland hormone, 334–39, 335*f*–38*f*

**hypopituitarism**, 622

**hyporesponsiveness of hormone**, 330, 331

**hyposecretion of hormone**, 330–31

**hypotension**, 346, 419–20, 419*f*

**hypothalamo-pituitary portal vessels** small veins that link the capillaries of the median eminence at the base of the hypothalamus to capillaries that bathe the cells of the anterior pituitary gland; neurohormones are secreted from the hypothalamus into these vessels, 333*f*, 334, 612–13, 613*f*

**hypothalamus** (hye-poh-THAL-ah-mus) brain region below thalamus; responsible for integration of many basic neural, endocrine, and behavioral functions, especially those concerned with regulation of internal environment, 173*t*, 174*f*, 175, 175*f*, 322, 322*f*, 330*f*, 333–39, 333*f*, 335*f*–38*f*

in emotion, 245, 245*f*

in motivation, 243–44

in sleep-wake cycle, 239

in stress response, 344–46

in temperature regulation, 594, 595*f*, 596

**hypothermia**, malignant, 296–97, 297*f*

**hypothyroidism**, 342–43

**hypotonia**, 313

**hypotonic solutions** (hye-poh-TAH-nik) solutions containing a lower concentration of effectively nonpenetrating solute particles than normal (isotonic) extracellular fluid, 108, 108*f*, 109*t*

**hypoventilation**, 463, 479*t*

**hypovolemic shock**, 420

**hypoxemia**, 700, 700*t*



**hypoxia**, 479–80, 479*t*  
**hypoxic hypoxia**, 479, 479*t*  
**H zone** one of transverse bands making up striated pattern of cardiac and skeletal muscle; light region that bisects A band, 259*f*, 260, 261*f*

**I**

**I band** one of transverse bands making up repeating striations of cardiac and skeletal muscle; located between A bands of adjacent sarcomeres and bisected by Z line, 259*f*, 260, 261*f*  
**IgA** class of antibodies secreted by, and acting locally in, lining of gastrointestinal, respiratory, and genitourinary tracts, 668, 674  
**IgD** class of antibodies whose function is unknown, 668, 674  
**IgE** class of antibodies that mediate immediate hypersensitivity and resistance to parasites, 668, 674, 683–84, 683*f*  
**IgG** gamma globulin; most abundant class of antibodies, 668, 674  
**IgM** class of antibodies that, along with IgG, provide major specific humoral immunity against bacteria and viruses, 668, 674  
**ileocecal valve (or sphincter)** (il-ee-oh-SEE-kal) ring of smooth muscle separating small and large intestines (that is, ileum and cecum), 559  
**ileum** (IL-ee-um) final, longest segment of small intestine; site of bile salt reabsorption, 533, 548  
**immediate hypersensitivity**, 683–84, 683*f*, 683*t*  
**immune-complex hypersensitivity**, 682–83, 683*t*  
**immune surveillance** (sir-VAY-lence) recognition and destruction of cancer cells that arise in body, 655  
**immune system** widely dispersed cells and tissues that participate in the elimination of foreign cells, microbes, and toxins from the body, 5*t*, 655  
 cells of, 656–57, 656*f*, 658*t*  
 harmful responses in, 681–85  
 mini-glossary for, 685*t*–86*t*  
 secretions of, 657  
**immune tolerance** the lack of immune responses to self components, 672  
**immunodeficiency**, 679–81  
**immunoglobulins** (im-mune-oh-GLOB-you-linz) proteins that are antibodies and antibody-like receptors on B cells (five classes are IgG, IgA, IgD, IgM, and IgE), 668–69, 669*f*, 674–75  
**immunology** the study of the defenses by which the body destroys or neutralizes foreign cells, microbes, and toxins, 655  
**immunosuppression**, 346  
**implantation** (im-plan-TAY-shun) event during which fertilized egg becomes embedded in uterine wall, 629*f*, 638  
**implicit memory**, 249  
**inactivation gate** portion of voltage-gated ion channels that closes the channel, 151  
**incontinence, urinary**, 500  
**incretins** category of hormones secreted from enteroendocrine cells of the small intestine that augment insulin secretion in response to glucose, 582, 582*f*  
**incus** one of three bones in the inner ear that transmit movements of the tympanic membrane to the inner ear, 217–18, 218*f*

**induced-fit model**, 74, 74*f*  
**infection**  
 factors altering resistance to, 679–81  
 systemic manifestations of, 677–79, 678*f*  
**inferior vena cava** (VEE-nah KAY-vah) large vein that carries blood from lower parts of body to right atrium of heart, 368, 373, 373*f*  
**infertility**, 648  
**inflammation** (in-flah-MAY-shun) local response to injury or infection characterized by swelling, pain, heat, and redness, 657–62, 684–85  
**inflammatory bowel disease**, 568–69, 685  
**inflammatory mediators**, 657–59, 660*t*, 685*t*–86*t*  
**infundibulum** (in-fun-DIBB-yoo-lum) the stalk of tissue connecting the median eminence at the base of the hypothalamus with the pituitary gland, 333  
**inhibin** (in-HIB-in) protein hormone secreted by seminiferous-tubule Sertoli cells and ovarian granulosa cells; inhibits FSH secretion, 613  
 in female physiology, 624–34, 628*t*, 629*f*  
 in male physiology, 617, 617*t*, 619–20, 619*f*  
**inhibitory postsynaptic potential (IPSP)**  
 hyperpolarizing graded potential that arises in postsynaptic neuron in response to activation of inhibitory synaptic endings upon it, 161–62, 161*f*–62*f*  
**inhibitory synapse** (SIN-aps) synapse that, when activated, decreases likelihood that postsynaptic neuron will fire an action potential (or decreases frequency of existing action potentials), 158, 160, 161–63, 163*f*  
**initial segment** first portion of axon plus the part of the cell body where axon arises, 138  
**initiation factors** proteins required for ribosomal assembly and the establishment of an initiation complex that allows new protein synthesis to begin, 60–61  
**innate immune responses** the nonspecific immune responses to conserved molecular features of pathogens; responses that nonselectively protect against foreign material without having to recognize its specific identity, 655–56, 657–64  
**inner cell mass** portion of the blastocyst that becomes the embryo, 629*f*, 638  
**inner ear** cochlea; contains organ of Corti auditory function of, 217–20, 218*f*–19*f*  
 vestibular function of, 221–24  
**inner emotions** emotional feelings that are entirely within a person, 244  
**inner hair cells** cells of the cochlea with stereocilia that transduce pressure waves into electrical signals, 220, 221*f*  
**inner segment** portion of photoreceptor that contains cell organelles; synapses with bipolar cells of retina, 209  
**inositol**, 89  
**inositol triphosphate (IP<sub>3</sub>)** (in-OS-ih-tol-tris-FOS-fate) second messenger that causes release of calcium from endoplasmic reticulum into cytosol, 128, 129*f*, 130*t*  
**inotropic factors** (usually extrinsic) that modify cardiac muscle contractility, 386  
**insensible water loss** water loss of which a person is unaware—that is, loss by evaporation from skin (excluding sweat) and respiratory passage lining, 503, 596  
 target cells of, 579*f*

**inspiration** air movement from atmosphere into lungs, 446, 453–55  
 respiratory muscles in, 453–55, 455*f*  
 sequence of events in, 453*f*–55*f*  
**inspiratory reserve volume (IRV)** maximal air volume that can be inspired above resting tidal volume, 458, 459*f*  
**insulin** (IN-suh-lin) peptide hormone secreted by beta cells of pancreatic islets of Langerhans; has metabolic and growth-promoting effects; stimulates glucose and amino acid uptake by most cells and stimulates protein, fat, and glycogen synthesis, 322*f*, 324, 324*f*, 347, 578–82  
 control of, 581–82  
 in diabetes mellitus, 599–601  
 in growth and development, 351, 351*t*  
**insulin-like growth factor 1 (IGF-1)** hormone that mediates mitosis-stimulating effect of growth hormone on bone and other tissues and has feedback effects on hypothalamus and anterior pituitary gland, 322*f*, 335, 349–51, 350*f*, 357–59, 357*f*  
**insulin-like growth factor 2 (IGF-2)** mitogenic hormone active during fetal life, 351  
**insulin resistance**, 599  
**integral membrane proteins** proteins embedded in membrane lipid layer; may span entire membrane or be located at only one side, 48, 48*f*  
**integrating center** brain region that compares the actual value of a variable such as body temperature to a set point, 10–11, 11*f*  
**integrative physiology**, 694–95  
**integrins** (in-TEH-grinz or IN-teh-grinz)  
 transmembrane proteins in plasma membrane; bind to specific proteins in extracellular matrix and on adjacent cells to help organize cells into tissues, 49  
**integumentary system**, 5*t*  
**intention tremor**, 311  
**intercalated disks** (in-TER-kuh-lay-tid) structures connecting adjacent cardiac myocytes, having components for tensile strength (desmosomes) and low-resistance electrical pathways (gap junctions), 293, 293*f*  
**intercellular clefts** narrow, water-filled spaces between capillary endothelial cells, 400, 401*f*  
**intercostal muscles** (in-ter-KOS-tal) skeletal muscles that lie between ribs and whose contraction causes rib cage movement during breathing, 449  
**interferon(s)**, 657, 659*t*, 662–63, 663*f*, 677, 677*f*  
**interferon-gamma**, 663, 677, 677*f*  
**interleukin(s)**, 367*t*, 659*t*, 671, 673, 676  
**interleukin 1 (IL-1)** cytokine secreted by macrophages and other cells that activates helper T cells; exerts many inflammatory effects; mediates many of the systemic, acute phase responses, including fever, 659*t*, 671, 671*f*, 673, 676, 676*f*  
**interleukin 2 (IL-2)** cytokine secreted by activated helper T cells that causes antigen-activated helper T, cytotoxic T, and NK cells to proliferate; also causes activation of macrophages, 659*t*, 673, 673*f*, 676, 676*f*–77*f*  
**interleukin 6 (IL-6)** cytokine secreted by macrophages and other cells that exerts multiple effects on immune system cells, inflammation, and the acute phase response, 679  
**intermediate filaments** actin-containing filaments associated with desmosomes, 55, 55*f*

**internal anal sphincter** smooth muscle ring around lower end of rectum, 560

**internal environment** extracellular fluid (interstitial fluid and plasma), 4–14. *See also* homeostasis

**internalization** down-regulation of plasma membrane receptors by receptor-mediated endocytosis, 122

**internal urethral sphincter** (you-REE-thrul) part of smooth muscle of urinary bladder wall that opens and closes the bladder outlet, 500

**internal work** energy-requiring activities in body; *compare* external work, 587

**interneurons** neurons whose cell bodies and axons lie entirely in CNS, 138–39, 140f, 140t, 304, 304f

**internodal pathways** (in-ter-NO-dal) low-resistance conducting-cell pathways connecting the sinoatrial and atrioventricular nodes of the heart, 375–76

**interstitial (Leydig) cells**, 610f, 616, 617f

**interstitial fluid** extracellular fluid surrounding tissue cells; excludes plasma, 4, 6f

**interstitium** (in-ter-STISH-um) interstitial space; fluid-filled space between tissue cells, 4

**interventricular septum** the muscular wall separating the right and left ventricles of the heart, 372, 373f

**intestinal phase** (of gastrointestinal control) initiation of neural and hormonal gastrointestinal reflexes by simulation of intestinal tract walls, 537, 544t

**intracellular chemical messengers**, 11–12, 12f

**intracellular fluid** fluid in cells; cytosol plus fluid in cell organelles, including nucleus, 4–5, 6f, 46 composition of, 105t movement between extracellular fluid and, 95–117 (*See also specific mechanisms*)

**intracellular receptors**, 119, 120f

**intracranial hemorrhage**, 254

**intrafusal fibers** modified skeletal muscle fibers in muscle spindle, 305, 305f, 306f

**intrapleural fluid** (in-trah-PLUR-al) thin fluid film in thoracic cavity between pleura lining the inner wall of thoracic cage and pleura covering lungs, 449, 449f

**intrapleural pressure** ( $P_{ip}$ ) pressure in pleural space; also called *intrathoracic pressure*, 449, 452f

**intrarenal baroreceptors** pressure-sensitive juxtaglomerular cells of afferent arterioles, which respond to decreased renal arterial pressure by secreting more renin, 512

**intrauterine device (IUD)**, 647

**intrinsic factor** glycoprotein secreted by stomach epithelium and necessary for absorption of vitamin B<sub>12</sub> in the ileum, 541

**intrinsic pathway** intravascular sequence of fibrin clot formation initiated by factor XII or, more usually, by the initial thrombin generated by the extrinsic clotting pathway, 433–35, 434f

**intrinsic tone** spontaneous low-level contraction of smooth muscle, independent of neural, hormonal, or paracrine input, 396

**introns** (IN-trahns) regions of noncoding nucleotides in a gene, 59–60, 60f

**inulin** polysaccharide that is filtered but not reabsorbed, secreted, or metabolized in the renal tubules; can be used to measure glomerular filtration rate, 500, 500f

**in vitro fertilization**, 648

**involuntary movement**, 304

**involuntary muscle**, 3

**iodide trapping** active transport of iodide from extracellular fluid across the thyroid follicular cell membrane, followed by transport of iodide into the colloid of the follicle, 339–41, 340f, 698–99

**iodine** chemical found in certain foods and as an additive to table salt; concentrated by the thyroid gland, where it is incorporated into the structure of thyroid hormone, 323

**ion** (EYE-on) atom or small molecule containing unequal number of electrons and protons and therefore carrying a net positive or negative electrical charge, 23 in action potentials, 150–56 diffusion of, 98–100, 99f distribution across plasma membrane, 144–45, 145t in graded potentials, 149–50, 150f–51f in resting membrane potential, 144–49, 145f–48f

**ion balance**, 503–18

**ion channels** small passages in plasma membrane formed by integral membrane proteins and through which certain small-diameter molecules and ions can diffuse, 98–100, 99f–100f. *See also* ligand-gated ion channels; mechanically gated ion channels; voltage-gated ion channels in action potentials, 150–56 in graded potentials, 149–50, 150f–51f inactivation gate in, 151 leak, 147 in resting membrane potential, 144–49

**ionic bond** (eye-ON-ik) strong electrical attraction between two oppositely charged ions, 25, 25f

**ionic molecules**, 26, 27t

**ionization**, 26

**ionotropic receptors** (eye-ohn-uh-TROPE-ik) membrane proteins through which ionic current is controlled by the binding of extracellular signaling molecules, 160, 170

**ion pumps**, 102–3, 103f, 148

**ipsilateral** (ip-sih-LAT-er-al) on the same side of the body, 307

**iris** ringlike structure surrounding and determining the diameter of the pupil of eye, 206, 207f

**iron** an element that forms part of each subunit of hemoglobin and binds molecular oxygen, 365–66, 366t, 557–8

**irreversible reactions** chemical reactions that release large quantities of energy and result in almost all the reactant molecules being converted to product; *compare* reversible reaction, 73, 73t

**ischemia**, 427, 704

**ischemic hypoxia**, 479

**islets of Langerhans** (EYE-lets of LAN-ger-hans) clusters of pancreatic endocrine cells; distinct islet cells secrete insulin, glucagon, somatostatin, and pancreatic polypeptide, 580, 581–82, 582f

**isometric contraction** (eye-soh-MET-rik) contraction of muscle under conditions in which it develops tension but does not change length, 269–72, 271f–72f

**isoosmotic** (eye-soh-oz-MAH-tik) having the same total solute concentration as extracellular fluid, 108–9, 109t

**isotonic** (eye-soh-TAH-nik) containing the same number of effectively nonpenetrating solute particles as normal extracellular fluid, 108, 108f, 109t. *See also* isotonic contraction

**isotonic contraction** contraction of muscle under conditions in which load on the muscle remains constant but muscle changes length, 269–72, 272f

**isotopes** atoms consisting of one or more additional neutrons than protons in their nuclei, 22

**isovolumetric ventricular contraction** (eye-sohvol-you-MET-rik) early phase of systole when atrioventricular and aortic valves are closed and ventricular size remains constant, 380–81, 381f–82f

**isovolumetric ventricular relaxation** early phase of diastole when atrioventricular and aortic valves are closed and ventricular size remains constant, 381, 381f–82f

**itch** somatic sensation of skin irritation that evokes a desire to scratch, 204

## J

**janus kinases (JAKs)** cytoplasmic kinases bound to a receptor but not intrinsic to it, 125

**jaundice**, 564

**jejunum** (jeh-JU-num) middle segment of small intestine, 533, 548

**J receptors** receptors in the lung capillary walls or interstitium that respond to increased lung interstitial pressure, 478–79

**junctional feet**, 267

**juxtacrine signaling**, 12

**juxtaglomerular apparatus (JGA)** (jux-tah gloh-MER-you-lar) renal structure consisting of macula densa and juxtaglomerular cells; site of renin secretion and sensors for renin secretion and control of glomerular filtration rate, 492f, 493, 494f

**juxtaglomerular (JG) cells** renin-secreting cells in the afferent arterioles of the renal nephron in contact with the macula densa, 493, 494f

**juxtamedullary (nephron)** functional unit of the kidney with glomeruli in the deep cortex and a long loop of Henle, which plunges into the medulla, 491f, 493

## K

**kallikrein** (KAL-ih-crine) an enzyme produced by gland cells that catalyzes the conversion of the circulating protein kininogen into the signaling molecule bradykinin, 397

**Kallmann syndrome**, 226

**Kaposi's sarcoma**, 680

**karyotype** chromosome characteristics of a cell, usually visualized with a microscope, 607

**K complexes** large-amplitude waveforms seen in the electroencephalogram during stage 2 sleep, 236, 237f

**keto acid** a class of breakdown products formed from the deamination of amino acids, 87, 87f, 576

**ketoacidosis, diabetic**, 599, 600f

**ketones** (KEE-tohnz) products of fatty acid metabolism that accumulate in blood during starvation and in severe untreated diabetes

mellitus; acetoacetic acid, acetone, or B-hydroxybutyric acid; also called *ketone bodies*, 578

#### **kidney(s)**

anatomy of, 489–90, 490f–92f  
arteriolar control in, 400t  
calcium homeostasis in, 353  
composition of, 4  
endocrine function of, 322f, 489, 490t  
functional unit of, 4, 490–93, 491f  
functions of, 489, 490t  
location of, 489  
physiology of, 488–527  
    basic processes in, 493–97, 494f, 495f  
    division of labor in, 499, 517, 518t  
    hydrogen ion regulation in, 520–24  
    ion and water balance in, 503–18  
    micturition in, 500–1  
    renal clearance in, 499–500

#### **kidney disease**

diabetes mellitus and, 498, 525–27  
dialysis for, 526–27

**kilocalories** (kcal) (KIL-oh-kal-ah-reez) 1 kcal is the amount of heat energy required to raise the temperature of 1 kg water by 1°C; also called *Calorie* (capital C), 72, 587

**kinesins** (kye-NEE-sinz) motor proteins that use the energy from ATP to transport attached cellular cargo along microtubules, 138, 139f

**kinesthesia** (kin-ess-THEE-zee-ah) sense of movement derived from movement at a joint, 201

**kininogen** (kye-NIN-oh-jen) plasma protein from which kinins are generated in an inflamed area, 397

**kinins** polypeptides that split from kininogens in inflamed areas and facilitate the vascular changes associated with inflammation; they also activate neuronal pain receptors, 659, 660t

**kisspeptin** peptide produced in neurons in the hypothalamus involved in the control of GnRH secretion, 612–13

**Klinefelter's syndrome**, 621, 621f

**knee-jerk reflex** often used in clinical assessment of nerve and muscle function; striking the tendon just below the kneecap causes reflex contraction of anterior thigh muscles, which extends the knee, 139, 305–7, 307f

**Korotkoff's sounds** (kor-OTT-koff) sounds caused by turbulent blood flow during determination of blood pressure with a pressurized cuff, 394, 394f

**Krebs, Hans**, 80

**Krebs cycle** mitochondrial metabolic pathway that utilizes fragments derived from carbohydrate, protein, and fat breakdown and produces carbon dioxide, hydrogen (for oxidative phosphorylation), and small amounts of ATP; also called *tricarboxylic acid cycle* or *citric acid cycle*, 78, 80–84, 80f, 81f, 82t, 84f

**kwashiorkor**, 406

## **L**

**labeled lines** principle describing the idea that a unique anatomical pathway of neurons connects a given sensory receptor directly to the CNS neurons responsible for processing that modality and location on the body, 193

**labyrinth** complicated bony structure that houses the cochlea and vestibular apparatus, 222

**lactase** (LAK-tase) small intestine enzyme that breaks down lactose (milk sugar) into glucose and galactose, 564

**lactate** ionized form of lactic acid, a three-carbon molecule formed by glycolytic pathway; production is increased in absence of oxygen, 80–85

**lactation** (lak-TAY-shun) production and secretion of milk by mammary glands, 645–47, 647f

**lacteal** (lak-TEEL) blind-ended lymph vessel in center of each intestinal villus, 547f, 548

**lactic acid**, 29

**lactogenesis** the synthesis of milk by the mammary glands, 645

**lactose intolerance**, 564

**lamina propria** layer of connective tissue under an epithelium, 535, 536f

**laminar flow** (LAM-ih-ner) when a fluid (e.g., blood) flows smoothly through a tube in concentric layers, without turbulence, 384

**language, cerebral dominance and**, 250–51, 250f–51f

**lansoprazole**, 562

**large fiber sensory neuropathy disease** characterized by loss of somatic sensory information, including proprioception, 314

