
Histology

Tissues

- Cells work together in functionally related groups called tissues
- Types of tissues:
  1. Epithelial – lining and covering
  2. Connective – support
  3. Muscle – movement
  4. Nervous – control

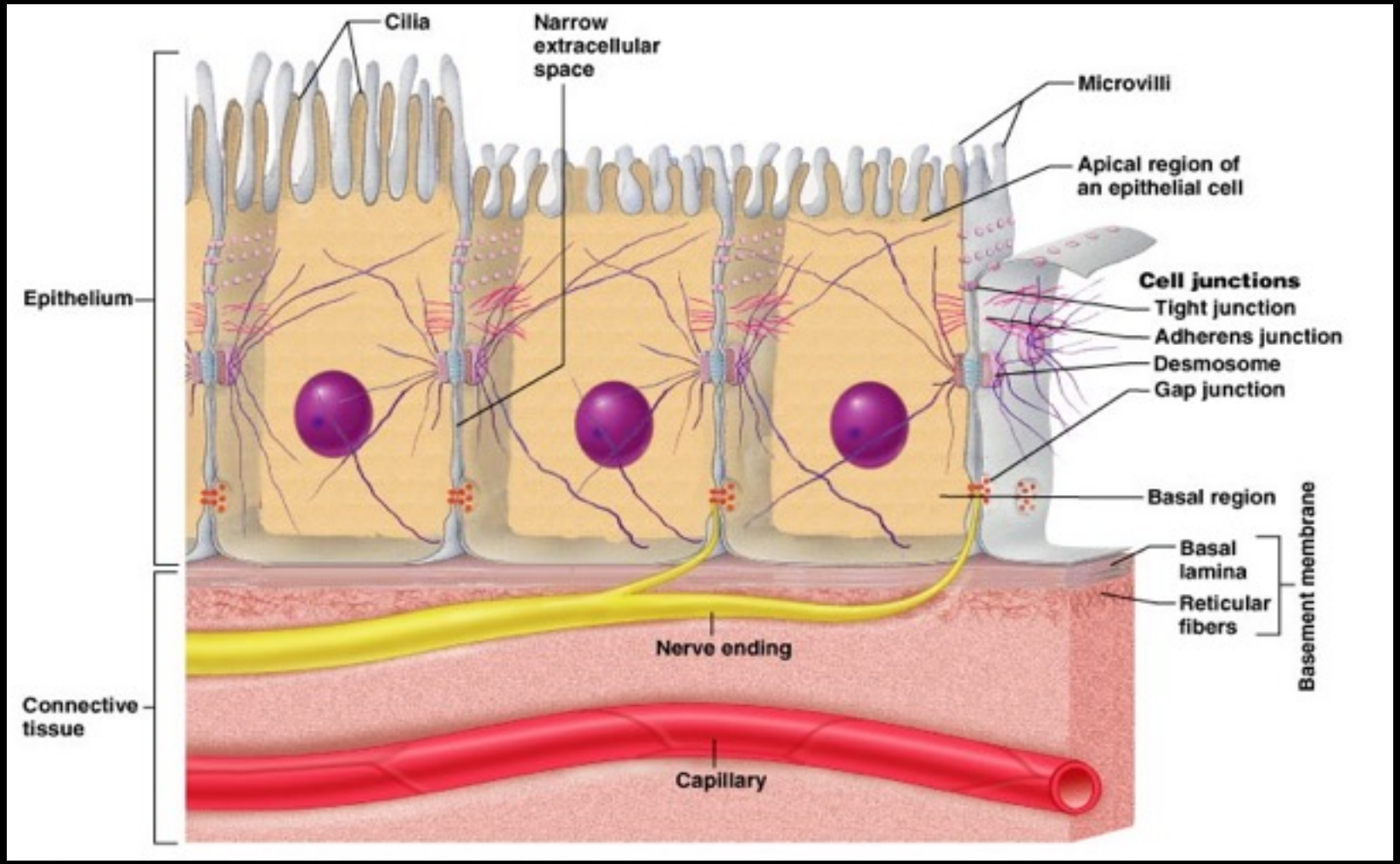
Epithelial Tissue – General Characteristics & Functions

- Covers a body surface or lines a body cavity
- Forms most glands
- Functions of epithelium
  - Protection
  - Absorption, secretion, and ion transport
  - Filtration
  - Forms slippery surfaces

Special Characteristics of Epithelia

- Cellularity
  - cells are in close contact with each other with little or no intercellular space between them
- Specialized contacts
  - may have junctions for both attachment and communication
- Polarity
  - epithelial tissues always have an apical and basal surface
- Support by connective tissue
  - at the basal surface, both the epithelial tissue and the connective tissue contribute to the basement membrane
- Avascular
  - nutrients must diffuse
- Innervated
- Regeneration
  - epithelial tissues have a high capacity for regeneration

Special Characteristics of Epithelia



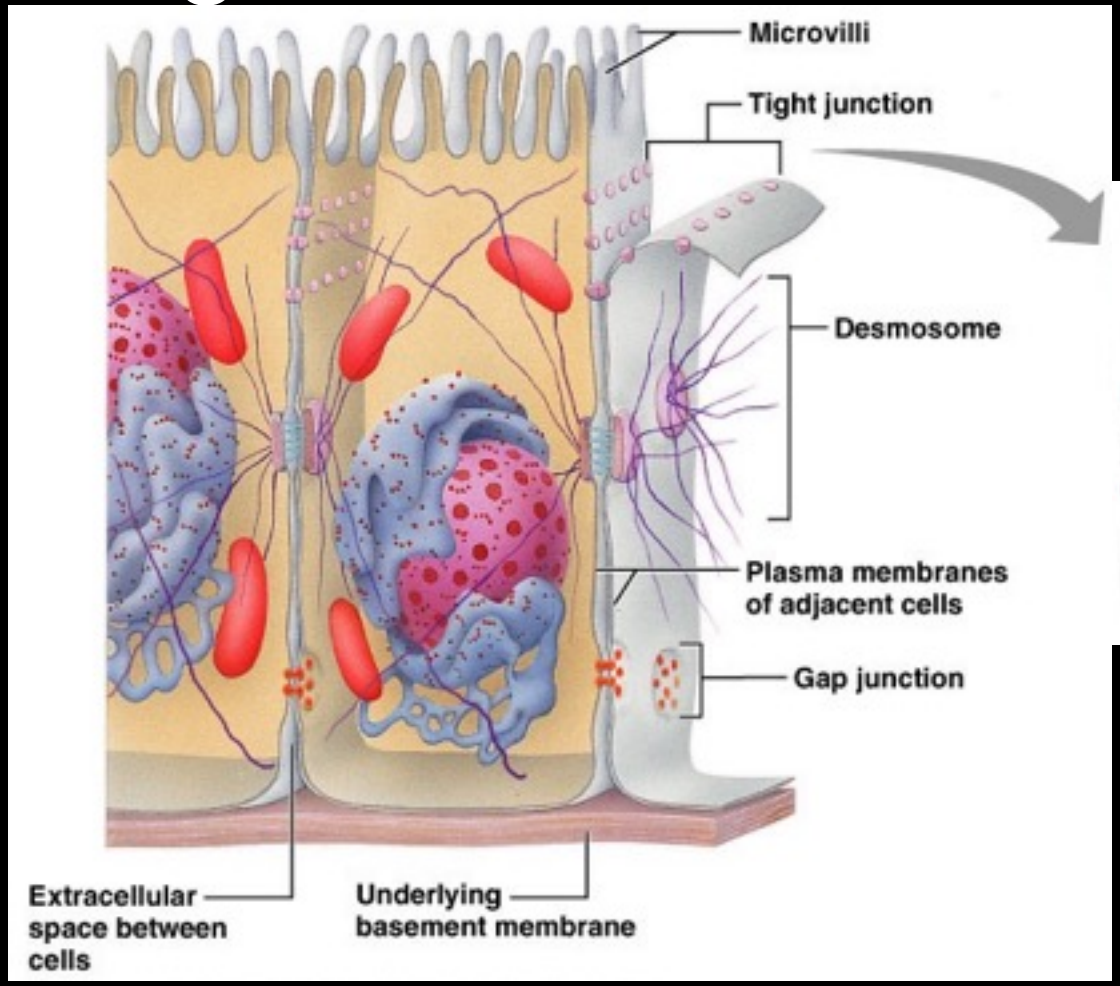
Lateral Surface Features

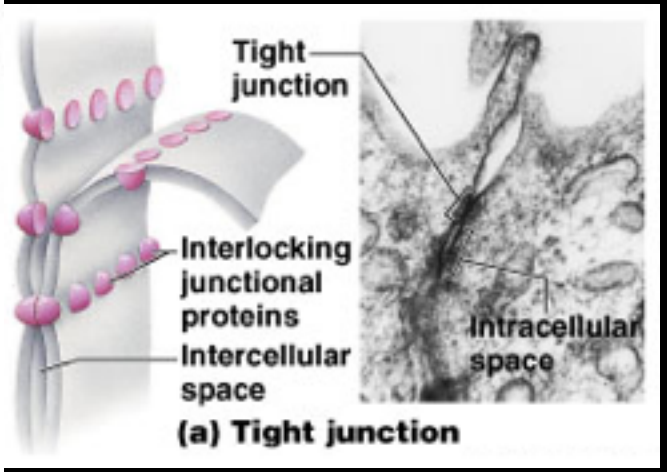
- Factors holding epithelial cells together
  - Adhesion proteins link plasma membranes of adjacent cells
  - Contours of adjacent cell membranes
  - Special cell junctions
    - Tight Junctions
    - Adherens Junctions
    - Desmosomes

Lateral Surface Features – Cell Junctions

- Tight junctions (zona occludens) – close off intercellular space
  - Found at apical region of most epithelial types
  - Some proteins in plasma membrane of adjacent cells are fused
  - Prevent molecules from passing between cells of epithelial tissue

