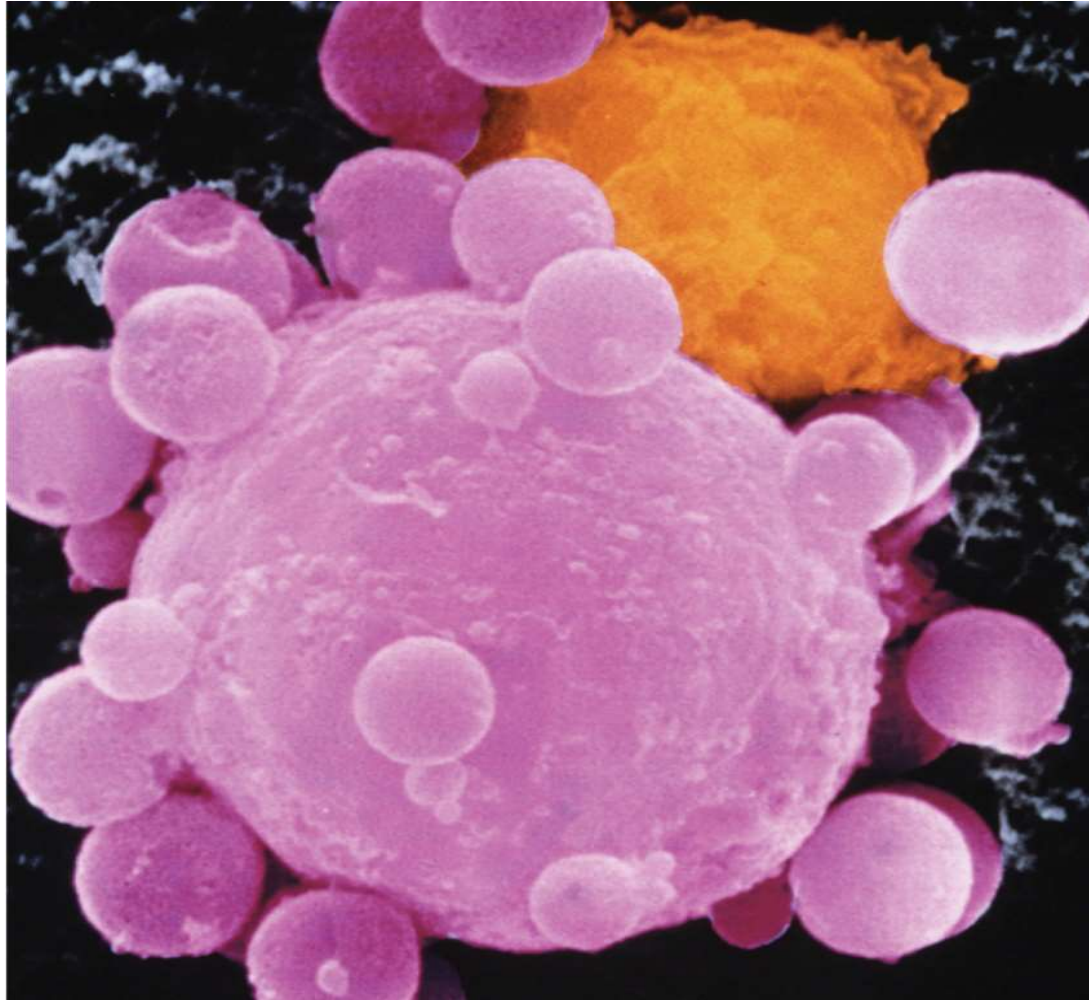


Chapter 5.2

The Four Tissue Types



What is Histology?



Histology is the study of **microscopic anatomy**. (See Interpreting Sections C5.1)

Hierarchy of Human Body

> atoms - molecules - organelles - cells - **tissues** - organs - systems

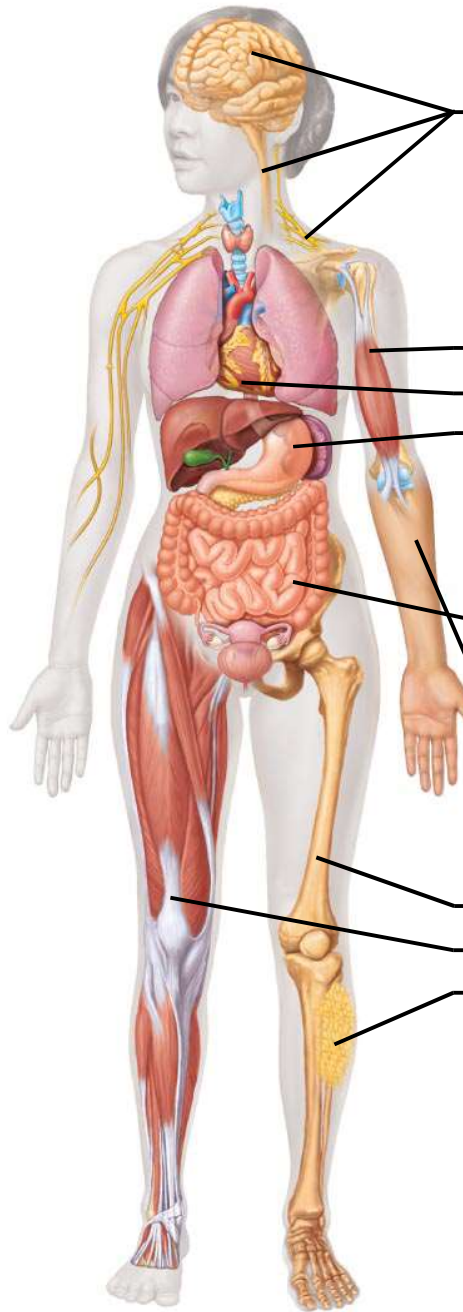
What is tissue?

- a group of similar cells
- arise from the same region of the embryo
- a tissue type has cells with similar structure and function
- different tissue types work together to perform a specific physiological function within an organ.

What are the four tissue types?

> ***epithelial / muscle / nervous / connective***

What are the four tissue types?



Nervous tissue: Internal communication

- Brain
- Spinal cord
- Nerves

Muscle tissue: Contracts to cause movement

- Muscles attached to bones (skeletal)
- Muscles of heart (cardiac)
- Muscles of walls of hollow organs (smooth)

Epithelial tissue: Forms boundaries between different environments, protects, secretes, absorbs, filters

- Lining of digestive tract organs and other hollow organs
- Skin surface (epidermis)

Connective tissue: Supports, protects, binds other tissues together

- Bones
- Tendons
- Fat and other soft padding tissue
- Blood
- Fat

The Four Tissue Types



- Epithelial (forms the coverings and linings of the body)
- Muscle (excitable tissue & able to shorten /// types = skeletal / smooth / cardiac)
- Connective tissue (most abundant & varied tissue type // forms structure for organs and holds things together)
 - Fibrous loose (areolar and reticular)
 - Fibrous dense (regular or irregular)
 - Fibroblasts – cell type
 - Adipose – cell type
 - Bone – a connective tissue type
 - Blood – a connective tissue type
 - Cartilage (hyaline / elastic / fibrous)
- Nervous (excitable tissue & voluntary or involuntary electrochemical communication)

Histology of muscle tissue in Chapter 11 and the histology of nervous tissue in Chapter 12. Blood is covered in Chapter 18.

Cells vs Matrix



The four primary tissues **differ from one another** by cellular functions and the form of their matrix

- the type of the matrix (material made by cells and secreted outside of the cell's plasma membrane) will determine the characteristic of the tissue. // e.g. hard bone or liquid blood
- The ratio between cell and matrix volumes helps to define the tissue type

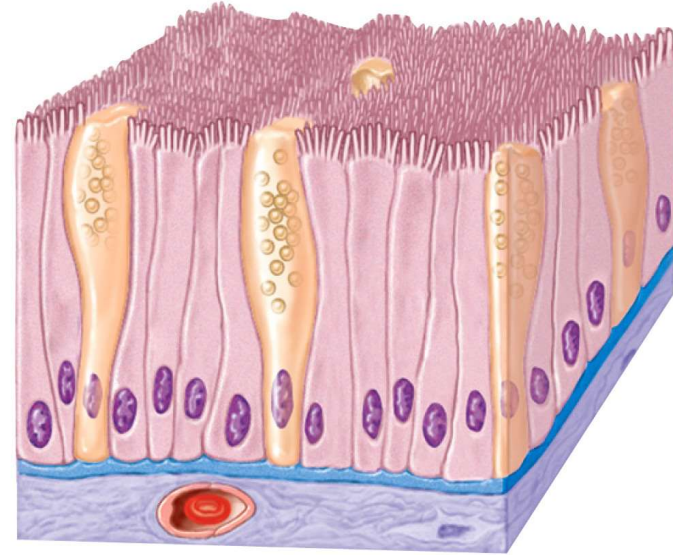
Much of the matrix in tissue is composed of “hydrated” fibrous proteins /// clear gel substance (**eg. hyaluronic acid = the “glue” that holds cells together**)

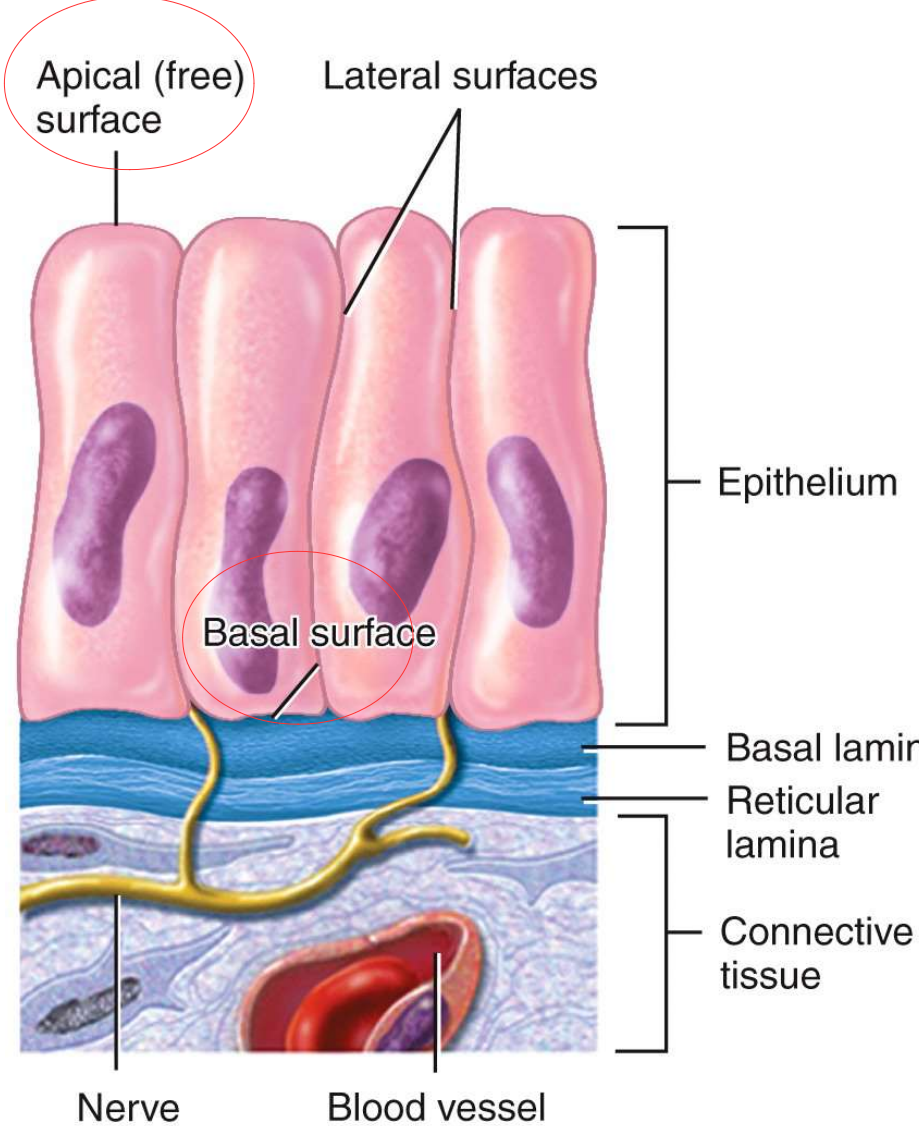
- Matrix also called:
 - ground substance
 - tissue fluid
 - extracellular fluid (ECF)
 - interstitial fluid
 - tissue gel

Epithelial Tissue



- consists of a flat sheet of closely adhering cells
- one or more cells thick (simple vs stratified)
- “free surface” / upper surface usually exposed to the environment or an internal space in the body = apical
- sits on basement membrane = basal surface
- covers body surfaces or lines body cavities
- forms the external and internal linings of many organs
- make up most glands
- extracellular material is so thin it is not visible with a light microscope
- epithelial is avascular /// tissue allows no room for blood vessels = avascular
- **loose connective tissue** under basement membrane provide blood vessels for nutrient procurement and waste removal





Basal lamina / produced by epithelial cells ★

Reticular lamina / produced by fibroblast

Basement membrane ★

Note: in diabetes mellitus / basement membrane thickens – this reduces diffusion between dermis and epithelium // lack of nutrients and build-up of metabolic waste products eventually causes cell death in tissues like the eye (blindness) and kidneys (renal failure)

Basement Membrane of Epithelial Tissue

- **Basement membrane** – matrix layer between epithelial tissue and the underlying connective tissue
 - basement membrane contains: **collagen** // **laminin** and **fibronectin** adhesive // glycoproteins // **heparin sulfate** - large protein-carbohydrate complex
 - anchors the epithelium to the connective tissue below it
- **Epithelial tissue has two “sides”**
 - **basal surface** – surface of an epithelial cell that faces the basement membrane
 - **apical surface** – surface of an epithelial cell that faces away from the basement membrane

