CHAPTER 1 ■ Summary

Cell and Cytoplasm

- Cells maintain proper homeostasis of the body
- Certain structural features common to all cells

The Cell Membrane

- Consists of phospholipid bilayer and integral (transmembrane) membrane proteins
- Peripheral membrane proteins located on external and internal cell surfaces
- Peripheral proteins anchored to microfilaments of cytoskeleton
- Cholesterol molecules within the cell membrane stabilize the cell membrane
- Carbohydrate glycocalyx covers cell surfaces
- Glycocalyx important for cell recognition, cell adhesion, and receptor binding sites

Molecular Organization of Cell Membrane

- Lipid bilayer in fluid state, hence the fluid mosaic model
- Phospholipids distributed in two layers with polar heads on inner and outer surfaces
- Nonpolar tails in center of membrane

Cell Membrane Permeability and Transport

- Cell membrane shows selective permeability and forms a barrier between internal and external cell environments
- Permeable to oxygen, carbon dioxide, water, steroids, and lipid-soluble chemicals
- Larger molecules enter cell by specialized transport mechanisms
- Endocytosis is ingestion of extracellular material into the cell
- Exocytosis is release of material from the cell
- Pinocytosis is ingestion of extracellular fluid
- Phagocytosis is uptake of large, solid particles
- Receptor-mediated endocytosis involves pinocytosis or phagocytosis via receptors on cell membrane and formation of clathrin-coated pits
- Uptake of low-density lipoproteins and insulin as example of receptor-mediated endocytosis

Cellular Organelles

Mitochondria

- Surrounded by cell membrane
- Shelflike cristae in protein-secreting cells and tubular cristae in steroid-secreting cells
- Present in all cells, especially numerous in highly metabolic cells
- Produce high-energy ATP molecules
- Cristae contain respiratory chain enzymes for ATP production
- Matrix contains enzymes, ribosomes, and circular mitochondrial DNA

Rough Endoplasmic Reticulum

- Exhibits interconnected cisternae with ribosomes
- Highly developed in protein-synthesizing cells
- Synthesizes proteins for export or lysosomes
- Synthesizes integral membrane proteins and phospholipids

Smooth Endoplasmic Reticulum

- Devoid of ribosomes and consists of anastomosing tubules
- Found in cells that synthesize phospholipids, cholesterol, and steroid hormones
- In liver cells, proliferates to deactivate or detoxify harmful chemicals
- In skeletal and cardiac muscle fibers, stores calcium between contractions

Golgi Apparatus

- Present in all cells, highly developed in secretory cells
- Consists of stacked, curved cisternae with convex side as the *cis* face
- Mature concave side is the *trans* face
- Cisternae enzymes modify, sort, and package proteins
- Adds sugars to proteins and lipids to form glycoproteins, glycolipids, and lipoproteins
- Secretory granules are modified, sorted, and packaged in membranes for export outside of cell or for lysosomes

Ribosomes

- Appear as free and attached (as to endoplasmic reticulum)
- Most abundant in protein-synthesizing cells
- Decode genetic messages from nucleus for amino acid sequence of protein synthesis
- Free ribosomes synthesize proteins for cell use
- Attached ribosomes synthesize proteins that are packaged for export or lysosomes use

Lysosomes

- Filled with hydrolyzing or digesting enzymes
- Separated from cytoplasm by membrane
- Functions in intracellular digestion or phagocytosis
- Digest microorganisms, cellular debris, worn-out cells, or cell organelles
- Residual bodies seen after phagocytosis
- Very abundant in phagocytic and certain white blood cells

Peroxisomes

- Contain oxidases that form cytotoxic hydrogen peroxide
- Contain enzyme catalase to eliminate excess hydrogen peroxide
- Abundant in liver and kidney cells, which remove much of the toxic material

The Cytoskeleton of the Cell

Microfilaments

- Thinnest microfilaments in the cytoskeleton
- Composed of protein actin
- Distributed throughout cell and used as anchors at cell junctions
- Form core of microvilli and terminal web at cell apices

Intermediate Filaments

- Thicker than microfilaments
- Epithelial cells contain keratin filaments
- Vimentin filaments found in mesenchymal cells
- Desmin filaments found in smooth and skeletal muscles
- Glial filaments found in astrocytic cells of the nervous system
- Lamin filaments found in nuclear membrane

Microtubules

- Largest filaments in cytoskeleton
- Composed of α and β tubulin
- Originate from centrosome
- Most visible in cilia and flagella

Centrosome and Centrioles

- Centrosome located near nucleus; contains two centrioles
- Centrioles perpendicular to one another; contain nine clusters of three microtubules each
- Before mitosis, centrioles replicate
- During mitosis, centrioles form mitotic spindles

Cytoplasmic Inclusions

- Temporary structures such as lipids, glycogen, crystals, and pigment

Nucleus and Nuclear Envelope

- Nucleus contains chromatin, nucleoli, nuclear matrix, and cellular DNA
- Double membrane called the nuclear envelope surrounds the nucleus
- Outer membrane of nuclear envelope contains ribosomes
- Nuclear pores at intervals in the nuclear envelope
- Nuclear pores control movements of material between nucleus and cytoplasm

Surfaces of Cells

Junctional Complex

- Tight junctions form an effective epithelial barrier
- Transmembrane proteins fuse the outer membranes of adjacent cells to form tight junctions
- In zonula adherens, transmembrane proteins attach to cytoskeleton and bind adjacent cells
- Desmosomes are spotlike structures, very prominent in skin and cardiac cells
- Desmosomes anchor cells through extension of transmembrane proteins into intercellular space between adjacent cells
- Gap junctions are spotlike structures with fluid channels called connexons
- Ions and chemicals diffuse through connexons from cell to cell
- Gap junctions allow rapid communications between cells for synchronized action

Basal Regions of Cells

Infolded Basal Regions of the Cell

- Infolded basal and lateral cell membranes function in ionic transport
- Found in kidney and salivary gland cells
- Na^+/K^+ ATPase pumps embedded in infolded membranes
- Numerous mitochondria in infoldings supply ATP for ion transport

Cilia

- Motile apical surface modifications
- Line cells in the respiratory organs, uterine tubes, and efferent ducts in testes
- Motility caused by sliding microtubule doublets
- Motor protein dynein uses ATP to move cilia

Microvilli

- Nonmotile apical surface modifications
- Well developed in small intestines and kidney
- Main function is absorption

CHAPTER 2 ■ Summary

SECTION 1 ■ Classification of Epithelial Tissue

Epithelial Tissue

Major Features

- Classification based on number of cell layers and cell morphology
- Basement membrane separates epithelium from connective tissue
- All epithelia are nonvascular; delivery of nutrients to cells and removal of metabolic waste occurs via diffusion
- Surface modifications include motile cilia, microvillli, and stereocilia