Tight Junction





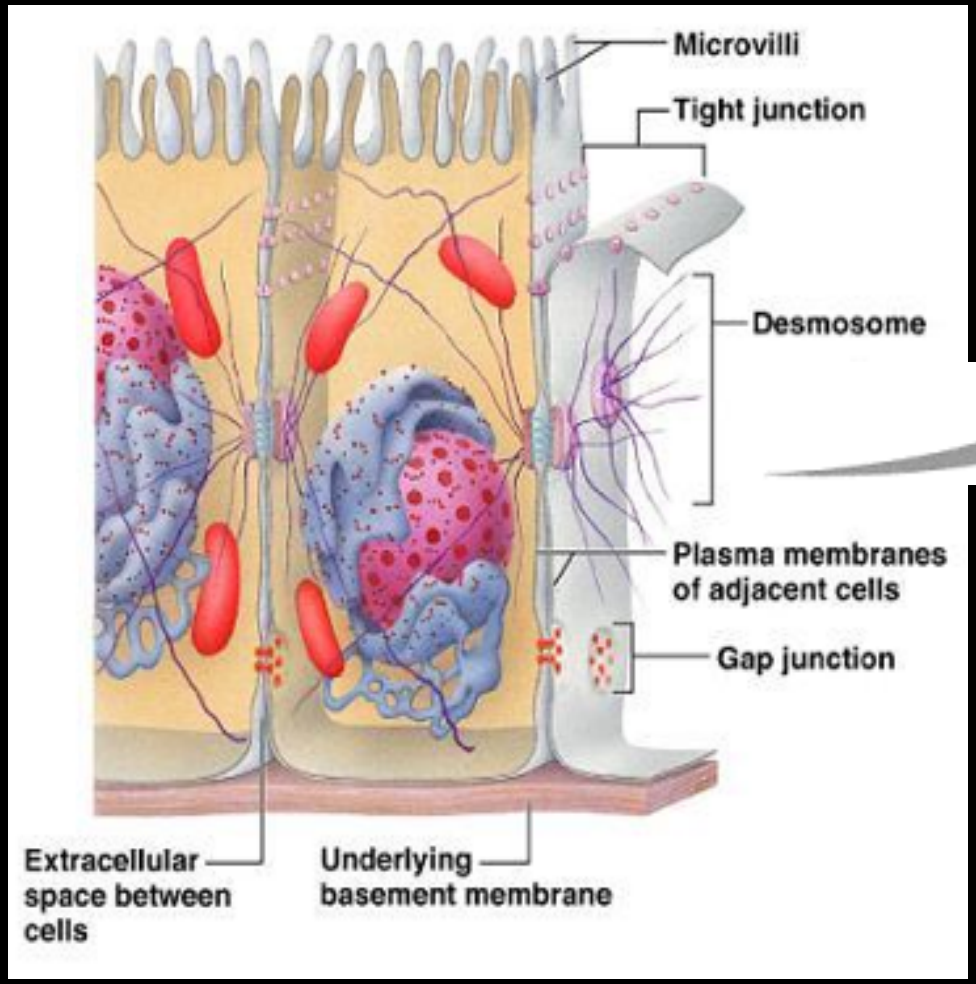
Lateral Surface Features – Cell Junctions

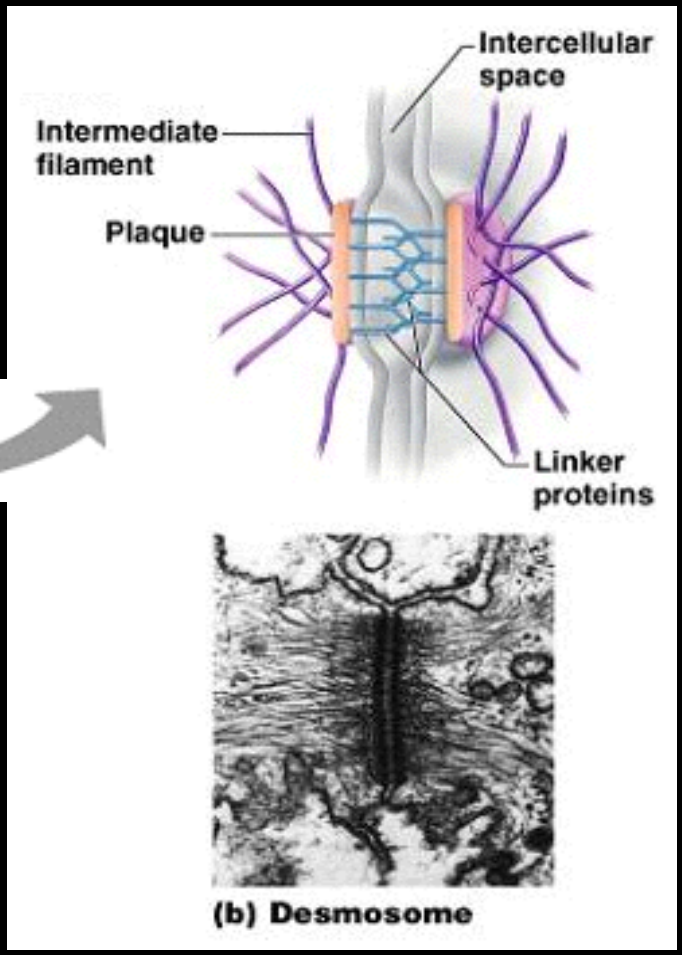
- Adherens junctions (zonula adherens) – anchoring junction
  - Transmembrane linker proteins attach to actin microfilaments of the cytoskeleton and bind adjacent cells
  - Along with tight junctions, form the tight junctional complex around apical lateral borders of epithelial tissues

Lateral Surface Features – Cell Junctions

- Desmosomes – two disc-like plaques connected across intercellular space
  - Plaques of adjoining cells are joined by proteins called cadherins
  - Proteins interdigitate into extracellular space
  - Intermediate filaments insert into plaques from cytoplasmic side

Desmosome

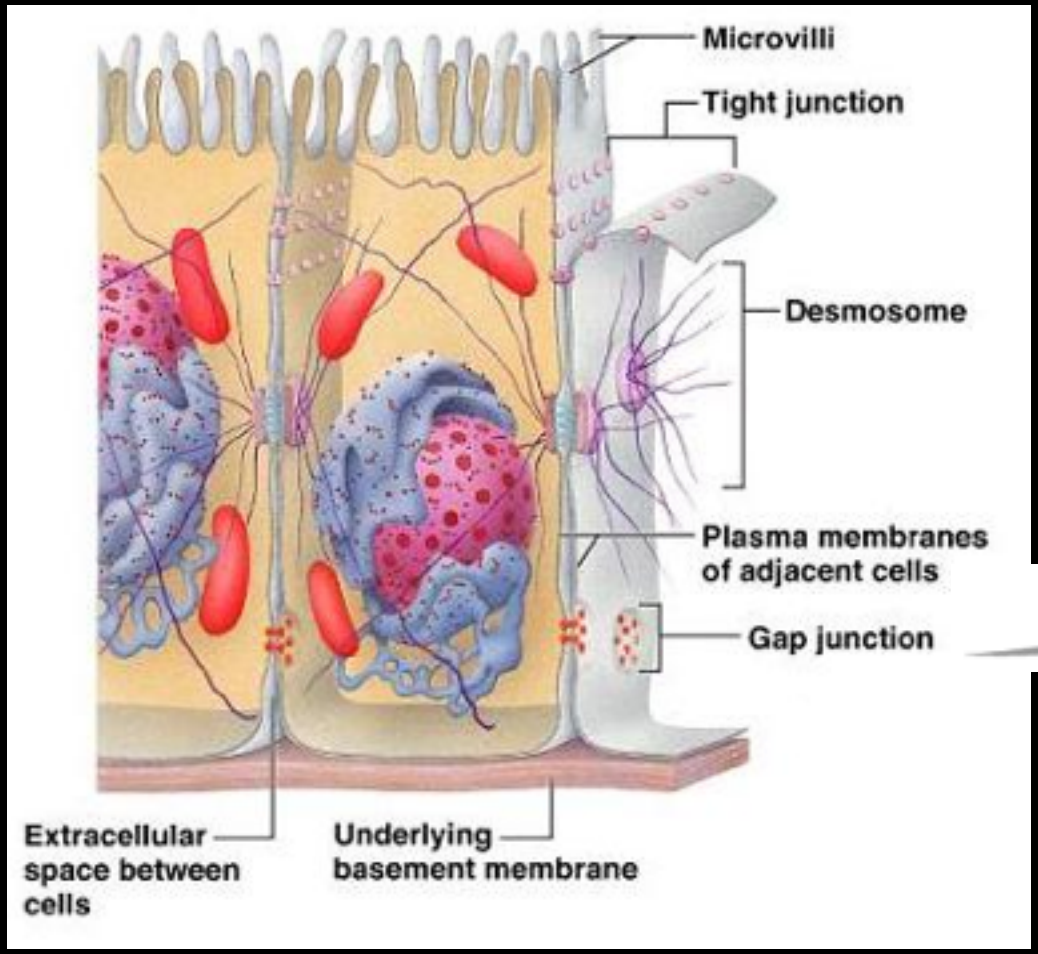

Microvilli
Tight junction
Desmosome
Plasma membranes of adjacent cells
Gap junction
Extracellular space between cells
Underlying basement membrane

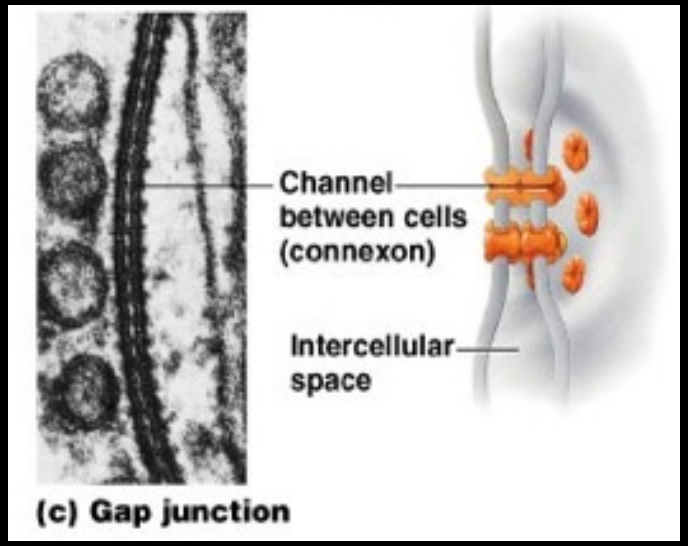

Intercellular space
Intermediate filament
Plaque
Linker proteins
(b) Desmosome

Lateral Surface Features – Cell Junctions

- Gap junctions – passageway between two adjacent cells
  - Let small molecules move directly between neighboring cells
  - Cells are connected by hollow cylinders of protein