**large intestine** part of the gastrointestinal tract between the small intestine and rectum; absorbs salts and water, 532, 532f, 538t, 559–61, 560f, 561t

**larynx** (LAR-inks) part of air passageway between pharynx and trachea; contains the vocal cords, 446, 446f

**latch state** contractile state of some smooth muscles in which force can be maintained for prolonged periods with very little energy use; cross-bridge cycling slows to the point where thick and thin filaments are effectively “latched” together, 289

**latent period** (LAY-tent) period lasting several milliseconds between action potential initiation in a muscle fiber and beginning of mechanical activity, 270

**late phase reaction**, 684

**lateral geniculate nucleus**, 213–14

**lateral inhibition** method of refining sensory information in afferent neurons and ascending pathways whereby fibers inhibit each other, the most active fibers causing the greatest inhibition of adjacent fibers, 195, 195f–96f

**lateral traction** force (in the lung) holding small airways open; exerted by elastic connective tissue linked to surrounding alveolar tissue, 457

**Law of Laplace** (lah-PLAHS) transmural pressure difference equals two times the surface tension divided by the radius of a hollow ball (e.g., an alveolus), 455–56, 457f

**law of mass action** maxim that an increase in reactant concentration causes a chemical reaction to proceed in direction of product formation; the opposite occurs with decreased reactant concentration, 73

**laxatives**, 564

**L-dopa** L-dihydroxyphenylalanine; precursor to dopamine formation; also called *levodopa*, 167

**leak channels** open, ungated ion channels through which ions diffuse according to the electrochemical gradient for that ion, 147

**learned reflexes**. *See* acquired reflexes

**learning** acquisition and storage of information as a result of experience, 248–50, 249f

**left ventricular hypertrophy**, 424–25

**lengthening contraction** contraction as an external force pulls a muscle to a longer length despite opposing forces generated by the active cross-bridges, 269–70, 281

**length-monitoring systems**, 305, 306f

**length-tension relation**, 273–74, 274f

**lens** adjustable part of eye's optical system, which helps focus object's image on retina, 206–9, 207f–8f

**leptin** adipose-derived hormone that acts within the brain to decrease appetite and increase metabolism, 322f, 588–89, 590f, 633

**leukocytes** (LOO-koh-sitz) white blood cells, 363, 364f, 366–67, 656, 656f, 658t

**leukotrienes** (loo-koh-TRYE-eenz) type of eicosanoid that is generated by lipoxygenase pathway and functions as inflammatory mediator, 130–31, 131f, 170

**lever action, muscle**, 281–82, 282f–84f

**Levitra**, 618

**levodopa (L-dopa)**, 311

**Lexapro (escitalopram)**, 246

**Leydig cells** (LYE-dig or LAY-dig) testosterone-secreting endocrine cells that lie between seminiferous tubules of testes; also called *interstitial cells*, 610f, 616, 617f

**LH surge** large rise in luteinizing hormone secretion by anterior pituitary gland about day 14 of menstrual cycle, 628, 629, 630t

**libido** (luh-BEE-doh) sex drive, 620

**lidocaine**, 153, 296

**ligand** (LYE-gand) any molecule or ion that binds to protein surface by noncovalent bonds, 66–71  
    competition between, 69  
    concentration of, 68, 69f  
    receptor interactions with, 119–22

**ligand-gated ion channels** membrane ion channels operated by the binding of specific molecules to channel proteins, 100, 123–25, 151

#### **light**

    absorption by photoreceptors, 210  
    properties of and vision, 205, 206f  
    refraction of, 207–8, 208f

**light adaptation** process by which photoreceptors in the retina adjust to sudden bright light, 211

**light chains** pairs of small polypeptides bound to each globular head of a myosin molecule; function is to *modulate* contraction, 260, 260f

**light microscopy**, of cells, 45, 45f

**limbic system** (LIM-bik) interconnected brain structures in cerebrum; involved with emotions and learning, 175, 244–45, 245f

**lingual papillae** taste buds located on the tongue, 224, 225f

**lipase**, 532, 539t, 550t, 554–5, 583

**lipid(s)** (LIP-idz) molecules composed primarily of carbon and hydrogen and characterized by insolubility in water, 30t, 31–34, 33f  
    in absorptive state, 574–76  
    as neurotransmitters, 170  
    in plasma membrane, 46–49, 49f  
    in postabsorptive state, 578

**lipid bilayer**, 46–48, 49, 49f, 98, 105t



**lipid rafts** cholesterol-rich regions of decreased membrane fluidity that are believed to serve as organizing centers for the generation of complex intracellular signals, 49

**lipid-soluble messengers**, 122–23, 123*f*

**lipolysis** (lye-POL-ih-sis) triglyceride breakdown, 32, 86, 577, 584*t*

**lipoprotein(s)** (lip-oh-PROH-teenz or LYE-poh proh-teenz) lipid aggregates partially coated by protein; involved in lipid transport in blood, 574

**lipoprotein lipase** capillary endothelial enzyme that hydrolyzes triglyceride in lipoprotein to monoglyceride and fatty acids, 574, 574*f*

**lipoxxygenase** (lye-POX-ih-jen-ase) enzyme that acts on arachidonic acid and leads to leukotriene formation, 130, 131*f*

**lisinopril**, 512

**lithium (Lithobid)**, 246–47

**liver** large organ located in the upper right portion of the abdomen with exocrine, endocrine, and metabolic functions, 532, 532*f*

bile formation and secretion in, 549*f*, 551–53, 561*t*

blood clotting role of, 435, 435*f*

cholesterol control in, 575–76, 575*f*

endocrine function of, 322*f*

exocrine function of, 538*t*, 548, 551–53

functional unit of, 551, 552*f*

sympathetic nerves to, 583

**load** external force acting on muscle, 269–75

**load-velocity relation**, 272, 272*f*

**local anesthetics**, 153

**local controls** mechanisms existing within tissues that modulate local blood flow independently of neural or hormonal input, 396

afferent, 304–8

of arteriolar blood flow, 396–97

of body movement, 302–3, 303*f*

**local homeostatic responses** (home-ee-oh-STAT-ik) responses acting in immediate vicinity of a stimulus, without nerves or hormones, and having net effect of counteracting stimulus, 11

**lock-and-key model**, 73–74, 74*f*

**lockjaw**, 316–317

**long bone, growth of**, 348, 348*f*

**longitudinal muscle**, 536*f*, 546

**long-loop negative feedback** inhibition of anterior pituitary gland and/or hypothalamus by hormone secreted by third endocrine gland in a sequence, 338, 338*f*

**long neural pathways**, 172

**long reflexes** neural loops from afferents in the gastrointestinal tract to the central nervous system and back to nerve plexuses and effector cells via the autonomic nervous system; involved in the control of motility and secretory activity, 536–37, 537*f*

**long-term depression (LTD)** condition in which nerves show decreased responses to stimuli after an earlier stimulation, 250

**long-term memories** information stored in the brain for prolonged periods, 249

**long-term potentiation (LTP)** process by which certain synapses undergo long-lasting increase in effectiveness when heavily used, 168–169, 250

**loop diuretics**, 517–18

**loop of Henle** (HEN-lee) hairpinlike segment of kidney nephron with *descending* and *ascending*

*limbs*; situated between proximal and distal tubules, 491*f*, 493, 494*f*

**losartan**, 512

**Lou Gehrig's disease** another name for amyotrophic lateral sclerosis (ALS), 313

**low-density lipoproteins (LDLs)** (lip-oh-PROH-teenz) protein-lipid aggregates that are major carriers of plasma cholesterol to cells, 574*f*, 576

**lower esophageal sphincter** smooth muscle of last portion of esophagus; can close off esophageal opening into the stomach, 539*f*, 540–41, 541*f*

**lower motor neurons** neurons that synapse directly onto muscle cells and stimulate their contraction, 313

**low-resistance shock**, 420, 704

**LSD**, 168

**L-type Ca<sup>2+</sup> channels (dihydropyridine [DHP] channels)** voltage-gated ion channels permitting calcium entry into heart cells during the action potential; L denotes the long-lasting open time that characterizes these channels, 293–94, 294*f*, 377

**lub sound of heart**, 384

**lumbar nerves**, 176–77, 178*f*

**lung(s)**

anatomy of, 446, 446*f*

circulation to and from, 368–69, 368*f*

mechanics of, 449–60

nonrespiratory functions of, 480

relation to thoracic (chest) wall, 449, 449*f*

**lung compliance (C<sub>L</sub>)** (come-PLYE-ance) change in lung volume caused by a given change in transpulmonary pressure; the greater the lung compliance, the more readily the lungs are expanded, 453–56, 456*f*–57*f*

**lung disease**, 458

**lung mechanics** physical interactions of the lungs, diaphragm, and chest wall that generate inspiration and expiration, 453–8

**lung volumes and capacities**, 458, 459*f*

**luteal phase** (LOO-tee-al) last half of menstrual cycle following ovulation; corpus luteum is active ovarian structure, 626, 626*f*, 627*f*, 629–31, 631*f*

**luteinizing hormone (LH)** (LOO-tee-en-ize-ing) glycoprotein gonadotropic hormone secreted by anterior pituitary gland; rapid increase in females at midmenstrual cycle initiates ovulation; stimulates Leydig cells in males, 322*f*, 335–37, 335*f*, 337*f*–38*f*, 612–13, 613*f* in female physiology, 627–31, 627*f*, 630*f*, 630*t*, 641

in male physiology, 619–20, 619*f*

**lymph** (limf) fluid in lymphatic vessels, 407–8, 665

**lymphatic capillaries** (lim-FAT-ik) smallest-diameter vessel types of the lymphatic system; site of entry of excess extracellular fluid, 407–8, 408*f*

**lymphatic nodules** local aggregates of lymphocytes scattered within the small intestine, most notably in the ileum, 534

**lymphatic system** network of vessels that conveys lymph from tissues to blood and to lymph nodes along these vessels, 5*t*, 407–9, 408*f*

**lymphatic vessels** vessels of the lymphatic system in which excess interstitial fluid is transported and returned to the circulation; along the way, the fluid (lymph) passes through lymph nodes, 407–9, 408*f*

**lymph nodes** small organs containing lymphocytes, located along lymph vessel; sites of lymphocyte cell division and initiation of adaptive immune responses, 407–9, 408*f*, 665, 665*f*

**lymphocyte(s)** (LIMF-oh-sites) leukocyte types responsible for adaptive immune defenses; B cells, T cells, and NK cells, 364*f*, 367, 656*f*, 657, 658*t*

circulation of, 664–66

functions of, 666, 668*f*

origins of, 666, 667*f*

**lymphocyte activation** cell division and differentiation of lymphocytes following antigen binding, 664

**lymphocyte receptors**, 668–70

**lymphoid organs** (LIMF-oid) bone marrow, lymph node, spleen, thymus, tonsil, or aggregate of lymphoid follicles, 664–66.

*See also* primary lymphoid organs; secondary lymphoid organs

**lysergic acid diethylamide (LSD)**, 168

**lysosomes** (LYE-soh-sohmz) membrane-bound cell organelles containing digestive enzymes in a highly acidic solution that breaks down bacteria, large molecules that have entered the cell, and damaged components of the cell, 47*f*, 53–54, 660*t*

## M

**macromolecules** large organic molecules composed of up to thousands of atoms, such as proteins or polysaccharides, 30

**macrophages** (MAK-roh-fahje-es or MAK-rohfayj-es) cells that phagocytize foreign matter, process it, present antigen to lymphocytes, and secrete cytokines (monokines) involved in inflammation, activation of lymphocytes, and systemic acute phase response to infection or injury, 365, 656, 658*t*, 661*f*, 670*f*, 679, 679*t*. *See also* activated macrophages

**macula densa** (MAK-you-lah DEN-sah) specialized sensor cells of renal tubule at end of loop of Henle; component of juxtaglomerular apparatus, 491*f*, 492*f*, 493, 494*f*

**macula lutea** a region at the center of the retina that is relatively free of blood vessels and that is specialized for highly acute vision, 207, 207*f*, 215

**macular degeneration**, 216

**magnetic resonance imaging (MRI)**, 235, 707, 707*f*, 708*f*

**major histocompatibility complex (MHC)** group of genes that code for major histocompatibility complex proteins, which are important for specific immune function, 669–70, 670*t*, 673*f*, 676, 676*f*

**malabsorption**, 556

**malaria**, 366

**malar (butterfly) rash**, 690, 690*f*

**male climacteric**, 622

**male pattern baldness**, 620

**male reproductive system**, 614–22

aging and, 622

anatomy of, 614–15, 615*f*

physiology of, 615–20

puberty in, 620–21

**malignant hyperthermia**, 296–97, 297*f*

**malleus** one of three bones in the inner ear that transmit movements of the tympanic membrane to the inner ear, 217–18, 218f

**malnutrition, protein**, 406

**mammary glands** milk-secreting glands in breast, 645–47, 646f

**mania**, 246

**mannitol**, 518

**margination** initial step in leukocyte action in inflamed tissues, in which leukocytes adhere to the endothelial cell, 660

**masculinization**, 610

**mass movement** contraction of large segments of colon; propels fecal matter into rectum, 560

**mast cells** tissue cells that release histamine and other chemicals involved in inflammation, 656–57, 658t, 683–84, 683f

**maternal-fetal unit**, 641

**matrix** (mitochondrial) the innermost mitochondrial compartment, 53, 54f

**maximal oxygen consumption ( $\dot{V}_{O_2}$ ) max** peak rate of oxygen use as physical exertion is increased; increments in workload above this point must be fueled by anaerobic metabolism, 424

**mean arterial pressure (MAP)** average blood pressure during cardiac cycle; approximately diastolic pressure plus one-third pulse pressure, 393–94, 394f, 411–18

**mechanically gated ion channels** membrane ion channels that are opened or closed by deformation or stretch of the plasma membrane, 100, 151

**mechanoreceptors** (meh-KAN-oh-ree-sep-torz or MEK-an-oh-ree-sep-torz) sensory neurons specialized to respond to mechanical stimuli such as touch receptors in the skin and stretch receptors in muscle, 190–91  
auditory (hair cells), 220, 221f  
posture and movement, 201  
touch and pressure, 200, 201f

**median eminence** (EM-ih-nence) region at base of hypothalamus containing capillary tufts into which hypophysiotropic hormones are secreted, 333f, 334

**mediated transport** movement of molecules across membrane by binding to protein transporter; characterized by specificity, competition, and saturation; includes facilitated diffusion and active transport, 100–105, 101f, 105t

**medulla oblongata** (ob-long-GOT-ah) part of the brainstem closest to the spinal cord; controls many vegetative functions such as breathing, heart rate and others, 172, 173f, 173t, 175–76

**medullary cardiovascular center** neuron cluster in medulla oblongata that serves as major integrating center for reflexes affecting heart and blood vessels, 415–16, 415f

**medullary collecting duct** terminal component of the nephron in which vasopressin-sensitive passive water reabsorption occurs, 491f, 493

**medullary respiratory center** part of the medulla oblongata involved in the neural control of rhythmic breathing, 472–73, 472f

**megakaryocytes** (meg-ah-KAR-ee-oh-sites) large bone marrow cells that give rise to platelets, 367

**meiosis** (my-OH-sis) process of cell division leading to gamete (sperm or egg) formation; daughter cells receive only half the chromosomes present in original cell, 605–7, 606f

**meiotic arrest** state of primary oocytes from fetal development until puberty, after which meiosis is completed, 625

**melanopsin** opsin-like pigment in a subclass of retinal ganglion cells that relay information about day length to the hypothalamus, 214

**melatonin** an amine derived from tryptophan produced in the pineal gland and that plays a role in circadian rhythms, 14, 322f

**membrane(s)**, 46–51, 48f. *See also specific membranes*  
excitable, 149  
movement across, 46, 95–117, 98f, 101f, 105t, 106f, 109f–13f  
semipermeable, 108

**membrane attack complex (MAC)** group of complement proteins that form channels in microbe surface and destroy microbe, 661, 674, 674f

**membrane junctions**, 49–51, 50f

**membrane potential** voltage difference between inside and outside of cell, 99, 100f, 143–58, 149t  
action, 150–56, 151f–56f, 157t  
depolarized, 149–53, 149f–53f, 159–60, 160f  
graded, 149–50, 150f–51f, 157t, 190–91, 191f, 235–37  
hyperpolarized, 149–53, 149f–53f  
overshoot in, 149, 149f  
repolarized, 149, 149f, 151–53, 151f–53f  
resting, 144–49, 144f–48f

**membrane proteins**, 48–49, 48f, 49f

**memory**, 248–50, 249f. *See also* declarative memory; procedural memory; working memory

**memory cells** B cells or T cells that differentiate during an initial infection and respond rapidly during subsequent exposure to same antigen, 664

**memory encoding** processes by which an experience is transformed to a memory of that experience, 248

**menarche** (MEN-ark-ee) onset, at puberty, of menstrual cycling in women, 633

**Ménière’s disease**, 229

**meninges** (men-IN-jees) protective membranes that cover brain and spinal cord, 181, 183f

**meningitis**, 181

**menopause** (MEN-ah-paws) cessation of menstrual cycling in middle age, 634

**menstrual cycles** (MEN-stroo-al) refers to cyclical rise and fall in female reproductive hormones and processes, beginning with menstruation, 623, 627–33, 632t  
ovarian changes in, 627–31, 627f–31f  
uterine changes in, 631–32, 631f

**menstrual phase** time during menstrual cycle in which menstrual blood is present, 631–32, 631f

**menstruation** (men-stroo-AY-shun) flow of menstrual fluid from uterus; also called *menstrual period*, 623

**mesangial cells** modified smooth muscle cells that surround renal glomerular capillary loops; they help to control glomerular filtration rate, 493, 494f

**mesocortical dopamine pathway** neural tract from midbrain to frontal lobe involved in signaling of positive emotions associated with rewarding events, 243

**mesolimbic dopamine pathway** neural pathway through the limbic system that uses dopamine as its neurotransmitter and is involved in reward, 243, 243f

**messenger RNA (mRNA)** ribonucleic acid that transfers genetic information for a protein’s amino acid sequence from DNA to ribosome, 58–62, 62t

**messengers, chemical.** *See* chemical messengers; *specific types*

**metabolic acidosis**, 476, 523–24, 524t

**metabolic alkalosis**, 476, 523–24, 524t

**metabolic bone diseases**, 355–356

**metabolic pathway** sequence of enzyme-mediated chemical reactions by which molecules are synthesized and broken down in cells, 76–90, 76f, 89f. *See also specific pathways*  
absorptive state, 573–76, 573f, 576t  
postabsorptive state, 576–78, 577f

**metabolic rate** total-body energy expenditure per unit time, 587–89, 588t

**metabolism** (meh-TAB-uhl-izm) chemical reactions that occur in a living organism, 71  
absorptive state, 573–76, 573f, 576t  
aerobic, 80–82  
anaerobic, 82–83  
in energy and stress, 584–85, 585f  
postabsorptive state, 576–78, 577f, 578t  
skeletal muscle, 275–77

**metabotropic receptors** (meh-tab-oh-TRO-pik) membrane receptors in neurons that initiate formation of second messengers when bound with ligand, 160, 170

**metarterioles** (MET-are-teer-ee-olz) blood vessels that directly connect arteriole and venule, 401

**methimazole**, 698

**methylphenidate**, 242

**MHC proteins (class I and class II)** plasma membrane proteins coded for by a major histocompatibility complex; restrict T-cell receptor’s ability to combine with antigen on cell, 669–71, 670t

**micelles** (MY-sellz) soluble clusters of amphipathic molecules in which molecules’ polar regions line surface and nonpolar regions orient toward center; formed from fatty acids, monoglycerides, and bile salts during fat digestion in small intestine, 555–6, 555f

**microbes** microorganisms including bacteria that cause disease, 655

**microcephaly** birth defect characterized by a small head and an underdeveloped brain, 142

**microcirculation** blood circulation in arterioles, capillaries, and venules, 368, 401–2, 401f

**microglia** a type of glial cell that acts as a macrophage, 141, 141f

**microscopy, of cells**, 45–46, 45f

**microtubules** tubular cytoplasmic filaments composed of the protein tubulin; provide internal support for cells and allow change in cell shape and organelle movement in cell, 47f, 55, 55f

**microvilli** (singular, **microvillus**) (my-kroh-VIL-i) small fingerlike projections from epithelial-cell surface; microvilli greatly increase surface area of cell; characteristic of epithelium lining small intestine and kidney nephrons, 547, 548f

**micturition** (mik-chur-RISH-un) urination, 500–1

**midbrain** the most rostral section of the brainstem, 172, 173f, 175–76

**middle ear** air-filled space in temporal bone; contains three ear bones that conduct sound waves from tympanic membrane to cochlea, 217–20, 218*f*–19*f*, 219*f*

**mifepristone**, 647–48

**migrating myoelectrical complex (MMC)** pattern of peristaltic waves that pass over small segments of intestine after absorption of meal, 559

**milk ejection reflex** process by which milk is moved from mammary gland alveoli into ducts, from which it can be sucked; due to oxytocin, 646

**mineral(s)**, digestion and absorption of, 557–8

**mineral elements** essential elements such as Na, Cl, K, S, Mg, Ca, and P that collectively make up most of the solutes in body fluids, 23, 89

**mineralization** the process of calcifying bone collagen to form lamellar bone, 353

**mineralocorticoid** (min-er-al-oh-KORT-ih koid) steroid hormone produced by adrenal cortex; has major effect on sodium and potassium balance; major mineralocorticoid is aldosterone, 325