Types of Epithelia

Simple Squamous Epithelium

- Single layer of flat or squamous cells, includes mesothelium and endothelium
- Mesothelium lines external surfaces of digestive organs, lung, and heart
- Endothelium lines inside of heart chambers, blood vessels, and lymphatic vessels
- Functions in filtration, diffusion, transport, secretion, and reduction of friction

Simple Cuboidal Epithelium

- Single layer of round cells
- Lines small ducts and kidney tubules
- Protects ducts; transports and absorbs filtered material in kidney tubules

Simple Columnar Epithelium

- All cells are tall, some lined by microvilli
- Lines the lumina of digestive organs
- Secretes protective mucus for stomach lining
- Absorption of nutrients in small intestine

Pseudostratified Columnar Epithelium, Epithelium with Cilia or Stereocilia

- All cells reach basement membrane, but not all reach the surface
- Ciliated cells interspersed among mucus-secreting goblet cells
- In respiratory passages, ciliated cells clean inspired air and transport particulate matter across cell surfaces
- In female reproductive tract and efferent ducts of testes, ciliated cells transport oocytes and sperm across cell surfaces
- In epididymis and vas deferens, the lining stereocilia absorb testicular fluid

Stratified Epithelium

- Formed by multiple layers of cells, the superficial cell layer determining epithelial type
- Nonkeratinized squamous epithelium contains live superficial cell layer
- Nonkeratinized squamous forms moist and protective layer in esophagus, vagina, and oral cavity
- Keratinized epithelium contains dead superficial cell layer
- Keratinized epithelium provides protection against abrasion, bacterial invasion, and desiccation
- Cuboidal epithelium lines large excretory ducts in different organs
- Cuboidal epithelium provides protection for the ducts

Transitional Epithelium

- Found exclusively in renal calyces, renal pelvis, ureters, and bladder
- Changes shape in response to stretching caused by fluid accumulation
- During extension or contraction, cell contact unbroken
- Forms protective barrier between urine and underlying tissue

CHAPTER 2 ■ Summary

SECTION 2 ■ Glandular Tissue

Glandular Tissue

Exocrine Glands

- Can be unicellular or multicellular
- Multicellular glands contain secretory portion and ductal portion
- Secretions enter the ductal system
- Simple tubular glands exhibit unbranched duct; found in intestinal glands
- Coiled tubular glands seen in sweat glands
- Compound glands exhibit repeated ductal branching with either acinar (alveolar) or tubular secretory portions
- Compound acinar glands seen in mammary glands
- Compound tubuloacinar glands seen in salivary glands
- Mucous glands lubricate and protect inner linings of organs
- Serous glands produce watery secretions that contain enzymes
- Mixed glands contain both serous and mucous cells
- Merocrine glands, like pancreas, release secretion without cell loss
- Holocrine glands, like sebaceous skin glands, release secretion with cell components

Endocrine Glands

- Are individual cells as enteroendocrine cells in digestive organs
- Are endocrine portions in organs such as pancreatic islets in pancreas
- Are endocrine glands such as pituitary, thyroid, or adrenal glands
- Do not have ducts
- Are highly vascularized
- Secretory products enter bloodstream (capillaries) for systemic distribution

CHAPTER 3 ■ Summary

Connective Tissue

Classification

- Develops from mesenchyme and consists of cells and ground substance
- Embryonic connective tissue is present in umbilical cord and developing teeth
- Classified as loose or dense connective tissue

Loose Connective Tissue

- More prevalent in body and exhibits loose, irregular arrangement of cells and fibers
- Abundant ground substance
- Collagen fibers, fibroblasts, adipose cells, mast cells, and macrophages predominate

Dense Irregular Connective Tissue

- Consists primarily of fibroblasts, and thick and densely packed collagen fibers
- Fewer other cell types and minimal ground substance
- Collagen fibers exhibit random orientation and provide strong tissue support
- Concentrated in areas where resistance to forces from differnt directions is needed

Dense Regular Connective Tissue

- Fibers densely packed with regular, parallel orientation
- Present in tendons and ligaments that are attached to bones
- Great resistance to forces pulling along single axis or direction
- Minimal ground substance; predominant cell is fibroblast

Cells of Connective Tissue

Fibroblasts

- Are active permanent cells that synthesize all collagen, reticular, and elastic connective tissue fibers
- Synthesize glycosaminoglycans, proteoglycans, and glycoproteins of ground substance

Fibrocytes

- Smaller than fibroblasts
- Inactive or resting connective tissue cells

White Adipose (Fat) Cells

- Occur singly or in groups
- When adipose cells predominate, the connective tissue is adipose tissue
- Store fat (lipid) as single large droplet primarily as tryglycerides
- Appear as empty cells because lipid is dissolved during tissue preparation
- Distributed throughout body, serves as insulation, and forms fat pads for organ protection
- Highly vascularized owing to high metabolic activity
- Exhibit numerous receptors for different hormones that influence accumulation and release of lipid
- Secrete hormone leptin to increase lipid metabolism and to inhibit appetite

Brown Adipose Cells

- Cells smaller than white adipose cells; store lipid as multiple droplets
- Best developed in hibernating animals
- In newborns or animals emerging from hibernation, generates body heat
- Norepinephrine from sympathetic nervous system promotes hydrolysis of lipids

Macrophages

- Most numerous in loose connective tissue
- Ingest bacteria, dead cells, cell debris, and foreign matter
- Are antigen-presenting cells to lymphocytes for immunologic response
- Derived from circulating blood monocytes
- Called Kupfer cells in liver, osteoclasts in bone, and microglia in central nervous system

Lymphocytes

- Most numerous in loose connective tissue of respiratory and gastrointestinal tracts
- Produce antibodies and kill virus-infected cells

Plasma Cells

- Characterized by chromatin distributed in radial pattern
- Derived from lymphocytes exposed to antigens
- Produce antibodies to destroy specific antigens

Mast Cells

- Closely associated with blood vessel
- Found in skin, respiratory, and digestive system connective tissue
- Spherical cells with fine, regular basophilic granules
- Release histamine when exposed to allergens, causing allergic reactions

Neutrophils

- Active phagocytes; engulf and destroy bacteria

Eosinophils

- Increase after parasitic infestation
- Phagocytize antigen–antibody complexes during allergic reactions

Collagen Fibers

- Type I found in skin, tendons, ligaments, and bone
- Type II found in hyaline and elastic cartilage
- Type III forms meshwork in liver, lymph node, spleen, and hemopoietic organs
- Type IV found in basal lamina of basement membrane

