Chapter 05
Lecture Outline

See separate PowerPoint slides for all figures and tables pre-inserted into PowerPoint without notes.

Because learning changes everything.™

Introduction

- There are 50 trillion cells of 200 different cell types
- Four broad categories of tissues
  - Epithelial tissue
  - Connective tissue
  - Nervous tissue
  - Muscular tissue
- Organ—structure with discrete boundaries that is composed of two or more tissue types
- Histology (microscopic anatomy)—the study of tissues and how they are arranged into organs

5.1 The Study of Tissues

- Expected Learning Outcomes
  - Name the four primary classes into which all adult tissues are classified.
  - Name the three embryonic germ layers and some adult tissues derived from each.
  - Visualize the three-dimensional shape of a structure from a two-dimensional tissue section.

The Primary Tissue Classes

- Tissue—a group of similar cells and cell products working together to perform a specific role in an organ
- The four primary tissues (epithelial, connective, nervous, and muscular) differ from each other in:
  - Types and functions of their cells
  - Characteristics of the matrix (extracellular material)
  - Relative amount of space occupied by cells versus matrix
- Matrix (extracellular material) is composed of:
  - Fibrous proteins
  - Clear gel called ground substance
    - Also known as tissue fluid, extracellular fluid (ECF), interstitial fluid, or tissue gel

Embryonic Tissues

- A fertilized egg becomes an embryo with layers
- Three primary germ layers
  - Ectoderm (outer)
    - Gives rise to epidermis and nervous system
  - Endoderm (inner)
    - Gives rise to mucous membrane lining digestive and respiratory tracts, digestive glands, among other things
  - Mesoderm (middle) becomes gelatinous tissue called mesenchyme
    - Wispy collagen fibers and fibroblasts in gel matrix
    - Gives rise to cartilage, bone, blood

Interpreting Tissue Sections 1

- Understanding histology requires awareness of how specimens are prepared
- Histologists preserve, slice and section tissues
  - Fixative prevents decay (formalin)
  - Histological sections: tissue is sliced into thin sections one or two cells thick
  - Stains: tissue is mounted on slides and artificially colored with histological stain
    - Stains bind to different cellular components
- Sectioning reduces three-dimensional structure to two-dimensional slice

Interpreting Tissue Sections 2

- Sectioning a cell with a centrally located nucleus
- Some slices miss the cell nucleus
- In some slices, the cell and nucleus appear smaller
- Curved and coiled ducts might not look continuous when viewed in two dimensions

Three-Dimensional Interpretation of Two-Dimensional Images

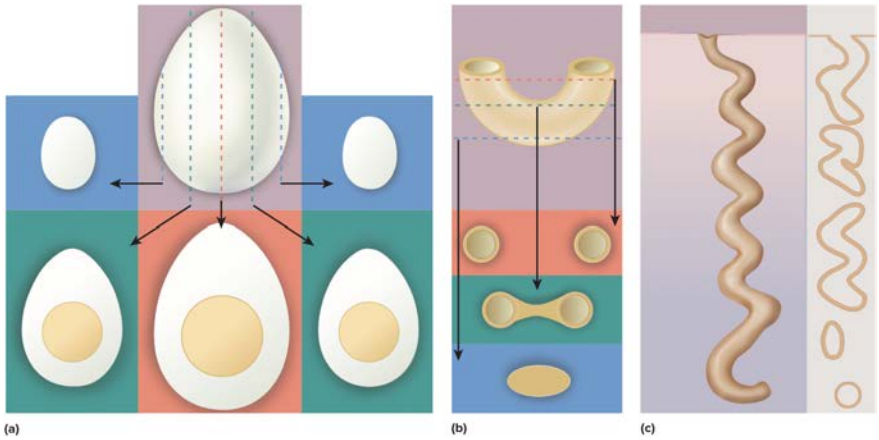


Figure 5.1

Interpreting Tissue Sections 3

- Longitudinal section (l.s.)
  - Tissue cut on its long axis
- Cross section (c.s. or x.s.) or transverse section (t.s.)
  - Tissue cut perpendicular to long axis of organ
- Oblique section
  - Tissue cut at angle between cross and longitudinal sections

Longitudinal, Cross, and Oblique Sections

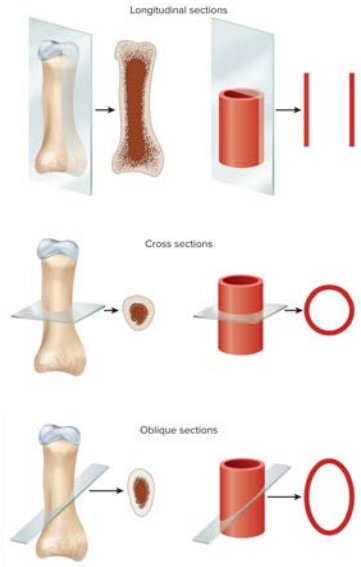


Figure 5.2

Interpreting Tissue Sections 4

- Smear—tissue is rubbed across a slide
  - Example: blood
- Spread— some membranes and cobwebby tissues are laid out on a slide
  - Example: areolar tissue

5.2 Epithelial Tissue

- Expected Learning Outcomes
  - Describe the properties that distinguish epithelium from other tissue classes.
  - List and classify eight types of epithelium, distinguish them from each other, and state where each type can be found in the body.
  - Explain how the structural differences between epithelia relate to their functional differences.
  - Visually recognize each epithelial type from specimens or photographs.

Epithelial Tissue 1

- Epithelia are sheets of closely adhering cells, one or more cells thick
- Covers body surfaces and lines body cavities
- Upper surface usually exposed to the environment or an internal space in the body
- Constitutes most glands
- Avascular (does not have blood vessels)
  - Usually nourished by underlying connective tissue

Epithelial Tissue 2

- Functions:
  - Protect deeper tissues from injury and infection
  - Produce and release chemical secretions
  - Excrete wastes
  - Absorb chemicals including nutrients
  - Selectively filter substances
  - Sense stimuli

Epithelial Tissue 3

- Epithelial cells are very close together
- Have a high rate of mitosis
- Basement membrane—layer between an epithelium and underlying connective tissue
  - Collagen, reticular proteins, glycoproteins, other protein-carbohydrate complexes
  - Anchors the epithelium to the connective tissue below it
- Basal surface—surface of epithelial cell facing the basement membrane
- Apical surface—surface of epithelial cell that faces away from the basement membrane

Epithelial Tissue 4

- Simple epithelia
  - Contain one layer of cells
  - Named by shape of cells
  - All cells touch basement membrane
- Stratified epithelia
  - Contain more than one layer
  - Named by shape of apical cells
  - Some cells rest on top of others and do not touch basement membrane

Cell Shapes and Epithelial Types

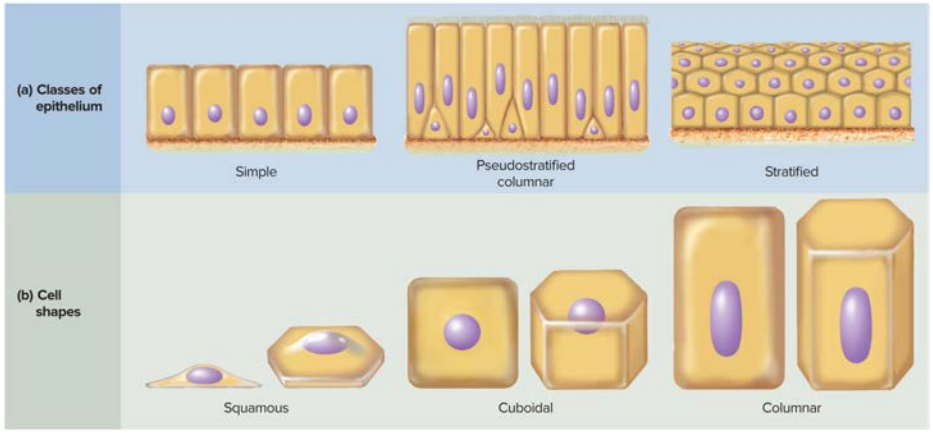
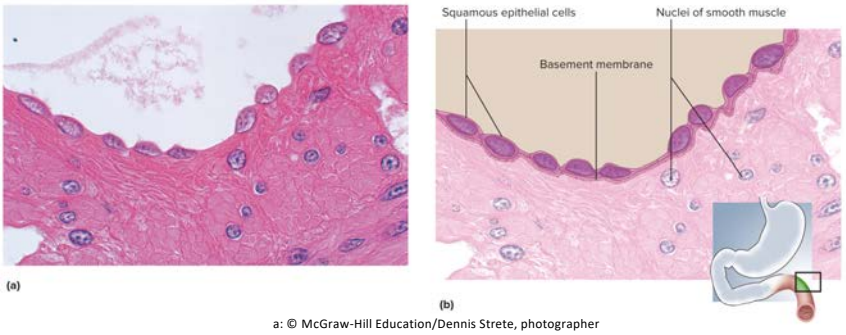