**minute ventilation** ( $\dot{V}_E$ ) total ventilation per minute; equals tidal volume times respiratory rate, 458–60

**miscarriage**, 640

**mitochondria** (my-toh-KON-dree-a) rod-shaped or oval cytoplasmic organelles that produce most of cell's ATP; sites of Krebs cycle and oxidative-phosphorylation enzymes, 47*f*, 52–53, 54*f*–55*f*

**mitosis** (my-TOH-sis) process in cell division in which DNA is duplicated and copies of each chromosome are passed to daughter cells as the nucleus divides, 605

**mitral valve** (MY-tral) valve between left atrium and left ventricle of heart, 372, 373*f*, 374*f*

**M line** transverse stripe occurring at the center of the A band in cardiac and skeletal muscle; location of energy-generating enzymes and proteins connecting adjacent thick filaments, 259*f*, 260, 261*f*

**modality** (moh-DAL-ih-tee) type of sensory stimulus, 192–93

**modulator molecule** ligand that, by acting at an allosteric regulatory site, alters properties of other binding sites on a protein and thus regulates its functional activity, 70, 70*f*

**mole** the amount of a compound in grams equal to its molecular weight, 28–29

**molecular weight** sum of atomic weights of all atoms in molecule, 28–29

**molecule** chemical substance formed by linking atoms together, 23–27  
covalent bonds in, 23–25, 24*f*  
ionic, 26, 27*t*  
organic, 30–39, 30*t*  
shape of, 25–26, 26*f*, 27*f*  
solubility of, 28, 28*f*

**monoamine oxidase (MAO)** enzyme that breaks down catecholamines in axon terminal and synapse, 167

**monoamine oxidase (MAO) inhibitors**, 167, 246

**monocular vision** visual perception by a single eye, 213, 213*f*

**monocytes** (MAH-noh-sites) types of leukocytes; leave bloodstream and are transformed into macrophages, 367, 656, 656*f*, 658*t*

**monoiodotyrosine (MIT)** a singly iodinated tyrosine molecule that is an intermediate in the synthesis of thyroid hormones, 340*f*, 341

**monomers**, 34

**monosaccharides** (mah-noh-SAK-er-eyedz) carbohydrates consisting of one sugar molecule, which generally contains five or six carbon atoms, 30–31, 30*f*

**monosynaptic reflex** (mah-noh-sih-NAP-tik) reflex in which the afferent neuron directly activates motor neurons, 305

**monounsaturated fatty acid** a fatty acid, such as oleic acid, in which one carbon-carbon double bond is formed within the hydrocarbon chain due to the removal of two hydrogen atoms, 31

**mood** a long-term inner emotion that affects how individuals perceive their environment, 418

**mood disorders**, 246–47

**morphine**, 170, 184

**motile cilia**, 56

**motilin** (moh-TIL-in) intestinal hormone thought to initiate the migrating myoelectrical complex in the GI tract, 559

**motility** movement of the gastrointestinal tract mediated by muscular contractions, 533, 534*f*, 535*t*  
gastric, 545–57, 545*f*–46*f*  
large intestine, 560–1  
small intestine, 558–9, 559*f*

**motion sickness**, 224

**motivations**. *See* primary motivated behavior

**motor** having to do with muscles and movement, 262

**motor association areas**, 308–9, 309*f*

**motor control hierarchy**, 302–4, 302*f*–303*f*, 303*t*

**motor cortex** strip of cerebral cortex along posterior border of frontal lobe; gives rise to many axons descending in corticospinal and multineuronal pathways; also called *primary motor cortex*, 308–9, 309*f*–10*f*

**motor end plate** specialized region of muscle cell plasma membrane that lies directly under axon terminal of a motor neuron, 260–65

**motor neuron pool** all the motor neurons for a given muscle, 301–2

**motor program** pattern of neural activity required to perform a certain movement, 302–3

**motor proteins**, 34*t*

**motor unit** motor neuron plus the muscle fibers it innervates, 260–65, 279*f*, 301–2

**mountain sickness**, 480

**mouth**, 532, 532*f*, 538–41, 540*f*, 561*t*

**MPTP** (1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine), 310

**mucosa** (mew-KOH-sah) three layers of gastrointestinal tract wall nearest lumen—that is, epithelium, lamina propria, and muscularis mucosa, 535, 536*f*, 547*f*

**mucus, immune function of**, 538–39, 539*t*, 657

**Müller cells** (Myoo-ler) funnel-shaped glial cells that aid light transmission through the retina, 209

**Müllerian ducts** (mul-AIR-ee-an) parts of embryo that, in a female, develop into reproductive system ducts, but in a male, degenerate, 607–11, 608*f*, 610*f*

**multimeric proteins**, 36–37, 37*f*, 70

**multiple sclerosis**, 185–86, 186*f*, 684

**multipotent hematopoietic stem cells** single population of bone marrow cells from which all blood cells are descended, 364, 364*f*

**multiunit smooth muscles** smooth muscles that exhibit little, if any, propagation of electrical activity from fiber to fiber and whose contractile activity is closely coupled to their neural input, 293, 295*t*

**murmurs, heart**, 384–85, 384*f*

**muscarinic receptors** (muss-kur-IN-ik) acetylcholine receptors that respond to the mushroom poison muscarine; located on smooth muscle, cardiac muscle, some CNS neurons, and glands, 166, 180*f*, 181, 181*t*

**muscle** many muscle fibers bound together by connective tissue, 2*f*, 3, 257–97 *See also specific types*  
cardiac, 3, 258, 293–95  
metabolic activity of, 588, 588*f*  
skeletal, 3, 258–87  
smooth, 3, 258, 287–93

**muscle cells** specialized cells containing actin and myosin filaments and capable of generating force and movement, 2–3, 2*f*. *See also specific types*

**muscle cramps**, 283, 313

**muscle fatigue** decrease in muscle tension with prolonged activity, 276–77, 276*f*

**muscle fiber** muscle cell, 258–59, 259*f*. *See also* skeletal muscle

**muscle soreness**, 281

**muscle spindle** a receptor organ, made up of specialized muscle fibers, that detects stretch of skeletal muscles, 305, 305*f*

**muscle-spindle stretch receptors** capsule-enclosed arrangements of afferent neuron endings around specialized skeletal muscle fibers; sensitive to stretch, 200–201, 305, 305*f*–306*f*

**muscle tissue** one of the four major tissue types in the body, comprising smooth, cardiac, and skeletal muscle; can be under voluntary or involuntary control, 2*f*, 3

**muscle tone** degree of resistance of muscle to passive stretch due to ongoing contractile activity  
skeletal muscle, 312–13  
smooth muscle, 290

**muscular dystrophy**, 283–84, 284*f*

**muscularis externa** two layers of muscle in the gastrointestinal tract consisting of circular and longitudinal muscle, 535, 536*f*, 547*f*

**muscularis mucosa** layer of muscular tissue beneath the lamina propria of the alimentary canal, 535, 536*f*, 547*f*

**musculoskeletal system**, 5*t*

**mutagens** (MUTE-uh-jenz) factors in the environment that increase mutation rate, 64

**mutation** (mew-TAY-shun) any change in base sequence of DNA that changes genetic information, 38, 64

**myasthenia gravis**, 284–85, 684

**myelin** (MYE-uh-lin) insulating material covering axons of many neurons; consists of layers of myelin-forming cell plasma membrane wrapped around axon, 138, 138*f*, 141*f* in action potential, 155–56, 156*f* in multiple sclerosis, 185–86, 186*f*

**myenteric plexus** (mye-en-TER-ik PLEX-us) nerve cell network between circular and



longitudinal muscle layers in esophagus, stomach, and intestinal walls, 535, 536f

**myoblasts** (MYE-oh-blasts) embryological cells that give rise to muscle fibers, 258–59

**myocardial infarction**, 427–30

**myocardium** (mye-oh-KARD-ee-um) cardiac muscle, which forms heart walls, 372, 373f

**myoepithelial cells** (mye-oh-ep-ih-THEE-lee-al) specialized contractile cells in certain exocrine glands; contraction forces gland's secretion through ducts, 645

**myofibrils** (mye-oh-FY-brils) bundles of thick and thin contractile filaments in cytoplasm of striated muscle; myofibrils exhibit a repeating sarcomere pattern along longitudinal axis of muscle, 259f–62f, 260–61

**myogenic responses** (mye-oh-JEN-ik) responses originating in muscle, 397

**myoglobin** (mye-oh-GLOH-bin) muscle fiber protein that binds oxygen, 277

**myometrium** (mye-oh-MEE-tree-um) uterine smooth muscle, 631, 631f

**myopia**, 208–9, 209f

**myosin** (MYE-oh-sin) contractile protein that forms thick filaments in muscle fibers, 259f, 260, 260f

**myosin ATPase** enzymatic site on globular head of myosin that catalyzes ATP breakdown to ADP and Pi, releasing the chemical energy used to produce force of muscle contraction, 260

**myosin light-chain kinase** smooth muscle protein kinase; when activated by  $\text{Ca}^{2+}$ –calmodulin, phosphorylates myosin light chain, 288–289

**myosin light-chain phosphatase** enzyme that removes high-energy phosphate from myosin; important in the relaxation of smooth muscle cells, 289

**myostatin** (my-oh-STAT-in) a protein secreted from skeletal muscle cells as a negative regulator of muscle growth, 281

**myxedema**, 343

## N

**NAD<sup>+</sup>** nicotinamide adenine dinucleotide; formed from the B-vitamin niacin and involved in transfer of hydrogens during metabolism, 74, 80–83, 80f

**Na-K-2Cl cotransporter (NKCC)** mediated-transport protein that is involved in active transport of  $\text{Na}^+$ ,  $\text{K}^+$ , and  $\text{Cl}^-$  in the ascending limb of the loop of Henle, 504

**$\text{Na}^+/\text{K}^+$ –ATPase pump** primary active-transport protein that hydrolyzes ATP and releases energy used to transport sodium ions out of cell and potassium ions in, 102–3, 103f

**narcolepsy**, 239

**natriuresis** significant increase in sodium excretion in the urine, which secondarily causes water loss, 513

**natural antibodies** antibodies to the erythrocyte antigens (of the A or B type), 681

**natural killer (NK)** cells lymphocytes that bind to virus-infected and cancer cells without specific recognition and kill them directly; participate in antibody-dependent cellular cytotoxicity, 657, 658t, 666, 671–72, 675, 677, 677f

**natural selection** the process whereby mutations in a gene lead to traits that favor survival of an organism, 64

**nearsightedness**, 208–9, 209f

**necrosis**, 703

**negative balance** loss of substance from body exceeds gain, and total amount in body decreases; also used for physical parameters such as body temperature and energy; *compare* positive balance, 14

**negative feedback** characteristic of control systems in which system's response opposes the original change in the system; *compare* positive feedback, 8, 8f, 10–11, 11f, 337–38, 338f

**negative nitrogen balance** net loss of amino acids in the body over any period of time, 88

**neoplasm**, 707

**nephritis**, 690

**nephrons** (NEF-ronz) functional units of kidney; have vascular and tubular components, 4, 490–93, 491f

**Nernst equation** calculation for electrochemical equilibrium across a membrane for any single ion, 146–47

**nerve** group of many axons from numerous neurons, encased in connective tissue and traveling together in peripheral nervous system, 3, 139, 140f, 172, 176–77

**nervous system**, 5t, 136–88. *See also specific divisions*  
cells of, 137–43  
growth and regeneration in, 141–42  
structure of, 172–85, 172f

**nervous tissue** one of the four major tissue types in the body, responsible for coordinated control of muscle activity, reflexes, and conscious thought, 2f, 3

**net filtration pressure (NFP)** algebraic sum of inward and outward-directed forces that determine the direction and magnitude of fluid flow across a capillary wall, 404

**net flux** difference between two one-way fluxes, 96–97, 98f

**net glomerular filtration pressure** sum of the relevant forces resulting in glomerular filtration; it is the hydrostatic pressure within the glomerular capillary ( $P_{GC}$ ) minus the hydrostatic pressure in Bowman's space ( $P_{BS}$ ) and minus the osmotic force in the glomerular capillary ( $\pi_{GC}$ ), 495–96

**neuroeffector communication**, 170

**neuromodulators** chemical messengers that act on neurons, usually by a second-messenger system, to alter response to a neurotransmitter, 165

**neuromuscular junction** synapselike junction between an axon terminal of an efferent neuron and a skeletal muscle fiber, 262–65, 263f

**neuron** (NUR-ahn) cell in nervous system specialized to initiate, integrate, and conduct electrical signals, 2, 2f, 3, 137–41, 137f, 140f, 140t  
afferent, 138–139, 140f, 140t  
death of (stroke), 183  
efferent, 138–39, 140f, 140t  
electrical activity of, 235–37  
graded potentials in, 149–50, 150f–51f  
growth and development of, 141–42  
motor, 177, 178t, 262–65, 263f, 279–80, 301–8  
polymodal, 197–98, 197f  
postganglionic, 179–81

postsynaptic, 139, 141f  
preganglionic, 179, 181  
presynaptic, 139, 141f  
receptive field of, 192, 192f  
resting membrane potential in, 144–49, 144f, 145f  
somatic, 176–77, 178t

**neuropeptides** family of more than 50 neurotransmitters composed of 2 or more amino acids; often also function as chemical messengers in nonneural tissues, 165t, 169–170

**neuropeptide Y** a peptide found in the brain whose actions include control of reproduction, appetite, and metabolism, 589

**neurotransmitters** chemical messengers used by neurons to communicate with each other or with effectors, 11, 12, 12f, 137, 165–70, 165t  
in audition, 220, 221f  
in autonomic nervous system, 180–81, 180f  
binding to receptors, 160  
release of, 159–60, 160f  
removal from synapse, 160  
reuptake of, 160  
terminology for, 166

**neurotrophic factors**, 142

**neutrons** noncharged components of the nucleus of an atom, 21, 21f

**neutrophils** (NOO-troh-filz) polymorphonuclear granulocytic leukocytes whose granules show preference for neither eosin nor basic dyes; function as phagocytes and release chemicals involved in inflammation, 364f, 367, 656, 656f, 658t

**nicotine**, 166

**nicotinic receptors** (nik-oh-TIN-ik) acetylcholine receptors that respond to nicotine; primarily, receptors at motor end plate and on postganglionic autonomic neurons, 166, 180f, 181, 181t

**nitric oxide** a gas that functions as intercellular messenger, including neurotransmitters; is endothelium-derived relaxing factor; destroys intracellular microbes, 170, 292, 397–99, 398–99, 432, 432f, 618, 618f, 660t, 661

**nitrogen balance**, 88

**nitroglycerin**, 429

**NMDA receptors** (N-methyl-D-aspartate receptors) ionotropic glutamate receptors involved in learning and memory, 168–169, 168f

**nociceptors** (NOH-sih-sep-torz) sensory receptors whose stimulation causes pain, 191, 201–3, 202f

**nodes of Ranvier** (RAHN-vee-ay) spaces between adjacent myelin-forming cells along myelinated axon where axonal plasma membrane is exposed to extracellular fluid; also called *neurofibril nodes*, 138, 138f

**noncholinergic, nonadrenergic autonomic neurons**, 398

**nonexercise activity thermogenesis (NEAT)** the generation of heat due to all activities other than sleep, eating and performing sports-like exercise; includes such things as standing, walking, and fidgeting, 588

**nonmotile cilia**, 56

**nonpenetrating solutes** dissolved substances that do not passively diffuse across a plasma membrane, 108

**nonpolar covalent bonds** bonds between two atoms of similar electronegativities, 25, 25t

**nonpolar molecules** any molecules with characteristics that favor solubility in oil and decreased solubility in water, 25

**nonpolar side chain**, 35, 35f

**non-REM sleep**, 236–37, 237f, 238t

**“nonsequence” hormones**, 338–39

**nonshivering thermogenesis** the creation of bodily heat by processes other than shivering; for example, certain hormones can stimulate metabolism in brown adipose tissue, resulting in heat production in infants (but this does not occur to any significant extent in adults), 595

**nonspecific ascending pathways** chains of synaptically connected neurons in CNS that are activated by sensory units of several different types; signal general information; *compare* specific ascending pathways, 197–98, 197f

**nonsteroidal anti-inflammatory drugs (NSAIDs)**, 131

**nontropical sprue**, 556

**nonvolatile acids** organic (e.g., lactic) or inorganic (e.g., phosphoric and sulfuric) acids not derived directly from carbon dioxide, 521

**norepinephrine** (nor-ep-ih-NEF-rin) biogenic amine (catecholamine) neurotransmitter released at most sympathetic postganglionic endings, from adrenal medulla, and in many CNS regions, 167, 180–81, 180f, 322f, 323, 323f  
in blood flow (arteriole) control, 398, 398f  
synthesis of, 167, 167f

**normal range**, 6–7

**Norpramin (desipramine)**, 246

**Novocaine (procaine)**, 153

**NREM sleep** sleep state associated with large, slow EEG waves and considerable postural muscle tone; also called *slow-wave sleep*, 236–37, 237f, 238t

**nuclear bag fiber** specialized stretch receptor in skeletal muscle spindles that responds to both the magnitude of muscle stretch and the speed at which it is stretched, 305

**nuclear chain fiber** specialized stretch receptor in skeletal muscle spindles that responds in direct proportion to the length of a muscle, 305

**nuclear envelope** double membrane surrounding cell nucleus, 47f, 51, 52f

**nuclear pores** openings in nuclear envelope through which molecular messengers pass between nucleus and cytoplasm, 47f, 51, 52f

**nuclear receptors** members of a family of receptor proteins that are localized in cell nuclei, or which are transported to the nucleus upon activation; include the steroid and thyroid hormone receptors, 122–23, 123f

**nucleic acids** (noo-KLAY-ik) nucleotide polymers in which phosphate of one nucleotide is linked to the sugar of the adjacent one; store and transmit genetic information; include DNA and RNA, 30t, 38–39

**nucleolus** (noo-KLEE-oh-lus or noo-klee-OH-lus) densely staining nuclear region containing portions of DNA that code for ribosomal proteins, 47f, 51, 52f

**nucleosomes** (NOO-clee-oh-sohmz) nuclear complexes of several histones and their associated coils of DNA, 57

**nucleotide** (NOO-klee-oh-tide) molecular subunit of nucleic acid; purine or pyrimidine base, sugar, and phosphate, 38–39, 38f

**nucleus** (NOO-klee-us) (plural, *nuclei*) (cell) large membrane-bound organelle that contains cell’s DNA; (neural) cluster of neuron cell bodies in CNS  
atomic, 21, 21f  
cellular, 46, 47f, 51, 52f  
neural, 172

**nutritional guidelines**, 592, 592t

**nystagmus**, 223

## O

**obesity**, 591–92, 600

**obligatory water loss** minimal amount of water required to excrete waste products, 506

**obstructive lung diseases**, 458

**obstructive sleep apnea**, 484–85, 484f–85f

**occipital lobe** (ok-SIP-ih-tul) posterior region of cerebral cortex where primary visual cortex is located, 173f, 174

**occipital lobe association area**, 197f

**oculomotor nerve (cranial nerve III)**, 177t

**odorant** molecule received by the olfactory system that induces a sensation of smell, 226

**Ohm’s law** current ( $I$ ) is directly proportional to voltage ( $V$ ) and inversely proportional to resistance ( $R$ ) such that  $I = V/R$ , 143–44

**olfaction** (ol-FAK-shun) sense of smell, 225–26, 226f

**olfactory bulbs** (ol-FAK-tor-ee) anterior protuberances of the brain containing cells that process odor inputs, 226, 226f

**olfactory cortex** region on the inferior and medial surface of the frontal lobe of the cerebral cortex where information about the sense of smell is processed, 197, 197f

**olfactory epithelium** mucous membrane in upper part of nasal cavity containing receptors for sense of smell, 226, 226f

**olfactory nerve (cranial nerve I)**, 177t

**oligodendrocytes** (oh-lih-goh-DEN-droh-sites) type of glial cells; responsible for myelin formation in CNS, 138, 138f, 141f

**omeprazole**, 562

**oncogenes**, 671

**oogenesis** (oh-oh-JEN-ih-sis) gamete production in female, 605–7, 606f, 624, 625f

**oogonium** (oh-oh-GOH-nee-um; plural, *oogonia*) primitive germ cell that gives rise to primary oocyte, 624, 625f

**open ion channels**, 100, 100f

**ophthalmoscope**, 207

**opioids, endogenous**, 170, 203, 204f

**opponent color cells** ganglion cells in the retina that are inhibited by input from one type of cone photoreceptor but activated by another type of cone photoreceptor, 214, 215f

**opsins** (OP-sinz) protein components of photopigment, 210, 211f

**opsonin** (op-SOH-nin or OP-soh-nin) any substance that binds a microbe to a phagocyte and promotes phagocytosis, 661, 662, 662f

**optic chiasm** (KYE-azm) place at base of brain at which optic nerves meet; some neurons cross here to other side of brain, 212–13

**optic disc** region of the retina where neurons to the brain exit the eye; lack of photoreceptors here results in a “blind spot,” 207, 207f

**optic nerve** bundle of neurons connecting the eye to the optic chiasm, 177t, 207

**optic tracts** bundles of neurons connecting the optic chiasm to the lateral geniculate nucleus of the thalamus, 213

**optimal length ( $L_0$ )** sarcomere length at which muscle fiber develops maximal isometric tension, 274

**oral anticoagulants**, 437

**oral contraceptives**, 647

**orexins** (oh-REK-sins) peptide neurotransmitters involved in the regulation of wakefulness, food intake, and energy expenditure; also known as *hypocretins*, 239–40