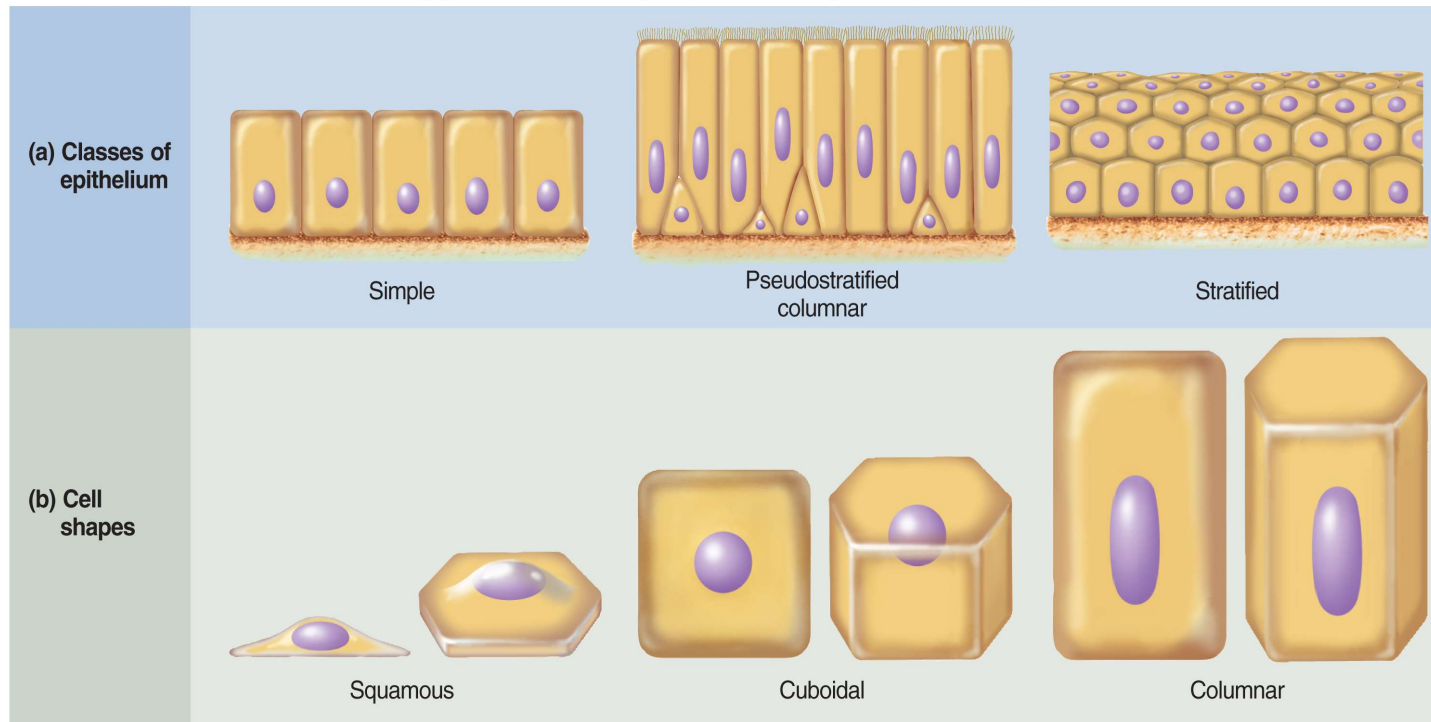
Epithelial Tissue Defined By Layers of Cells

- **Simple epithelium**
 - contains one layer of cells
 - all cells touch the basement membrane
- **Stratified epithelium**
 - contains more than one layer
 - named by shape of apical cells
 - some cells rest on top of others and they do not touch basement membrane

Epithelial Tissue Defined

Shape of Cells

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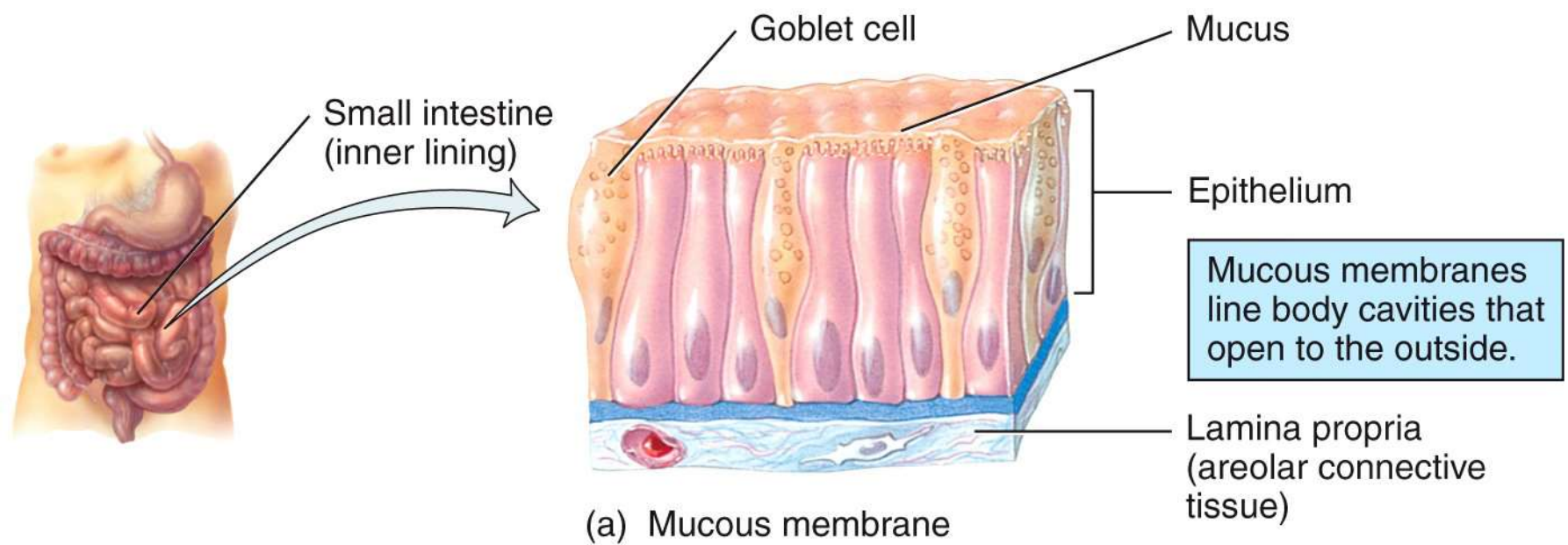
Terms combined to name tissue. (e.g. simple cuboidal)

Simple Epithelia

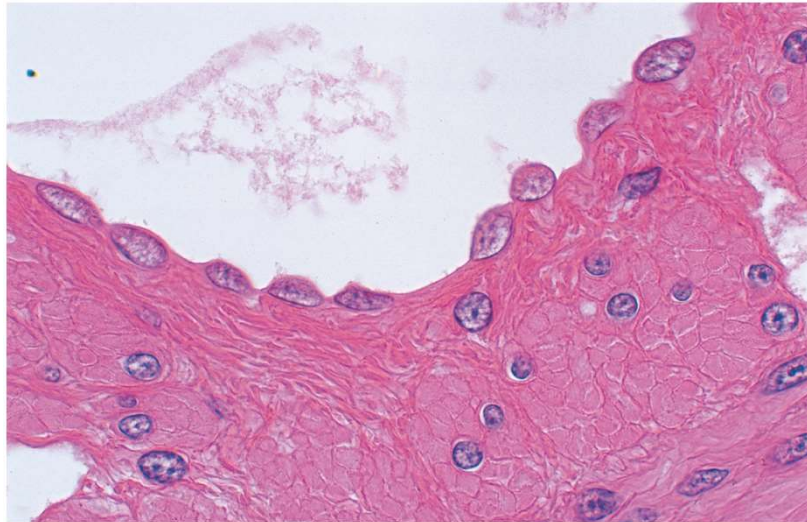
- four types of simple epithelia
- three named for their cell shapes
 - simple squamous (thin scaly cells)
 - simple cuboidal (square or round cells)
 - simple columnar (tall narrow cells)
- fourth type // pseudostratified columnar
 - not all cells reach the free surface
 - shorter cells are covered over by taller ones
 - looks stratified
 - every cell reaches the basement membrane



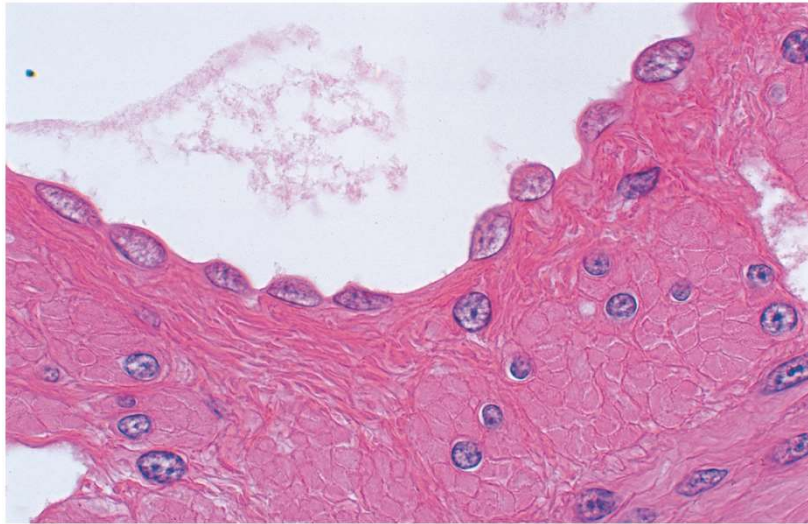
What is a goblet cell? – unicellular gland /// wineglass-shaped mucus secreting cells found in simple columnar and pseudostratified epithelia



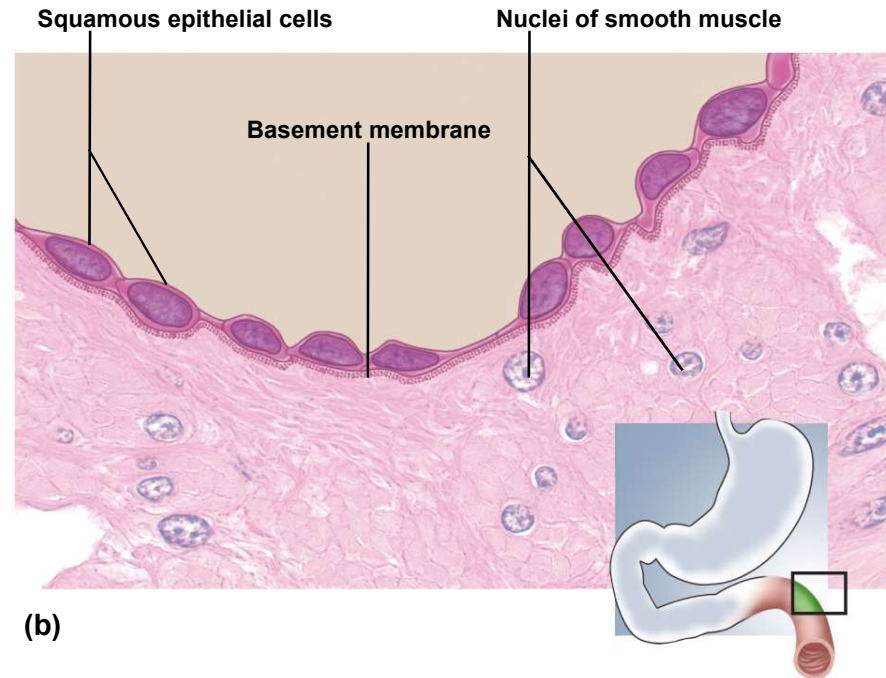
Slide Review of Different Epithelial Tissues



Simple Squamous Epithelium



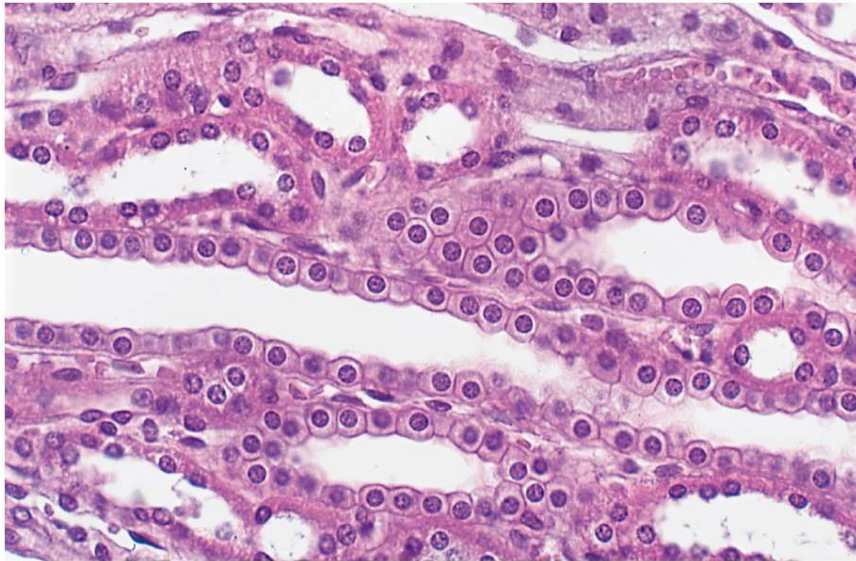
(a)



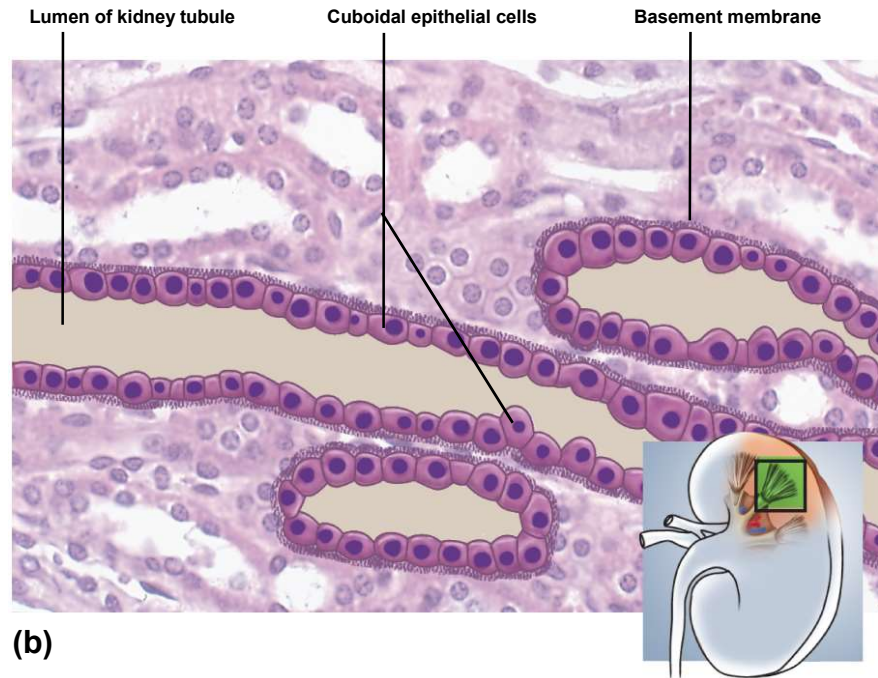
(b)

- single row of thin cells
- permits rapid diffusion or transport of substances
- secretes serous fluid
- alveoli, glomeruli, **endothelium, and serosa**

