

Tissues

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Tissues

- Cells work together in functionally related groups called *tissues*
- Tissue
 - A group of closely associated cells that perform related functions and are similar in structure

Four Basic Tissue Types and Basic Functions

- Epithelial tissue—covering
- Connective tissue—support
- Muscle tissue—movement
- Nervous tissue—control

Epithelial Tissue

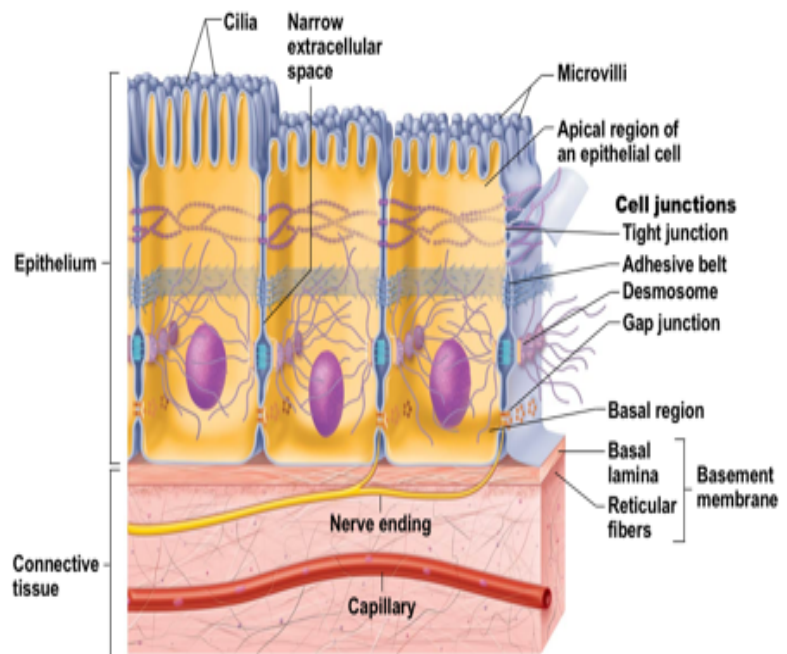
- Covers a body surface or lines a body cavity
- Forms parts of *most glands*
- Functions of epithelia
 - Protection
 - Secretion
 - Absorption
 - Diffusion
 - Filtration
 - Sensory reception

Special Characteristics of Epithelia

- Cellularity
 - Cells separated by minimal extracellular material
- Specialized contacts
 - Cells joined by special junctions
- Polarity
 - Cell regions of the apical surface differ from the basal surface

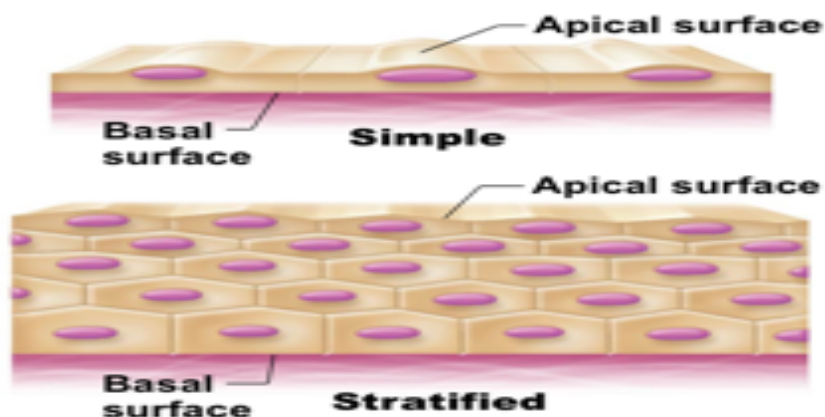
Special Characteristics of Epithelia

- Support by connective tissue
- *Avascular* but innervated
 - Epithelia receive nutrients from underlying connective tissue
- Regeneration
 - Lost cells are quickly replaced by cell division



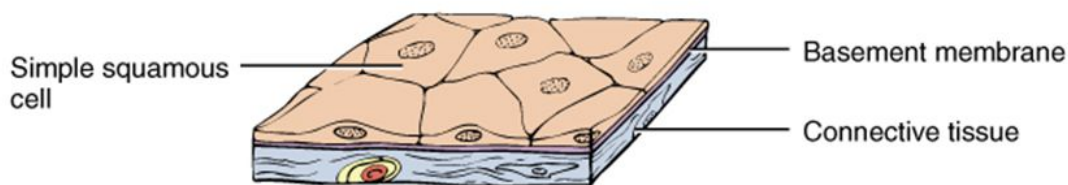
Classifications of Epithelia

- First name of tissue indicates *number of cell layers*
- Simple epithelia
 - Single layer of cells
 - Stratified epithelia
- Last name of tissue describes *shape of cells*
 - Squamous—cells are wider than tall (plate-like)
 - Cuboidal—cells are as wide as tall, like cubes
 - Columnar—cells are taller than they are wide, like columns



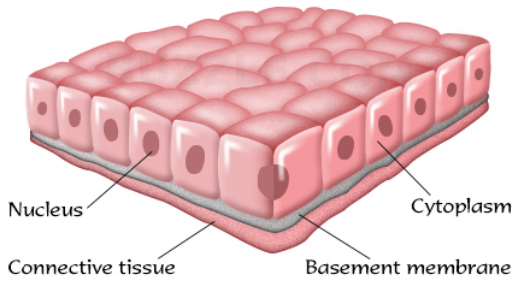
Simple Squamous Epithelium

- Description—single layer; flat cells with disc-shaped nuclei
- Function
 - Passage of materials by passive diffusion and filtration
 - Secretes lubricating substances in serosae
- Location
 - Renal corpuscles
 - Alveoli of lungs
 - Lining of heart, blood, and lymphatic vessels
 - Lining of ventral body cavity (serosae)