Ground Substance

- Consists of extracellular matrix, a semifluid gel with high water content
- Contains polysaccharide chains of glycosaminoglycans, proteoglycans, and adhesive glycoproteins
- Hyaluronic acid is main glycosaminoglycan
- Other glycosaminoglycans form proteoglycan aggregates, which attract water
- Facilitates diffusion between cells and blood vessels
- Barrier to spread of pathogens
- Bacteria can hydrolyze hyaluronic acid and reduce barrier viscocity
- Contains several adhesive glycoproteins, such as fibronectin, that bind cells to fibers

CHAPTER 4 ■ Summary

SECTION 1 ■ Cartilage

Characteristics of Cartilage

- Develops from mesenchyme and consists of cells, connective tissue fibers, and ground substance
- Nonvascular, gets nutrients via diffusion through ground substance
- Performs numerous supportive functions
- Cells include chondrocytes and chondroblasts
- Three types of cartilage are the hyaline, elastic, and fibrocartilage

Hyaline Cartilage

- Most common in the body and serves as a skeletal model for most bones
- Replaced by bone during endochondral ossification
- Contains type II collagen fibrils
- In adults, present on articular surfaces of bones, ends of ribs, nose, larynx, trachea, and bronchi

Elastic Cartilage

- Contains branching elastic fibers in matrix and is highly flexible
- Found in external ear, auditory tube, epiglottis, and larynx

Fibrocartilage

- Filled with dense bundles of type I collagen fibers that alternate with cartilage matrix
- Provides tensile strength, bears weight, and resists compression
- Found in intervertebral disks, symphysis pubis, and certain joints

Perichondrium

- Found on peripheries of hyaline and elastic cartilage
- Peripheral layer is dense vascular connective tissue with type I collagen
- Inner layer is chondrogenic and gives rise to chondroblasts that secrete cartilage matrix
- Articular hyaline cartilage of bones and fibrocartilage not lined by perichondrium

Cartilage Matrix

- Produced and maintained by chondrocytes and chondroblasts
- Contains large proteoglycan aggregates and is highly hydrated
- Allows diffusion and is semirigid shock absorber
- Adhesive glycoprotein chondronectin binds cells and fibrils to surrounding matrix
- Elastic cartilage provides structural support and increased flexibility

Cartilage Cells

- Primitive mesenchyme cells differentiate into chondroblasts that synthesize the matrix
- Mature cartilage cells, chondrocytes, become enclosed in lacunae
- Inner layer of surrounding connective tissue perichondrium is chondrogenic
- Chondroblasts enlarge the cartilage by both interstitial and appositional growth

CHAPTER 4 ■ Summary

SECTION 2 ■ Bone

Characteristics of Bone

- Consists of cells, fibers, and extracellular material
- Mineral deposits in bone matrix produce hard structure for protecting various organs
- Functions in hemopoiesis and as reservoir for calcium and minerals

Process of Bone Formation

Endochondral Ossification

- In endochondral ossification, hyaline cartilage model calcifies and cells die
- Mesenchyme cells in periosteum differentiate into osteoprogenitor cells and form osteoblasts
- Osteoblasts synthesize osteoid matrix, which calcifies and traps osteoblasts in lacunae as osteocytes
- Osteocytes establish cell-to-cell communication via canaliculi
- Primary ossification center forms in diaphysis and secondary center of ossification in epiphysis
- Epiphyseal plate between diaphysis and epiphysis allows for growth in bone length
- All cartilage is replaced except the articular cartilage

Intramembranous Ossification

- Bone develops directly from osteoblasts that produce the osteoid matrix
- Initially form spongy bone that consists of trabeculae
- Mandible, maxilla, clavicle, and flat skull bones are formed by this process
- Fontanelles in newborn skull represent areas where intramembranous ossification is occurring

Bone Types

- In long bones, outer part is compact bone and inner surface is cancellous bone
- Both bone types have the same microscopic appearance
- In compact bones, collagen fibers arranged in lamellae
- Lamellae deep to the periosteum are outer circumferential lamellae
- Lamellae surrounding the bone marrow are inner circumferential lamellae
- Lamellae surrounding the blood vessels, nerves, and loose connective tissue are osteons
- Within an osteon is the central canal, which is found in most compact bone

Bone Matrix

- Highly vascularized to aid diffusion in calcified matrix
- Organic components of bone resist tension, whereas mineral components resist compression
- Major component is coarse type I collagen fibers
- Glycoprotein components bind to calcium crystals during mineralization
- Hormones from parathyroid and thyroid glands responsible for proper mineral content of blood

Bone Cells

- Osteoprogenitor cells are located in the periosteum, endosteum, osteons, and perforating canals
- Osteoblasts are on the bone surfaces and synthesize osteoid matrix
- Osteocytes are mature osteoblasts, are branched, are located in lacunae, and use canaliculi for communication and exchange
- Osteocytes maintain homeostasis of bone and blood concentrations of calcium and phosphate

- Osteoclasts are multinucleated cells responsible for resorption, remodeling, and bone repair
- Osteoclasts belong to the mononuclear macrophage-monocyte cell line and are found in enzyme-eroded depressions (Howship's lacunae)

Bone Characteristics

- Continually remodeled in response to mineral needs, mechanical stress, thinning, or disease
- Maintain normal calcium levels in blood, critical to functions of numerous organs and life
- Parathyroid hormone stimulates osteoclasts to resorb bone and release calcium into blood
- Hormone from thyroid gland inhibits osteoclast action and decreases bone resorption

CHAPTER 5 ■ Summary

Blood

- Consists of formed elements, erythrocytes, leukocytes, and platelets suspended in plasma

Hemopoiesis

- Blood cells constantly replaced in red marrow because of limited life span
- Common pluripotential stem cell forms pluripotential myeloid and lymphoid stem cells
- Myeloid stem cells give rise to erythrocytes, eosinophils, neutrophils, basophils, monocytes, and megakaryocytes
- Lymphoid stem cells give rise to B lymphocytes and T lymphocytes
- B and T lymphocytes reside in peripheral lymphoid tissue, lymph nodes, and spleen

Sites of Hemopoiesis

- In embryo, hemopoiesis takes place in yolk sac, liver, spleen, and lymph nodes
- In adult, hemopoiesis is limited to red bone marrow (skull, sternum, ribs, vertebrae, pelvis)

Formed Elements: Major Blood Cell Types

Erythrocytes

- Most numerous cells in blood
- Erythrocytes are nonnucleated cells that remain in the blood
- Contain hemoglobin with iron molecules in cytoplasm
- Carry oxygen as oxyhemoglobin and carbon dioxide as carbaminohemoglobin
- Biconcave shape increases surface area to carry respiratory gases
- Life span is about 120 days, after which cells are phagocytosed in spleen, liver, and bone marrow