**organ(s)** collections of tissues joined in structural units to serve common function, 2f, 3, 4

**organelles**, 46, 51–56

**organic molecules**, 30–39, 30t. *See also specific types*

**organ of Corti** (KOR-tee) structure in inner ear capable of transducing sound wave energy into action potentials, 218, 219f, 220

**organ systems** organs that together serve an overall function, 2f, 3, 4, 5t

**orgasm** (OR-gazm) inner emotions and systemic physiological changes that mark apex of sexual intercourse, usually accompanied in the male by ejaculation, 619, 634

**orienting response** behavior in response to a novel stimulus; that is, the person stops what he or she is doing, looks around, listens intently, and turns toward stimulus, 241–42

**osmol** (OZ-mole) 1 mole of solute ions and molecules, 106–7

**osmolality** (oz-moh-LAR-ih-tee) total solute concentration of a solution; measure of water concentration in that the higher the solution osmolality, the lower the water concentration, 106–9, 109t

**osmoreceptors** (OZ-moh-ree-sep-torz) receptors that respond to changes in osmolality of surrounding fluid, 514f, 515–16

**osmosis** (oz-MOH-sis) net diffusion of water across a selective barrier from region of higher water concentration (lower solute concentration) to region of lower water concentration (higher solute concentration), 105–9, 106f, 107f, 403–4

**osmotic diuresis** increase in urine flow resulting from increased solute excretion (e.g., glucose in uncontrolled diabetes mellitus), 506

**osmotic diuretics**, 518

**osmotic pressure** (oz-MAH-tik) pressure that must be applied to a solution on one side of a membrane to prevent osmotic flow of water across the membrane from a compartment of pure water; a measure of the solution’s osmolality, 108

**osteoblasts** (OS-tee-oh-blats) cell types responsible for laying down protein matrix of bone; called osteocytes after calcified matrix has been set down, 348, 353, 353f

**osteoclasts** (OS-tee-oh-clats) cells that break down previously formed bone, 353, 353f

**osteocytes** cells transformed from osteoblasts when surrounded by mineralized bone matrix, 353, 353f

**osteoid** collagen matrix in bone that becomes mineralized, 352–53

**osteomalacia**, 355

**osteoporosis**, 346, 355, 634

**otoliths** (OH-toe-liths) calcium carbonate crystals embedded in the mucous covering of the auditory hair cell, 223, 223f

**outer ear**, 217, 218f

**outer hair cells** cells of the cochlea with stereocilia that sharpen frequency tuning by modulating the movement of the tectorial membrane, 220, 221f

**outer segment** light-sensitive portion of the photoreceptor containing photopigments, 209

**ova** (singular, **ovum**) gametes of female; eggs, 605, 606f, 623, 624, 625f

**oval window** membrane-covered opening between middle ear cavity and scala vestibuli of inner ear, 217–18, 218f, 219f

**ovary** (OH-vah-ree; plural, **ovaries**) gonad in female, 623, 623f  
cyclical changes in, 624–26, 627–31, 627f–31f  
development of, 607, 608f  
endocrine function of, 322f, 325–26, 326f  
functions of, 624–27  
hormonal control of, 627–33  
oogenesis in, 605–7, 606f, 624, 625f

**overshoot** part of the action potential in which the membrane potential goes above zero, 149, 149f

**overweight**, 591–92, 600–601

**ovulation** (ov-you-LAY-shun) release of egg, surrounded by its zona pellucida and granulosa cells, from ovary, 623, 624–27, 629, 630f, 636

**oxidative deamination** (dee-am-ih-NAY-shun) reaction in which an amino group ( $-\text{NH}_2$ ) from an amino acid is replaced by oxygen to form a keto acid, 87–88, 87f–88f

**oxidative fibers** muscle fibers that have numerous mitochondria and therefore a high capacity for oxidative phosphorylation; red muscle fibers, 277–78

**oxidative phosphorylation** (fos-for-ih-LAY-shun) process by which energy derived from reaction between hydrogen and oxygen to form water is transferred to ATP during its formation, 78, 80, 82–84, 83f, 84f, 84t, 275f, 276

**oxygen**  
content in systemic arterial blood, 466t  
and hemoglobin, 466–67, 466f–67f  
and hypoxia, 479, 479t  
partial pressure of and gas exchange, 461–62, 462f  
respiratory exchange of, 460–65, 461f  
transport in blood, 365, 465–70  
and ventilation control, 473–75, 474f, 477f  
and ventilation during exercise, 477, 478f  
ventilation-perfusion inequality and, 479

**oxygen-carrying capacity** maximum amount of oxygen the blood can carry; usually proportional to the amount of hemoglobin per unit volume of blood, 466

**oxygen consumption, maximal**, 424

**oxygen debt** decrease in energy reserves during exercise that results in an increase in oxygen consumption and an increased production of ATP by oxidative phosphorylation following the exercise, 276

**oxygen-hemoglobin dissociation curve** S-shaped (sigmoid) relationship between the gas pressure of oxygen (partial pressure of  $\text{O}_2$ ) and amount of oxygen bound to hemoglobin per unit blood (hemoglobin saturation), 466, 466f

**oxyhemoglobin ( $\text{HbO}_2$ )** (ox-see-HEE-moh-gloh-bin) hemoglobin combined with oxygen, 465, 471

**oxymetazoline**, 122

**oxytocin** (ox-see-TOE-sin) peptide hormone synthesized in hypothalamus and released from posterior pituitary; stimulates mammary glands to release milk and uterus to contract, 322f, 334, 643, 645, 645f, 647f

**P**

**pacemaker** neurons that set rhythm of biological clocks independent of external cues; any neuron or muscle cell that has an inherent autorhythmicity and determines activity pattern of other cells circadian, 13–14  
ectopic, 378  
sinoatrial node as, 375–78, 385, 385f

**pacemaker, artificial**, 378

**pacemaker potential** spontaneous gradual depolarization to threshold of some neurons and muscle cells' plasma membrane, 149t, 156, 291, 377–78, 377f

**pain**, 201–3, 202f–3f

**pain receptors**, 191, 201–3, 202f

**palpitations**, 695–99

**pancreas** elongated gland behind the stomach with both exocrine (secretes digestive enzymes into the gastrointestinal tract) and endocrine (secretes insulin into the blood) functions, 322f, 532, 532f, 538t, 548–51, 549f, 551f, 561t

**pancreatic enzymes**, 548–51, 550f, 550t

**pancreatic lipase** hydrolytic enzyme secreted from the pancreas into the small intestine, where it digests triglycerides, 550t, 554–5

**papilla** (puh-PIL-ah) connection between the tip of the medulla and the calyx in the kidney, 490, 490f

**papillary muscles** (PAP-ih-lair-ee) muscular projections from interior of ventricular chambers that connect to atrioventricular valves and prevent backward flow of blood during ventricular contraction, 372, 373f

**paracellular pathway** the space between adjacent cells of an epithelium through which some molecules diffuse as they cross the epithelium, 111, 111f

**paracrine substances** (PAR-ah-krin) chemical messengers that exert their effects on cells near their secretion sites; by convention, exclude neurotransmitters; *compare* autocrine substances, 11–12, 12f

**paradoxical sleep**. *See* REM sleep

**parasympathetic division (of the autonomic nervous system)** (par-ah-sim-pah-THET-ik) portion of autonomic nervous system whose preganglionic fibers leave CNS from brainstem and sacral portion of spinal cord; most of its postganglionic fibers release acetylcholine; *compare* sympathetic division, 178–81, 179f, 180f, 182t, 398

**parathyroid glands** four parathyroid-hormone-secreting glands on thyroid gland surface, 322f, 353–54, 354f

**parathyroid hormone (PTH)** polypeptide hormone secreted by parathyroid glands; regulates calcium and phosphate concentrations of extracellular fluid, 133–34, 353–56, 354f, 517

**parietal cells** (pah-RYE-ih-tal) gastric gland cells that secrete hydrochloric acid and intrinsic factor, 541, 542f, 543f

**parietal lobe** region of cerebral cortex containing sensory cortex and some association cortex, 173f, 174

**parietal lobe association area**, 197f

**parietal-lobe association cortex** region of cerebrum involved in integrating inputs from primary sensory cortices, as well as higher-order cognitive processing and motor control, 308–9, 309f

**parietal pleura** (pah-RYE-it-al ploor-ah) serous membranes covering the inside of the chest wall, the diaphragm, and the mediastinum, 449, 449f

**Parkinson's disease**, 310–11

**parotid gland**, 532f, 538, 539f

**paroxetine**, 167, 246

**partial pressures** those parts of total gas pressure due to molecules of one gas species; measures of concentration of a gas in a gas mixture, 461–62, 466–67, 473–76

**parturition** events leading to and including delivery of infant, 643–45, 644f, 645f

**passive immunity** resistance to infection resulting from direct transfer of antibodies or sensitized T cells from one person (or animal) to another; *compare* active immunity, 675

**pathogen-associated molecular patterns (PAMPs)** conserved molecular features common to many types of pathogens; they are recognized by cells mediating the innate immune response, 663

**pathogens** viruses or microbes that elicit immune responses in the body, and which may cause disease, 655–56

**pathophysiology** the study of the mechanisms of disease states, 2, 7, 694

**pathway** series of connected neurons that move a particular type of information from one part of the brain to another part ascending (sensory), 196–98, 197f  
CNS, 172  
motivation, 243–44, 243f  
somatosensory, 204–5, 205f  
vestibular, 223–24  
vision, 211–14

**pattern-recognition receptors (PRRs)** a family of proteins that bind to ligands found in many types of pathogens; include the Toll-like receptors found on dendritic cells, 664

**Paxil (paroxetine)**, 167, 246

**pendrin** sodium-independent chloride/iodide transporter, 340f, 341

**penicillin**, 681

**pentoses** five-carbon monosaccharides, 31

**pepsin** (PEP-sin) family of several protein-digesting enzymes formed in the stomach; breaks protein down to peptide fragments, 544–45, 545f, 554

**pepsinogen** (pep-SIN-ah-jen) inactive precursor of pepsin; secreted by chief cells of gastric mucosa, 544–45, 545f

**peptidases**, 554, 554f

**peptide bond** polar covalent chemical bond joining the amino and carboxyl groups of two amino acids; forms protein backbone, 35, 35f

**peptide hormones** members of a family of hormones, like insulin, composed of approximately two to 50 amino acids; generally soluble in acid, unlike larger protein hormones, which are insoluble, 323–24, 324f, 328–29



**peptidergic** neuron that releases peptides, 169

**percent hemoglobin saturation** the percentage of available hemoglobin subunits bound to molecular oxygen at any given time, 466

**perception** understanding of objects and events of external world that we acquire from neural processing of sensory information, 190, 198, 242–43

**percutaneous transcatheter aortic valve replacement (TAVR)**, 440

**perforated ulcer**, 563*f*

**perforation**, 703

**perforin** protein secreted by cytotoxic T cells; may form channels in plasma membrane of target cell, which destroys it, 677

**pericardium** (per-ee-KAR-dee-um) connective-tissue sac surrounding heart, 372, 373*f*

**perilymph** fluid that fills the cochlear duct of the inner ear, 218

**perimenopause** beginning period leading to cessation of menstruation, 634

**peripheral chemoreceptors** carotid or aortic bodies; respond to changes in arterial blood  $P_{O_2}$  and  $H^+$  concentration, 473–76, 473*f*, 474*t*

**peripheral membrane proteins** hydrophilic proteins associated with cytoplasmic surface of cell membrane, 48–49, 48*f*

**peripheral nervous system (PNS)** nerves extending from CNS, 137, 172*f*, 176–77  
 afferent division of, 172*f*, 176  
 autonomic division of, 176–81, 178*t*  
 efferent division of, 172*f*, 176  
 glial cells of, 141  
 nerves of, 139, 140*f*, 172  
 somatic division of, 176–77, 178*t*

**peripheral thermoreceptors** cold or warm receptors in skin or certain mucous membranes, 594, 595*f*

**peripheral veins** blood vessels outside the chest cavity that return blood from capillaries toward the heart, 406

**peristalsis** wavelike muscular movements along the length of a segment of the alimentary canal, 533

**peristaltic waves** (per-ih-STAL-tik) progressive waves of smooth muscle contraction and relaxation that proceed along wall of a tube, compressing the tube and causing its contents to move  
 esophageal, 540–41  
 gastric, 545–57, 545*f*

**peritoneal dialysis**, 526–27

**peritonitis**, 703–5

**peritubular capillaries** capillaries closely associated with renal tubule, 491*f*, 493

**permissiveness** the facilitation of the action of one hormone by another; for example, the effects of epinephrine are exacerbated by thyroid hormone and by cortisol, 328, 328*f*

**pernicious anemia**, 365, 557

**peroxisomes** (per-OX-ih-sohmz) cell organelles that destroy certain toxic products by oxidative reactions, 47*f*, 54

**persistent vegetative state**, 240

**pH** expression of a solution's acidity; negative logarithm to base 10 of  $H^+$  concentration; pH decreases as acidity increases, 29, 521

**phagocytes** (FA-go-sytz) any cells capable of phagocytosis, 657, 661, 661*f*, 662*f*

**phagocytosis** (fag-oh-sye-TOH-sis) engulfment of particles by a cell, 109, 110*f*, 656, 661, 661*f*, 674, 674*f*

**phagolysosome** an intracellular vesicle formed when a lysosome and a phagosome combine; the contents of the lysosome begin the process of destroying the contents of the phagosome, 661, 661*f*

**phagosomes** plasma-membrane-bound, intracellular sacs formed when a phagocyte engulfs a microbe, 109, 110*f*, 661, 661*f*

**phantom limb**, 198

**pharmacological effects**, 329

**pharynx** (FA-rinks) throat; passage common to routes taken by food and air, 446, 446*f*, 532, 532*f*, 539–540, 561*t*  
 digestive functions of, 538–41, 540*f*

**phase-shift** a resetting of the circadian clock due to altered environmental cues, 13

**phenotype** (FEE-noh-type) gender based on physical appearance, 607

**phenylephrine**, 122

**phenytoin**, 709

**phlebotomy**, 558

**phosphate**, renal regulation of, 517

**phosphate group**, of nucleotides, 38–39, 38*f*, 39*f*

**phosphatidylinositol biphosphate (PIP<sub>2</sub>)**, 128, 129*f*

**phospholipase A<sub>2</sub>** (fos-foh-LY-pase A-two) enzyme that splits arachidonic acid from plasma membrane phospholipid, 130, 131*f*

**phospholipase C** receptor-controlled plasma membrane enzyme that catalyzes phosphatidylinositol bisphosphate breakdown to inositol triphosphate and diacylglycerol, 128

**phospholipids** (fos-foh-LIP-idz) lipid subclass similar to triglycerides except that a phosphate group ( $—PO_4^{2-}$ ) and small nitrogen-containing molecule are attached to third hydroxyl group of glycerol; major components of cell membranes, 32–34, 33*f*, 555–6  
 in plasma membrane, 46–48, 49, 49*f*

**phosphoprotein phosphatases** (FOS-fah-tases) enzymes that remove phosphate from protein, 71

**phosphorylation** (fos-for-ah-LAY-shun) addition of phosphate group to an organic molecule, 70–71  
 oxidative, 78, 82–84, 83*f*, 84*f*, 84*t*, 275*f*, 276  
 receptor, 131  
 substrate-level, 80

**photopigments** light-sensitive molecules altered by absorption of photic energy of certain wavelengths; consist of opsin bound to a chromophore, 210, 211*f*

**photoreceptors** sensory cells specialized to respond to light; contain pigments that make them sensitive to different light wavelengths, 191, 207, 209–14, 2110*f*–12*f*

**phrenic nerves** main motor nerves innervating the diaphragm and providing the impulses to inspire, 452

**physiological dead space** sum of the anatomical and alveolar dead spaces; it is the part of the respiratory tree in which gas exchange with blood does not occur, 460

**physiology** (fiz-ee-OL-uh-jee) branch of biology dealing with the mechanisms by which living organisms function compartmentalization in, 5  
 general principles of, 14–15

homeostasis as defining feature of, 5–7  
 integrative, 694–95  
 medical, 694–709

**pia mater** (PEE-ah MAH-ter) innermost of three membranes (meninges) covering the brain, 181, 183*f*

**pigment epithelium** dark, innermost layer of the retina; absorbs light that bypasses photopigments, 209

**pineal gland** part of the epithalamus of the brain; produces melatonin involved in circadian rhythms, 14, 175, 322*f*

**pinna**, 217, 218*f*

**pinocytosis** (pin-oh-sye-TOH-sis or PYE-no-sye-toh-sis) endocytosis when the vesicle encloses extracellular fluid or specific molecules in the extracellular fluid that have bound to proteins on the extracellular surface of the plasma membrane, 109, 110*f*

**pituitary gland** (pih-TOO-ih-tar-ee) endocrine gland that lies in bony pocket below hypothalamus; constitutes anterior pituitary gland and posterior pituitary gland, 174*f*, 175, 322*f*, 333–39, 333*f*, 344–46

**pituitary tumors**, 651–52, 652*f*

**placebo**, 203–4

**placenta** (plah-SEN-tah) interlocking fetal and maternal tissues that serve as organ of molecular exchange between fetal and maternal circulations, 638–39, 640*f*

**plasma** (PLAS-muh) liquid portion of blood; component of extracellular fluid, 4, 6*f*, 363–64, 371*t*  
 bicarbonate addition to, 522–23, 522*f*–23*f*  
 protein-free, flow across capillary wall, 403–6

**plasma cells** cells that differentiate from activated B lymphocytes and secrete antibodies, 657, 658*t*

**plasma flow, renal**, 500

**plasma membrane** membrane that forms outer surface of cell and separates cell's contents from extracellular fluid, 46–51, 47*f*–50*f*, 47*t*  
 ion distribution across, 144–45, 145*t*  
 movement across, 46, 95–117, 98*f*, 101*f*, 105*t*, 106*f*, 109*f*–13*f*  
 potentials of, 99, 143–57

**plasma membrane receptors**, 119, 120*f*

**plasmapheresis**, 285

**plasma proteins** most are albumins, globulins, or fibrinogen, 364

**plasmin** (PLAZ-min) proteolytic enzyme able to decompose fibrin and thereby to dissolve blood clots, 436, 436*f*

**plasminogen** (plaz-MIN-oh-jen) inactive precursor of plasmin, 436, 436*f*

**plasminogen activators** plasma proteins that activate proenzyme plasminogen, 436, 436*f*

**plasticity** (plas-TISS-ih-tee) ability of neural tissue to change its responsiveness to stimulation because of its past history of activation, 142, 164, 250

**platelet(s)** (PLATE-lets) cell fragments present in blood; play several roles in blood clotting, 363, 364*f*, 367

**platelet-activating factor**, 660*t*

**platelet activation** changes in the metabolism, shape, and surface proteins of platelets that begin the clotting process, 431

**platelet aggregation** positive feedback process resulting in platelets sticking together, 431, 435

**platelet factor (PF)** phospholipid exposed in membranes of aggregated platelets; important in activation of several plasma factors in clot formation, 433

**platelet plug** blockage of a vessel by activated, adherent platelets, 431–32, 432f

**pleura** (PLOOR-ah) thin cellular sheet attached to thoracic cage interior (*parietal pleura*) and, folding back upon itself, attached to lung surface (*visceral pleura*); forms two enclosed pleural sacs in thoracic cage, 449, 449f

**pleural sac** membrane enclosing each lung, 449

**pneumotaxic center** (noo-moh-TAK-sik) area of the upper pons in the brain that modulates activity of the apneustic center, 472f, 473

**pneumothorax**, 452, 452f

**podocytes** epithelial cells lining Bowman's capsule, whose foot processes form filtration slits, 491, 492f, 494f

**Poiseuille's law** (PWAA-zuh-eez) resistance is directly proportional to fluid viscosity and vessel length, and inversely proportional to the fourth power of the vessel radius, 370

**polar body**, 606–7, 606f

**polar covalent bonds** covalent chemical bonds in which two electrons are shared unequally between two atoms of different electronegativities; atom to which the electrons are drawn becomes slightly negative, while other atom becomes slightly positive; also called *polar bonds*, 24–25, 25t

**polar molecules** pertaining to molecules or regions of molecules containing polar covalent bonds or ionized groups; parts of molecules to which electrons are drawn become slightly negative, and regions from which electrons are drawn become slightly positive; molecules are soluble in water, 25

**polar side chain**, 35, 35f

**poliomyelitis**, 283

**polycythemia**, 366

**polymers** (POL-ih-merz) large molecules formed by linking together smaller similar subunits, 30

**polymodal neurons** sensory neurons that respond to more than one type of stimulus, 197–98, 197f

**polypeptide** (pol-ee-PEP-tide) polymer consisting of amino acid subunits joined by peptide bonds, 35–38, 35f

**polysaccharides** (pol-ee-SAK-er-eyedz) large carbohydrates formed by linking monosaccharide subunits together, 31, 32f

**polysynaptic** a neuronal pathway such as occurs in some reflexes in which two or more synapses are present, 305

**polyunsaturated fatty acid** fatty acid that contains more than one double bond, 31, 33f

**pons** large area of the brainstem containing many neuron axons, 172, 173f, 173t, 175–76

**pontine respiratory group** neurons in the pons that modulate respiratory rhythms, 472f, 473

**pool** the readily available quantity of a substance in the body; often equals amounts in extracellular fluid, 14

**portal system** a type of circulation characterized by two capillary beds connected by veins called portal veins, 369

**portal triads**, 551, 552f

**positive balance** gain of substance exceeds loss, and amount of that substance in body increases; *compare* negative balance, 14