Simple Cuboidal Epithelium



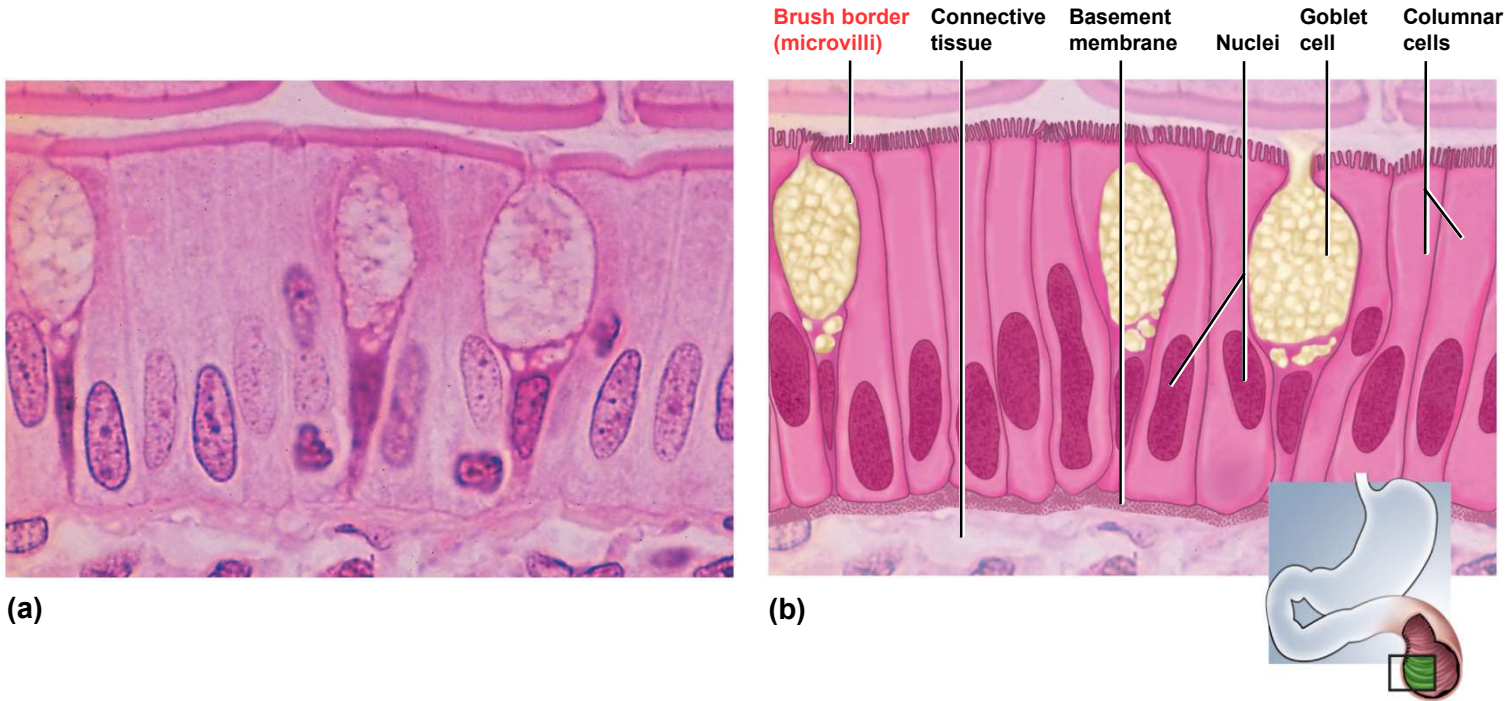
(a)



(b)

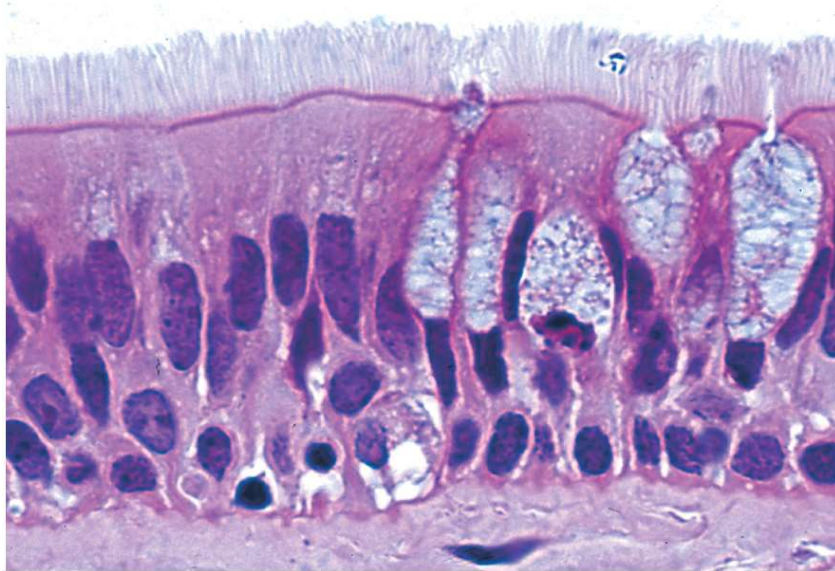
- single layer of square or round cells
- absorption and secretion, mucus production and movement
- liver, thyroid, mammary and salivary glands, **bronchioles**, and **kidney tubules**

Simple Columnar Epithelium

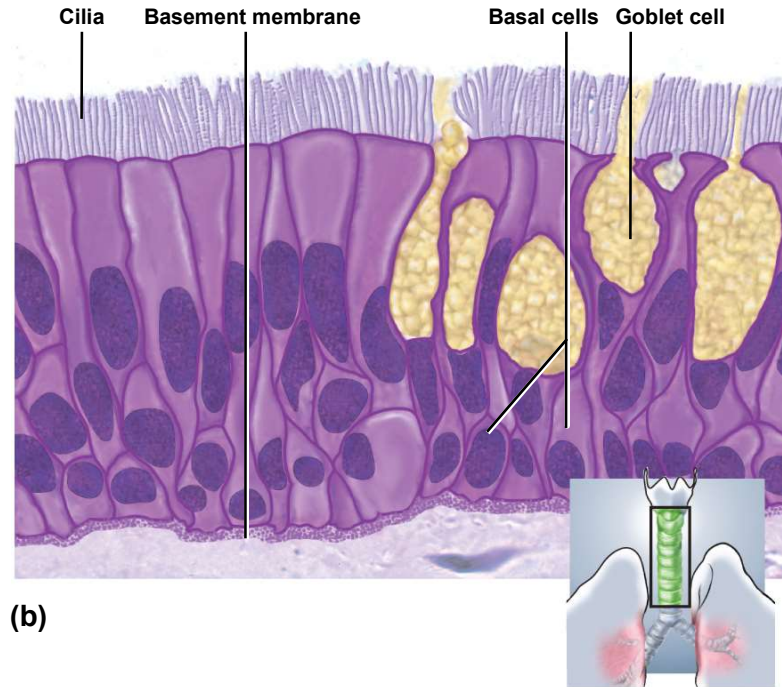


- single row tall, narrow cells
 - oval nuclei in basal half of cell
 - brush border of microvilli, ciliated in some organs, may possess goblet cells
- absorption and secretion; mucus secretion
- **lining of GI tract**, uterus, kidney and uterine tubes

Pseudostratified Epithelium



(a)



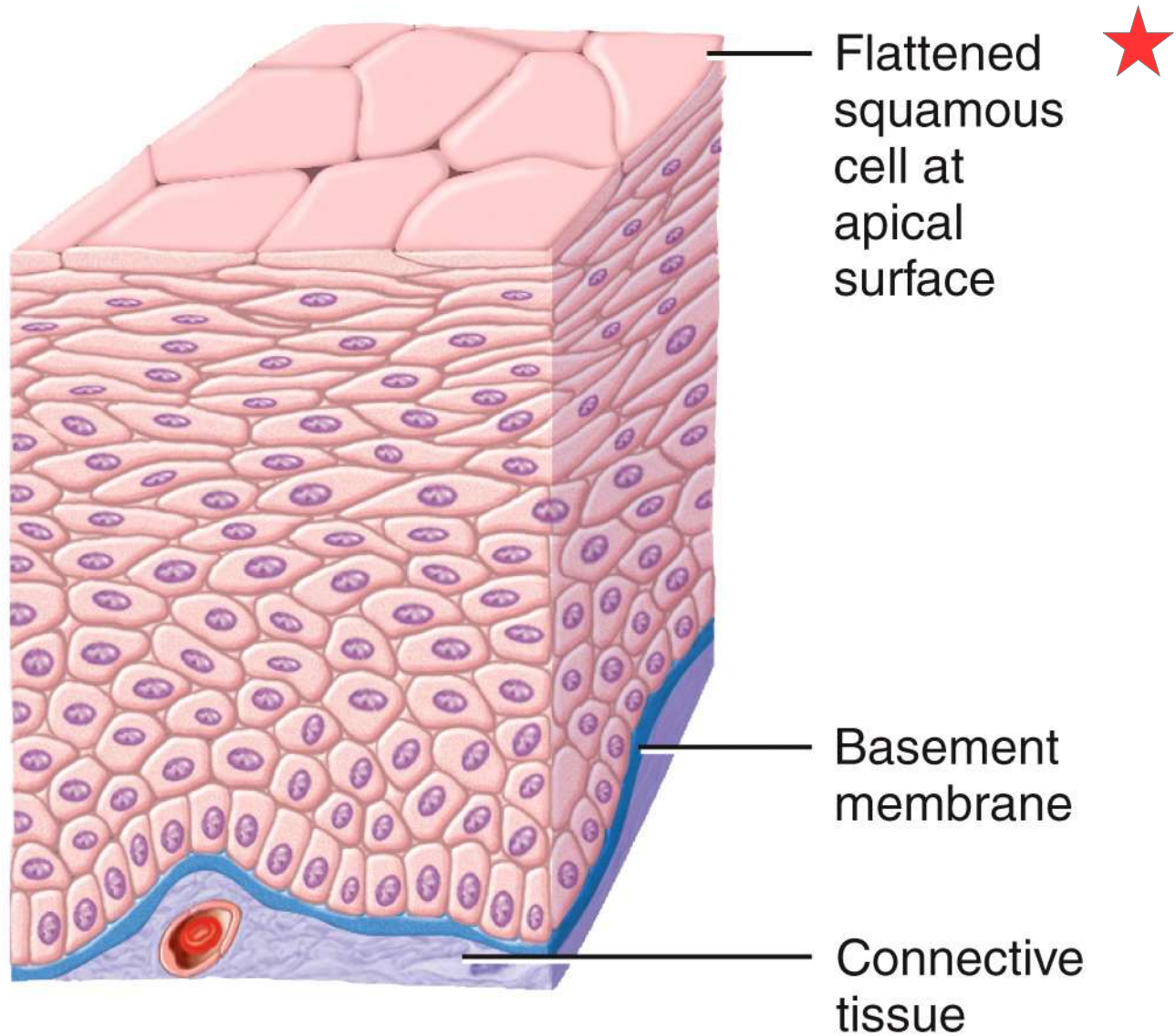
(b)

- looks multilayered; some not reaching free surface; all touch basement membrane
 - nuclei at several layers
 - with cilia and goblet cells
- secretes and propels mucus
- **respiratory tract** and portions of male urethra

Stratified Epithelia



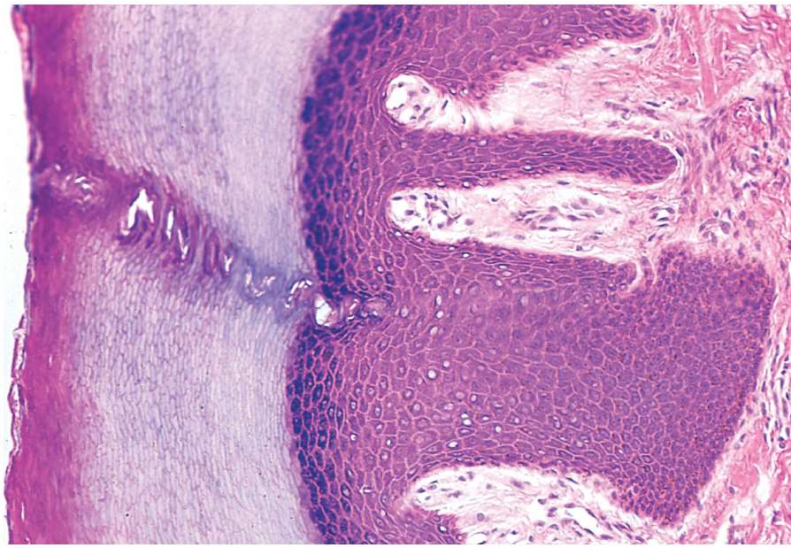
- range from 2 to 20 or more layers of cells
- cells resting directly on other cells
- only the deepest layer attaches to the basement membrane
- three stratified epithelia are named for the shapes of their surface cells
 - stratified squamous
 - stratified cuboidal
 - stratified columnar (rare)
- fourth type
 - transitional epithelium
- most widespread epithelium in the body
- deepest layers undergo continuous mitosis
 - their daughter cells push toward the surface and become flatter as they migrate farther 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 (e.g. lining of mouth and vagina)



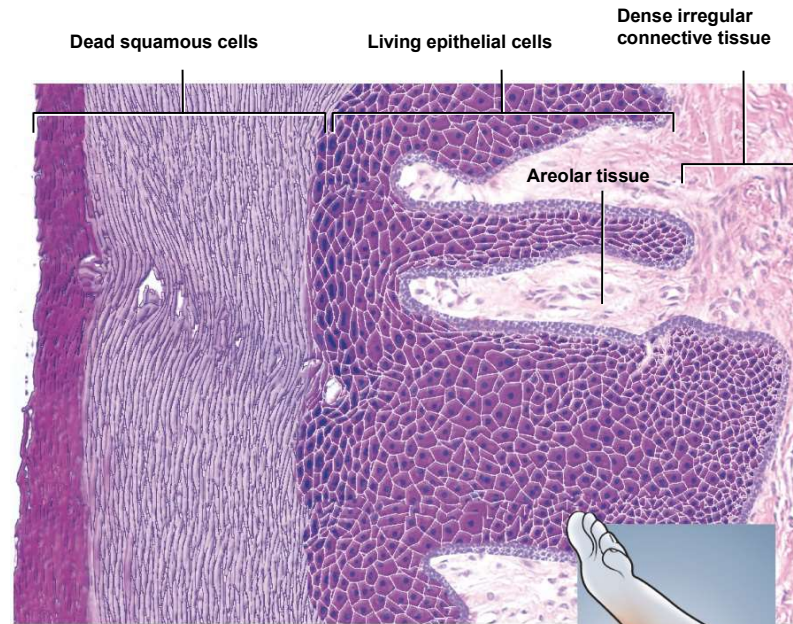
Nonkeratinized stratified squamous epithelium

e.g. lining of the bucal cavity

Keratinized Stratified Squamous



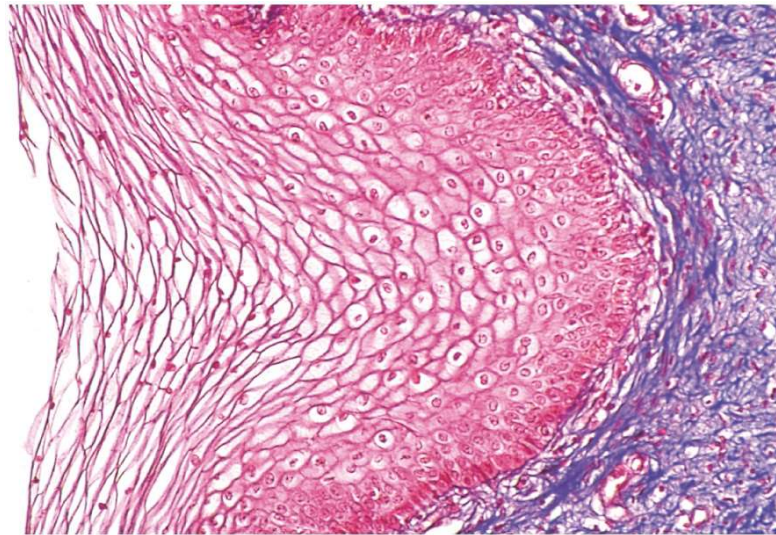
(a)