Figure 5.3

Simple Epithelia

- Four types on epithelia with only one layer of cells
  - Simple squamous (thin, scaly cells)
  - Simple cuboidal (square or round cells)
  - Simple columnar (tall, narrow cells)
  - Pseudostratified columnar
    - Falsely appears stratified, as some cells taller than others
    - Every cell reaches the basement membrane (but not all cells reach the free surface)
- Goblet cells—wineglass-shaped mucus-secreting cells in simple columnar and pseudostratified epithelia

Simple Squamous Epithelium

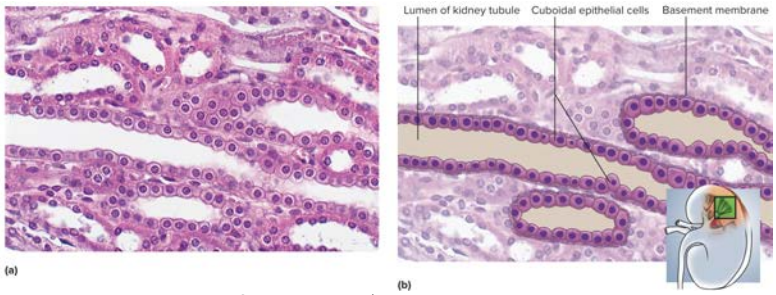


a: © McGraw-Hill Education/Dennis Strete, photographer

- **Simple squamous epithelium**
  - Single row of thin cells
  - Permits rapid diffusion or transport of substances
  - Secretes serous fluid
  - Locations: alveoli, glomeruli, endothelium, and serosa

Figure 5.4a,b

Simple Cuboidal Epithelium

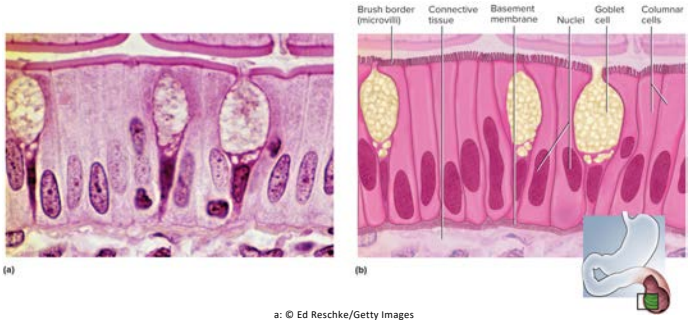


a: © McGraw-Hill Education/Dennis Strete, photographer

- Simple cuboidal epithelium
  - Single layer of square or round cells
  - Absorption and secretion, mucus production and movement
  - Locations: liver, thyroid, mammary and salivary glands, bronchioles, and kidney tubules

Figure 5.5a, b

Simple Columnar Epithelium

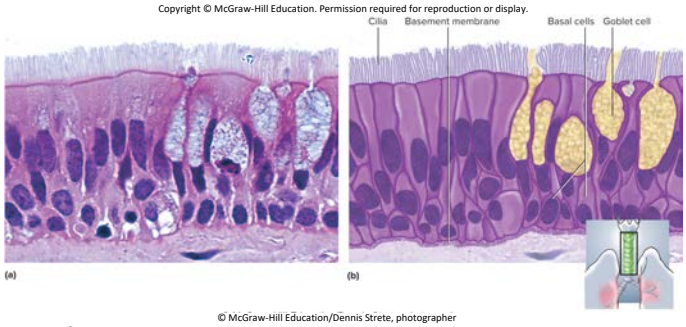


a: © Ed Reschke/Getty Images

- Simple columnar epithelium
  - Single row of tall, narrow cells
  - Oval nuclei in basal half of cell
  - Brush border of microvilli, ciliated in some organs, may possess goblet cells
  - Absorption and secretion; secretion of mucus
  - Locations: lining of GI tract, uterus, kidney, and uterine tubes

Figure 5.6a,b

Pseudostratified Epithelium



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- Pseudostratified epithelium
  - Looks multilayered, but all cells touch basement membrane
  - Nuclei at several layers
  - Has cilia and goblet cells
  - Secretes and propels mucus
  - Locations: respiratory tract and portions of male urethra

Figure 5.7a,b

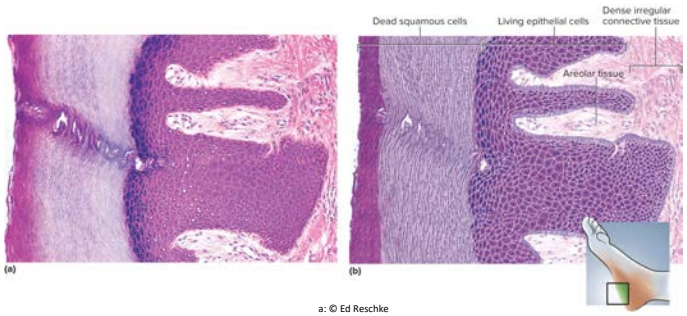
Stratified Epithelia 1

- Range from 2 to 20 or more layers of cells
- Some cells rest directly on others
  - Only the deepest layer attaches to basement membrane
- Three stratified epithelia are named for the shapes of their apical surface cells
  - Stratified squamous
  - Stratified cuboidal
  - Stratified columnar (rare)
- Fourth type
  - Transitional epithelium

Stratified Epithelia 2

- Stratified squamous is most widespread epithelium in the body
- Deepest layers undergo continuous mitosis
  - Daughter cells push toward the surface and become flatter as they migrate upward
  - Finally die and flake off—exfoliation or desquamation
- Two kinds of stratified squamous epithelia
  - Keratinized—found on skin surface, abrasion resistant
  - Nonkeratinized—lacks surface layer of dead cells

Keratinized Stratified Squamous Epithelium

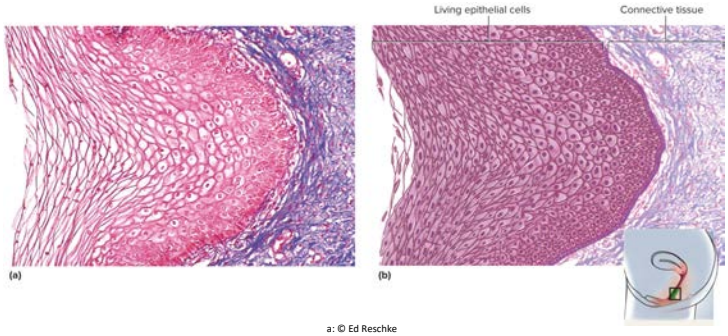


a: © Ed Reschke

- Keratinized stratified squamous
  - Multiple cell layers; cells become flat and scaly toward surface
  - Resists abrasion; retards water loss through skin; resists penetration by pathogenic organisms
  - Locations: epidermis; palms and soles heavily keratinized