Simple Cuboidal Epithelium

- Description
 - Single layer of cubelike cells with large, spherical central nuclei
- Function
 - Secretion and absorption
- Location
 - Kidney tubules, secretory portions of small glands, ovary surface



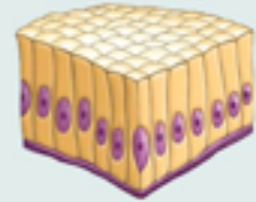
Simple Columnar Epithelium

- Description—single layer of column-shaped (rectangular) cells with oval nuclei
 - Some bear cilia at their apical surface
 - May contain goblet cells
- Function
 - Absorption; secretion of mucus, enzymes, and other substances
 - Ciliated type propels mucus or reproductive cells by ciliary action
- Location
 - Nonciliated form
 - Lines digestive tract, gallbladder, ducts of some glands
 - Ciliated form
 - Lines small bronchi, uterine tubes, and uterus

Pseudostratified Columnar Epithelium

- Description
 - All cells originate at basement membrane
 - Only tall cells reach the apical surface
 - May contain goblet cells and bear cilia
 - Nuclei lie at varying heights within cells
 - Gives false impression of stratification
- Function—secretion of mucus; propulsion of mucus by cilia
- Locations
 - Nonciliated type
 - Ducts of male reproductive tubes
 - Ducts of large glands
 - Ciliated variety
 - Lines trachea and most of upper respiratory tract

Description: Single layer of tall cells with *round to oval* nuclei; some cells bear cilia; layer may contain mucus-secreting unicellular glands (goblet cells).

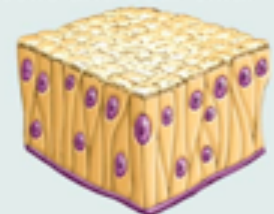


Function: Absorption; secretion of mucus, enzymes, and other substances; ciliated type propels mucus (or reproductive cells) by ciliary action.

Location: Nonciliated type lines most of the digestive tract (stomach to anal canal), gallbladder, and excretory ducts of some glands; ciliated variety lines small bronchi, uterine tubes, and some regions of



Description: Single layer of cells of different heights, some not reaching the free surface; nuclei seen at different levels; may contain mucus-secreting goblet cells and bear cilia.



Function: Secretion, particularly of mucus; propulsion of mucus by ciliary action.

Location: Nonciliated type in male's sperm-carrying ducts and ducts of large glands; ciliated variety lines the trachea, most of the upper respiratory tract.

Trachea

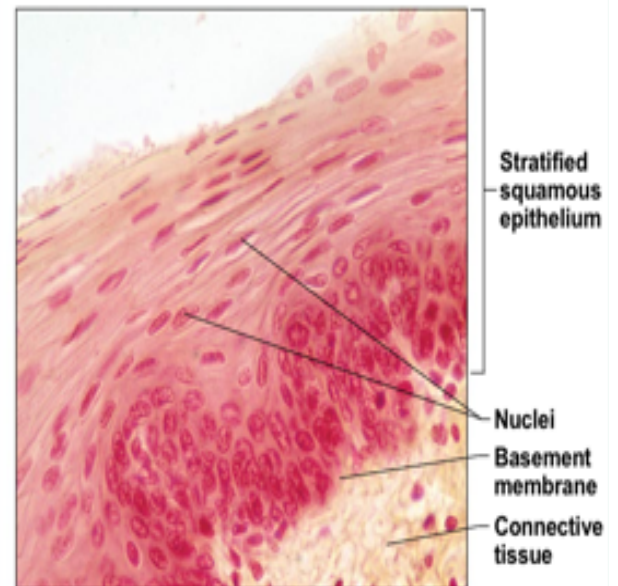


Stratified Epithelia

- Properties
 - Contain *two or more* layers of cells
 - Regenerate from below (basal layer)
 - Major role is protection
 - Named according to shape of cells at *apical layer*
- Description
 - Many layers of cells are squamous in shape
 - Deeper layers of cells appear cuboidal or columnar
 - Thickest epithelial tissue
 - Adapted for protection from abrasion

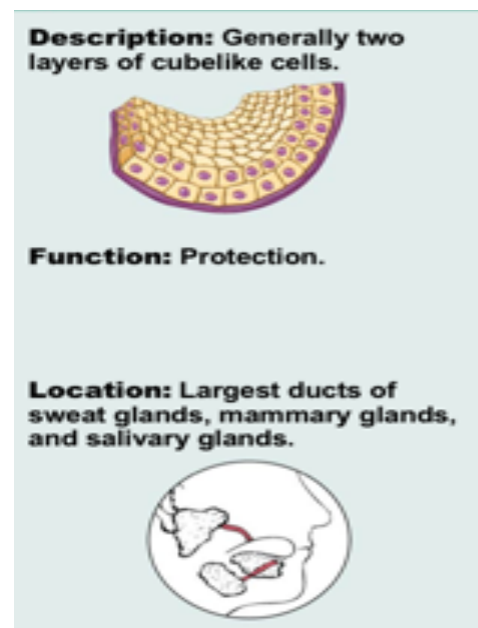
Stratified Squamous Epithelium

- Two types—keratinized and nonkeratinized
 - Keratinized
 - Location—epidermis
 - Contains the protective protein keratin
 - Waterproof
 - Surface cells are dead and full of keratin
 - Nonkeratinized
 - Forms moist lining of body openings
- Function—Protects underlying tissues in areas subject to abrasion
- Location
 - Keratinized—forms epidermis
 - Nonkeratinized—forms lining of mucous membranes
 - Esophagus
 - Mouth
 - Anus
 - Vagina
 - Urethra