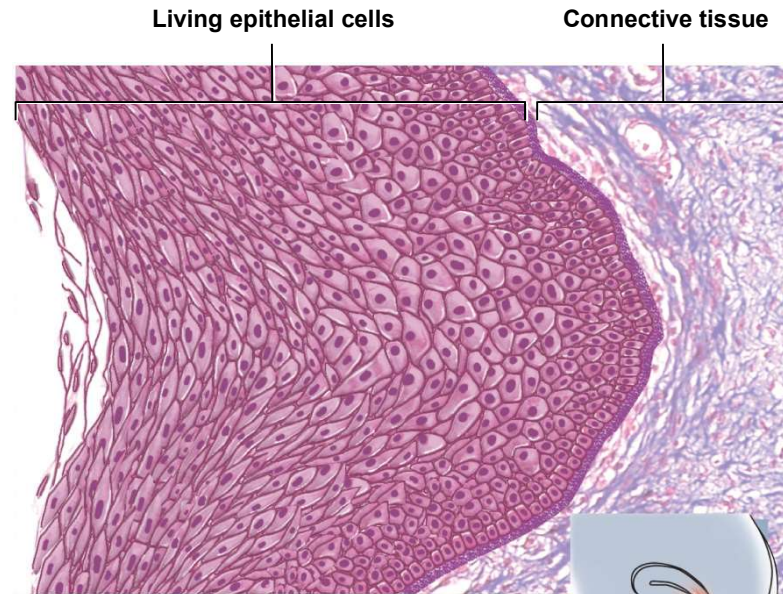
(b)

- multiple cell layers with cells becoming flat and scaly toward surface
- epidermis; palms and soles heavily keratinized
- resists abrasion; retards water loss through skin; resists penetration by pathogenic organisms
- **Cutaneous membrane (i.e. skin)**

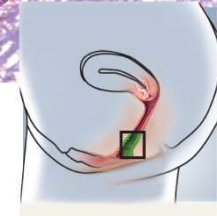
Nonkeratinized Stratified Squamous



(a)

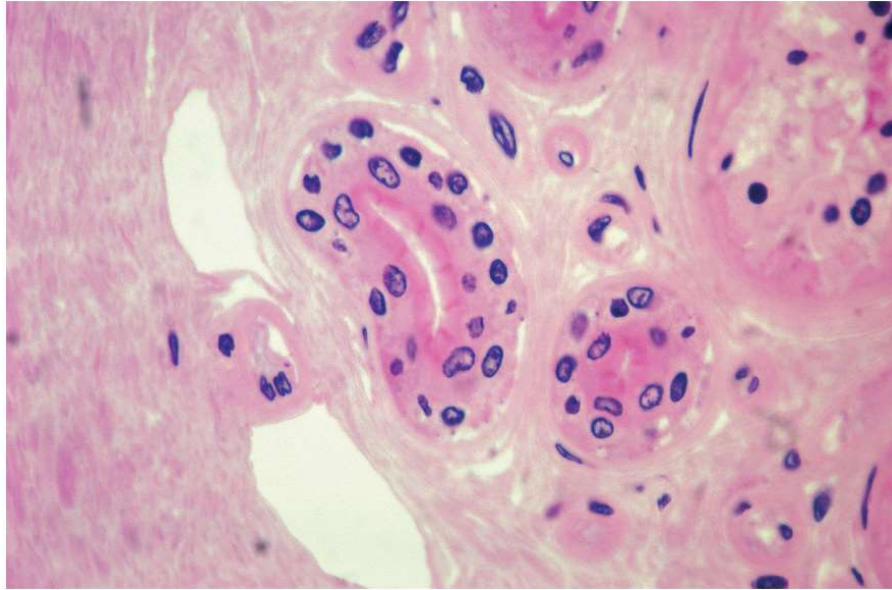


(b)

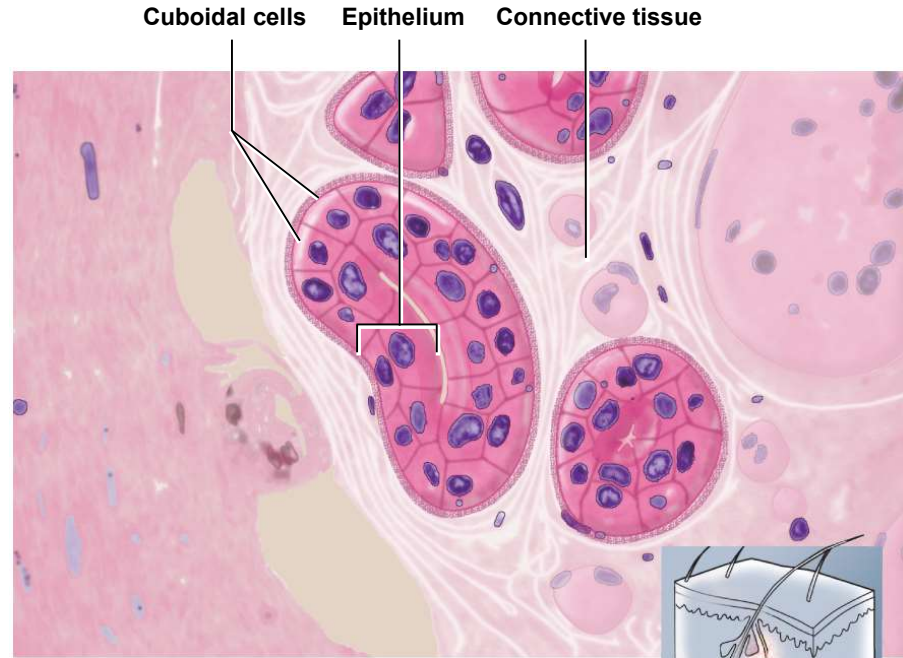


- same as keratinized epithelium without the surface layer of dead cells
- tongue, oral mucosa, esophagus and vagina
- resists abrasion and penetration of pathogens
- **adult vagina, oral cavity, esophagus**
- **note: prior to puberty lining of vagina is simple nonkeratinized epithelium**

Stratified Cuboidal Epithelium



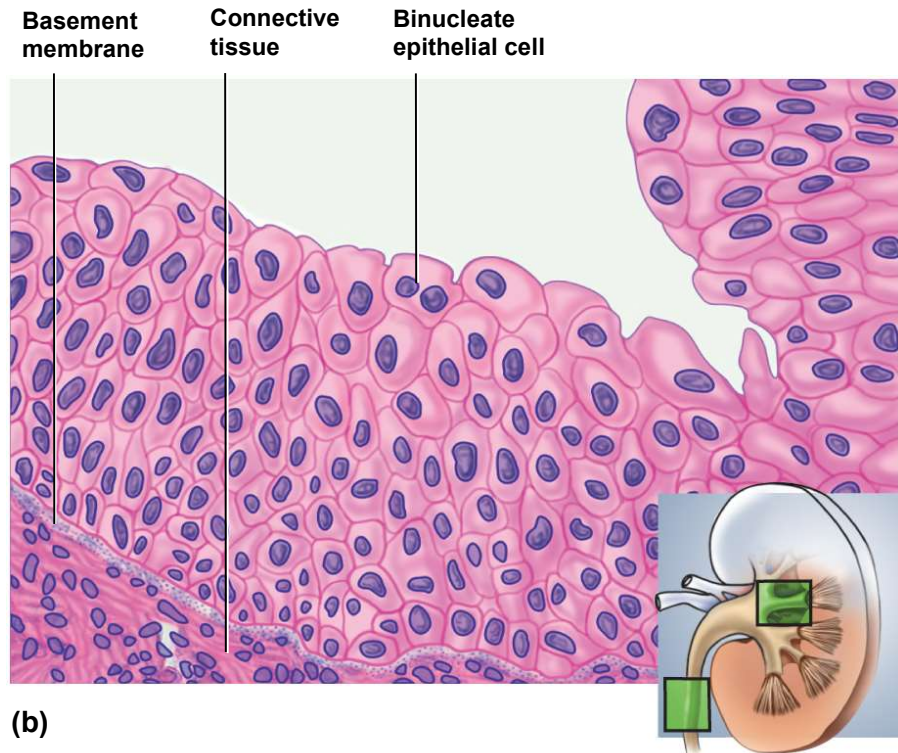
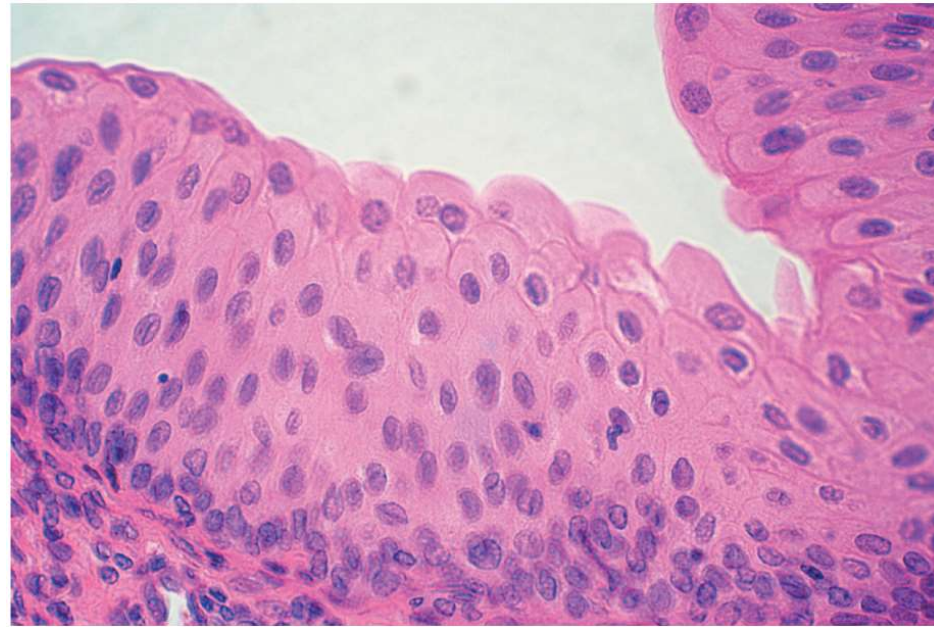
(a)



(b)

- two or more cell layers; surface cells square or round
- secretes sweat; sperm production and produces ovarian hormones
- **sweat gland ducts**; ovarian follicles and seminiferous tubules

Transitional Epithelium

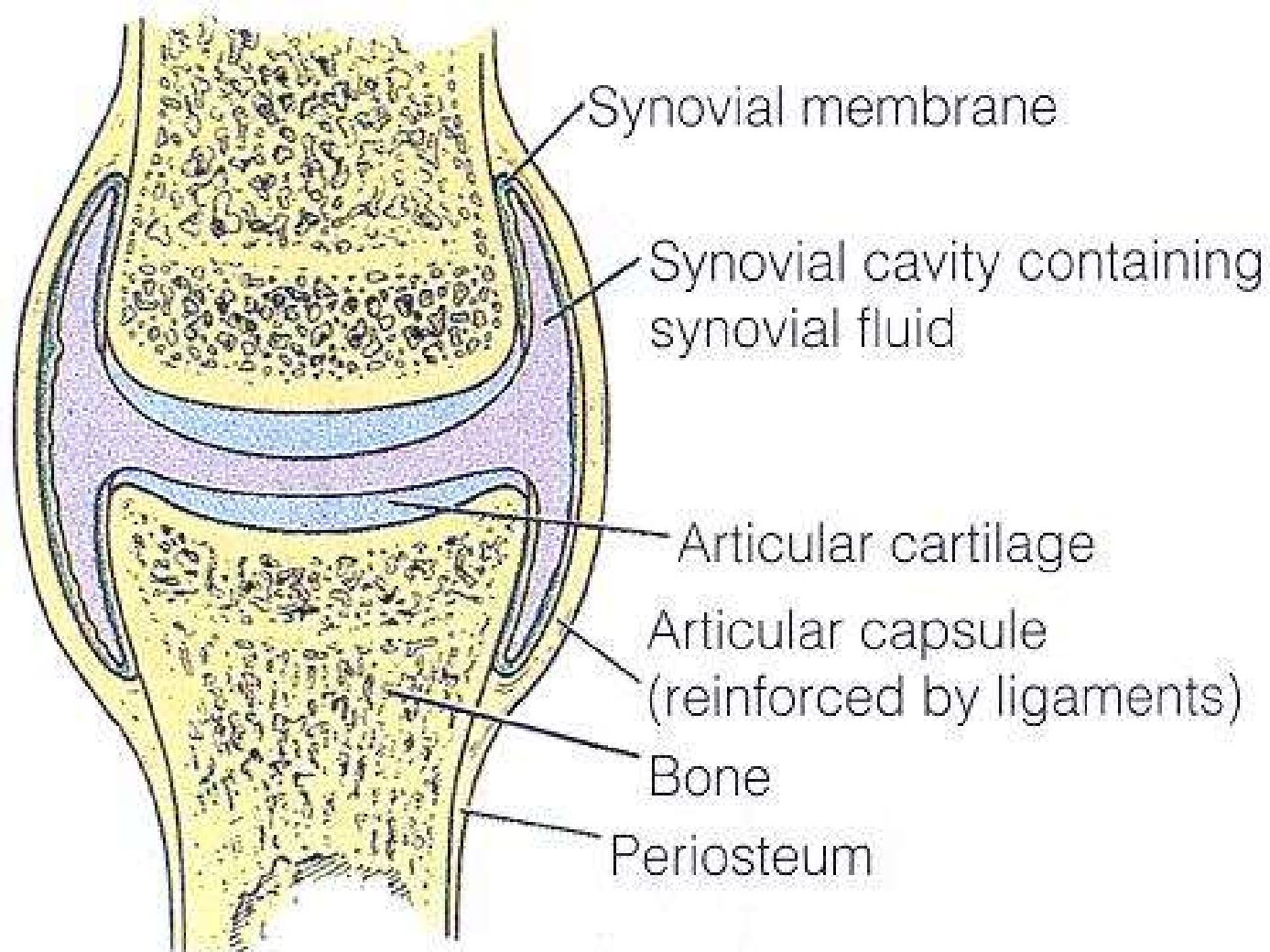


- multilayered epithelium surface cells that change from round to flat when stretched
- allows for filling of urinary tract
- **ureter and bladder**