Figure 5.8a,b

Non-keratinized Stratified Squamous Epithelium

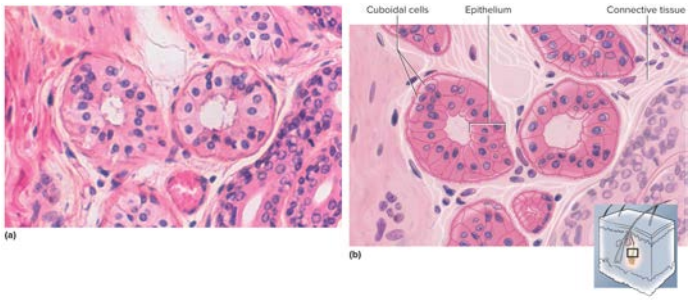


a: © Ed Reschke

- Nonkeratinized stratified squamous
  - Same as keratinized epithelium without surface layer of dead cells
  - Resists abrasion and penetration of pathogens
  - Locations: tongue, oral mucosa, esophagus, and vagina

Figure 5.9a,b

Stratified Cuboidal Epithelium

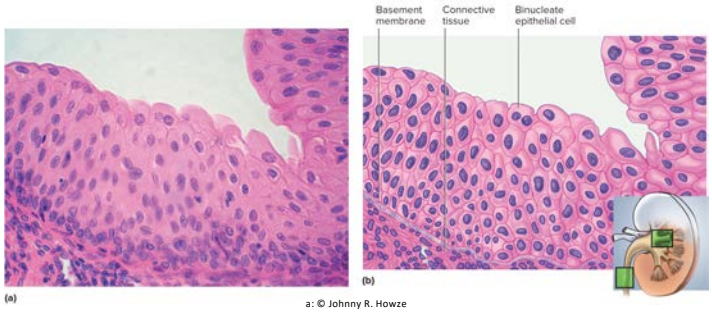


a: © Lester V. Bergman/Corbis

- Stratified cuboidal epithelium
  - Two or more cell layers; surface cells square or round
  - Secretes sweat; produces sperm, produces ovarian hormones
  - Locations: sweat gland ducts; ovarian follicles and seminiferous tubules

Figure 5.10a,b

Transitional Epithelium



a: © Johnny R. Howze

- Transitional epithelium
  - Multilayered epithelium with surface cells that change from round to flat when stretched
  - Allows for filling of urinary tract
  - Locations: ureter and bladder

Figure 5.11a,b

5.3 Connective Tissue

- Expected Learning Outcomes
  - Describe the properties that most connective tissues have in common.
  - Discuss the types of cells found in connective tissue.
  - Explain what the matrix of a connective tissue is and describe its components.
  - Name and classify 10 types of connective tissue, describe their cellular components and matrix, and explain what distinguishes them from each other.
  - Visually recognize each connective tissue type from specimens or photographs.

Connective Tissue: Overview 1

- Connective tissue—a diverse, abundant type of tissue in which cells occupy less space than matrix
  - Most cells are not in direct contact with each other
- Supports, connects and protects organs
- Highly variable vascularity
  - Loose connective tissues have many blood vessels
  - Cartilage has few or no blood vessels

Connective Tissue: Overview 2

- Functions of connective tissues:
  - Connecting organs—tendons and ligaments
  - Support—bones and cartilage
  - Physical protection—cranium, ribs, sternum
  - Immune protection—white blood cells attack foreign invaders
  - Movement—bones provide lever system
  - Storage—fat, calcium, phosphorus
  - Heat production—metabolism of brown fat in infants
  - Transport—blood

Fibrous Connective Tissue 1

- Cells of fibrous connective tissue
  - Fibroblasts produce fibers and ground substance of matrix
  - Macrophages phagocytize foreign material and activate immune system when they sense foreign matter (antigens)
    - Arise from monocytes
  - Leukocytes, or white blood cells
    - Neutrophils attack bacteria
    - Lymphocytes react against bacteria, toxins, and other foreign agents
  - Plasma cells synthesize antibodies (proteins)
    - Arise from lymphocytes
  - Mast cells often found alongside blood vessels
    - Secrete heparin to inhibit clotting
    - Secrete histamine to dilate blood vessels
  - Adipocytes store triglycerides (fat molecules)

Fibrous Connective Tissue 2

- Fibers of fibrous connective tissue
  - Collagenous fibers
    - Collagen is most abundant of the body's proteins—25%
    - Tough, flexible, and stretch-resisant
    - Tendons, ligaments, and deep layer of the skin are mostly collagen
    - Less visible in matrix of cartilage and bone
  - Reticular fibers
    - Thin collagen fibers coated with glycoprotein
    - Form framework of spleen and lymph nodes
  - Elastic fibers
    - Thinner than collagenous fibers
    - Branch and rejoin each other
    - Made of protein called elastin
    - Allows stretch and recoil

Fibrous Connective Tissue 3

- Ground substance of fibrous connective tissue
  - Usually has a gelatinous to rubbery consistency
  - Glycosaminoglycans (GAGs)
    - Long polysaccharides composed of amino sugars and uronic acid (disaccharides)
    - Regulate water and electrolyte balance of tissues
    - Chondroitin sulfate—most abundant GAG
      - Responsible for stiffness of cartilage
    - Other examples: heparin and hyaluronic acid
  - Proteoglycans
    - Gigantic molecules (core protein plus GAGs) shaped like bottle brushes
    - Form gravy-like colloids that hold tissues together
  - Adhesive glycoproteins
    - Protein-carbohydrate complexes
    - Bind components of a tissue together

Types of Fibrous Connective Tissue 1

- Loose connective tissue
  - Much gel-like ground substance between cells
  - Types
    - Areolar
    - Reticular
- Dense connective tissue
  - Fibers fill spaces between cells
  - Types vary in fiber orientation
    - Dense regular connective tissue
    - Dense irregular connective tissue

Tendons and Ligaments

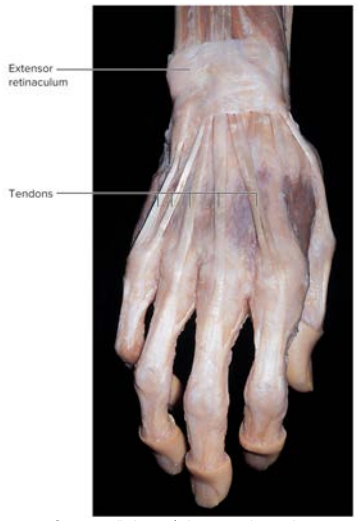
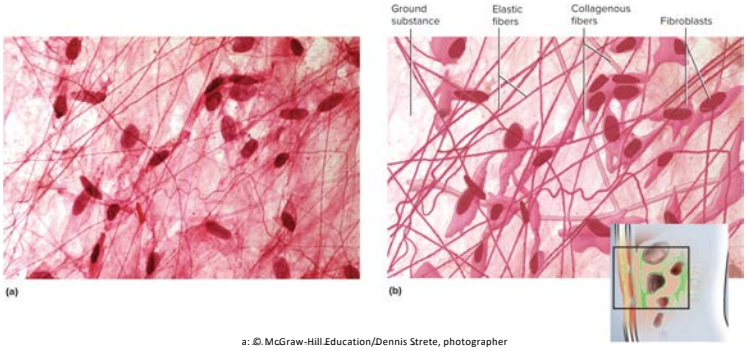


Figure 5.13

Types of Fibrous Connective Tissue 2

- Areolar tissue—loosely organized fibers, abundant blood vessels, and a lot of seemingly empty space
- Possess all six cell types
- Fibers run in random directions
  - Mostly collagenous, but elastic and reticular also present
- Found in tissue sections from almost every part of the body
  - Surrounds blood vessels and nerves
- Nearly every epithelium rests on a layer of areolar tissue
  - Blood vessels provide nutrition to epithelium and waste removal
  - Ready supply of infection-fighting leukocytes that move about freely in areolar tissue