Stratified Cuboidal Epithelium

- Description—generally two layers of cube-shaped cells
- Function—protection
- Location
 - Forms ducts of
 - Mammary glands
 - Salivary glands
 - Largest sweat glands



Stratified Columnar Epithelium

- Description—several layers; basal cells usually cuboidal; superficial cells elongated
- Function—protection and secretion
- Location
 - Rare tissue type
 - Found in male urethra and large ducts of some glands

Transitional Epithelium

- Description
 - Has characteristics of stratified cuboidal and stratified squamous
 - Superficial cells dome-shaped when bladder is relaxed, squamous when full
- Function—permits distension of urinary organs when they are filled with urine
- Location—epithelium of urinary bladder, ureters, proximal urethra

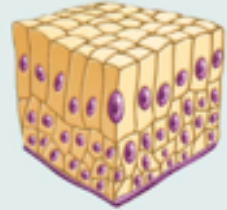
Glands

- **Endocrine glands**
 - Ductless glands that secrete directly into surrounding tissue fluid
 - Produce messenger molecules called hormones
- **Exocrine glands**
 - *Ducts* carry products of exocrine glands to epithelial surface
 - Include the following diverse glands:
- Mucus-secreting glands
- Sweat and oil glands
- Salivary glands
- Liver and pancreas

Unicellular Exocrine Glands (The Goblet Cell)

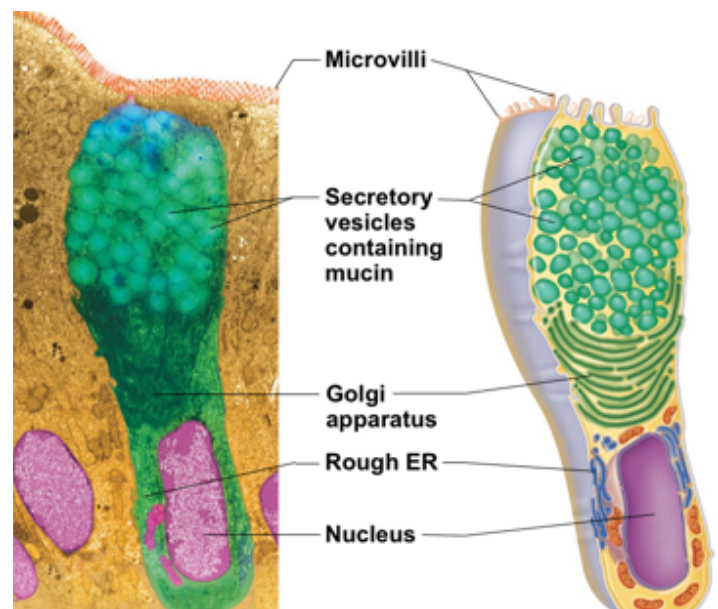
- Goblet cells produce mucin
 - Mucin + water → mucus
 - Protects and lubricates many internal body surfaces
 - Goblet cells are a unicellular exocrine gland

Description: Several cell layers; basal cells usually cuboidal; superficial cells elongated and columnar.



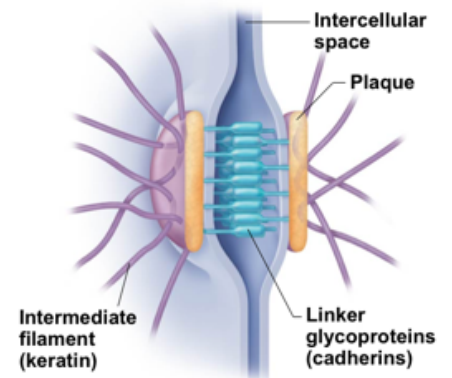
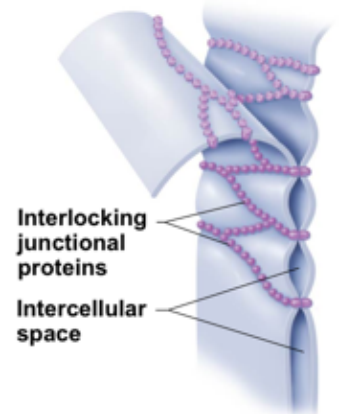
Function: Protection; secretion.

Location: Rare in the body; small amounts in male urethra and in large ducts of some glands.



Lateral Surface Features—Cell Junctions

- Factors binding epithelial cells together
 - Adhesion proteins link plasma membranes of adjacent cells
 - Contours of adjacent cell membranes
 - Special cell junctions
- Tight junctions (zona occludens)—close off intercellular space
 - Found at *apical region* of most epithelial tissues types
 - Some proteins in plasma membrane of adjacent cells are fused
 - *Prevent* certain molecules from passing between cells of epithelial tissue
- Adhesive belt junctions (zonula adherens)—anchoring junction
 - Transmembrane linker proteins attach to actin microfilaments of the cytoskeleton and bind adjacent cells
 - With tight junctions, these linker proteins form the tight junctional complex around apical lateral borders of epithelial tissues
- Desmosomes—main junctions for binding cells together
 - Scattered along abutting sides of adjacent cells
 - Cytoplasmic side of each plasma membrane has a plaque
 - Plaques are joined by linker proteins
- Intermediate filaments extend across the cytoplasm and anchor at desmosomes on opposite side of the cell
- Are common in cardiac muscle and epithelial tissue
- Gap junctions—passageway between two adjacent cells
 - *These let small molecules move directly between neighboring cells*
 - Cells are connected by hollow cylinders of protein
 - Function in intercellular communication