Gap Junction





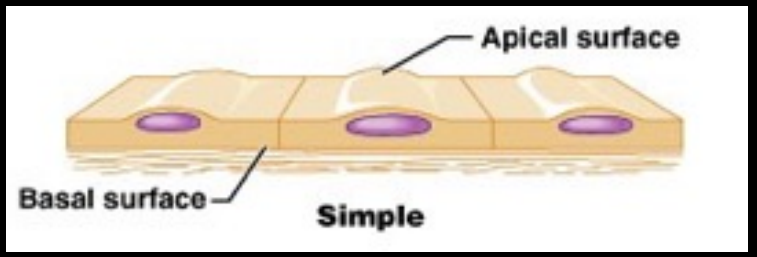
Basal Feature: The Basal Lamina

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

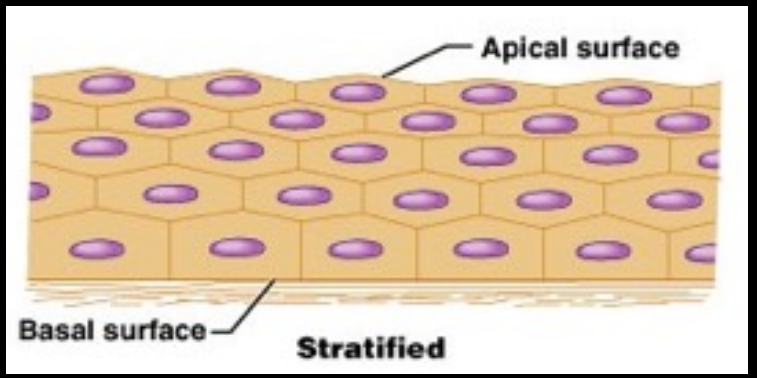
Epithelial Tissues

Classifications & Naming of Epithelia

- First name of tissue indicates number of layers
  - Simple – one layer of cells



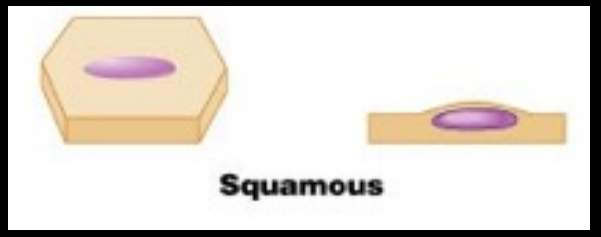
  - Stratified – more than one layer of cells

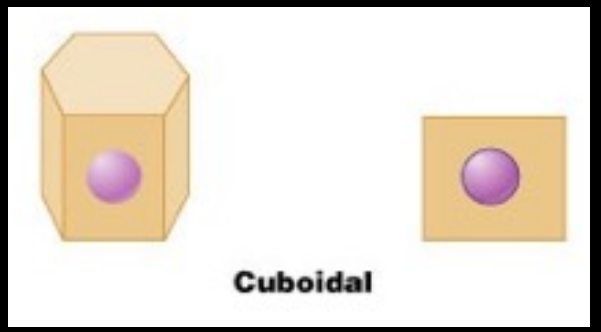


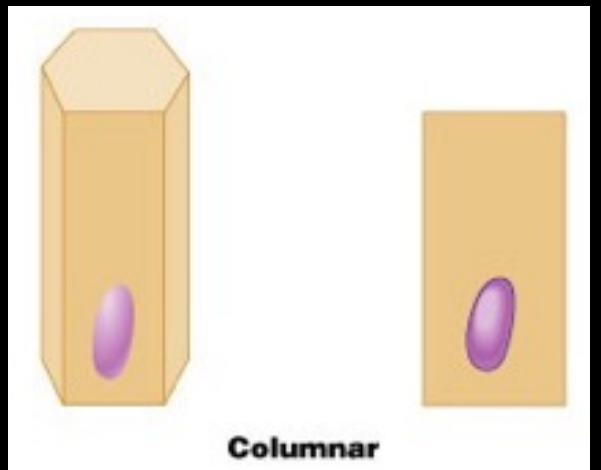
Classification & Naming of Epithelia

- Last name of tissue describes shape of cells
  - Squamous – cells wider than tall (plate or “scale” like)
  - Cuboidal – cells are as wide as tall, as in cubes

Columnar – cells are taller than they are wide, like columns







Naming Epithelia

- Naming the epithelia includes both the layers (first) and the shape of the cells (second)
  - i.e. stratified cuboidal epithelium
- The name may also include any accessory structures
  - Goblet cells
  - Cilia
  - Keratin
- Special epithelial tissues (don’t follow naming convention)
  - Psuedostratified
  - Transitional

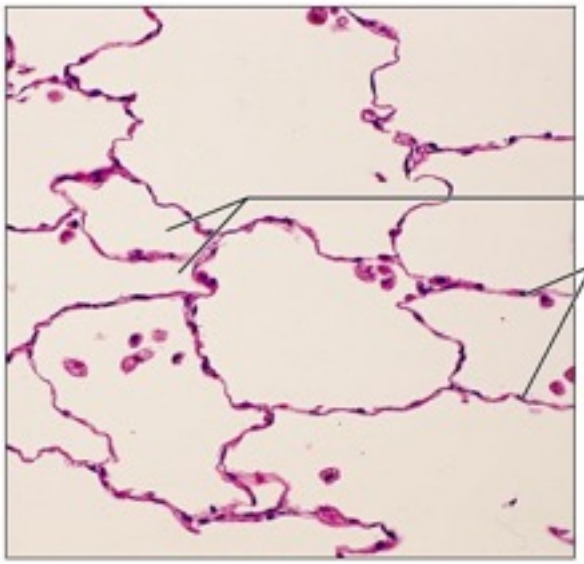
Simple Squamous Epithelium

- Description
  - single layer of flat cells with disc-shaped nuclei
- Special types
  - Endothelium (inner covering)
    - slick lining of hollow organs
  - Mesothelium (middle covering)
    - Lines peritoneal, pleural, and pericardial cavities
    - Covers visceral organs of those cavities

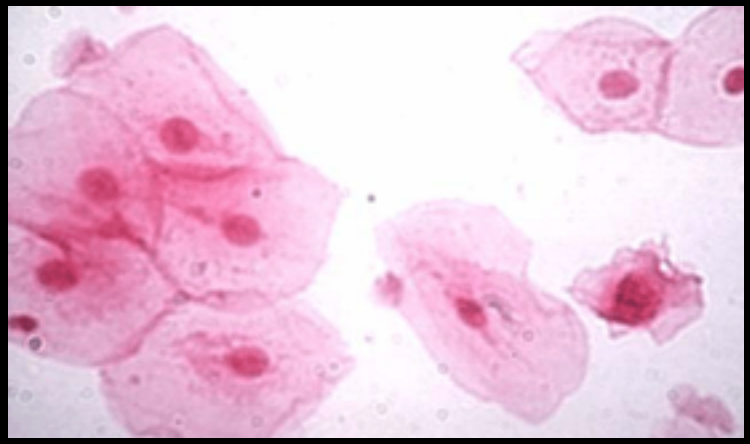
Simple Squamous Epithelium

- 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)

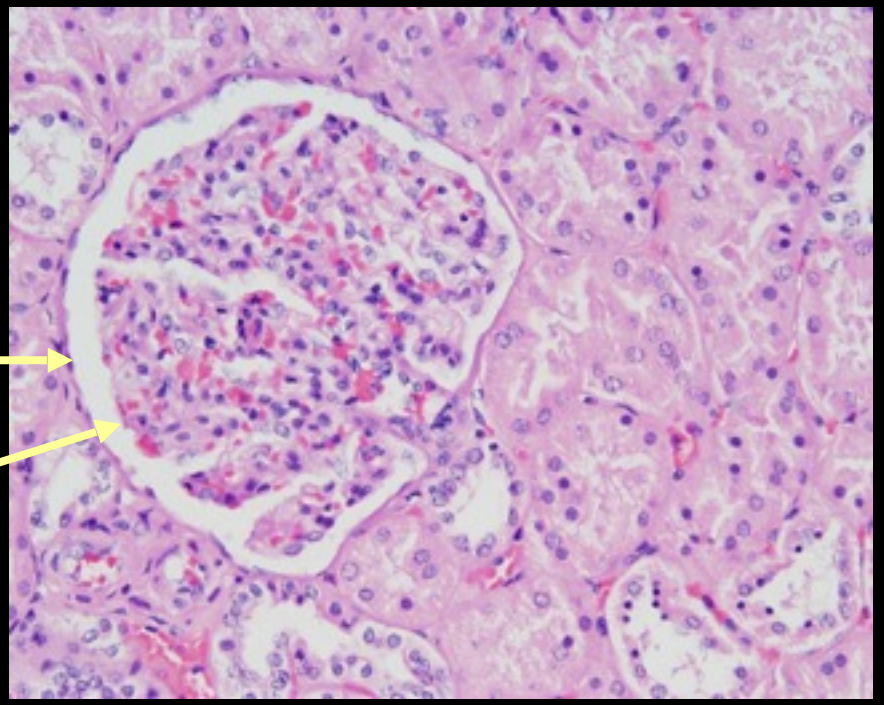
Simple Squamous Epithelium



Photomicrograph: Simple squamous epithelium forming part of the alveolar (air sac) walls (400×).