Areolar Tissue

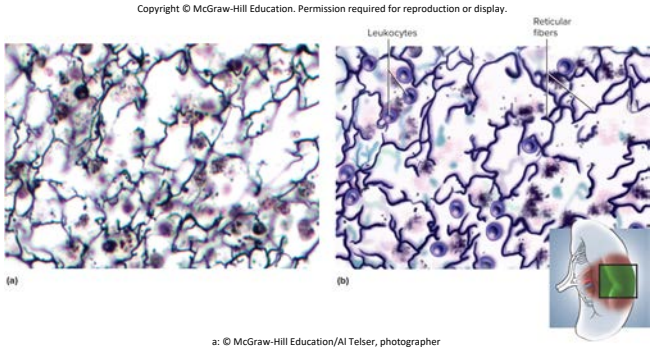


a: © McGraw-Hill Education/Dennis Strete, photographer

- Areolar tissue
  - Loosely organized fibers, abundant blood vessels
  - Underlies epithelia, in serous membranes, between muscles, passageways for nerves and blood vessels

Figure 5.14a,b

Reticular Tissue

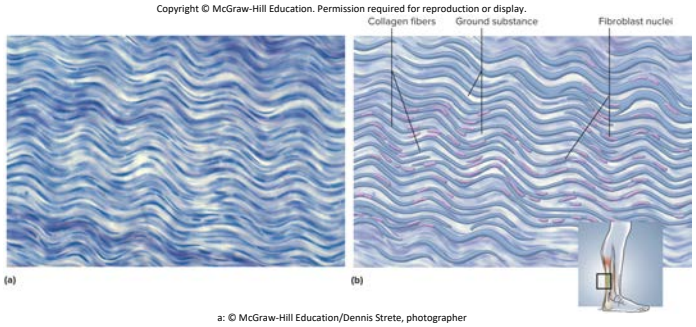


a: © McGraw-Hill Education/Al Telser, photographer

- Reticular tissue
  - Mesh of reticular fibers and fibroblasts
  - Forms supportive stroma (framework) for lymphatic organs
  - Found in lymph nodes, spleen, thymus, and bone marrow

Figure 5.15a,b

Dense Regular Connective Tissue

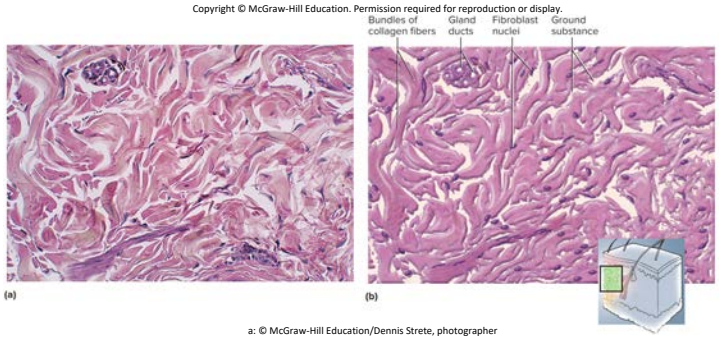


a: © McGraw-Hill Education/Dennis Strete, photographer

- Dense regular connective tissue
  - Densely packed, parallel collagen fibers
  - Compressed fibroblast nuclei
  - Elastic tissue forms wavy sheets in some locations
  - Tendons attach muscles to bones and ligaments hold bones together

Figure 5.16a,b

Dense Irregular Connective Tissue



a: © McGraw-Hill Education/Dennis Strete, photographer

- Dense irregular connective tissue
  - Densely packed, randomly arranged, collagen fibers and few visible cells
  - Withstands unpredictable stresses
  - Locations: deeper layer of skin; capsules around organs

Figure 5.17a,b

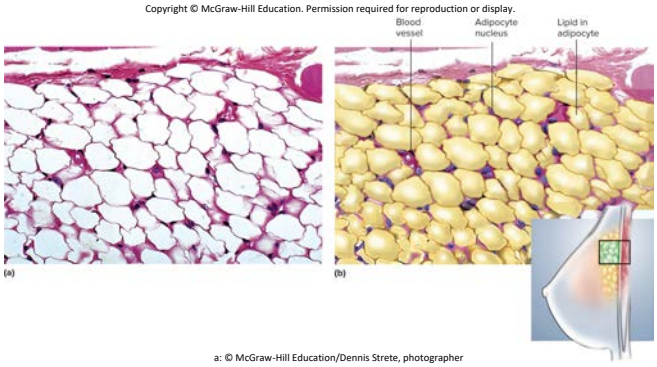
Adipose Tissue 1

- Adipose tissue (fat)—tissue in which adipocytes are the dominant cell type
- Space between adipocytes is occupied by areolar tissue, reticular tissue, and blood capillaries
- Fat is the body's primary energy reservoir
  - The quantity of stored triglyceride and the number of adipocytes are quite stable in a person
  - Fat is recycled continuously
    - New triglyceride synthesized while old molecules hydrolyzed and released to blood

Adipose Tissue 2

- Two types of fat: white and brown
- White fat is main type (only fat in adults)
  - Specimens resemble chicken wire
  - Provides thermal insulation
  - Cushions organs such as eyeballs, kidneys
  - Contributes to body contours—female breasts and hips
- Brown fat—in fetuses, infants, children
  - Color comes from blood vessels and mitochondrial enzymes
  - Functions as a heat-generating tissue

Adipose Tissue 3



a: © McGraw-Hill Education/Dennis Strete, photographer

- Empty-looking cells with thin margins; nucleus pressed against cell membrane
- Energy storage, insulation, cushioning
  - Subcutaneous fat and organ packing
  - Brown fat of juveniles produces heat

Figure 5.18a,b

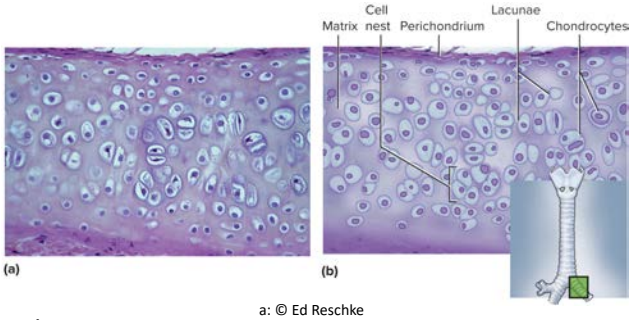
Cartilage 1

- Stiff connective tissue with flexible matrix
- Gives shape to ear, tip of nose, and larynx
- Chondroblasts—cartilage cells that produce the matrix that will trap them
- Chondrocytes—cartilage cells that are trapped in lacunae (cavities)
- Perichondrium—sheath of dense irregular connective tissue that surrounds elastic and most hyaline cartilage (not articular cartilage)
  - Contains a reserve population of chondroblasts that contribute to cartilage growth throughout life

Cartilage 2

- No blood vessels
  - Diffusion brings nutrients and removes wastes
  - Heals slowly
- Matrix rich in GAGs and contains collagen fibers
- Types of cartilage vary with fiber composition
  - Hyaline cartilage, fibrocartilage, and elastic cartilage

Hyaline Cartilage

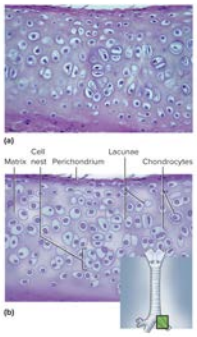


a: © Ed Reschke

- Hyaline cartilage
  - Clear, glassy appearance because of fineness of collagen fibers
- Eases joint movement, holds airway open, moves vocal cords, growth of juvenile long bones
- Locations: articular cartilage, costal cartilage, trachea, larynx, fetal skeleton