Basal Feature: The Basal Lamina

- Located at the boundary between the epithelium and connective tissue
- Noncellular supporting sheet between the epithelial tissue and the connective tissue deep to it
- Functions
 - Acts as a *selective filter*, determining which molecules from capillaries enter the epithelium
 - Acts as *scaffolding* along which regenerating epithelial tissue cells can migrate
 - Basal lamina and reticular layers of the underlying connective tissue deep to it form *the basement membrane*

Epithelial Surface Features

- Apical surface features
 - Microvilli—fingerlike extensions of plasma membrane
 - Have a core of actin filaments that stiffen the microvillus
 - Abundant in kidney tubules and small intestine
 - Maximize surface across which small molecules enter or leave cells
- Apical surface features
 - Cilia—whiplike, highly motile extensions of apical surface membranes
 - Contain a core of microtubules held together by cross-linking and radial proteins
 - Microtubules arranged in pairs called doublets
 - Movement is generated when adjacent doublets grip each other with the motor protein dynein
 - Cilia originate as microtubules assemble around centrioles

Connective Tissue

- *Most diverse and abundant tissue*
- Main classes of connective tissue
 - Connective tissue proper
 - Cartilage
 - Bone tissue
 - Blood
- Important functions of connective tissue types
 - Form basis of the skeleton
 - Store and carry nutrients
 - Surround blood vessels and nerves
 - Lead fight against infection

Special Characteristics of Connective Tissue

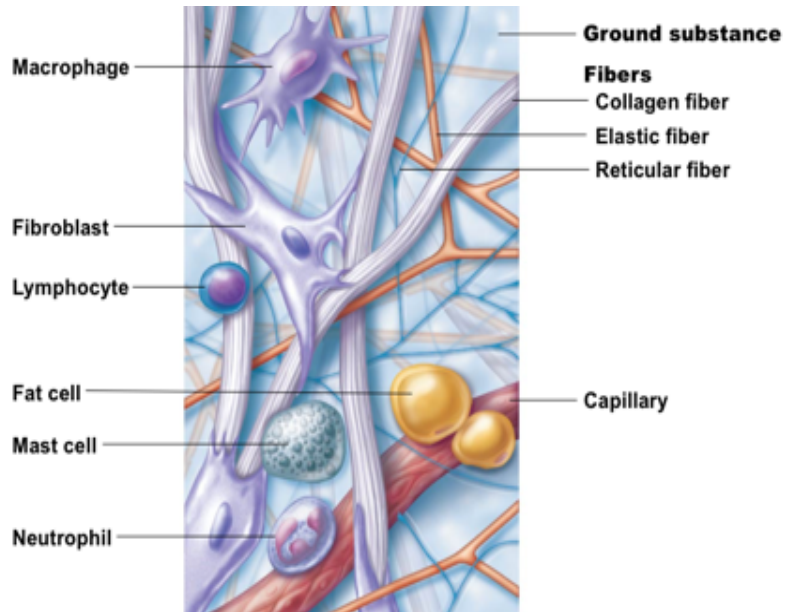
- Few cells, abundant extracellular matrix
- Extracellular matrix is composed of
 - Ground substance
 - Fibers
- Extracellular matrix is produced by cells of the connective tissue
- Common embryonic origin is mesenchyme

Structural Elements of Connective Tissue

- Connective tissues differ in structural properties
- Differences in types of cells
- Differences in composition of extracellular matrix
- However, connective tissues all share structural elements
- Loose areolar connective tissue
 - Will illustrate connective tissue features

Structural Elements of Connective Tissue - Cells

- Primary cell type of connective tissues produces the extracellular matrix
 - Fibroblasts
 - In connective tissue proper
 - Make protein subunits
 - Chondroblasts secrete matrix in cartilage
 - Osteoblasts secrete matrix in bone
- Cells in blood are an exception—they do not produce the plasma matrix of blood
- Many other important cell types are found in connective tissue
- Areolar connective tissue contains:
 - Fat cells
 - White blood cells
 - Mast cells



Structural Elements of Connective Tissue - Fibers

- Extracellular matrix is composed of fibers and ground substance
- Fibers function in support and also have unique properties
- Collagen fibers—strongest; resist tension
- Reticular fibers—bundles of special type of cartilage
- Elastic fibers—contain elastin
- Recoil after stretching

Structural Elements of Connective Tissue - Ground substance

- Is produced by primary cell type of the tissue
- Is usually gel-like substance consisting of:
- Cushions and protects body structures
- Holds tissue fluid
- Blood is an exception
 - Plasma is not produced by blood cells

Major Functions of Connective Tissue

- Structure of areolar connective tissue reflects its functions
 - Support and binding of other tissues
 - Holding body fluids (interstitial fluid → lymph)
 - Defending body against infection
 - Storing nutrients as fat