Epithelial Cells Form Membranes

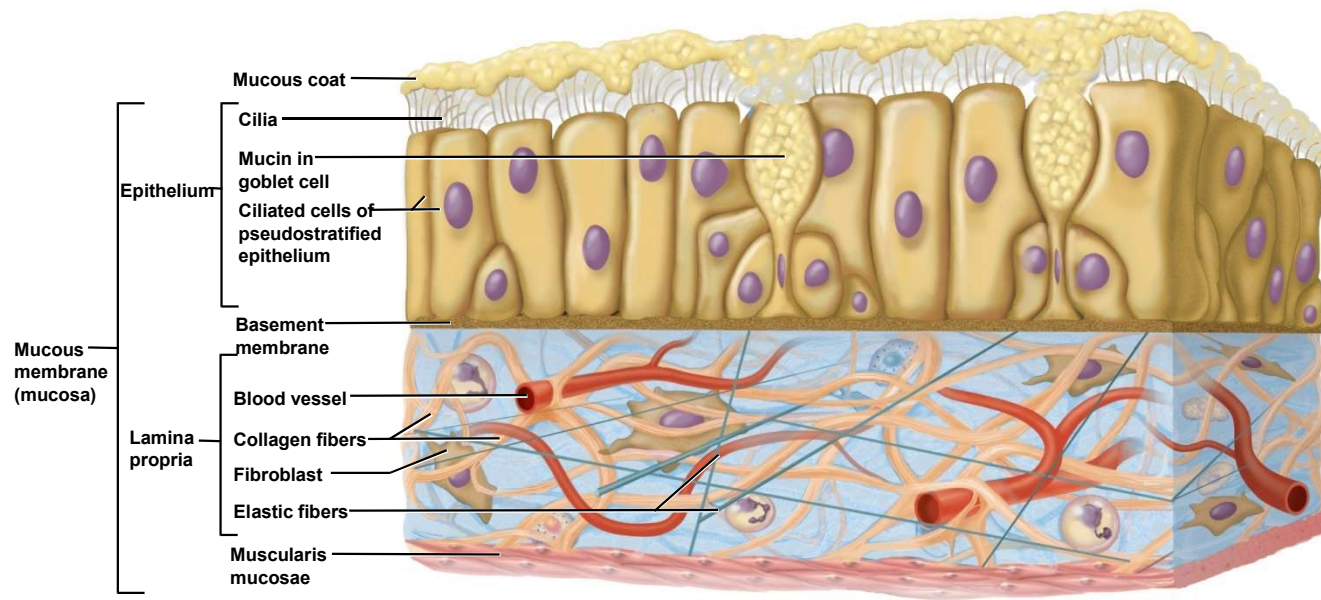


- These membranes cover body surfaces, line body surfaces and cavities, and cover the viscera (organs)
- Four Type
 - **cutaneous membrane** (covered in Chapter 6)
 - **serous membrane** (serosa)
 - **mucous membrane** (mucosa)
 - **synovial membrane** (not a true epithelial cell line)



General structure of a synovial joint.

- Synovial membrane - lines joint cavities
- secretes synovial fluid
- cells which form this membrane are not epithelial but connective tissue cells



- **Mucous Membranes (The Mucosa)**

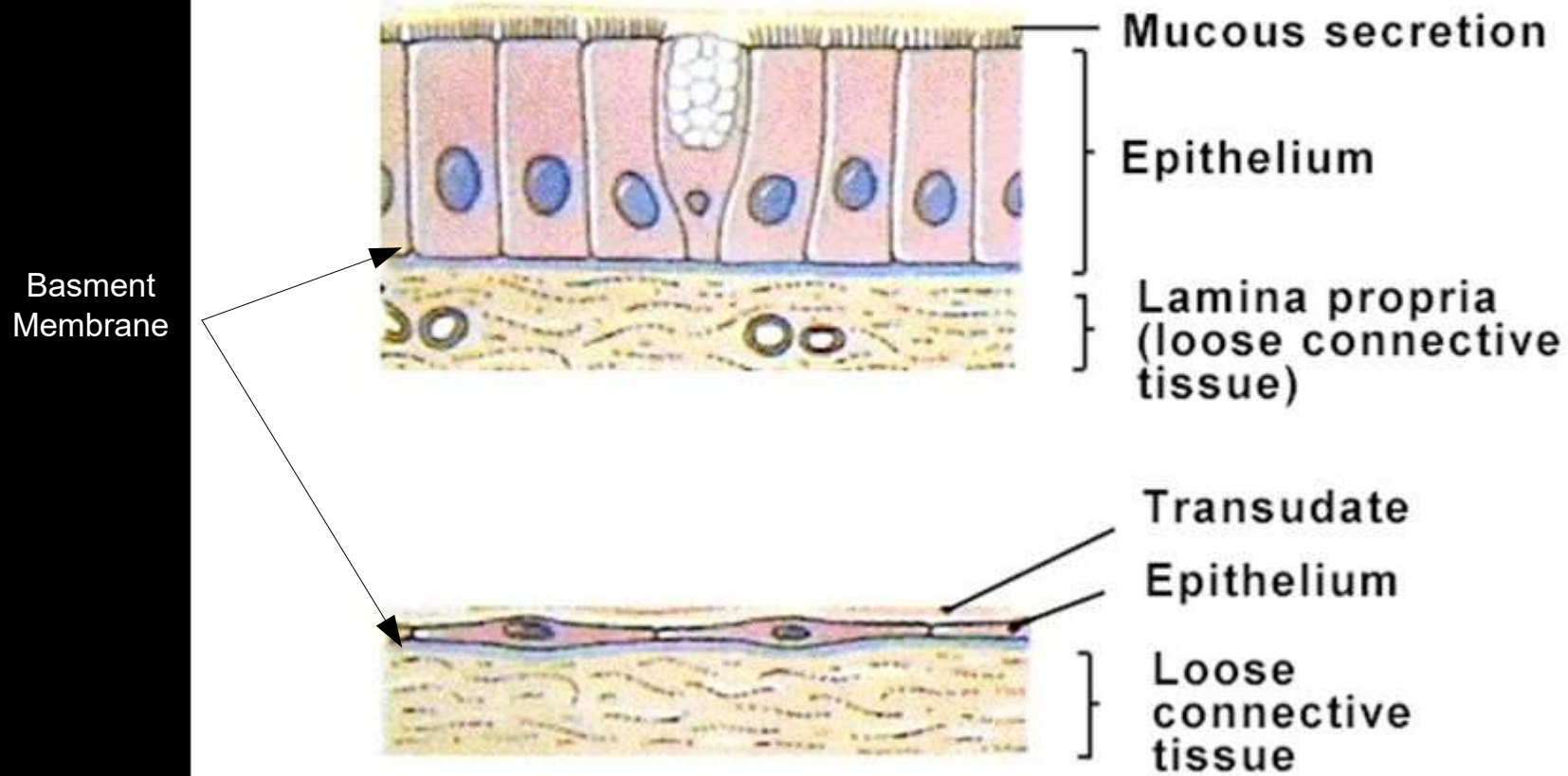
- lines passages that open to the external environment
- digestive, respiratory, urinary, and reproductive tracts
- consists of three layers:
 - **epithelium**
 - **lamina propria** – areolar connective tissue
 - **muscularis mucosae** – smooth muscle layer
- absorptive, secretory, and protective functions
- covered with mucus

Serous Membranes



- Serous membrane (serosa) - internal membrane
 - simple squamous epithelium over areolar tissue
 - produces serous fluid that arises from blood
 - covers organs and lines walls of body cavities
 - endothelium lines blood vessels and heart
 - mesothelium line body cavities (pericardium, peritoneum and pleura)

Mucous vs. Serous Membrane





Different Types of Epithelial Glands

- **Endocrine vs exocrine**
- **Unicellular vs multicellular**

Glands



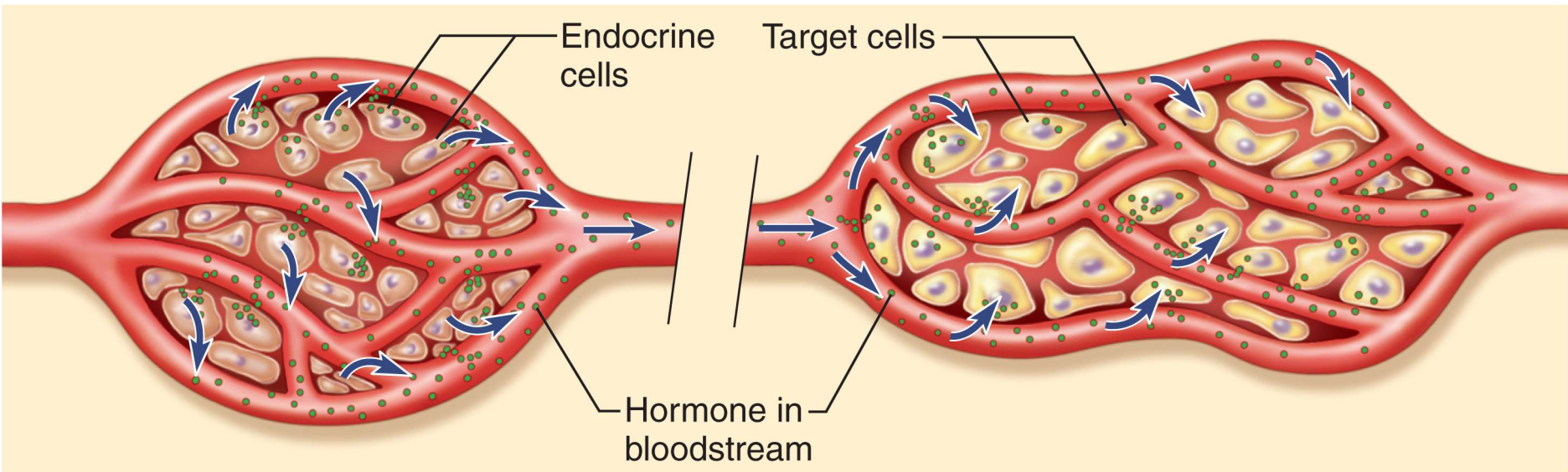
- What is a gland?
 - A gland may be a single cell or a group of cells
 - Glands releases substance onto a free surface (i.e. exocrine) or into the blood (i.e. endocrine)
 - commonly composed of epithelial tissue in a connective tissue framework and/or capsule
- Some organs have both endocrine and exocrine function // e.g. = liver, gonads, pancreas

Glands



-
- **exocrine glands** – cell's secretion delivered to surface by way of a **duct** /// e.g. sweat glands, salivary glands, mammary gland, and tear glands // also called **merocrine glands**
 - **endocrine glands** - secretory product is a molecule which is released into the blood
 - Cell's secretory product called **hormones** = messenger molecule
 - secrete (hormones) directly into blood
 - e.g. thyroid, adrenal and pituitary glands
 - **unicellular glands** – found in epithelium that is predominantly non-secretory tissue
 - can be endocrine or exocrine
 - mucus-secreting goblet or endocrine cells of stomach and small intestine

Structure of Endocrine Glands

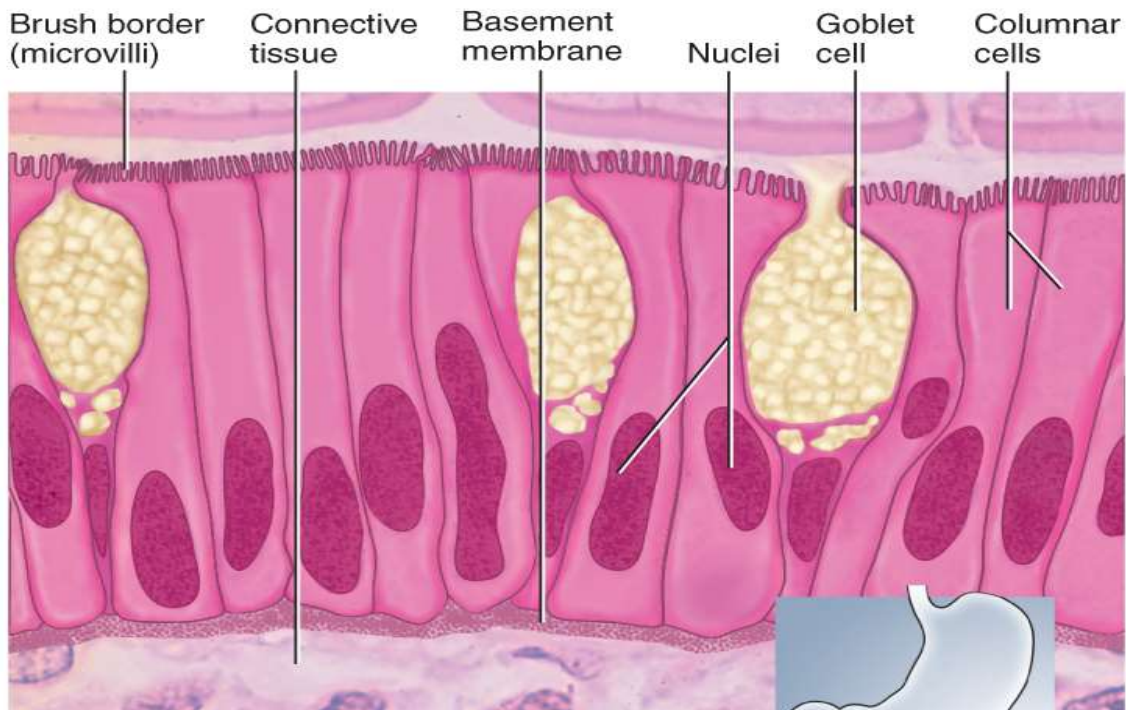


(b) Endocrine system

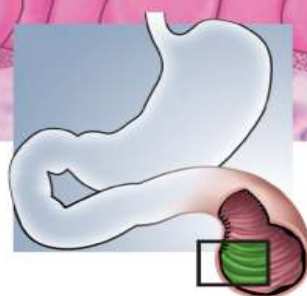
Endocrine glands use hormones, messenger molecules. Secreted into blood by by one group of cells where they travel to another cell with a docking station (receptor) matched to the shape of the hormone. Receptor maybe on plasma membrane or in cytoplasm determined by the hormones chemistry. Hormones change the metabolism of the target tissue (tissue with receptors).