Platelets

- Are fragments of bone marrow megakaryocytes and not blood cells
- Function in blood vessels to promote blood clotting when blood vessel wall is damaged
- In damaged vessels form plug; increase plug size through adhesive glycoproteins and fibrin
- Fibrin traps platelets and blood cells, and forms blood clot
- Cause clot retraction and removal through enzymatic action

Leukocytes

- Granulocytes contain cytoplasmic granules; they are neutrophils, eosinophils, and basophils
- Agranulocytes are without cytoplasmic granules; they are monocytes and lymphocytes

Granulocytes

Neutrophils

- Cytoplasm appears clear under microscope
- Nucleus contains several lobes connected by thin chromatin strands
- Have a short life span in blood or connective tissue, from hours to days
- Are very active phagocytes that are attracted to foreign material by chemotactic factors
- Destroy phagocytosed (ingested) material with lysosomal enzymes
- Constitute about 60 to 70% of blood leukocytes

Eosinophils

- Cytoplasm filled with large pink or eosinophilic granules
- Nucleus typically bilobed
- Have a short life span, in blood or connective tissue
- Are phagocytic with affinity for antigen–antibody complexes
- Release chemical that neutralizes histamine and other mediators of inflammatory reactions
- Increase during parasitic infestation to destroy helminthic parasites
- Constitute about 2 to 4% of the blood leukocytes

Basophils

- Cytoplasm contains dark blue or brown granules
- Have a short life span
- Nucleus stains pale basophilic, but is normally obscured by dense cytoplasmic granules
- Granules contain histamine and heparin
- Exposure to allergens releases histamine that causes intense inflammatory response in severe allergic reactions
- Constitute less than 1% of blood leukocytes

Agranulocytes

Lymphocytes

- No granules in cytoplasm and vary in size from small to large
- Dense-staining nucleus surrounded by a narrow cytoplasmic rim

- Life span is from days to months
- Essential in immunologic defense of organism
- When exposed to specific antigens, B lymphocytes form plasma cells in connective tissue
- Plasma cells release antibodies to counteract or destroy invading organisms
- Constitute about 20 to 30% of blood leukocytes

Monocytes

- Largest agranular leukocyte characterized primarily by horseshoe-shaped nucleus
- Live in connective tissue for months where they become powerful phagocytes
- Are part of the mononuclear phagocyte system
- Constitute about 3 to 8% of blood leukocytes

CHAPTER 6 ■ Summary

Muscle Tissue

- Three muscle types: skeletal muscle, cardiac muscle, and smooth muscle
- All muscles composed of elongated cells called fibers
- Muscle cytoplasm is sarcoplasm and muscle cell membrane is sarcolemma
- Muscle fibers contain myofibrils, made of contractile proteins actin and myosin

Skeletal Muscle

- Fibers are multinucleated with peripheral nuclei
- Actin and myosin filaments form distinct cross-striation patterns
- Muscle is surrounded by connective tissue epimysium
- Muscle fascicles surrounded by connective tissue perimysium
- Each muscle fiber surrounded by connective tissue endomysium
- Voluntary muscles under conscious control
- Motor end plates the site of nerve innervation and transmission of stimuli to muscle
- Axon terminals contain neurotransmitter acetylcholine
- Action potential releases acetylcholine into synaptic cleft
- Acetylcholine combines with its receptors on muscle membrane
- Acetylcholinesterase in synaptic cleft neutralizes acetylcholine and prevents further contraction
- Neuromuscular spindles are specialized stretch receptors in almost all skeletal muscles
- Stretching of muscle produces a stretch reflex and movement to shorten muscle

Transmission Electron Microscopy of Skeletal Muscle

- Light bands are I bands and are formed by thin actin filaments
- I bands are crossed by dense Z lines
- Between Z lines is the smallest contractile unit of muscle, the sarcomere
- Dark bands are A bands and are located in the middle of sarcomere
- A bands are formed by overlapping actin and myosin filaments
- M bands in the middle of A bands represent linkage of myosin filaments
- H bands on each side of M bands contain only myosin filaments
- Sarcoplasmic reticulum and mitochondria surround each sarcomere
- When muscle contracts, I and H bands shorten, while A bands stay same
- Sarcolemma invaginations into each myofiber form T tubules
- Expanded terminal cisternae of sarcoplasmic reticulum and T tubules form triads
- Triads are located at A-I junctions in mammalian skeletal muscles
- Stimulus for muscle contraction carried by T tubules to every myofiber
- After stimulation, sarcoplasmic reticulum releases calcium ions into sarcomeres
- Calcium activates the binding of actin and myosin, causing muscle contraction
- After end of contraction, calcium actively transported and stored in sarcoplasmic reticulum

Cardiac Muscle

- Located in heart and large vessels attached to heart
- Cross-striations of actin and myosin form similar I bands, A bands, and Z lines as in skeletal muscle
- Contains one or two central nuclei; fibers are branched
- Characterized by dense junctional complexes called intercalated disks that contain gap junctions
- T tubules located at Z lines; larger than in skeletal muscle
- Sarcoplasmic reticulum less well developed
- Gap junctions couple all fibers for rhythmic contraction
- Exhibit autorhythmicity and spontaneously generate stimuli
- Autonomic nervous system innervates heart and influences heart rate and blood pressure

Smooth Muscle

- Found in hollow organs and blood vessels
- Contain actin and myosin filaments without cross-striation patterns
- Fibers are fusiform in shape and contain single nuclei
- In intestines, muscles arranged in concentric layers
- Actin and myosin filaments do not show regular arrangement and there are not striations
- Actin and myosin form lattice network and insert into dense bodies in the sarcoplasm
- Actin and myosin contract and shorten muscle by sliding mechanism similar to skeletal muscle
- Exhibit spontaneous activity and maintain tonus in hollow organs
- Peristaltic contractions propel contents in the organs
- Gap junctions couple muscle and allow ionic communication between all fibers
- Involuntary muscles regulated by autonomic nervous system, hormones, and stretching

CHAPTER 7 ■ Summary

SECTION 1 ■ The Central Nervous System: Brain and Spinal Cord

The Mammalian Nervous System

- Central nervous system (CNS) consists of the brain and spinal cord
- Peripheral nervous system (PNS) consists of cranial and spinal nerves

Central Nervous System

- Surrounded by bones and cerebrospinal fluid
- Dura mater is the tough outermost connective tissue layer around the CNS
- Delicate arachnoid mater and dura cover CNS on external surfaces
- Pia mater adheres to surface of brain and spinal cord
- Between pia mater and arachnoid mater is subarachnoid space
- Cerebrospinal fluid circulates in subarachnoid space

Cerebrospinal Fluid

- Clear, colorless fluid cushions and protects brain and spinal cord
- Continually produced by choroid plexuses in brain ventricles
- Important for homeostasis and brain metabolism
- Reabsorbed into venous blood (superior sagittal sinus) via arachnoid villi