Figure 5.19a,b

Elastic Cartilage

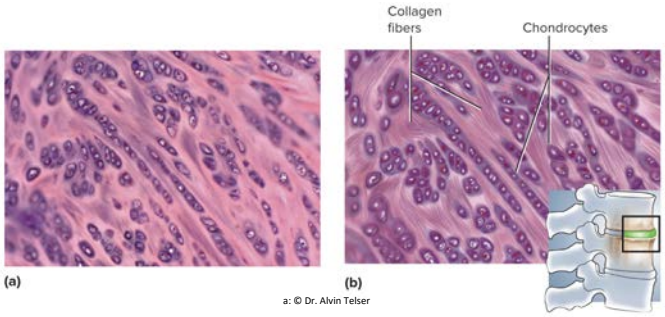


a: © Ed Reschke

- Elastic cartilage
  - Cartilage containing abundance of elastic fibers
- Covered with perichondrium
- Provides flexible, elastic support
  - Locations: external ear and epiglottis

Figure 5.20a,b

Fibrocartilage



a: © Dr. Alvin Telser

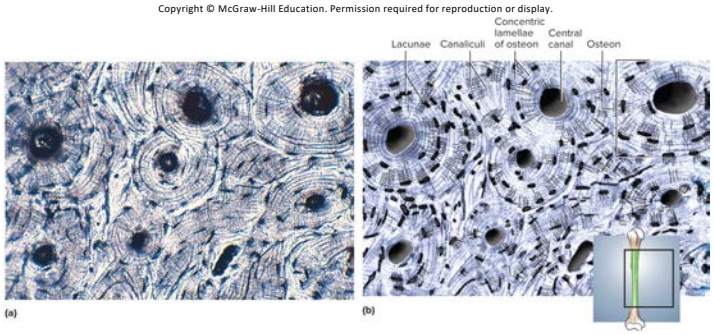
- Fibrocartilage
  - Cartilage containing large, coarse bundles of collagen fibers
- Resists compression and absorbs shock
  - Locations: pubic symphysis, menisci, and intervertebral discs

Figure 5.21a,b

Bone 1

- Bone (osseous) tissue is a calcified connective tissue
  - Bones of the skeleton are organs made of bone tissue, cartilage, marrow, and other tissue types
- Two forms of osseous tissue
  - Spongy bone: porous appearance
    - Delicate struts of bone: trabeculae
    - Covered by compact bone
    - Found in heads of long bones and in middle of flat bones such as the sternum
  - Compact bone: denser, calcified tissue with no visible spaces
    - More complex arrangement
    - Cells and matrix surround vertically oriented blood vessels in long bones

Compact Bone



a: © McGraw-Hill Education/Dennis Strete, photographer

- Compact bone is arranged in cylinders that surround central (haversian or osteonic) canals that run longitudinally through shafts of long bones
  - Blood vessels and nerves travel through central canal
- Bone matrix deposited in concentric lamellae
  - Onion-like layers around each central canal

Figure 5.22a,b

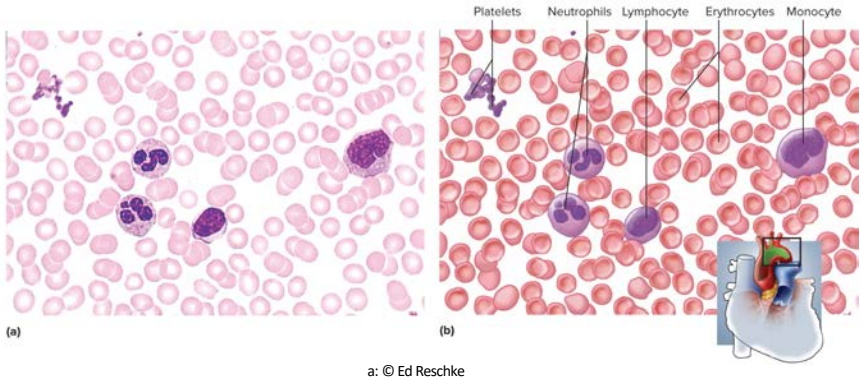
Bone 2

- Osteon—central canal and its surrounding lamellae
- Osteocytes—mature bone cells within lacunae
- Canaliculi—delicate canals radiating from each lacuna to its neighbors, allowing osteocytes to contact each other
- Periosteum—tough fibrous connective tissue covering the whole bone

Blood

- Fluid connective tissue
- Transports cells and dissolved matter from place to place
- Plasma—blood's ground substance
- Formed elements—cells and cell fragments
  - Erythrocytes—red blood cells (RBCs): transport O_2 and CO_2
  - Leukocytes—white blood cells (WBCs): defend against infection and disease
    - Neutrophils, eosinophils, basophils, lymphocytes, monocytes
  - Platelets—cell fragments involved in clotting

Blood Smear



a: © Ed Reschke

Figure 5.23

5.4 Nervous and Muscular Tissues—Excitable Tissues

- Expected Learning Outcomes
  - Explain what distinguishes excitable tissues from other tissues.
  - Name the cell types that compose nervous tissue.
  - Identify the major parts of a nerve cell.
  - Visually recognize nervous tissue from specimens or photographs.
  - Name the three kinds of muscular tissue and describe the differences between them.
  - Visually identify any type of muscular tissue from specimens or photographs.

Nervous and Muscular Tissues—Excitable Tissues

- Excitability—ability to respond to stimuli by changing membrane potential
  - Developed to highest degree in nervous and muscular tissues
- Membrane potential—electrical charge difference (voltage) that occurs across the cell membrane
- In nerve cells: changes in voltage result in rapid transmission of signals to other cells
- In muscle cells: changes in voltage result in contraction, shortening of the cell

Nervous Tissue 1

- Nervous tissue—specialized for communication by electrical and chemical signals
- Consists of neurons (nerve cells)
  - Detect stimuli
  - Respond quickly
  - Transmit coded information rapidly to other cells
- Neuroglia (glial)
  - Protect and assist neurons
  - "Housekeepers" of nervous system
  - More numerous than neurons

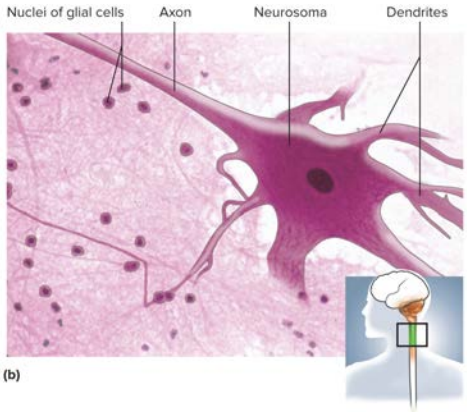


Figure 5.24b

Nervous Tissue 2

- Neuron parts
  - Neurosoma (cell body)
    - Houses nucleus and other organelles
    - Controls protein synthesis
  - Dendrites
    - Multiple short, branched processes
    - Receive signals from other cells
    - Transmit messages to neurosoma
  - Axon (nerve fiber)
    - Sends outgoing signals to other cells
    - Can be more than a meter long

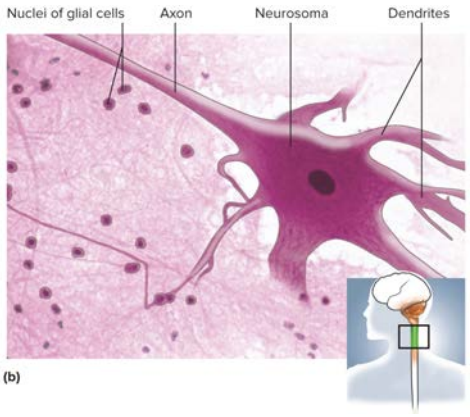


Figure 5.24b

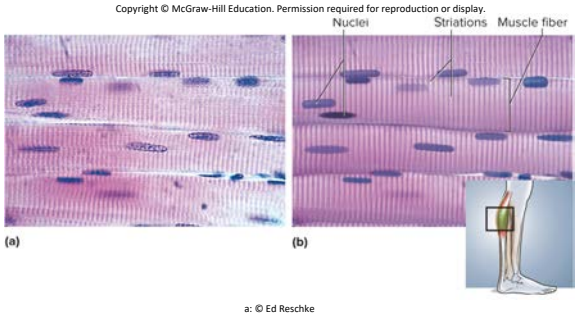
Muscular Tissue

- Muscular tissue—elongated cells that are specialized to contract in response to stimulation
- Primary job is to exert physical force on other tissues and organs
- Creates movements involved in body and limb movement, digestion, waste elimination, breathing, speech, and blood circulation
- Important source of body heat
- Three types of muscle: skeletal, cardiac, and smooth