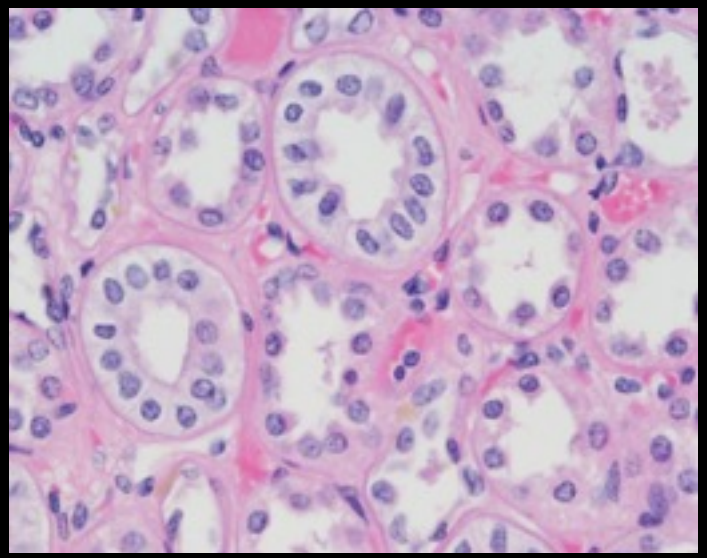


Simple squamous lining the walls of the capillary



Simple Cuboidal Epithelium

- Description
  - single layer of cube-like cells with large, spherical central nuclei
- Function
  - secretion and absorption
- Location
  - kidney tubules, secretory portions of small glands, ovary & thyroid follicles

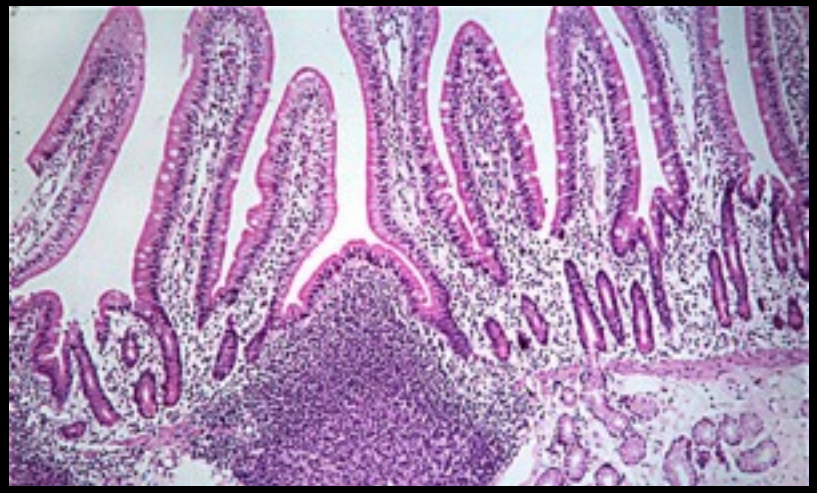


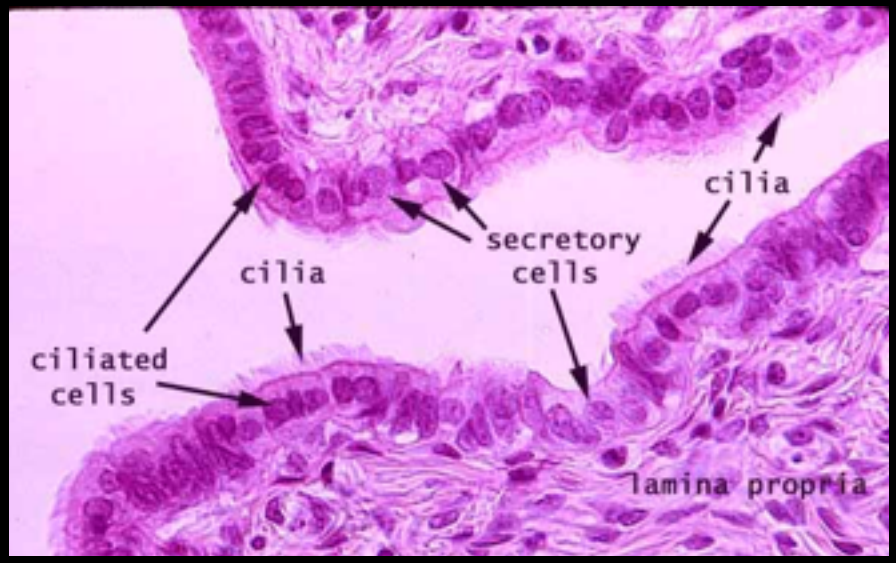
Simple Columnar Epithelium

- 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

Simple Columnar Epithelium

- Location
  - Non-ciliated form
    - Lines digestive tract, gallbladder, ducts of some glands
  - Ciliated form
    - Lines small bronchi, uterine tubes, uterus



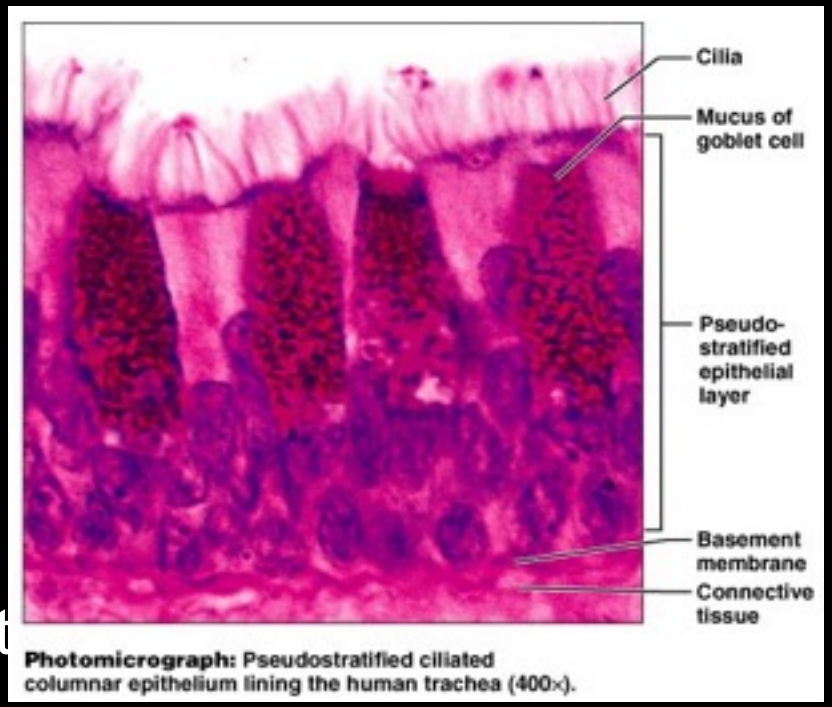


Pseudostratified Columnar Epithelium

- 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

Pseudostratified Columnar Epithelium

- Locations
  - Non-ciliated type
    - Ducts of male reproductive tubes
    - Ducts of large glands
  - Ciliated variety
    - Lines trachea and most of upper respiratory tract



Photomicrograph: Pseudostratified ciliated columnar epithelium lining the human trachea (400×).

Stratified Epithelia

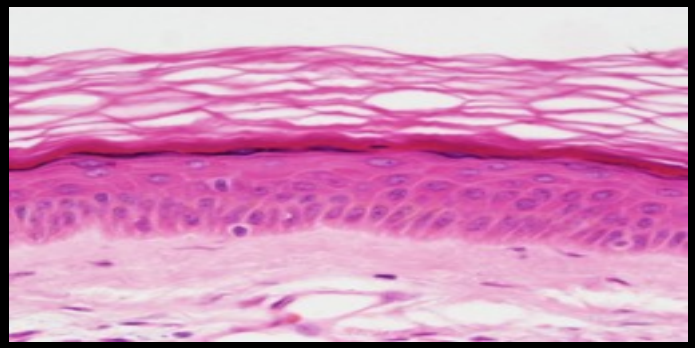
- Contain two or more layers of cells
- Regenerate from below
- Major role is protection
- Are named according to the shape of cells at apical layer

Stratified Squamous Epithelium

- Description
  - Many layers of cells – squamous in shape
  - Deeper layers of cells appear cuboidal or columnar
  - Thickest epithelial tissue – adapted for protection

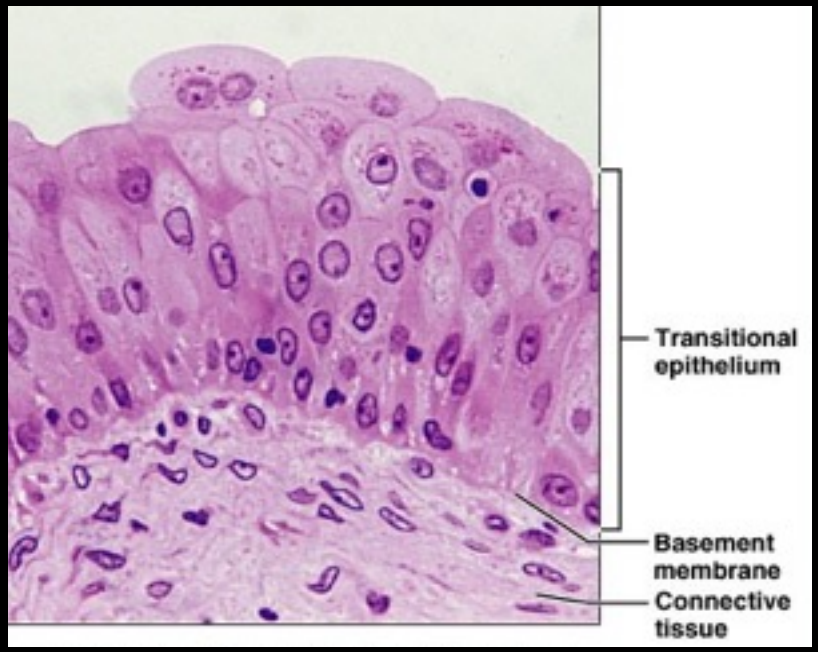
Stratified Squamous Epithelium

- Specific types
  - Keratinized – contain the protective protein keratin
    - Surface cells are dead and full of keratin
  - Non-keratinized – forms moist lining of body openings
- Function
  - Protects underlying tissues in areas subject to abrasion
- Location
  - Keratinized – forms epidermis
  - Non-keratinized – forms lining of esophagus, mouth, and vagina



Transitional Epithelium

- Description
  - Basal cells usually cuboidal or columnar
  - Superficial cells dome-shaped or squamous
- Function
  - stretches and permits distension of urinary bladder
- Location
  - Lines ureters, urinary bladder and part of urethra