Goblet Cells Are Unicellular Gland

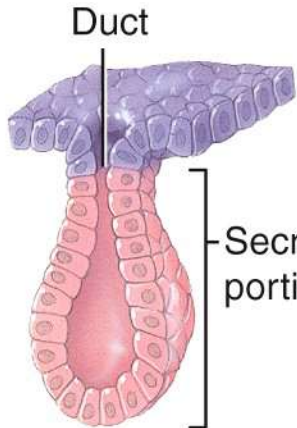


(b)

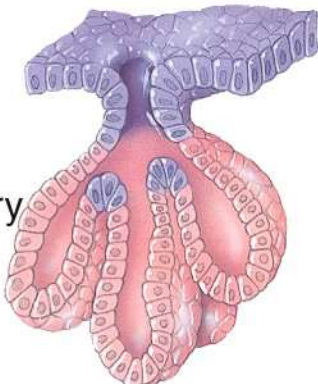


(a) © Lester V. Bergman

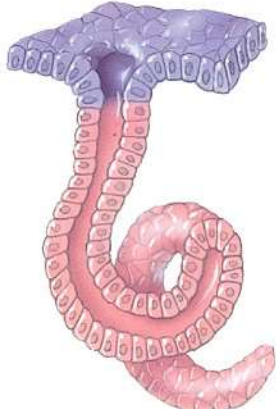
Structural Types of Exocrine Glands



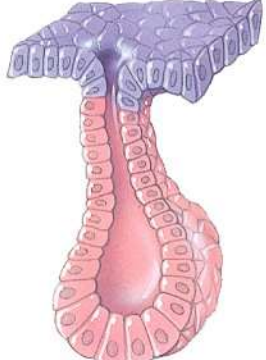
(a) Simple tubular



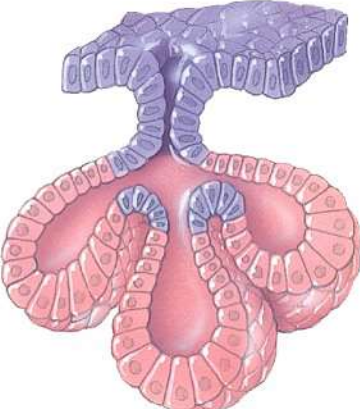
(b) Simple branched tubular



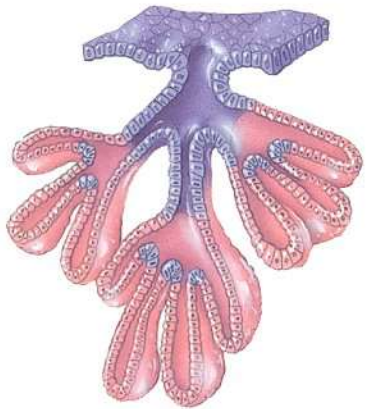
(c) Simple coiled tubular



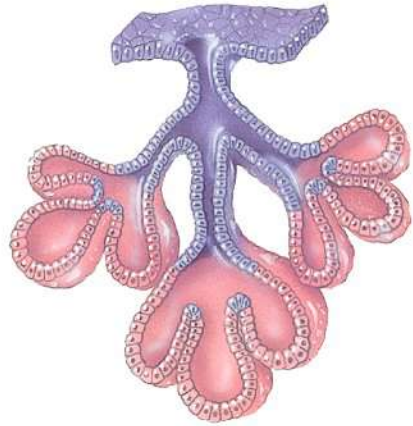
(d) Simple acinar



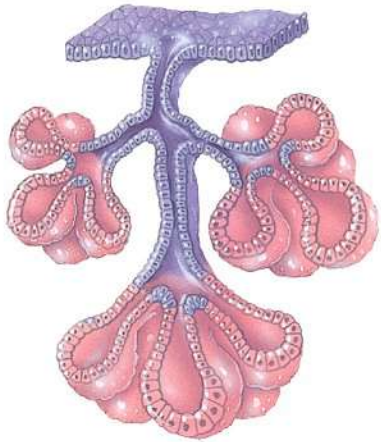
(e) Simple branched acinar



(f) Compound tubular



(g) Compound acinar



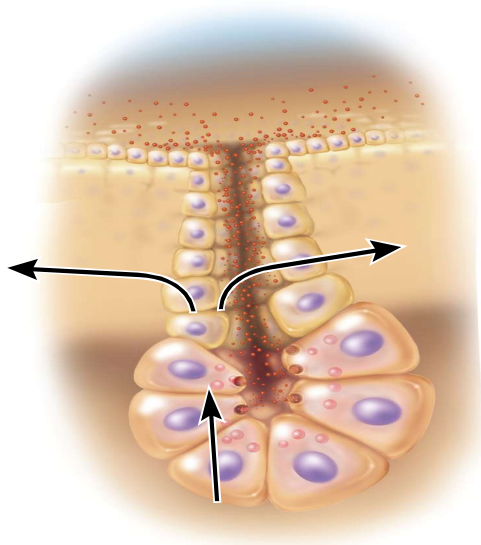
(h) Compound tubuloacinar

Exocrine Gland Secretion Types



- **serous glands** // produce thin, watery secretions /// perspiration, milk, tears and digestive juices
- **mucous glands** /// produce glycoprotein, **mucin**, that absorbs water to form a sticky secretion called **mucus** – e.g. **salivary glands in bucal cavity (mouth)**
- **mixed glands** /// contain both cell types and produce a mixture of the two types of secretions
- **cytogenic glands** // release whole cells, sperm and egg cells

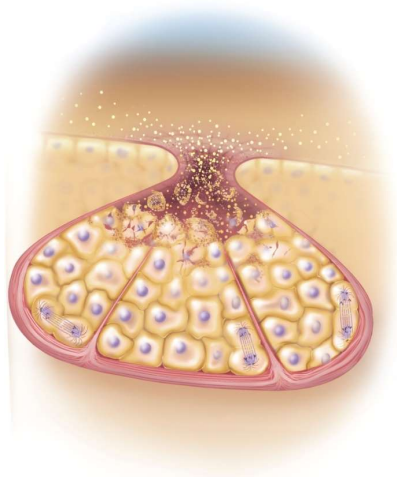
Define Glands by Method of Secretion



- **Merocrine glands**

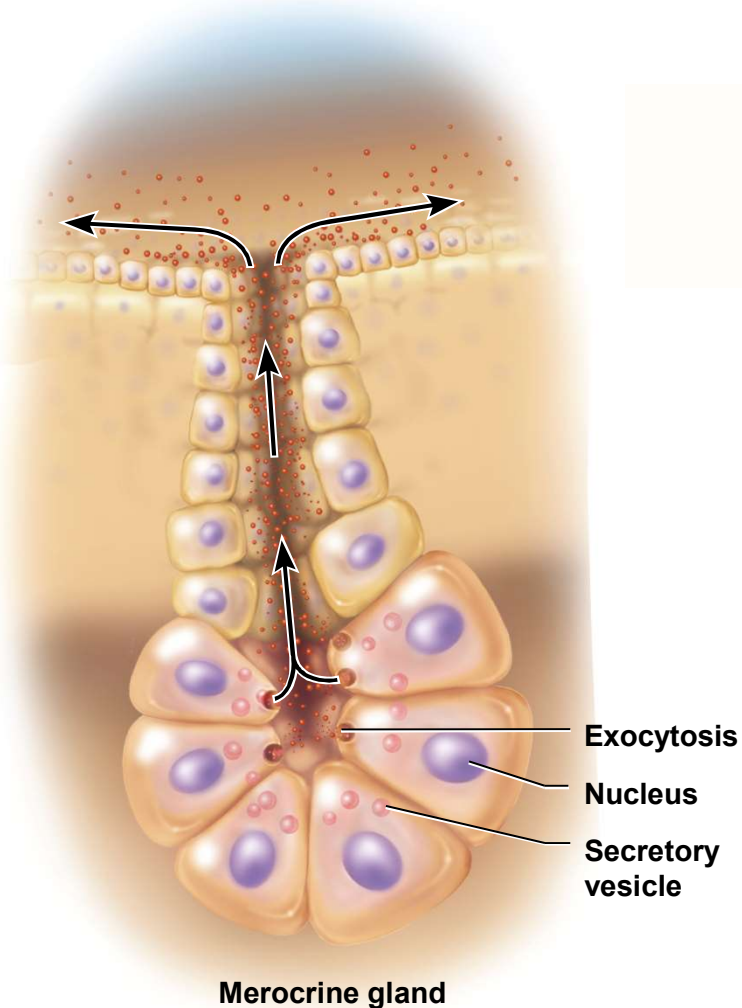
- **Apocrine glands**

- **Holocrine glands**

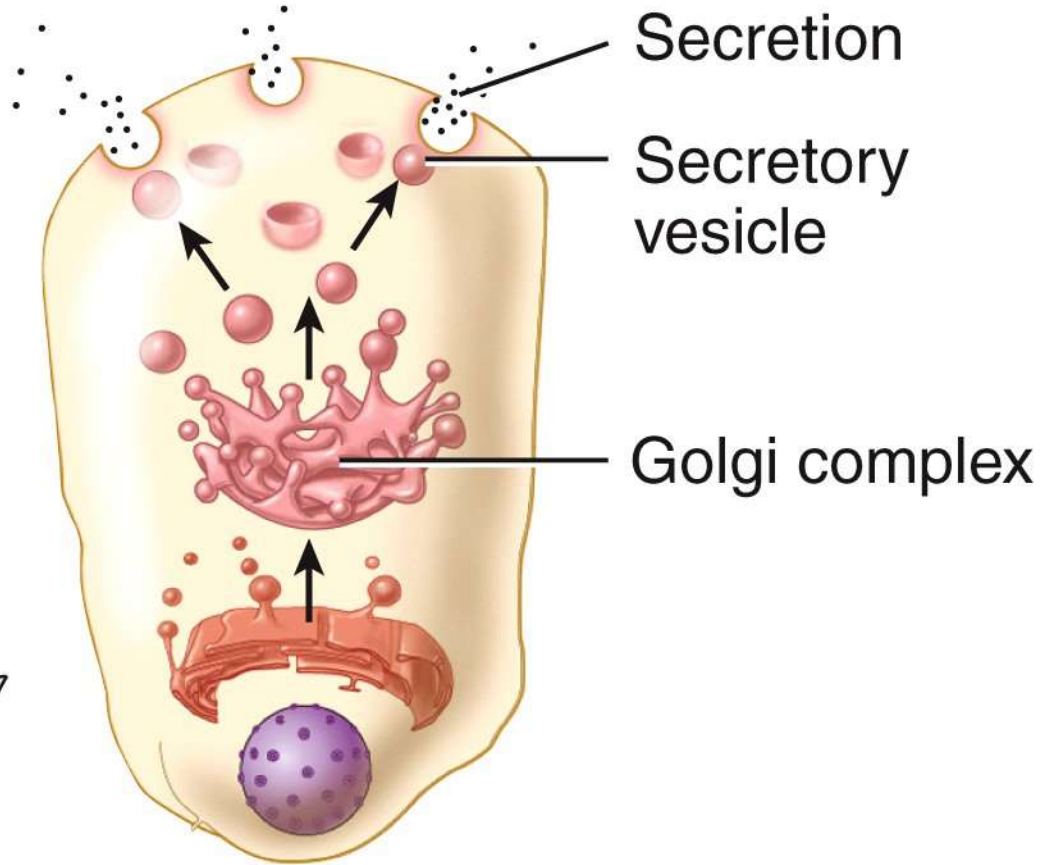
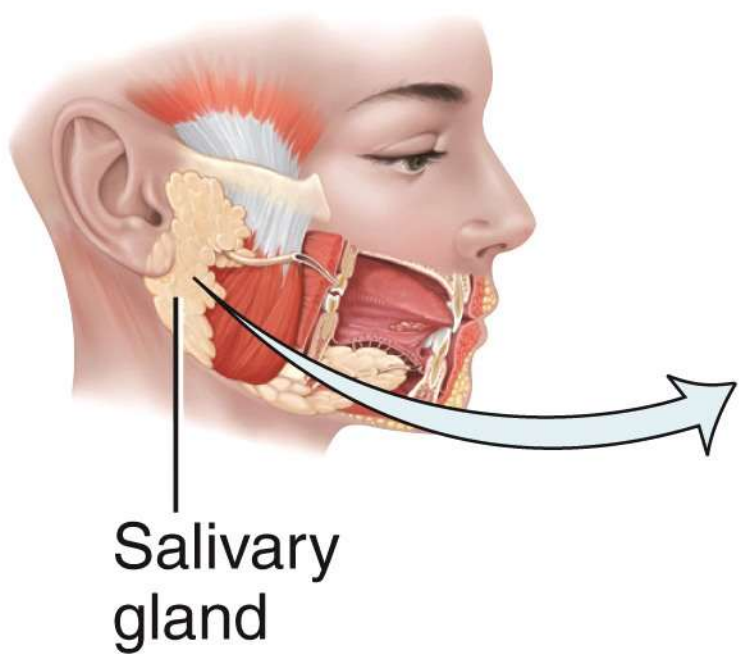


How do these glands release their secretions?

Merocrine Glands



- Merocrine glands (also called exocrine glands)
 - Cell product excreted by exocytosis
 - cells produce secretory products inside vesicles then release vesicles by exocytosis
 - e.g tear glands, pancreas, gastric glands, salivary glands

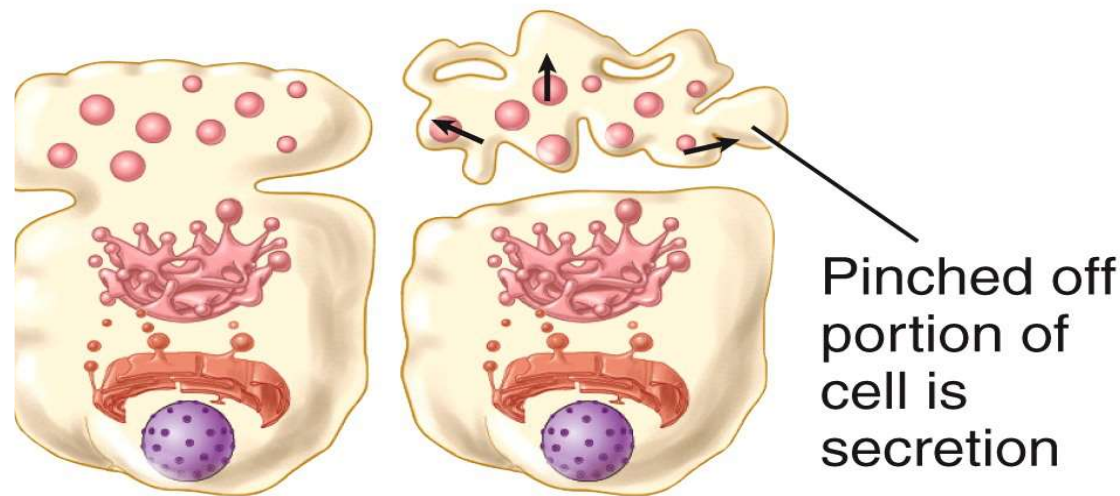


(a) Merocrine secretion

Apocrine glands – pinches off part of the cells cytoplasm to release secretion



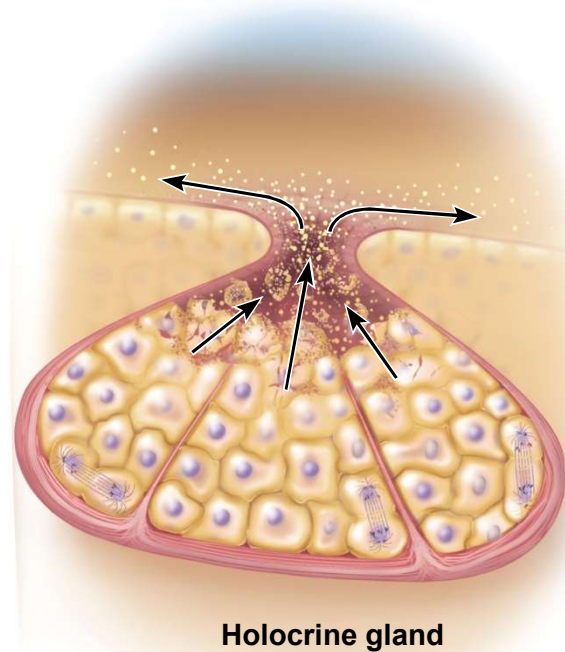
- some “types of apocrine glands” only become active during adolescence
- these apocrine glands produce scent molecules
- located in axillary, genital, beards of male, areola of females
- note: mammary gland also release secretory products as an apocrine secretion