Skeletal Muscle Tissue

- Skeletal muscle
  - Made of muscle fibers—long thin cells
  - Most skeletal muscles attach to bone
  - Contains multiple nuclei adjacent to plasma membrane
  - Striations—alternating dark and light bands
  - Voluntary—conscious control over skeletal muscles

Figure 5.25a,b

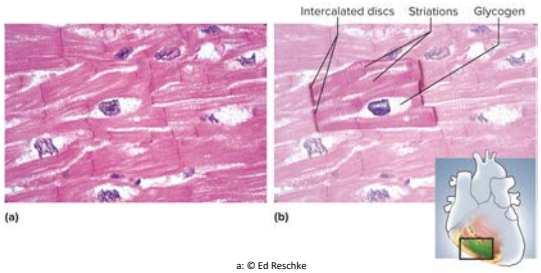


a: © Ed Reschke

Cardiac Muscle Tissue

- Cardiac muscle
  - Limited to the heart
  - Cardiomyocytes are branched, shorter than skeletal muscle fibers
  - Contain one centrally located nucleus
  - Intercalated discs join cardiomyocytes end to end
    - Provide electrical and mechanical connection
  - Striated and involuntary (not under conscious control)

Figure 5.26a,b

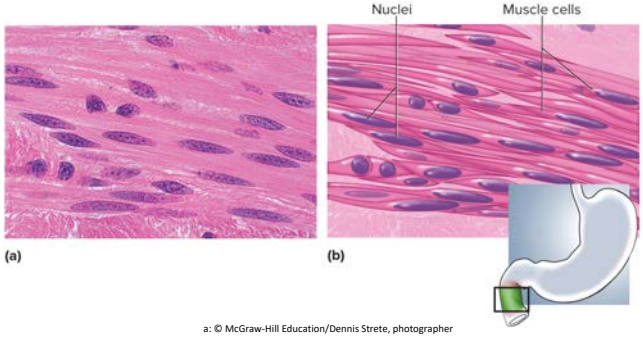


a: © Ed Reschke

Smooth Muscle Tissue

- Smooth muscle
  - Made of fusiform myocytes lacking striations
    - Cells are relatively short and have one central nucleus
  - Involuntary function
  - Most is visceral muscle—making up parts of walls of hollow organs

Figure 5.27a,b



a: © McGraw-Hill Education/Dennis Strete, photographer

5.5 Cell Junctions, Glands, and Membranes

- Expected Learning Outcomes
  - Describe the junctions that hold cells and tissues together.
  - Describe or define different types of glands.
  - Describe the typical anatomy of a gland.
  - Name and compare different modes of glandular secretion.
  - Describe the types and composition of the body's membranes.

Cell Junctions

- Cell junctions—connections between two cells
- Most cells are anchored to each other or their matrix
- Cells communicate with each other, resist mechanical stress, and control what moves through the gaps between them

Tight Junctions and Desmosomes

- Tight junction—linkage between two adjacent cells by transmembrane cell-adhesion proteins
  - In epithelia, they form a zone that completely encircles each cell near its apical pole
  - Seals off intercellular space, making it difficult for substance to pass between cells
- Desmosome—patch that holds cells together (like a clothing snap)
- Keeps cells from pulling apart—resist mechanical stress
- Hook-like, J-shaped proteins arise from cytoskeleton
  - Anchor cytoskeleton to membrane plaque
  - Transmembrane proteins from each cell joined by cell adhesion proteins
- Hemidesmosomes—half desmosomes that anchor basal cells of an epithelium to underlying basement membrane
  - Epithelium cannot easily peel away from underlying tissues

Gap Junctions

- Gap (communicating) junction—formed by ring-like connexons
  - Connexon consists of six transmembrane proteins arranged like segments of an orange around water-filled pore
  - Ions, nutrients, and other small solutes pass between cells
  - Located in cardiac and smooth muscle, embryonic tissue, lens and cornea

Types of Cell Junctions

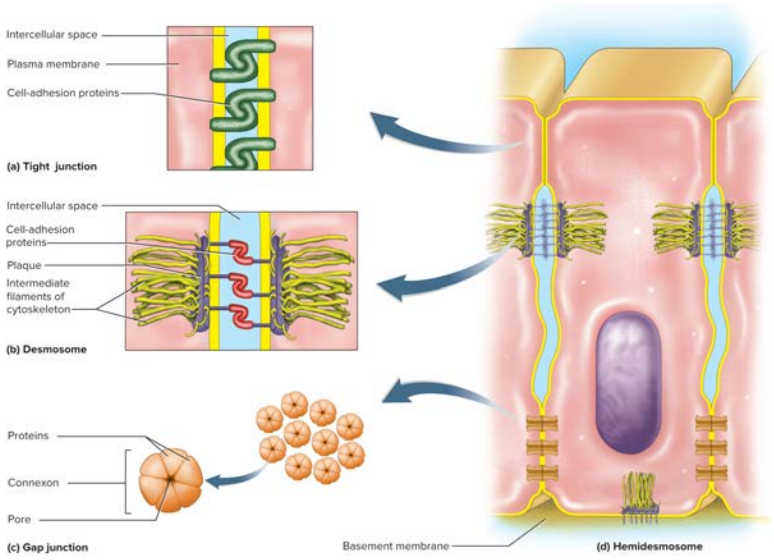


Figure 5.28

Glands

- Gland—cell or organ that secretes substances for use elsewhere in the body or releases them for elimination from the body
  - Usually composed of epithelial tissue in a connective tissue framework and capsule
  - Secretion—product useful to the body
  - Excretion—waste product

Endocrine and Exocrine Glands 1

- Exocrine glands—maintain their contact with surface of epithelium by way of a duct
  - Surfaces can be external (examples: sweat, tear glands) or internal (examples: pancreas, salivary glands)
- Endocrine glands—have no ducts; secrete hormones directly into blood
  - Hormones: chemical messengers that stimulate cells elsewhere in the body
  - Examples: thyroid, adrenal, and pituitary glands
- Some organs have both endocrine and exocrine functions
  - Examples: liver, gonads, pancreas

General Structure of Endocrine and Exocrine Glands

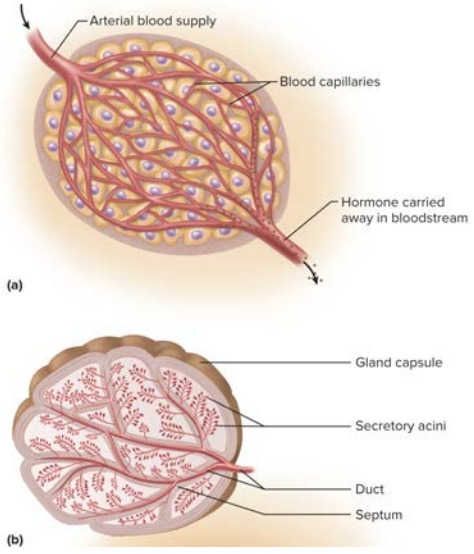


Figure 5.30a,b

Endocrine and Exocrine Glands 2

- Unicellular glands—found in an epithelium that is predominantly nonsecretory
  - Can be exocrine or endocrine
  - Examples: mucus-secreting goblet cells in trachea or endocrine cells of stomach