**positive feedback** characteristic of control systems in which an initial disturbance sets off train of events that increases the disturbance even further; *compare* negative feedback, 8, 9f

**positive nitrogen balance** a period in which there is net gain of nitrogen (amino acids) in the body, 88

**positron emission tomography (PET)**, 22, 22f, 235

**postabsorptive state** period during which nutrients are not being absorbed by gastrointestinal tract and energy must be supplied by body's endogenous stores, 573

**endocrine and neural control of**, 578–84, 579f

**nutrient metabolism in**, 576–78, 577f, 578t

**posterior pituitary** portion of pituitary gland from which oxytocin and vasopressin are released, 333f, 334

**postganglionic neurons** (post-gang-gee-ON-ik) autonomic-nervous-system neurons whose cell bodies lie in a ganglion; conduct impulses away from ganglion toward periphery; *compare* preganglionic neurons, 177, 179–81

**postsynaptic density** area in the postsynaptic cell membrane that contains neurotransmitter receptors and structural proteins important for synapse function, 159

**postsynaptic mechanisms**, 164

**postsynaptic neuron** (post-sin-NAP-tik) neuron that conducts information away from a synapse, 139, 141f, 159f, 160–61

**posttranslational modifications**, 62, 62f

**postural reflexes** reflexes that maintain or restore upright, stable posture, 313–14

**posture**, 223–24

**blood pressure effects of**, 420–21, 421f

**maintenance of**, 313–14, 314f

**sense of**, 200–201

**potassium** (potassium ions)

**in action potential**, 151–56

**in cardiac muscle contraction**, 376–77, 376f–77f

**in graded potentials**, 149–50

**renal regulation of**, 516–17, 517f

**in resting membrane potential**, 143–49, 145f–48f, 145t

**potassium-sparing diuretics**, 518

**potential**, 143–44, 149t. *See also* action potential(s); graded potentials

**potential difference** a difference in charge between two points, 143, 149t

**potentiation** (poh-ten-she-AY-shun) presence of one agent enhances response to a second such that final response is greater than sum of the two individual responses, 537

**potocytosis** (poh-toe-sye-TOE-sis) a type of receptor-mediated endocytosis in which vesicle contents are delivered directly to the cytosol, 111

**power stroke** the step of a cross-bridge cycle involving physical rotation of the globular head, 269

**pralidoxime**, 264

**preattentive processing** neural processes that occur to direct our attention to a particular aspect of the environment, 241

**pre-Botzinger complex** neurons of the ventral respiratory group in the medulla that are the respiratory rhythm generator, 473

**precapillary sphincter** (SFINK-ter) smooth muscle ring around capillary where it exits from thoroughfare channel or arteriole, 401

**precocious puberty**, 634

**preeclampsia**, 642–43

**preganglionic neurons** autonomic-nervous system neurons whose cell bodies lie in CNS and whose axon terminals lie in a ganglion; conduct action potentials from CNS to ganglion; *compare* postganglionic neurons, 177, 179–80

**pregnancy**, 636–45

**digestive function in**, 541

**ectopic**, 637

**hormonal changes in**, 641–42, 641f, 642t

**maternal-fetal unit in**, 641

**maternal responses to**, 642t

**prevention of**, 647–48, 648t

**pregnancy sickness**, 643

**preinitiation complex** a group of transcription factors and accessory proteins that associate with promoter regions of specific genes; the complex is required for gene transcription to commence, 63

**prekallikrein** precursor for kallikrein, 397

**preload** the amount of filling of ventricles just prior to contraction; the end-diastolic volume, 386

**premenstrual dysphoric disorder (PMDD)**, 632

**premenstrual syndrome (PMS)**, 632

**premenstrual tension**, 632

**premotor area** region of the cerebral cortex found on the lateral sides of the brain in front of the primary motor cortex; involved in planning and enacting complex muscle movements, 308–9, 309f

**pre-mRNA**. *See* primary RNA transcript

**presbyopia**, 208

**pressure**, sensation of, 200, 201f

**pressure natriuresis** increase in sodium excretion induced by a local action within the renal tubules due to an increase in the arterial pressure within the kidney, 513

**presynaptic facilitation** (pre-sin-NAP-tik) excitatory input to neurons through synapses at the nerve terminal, 163

**presynaptic inhibition** inhibitory input to neurons through synapses at the axon terminal, 163

**presynaptic mechanisms**, 163–64, 163f

**presynaptic neuron** neuron that conducts action potentials toward a synapse, 139, 141f

**presyncope**, 229

**primary active transport** active transport in which chemical energy is transferred directly from ATP to transporter protein, 102–3, 103f

**primary adrenal insufficiency**, 346

**primary cilia**, 56

**primary hyperparathyroidism**, 355–356

**primary hypersecretion**, 331

**primary hypertension**, 425

**primary hypoparathyroidism**, 356

**primary hyposecretion**, 330–31

**primary lymphoid organs** organs that supply secondary lymphoid organs with mature lymphocytes; bone marrow and thymus, 664–65

**primary motivated behavior** behavior related directly to achieving homeostasis, 243–44

**primary motor cortex.** *See* motor cortex

**primary oocytes** (OH-oh-sites) female germ cells; can undergo first meiotic division to form secondary oocyte and polar body, 605, 606*f*, 625, 625*f*

**primary RNA transcript** an RNA molecule transcribed from a gene before intron removal and splicing, 59, 59*f*

**primary sensory coding,** 192–96

**primary spermatocytes** (sper-MAT-uh-sites) male germ cells derived from spermatogonia; each undergoes meiotic division to form two secondary spermatocytes, 605, 606*f*

**primary structure** the amino acid sequence of a protein, 36, 36*f*

**primordial follicles** (FAH-lik-elz) immature oocytes encased in a single layer of granulosa cells, 625, 626*f*

**procaine,** 153

**procedural memory** the memory of how to do things, 248–50, 249*f*

**progesterone** (proh-JES-ter-own) steroid hormone secreted by corpus luteum and placenta; stimulates uterine gland secretion, inhibits uterine smooth muscle contraction, and stimulates breast growth, 322*f*, 326, 605, 612, 612*f* effects of, 632, 633*t* in menstrual cycle, 627–33, 627*f*, 628*t*, 629*f*, 632*t* in pregnancy, 641–42, 641*f*

**prognathism,** 358

**prohormones** peptide precursors from which are cleaved one or more active peptide hormones, 322–24, 324*f*

**prokaryotic cells** cells such as bacteria that do not contain their genetic information within membrane-enclosed nuclei, 46

**prolactin** (pro-LAK-tin) polypeptide hormone secreted by anterior pituitary gland; stimulates milk synthesis by mammary glands, 322*f*, 335–36, 335*f*, 646, 647*f*, 651–52

**prolactinomas,** 652

**prolactin-releasing factor (PRF)** putative hypothalamic factor that stimulates prolactin release, 646

**prolapse (valve),** 372

**proliferative phase** (pro-LIFF-er-ah-tive) stage of menstrual cycle between menstruation and ovulation during which endometrium repairs itself and grows, 631–32, 631*f*

**promoter** specific nucleotide sequence at beginning of gene that controls the initiation of gene transcription; determines which of the paired strands of DNA is transcribed into RNA, 59, 59*f*

**proprioception** (PROH-pree-oh-sep-shun) sense of posture and position; sensory information dealing with the position of the body in space and its parts relative to one another, 224, 303

**proptosis,** 695, 696*f*

**propylthiouracil,** 698

**prosody** (PRO-so-dee) attributes of human speech that include rhythm, emphasis, and intonation, 251

**prostacyclin** eicosanoid that inhibits platelet aggregation in blood clotting; also called *prostaglandin I<sub>2</sub>* (PGI<sub>2</sub>), 399, 432, 432*f*

**prostaglandin(s)** (pross-tah-GLAN-dinz) members of one class of a group of modified unsaturated fatty acids (eicosanoids) that function mainly as paracrine or autocrine factors, 130–31, 131*f*, 170, 645, 645*t* in female physiology, 631–32, 643–45, 645*t* in male physiology, 615

**prostaglandin I<sub>2</sub>** (PGI<sub>2</sub>). *See* prostacyclin

**prostate cancer,** 620

**prostate gland** (PROSS-tate) large gland encircling urethra in the male; secretes seminal fluid into urethra, 615, 615*f*

**proteases** (PROH-tee-ases) enzymes capable of breaking peptide bonds in a protein, 87, 532

**proteasome** a complex of proteins capable of denaturing (unfolding) other proteins and assisting in protein degradation, 64

**protective reflexes,** in ventilation, 478

**protein** large polymer consisting of one or more sequences of amino acid subunits joined by peptide bonds to form a functional molecule with multiple levels of structure, 30*t*, 34–38, 34*t*, 68–69, 68*f*–69*f* in absorptive state, 576 affinity of, 68, 68*f* amino acid sequences of, 38, 58, 58*f* assembly of, 60–62 binding sites of, 66–71, 67*f*–70*f* conformation of, 36–38 degradation of, 64 digestion and absorption of, 554, 554*f* functions of, 34*t*, 71–77 inflammation and permeability to, 659–60 integral membrane, 48, 48*f* intracellular, 4 metabolism of, 87–88, 87*f*, 88*f* multimeric, 36–37, 37*f*, 70 peripheral membrane, 48–49, 48*f* posttranslational modification of, 62, 62*f* primary structure of, 36, 36*f* receptor, 10, 109–10, 119–22 secondary structure of, 36, 37*f* secretion of, 64–65, 65*f* synthesis of, 51, 57–64, 57*f*, 59*f*, 60*f*, 62*t*, 63*f* tertiary structure of, 36, 37*f* transmembrane, 48, 48*f*, 49*f*, 119, 120*f* transporter, 100–105

**protein C** plasma protein that inhibits clotting, 435–36, 435*f*

**protein hormones,** 323–24

**protein kinase** (KYE-nase) any enzyme that phosphorylates other proteins by transferring to them a phosphate group from ATP, 71, 123–29

**protein kinase A,** 126*f*, 127

**protein kinase C** enzyme that phosphorylates certain intracellular proteins when activated by diacylglycerol, 128

**protein malnutrition,** 406

**proteolysis** the process whereby peptides and proteins are cleaved into smaller molecules, by the actions of specific enzymes (proteases), 87

**proteome** all of the proteins expressed by a particular cell at a given time, 59

**prothrombin** (proh-THROM-bin) inactive precursor of thrombin; produced by liver and normally present in plasma, 432–34, 433*f*

**protons** (PROH-tahnz) positively charged subatomic particles, 21–22, 21*f*

**proximal tubule** first tubular component of a nephron after Bowman's capsule; comprises *convoluted* and *straight segments*, 491*f*–92*f*, 493

**Prozac (fluoxetine),** 246

**pseudohypoparathyroidism,** 133–34, 356

**psychoactive substances,** 244–48, 248*t*

**PTH-related peptide (PTHrp),** 356

**puberty** attainment of sexual maturity when conception becomes possible; as commonly used, refers to 3 to 5 years of sexual development that culminates in sexual maturity, 620 female, 633–34 male, 620–21

**puberty, precocious,** 634

**pulmonary** (PUL-mah-nar-ee) pertaining to lungs, 445

**pulmonary arterial pressure,** 412, 414*t*

**pulmonary arteries** large, branching vessels carrying oxygen-poor blood away from the heart toward the lungs, 368*f*, 369*f*, 373*f*

**pulmonary circulation** circulation through lungs; portion of circulatory system between pulmonary trunk, as it leaves the right ventricle, and pulmonary veins, as they enter the left atrium, 368–69, 368*f*

**pulmonary circulation pressures,** 384, 384*f*

**pulmonary edema,** 426–27, 464, 480, 704

**pulmonary embolism,** 479, 699–702, 700*f*

**pulmonary function tests,** 458

**pulmonary hypertension,** 484

**pulmonary stretch receptors** afferent neuron endings located in airway smooth muscle and activated by lung inflation, 473

**pulmonary trunk** large artery that splits into the pulmonary arteries that carry blood from right ventricle of heart to lungs, 368, 368*f*, 373*f*

**pulmonary valves** valves between right ventricle of heart and pulmonary trunk, 372–73, 373*f*, 374*f*

**pulmonary veins** large, converging vessels that return oxygen-rich blood toward the heart from the lungs, 368, 368*f*, 373*f*

**pulse pressure** difference between systolic and diastolic arterial blood pressures, 392

**pupil** opening in iris of eye through which light passes to reach retina, 206–9, 207*f*

**purine** (PURE-ene) double-ring, nitrogen-containing subunit of nucleotide; adenine or guanine, 38–39, 38*f*, 39*f*, 165*t*, 170

**Purkinje fibers** (purrr-KIN-jee) specialized myocardial cells that constitute part of conducting system of heart; convey excitation from bundle branches to ventricular muscle, 375*f*, 376

**pus,** 703

**P wave** component of electrocardiogram reflecting atrial depolarization, 378, 378*f*, 380*f*

**pyloric sphincter** (py-LOR-ik) ring of smooth muscle between stomach and small intestine, 541, 541*f*, 545*f*, 545–46

**pyramidal cells** large neurons with characteristic pyramid-shaped cell body and apical dendrite, 174, 174*f*

**pyramidal system** descending nervous system pathways that originate in the cerebral cortex, cross over the midline in the medulla,



and control fine movements of the distal extremities, 312

**pyramidal tracts.** *See* corticospinal pathways  
**pyridostigmine**, 284

**pyrimidine** (pi-RIM-ih-deen) single-ring, nitrogen-containing subunit of nucleotide; cytosine, thymine, or uracil, 38–39, 38f, 39f

**pyrogen, endogenous**, 596–97

**pyruvate** (PYE-roo-vayt or pye-ROO-vayt) anion formed when pyruvic acid loses a hydrogen ion, 78–81, 79f–80f

**pyruvic acid** (pye-ROO-vik) three-carbon intermediate in glycolysis that, in absence of oxygen forms lactic acid or, in presence of oxygen, enters Krebs cycle, 78, 79f

## Q

**QRS complex** component of electrocardiogram corresponding to ventricular depolarization, 378, 378f, 380f

**quaternary structure** formed when two or more polypeptides associate with each other by hydrogen bonds and other forces; the individual polypeptides are then termed subunits, 36–37

## R

**radiation** emission of heat from the surface of an object, 593, 595–96

**radioactive iodine**, 698–99

**radioisotopes** unstable isotopes of atoms that spontaneously emit energy or components of the atom itself, 22

**rapid eye movement (REM) sleep**, 236–37, 237f, 238t

**rapidly adapting receptors** sensory receptors that fire for a brief period at the onset and/or offset of a stimulus, 192, 192f

**rate-limiting reaction** slowest reaction in metabolic pathway; catalyzed by rate-limiting enzyme, 76

**reactive hyperemia** (hye-per-EE-me-ah) transient increase in blood flow following release of occlusion of blood supply, 397

**receptive field** (of neuron) area of body that, if stimulated, results in activity in that neuron, 192–95, 192f, 194f–95f, 212, 213f

**receptive relaxation** relaxation of the smooth muscles of the stomach (fundus and body) when food is swallowed; mediated by parasympathetic nerves in the enteric nerve plexuses, 545

**receptor** (for messengers) protein either on cell surface, in the cytosol, or in the nucleus that binds a chemical messenger such as a hormone or neurotransmitter and mediates its actions; (in sensory system) specialized peripheral ending of afferent neuron, or separate cell intimately associated with it, that detects changes in some aspect of environment, 10, 109–10, 119–23, 121f, 121t. *See also specific types* as enzymes, 125  
G-protein-coupled, 125–26  
hormone, 327–28

inactivation of, 131

ionotropic, 160

as ligand-gated ion channels, 123–25

neurotransmitter binding to, 160

nuclear, 122–23, 123f

in reflex arc, 10, 10f, 11f

sensory, 138–39, 190–92, 191f

**receptor activation** change in receptor conformation caused by combination of messenger with receptor, 122

**receptor desensitization** temporary inability of a receptor to respond to its ligand due to prior ligand binding, 164

**receptor-mediated endocytosis** the specific uptake of ligands in the extracellular fluid by regions of the plasma membrane that invaginate and form intracellular vesicles, 109–10, 110f

**receptor potential** graded potential that arises in afferent neuron ending, or a specialized cell intimately associated with it, in response to stimulation, 149t, 156, 191–92, 191f–92f

**receptor tyrosine kinases** the major types of receptor proteins that are themselves enzymes; these receptors are on plasma membranes and respond to many different water-soluble chemical messengers, 125

**reciprocal innervation** inhibition of motor neurons activating muscles whose contraction would oppose an intended movement, 307

**recognition** binding of antigen to receptor specific for that antigen on lymphocyte surface, 672–74

**recombinant t-PA**, 437, 701–2

**recruitment** activation of additional cells in response to increased stimulus strength; increasing the number of active motor units in a muscle, 193, 279

**rectum** short segment of large intestine between sigmoid colon and anus, 532f

**red blood cells.** *See* erythrocytes

**red muscle fibers** muscle fibers having high oxidative capacity and large amount of myoglobin, 277

**referred pain**, 201–2, 202f, 203f

**reflex** (REE-flex) biological control system linking stimulus with response and mediated by a reflex arc, 10–11. *See also specific reflexes*

learned or acquired, 10

long, 536–37, 537f

monosynaptic, 305

polysynaptic, 305

postural, 313–14

short, 536–37, 537f

stretch, 305–7, 307f

temperature-regulating, 594–96, 595f

use of term, 11

withdrawal, 307–8, 308f

**reflex arc** neural or hormonal components that mediate a reflex; usually includes receptor, afferent pathway, integrating center, efferent pathway, and effector, 10, 10f, 11f

**reflexive memory**, 249

**refraction** bending of light rays when passing between compartments of different density, as from air into the cornea of the eyes, 207–8, 208f

**refraction errors**, 208–9, 209f

**refractory periods**, 153–54, 154f, 380, 380f

**regulatory site** site on protein that interacts with modulator molecule; alters functional site properties, 70, 70f

**regulatory T cells** immune (T) cells that are believed to suppress immune function and may minimize the likelihood of autoimmunity, 666

**relative refractory period** time during which excitable membrane will produce action potential but only to a stimulus of greater strength than the usual threshold strength, 154, 154f

**relaxation** return of muscle to a low force-generating state, caused by detachment of cross-bridges, 262

**relaxin** hormone secreted by the placenta that influences the maternal cardiovascular system, 642

**REM sleep** sleep state associated with small, rapid EEG oscillations, complete loss of tone in postural muscles, and dreaming; also called *rapid eye movement sleep*, *paradoxical sleep*, 236–37, 237f, 238t

**renal** (REE-nal) pertaining to kidneys, 489

**renal artery** high-pressure vessel bringing blood to the kidney, 490, 490f

**renal capsule**, 490, 490f

**renal clearance**, 499–500, 500f

**renal corpuscle** combination of glomerulus and Bowman's capsule, 491f, 492f, 494f

**renal cortex** outer portion of the kidney, 490, 490f

**renal hypertension**, 425, 526

**renal medulla** inner portion of the kidney, 490, 490f

**renal papilla**, 490, 490f

**renal pelvis** cavity at base of each kidney; receives urine from collecting-duct system and empties it into ureter, 490f, 491f, 493

**renal physiology**, 488–527

basic processes in, 493–97, 494f, 495f

division of labor in, 499, 517, 518t

hydrogen ion regulation in, 520–24

ion and water balance in, 503–18

micturition in, 500–1

renal clearance in, 499–500

**renal plasma flow** the total amount of plasma (blood minus red cell volume) that passes through both kidneys per unit time, 500

**renal vein** low-pressure vessel draining blood from the kidney, 490, 490f

**renin** (REE-nin) enzyme secreted by kidneys that catalyzes splitting off of angiotensin I from angiotensinogen in plasma, 511

**renin-angiotensin system** hormonal system consisting of renin-stimulated angiotensin I production followed by conversion to angiotensin II by angiotensin-converting enzyme, 511–13, 511f–12f

**repetitive transcranial magnetic stimulation (rTMS)**, 246

**repolarized** transmembrane potential returned to its resting level after a depolarization, 149, 149f, 151–53, 151f–53f

**reproduction**

definition of, 605

general endocrinologic principles in, 611–13  
processes in, 605

**reproductive system, 5t**  
 female, 623–48  
 male, 614–22

**residual volume (RV)** air volume remaining in lungs after maximal expiration, 458, 459f

**resistance (R)** hindrance to movement through a particular substance, tube, or opening, 143, 369–70, 370f

**resistance to infection, 679–81**

**respiration** (1) utilization of oxygen and production of carbon dioxide at the cellular level (i.e., cellular respiration); (2) exchange of oxygen and carbon dioxide between the organism and the environment via the lungs, 445  
 altitude and, 480, 480t  
 control of, 471–79, 477f  
 exercise and, 477, 478f  
 hydrogen ions and, 476, 476f, 477, 477f, 478f  
 neural generation of rhythmic breathing in, 471–73, 472f  
 partial pressure of carbon dioxide and, 475–76, 475f, 477, 477f, 478f  
 partial pressure of oxygen and, 473–75, 474f, 477, 477f, 478f  
 protective reflexes in, 478  
 ventilation process in, 449–60  
 voluntary control of, 478

**respiratory acidosis, 471, 523–24, 524t**

**respiratory alkalosis, 471, 523–24, 524t**

**respiratory bronchioles** largest branch of the respiratory tree in which the units of gas exchange (alveoli) appear, 447, 447f, 448f