(b) Apocrine secretion

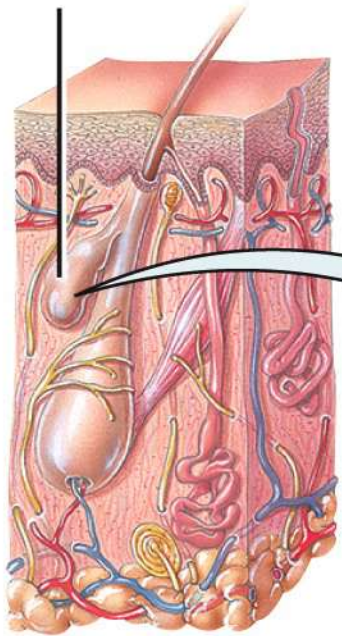


Holocrine Glands

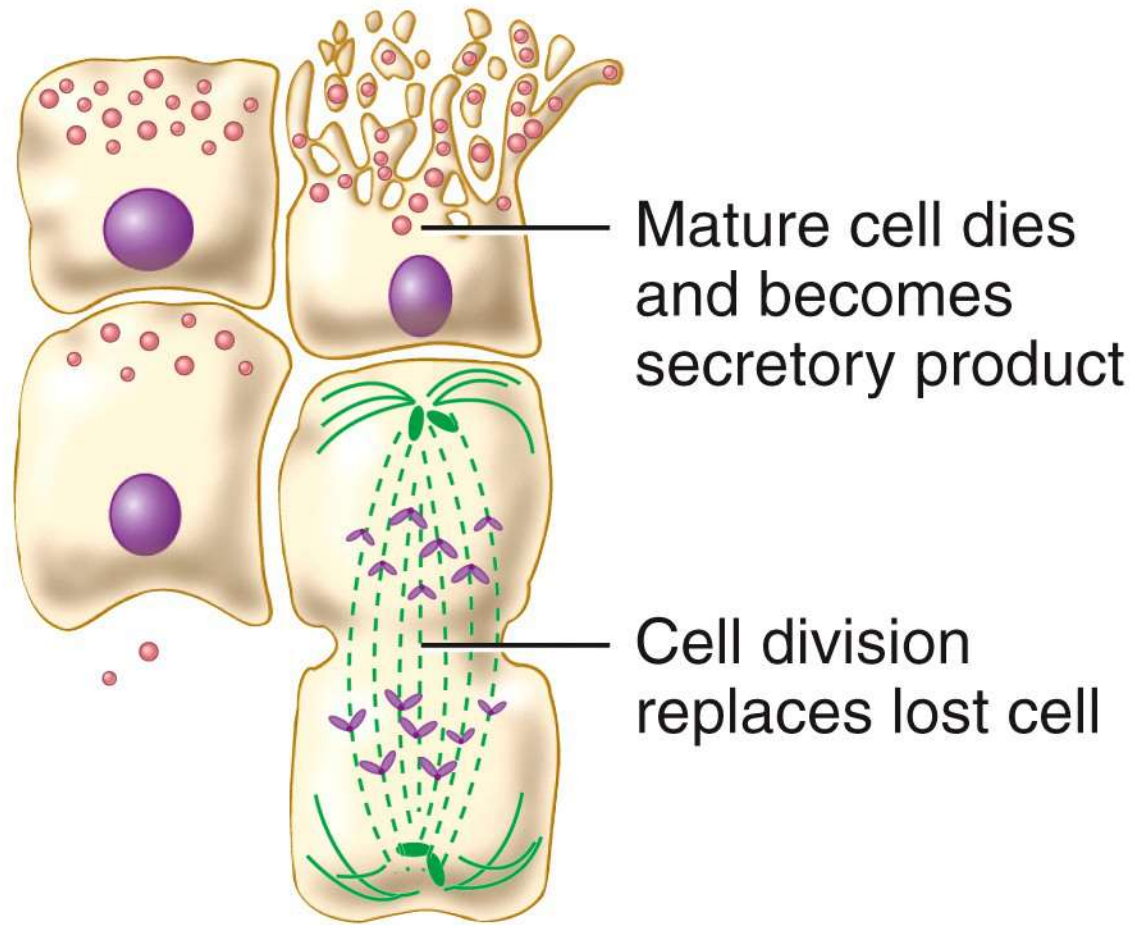


- Cells accumulate a product and then the entire cell disintegrates
 - secretion a mixture of cell fragments and synthesized substance
 - oil glands of scalp, glands of eyelids

Sebaceous
(oil) gland



Skin



(c) Holocrine secretion

Connective Tissue Has Many Functions



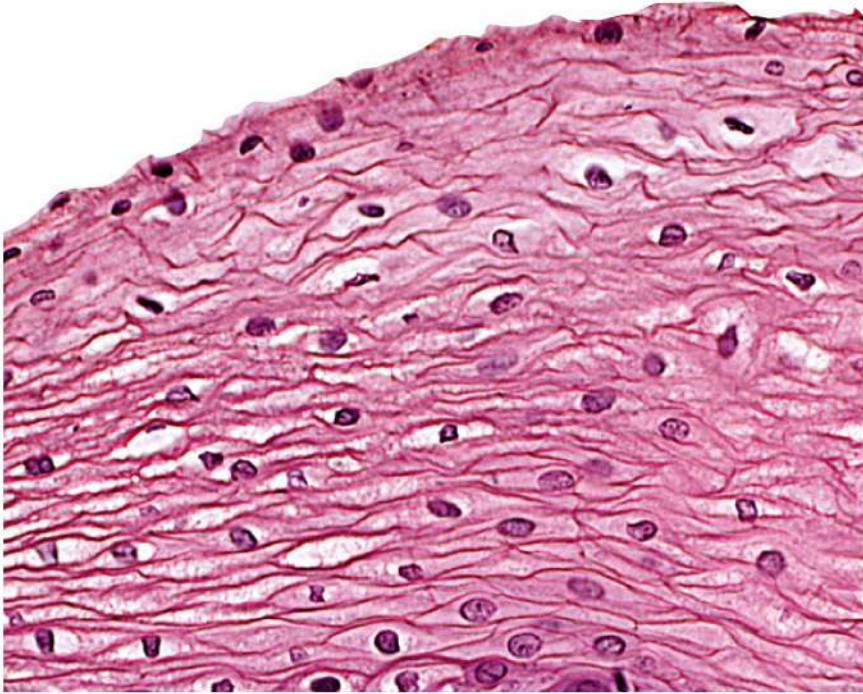
- **binding of organs** – tendons and ligaments
- **support** – bones and cartilage
- **physical protection** – cranium, ribs, sternum
- **immune protection** – white blood cells attack foreign invaders
- **movement** – bones provide lever system
- **storage** – fat, calcium, phosphorus
- **heat production** – metabolism of brown fat in infants
- **transport** - blood

Characteristics of Connective Tissue (Bone, Cartilage, Blood)



- most abundant, widely distributed, and histologically variable of the four tissue types
- connective tissue cells usually occupy less space than the extracellular material
- binds organs to each other // support and protect organs
- most cells of connective tissue are not in direct contact with each other /// cells separated by extracellular material - matrix
- CT is the “highway” used by WBC to transit the human body (endothelial system)
- CT constructed by cells, extracellular fibers, and matrix
- more matrix volume than cellular volume / matrix determines CT characterist

Mark Nielsen



(a) Epithelial tissue with many cells tightly packed together and little to no extracellular matrix



Mark Nielsen

(b) Connective tissue with a few scattered cells surrounded by large amounts of extracellular matrix

Different Types of Connective Tissue Cells



- **fibroblasts** produce different types of extracellular fibers (e.g. collagen, elastic, reticular) and an extracellular substance /// **How does this relate to the fibroblast's genes?**
- **adipocytes** store triglycerides (fat molecules)
- **blood cells = formed elements of blood** (RBC & WBC /// WBC = monocytes, macrophage, lymphocytes – basophils, T cells, B-cells, platelets)
- Note: Blood tissue will be covered in Chapter 19

Connective Tissue Fibers



(Collagen, Reticular, Elastic)

- All three fiber types are polymers of protein /// these are extracellular proteins
- **Collagenous fibers** /// most abundant of the body's proteins – 25%
 - tough, flexible, and resist stretching // if stretched will not return to resting length – like taffy!
 - tendons, ligaments, and deep layer of the skin are mostly collagen
 - less visible in matrix of cartilage and bone
 - white fibers

Connective Tissue Fibers

- **Fiber Type // reticular fibers**
 - thin collagen fibers coated with glycoprotein
 - form framework of such organs as spleen and lymph nodes (the stroma)
 - form walls of blood vessels

Connective Tissue Fibers

- **Fiber Type // elastic fibers**
 - thinner than collagenous fibers
 - branch and rejoin each other
 - made of protein called **elastin**
 - allows stretch and recoil // up to 150% and return to resting length
 - yellow fibers – fresh elastic fibers

The Matrix

- **Ground Substance (part of the matrix / CT fibers embedded in GS)** // usually a gelatinous to rubbery consistency resulting from three classes of large molecules
 - **glycosaminoglycans (GAG)** // long polysaccharide composed of unusual disaccharides called **amino sugars** and **uronic acid**
 - play important role of regulating water and electrolyte balance in the tissues // trap water = hydrated proteins!!!!
 - **chondroitin sulfate** – most abundant GAG
 - in blood vessels and bone
 - responsible for stiffness of cartilage



Ground Substance

- **Hyaluronic acid** – a type of GAG
 - nicknamed - “the glue that holds our cells together”
 - viscous, slippery substance
 - forms an effective lubricant in joints
 - constitutes much of the vitreous body of the eyeball
 - WBC, sperm, and some bacteria produce hyaluronidase = enzyme that breaks down hyaluronic acid

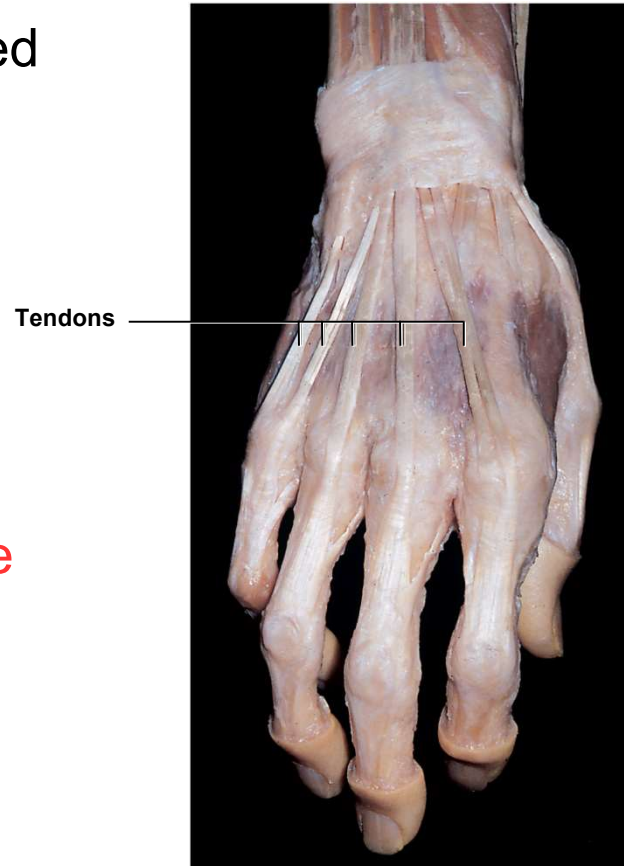
Ground Substance

– *Proteoglycan*

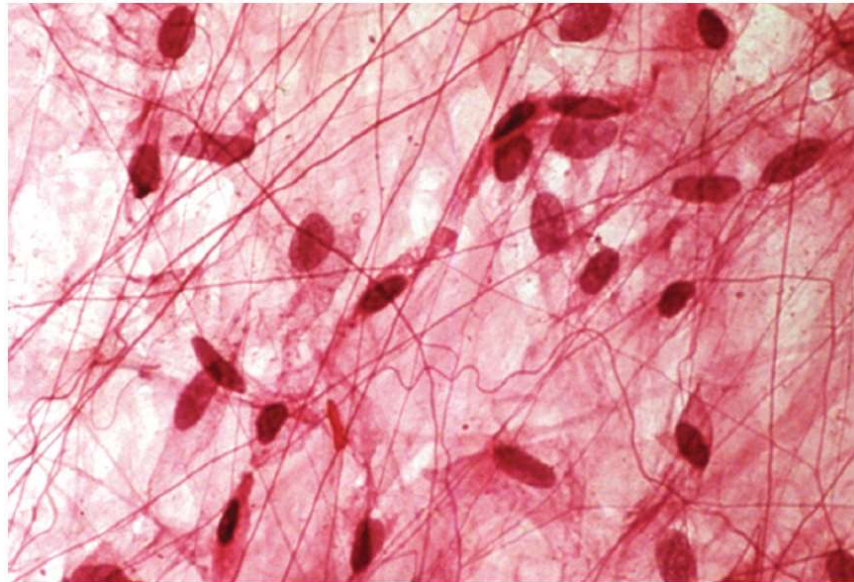
- gigantic molecule shaped like a test-tube brush // proteoglycan form the “core” and the GAG project off of the proteoglycan
- forms thick colloids that creates strong structural bond between cells and extracellular macromolecules – holds tissues together

Loose VS Dense Fibrous Connective Tissue ★ ★

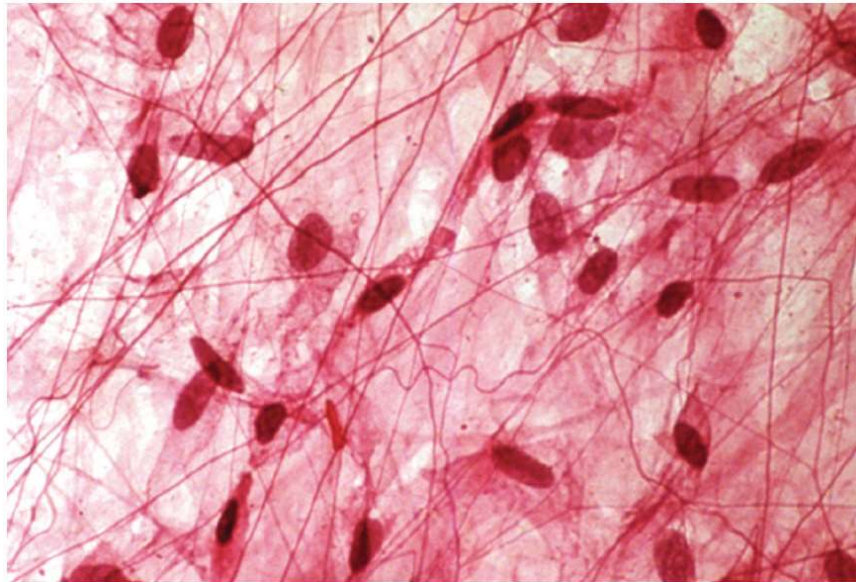
- loose connective tissue // gel-like ground substance between cells // may be arranged either as **areolar or reticular**
- dense connective tissue // (e.g. forms tendons, ligaments, capsules surrounding organs)
 - **different types of dense connective tissue forms based on fiber orientation**
 - **dense regular** connective tissue (tendons & ligaments)
 - **dense irregular** connective tissue (forms sheets which surround organs or structured as 3D tissue as in the dermis)