Exocrine Gland Structure

- Capsule—connective tissue covering of exocrine gland
  - Septa or trabeculae: extensions of capsule that divide interior of gland into compartments (lobes and lobules)
- Stroma—connective tissue framework of the gland
  - Supports and organizes glandular tissue
- Parenchyma—cells that perform the tasks of synthesis and secretion
  - Typically cuboidal or simple columnar epithelium
- Classification of glands
  - Duct shape: simple (unbranched) vs. compound (branched)
  - Gland shape
    - Tubular: narrow secretory portion
    - Acinar: secretory cells form dilated sac (acinus or alveolus)
    - Tubuloacinar: both tubular and acinar portions

Some Types of Exocrine Glands

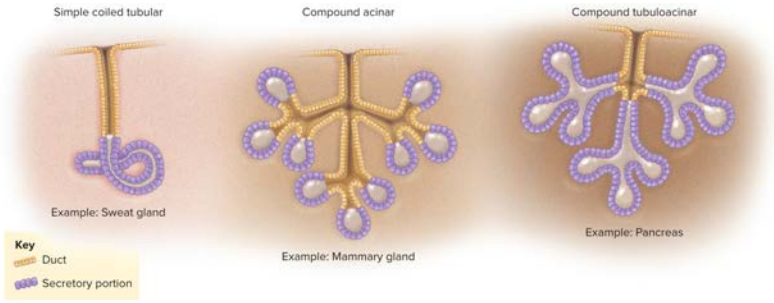


Figure 5.31

Types of Secretions

- Serous glands
  - Produce thin, watery secretions
    - Perspiration, milk, tears, digestive juices
- Mucous glands
  - Produce glycoprotein, mucin, which absorbs water to form mucus
  - Goblet cells: unicellular mucous glands
- Mixed glands
  - Contain both serous and mucous cell types and produce a mixture of the two types of secretions

Modes of Secretion

- Merocrine secretion (used by eccrine glands) uses vesicles that release their secretion by exocytosis
  - Examples: tear glands, pancreas, gastric glands, and others
- Apocrine secretion—lipid droplet covered by membrane and cytoplasm buds from cell surface
  - Mode of milk fat secretion by mammary gland cells
  - Also "apocrine" is used to describe axillary sweat glands even though they use merocrine secretion mode
- Holocrine secretion—cells accumulate a product until they disintegrate
  - Secrete a mixture of cell fragments and synthesized substances
  - Examples: oil glands of scalp and skin, and glands of eyelids

The Three Modes of Exocrine Secretion

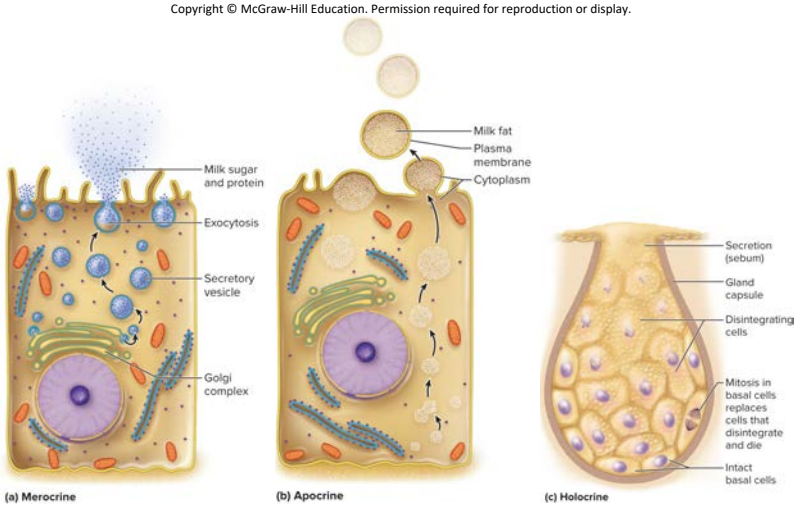


Figure 5.32

Membranes

- Membranes may be only epithelial, only connective, or a mix of epithelial, connective, and muscular tissues
  - Examples of membranes of only connective tissue: dura mater, synovial membranes, periosteum
  - Examples of membranes of only epithelium: anterior surfaces of cornea and lens of eye
- Cutaneous membrane (the skin)—largest membrane in the body
  - Stratified squamous epithelium (epidermis) resting on a layer of connective tissue (dermis)
  - Relatively dry layer serves protective function

Mucous and Serous Membranes

- Mucous membrane (mucosa) lines passages that open to the external environment (example: digestive tract)
  - Sublayers: epithelium, lamina propria (areolar tissue), muscularis mucosa (smooth muscle)
  - Absorptive, secretory, and protective functions
  - Often have mucus producing goblet cells
- Serous membrane (serosa)—internal membrane
  - Simple squamous epithelium resting on a layer of areolar tissue
  - Produces serous fluid that arises from blood
  - Covers organs and lines walls of body cavities
    - Endothelium lines blood vessels and heart
    - Mesothelium lines body cavities (pericardium, peritoneum, and pleura)

Mucous Membrane

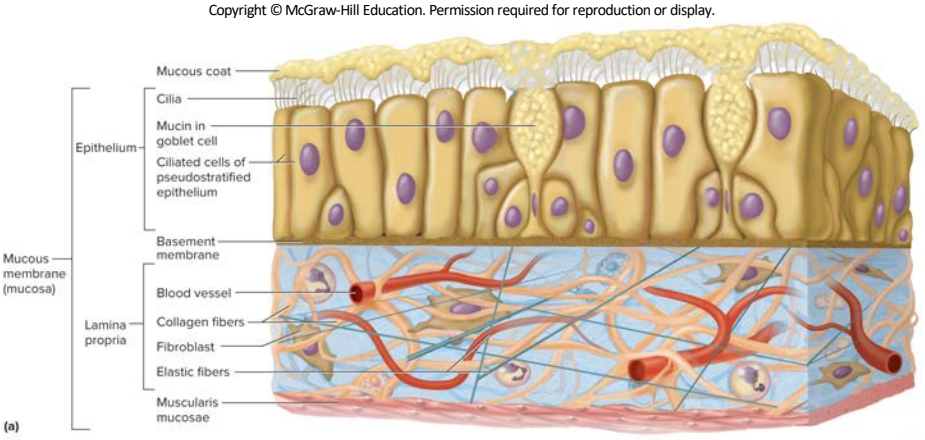


Figure 5.33a

Serous Membrane

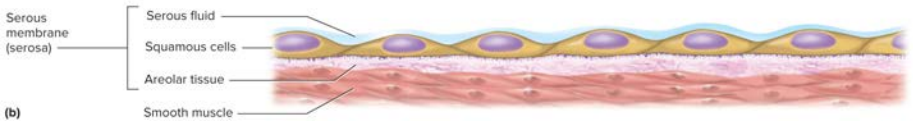


Figure 5.33b

5.6 Tissue Growth, Development, Repair, and Degeneration

- Expected Learning Outcomes
  - Name and describe the modes of tissue growth.
  - Define *adult* and *embryonic stem cells* and their varied degrees of developmental plasticity.
  - Name and describe the ways that a tissue can change from one type to another.
  - Name and describe the modes and causes of tissue shrinkage and death.
  - Name and describe the ways the body repairs damaged tissues.