Connective Tissue Proper

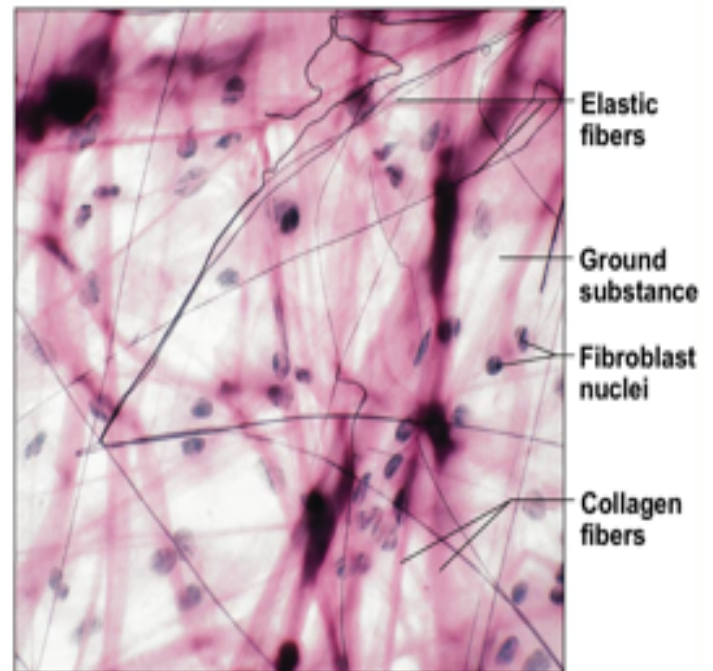
- Has two subclasses
 - Loose connective tissue
 - Areolar, adipose, and reticular
 - Dense connective tissue
 - Dense irregular, dense regular, and elastic

Areolar Connective Tissue—A Model Connective Tissue

- Underlies epithelial tissue
- Surrounds small nerves and blood vessels
- Has structures and functions shared by other connective tissues
- Borders all other tissues in the body

Areolar Connective Tissue

- Fibers provide support
 - Three types of protein fibers in extracellular matrix
 - Collagen fibers
 - Reticular fibers
 - Elastic fibers
- Fibroblasts produce these fibers
- Description
 - Gel-like matrix with *all three fiber types*
 - Cells of areolar connective tissue
 - Fibroblasts, macrophages, mast cells, and white blood cells
- Function
 - Wraps and cushions organs
 - Holds and conveys tissue fluid (interstitial fluid)
 - Important role in inflammation
- Locations
 - Widely distributed under epithelia
 - Packages organs
 - Surrounds capillaries

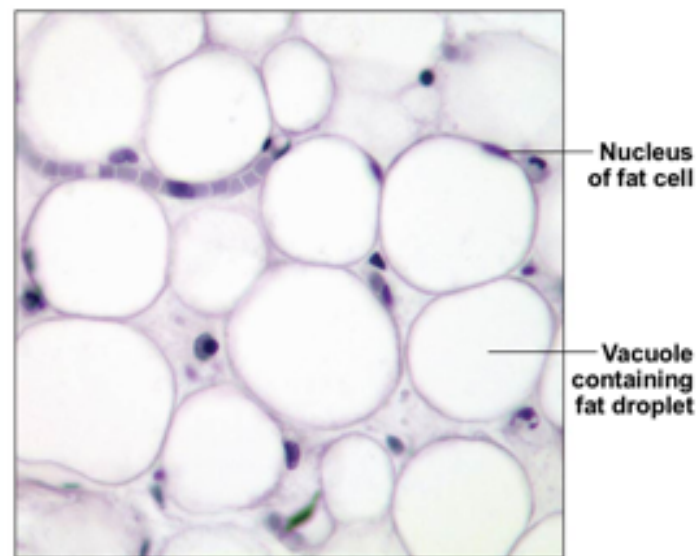


Areolar Connective Tissue - continued

- Tissue fluid (interstitial fluid)
 - Watery fluid occupying extracellular matrix
 - Tissue fluid derives from blood
- Ground substance
 - Viscous, spongy part of extracellular matrix
 - Consists of sugar and protein molecules
 - *Made and secreted by fibroblasts*
- *Main battlefield in fight against infection*
- Defenders gather at infection sites
 - Macrophages
 - Plasma cells
 - Mast cells
 - White blood cells

Adipose Tissue

- Description
 - Closely packed adipocytes
 - Have nucleus pushed to one side by fat droplet
 - Richly vascularized
- Function
 - Provides reserve food fuel
 - Insulates against heat loss
 - Supports and protects organs
- Location
 - Under skin
 - Around kidneys
 - Behind eyeballs, within abdomen, and in breasts
 - Hypodermis



Adipose Connective Tissue - Brown Adipose Tissue

- Produces heat
- Occurs in babies to aid thermoregulation
- Has been found in adults
 - Between scapulae
 - Sides of anterior neck
 - Anterior abdominal wall
- Richly vascularized; cells contain many lipid droplets and numerous mitochondria



Reticular Connective Tissue

- Description
- Network of reticular fibers in loose ground substance
- Function
 - Forms a soft, internal skeleton (stroma)
 - Supports other cell types
- Location - Lymph nodes, bone marrow, and spleen

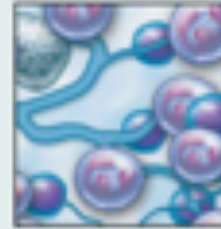
Dense Connective Tissue

- Three types of dense connective tissue
 - Dense irregular connective tissue
 - Dense regular connective tissue
 - Elastic connective tissue
- Dense connective tissues
 - Resist strong pulling forces
 - Have more collagen than areolar connective tissue

Dense Irregular Connective Tissue

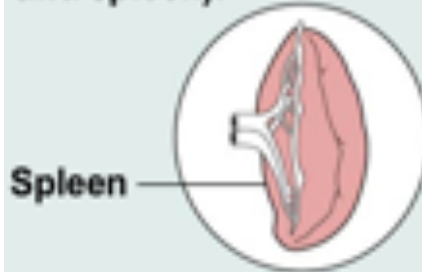
- Description
 - Collagen fibers are thick and irregularly arranged
 - Contains some elastic fibers and fibroblasts
- Function
 - Withstands tension
 - Provides structural strength
- Location
 - Dermis of skin
 - Submucosa of digestive tract
 - Fibrous capsules of joints
 - Capsules surrounding organs, such as kidneys, bones, and lymph nodes

Description: Network of reticular fibers in a typical loose ground substance; reticular cells lie on the network.