**respiratory cycle** changes in the lung volumes from the beginning of an inspiration, including the expiration, to the beginning of the next inspiration, 446

**respiratory distress syndrome of the newborn, 456**

**respiratory muscles, 453–55, 455f**

**respiratory pump** mechanism whereby reductions in intrathoracic pressure during the breathing cycle tend to favor the return of blood to the heart from peripheral veins, 406–7, 422–23, 422f

**respiratory quotient (RQ)** ratio of carbon dioxide produced to oxygen consumed during metabolism, 460

**respiratory rhythm generator** neural network in the brainstem that generates output to the phrenic nerve, 473

**respiratory system** the anatomical pathway of air from the atmosphere to the alveoli, 5t  
 functions of, 480, 480t  
 organization of, 446–49, 446f  
 physiology of, 445–85

**respiratory zone** portion of airways from beginning of respiratory bronchioles to alveoli; contains alveoli across which gas exchange occurs, 447, 447f, 449f

**resting membrane potential** voltage difference between inside and outside of cell in absence of excitatory or inhibitory stimulation; also called *resting potential*, 144–49, 144f–48f, 149t

**rest-or-digest state** homeostatic state characteristic of parasympathetic nervous system activation, 181

**restrictive lung diseases, 458**

**retching, 562**

**rete testis** (REE-tee TES-tis) network of canals at the end of the seminiferous tubule in the testis, 614, 615f

**reticular activating system (RAS)** extensive neuron network extending through brainstem core; receives and integrates information from many afferent pathways and from other CNS regions; also called *reticular formation*, 175–76, 238–39, 239f

**reticular formation.** *See* reticular activating system (RAS)

**reticulocyte** (ruh-TIK-you-low-site) name given to immature red blood cells that have a weblike pattern in the cytosol due to the persistence of ribosomes, 365

**retina** thin layer of neural tissue lining back of eyeball; contains receptors for vision, 207–8, 207f–8f, 210f  
 photoreceptors of, 191, 207, 209–14  
 signal processing in, 212

**retinal** (ret-in-AL) form of vitamin A that forms chromophore component of photopigment, 210

**retinal pigment epithelium, 209**

**retrograde** movement of a substance or action potential backward along a neuron, from axon terminals toward the cell body and dendrites, 138

**retrograde amnesia, 249**

**retrograde transport, 138, 139f**

**retroperitoneal organs, 489**

**retropulsion, 546**

**reuptake** active process that recaptures excess secreted neurotransmitter back into the presynaptic cell; can be inhibited with drugs, 160

**reversible reaction** chemical reaction in which energy release is small enough for reverse reaction to occur readily; *compare* irreversible reaction, 72–73, 73t

**reward systems, 243–44**

**rhabdomyolysis, 297**

**rheumatoid arthritis, 684, 685**

**Rh factor** group of erythrocyte plasma membrane antigens that may (Rh<sup>+</sup>) or may not (Rh<sup>-</sup>) be present, 682

**rhodopsin** (roh-DOP-sin) photopigment in rods, 211

**rhythmic breathing, neural generation of, 471–73, 472f**

**rhythm method, 648**

**rhythms, biological, 13–14, 13f**

**ribonuclease, 550t**

**ribonucleic acid (RNA)** (rye-boh-noo-KLAY-ik) single-stranded nucleic acid involved in transcription of genetic information and translation of that information into protein structure; contains the sugar ribose, 38–39. *See also* messenger RNA; ribosomal RNA; transfer RNA  
 composition of, 38f  
 transcription to, 57–60, 57f, 59f, 60f, 62t, 63  
 translation from, 57, 57f, 60–62, 62f, 62t  
 vault, 54–55

**ribose** the sugar backbone of RNA, 38f, 39

**ribosomal RNA (rRNA)** (rye-boh-SOME-al) type of RNA used in ribosome assembly; becomes part of ribosome, 58, 60

**ribosomes** (RYE-boh-sohmz) cytoplasmic particles that mediate linking together of amino acids to form proteins; attached to endoplasmic reticulum as bound ribosomes, or suspended in cytoplasm as free ribosomes, 47f, 51, 53f, 60–62, 61f–62f

**rickets, 355**

**rigidity, 313**

**rigor mortis** (rig-or MOR-tiss) stiffness of skeletal muscles after death due to failure of cross-bridges to dissociate from actin because of the loss of ATP, 269

**Ritalin (methylphenidate), 242**

**RNA.** *See* ribonucleic acid

**RNA polymerase** (poh-LIM-uh-rase) enzyme that forms RNA by joining together appropriate nucleotides after they have base-paired to DNA, 58

**rocuronium, 264–65**

**rods** members of one of two receptor types for photic energy; contain the photopigment rhodopsin, 209–11

**rough endoplasmic reticulum, 47f, 52, 53f, 64–65, 65f**

**round window** membrane-covered opening in the cochlea that responds to fluid movement in the scala tympani, 218, 218f, 219f

**ryanodine receptor** calcium-release channel found in the lateral sacs of the sarcoplasmic reticulum in striated muscle cells, 267, 296–97

**S**

**saccades** (sah-KAADZ) short, jerking eyeball movements, 216

**saccule** structure in the semicircular canals that responds to changes in linear movement of the head by mechanical forces on otoliths located on its surface, 222–23, 222f

**sacral nerves, 176–177, 178f**

**saliva** watery solution of salts and proteins, including mucins and amylase, secreted by salivary glands, 538–39, 539t

**salivary glands** three pairs of exocrine glands around the mouth that produce saliva, 532f, 538–39, 561t

**salt appetite** desire for salt, consisting of hedonistic and regulatory components, 515–16

**saltatory conduction** propagation of action potentials along a myelinated axon such that the action potentials jump from one node of Ranvier in the myelin sheath to the next, 156, 156f

**salty taste, 224**

**sarcolemma** (sar-ko-LEM-uh) the plasma membrane surrounding muscle cells, 261

**sarcomere** (SAR-kuh-meer) repeating structural unit of myofibril; composed of thick and thin filaments; extends between two adjacent Z lines, 259f–61f, 260–61

**sarcoplasmic reticulum** (sar-koh-PLAZ-mik reh-TIK-you-lum) endoplasmic reticulum in muscle fiber; site of storage and release of calcium ions, 261, 261f

**sarin, 166**

**satellite cells** undifferentiated cells found within skeletal muscle tissue that can fuse and develop into new muscle fiber following muscle injury, 259

**satiety** a sensation of “fullness” after eating; a lack of hunger, 589–90

**saturated fatty acid** fatty acid whose carbon atoms are all linked by single covalent bonds, 31, 33f

**saturation** occupation of all available binding sites by their ligand, 68–69, 69*f*, 119, 121*f*, 121*t*

**scala tympani** (SCALE-ah TIM-pah-nee) fluid-filled inner-ear compartment that receives sound waves from basilar membrane and transmits them to round window, 218–19, 218*f*, 219*f*

**scala vestibuli** (ves-TIB-you-lee) fluid-filled inner-ear compartment that receives sound waves from oval window and transmits them to basilar membrane and cochlear duct, 218–19, 218*f*–19*f*, 219*f*

**schizophrenia**, 198, 245

**Schwann cells** nonneural cells that form myelin sheath in peripheral nervous system, 138, 138*f*, 141

**sclera** (SKLAIR-ah) the tough, outermost tissue layer of the eyeball, 206, 207*f*

**scrotum** (SKROH-tum) sac that contains testes and epididymides, 614

**secondary active transport** active transport in which energy released during transmembrane movement of one substance from higher to lower concentration is transferred to the simultaneous movement of another substance from lower to higher concentration, 102, 103–5, 104*f*

**secondary adrenal insufficiency**, 346

**secondary amenorrhea**, 633, 651–52, 651*f*

**secondary hyperparathyroidism**, 356

**secondary hypersecretion**, 331

**secondary hypertension**, 425

**secondary hyposecretion**, 331

**secondary lymphoid organs** lymph node, spleen, tonsil, or lymphocyte accumulation in gastrointestinal, respiratory, urinary, or reproductive tract; sites of stimulation of lymphocyte response, 665

**secondary oocyte** daughter cell (23 chromosomes) retaining most cytoplasm resulting from first meiotic division in the ovary, 606, 606*f*, 625, 625*f*

**secondary peristalsis** (per-ih-STAL-sis) esophageal peristaltic waves not immediately preceded by pharyngeal phase of swallow, 541

**secondary sexual characteristics** external differences between male and female not directly involved in reproduction, 612

**secondary spermatocytes** 23-chromosome cells resulting from the first meiotic division of the primary spermatocytes in the testes, 606, 606*f*

**secondary structure** the alpha-helical and beta pleated sheet structures of a protein, 36, 37*f*

**second messengers** intracellular substances that serve as relays from plasma membrane to intracellular biochemical machinery, where they alter some aspect of cell's function, 123, 126–29, 130*t*

**second polar body** nonfunctional structure containing one of two nuclei resulting from the second meiotic division in the ovary, 606*f*, 607

**secretin** (SEEK-reh-tin) peptide hormone secreted by upper small intestine; stimulates pancreas to secrete bicarbonate into small intestine, 239, 322*f*, 537, 538*t*, 551–53

**secretion** (sih-KREE-shun) elaboration and release of organic molecules, ions, and water by cells in response to specific stimuli, 532–33, 534*f*, 535*f*, 535*t*. *See also specific types*

**secretory phase** (SEEK-rih-tor-ee) stage of menstrual cycle following ovulation during

which secretory type of endometrium develops, 631–32, 631*f*

**secretory vesicles** membrane-bound vesicles produced by Golgi apparatus; contain protein to be secreted by cell, 47*f*, 52, 65, 65*f*

**segmentation** (seg-men-TAY-shun) series of stationary rhythmic contractions and relaxations of rings of intestinal smooth muscle; mixes intestinal contents, 559, 559*f*

**seizures**, 235–36, 236*f*, 706

**selective attention** paying attention to or focusing on a particular stimulus or event while ignoring other ongoing sources of information, 241–42

**selective estrogen receptor modulators (SERMs)**, 355

**selective serotonin reuptake inhibitors (SSRIs)**, 167–68

**sella turcica**, 333*f*

**semen** (SEE-men) sperm-containing fluid of male ejaculate, 615

**semicircular canals** passages in temporal bone; contain sense organs for equilibrium and movement, 218*f*, 222, 222*f*, 223*f*

**semilunar valves**, 372–73, 373*f*, 374*f*

**seminal vesicles** exocrine glands (in males) that secrete fluid into vas deferens, 615, 615*f*

**seminiferous tubules** (sem-ih-NIF-er-ous) tubules in testes in which sperm production occurs; lined with Sertoli cells, 614, 615*f*

**semipermeable membrane** (sem-ee-PER-me-ahbul) membrane permeable to some substances (usually water) but not to others (some solutes), 108

**sensation** the mental perception of a stimulus, 190

**sensitivity**, to receptor, 121*t*

**sensorimotor cortex** (sen-sor-ee-MOH-tor) all areas of cerebral cortex that play a role in skeletal muscle control, 302–3, 302*f*

**sensory information** information that originates in stimulated sensory receptors, 190

**sensory neglect**, 242–43, 242*f*

**sensory pathways** groups of neuron chains, each chain consisting of three or more neurons connected end to end by synapses; carry action potentials to those parts of the brain involved in conscious recognition of sensory information, 196–98, 197*f*

**sensory physiology**, 189–230. *See also specific senses*

adaptation in, 192, 192*f*

ascending neural pathways in, 196–98

central control of afferent information in, 196, 196*f*

general principles of, 190–200, 199*t*

primary coding in, 192–96

**sensory receptors** cells or portions of a cell that contain structures or chemical molecules sensitive to changes in an energy form in the outside world or internal environment; in response to activation by this energy, the sensory receptors initiate action potentials in those cells or adjacent ones, 138–39, 190–92, 191*f*

**sensory system** part of nervous system that receives, conducts, or processes information that leads to perception of a stimulus, 190

**sensory transduction** neural process of changing a sensory stimulus into a change in neuronal function, 191–92, 191*f*–92*f*

**sensory unit** afferent neuron plus receptors it innervates, 192

**sepsis**, 704–5

**septal defect**, 384

**septic shock**, 684, 704–5, 704*f*

**serosa** (sir-OH-sah) connective-tissue layer surrounding outer surface of stomach and intestines, 535, 536*f*, 547*f*

**serotonin** (sair-oh-TONE-in) biogenic amine neurotransmitter; paracrine agent in blood platelets and digestive tract; also called 5-hydroxytryptamine or 5-HT, 167–68

**serotonin-specific reuptake inhibitors**, 167–68, 246

**Sertoli cell(s)** (sir-TOH-lee) cells intimately associated with developing germ cells in seminiferous tubule; create blood-testis barrier, secrete fluid into seminiferous tubule, and mediate hormonal effects on tubule, 610*f*, 616, 617*f*, 617*t*

**Sertoli cell barrier** barrier to the movement of chemicals from the blood into the lumen of the seminiferous tubules in the testes, 616, 617*f*

**sertraline**, 246

**serum** (SEER-um) blood plasma from which fibrinogen and other clotting proteins have been removed as result of clotting, 364

**set point** steady-state value maintained by homeostatic control system, 7–9

**severe combined immunodeficiency (SCID)**, 679

**sevoflurane**, 296

**sex chromatin** (CHROM-ah-tin) nuclear mass not usually found in cells of males; condensed X chromosome, 607

**sex chromosomes** X and Y chromosomes, 607

**sex determination** genetic basis of individual's sex, XY determining male, and XX, female, 607

**sex differentiation** development of male or female reproductive organs, 607–11, 608*f*–609*f*

**sex hormones** estrogen, progesterone, testosterone, or related hormones, 605, 611–13, 612*f*, 613*t*, 619–21, 619*f*, 627–34

**sexual dimorphism** sex-linked differences in appearance or form, 611

**sexual intercourse**, 636

**sexually transmitted diseases (STDs)**, 647

**shaft** portion of bone between epiphyseal plates, 348, 348*f*

**shivering thermogenesis** neurally induced cycles of contraction and relaxation of skeletal muscle in response to decreased body temperature; little or no external work is performed, and thus the increased metabolism of muscle leads primarily to heat production, 594–95

**shock**, 420, 684, 704–5, 704*f*

**short-loop negative feedback** inhibition of hypothalamus by an anterior pituitary gland hormone, 338, 338*f*

**short reflexes** local neural loops from gastrointestinal receptors to nerve plexuses, 536–37, 537*f*

**short stature**, 349, 350–51

**short-term memory** storage of incoming neural information for seconds to minutes; may be converted into long-term memory, 249

**shunt**, 464, 479*t*

**sickle-cell disease**, 38, 41–42, 42*f*, 366

**sickle-cell trait**, 41–42

**sigmoidoscopy**, 562

**signal recognition particle**, 64



**signal sequence** initial portion of newly synthesized protein (if protein is destined for secretion), 64–65, 65f

**signal transduction** the process by which a messenger molecule initiates a sequence of intracellular events that leads to a cell's response to that messenger, 119–31  
first messengers in, 123, 124f  
receptors in, 119–22  
second messengers in, 123, 126–29, 130t

**signal transduction pathways** sequences of mechanisms that relay information from plasma membrane receptor to cell's response mechanism, 122–31, 123f–24f

**sildenafil (Viagra)**, 398, 618

**simple diffusion** movement of solutes down a concentration gradient without a transporter or ATP hydrolysis, 96, 96f

**Sinequan (doxepin)**, 246

**single-unit smooth muscles** smooth muscles that respond to stimulation as single units because gap junctions join muscle fibers, allowing electrical activity to pass from cell to cell, 292–93, 292f, 295t

**sinoatrial (SA) node** (sy-eh-noh-AY-tree-ah)  
region in right atrium of heart containing specialized cardiac muscle cells that depolarize spontaneously faster than other cells in the conducting system; determines heart rate, 375–78, 375f, 385, 385f

**sinus** vascular channel for the passage of blood or lymph, 414, 638

**Sjögren's syndrome**, 539

**skeletal muscle** striated muscle attached to bone or skin and responsible for skeletal movements and facial expression; controlled by somatic nervous system, 3, 258–87, 259f–62f  
adaptation to exercise, 280–81  
aging and, 281  
arteriolar control in, 400t  
contraction of, 262–65, 262–75, 264f–68f, 270t  
ATP function in, 268–69, 268f, 269t, 275–76  
cross-bridges in, 260, 260f, 262, 265–69, 265f–68f, 289f  
excitation-contraction coupling in, 265–67, 265f–66f  
frequency-tension relation in, 272–73, 272f  
length-tension relation in, 273–74, 274f  
load-velocity relation in, 272, 272f  
shortening velocity of, 280  
single-fiber, mechanics of, 269–75  
sliding-filament mechanism of, 267–69, 267f–68f  
tension of, 278–80, 279t  
twitch, 270–72, 271f–72f  
whole-muscle, 278–80  
control of, 301–12, 302f–303f, 303t  
development of, 258–59  
disorders of, 282–85  
energy metabolism of, 275–77, 588, 588f  
fatigue of, 276–77, 276f  
fiber types of, 277–78, 277f, 278f, 279t  
hypertrophy of, 259  
length-monitoring systems of, 305, 306f  
lever action of, 281–82, 282f–84f  
relaxation of, 262  
somatic neurons of, 176–77, 178t

synergistic, 307  
tension-monitoring systems of, 307, 307f  
tone of, 312–13

**skeletal muscle cells**, 2–3, 259, 295t

**skeletal muscle pump** pumping effect of contracting skeletal muscles on blood flow through underlying vessels, 406–7, 407f, 422–23, 422f

**skin receptors**, 200, 201f

**sleep**, 236–40, 237f, 238t, 239f

**sleep apnea**, 237, 484–85, 484f–85f

**“sleep center”**, 239–40, 239f

**sleep spindles** high-frequency waveforms seen in the electroencephalogram during stage 2 sleep, 236, 237f

**sliding-filament mechanism** process of muscle contraction in which shortening occurs by thick and thin filaments sliding past each other, 267–69, 267f–68f

**slow fibers** muscle fibers whose myosin has low ATPase activity, 277–78, 277f, 278f, 279t

**slowly adapting receptors** sensory receptors that fire repeatedly as long as a stimulus is ongoing, 192, 192f

**slow-oxidative fibers** skeletal muscle fibers that have slow intrinsic contraction speed but fatigue very slowly due to abundant capacity for production of ATP by aerobic oxidative phosphorylation, 276t, 277–78, 277f, 278f

**slow waves** slow, rhythmic oscillations of smooth muscle membrane potentials toward and away from threshold, due to regular fluctuations in ionic permeability, 291, 291f

**slow-wave sleep**, 236–37, 237f, 238t

**small intestine** longest portion of the gastrointestinal tract; between the stomach and large intestine, 532, 532f, 538t, 547–59, 547f–58f, 561t

**smell, sense of.** *See* olfaction

**smooth endoplasmic reticulum**, 47f, 52, 53f

**smooth muscle** nonstriated muscle that surrounds hollow organs and tubes, 3, 258, 258f, 287–93, 288f. *See also* multiunit smooth muscles; single-unit smooth muscles  
contraction of, 288–93, 289f, 290t, 291f  
vascular, 398–99

**smooth muscle cells**, 2–3, 287–88, 288f, 295t

**smooth muscle tone** smooth muscle tension due to low-level cross-bridge activity in absence of external stimuli, 290

**SNARE proteins** soluble N-ethylmaleimidesensitive fusion protein attachment protein receptors, 159–60, 160f

**sneeze reflex**, 478

**sodium (sodium ions)**  
in action potential, 151–56  
in cardiac muscle contraction, 376–77, 376f–77f  
exercise and, 114–15, 115f  
imbalances of, 114–15  
renal regulation/reabsorption of, 503–13, 504f, 510f–12f  
in resting membrane potential, 143–49, 145f–48f, 145t  
thirst/salt appetite and, 515–16, 516f

**sodium chloride**, total-body-balance for, 503, 503t

**sodium-potassium-ATPase pump**, 102–3, 103f

**solutes** (SOL-yoots) substances dissolved in a liquid, 28–29, 106–7

**solution** liquid (solvent) containing dissolved substances (solutes), 27–30, 106–9, 108f, 109t

**solvent** liquid in which substances are dissolved, 27

**soma**, 137, 137f

**somatic nervous system** component of efferent division of peripheral nervous system; innervates skeletal muscle; *compare* autonomic nervous system, 176–77, 178t, 180f

**somatic neurons**, 176–77, 178t

**somatic receptors** neural receptors in the framework or outer wall of the body that respond to mechanical stimulation of skin or hairs and underlying tissues, rotation or bending of joints, temperature changes, or painful stimuli, 197

**somatic sensation** feelings/perceptions coming from muscle, skin, and bones, 200–205

**somatosensory cortex** (suh-mat-uh-SEN-suh-ree) strip of cerebral cortex in parietal lobe in which neurons transmitting somatic sensory information synapse, 197, 197f, 204–5, 205f–6f, 308–9, 309f–10f

**somatosensory system**, 204–5, 205f

**somatostatin (SST)** (suh-mat-uh-STAT-in)  
hypophysiotropic hormone that inhibits growth hormone secretion by anterior pituitary gland; also found in stomach and pancreatic islets, 337, 350, 542, 543f

**somatotopic map** a representation of the different regions of the body formed by neurons of the cerebral cortex, 308–9, 310f

**somatotropin.** *See* growth hormone

**sound**, 216–17

**sound levels**, 220, 221t

**sound wave**, 216

**sour taste**, 224

**spasms**, 313

**spasticity**, 313

**spatial summation** adding together effects of simultaneous inputs to different places on a neuron to produce potential change greater than that caused by single input, 162, 162f