Morphology and Types of Neurons in CNS

- Structural and functional units of CNS
- Consist of soma or cell body, dendrites, and axon
- Three main types are multipolar, bipolar, and unipolar
- Multipolar are most common and include all motor neurons and interneurons
- Multipolar neurons contain numerous dendrites and a single axon
- Bipolar neurons are sensory and found in eyes, nose, and ears
- Bipolar neurons contain single dendrite and single axon
- Unipolar neurons are found in sensory ganglia and spinal nerves
- Unipolar neurons contain one process from the cell body and are sensory
- Interneurons found in CNS integrate and coordinate stimuli between sensory, motor, and other interneurons

Myelin Sheath and Myelination of Axons

- Specialized cells wrap around axons to form lipid-rich, insulating myelin sheath
- Myelin sheath extends along length of axon to its terminal branches
- Gaps between myelin sheath are nodes of Ranvier
- In PNS, Schwann cells myelinate axons and envelope unmyelinated axons
- Unmyelinated axons do not show nodes of Ranvier
- In CNS, neuroglial oligodendrocyte cells myelinate numerous axons

White and Gray Matter

- Gray matter contains neurons, dendrites, and neuroglia
- Site of synapse between neurons and dendrites in gray matter
- Posterior horns of spinal cord associated with axons of posterior roots
- Anterior horns of spinal cord associated with axons of anterior roots
- White matter contains only myelinated axons, unmyelinated axons, and neuroglia

Spinal Cord

- Thoracic region of spinal cord contains anterior, posterior, and lateral gray horns
- Lateral horns contain motor neurons of sympathetic division of autonomic nervous system
- Anterior horns of gray matter contain motor neurons
- Axons from anterior horns form anterior roots of spinal nerves
- White matter contains closely packed ascending and descending axons
- Posterior columns of white matter contain fasciculus gracilis and fasciculus cuneatus
- Gray matter inside the spinal cord is H-shaped and contains neurons and interneurons
- Gray commissure connects two sides of the gray matter and contains the central canal

Neurons, Axons, and Dendrites

- Classified as afferent (sensory), efferent (motor), or interneurons
- Neuron cell body and dendrites contain Nissl substance (granular endoplasmic reticulum)
- Neurofibrils in neuron cell body extend into dendrites and axons
- Axons arise from funnel-shaped region called axon hillock
- Axon and axon hillock are devoid of Nissl substance
- Afferent neurons conduct impulses via axons from internal or external receptor into the CNS
- Efferent neurons conduct impulses via axons from CNS to muscles or glands
- Neurons synthesize neurotransmitters in cell body
- Axons transport neurotransmitters in microtubules to synapses

- Stimuli cause conduction of nerve impulse (action potential) along the axons
- Initial segment of axon is site where stimuli are summated and nerve impulse generated
- Rate of impulse conduction dependent on axon size and myelination
- Dendrites are covered with dendritic spines for connections (synapses) with other neurons
- Dendrites receive and integrate information from dendrites, neurons, or axons

Supportive Cells in the CNS: Neuroglia

- Supportive, nonneural cells that surround neurons, axons, and dendrites
- Small cells that do not conduct impulses
- Ten times more numerous than neurons
- Four types: astrocytes, oligodendrocytes, microglia, and ependymal cells

Astrocytes

- Are the largest and most numerous in gray matter
- Consist of two types, fibrous astrocytes and protoplasmic astrocytes
- Both types abut on capillaries and neurons, and form blood-brain barrier
- Form glial limiting membrane that surrounds the brain and spinal cord
- Support metabolic exchange and contribute to energy metabolism of CNS
- Control chemical environment around neurons by clearing neurotransmitters

Oligodendrocytes

- Surround and myelinate numerous axons at one time, in contrast to Schwann cells

Microglia

- Part of the mononuclear phagocyte system and found throughout CNS
- Phagocytic cells in the CNS, similar to connective tissue macrophages

Ependymal Cells

- Line the ventricles in the brain and central canal of the spinal cord
- Ciliated cells move the CSF through the central canal of spinal cord

Cerebral Cortex: Gray Matter (Layers I to IV)

- Molecular layer (I): most superficial and covered by pia mater; contains neuroglial cells and horizontal cells of Cajal
- External granular layer (II): contains neuroglial cells and small pyramidal cells
- External pyramidal layer (III): medium-sized pyramidal cells predominant type
- Internal granular layer (IV): thin layer with small granule, pyramidal cells, and neuroglia
- Internal pyramidal layer (V): contains neuroglial cells and largest pyramidal cells
- Multiform layer (VI): deepest layer, adjacent to white matter with various cell types

Cerebellar Cortex

- Deep folds in cortex called cerebellar folia separated by sulci
- Outer molecular layer contains small neurons and fibers
- Middle Purkinje layer contains large Purkinje cells whose dendrites branch in molecular layer
- Granule cell layer contains small granule cells, Golgi type II cells, and empty spaces called glomeruli

CHAPTER 7 ■ Summary

SECTION 2 ■ The Peripheral Nervous System

Peripheral Nervous System

- Consists of neurons, neuroglia, nerves, and axons outside of the CNS
- Cranial nerves arise from brain and spinal nerves from spinal cord
- Ganglia are accumulations of neurons and ganglia covered by connective tissue
- Contains both sensory and motor nerves
- Neurons of peripheral nerves can be located in CNS or in ganglia

Connective Tissue Layers in Peripheral Nerves

- Peripheral nerves are partitioned by layers of connective tissue into fascicles
- Outermost connective tissue around the nerve is epineurium
- Connective tissue perineurium surrounds one or more nerve fascicles
- Vascular connective tissue layer endoneurium surrounds individual axons

Peripheral Nerves

- Nuclei seen between individual axons are Schwann cells and fibrocytes
- Schwann cells myelinate and surround individual axons, or enclose unmyelinated axons
- Between individual Schwann cells in myelinated axons are the nodes of Ranvier
- Conduction along myelinated axon is called saltatory conduction
- Small satellite cells surround neurons of PNS ganglia
- Satellite cells provide structural support, insulate, and regulate metabolic exchanges

Dorsal Root Ganglia and Unipolar Neurons of PNS

- Situated on dorsal nerve roots that join the spinal cord
- Sensory or round unipolar neurons constitute the ganglia
- Bundles of sensory nerve fibers or axons pass between the unipolar neurons
- Connective tissue capsule encloses the ganglia and merges with epineurium of peripheral nerve
- Unipolar neurons are surrounded by satellite cells, which are enclosed by connective tissue capsule cells