Function: Fibers form a soft internal skeleton (stroma) that supports other cell types including white blood cells, mast cells, and macrophages.

Location: Lymphoid organs (lymph nodes, bone marrow, and spleen).



Dense Regular Connective Tissue

- Description
 - Collagen fibers are parallel to the direction of pull
 - Fibroblasts are located between collagen fibers
 - Contains few elastic fibers
 - Has great tensile strength
 - Poorly vascularized
 - Forms fascia
- Function
 - Attaches muscle to bone
 - Attaches bone to bone
 - Withstands great stress in one direction
- Location
 - Tendons and ligaments
 - Aponeuroses
 - Fascia around muscles

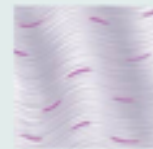
Elastic Connective Tissue

- Description
 - Elastic fibers predominate
- Function
 - Allows recoil after stretching
- Location
 - Within walls of arteries
 - In certain ligaments
 - Surrounding bronchial tubes

Cartilage

- All cartilages have similar structural components
 - Firm, flexible tissue
 - Contains no blood vessels or nerves
 - Matrix contains up to 80% water
 - Cell type is the chondrocyte
 - Chondroblasts are immature cartilage cells
 - Secrete matrix during cartilage growth
- Three types of cartilage
 - Hyaline cartilage
 - Elastic cartilage
 - Fibrocartilage
- Each cartilage has specialized functions

Description: Primarily parallel collagen fibers; a few elastic fibers; major cell type is the fibroblast.



Function: Attaches muscles to bones or to muscles; attaches bones to bones; withstands great tensile stress when pulling force is applied in one direction.

Location: Tendons, most ligaments, aponeuroses.



Hyaline Cartilage

- Description
 - Imperceptible collagen fibers (hyaline = glassy)
 - Chondroblasts produce matrix
 - Chondrocytes
 - Are mature cartilage cells
 - Lie within lacunae
- Function
 - Supports and reinforces
 - Resilient cushion
 - Resists repetitive stress
- Location
 - Fetal skeleton
 - Ends of long bones
 - Costal cartilage of ribs
 - Cartilages of nose, trachea, and larynx

Elastic Cartilage

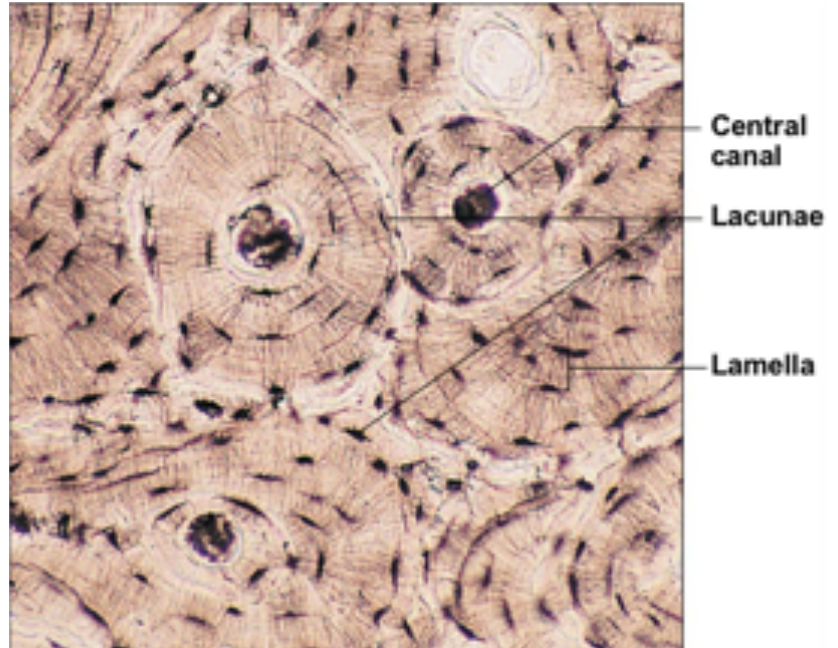
- Description
 - Similar to hyaline cartilage
 - More elastic fibers in matrix
- Function
 - Maintains shape of structure
 - Allows great flexibility
- Location
 - Supports external ear
 - Epiglottis

Fibrocartilage

- Description
 - Matrix similar but less firm than hyaline cartilage
 - Thick collagen fibers predominate
- Function
 - Tensile strength and ability to absorb compressive shock
- Location
 - Intervertebral discs
 - Pubic symphysis
 - Discs of knee joint