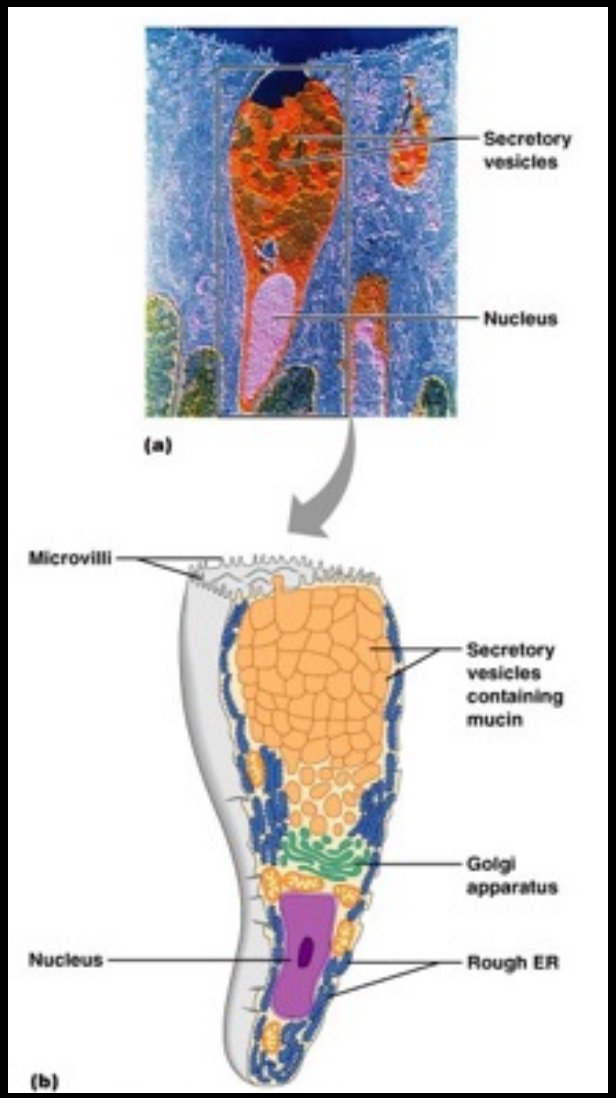


Glandular Epithelium

- 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
  - Mammary glands
- May be: unicellular or multicellular

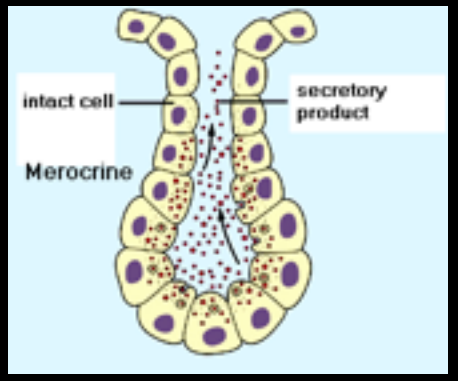
Unicellular Exocrine Glands (The Goblet Cell)

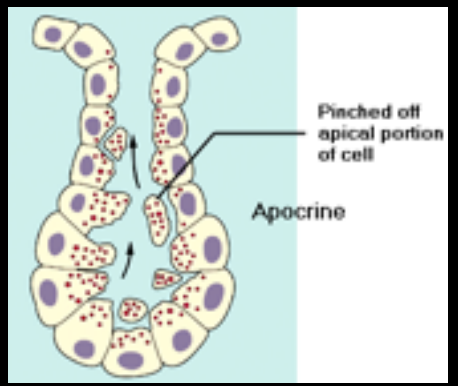
- Goblet cells produce mucin
- Mucin + water → mucus
- Protects and lubricates many internal body surfaces

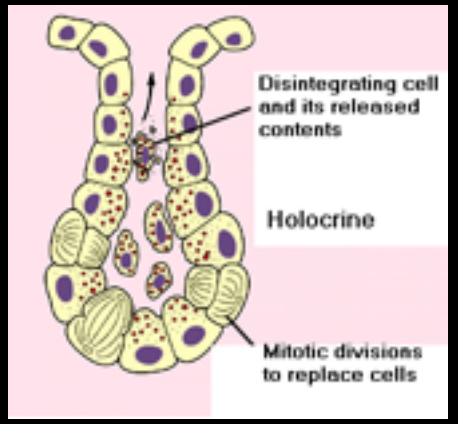


Multicellular Exocrine Glands

- Classified by structure (branching & shape) of duct
- Can also be classified by mode or type of secretion
  - Merocrine secretion – secretory vesicles released via exocytosis (saliviary glands)
  - Apocrine secretion – apical portion of the cell is lost, cytoplasm + secretory product (mammary glands)
  - Holocrine secretion – entire cell is destroyed during secretion (sebaceous gland)







May also be classified by types of secretions from exocrine glands

- Serous
  - mostly water but also contains some enzymes
  - Ex. parotid glands, pancreas
- Mucous
  - mucus secretions
  - Ex. sublingual glands, goblet cells
- Mixes
  - serous & mucus combined
  - Ex. submandibular gland

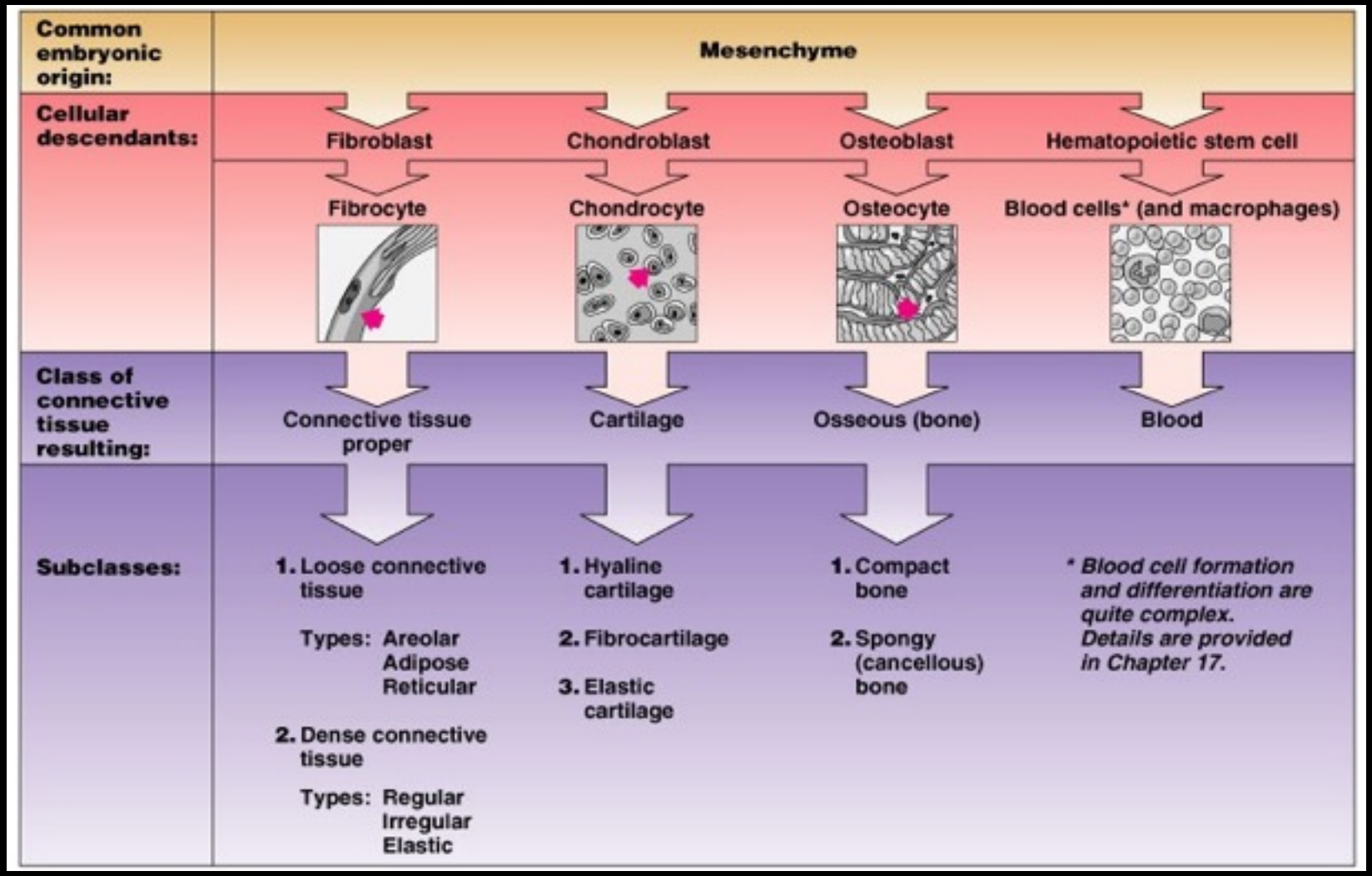
Connective Tissues

Connective Tissue

- Most diverse and abundant tissue
- Main classes
  - Connective tissue proper
  - Blood – Fluid connective tissue
  - Cartilage
  - Bone tissue

  } Supporting connective tissues
- Components of connective tissue:
  - Cells (varies according to tissue)
  - Matrix
    - Protein fibers (varies according to tissue)
    - Ground substance (varies according to tissue)
- Common embryonic origin – mesenchyme

Classes of Connective Tissue



Connective Tissue Proper - Structures

- Variety of cells, fibers & grounds substances
  - Types of depend on use
- Cells found in connective tissue proper
  - Fibroblasts
  - Macrophages, lymphocytes (antibody producing cells)
  - Adipocytes (fat cells)
  - Mast cells
  - Stem cells
- Fibers:
  - Collagen – very strong & abundant, long & straight
  - Elastic – branching fibers with a wavy appearance (when relaxed)
  - Reticular – form a network of fibers that form a supportive framwork in soft organs (i.e. Spleen & liver)
- Ground substance:
  - Along with fibers, fills the extracellular space
  - Ground substance helps determine functionality of tissue