**specific ascending pathways** chains of synaptically connected neurons in CNS, all activated by sensory units of same type, 197, 197f

**specificity** selectivity; ability of binding site to react with only one, or a limited number of, types of molecules, 67–68, 67f–68f

**sperm.** *See* spermatozoan

**spermatic cord** structure including the vas deferens and blood vessels and nerves supplying the testes, 615

**spermatids** (SPER-mah-tid) immature sperm, 606f, 607

**spermatogenesis** (sper-mah-toh-JEN-ih-sis) sperm formation, 605–7, 606f, 614, 615–17, 616f, 617f

**spermatogonium** (sper-mah-toh-GOH-nee-um) undifferentiated germ cell that gives rise to primary spermatocyte, 615

**spermatozoan** (sper-ma-toh-ZOH-in; plural, **spermatozoa**) male gamete; also called *sperm*, 605–7, 606f, 615–17, 616f

**sperm transport**, 617–18, 636

**sphincter** (SFINK-ter) smooth muscle ring that surrounds a tube, closing tube as muscle contracts, 267, 289

**sphincter of Oddi** (OH-dee) smooth muscle ring surrounding common bile duct at its entrance into duodenum, 538*t*, 549*f*, 553, 553*f*

**sphygmomanometer**, 394, 394*f*

**spinal cord**, 173*f*, 176, 176*f*, 179*f*

**spinal injuries**, 142

**spinal nerve** one of 86 peripheral nerves (43 pairs) that join spinal cord, 176–77, 176*f*, 178*f*, 179*f*

**spironolactone**, 518

**spleen** largest lymphoid organ; located between stomach and diaphragm, 400*t*, 665

**spliceosome** protein and nuclear RNA complex that removes introns and links exons together during gene transcription, 59–60, 60*f*

**split-brain** describes a procedure in which the two hemispheres of the brain are surgically isolated from each other to treat severe epilepsy; study of split-brain patients has revealed functions attributed to specific hemispheres, 251

**SRY gene** gene on the Y chromosome that determines development of testes in genetic male, 607–11, 608*f*, 610*f*

**stable balance** net loss of substance from body equals net gain, and amount of substance in body neither increases nor decreases; *compare* negative balance, positive balance, 14

**stapedius** (stah-PEE-dee-us) skeletal muscle that attaches to the stapes and protects the auditory apparatus by dampening the movement of the ear ossicles during persistent, loud sounds, 217–18

**stapes** one of three bones in the inner ear that transmit movements of the tympanic membrane to the inner ear, 217–18, 218*f*

**Starling forces** factors that determine direction and magnitude of fluid movement across capillary wall, 404, 405*f*, 495

**Starling's law of the heart**, 386–87, 426, 426*f*

**states of consciousness** degrees of mental alertness—that is, whether awake, drowsy, asleep, and so on, 235–41

altered, 245–48

EEG of, 236–38, 237*f*

neural substrates of, 238–40, 239*f*

**statins**, 92, 92*f*, 429

**steady state** no net change; continual energy input to system is required, however, to prevent net change; *compare* equilibrium, 7

**steatorrhea**, 564

**stem cell factor**, 367*t*

**stem cells** undifferentiated cells that divide and form supply of cells for differentiation into mature cells, 141–42, 364*f*, 638

**stereocilia** (ster-ee-oh-SIL-ee-ah) nonmotile cilia containing actin filaments

auditory, 220, 221*f*

vestibular, 222, 223*f*

**steroid(s)** (STER-oidz) lipid subclass; molecules consist of four interconnected carbon rings to which polar groups may be attached, 34, 34*f*

**steroid hormones** members of a family of hormones, like progesterone, whose structure is derived from cholesterol, 324–26, 325*f*–26*f*, 329, 351, 605, 611–13, 612*f*

**stimulation-produced analgesia**, 202–3

**stimulus** detectable change in internal or external environment, 10

adequate, 190, 192

intensity of, 193, 193*f*

location of, 193–94, 194*f*

modality of, 192–93

receptive field overlap and, 194–95, 194*f*–95*f*

reflex arc, 10, 11*f*

sensory, 190, 192–95

**stomach** expandable, saclike structure in the gastrointestinal tract between the esophagus and small intestine; site of initial digestion of proteins, 532, 532*f*, 538*t*, 539*f*, 541–47, 541*f*–46*f*, 544*t*, 561*t*

**stop codon**, 61

**stop signals** three-nucleotide sequences in mRNA that signify end of protein-coding sequence, 58

**stress** a perceived or real environmental or internal threat to health and life; event that elicits increased cortisol secretion, 344–47, 347*t*, 415, 418

energy homeostasis in, 584–85

**stress incontinence**, 500

**stretch receptors**, 200–201, 305

muscle-spindle, 305, 305*f*–306*f*

pulmonary, 473

**stretch reflex** monosynaptic reflex, mediated by muscle-spindle stretch receptor, in which muscle stretch causes contraction of that muscle, 305–7, 307*f*

**striated muscle** (STRY-ay-ted) muscle having transverse banding pattern due to repeating sarcomere structure, 258, 258*f*. *See also* cardiac muscle; skeletal muscle

**strictures, intestinal**, 568–69, 569*f*

**stroke**, 183, 424–25, 429–30

**stroke volume (SV)** blood volume ejected by a ventricle during one heartbeat, 381, 386–87, 387*f*, 392, 421–24, 423*t*, 424*f*

**strong acids** acids that ionize completely to form hydrogen ions and corresponding anions when dissolved in water; *compare* weak acids, 29

**structural proteins**, 34*t*

**structure-function relationship**, 15, 390

**strychnine**, 169

**subarachnoid space** space between the arachnoid and pia mater meninges containing cerebrospinal fluid, 181, 183*f*

**subatomic particles**, 21–22, 21*f*

**subcortical nuclei** groups of cells in brain below the cerebral cortex, 173

**subdural hematoma**, 254

**sublingual gland**, 532*f*, 538, 539*f*

**submandibular gland**, 532*f*, 538, 539*f*

**submucosa** layer of tissue beneath the gastrointestinal mucosa, 535, 536*f*, 547*f*

**submucosal plexus** (sub-mu-KOH-zal PLEX-us) neuronal network in submucosa of esophageal, stomach, and intestinal walls, 535, 536*f*

**substance dependence**, 247, 248*t*

**substance P**, 201, 202*f*

**substance use disorder** condition associated with abuse of psychoactive substances; formerly called addiction or dependence, 247, 248*t*

**substantia nigra** (sub-STAN-sha NIE-gra) a subcortical nucleus containing dark-staining neurons that release dopamine and are

important for suppressing extraneous muscle activity, 310

**substrate-level phosphorylation** (fos-for-ih-LAY-shun) direct transfer of phosphate group from metabolic intermediate to ADP to form ATP, 80

**substrates** (SUB-strates) reactants in enzyme-mediated reaction, 70–71, 73–76, 74*f*–75*f*

**subthreshold potentials**, 152, 153*f*

**subthreshold stimuli**, 152, 153*f*

**succinylcholine**, 264–65

**sucrose** (SOO-krose) disaccharide composed of glucose and fructose; also called *table sugar*, 31, 31*f*

**sugar**, of nucleotides, 38–39, 38*f*, 39*f*

**sulcus** (plural, *sulci*) a deep groove between gyri on the surface of the cerebral cortex, 174, 174*f*

**sulfasalazine**, 569

**sulfonylureas**, 600

**summation** (sum-MAY-shun) increase in muscle tension or shortening in response to rapid, repetitive stimulation relative to single twitch, 150, 162, 162*f*, 272*f*, 273

**superior vena cava** (VEE-nah KAY-vah) large vein that carries blood from upper half of body to right atrium of heart, 368, 373*f*

**supplementary motor cortex** region of the cerebral cortex found on the medial side of brain hemispheres in front of the primary motor cortex; involved in planning and enacting complex muscle movements, 308–9, 309*f*–10*f*

**suprachiasmatic nucleus** group of cells in the hypothalamus involved in production of circadian rhythms, 13, 214, 239, 239*f*

**surface tension** attractive forces between water molecules at an air-water interface resulting in net force that acts to decrease surface area, 455–56

**surfactant** (sir-FAK-tent) detergent-like phospholipid-protein mixture produced by pulmonary type II alveolar cells; decreases surface tension of fluid film lining alveoli, 455–56, 457*t*

**swallowing**, 539–541, 540*f*

**swallowing center** area of the medulla oblongata in the central nervous system that receives afferent neural input from the mouth and sends efferent output to the muscles of the pharynx, esophagus, and respiratory system, coordinating swallowing, 539–40

**sweat glands** glands beneath the skin that are capable of secreting a salty fluid through ducts to the surface of the skin in response to heat-induced neural signals from the autonomic nervous system, 17–18, 18*f*, 112, 596

**sweating**, 13, 17–18, 515, 515*f*, 596

**sweet taste**, 224

**Sylvian fissure**, 250, 250*f*

**sympathetic division (of the autonomic nervous system)** portion of autonomic nervous system whose preganglionic fibers leave CNS at thoracic and lumbar portions of spinal cord; *compare* parasympathetic division, 178–81, 179*f*, 180*f*, 182*t*

in blood flow (arteriole) control, 397–98, 398*f*

stress response of, 347, 347*t*

**sympathetic trunks** paired chains of interconnected sympathetic ganglia that lie on either side of vertebral column, 178–79, 180*f*

**synport**, 104–5

**synapse** (SIN-aps) anatomically specialized junction between two neurons where electrical activity in one neuron influences excitability of second, 139, 141*f*, 158–70. *See also* chemical synapse; electrical synapses; excitatory synapse; inhibitory synapse

axo-axonic, 163–64, 163*f*

convergence of, 158, 158*f*

diseases affecting, 165

divergence of, 158, 158*f*

drugs affecting, 164, 164*f*

neurotransmitter release at, 159–60, 160*f*

neurotransmitter removal from, 160

strength of, 163–65

**synaptic cleft** narrow extracellular space separating pre-and postsynaptic neurons at chemical synapse, 159, 159*f*

**synaptic delay**, 160

**synaptic integration**, 161–63

**synaptic potential** a change in membrane potential caused by synaptic input to a cell, 149*t*, 156

**synaptic vesicles** cellular structures that hold and release neurotransmitter at the synapse, 159, 159*f*

**synaptotagmins** (sin-ap-toh-TAG-minz) proteins present in wall of synaptic vesicle that bind calcium and help stimulate the process of exocytosis, 160

**syncope**, 229, 420

**synergistic muscles** (sin-er-JIS-tik) muscles that exert force to aid intended motion, 307

**systemic arterial pressure**, 411

**systemic circulation** (sis-TEM-ik) circulation from left ventricle through all organs except lungs and back to heart, 368, 368*f*

**systemic inflammatory response**, 704

**systemic lupus erythematosus (SLE)**, 690–91, 690*f*

**systole** (SIS-toh-lee) period of ventricular contraction, 380–83, 381*f*–82*f*

**systolic dysfunction**, 426, 426*f*

**systolic pressure (SP)** (sis-TAHL-ik) maximum arterial blood pressure during cardiac cycle, 392–93, 394*f*

## T

**tachycardia**, 695

**tachypnea**, 695

**tacrolimus**, 569

**tadalafil (Cialis)**, 398, 618

**target cells** cells influenced by certain hormones, 11, 12*f*

**taste**. *See* gustation

**taste buds** sense organs that contain chemoreceptors for taste, 224–25, 225*f*

**T cells**. *See* T lymphocytes

**tectorial membrane** (tek-TOR-ee-al) structure in organ of Corti in contact with receptor cell hairs, 220, 221*f*

**temperature**

body (*See* body temperature)

sensation of, 191, 201, 594, 595*f*

**template strand** the DNA strand with the correct orientation relative to a promoter to bind RNA polymerase, 59, 59*f*

**temporal lobe** region of cerebral cortex where primary auditory cortex and Wernicke's speech center are located, 173*f*, 174

**temporal lobe association area**, 197*f*

**temporal summation** membrane potential produced as two or more inputs, occurring at different times, are added together; potential change is greater than that caused by single input, 162, 162*f*

**tendons** (TEN-donz) collagen fiber bundles that connect skeletal muscle to bone and transmit muscle contraction force to the bone, 259–60, 259*f*

**tension** in muscle physiology, the force exerted by a contracting muscle on object, 269

in skeletal muscle, 269–75, 271*f*–72*f*, 278–80, 279*t*

in smooth muscle, 288

**tension-monitoring systems**, 307, 307*f*

**tensor tympani muscle** skeletal muscle that attaches to the ear drum and protects the auditory apparatus from loud sounds by dampening the movement of the tympanum, 217–18

**teratogen**, 641

**terminal bronchioles**, 447*f*, 448*f*

**terminal cisternae** (ter-mih-null sys-TER-nay) expanded regions of sarcoplasmic reticulum, associated with T-tubules and involved in the storage and release of Ca<sup>2+</sup> in skeletal muscle cells; also known as *lateral sacs*, 261, 261*f*

**tertiary structure** the three-dimensional folded structure of a protein formed by hydrogen bonds, hydrophobic attractions, electrostatic interactions, and cysteine cross-bridges, 36, 37*f*

**testicular feminization**, 610

**testis** (TES-tiss) (plural, **testes**) gonad in male, 605

anatomy of, 614–15, 615*f*

development of, 607, 608*f*

disorders of, 621–22

endocrine function of, 322*f*, 325–26, 326*f*

hormonal control of, 619–20, 619*f*

spermatogenesis in, 605–7, 606*f*, 614, 615–17, 617*f*

**testosterone** (test-TOS-ter-own) steroid hormone produced in interstitial (Leydig) cells of testes; major male sex hormone, 322*f*, 325–26, 325*f*, 326*f*, 605, 611, 612*f*

in growth and development, 351, 351*t*

in male physiology, 619–20, 619*f*, 620*t*

**tetanospasm**, 317

**tetanus** (TET-ah-nus) maintained mechanical response of muscle to high-frequency stimulation; also the disease lockjaw, 273, 273*f*, 317

**tetanus immune globulin (TIG)**, 317

**tetanus toxin**, 165

**tetany, hypocalcemic**, 283, 356

**tetrahydrocannabinol (THC)** the principal psychoactive substance in plants of the genus *Cannabis*, 170

**tetrodotoxin**, 153

**thalamus** (THAL-ah-mus) subdivision of diencephalon; integrating center for sensory

input on its way to cerebral cortex; also contains motor nuclei, 173*t*, 174*f*, 175, 175*f*, 242, 303, 303*f*

**theca** (THEE-kah) cell layer that surrounds ovarian-follicle granulosa cells, 625, 628–9

**thermogenesis**

diet-induced, 588

nonshivering, 595

shivering, 594–95

**thermoneutral zone** temperature range over which changes in skin blood flow can regulate body temperature, 596

**thermoreceptors** sensory receptors for temperature and temperature changes, particularly in low (cold receptor) or high (warm receptor) range, 191, 201, 594, 595*f*

**thermoregulation** the maintenance of body temperature within a normal range by changes in heat production and heat loss, 593–96

**theta rhythm** slow-frequency, high-amplitude waves of the EEG associated with early stages of slow-wave sleep, 236, 237*f*

**thick filaments** myosin filaments in muscle cell in skeletal muscle, 259*f*–61*f*, 260–61

in smooth muscle, 288, 288*f*

**thin filaments** actin filaments in muscle cell in skeletal muscle, 259*f*–61*f*, 260–61

in smooth muscle, 288, 288*f*

**thirst**, 515–16, 516*f*

**thoracic nerves**, 176–77, 178*f*

**thorax** (THOR-aks) closed body cavity between neck and diaphragm; contains lung, heart, thymus, large vessels, and esophagus; also called the *chest*, 449

**threshold potential** membrane potential above which an excitable cell fires an action potential, 151, 151*f*

**threshold stimuli** stimuli capable of depolarizing membrane just to threshold, 149*t*, 152–53

**thrifty genes** genes postulated to have evolved in order to increase the body's ability to store fat, 591

**thrombin** (THROM-bin) enzyme that catalyzes conversion of fibrinogen to fibrin; has multiple other actions in blood clotting, 432–34, 433*f*, 435*f*, 436*t*

**thrombocytopenia**, 690

**thrombolytic (fibrinolytic) system**, 436, 436*f*

**thrombolytic therapy**, 437

**thrombomodulin** an endothelial receptor to which thrombin can bind, thereby eliminating thrombin's clot-producing effects and causing it to bind and activate protein C, 435–36, 435*f*

**thrombopoietin**, 367*t*

**thromboxane(s)** eicosanoids derived from arachidonic acid by the action of cyclooxygenase; among other functions, thromboxanes are involved in platelet aggregation, 130–31, 131*f*, 170

**thromboxane A<sub>2</sub>** an eicosanoid formed in platelets that stimulates platelet aggregation and secretion of clotting factors, 431–32, 432*f*, 437

**thrombus** (THROM-bus) blood clot, 432–33, 700

**thymectomy**, 285

**thymine** (T) (THIGH-meen) pyrimidine base in DNA but not RNA, 38–39, 38*f*, 39*f*, 57–58



**thymus** (THIGH-mus) lymphoid organ in upper part of chest; site of T-lymphocyte differentiation, 664–66

**thyroglobulin** (thigh-roh-GLOB-you-lin) large protein precursor of thyroid hormones in colloid of follicles in thyroid gland; storage form of thyroid hormones, 340f, 341

**thyroid follicles**, 339–41, 340f

**thyroid gland**, 322f, 339–43, 340f

**thyroid hormones** collective term for amine hormones released from thyroid gland—that is, thyroxine (T<sub>4</sub>) and triiodothyronine (T<sub>3</sub>), 322f, 323, 323f, 339–43  
actions and effects of, 329, 341–42, 351, 351t  
control of, 336, 337f–38f, 341, 341f  
imbalances of, 133–34, 342–43, 587, 695–99  
metabolic effects of, 587  
synthesis of, 323, 339–41, 340f

**thyroiditis, autoimmune**, 342–43

**thyroid peroxidase** enzyme within the thyroid gland that mediates many of the steps of thyroid hormone synthesis, 341

**thyroid-stimulating hormone (TSH)**  
glycoprotein hormone secreted by anterior pituitary gland; induces secretion of thyroid hormone; also called *thyrotropin*, 322f, 335, 335f, 337f–38f, 341, 341f, 697–98, 697f

**thyroid-stimulating immunoglobulins (TSIs)**, 696–98, 697f

**thyrotoxicosis**, 343, 695–99

**thyrotropin-releasing hormone (TRH)**  
hypophysiotropic hormone that stimulates thyrotropin and prolactin secretion by anterior pituitary gland, 336–37, 337f–38f, 341, 341f

**thyroxine (T<sub>4</sub>)** (thigh-ROCKS-in)  
tetraiodothyronine; iodine-containing amine hormone secreted by thyroid gland, 323f, 339–43, 340f–41f, 696–97

**tidal volume (V<sub>t</sub>)** air volume entering or leaving lungs with single breath during any state of respiratory activity, 458, 459f

**tight junction** cell junction in which extracellular surfaces of the plasma membrane of two adjacent cells are joined together; extends around epithelial cell and restricts molecule diffusion through space between cells, 3f, 4, 50f, 51, 111, 111f

**tinnitus**, 220

**tip links** small, extracellular fibers connecting adjacent stereocilia that activate ion channels when the cilia are bent, 220, 221f

**tissue(s)** aggregates of single type of specialized cell; also denote general cellular fabric of a given organ, 2f, 3. *See also specific types*

**tissue factor** protein involved in initiation of clotting via the extrinsic pathway; located on plasma membrane of subendothelial cells, 434

**tissue factor pathway inhibitor (TFPI)** a plasma protein secreted by endothelial cells; one of several mechanisms for protecting against excessive blood coagulation, 435

**tissue plasminogen activator (t-PA)** plasma protein produced by endothelial cells; after binding to fibrinogen, activates the proenzyme plasminogen, 436, 701–2

**tissue repair**, 662

**titin** protein that extends from the Z line to the thick filaments and M line of skeletal muscle sarcomere, 260, 261f, 273–74

**T lymphocytes (T cells)** lymphocytes derived from precursor that differentiated in thymus, 364f, 367, 657, 658t. *See also* cytotoxic T cells; helper T cells  
in antibody-mediated responses, 672–74, 673f  
antigen presentation to, 670–72, 671f  
functions of, 666, 668f  
in HIV/AIDS, 680, 680f  
receptors for, 669–70

**tolerance**, 247, 248t

**Toll-like receptors (TLRs)** members of the pattern-recognition-receptor family that bind to ligands commonly found on many types of pathogens, 663–64

**tone**  
skeletal muscle, 313  
smooth muscle, 290

**tonicity of solution**, 108–9, 108t, 109f, 109t

**tonsils** several small lymphoid organs in pharynx, 665–66

**total-blood carbon dioxide** sum total of dissolved carbon dioxide, bicarbonate, and carbamino-CO<sub>2</sub>, 471

**total-body energy stores**, 589

**total-body water balance**, 503, 503t

**total energy expenditure** sum of external work done plus heat produced plus energy stored by body, 587

**total peripheral resistance (TPR) or systemic vascular resistance (SVR)** total resistance to flow in systemic blood vessels from beginning of aorta to ends of venae cavae, 411–12