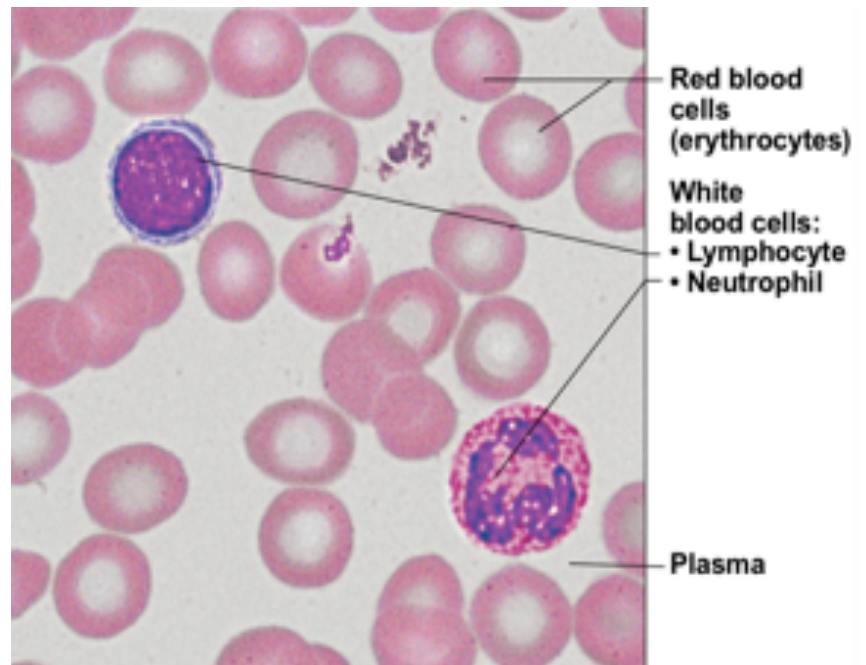
Bone Tissue

- Description
 - Bone matrix contains
 - Inorganic calcium salts
 - Abundance of collagen fibers
 - Osteoblasts—secrete collagen fibers and ground substance of the matrix
 - Osteocytes—mature bone cells in lacunae
 - Well vascularized
- Function
 - Supports and protects organs
 - Provides levers and attachment site for muscles
 - Stores calcium and other minerals
 - Stores fat
 - Marrow is site for blood cell formation
- Location - Bones



Blood Tissue

- An atypical connective tissue
- Develops from mesenchyme
- Consists of cells surrounded by nonliving matrix
- Description
 - Red and white blood cells in a fluid matrix
- Function
 - Transport of respiratory gases, nutrients, and wastes
- Location - Within blood vessels

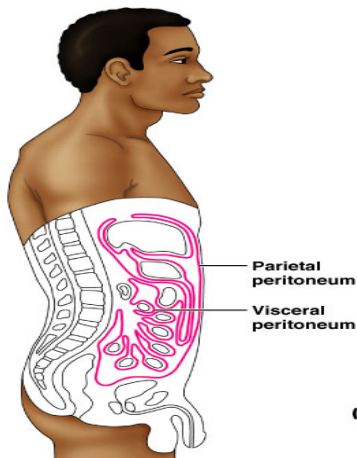
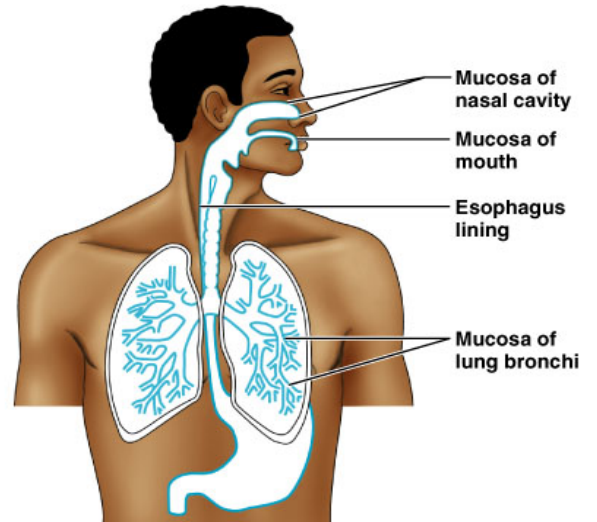


Covering and Lining Membranes

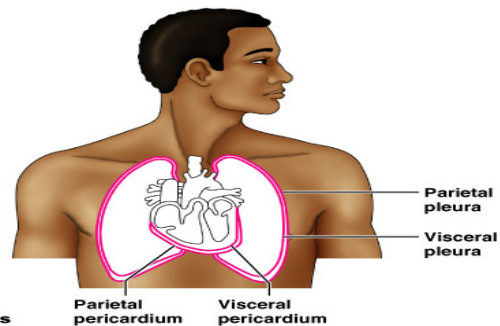
- Combine epithelial tissues and connective tissues
- Cover broad areas within body
- Consist of epithelial sheet plus underlying connective tissue

Three Types of Membranes

- Cutaneous membrane
 - Skin
- Mucous membranes
 - Lines hollow organs that open to surface of body
- Serous membrane
 - Simple squamous epithelium called mesothelium lying on areolar connective tissue
 - Lines closed cavities
 - Pleural cavity
 - Peritoneal cavity
 - Pericardial cavity
 - Produces serous fluid



(c) Serous membranes



Muscle Tissue

- Is a composite tissue
 - Contains areolar connective tissue in addition to muscle tissue
- Most muscle cells are called muscle fibers
- Cells contain myofilaments
 - Myofilaments contain actin and myosin
- Three types of muscle tissue
 - Skeletal muscle tissue
 - Cardiac muscle tissue
 - Smooth muscle tissue

Skeletal Muscle Tissue

- Description
 - Long, cylindrical cells
 - Multinucleate
 - Obvious striations
- Function
 - Voluntary movement
 - Manipulation of environment
 - Facial expression
- Location
 - Skeletal muscles attached to bones (occasionally to skin)

Description: Long, cylindrical, multinucleate cells; obvious striations.



Function: Voluntary movement; locomotion; manipulation of the environment; facial expression.