Connective Tissue Proper - Classifications

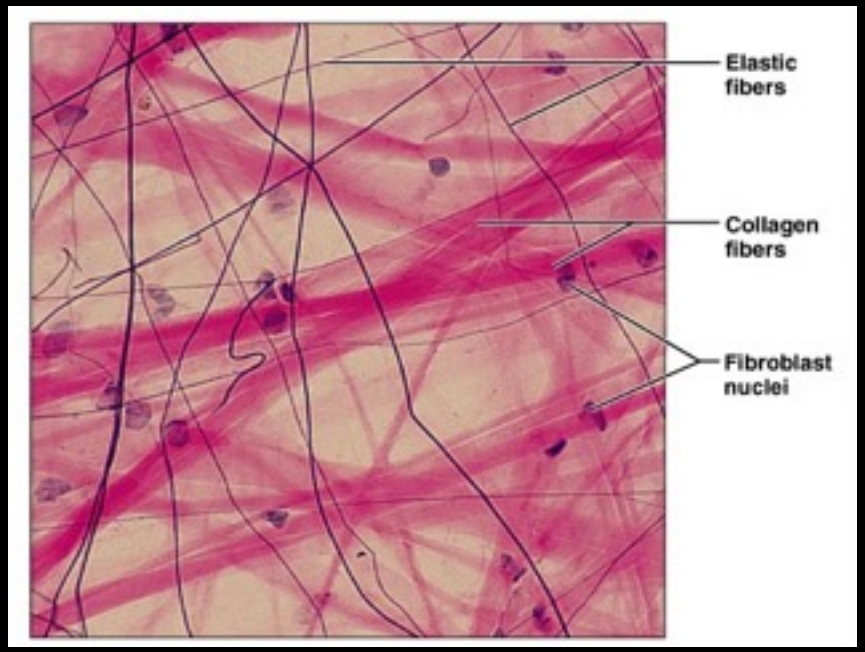
- Loose Connective Tissue
  - Areolar
  - Reticular
  - Adipose
- Dense Connective Tissue
  - Regular
  - Irregular
  - Elastic

Areolar Connective Tissue

- Description
  - Gel-like matrix with:
    - all three fiber types (collagen, reticular, elastic) for support
    - Ground substance is made up by glycoproteins also made and secreted by the fibroblasts.
  - Cells – fibroblasts, macrophages, mast cells, white blood cells, adipocytes
  - Highly vascular tissue
- Function
  - Wraps and cushions organs
  - Holds and conveys tissue fluid
  - Important role in inflammation
  - Main battlefield in fight against infection

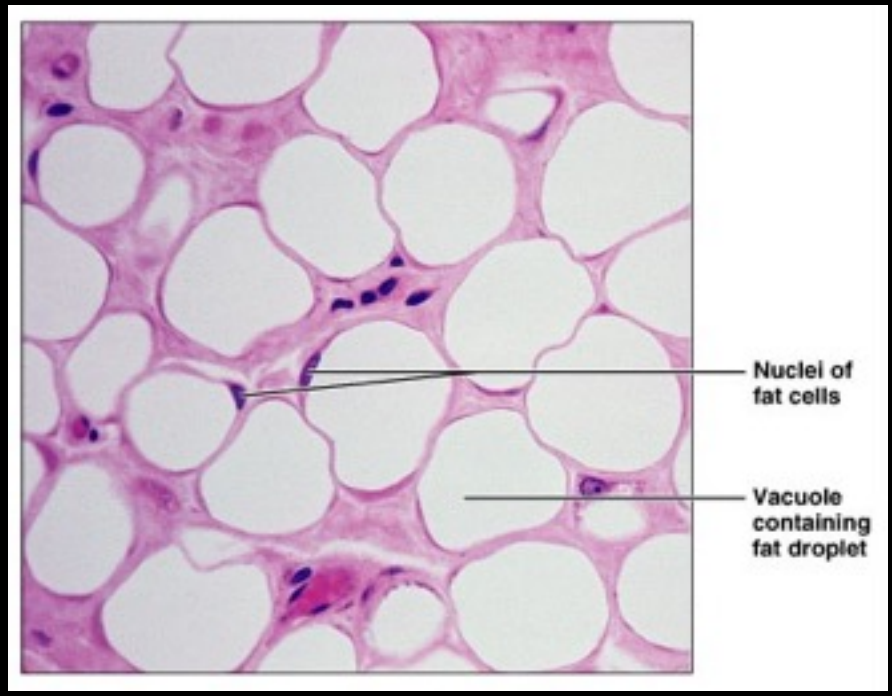
Areolar Connective Tissue

- Location
  - Widely distributed under epithelia
  - Packages organs
  - Surrounds capillaries



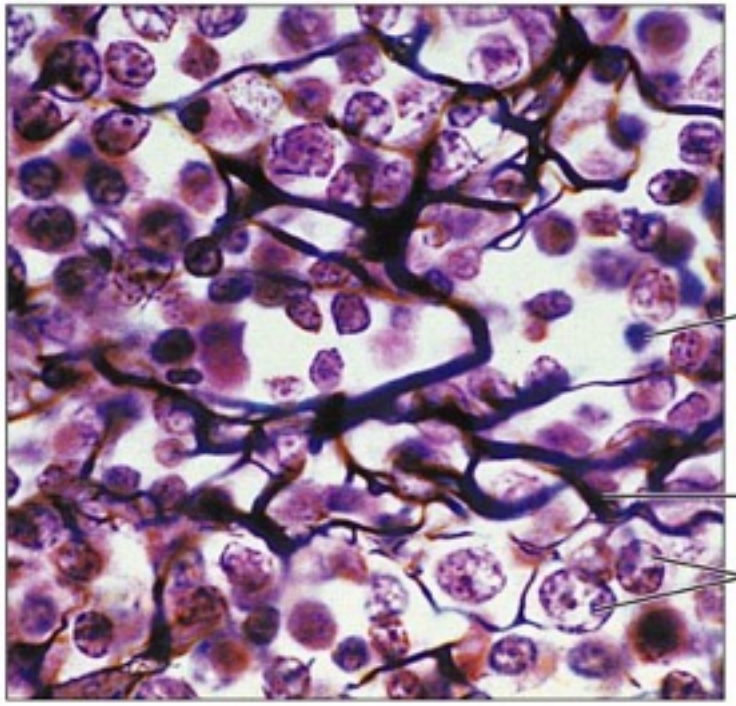
Adipose Tissue

- Description
  - Closely packed adipocytes
  - Have nucleus pushed to one side by fat droplet 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



Reticular Connective Tissue

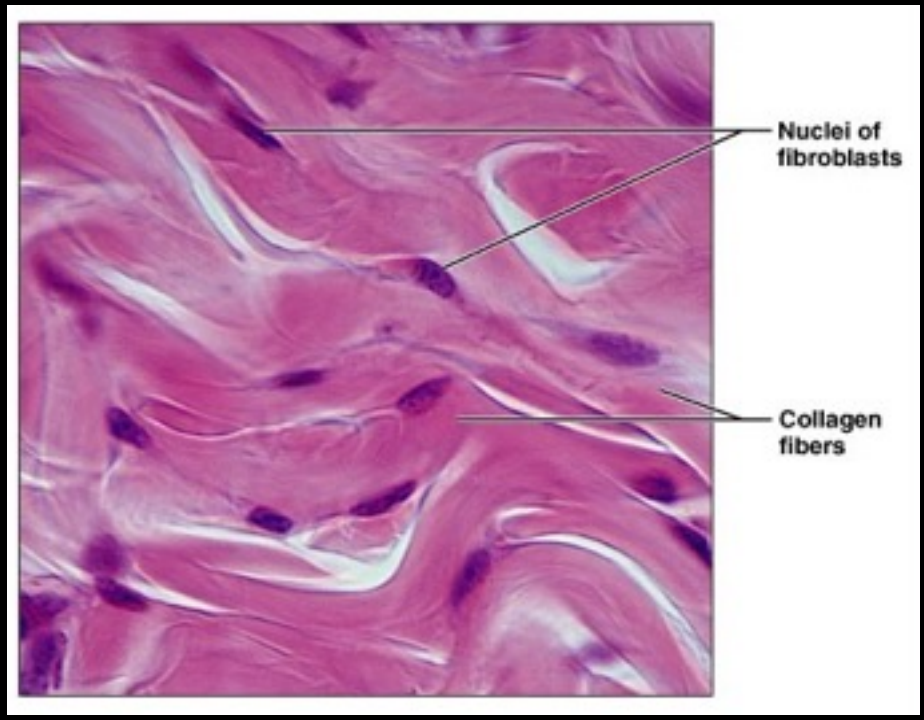
- Description – network of reticular fibers in loose ground substance
- Function – form a soft, internal skeleton (stroma) – supports other cell types
- Location – lymphoid organs
  - Lymph nodes, bone marrow, and spleen



Photomicrograph: Dark-staining network of reticular connective tissue fibers forming the internal skeleton of the spleen (350×).

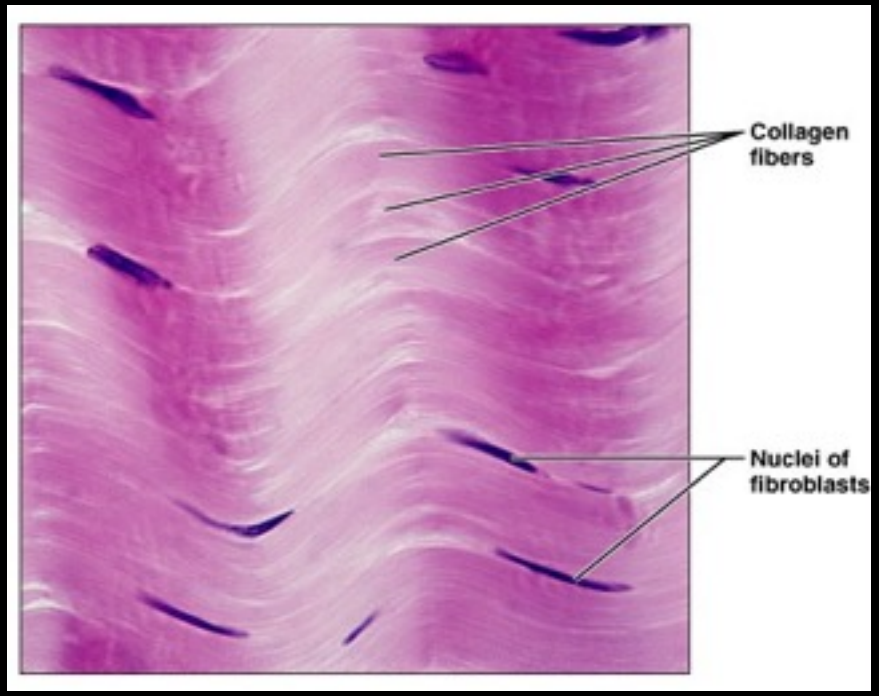
Dense Irregular Connective Tissue

- Description
  - Primarily *irregularly* arranged collagen fibers
  - Some elastic fibers and fibroblasts
- Function
  - Withstands tension
  - Provides structural strength
- Location
  - Dermis of skin
  - Submucosa of digestive tract
  - Fibrous capsules of joints and organs