**totipotent** cells of the conceptus that have the capacity to develop into a normal, mature fetus; stem cells, 638

**touch**, 200, 201f

**toxemia of pregnancy**, 642–43

**trace elements** minerals present in body in extremely small quantities, 23

**trachea** (TRAY-kee-ah) single airway connecting larynx with bronchi; windpipe, 446–47, 446f, 448f, 539f

**tract** large, myelinated axon bundle in CNS, 172

**transamination** (trans-am-in-NAY-shun) reaction in which an amino acid amino group (—NH<sub>2</sub>) is transferred to a keto acid, the keto acid thus becoming an amino acid, 87f, 88, 88f

**transcatheter aortic valve replacement (TAVR)**, 440

**transcellular pathway** crossing an epithelium by movement into an epithelial cell, diffusion through the cytosol of that cell, and exit across the opposite membrane, 111–12, 111f

**transcription** formation of RNA containing, in linear sequence of its nucleotides, the genetic information of a specific gene; first stage of protein synthesis, 57–60, 57f, 59f, 60f, 62t, 63

**transcription factors** proteins that act as gene switches, regulating the transcription of a particular gene by activating or repressing the initiation process, 63, 63f

**transcutaneous electrical nerve stimulation (TENS)**, 204

**transcutaneous oxygen monitor**, 706

**transducin** (trans-DOO-sin) G protein in disc membranes of photoreceptor; initiates inactivation of cGMP, 210–11, 211f

**trans fatty acids** unsaturated fatty acids in which the hydrogen atoms around a carbon:carbon double bond are distributed in a trans orientation (on the same side); implicated in a variety of negative health consequences, 32

**transferrin** (trans-FERR-in) iron-binding protein that carries iron in plasma, 365, 557

**transfer RNA (tRNA)** type of RNA; different tRNAs combine with different amino acids and with codon on mRNA specific for that amino acid, thus arranging amino acids in sequence to form specific protein, 58, 60–62, 61f

**transfusion reaction**, 681–82

**transient ischemic attacks (TIAs)**, 430

**transient receptor potential (TRP) proteins**  
family of ion channel proteins involved in sensing temperature, 201

**translation** during protein synthesis, assembly of amino acids in correct order according to genetic instructions in mRNA; occurs on ribosomes, 57, 57f, 60–62, 62f, 62t

**transmembrane proteins** proteins that span the plasma membrane and contain both hydrophilic and hydrophobic regions; often act as receptors or ion channels, 48, 48f, 49f, 119, 120f

**transmural pressure** pressure difference between inside and outside of a wall, 451, 451f, 452t

**transport**  
active, 102–5, 102f–4f, 112–13, 112f–13f  
axonal, 138, 139f  
epithelial, 111–13, 111f–13f  
mediated, 100–105, 101f, 105t

**transporters** integral membrane proteins that mediate passage of molecules through membrane; also called *carrier*, 34t, 100–105

**transport maximum (T<sub>m</sub>)** upper limit to amount of material that carrier-mediated transport can move across the renal tubule, 498

**transpulmonary pressure (P<sub>p</sub>)** difference in pressure between the inside and outside of the lung (alveolar pressure minus the intrapleural pressure), 451, 452f, 452t

**transverse colon**, 560, 560f

**transverse tubule (T-tubule)** tubule extending from striated muscle plasma membrane into the fiber, passing between opposed sarcoplasmic reticulum segments; conducts muscle action potential into muscle fiber, 261, 261f, 266–67, 266f

**traveler's diarrhea**, 565

**triarterene**, 518

**tricarboxylic acid cycle**. *See* Krebs cycle

**tricuspid valve** (try-CUSS-pid) valve between right atrium and right ventricle of heart, 372, 373f, 374f

**tricyclic antidepressant drugs**, 246

**trigeminal nerve** (cranial nerve V), 177t

**triglyceride** subclass of lipids composed of glycerol and three fatty acids, 32, 33f, 86, 574–75, 574f

**triiodothyronine (T<sub>3</sub>)** (try-eye-oh-doh-THIGH-roh-noon) iodine-containing amine hormone secreted by thyroid gland or produced in target cells from T<sub>4</sub>, 323f, 339–42, 340f–41f, 351, 587, 696–97

**triplet code**, 58, 58f

**trochlear nerve (cranial nerve IV)**, 177t

**trophoblast** (TROH-foh-blast) outer layer of blastocyst; gives rise to fetal portion of placental tissue, 629f, 638

**tropic hormone** hormone that stimulates the secretion of another hormone; also known as *trophic hormone*, 329

**tropomyosin** (troh-poh-MY-oh-sin) regulatory protein capable of reversibly covering binding sites on actin; associated with muscle thin filaments, 260, 260f, 265–66, 265f–66f

**tropenin** (troh-POH-nin) regulatory protein bound to actin and tropomyosin of striated muscle thin filaments; site of calcium binding that initiates contractile activity, 260, 260f, 265–66, 265f–66f

**trypsin** (TRIP-sin) enzyme secreted into small intestine by exocrine pancreas as precursor trypsinogen; breaks certain peptide bonds in proteins and polypeptides, 549, 550f, 550t, 554

**trypsinogen** (trip-SIN-oh-jen) inactive precursor of trypsin; secreted by exocrine pancreas, 549, 550f

**T-tubule**, 261, 261f, 266–67, 266f

**T-type  $\text{Ca}^{2+}$  channels** ion channels that carry inward calcium current that briefly supports diastolic depolarization of cardiac pacemaker cells (T: tensor), 377

**tuberculosis**, 346

**tubular reabsorption** transfer of materials from kidney tubule lumen to peritubular capillaries, 493–94, 494f, 497–98, 497f, 497t

calcium, 517

potassium, 516–17

sodium, 503, 504f, 510–13

sodium-water, 503–4, 504f

water, 515–16

**tubular secretion** transfer of materials from peritubular capillaries to kidney tubule lumen, 493–94, 494f, 497f, 499

**tubule** a hollow structure lined by epithelial cells, often involved in transport processes such as those in the kidney nephrons, 490, 491f–92f, 493

**tubulin** (TOOB-you-lin) the major protein component of microtubules, 55

**tumor necrosis factor- $\alpha$  (TNF- $\alpha$ )** (neh-KROH-sis) cytokine secreted by macrophages (and other cells); has many of the same functions as IL-1, 671, 671f, 673f, 676, 676f

**turbulent flow**, 384–85, 384f

**T wave** component of electrocardiogram corresponding to ventricular repolarization, 378, 378f, 380f

**twitch** mechanical response of muscle to single action potential, 270–72, 271f–72f

**tympanic membrane** (tim-PAN-ik) membrane stretched across end of ear canal; also called *eardrum*, 217, 218f, 219f

**type 1 diabetes mellitus**, 599–600, 600f, 684

**type 2 diabetes mellitus**, 331, 599–601

**type I alveolar cells** flat epithelial cells that with others form a continuous layer lining the air-facing surface of the pulmonary alveoli, 447–48, 449f

**type II alveolar cells** pulmonary cells that produce surfactant, 448, 449f

**type I interferons** (in-ter-FEER-onz) family of proteins that nonspecifically inhibit viral replication inside host cells, 662–63, 663f

**type II interferons (interferon gamma)** stimulate the killing ability of macrophages and NK cells, 663, 677, 677f

**U**

**ubiquitin** (you-BIK-wit-in) small intracellular peptide that attaches to proteins and directs them to proteasomes, 64

**ulcerative colitis**, 569

**ulcers, gastric and duodenal**, 561–62, 563f

**ultrafiltrate** (ul-tra-FIL-trate) protein-free fluid formed from plasma as it is forced through capillary walls by pressure gradient, 493

**umami** (oo-MOM-ee) unique taste sensation roughly equivalent to “flavorfulness,” 224

**umbilical arteries** arteries transporting blood from the fetus into the capillaries of the chorionic villi, 638, 640f

**umbilical cord** (um-BIL-ih-kul) long, ropelike structure that connects the fetus to the placenta and contains umbilical arteries and vein, 638, 640f

**umbilical vein** vein transporting blood from the chorionic villi capillaries back to the fetus, 638, 640f

**unfused tetanus** stimulation of skeletal muscle at a low-to-moderate action potential frequency that results in oscillating, submaximal force, 273, 273f

**unsaturated fatty acids** fatty acids containing one or more double bonds, 31

**upper airways** parts of the respiratory tree consisting of the nose, mouth, pharynx, and larynx, 446

**upper esophageal sphincter** (ih-soff-ih-JEE-al SFINK-ter) skeletal muscle ring surrounding esophagus just below pharynx that, when contracted, closes entrance to esophagus, 539f, 540–41, 540f

**upper motor neurons** neurons of the motor cortex and descending pathways involved in motor control; they are not technically “motor neurons” because they synapse on neurons, not muscle cells, 313

**up-regulation** increase in number of target-cell receptors for given messenger in response to chronic low extracellular concentration of that messenger; *compare* down-regulation, 121t, 122, 164, 327–28

**uracil (U)** (YOOR-ah-sil) pyrimidine base; present in RNA but not DNA, 38f, 39

**Urbach-Wiethe disease**, 244

**urea** (you-REE-ah) major nitrogenous waste product of protein breakdown and amino acid catabolism, 88, 489

**urea recycling**, 508, 508f

**uremia**, 526

**ureters** (YOOR-ih-terz) tubes that connect kidneys to bladder, 489, 490f

**urethral sphincters**, 500

**urethra** (you-REE-thrah) tube that connects bladder to outside of body, 489, 490f

**urge incontinence**, 500

**uric acid** (YOOR-ik) waste product derived from nucleic acid catabolism, 489

**urinary bladder**. *See* bladder

**urinary incontinence**, 500

**urinary system**, 2f, 4, 5t

anatomy of, 489–90, 490f–92f

physiology of, 488–527

**urine concentration**, 506–8, 507f

**uterus** (YOU-ter-us) hollow organ in pelvic region of females; houses fetus during pregnancy; also called *womb*, 623, 623f, 624f

menstrual cycle changes in, 631–32, 631f

parturition and, 643–45, 644f, 645f

**utricle** structure in the semicircular canals that responds to changes in linear movement of the head by mechanical forces on otoliths located on its surface, 222–23, 222f

**V**

**vaccine**, 675

**vagina** (vah-JY-nah) canal leading from uterus to outside of body, 623, 623f, 624f

**vagus nerve** (VAY-gus) cranial nerve X; major parasympathetic nerve, 177t

**Valium (diazepam)**, 169, 239

**valve insufficiency**, 384–85, 384f

**valve prolapse**, 372

**valves**, of heart, 372–73, 373f, 374f, 384–85, 384f

**valve stenosis**, 384–85, 384f, 438–40, 439f

**valvuloplasty, balloon**, 440

**van der Waals forces**, 36

**varafenafil**, 618

**varicosities** (vair-ih-KOS-ih-teez) swollen regions of axon; contain neurotransmitter-filled vesicles; analogous to presynaptic endings, 138, 291, 291f

**vasa recta** (VAY-zuh REK-tah) blood vessels that form loops parallel to the loops of Henle in the renal medulla, 491f, 493

**vascular system** closed system of blood vessels that includes all arteries, arterioles, capillaries, venules, and veins, 390–409

comparative features of, 390–91, 391f

components and functions of, 371t

endothelial cells of, 390–91, 392t, 398–99

smooth muscle of, 398–99

**vas deferens** (vas DEF-er-enz) one of paired male reproductive ducts that connect epididymis of testis to urethra; also called *ductus deferens*, 614, 615f

**vasectomy**, 618

**vasoconstriction** (vayz-oh-kon-STRIK-shun) decrease in blood vessel diameter due to vascular smooth muscle contraction, 395–99

**vasodilation** (vayz-oh-dy-LAY-shun) increase in blood vessel diameter due to vascular smooth muscle relaxation, 395–99, 659–60

**vasodilator drugs**, 427t, 429

**vasopressin** (vayz-oh-PRES-sin) peptide hormone synthesized in hypothalamus and released from posterior pituitary gland; increases water permeability of kidneys’ collecting ducts and causes vasoconstriction; also called *antidiuretic hormone (ADH)*, 322f, 334, 347, 398, 416

baroreceptor control of, 514–15, 514f

osmoreceptor control of, 513–14, 514f

in renal physiology, 505–9, 509, 509f, 513–15, 514f

**vasovagal syncope**, 420

**vaults** cytoplasmic structures composed of protein and RNA; their function is uncertain but may involve cytoplasmic-nuclear transport and modulation of a cell’s sensitivity to certain drugs, 47f, 54–55

**vecuronium**, 264–65

**veins** any vessels that return blood to heart, 371*t*, 391*f*, 406–7, 406*f*–407*f*

**vena cavae**, 368, 368*f*, 373, 373*f*

**venous pressure**, 406–7, 406*f*–407*f*

**venous return** blood volume flowing to heart per unit time, 386

**ventilation** air exchange between atmosphere and alveoli, 449–60, 453*f*–55*f*  
altitude and, 480, 480*t*  
alveolar, 458–60, 460*t*, 461*f*  
Boyle's law and, 450, 451*f*, 453  
control of, 471–79  
exercise and, 477, 478*f*  
hydrogen ions and, 476, 476*f*, 477, 477*f*, 478*f*  
matching of blood flow to, 464–65, 465*f*  
partial pressure of carbon dioxide and, 475–76, 475*f*, 477, 477*f*, 478*f*  
partial pressure of oxygen and, 473–75, 474*f*, 477, 477*f*, 478*f*  
pressure differences in, 449–53, 450*f*–51*f*, 452*f*, 452*t*

**ventilation-perfusion inequality**, 464–65, 465*f*, 479, 479*t*

**ventilation-perfusion scan**, 700–01, 700*f*

**ventral horns** the ventral gray matter of the spinal cord that contains cell bodies of motor neurons, 176, 176*f*

**ventral respiratory group (VRG)** region of the brainstem containing expiratory neurons important during exercise, 472*f*, 473

**ventral roots** two groups of efferent fibers that leave ventral side of spinal cord, 176, 176*f*

**ventricle** (VEN-trih-kul) cavity, as in cerebral ventricle or heart ventricle; lower chamber of heart  
cardiac, 368, 371*t*, 372–73, 373*f*  
cerebral, 172, 174*f*, 183*f*

**ventricular ejection** phase of the cardiac pump cycle during ventricle contraction when blood exits through the semilunar valves, 381

**ventricular fibrillation**, 428

**ventricular filling** phase of the cardiac pump cycle during which the ventricles are resting and blood enters through the atrioventricular valves, 381, 381*f*–82*f*, 383

**ventricular-function curve** relation of the increase in stroke volume as end-diastolic volume increases, 386, 386*f*

**venules** (VEEN-yoolz) small vessels that carry blood from capillary network to vein, 368, 371*t*, 391*f*

**vertigo**, 229

**very-low-density lipoproteins (VLDLs)** (lip-oh-PROH-teenz) lipid-protein aggregates having high proportion of fat, 574, 574*f*

**vestibular apparatus** sense organ in temporal bone of skull; consists of three semicircular canals, a utricle, and a saccule; also called *sense organ of balance*, *vestibular system*, 221–22

**vestibular disorders**, 229–30

**vestibular system**, 221–24

**vestibulocochlear nerve** (ves-tibb-yoo-loh-KOKE-lee-ar) eighth cranial nerve; transmits sensory information about sound and motion from the inner ear to the brain, 177*t*, 218*f*, 220, 223*f*

**Viagra**, 398, 618

**villi** (singular, **villus**) (VIL-eye and VIL-us) fingerlike projections from highly folded surface of small intestine; covered with single-layered epithelium, 533–34, 547, 547*f*

**virilization**, 610, 611*f*, 633

**viruses**, 656, 675–77, 676*f*, 678*t*

**visceral pleura** (VISS-er-al PLOO-rah) serous membranes covering the surface of the lung, 449, 449*f*

**viscosity** (viss-KOS-ih-tee) measure of friction between adjacent layers of a flowing liquid; property of fluid that makes it resist flow, 370

**visible spectrum** wavelengths of electromagnetic radiation capable of stimulating photoreceptors of the eye, 205, 206*f*

**vision**, 205–16  
binocular, 213, 213*f*  
color, 214–15, 214*f*, 215*f*  
defects of (refraction errors), 208–9, 209*f*  
light and, 205, 206*f*  
monocular, 213, 213*f*  
neural pathways of, 211–14  
optics of, 207–9, 208*f*, 209*f*  
photoreceptors in, 191, 209–14

**visual cortex** region of the occipital lobe of the cerebral cortex that receives ascending pathways from the eyes, 197, 197*f*

**visual neglect**, 242–43, 242*f*

**visual perception**, 242

**vital capacity (VC)** maximal amount of air that can be expired, regardless of time required, following maximal inspiration, 458, 459*f*

**vitamin(s)** organic molecules required in trace amounts for normal health and growth; usually not manufactured in the body and must be supplied by diet; classified as water-soluble (vitamins C and the B complex) and fat-soluble (vitamins A, D, E, and K), 74, 89–90  
digestion and absorption of, 556–7  
fat-soluble, 89, 556–7  
water-soluble, 89, 534

**vitamin B<sub>12</sub>** an essential vitamin found in animal products that plays an important role in the production of red blood cells, 365–66, 556–7

**vitamin D** secosteroid absorbed in the diet or released from the skin under UV light; there are two forms: D<sub>2</sub> is from plants and D<sub>3</sub> is from animals, 354–55, 355*f*

**vitamin D<sub>2</sub>** (ergocalciferol) plant vitamin D, 354

**vitamin D<sub>3</sub>** (cholecalciferol) animal vitamin D, 354

**vitamin K** a lipid-soluble substance absorbed from the diet and manufactured by bacteria of the large intestine; required for production of numerous factors involved in blood clotting, 435, 435*f*, 437

**vitamin toxicity**, 90

**vitreous humor** jellylike fluid filling the posterior chamber of the eye, 207, 207*f*

**vocal cords** two elastic-tissue bands stretched across laryngeal opening and caused to vibrate when air moves past them, producing sounds, 446

**volt (V)** unit of measurement of electrical potential between two points, 143

**voltage** measure of potential of separated electrical charges to do work; measure of electrical force between two points, 143

**voltage-gated ion channels** cell membrane ion channels opened or closed by changes in membrane potential, 100, 151–53, 151*f*–53*f*

**voltmeter**, 144*f*

**voluntary movement** consciously carried-out motions mediated by the somatic nervous system and skeletal muscle contraction, 304

**vomiting (emetic) center** neurons in brainstem medulla oblongata that coordinate vomiting reflex, 562

**von Willebrand factor (vWF)** (von-VILL-ihbrant) plasma protein secreted by endothelial cells; facilitates adherence of platelets to damaged vessel wall, 431

**vulva** (VUL-vah) female external genitalia; mons pubis, labia majora and minora, clitoris, vestibule of vagina, and vestibular glands, 624

## W

**waking state**, EEG in, 236, 236*f*

**walking**, 314–15

**water**  
as body fluid, 4  
chemical reactions of, 27–28  
digestion and absorption of, 534, 539*t*, 557  
as essential nutrient, 89  
movement across epithelium, 112–13, 113*f*  
as solvent, 28–30

**water balance**, 503–18  
basic renal processes for, 503–10  
diuretics and, 517–18  
renal reabsorption and, 503–4, 504*f*  
renal regulation of, 513–15, 514*f*  
thirst/salt appetite and, 515–16, 516*f*  
total-body, 503, 503*t*

**water diuresis** increase in urine flow due to increased water output (usually due to decreased secretion or action of vasopressin), 506

**water loss, insensible**, 596

**water-soluble messengers**, 123–26, 124*f*

**water-soluble vitamins**. *See* vitamin(s)

**wavelength** distance between two successive wave peaks in oscillating medium, 205, 206*f*

**weak acids** acids whose molecules do not completely ionize to form hydrogen ions when dissolved in water; *compare* strong acids, 29

**Wernicke's area** brain area involved in language comprehension, 250*f*, 251

**white blood cells**. *See* leukocytes

**white matter** portion of CNS that appears white in unstained specimens and contains primarily myelinated axons, 173, 174*f*, 176, 176*f*

**white muscle fibers** muscle fibers lacking appreciable amounts of myoglobin, 277

**withdrawal**, 247, 248*t*

**withdrawal reflex** bending of those joints that withdraw an injured part away from a painful stimulus, 307–8, 308*f*



**Wolffian ducts** (WOLF-ee-an) parts of embryonic duct system that, in male, remain and develop into reproductive system ducts, but in female, degenerate, 607–11, 608*f*, 610*f*  
**working memory**, 249

## X

**Xanax (alprazolam)**, 169, 239  
**X chromosome** one of the two sex chromosomes; found in females and males, 607  
**Xylocaine (lidocaine)**, 153, 296

## Y

**Y chromosome** one of the two sex chromosomes; found only in genetic males, 607

## Z

**Zika virus** mosquito-borne virus that causes birth defects, 142  
**Z line** structure running across myofibril at each end of striated muscle sarcomere; anchors one end of thin filaments and titin, 259*f*, 260, 261*f*

**Zoloft (sertraline)**, 246  
**zona fasciculata**, 325, 326*f*  
**zona glomerulosa**, 325, 326*f*  
**zona pellucida** (ZOH-nah peh-LOO-sih dah) thick, clear layer separating egg from surrounding granulosa cells, 625, 626*f*  
**zona reticularis**, 325, 326*f*  
**zonular fibers** fibers that connect the ciliary muscles with the lens of the eye, 206, 207*f*, 208, 208*f*  
**zygote** (ZYE-goat) a newly fertilized egg, 606*f*, 607, 629*f*, 636–37  
**zymogens** (ZYE-moh-jenz) enzyme precursors requiring some change to become active, 544