Location: In skeletal muscles attached to bones or occasionally to skin.



Cardiac Muscle Tissue

- Description
 - Branching cells, striated
 - Cells interdigitate at intercalated discs
- Function
 - Contracts to propel blood into circulatory system
- Location - Walls of heart

Smooth Muscle Tissue

- Description
 - Spindle-shaped cells with central nuclei
 - Arranged closely to form sheets
 - No striations
- Function
 - Propels substances along internal passageways
 - Involuntary control
- Location - Walls of hollow organs

Description: Spindle-shaped cells with central nuclei; no striations; cells arranged closely to form sheets.



Function: Propels substances or objects (foodstuffs, urine, a baby) along internal passageways; involuntary control.

Location: Mostly in the walls of hollow organs.



Nervous Tissue

- Description
- Main components are brain, spinal cord, and nerves
- Contains two types of cells
 - Neurons
 - Generate and conduct nerve impulses
 - Neuroglia
 - Supporting cells that nourish, insulate, and protect neurons
- Function
 - Transmit electrical signals from sensory receptors to effectors
- Location - Brain, spinal cord, and nerves

Tissue Response to Injury

- Inflammatory response
 - Nonspecific, local response
 - Limits damage to injury site
- Immune response
 - Takes longer to develop and very specific
 - Destroys particular microorganisms at site of infection

Inflammation

- Acute inflammation
 - Heat
 - Redness
 - Swelling
 - Pain
 - Chemicals signal nearby blood vessels to dilate
- Histamine increases permeability of capillaries

Inflammation

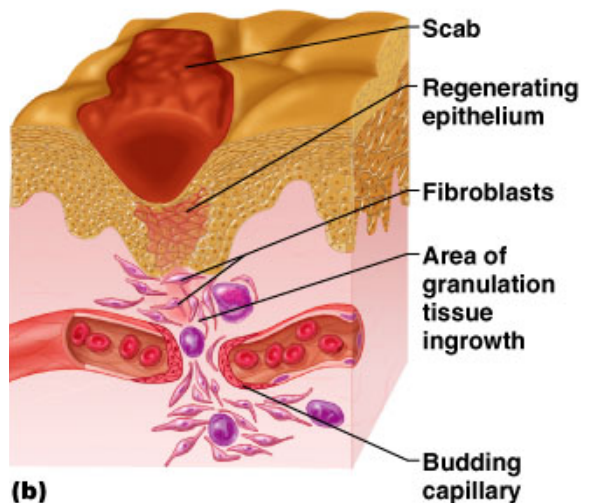
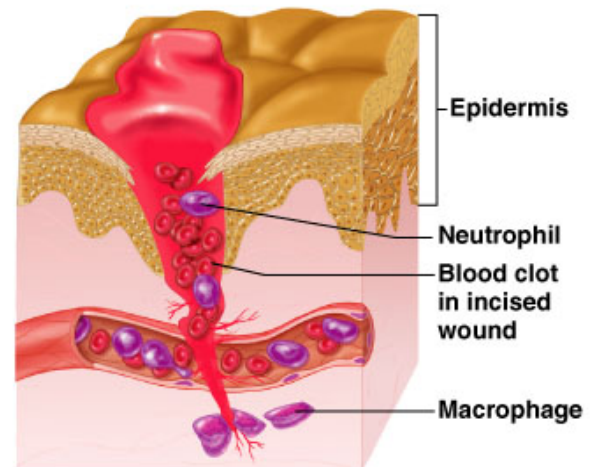
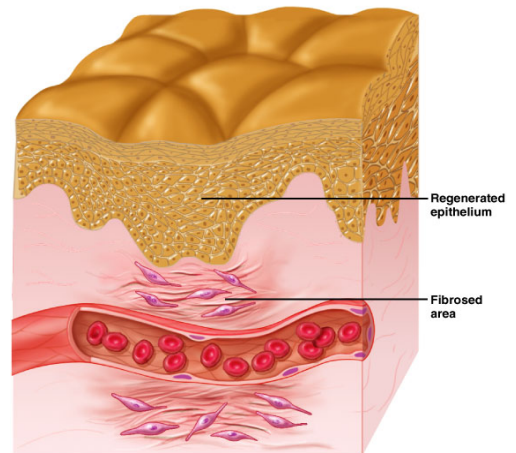
- Edema—accumulation of fluid
 - Helps dilute toxins secreted by bacteria
 - Brings oxygen and nutrients from blood
 - Brings antibodies from blood to fight infection

Repair

- Regeneration
 - Replacement of destroyed tissue with same type of tissue
- Fibrosis
 - Proliferation of scar tissue
- Organization
 - Clot is replaced by granulation tissue

The Tissues Throughout Life

- At the end of second month of development:
 - Primary tissue types have appeared
 - Major organs are in place
- Adulthood
 - Only a few tissues regenerate
 - Many tissues still retain populations of stem cells



(b)

Capacity for Regeneration

- Good to excellent:
 - Epithelial tissue, bone connective tissue, areolar connective tissue, dense irregular connective tissue, and blood-forming connective tissue
- Moderate:
 - Smooth muscle tissue, dense regular connective tissue

Capacity for Regeneration

- Weak:
 - Skeletal muscle tissue, cartilage
- None or almost none:
 - Cardiac muscle tissue, nervous tissue

The Tissues Throughout Life

- With increasing age:
 - Epithelia thin
 - Collagen decreases
 - Bones, muscles, and nervous tissue begin to atrophy
 - Poor nutrition and poor circulation lead to poor health of tissues