CHAPTER 8 ■ Summary

Blood Vascular System

- Consists of heart, major arteries, arterioles, capillaries, veins, and venules

Type of Arteries

Elastic Arteries

- Are the largest vessels in the body
- Include aorta, pulmonary trunk, and their major branches
- Wall primarily composed of elastic connective tissue
- Exhibit resilience and flexibility during blood flow
- Walls greatly expand during systole (heart contraction)
- During diastole (heart relaxation), walls recoil and force blood forward

Muscular Arteries, Arterioles, and Capillaries

- Wall contains much smooth muscle
- Control of blood flow through vasoconstriction or vasodilation of lumina
- Smooth muscles in arterial walls controlled by autonomic nervous system
- Arterioles are the small blood vessels with one to five layers of smooth muscle
- Terminal arterioles deliver blood to smallest blood vessels, the capillaries
- Capillaries are sites of metabolic exchanges between blood and tissues
- Capillaries connect arterioles with venules

Structural Plan of Arteries

- Wall consists of three layers: inner tunica intima, middle tunica media, and outer tunica adventitia
- Tunica intima consists of endothelium and subendothelial connective tissue
- Tunica media is composed mainly of smooth muscle fibers
- Tunica adventitia contains primarily collagen and elastic fibers
- Smooth muscles produce the extracellular matrix
- Internal elastic lamina separates tunica intima from tunica media
- External elastic lamina separates tunica media from tunica adventitia

Structural Plan of Veins

- Capillaries unite to form larger vessels called venules and postcapillary venules
- Thinner walls, larger diameters, and more structural variation than arteries
- In veins of extremities, valves present to prevent backflow of blood
- Blood flows toward heart owing to muscular contractions around veins
- Wall consists of three layers: inner tunica intima, middle tunica media, and outer tunica adventitia
- Tunica intima consists of endothelium and subendothelial connective tissue
- Tunica media is thin, and smooth muscle intermixes with connective tissue fibers
- Tunica adventitia is the thickest layer with longitudinal smooth muscle fibers

Vasa Vasorum

- Found in walls of large arteries and veins
- Small blood vessels supply tunica media and tunica adventitia

Types of Capillaries

- Average diameter is about the size of red blood cell
- Continuous capillaries are most common; endothelium forms solid lining
- Continuous capillaries found in most organs
- Fenestrated capillaries contain pores or fenestrations in endothelium
- Fenestrated capillaries found in endocrine glands, small intestine, and kidney glomeruli
- Sinusoidal capillaries exhibit wide diameters with wide gaps between endothelial cells
- Basement membrane incomplete or absent in sinusoidal capillaries
- Sinusoidal capillaries found in liver, spleen, and bone marrow

Lymph Vascular System

- Consists of lymph capillaries and vessels
- Starts as blind lymphatic capillaries
- Collects excess interstitial fluid lymph and returns it to venous blood
- Vessels very thin for greater permeability
- Lymph vessels contain valves
- Lymph flows through lymph nodes and is exposed to macrophages
- Lymph contains lymphocytes, fatty acids, and immunoglobulins (antibodies)

Endothelium

- Forms a permeability barrier between blood and interstitial tissue
- Provides smooth surface for blood flow and produces anticoagulants to prevent blood clotting
- Dilates and constricts blood vessels

- Produces cell adhesion molecules to induce leukocyte adhesion and accumulation
- Converts angiotensin I to angiotensin II to increase blood pressure
- Converts certain chemicals to inactive compounds, degrades lipoproteins, and produces growth factors

Heart Wall – Endocardium, Myocardium, and Epicardium

Pacemaker

- Impulse conduction by specialized cardiac cells located in SA and AV nodes
- SA and AV nodes located in the wall of the right atrium
- SA node sets the pace for the heart and is the pacemaker of the heart
- Impulse from SA node conducted via gap junctions to all heart musculature
- Atrioventricular bundles located on right and left sides of the interventricular septum
- Atrioventricular bundles become Purkinje fibers
- Pacemaker activities influenced by autonomic nervous system and hormones

Purkinje Fibers

- Larger than cardiac fibers with more glycogen and lighter staining
- Part of the conduction system of the heart
- Located beneath the endocardium on either side of the interventricular septum
- Branch throughout the myocardium and deliver stimuli via gap junctions to rest of heart

Atrial Natriuretic Hormone

- Certain atrial cells contain granules of atrial natriuretic hormone
- Released when atrial wall is stretched
- Decreases blood pressure by inhibiting renin and aldosterone release
- Kidney loses more sodium and water, which decreases blood volume and pressure

CHAPTER 9 ■ Summary

Lymphoid System

- Collects excess interstitial fluid
- Protects organism against invading pathogens or antigens by producing immune responses
- Includes all cells, tissues, and organs that contain lymphocytes
- Major organs are lymph nodes, spleen, thymus, and tonsils

Lymphoid Organs

Lymph Nodes

- Distributed along the paths of lymphatic vessels
- Most prominent in inguinal and axillary regions
- Surrounded by connective tissue capsule that sends trabeculae into interior
- Afferent lymph vessels with valves penetrate the capsule and enter subcapsular sinus
- Major blood vessels present in connective tissue trabeculae
- Exhibit an outer dark-staining cortex and an inner light-staining medulla
- Medullary cords in the medulla contain plasma cells, macrophages, and lymphocytes
- Medullary sinuses are capillary channels that drain lymph from cortical regions
- Efferent lymphatic vessels drain lymph from medullary sinuses to exit at the hilus
- Deeper region of the cortex is the paracortex, occupied by T cells
- Major function is lymph filtration and phagocytosis of foreign material from lymph
- Produce, store, and recirculate B and T cells
- B cells accumulate in lymphatic nodules
- T cells concentrate in deep cortical or paracortex regions
- Activate B cells to give rise to plasma cells and memory B cells
- B and T cells enter lymph nodes through postcapillary venules
- Postcapillary venules contain lymphocyte-homing receptors and high endothelium

Lymphatic Nodules

- Contain nonencapsulated lymphocytes collected in the cortex
- Peripheral zone stains dense owing to accumulation of small lymphocyte
- A lighter central region is the germinal center with medium-sized lymphocytes

Lymphoid Cells

- Originate from hemopoietic stem cells in bone marrow

T Lymphocytes (T Cells)

- Stimulated lymphocytes produce B cells and T cells
- T cells arise from lymphocytes that left bone marrow and matured in thymus gland
- After maturation, T cells are distributed to all lymph tissues and organs
- On encountering antigens, T cells destroy them by cytotoxic action or activating B cells
- Four types of differentiated T cells: helper T cells, cytotoxic T cells, memory T cells, and suppressor T cells
- Helper T cells secrete cytokines or interleukins when encounter antigens
- Cytokines stimulate B cells to differentiate into plasma cells and to secrete antibodies
- Cytotoxic T cells attack and destroy virus-infected, foreign, or malignant cells
- Memory T cells are long-living progeny of T cells and respond to same antigens
- Suppressor T cells inhibit the functions of helper T cells
- Maturation of T cells a very complicated process, involving positive and negative selection
- Most T cells recognize self-antigens and die (negative selection)
- T cells that recognize foreign antigens reach maturity and enter bloodstream (positive selection)