Tissue Growth

- Tissue growth—increasing the number of cells or size of existing cells
- Hyperplasia—growth through cell multiplication
- Hypertrophy—enlargement of preexisting cells
  - Muscle growth through exercise
  - Accumulation of body fat
- Neoplasia—development of a tumor (neoplasm)
  - Benign or malignant
  - Composed of abnormal, nonfunctional tissue

Tissue Development

- Tissues can change types within certain limits
- Differentiation—development of more specialized form and function by unspecialized tissue
  - Example: embryonic mesenchyme becoming cartilage and bone
- Metaplasia
  - Changing from one type of mature tissue to another
    - Simple cuboidal tissue of vagina before puberty changes to stratified squamous after puberty
    - Pseudostratified columnar epithelium of bronchi of smokers to stratified squamous epithelium

Stem Cells 1

- Stem cells—undifferentiated cells that are not yet performing any specialized function
  - Have potential to differentiate into one or more types of mature functional cells
- Developmental plasticity—ability of a stem cell to give rise to a diversity of mature cell types

Stem Cells 2

- Embryonic stem cells
  - Totipotent: have potential to develop into any type of fully differentiated human cell including accessory organs of pregnancy
    - Source—cells of very early embryo
  - Pluripotent: can develop into any type of cell in the embryo (but not accessory organs of pregnancy)
    - Source—cells of inner cell mass of embryo (blastocyst)
- Adult stem cells—undifferentiated cells found in mature organs
  - Some are multipotent—able to develop into two or more cell lines (example: bone marrow stem cells)
  - Some are unipotent—produce only one cell type (example: cells giving rise to sperm)

Tissue Repair

- Damaged tissues can be repaired in two ways:
  - Regeneration: replacement of dead or damaged cells by the same type of cell as before
    - Restores normal function
    - Examples: repair of minor skin or liver injuries
  - Fibrosis: replacement of damaged cells with scar tissue
    - Scar holds organs together, but does not restore function
    - Examples: repair of severe cuts and burns, scarring of lungs in tuberculosis

Stages in the Healing of a Skin Wound 1

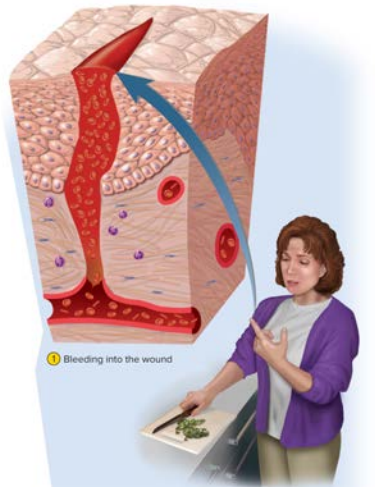


Figure 5.34 (1)

- Healing of a cut in the skin:
  - Severed vessels bleed into cut
  - Mast cells and damaged cells release histamine
  - Histamine dilates blood vessels and makes capillaries more permeable
- Blood plasma seeps into the wound carrying:
  - Antibodies
  - Clotting proteins

Stages in the Healing of a Skin Wound 2

- Blood clot forms
  - Knits edges of cut together
  - Inhibits spread of pathogens
- Forms scab that temporarily seals wound and blocks infection
- Macrophages phagocytize and digest tissue debris

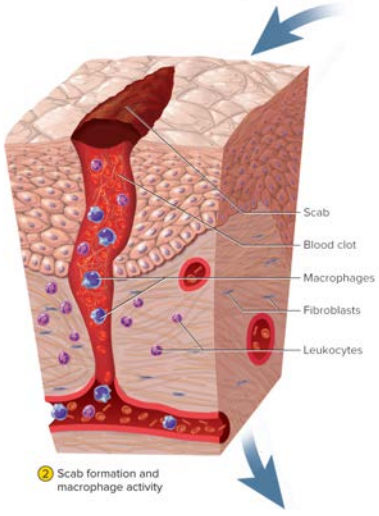


Figure 5.34 (2)

Stages in the Healing of a Skin Wound 3

- New capillaries sprout from nearby vessels
- Deeper portions of clot become infiltrated by capillaries and fibroblasts
  - Transform into soft mass called granulation tissue
  - Macrophages remove the blood clot
  - Fibroblasts deposit new collagen
  - Begins 3–4 days after injury and lasts up to 2 weeks

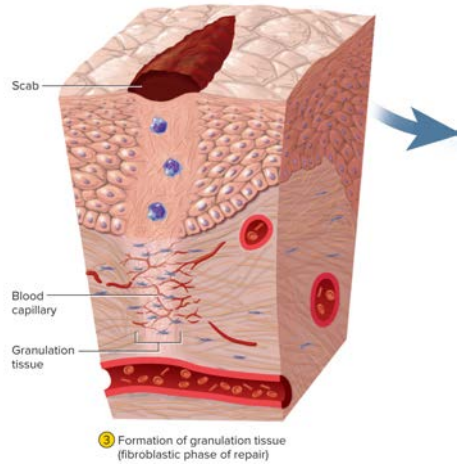


Figure 5.34 (3)

Stages in the Healing of a Skin Wound 4

- Epithelial cells around wound multiply and migrate beneath scab (tissue regenerates)
- Underlying connective tissue undergoes fibrosis
  - Scar tissue may or may not show through epithelium
- Remodeling (maturation) phase begins several weeks after injury and may last up to 2 years

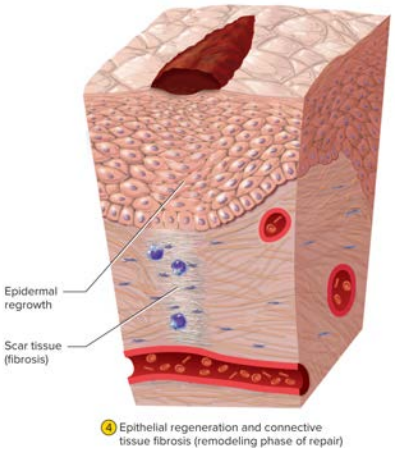


Figure 5.34 (4)

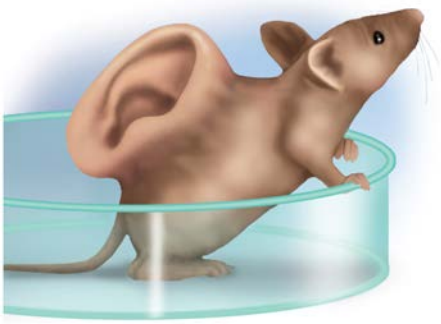
Tissue Engineering 1

- Tissue engineering—artificial production of tissues and organs in the lab for implantation in the human body
  - A framework of collagen or biodegradable polyester fibers is seeded with human cells
  - Grown in "bioreactor" (example: inside mouse)
    - Supplies nutrients and oxygen to growing tissue

Tissue Engineering 2

- Skin grafts already available
- Research in progress on heart valves, coronary arteries, bone, liver, tendons
- Human outer ear grown on back of mouse

Figure 5.35



Tissue Degeneration and Death 1

- Atrophy—shrinkage of a tissue through loss in cell size or number
  - Senile atrophy through normal aging
  - Disuse atrophy from lack of use
- Necrosis—pathological tissue death due to trauma, toxins, or infections
  - Infarction—sudden death of tissue when blood supply is cut off
  - Gangrene—tissue necrosis due to insufficient blood supply (usually involves infection)
    - Decubitus ulcer (bed sore or pressure sore)—form of dry gangrene where continual pressure on skin of immobilized patient cuts off blood flow
    - Dry gangrene: common complication of diabetes
    - Wet gangrene: liquefaction of internal organs with infection
    - Gas gangrene: usually from infection of soil bacterium that results in hydrogen bubbles in tissues

Tissue Degeneration and Death 2

- Apoptosis—programmed cell death
  - Normal death of cells that have completed their function and best serve the body by dying and getting out of the way
- Phagocytized by macrophages and other cells
- Billions of cells die by apoptosis
- Every cell has a built-in "suicide program"
  - Extracellular suicide signal binds receptor protein in the plasma membrane called *Fas*
  - Fas activates enzymes: endonuclease chops up DNA and protease destroys proteins

The Stem-Cell Controversy

- Recent U.S. Presidents have disagreed on the morality of stem cell use
- Biologists see many possibilities for the use of embryonic stem cells in treating disease
  - Possibilities include treatments for: parkinsonism, brain cell loss, diabetes, heart damage, and spinal cord injury
  - Most embryonic stem cells are donated by couples using *in vitro* fertilization
  - Adult stem cells seem limited, as they are hard to harvest and culture and have narrower developmental potential
    - Researchers are trying to induce adult cells to revert to embryonic levels of developmental plasticity
- There are several technical, ethical, and legal issues