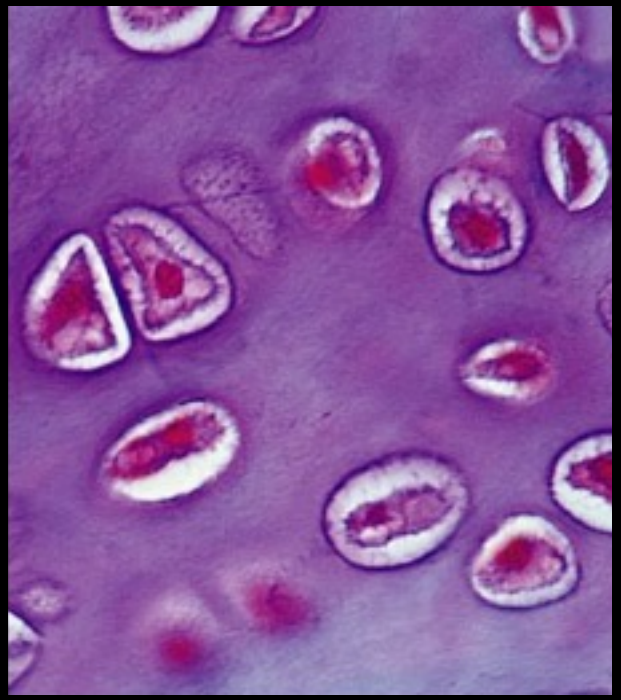
Dense Regular Connective Tissue

- Description
  - Primarily *parallel* collagen fibers
  - Fibroblasts and some elastic fibers
  - Poorly vascularized
- Function
  - Attaches muscle to bone
  - Attaches bone to bone
  - Withstands great stress in one direction
- Location
  - Tendons and ligaments
  - Aponeuroses
  - Fascia around muscles



Cartilage

- Characteristics:
  - Firm, flexible tissue
  - Contains no blood vessels or nerves
  - Matrix contains up to 80% water
  - Cell type – chondrocyte
- Types:
  - Hyaline
  - Elastic
  - Fibrocartilage

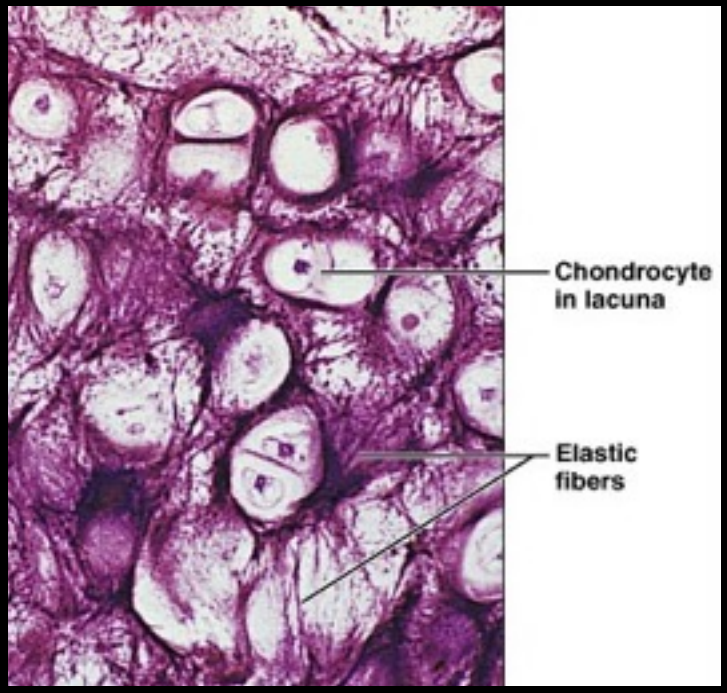


Hyaline Cartilage

- Description
  - Imperceptible collagen fibers (hyaline = glassy)
  - Chodroblasts produce matrix
  - Chondrocytes lie in lacunae
- Function
  - Supports and reinforces
  - Resilient cushion
  - Resists repetitive stress
- Location
  - Ends of long bones
  - Costal cartilage of ribs
  - Cartilages of nose, trachea, and larynx Location

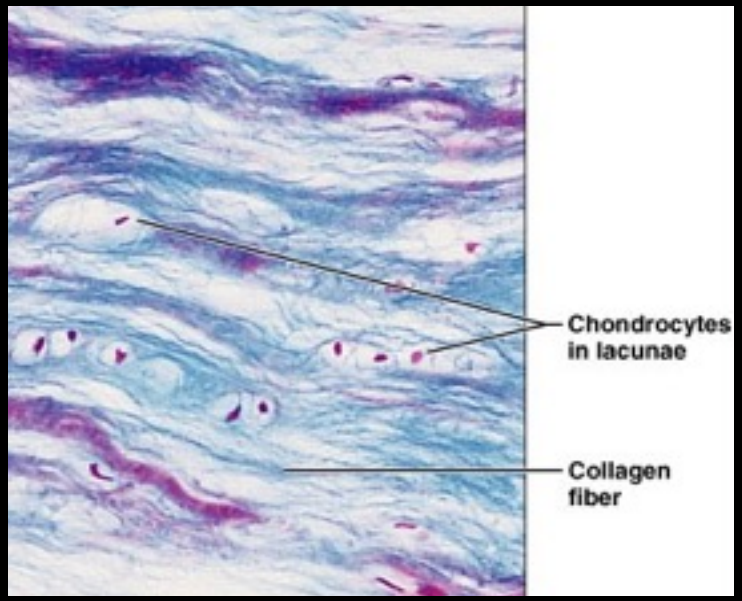
Elastic Cartilage

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



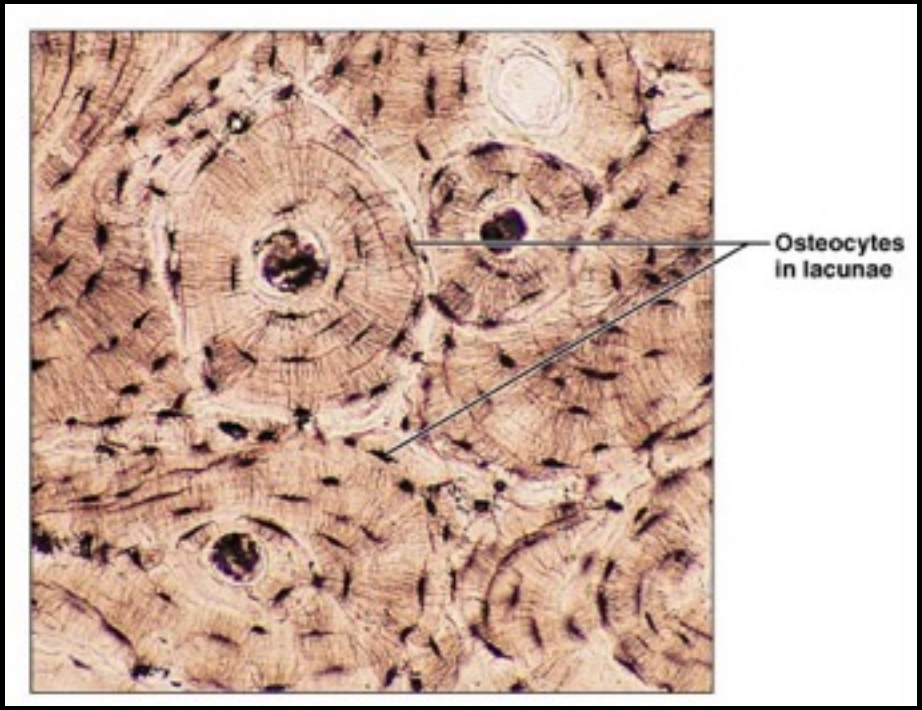
Fibrocartilage

- 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



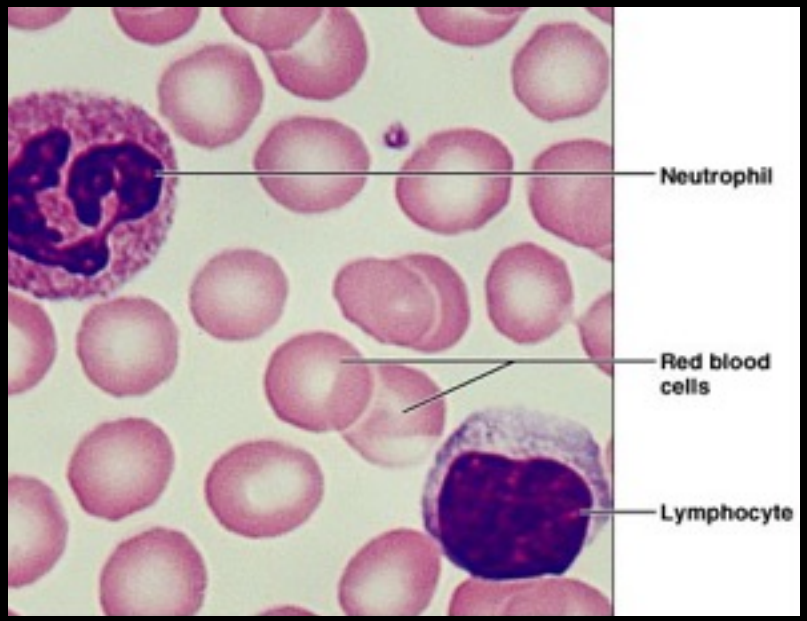
Bone Tissue

- 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

- Description
  - red and white blood cells in a fluid matrix
- Function
  - transport of respiratory gases, nutrients, and wastes
- Location
  - within blood vessels
- Characteristics
  - An atypical connective tissue
  - Consists of cells surrounded by fluid matrix