B Lymphocytes (B Cells)

- B cells remain and mature in bone marrow, then move to lymphoid tissues and organs
- Recognize antigens as a result of antigen receptors on cell membranes and become activated
- Response more intense when helper T cells present antigens to B cells
- Cytokines secreted by helper T cells increase proliferation of activated B cells
- B cells secrete antibodies and destroy foreign substance
- Other activated B cells remain as memory B cells for future defense against same antigens

Other Cells in Immune Responses

- Natural killer cells attack virally infected cells and cancer cells
- Antigen-presenting cells phagocytose and present antigens to T cells for immune response
- Connective tissue macrophages such as perisinusoidal cells in liver, Langerhans cells in skin, and other lymphoid organs

Types of Immune Responses

Cell-Mediated Immune Response

- T cells stimulated by antigens secrete cytokines that stimulate other lymphocytes
- Cytotoxic T cells produce protein perforin to puncture target cells or induce apoptosis

Humoral Immune Response

- Exposure of B cells to antigen induces proliferation and plasma cell formation
- Plasma cells produce antibodies to destroy specific foreign substance
- Helper T cells cooperate and produce cytokines

Spleen

- Largest lymphoid organ with extensive blood supply; filters blood and serves as blood reservoir
- Surrounded by connective tissue capsule that divides it into compartments called splenic pulp
- White pulp consists of lymphatic nodules with germinal center around a central artery
- Red pulp consists of splenic cords and splenic (blood) sinusoids
- Splenic cords contain macrophages, lymphocytes, plasma cells, and different blood cells
- Does not exhibit cortex and medulla, but contains lymphatic nodules
- White pulp is the site of immune response to bloodborne antigens
- T cells surround the central arteries, whereas B cells are mainly in the lymphatic nodules
- Antigen-presenting cells and macrophages are found in white pulp
- Breaks down hemoglobin from worn-out erythrocytes and recycles iron to bone marrow
- Degrades heme from hemoglobin, which is then excreted in the bile
- During fetal life is an important hemopoietic organ

Thymus Gland

- Lobulated lymphoepithelial organ with dark-staining cortex and light-staining medulla
- Most active in childhood and has an important role early in life in immune system development
- Site where immature lymphocytes from bone marrow mature into T cells, helper T cells, and cytotoxic T cells
- Thymic nurse cells promote lymphocyte differentiation, proliferation, and maturation
- Blood-thymus barrier prevents developing lymphocytes contacting bloodborne antigens
- Sends mature T cells to populate lymph nodes, spleen, and lymphatic tissues
- Epithelial reticular cells secrete hormones needed for lymphocyte maturation
- Epithelial reticular cells form thymic (Hassall's) corpuscles in medulla
- Involutes and becomes filled with adipose tissues as individual ages
- Removal early in life results in loss of immunologic competence

CHAPTER 10 ■ Summary

Integumentary System

- Skin and derivatives form the integumentary system
- Consists of superficial epidermis and deeper dermis
- Nonvascular epidermis is covered by keratinized stratified squamous epithelium
- Vascular dermis consists of irregular connective tissue

Epidermis: Thick Versus Thin Skin

- Palms and soles, because of wear and tear, are covered by thick skin
- Thick skin contains sweat glands, but lacks hair, sebaceous glands, and smooth muscle
- Thin skin contains sebaceous glands, hair, sweat glands, and arrector pili smooth muscle
- Keratinocytes are predominant cell type in the epidermis
- Less numerous epidermal cells are the melanocytes, Langerhans cells, and Merkel's cells
- Basement membrane separates dermis from epidermis

Dermis

Papillary Layer

- Is the superficial layer in dermis and contains loose irregular connective tissue
- Dermal papillae and epidermal ridges form evaginations and interdigitations
- Connective tissue filled with fibers, cells, and blood vessels
- Sensory receptors Meissner's corpuscles are present in dermal papillae

Reticular Layer

- Is the deeper and thicker layer in dermis, filled with dense irregular connective tissue
- Few cells present and collagen is type I
- No distinct boundary between papillary and reticular layers
- Blends inferiorly with hypodermis or subcutaneous layer (hypodermis) of superficial fascia
- Contains arteriovenous anastomoses and sensory receptors Pacinian corpuscles
- Concentric lamellae of collagen fibers surround myelinated axons in Pacinian corpuscles

Epidermal Cell Layers

Stratum Basale (Germinativum)

- Deepest or basal single layer of cells that rests on the basement membrane
- Cells attached by desmosomes and by hemidesmosomes to basement membrane
- Cells serve as stem cells for epidermis and show increased mitosis
- Cells migrate upward in epidermis and produce intermediate keratin filaments

Stratum Spinosum

- Is the second layer above stratum basale that consists of four to six rows of cells
- During histologic preparation, cells shrink and intercellular spaces appear as spines
- Cells synthesize keratin filaments that become assembled into tonofilaments
- Spines represent sites of desmosome attachments to keratin tonofilaments

Stratum Granulosum

- Cells are above stratum spinosum and consists of three to five cell layers of flattened cells
- Cells filled with dense keratohyalin granules and membrane-bound lamellar granules
- Keratohyalin granules associate with keratin tonofilaments to produce soft keratin
- Lamellar granules discharge lipid material between cells and waterproof the skin

Stratum Lucidum

- Lies superior to stratum granulosum, found in thick skin only, translucent and barely visible
- Cells lack nuclei or organelles and are packed with keratin filaments

Stratum Corneum

- Most superficial layer and consists of flat, dead cells filled with soft keratin
- Keratinized cells continually shed or desquamated and replaced by new cells
- During keratinization, hydrolytic enzymes eliminate nucleus and organelles

Other Skin Cells

Melanocytes

- Arise from neural crest cells and are located between stratum basale and stratum spinosum
- Long irregular cytoplasmic extensions branch into epidermis
- Synthesize from amino acid tyrosine a dark brown pigment, melanin
- Melanin transferred to keratinocytes in basal cell layers
- Melanin darkens skin color and protect it from ultraviolet radiation

Langerhans Cells

- Found mainly in stratum spinosum; part of immune system of body
- Are antigen-presenting cells of the skin

Merkel's Cells

- Present in the basal layer of epidermis and function as mechanoreceptors for pressure