Covering and Lining Membranes

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

Types of Membranes

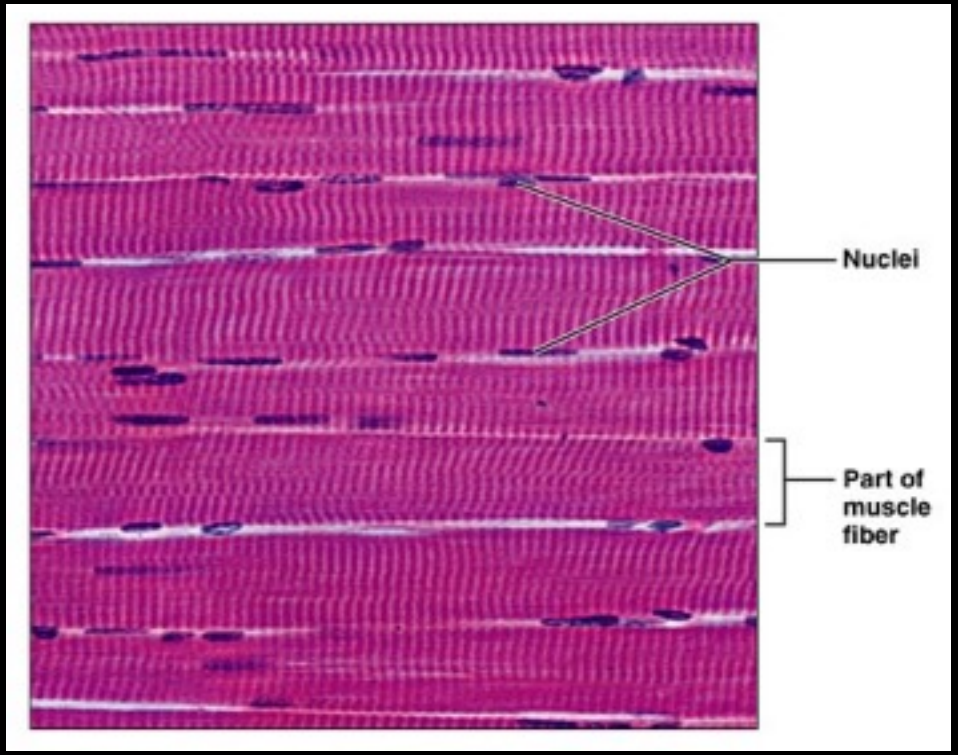
- Cutaneous membrane – skin
- Mucous membrane
  - Lines hollow organs that open to surface of body
  - An epithelial sheet underlain with layer of *lamina propria*
- Serous membrane – slippery membranes
  - Simple squamous epithelium lying on areolar connective tissue
  - Line closed cavities
    - Pleural, peritoneal, and pericardial cavities
- Synovial membranes – lining joint cavities
  - Loose connective (areolar) + simple squamous epithelium
  - Secretes fluid (synovial fluid) which lubricates, protects & cushions joint structures

Muscle Tissue

- Types
  - Skeletal muscle tissue
  - Cardiac muscle tissue
  - Smooth muscle tissue

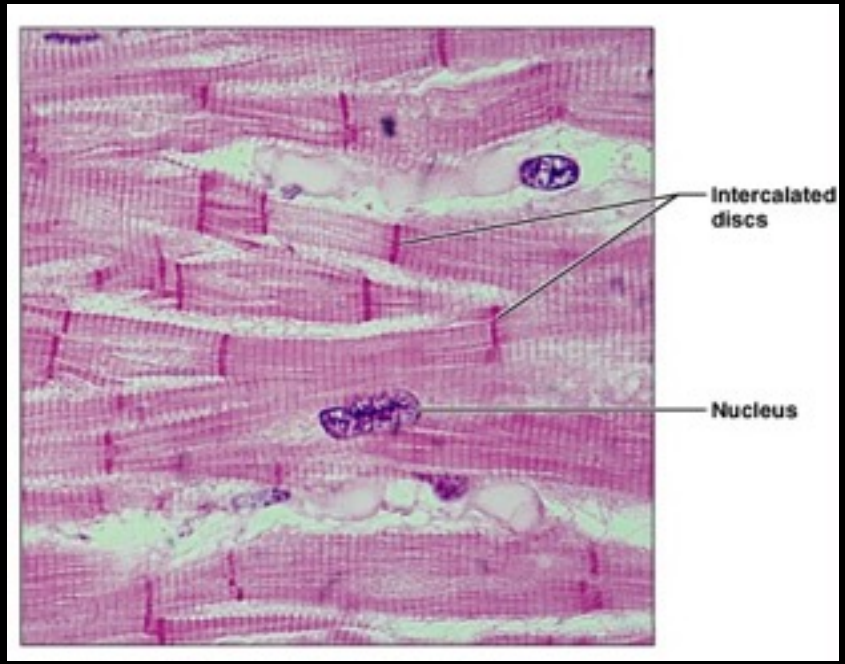
Skeletal Muscle Tissue

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



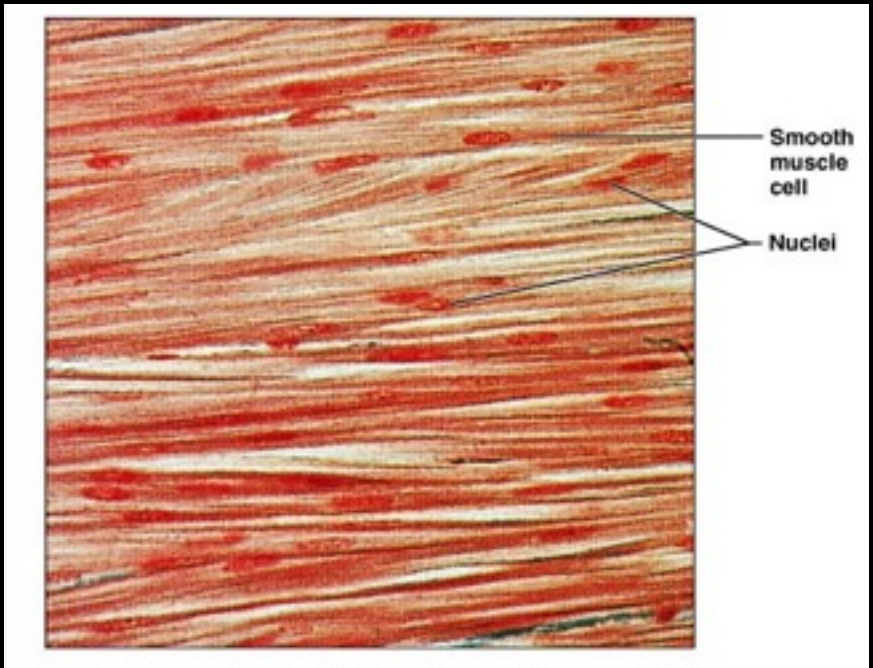
Cardiac Muscle Tissue

- Function
  - Contracts to propel blood into circulatory system
- Characteristics
  - Branching cells
  - Uni-nucleate
  - Intercalated discs
- Location
  - Occurs in walls of heart



Smooth Muscle Tissue

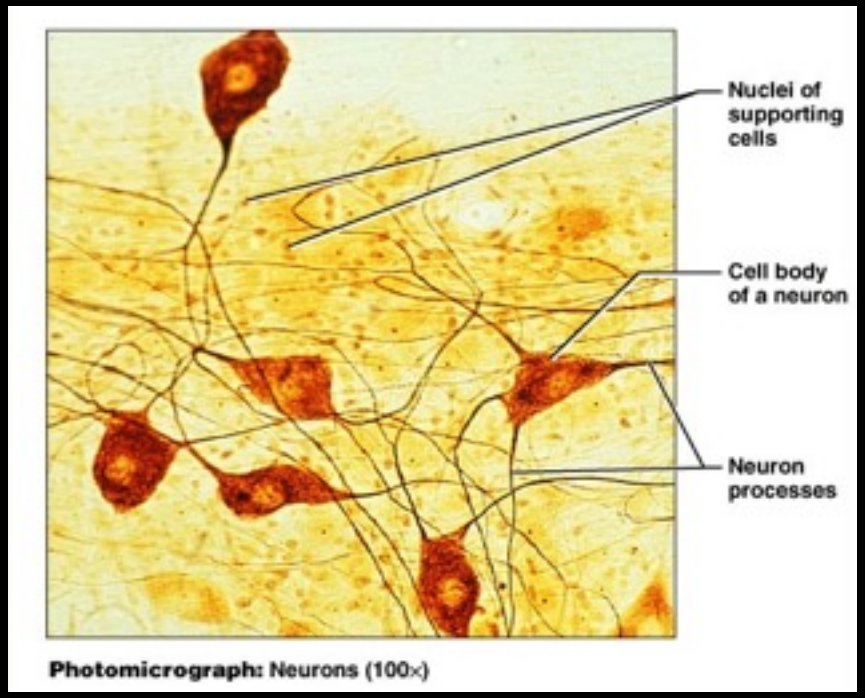
- Characteristics
  - Spindle-shaped cells with central nuclei
  - Arranged closely to form sheets
  - No striations
- Function
  - Propels substances along internal passageways
  - Involuntary control
- Location
  - Mostly walls of hollow organs



Nervous Tissue

Nervous Tissue

- Function
  - Transmit electrical signals from sensory receptors to effectors
- Location
  - Brain, spinal cord, and nerves
- Description
  - Main components are brain, spinal cord, and nerves
  - Contains two types of cells
    - Neurons – excitatory cells
    - Supporting cells (neuroglial cells)



Photomicrograph: Neurons (100×)

Tissue Response to Injury

- Restoration involves
  - Inflammation
  - Regeneration (repair)

- Inflammation
  - Due to something that damages/kills cells or fibers or in some way damage tissue, causing . . .
    - Swelling
    - Warmth
    - Redness
    - Pain
  - These common conditions are a result of mast cell activation – releases vasodilators such as histamine

Tissue Response to Injury

- Goal:
  - Restore normal function to tissue
- Process:
  - Fibroblasts activated to produce fibrous tissue
  - Usually remodeled over time
- Challenges
  - Some tissues are non-vascular and will repair very slowly
  - If excitable tissue is replaced by scar tissue – function is lost!

The Tissues Throughout Life

- Early on – Gastrulation
  - The most important time in your life!!
    - This is when tissues differentiate – mess up here and you don't develop correctly
- 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
- With increasing age:
  - Epithelia thin
  - Collagen decreases
  - Bones, muscles, and nervous tissue begin to atrophy
  - Poor nutrition and poor circulation – poor health of tissues
  - Increased chance of developing cancer