Major Skin Functions

- Protection through keratinized epidermis from abrasion and entrance of pathogens
- Impermeable to water owing to lipid layer in epidermis
- Body temperature regulation as a result of sweating and changes in vessel diameters
- Sensory perception of touch, pain, pressure, and temperature changes because of nerve endings
- Excretions through sweat of water, sodium salts, urea, and nitrogenous waste
- Formation of vitamin D from precursor molecules produced in epidermis when exposed to sun

Skin Derivatives

Hairs

- Develop from surface epithelium of the epidermis and reside deep in the dermis
- Are hard cylindrical structures that arise from hair follicles
- Surrounded by external and internal root sheaths
- Grow from expanded hair bulb of the hair follicle
- Hair bulb indented by connective tissue (dermal) papilla that is highly vascularized
- Hair matrix situated above papilla contain mitotic cells and melanocytes

Sebaceous Glands

- Numerous sebaceous glands associated with each hair follicle
- Cells in sebaceous glands grow, accumulate secretions, die, and become oily secretion sebum
- Smooth muscles arrector pili attach to papillary layer of dermis and to sheath of hair follicle
- Contraction of arrector pili muscle stands hair up and forces sebum into lumen of hair follicle

Sweat Glands

- Widely distributed in skin and are of two types: eccrine and apocrine
- Assist in temperature regulation and excretion of water, salts, and some nitrogenous waste

Eccrine Sweat Glands

- Are simple coiled glands located deep in dermis in skin of palms and soles
- Consist of clear and dark secretory cells, and excretory duct
- Clear cells secrete watery product, whereas dark cells secrete mainly mucus
- Contractile myoepithelial cells surround only the secretory cells
- Excretory duct is thin, dark-staining, and lined by stratified cuboidal cells
- Excretory duct ascends, straightens, and penetrates epidermis to reach surface of skin

Apocrine Sweat Glands

- Found coiled in deep dermis of axilla, anus, and areolar regions of the breast
- Ducts of glands open into hair follicles
- Lumina wide and dilated, with low cuboidal epithelium
- Contractile myoepithelial cells surround secretory portion of glands
- Become functional at puberty, when sex hormones are present
- Secretion has unpleasant odor after bacterial decomposition

CHAPTER 15 ■ Summary

Components of Respiratory System

- Conducting portion consists of solid passageways that move air in and out of lungs
- Pseudostratified ciliated epithelium with numerous goblet cells line the larger passageways
- As passageways branch, there is a decrease in epithelium height and tubule size
- Terminal bronchioles represent the terminal portion of conducting portion
- Respiratory bronchioles represent the transition zone between conducting and respiratory zones

Conducting Portion of Respiratory System: Extrapulmonary and Intrapulmonary

- Extrapulmonary structures are the nose, pharynx, larynx, trachea, and bronchi
- Conditions air by humidifying, warming, and filtering it owing to cilia and mucus in passageways
- Intrapulmonary structures include bronchi, bronchioles, and terminal bronchioles
- Incomplete hyaline cartilage C-rings encircle and keep trachea patent (open)
- In the lungs, hyaline cartilage plates replace C rings and encircle the larger bronchi
- Bronchioles of about 1 mm diameter no longer have cartilage
- As tubular size decreases, epithelium becomes simple ciliated and goblet cells disappear

Clara Cells

- Replace goblet cells and become predominant cells in terminal and respiratory bronchioles
- Are secretory, nonciliated cells that increase in number as ciliated cells decrease
- Secrete lipoprotein components of surfactant, a tension-reducing agent
- May also function as stem cells to replace lost or injured bronchial epithelial cells
- May secrete proteins into bronchial tree to protect lung from inflammation or toxic pollutants

Respiratory Portion of Respiratory System

- Starts with a passageway where initial respiration can take place
- Terminal bronchioles give rise to respiratory bronchioles
- Respiratory bronchioles exhibit thin-walled alveoli, where respiration can take place
- Gaseous exchange can take place only when alveoli are present
- Consists of respiratory bronchioles, alveolar ducts, alveolar sacs, and alveoli
- Goblet cells are absent from alveoli and the lining is very thin where respiration occurs

Cells of Lung Alveoli

- Type I alveolar cells (type I pneumocytes)
- Are very thin and line the lung alveoli
- With capillary endothelium, form the thin blood-air barrier
- Type II alveolar cells (type II pneumocytes)
- Are adjacent to type I cells
- Are secretory cells, whose apices project above type I cells
- Contain numerous secretory lamellar bodies
- Synthesize phospholipid surfactant for release into individual alveoli
- Surfactant reduces alveolar surface tension, allowing expansion and preventing collapse

Alveolar Macrophages

- Are monocytes that enter pulmonary connective tissue and alveoli
- Clean alveoli of invading organisms and phagocytose particular matter

Olfactory Epithelium

- Located in the roof of the nasal cavity and on each side of the superior concha
- Contains supportive, basal, and olfactory cells, the sensory bipolar neurons, without goblet cells
- Olfactory cells span the thickness of epithelium and are distributed in the middle of epithelium
- Surface of cells shows small, round olfactory vesicles with nonmotile olfactory cilia
- Olfactory cilia contain odor-binding receptors that are stimulated by odor molecules
- Below epithelium are serous olfactory glands that bathe olfactory cilia and provide odor solvents
- Olfactory nerves in lamina propria leave olfactory cells and continue into cranial cavity
- Supportive cells provide mechanical support; basal cells serve as stem cells for epithelium
- Transition from olfactory to respiratory epithelium is abrupt

Epiglottis

- Superior part of larynx that projects upward from larynx wall
- A central elastic cartilage forms core of the epiglottis
- Stratified squamous epithelium lines lingual (anterior) and part of laryngeal (posterior) surface
- Base of epiglottis lined with pseudostratified ciliated columnar epithelium
- Taste buds may be present in lingual or laryngeal epithelium

Larynx

- Pseudostratified ciliated columnar epithelium lines false vocal fold, as in posterior epiglottis
- Mixed seromucous glands, blood vessels, lymphatic nodules, and adipose cells in lamina propria
- Ventricle, a deep indentation, separates false vocal fold from true vocal fold
- True vocal fold lined by stratified squamous nonkeratinized epithelium
- Vocalis ligament is at the apex of true vocal fold and skeletal vocalis muscle is adjacent
- Hyaline thyroid cartilage and cricoid cartilage provide support for the larynx
- Epithelium in lower larynx changes back to pseudostratified ciliated columnar

Trachea

- Wall consists of mucosa, submucosa, hyaline cartilage, and adventitia
- Cartilage C rings keep trachea open with gaps between rings filled with trachealis muscle
- The lining is pseudostratified ciliated columnar epithelium with goblet cells
- Submucosa contains seromucous tracheal glands with ducts opening into trachea lumen