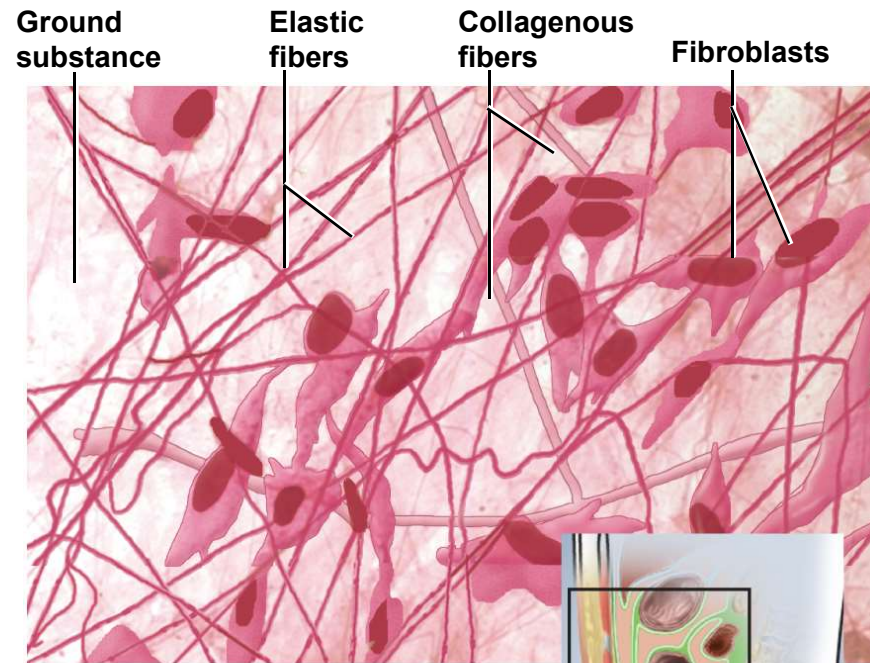
Slide Review of Different Connective Tissues



Areolar CT (fibrous loose)



(a)



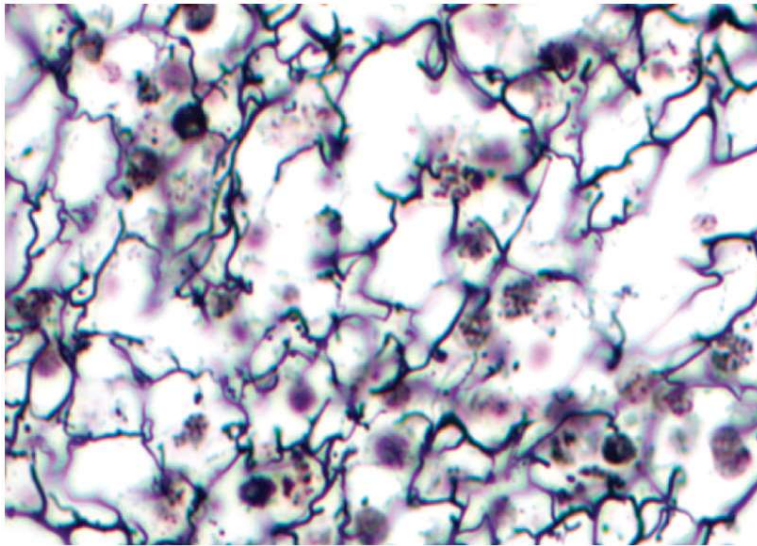
(b)

- loosely organized fibers, abundant blood vessels, and a lot of seemingly empty space
- **underlies all epithelia**, in serous membranes, **between muscles**, passageways for nerves and blood vessels

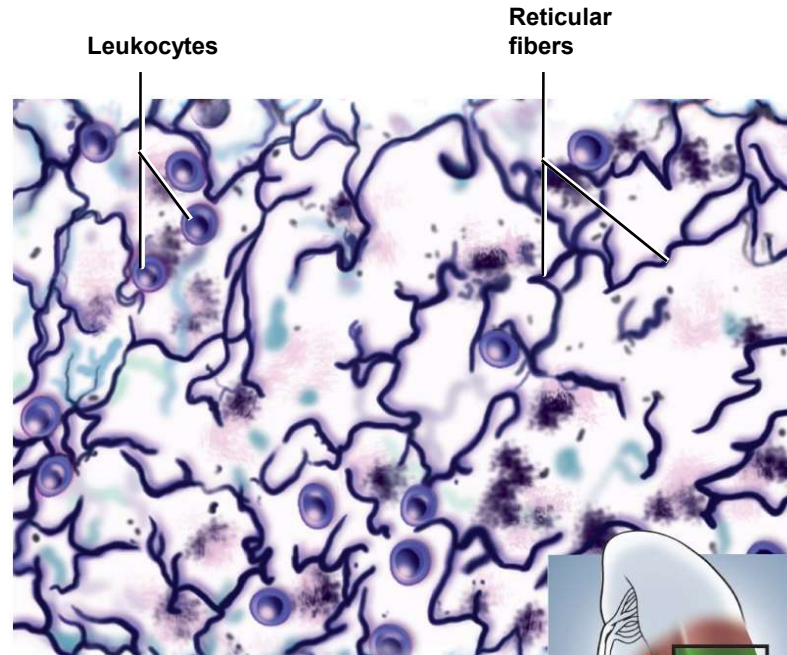
Areolar Connective Tissue

- loosely organized fibers, abundant blood vessels, and a lot of seemingly empty space
- may 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 all 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

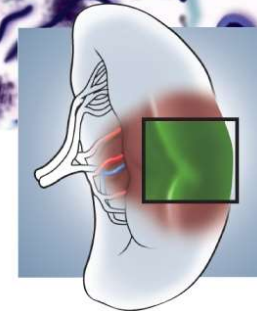
Reticular CT (fibrous loose)



(a)

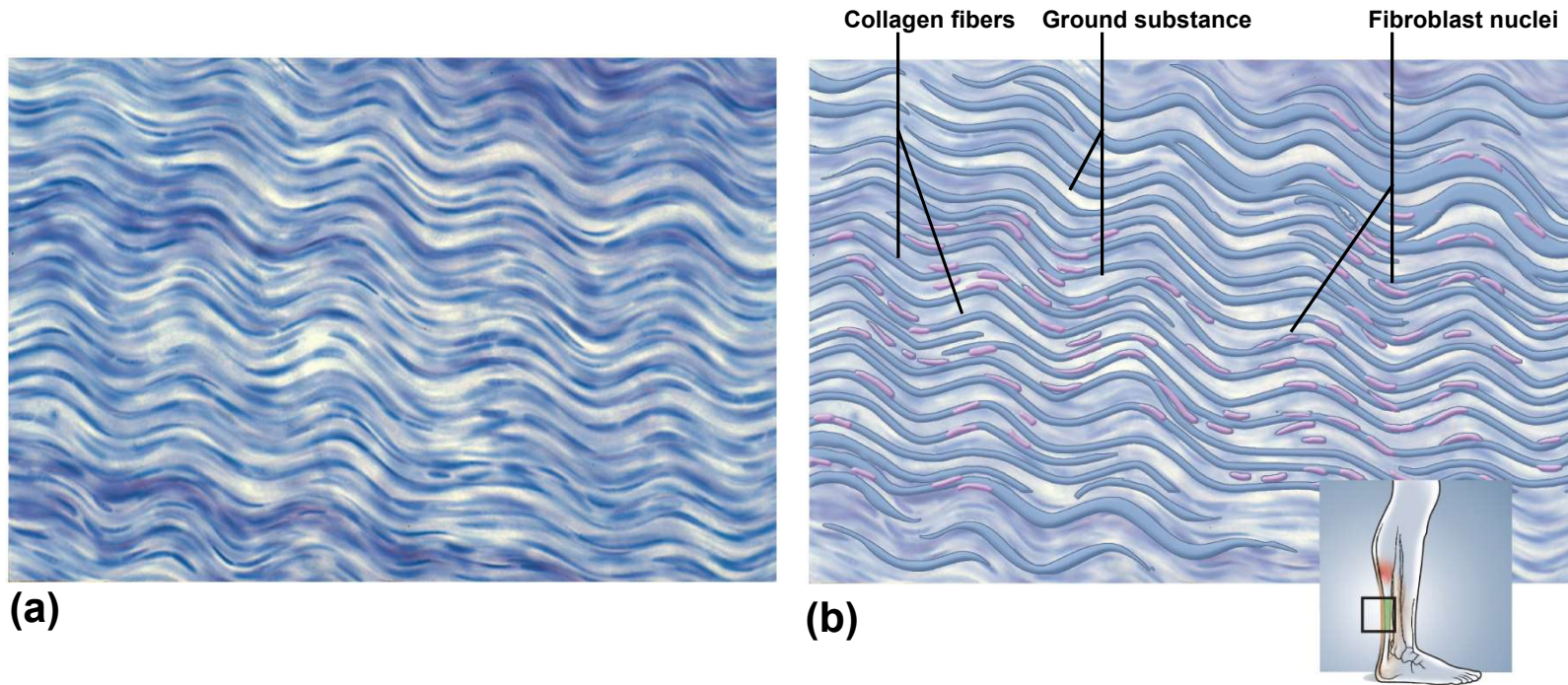


(b)



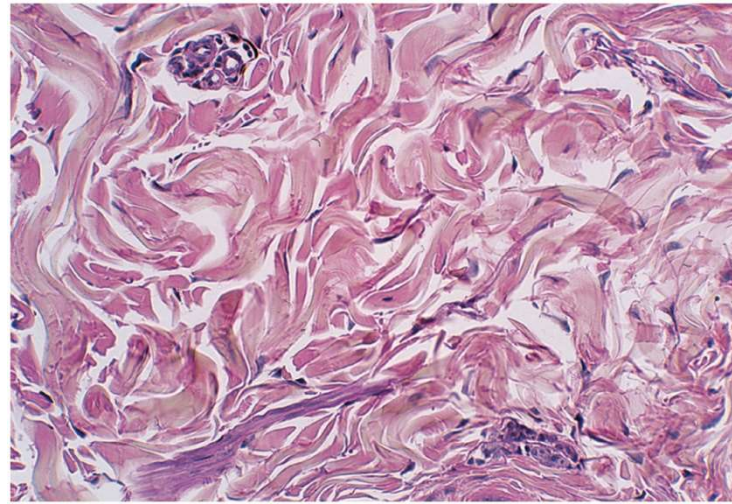
- mesh of reticular fibers and fibroblasts
- forms supportive **stroma (framework) for lymphatic organs**
- found in lymph nodes, spleen, thymus and bone marrow

Fibrous Dense Regular Connective Tissue

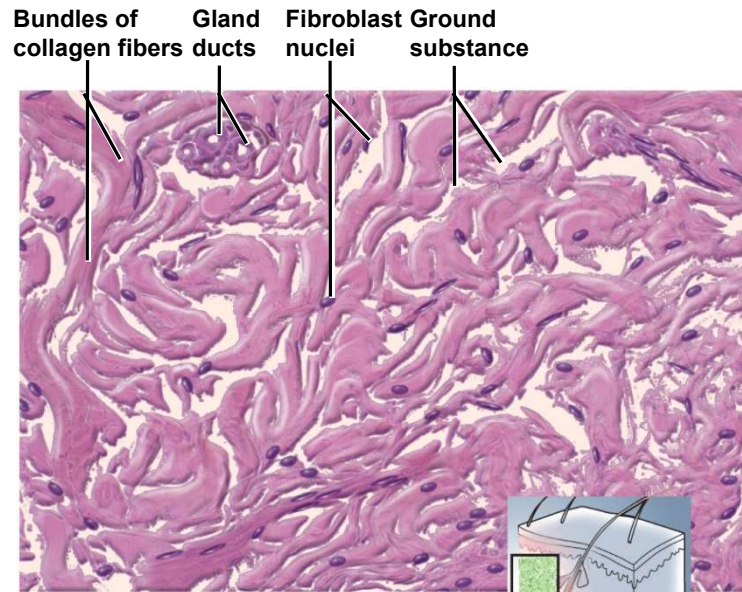


- densely, packed, parallel collagen fibers
 - compressed fibroblast nuclei
- **tendons** attach muscles to bones and **ligaments** hold bones together

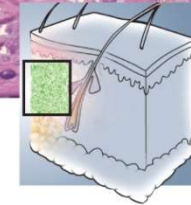
Fibrous Dense Irregular Connective Tissue



(a)



(b)



- densely packed, randomly arranged, collagen fibers and few visible cells
 - withstands unpredictable stresses
 - deeper layer of skin; also capsules around organs

Adipose Tissue



anchors and cushions organs such as eyeball, kidneys

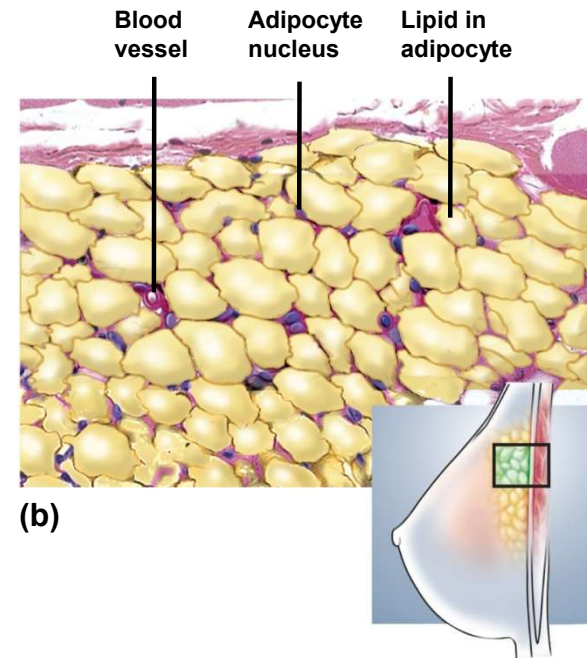
contributes to **body contours** – female breast and hips

on average, women have more fat than men

too little fat can reduce **female fertility**

most adult fat is called **white fat – stores energy and used to make ATP for cellular work**

brown fat – in fetuses, infants, children – converted directly into heat // not used to do cellular work



Adipose Tissue



- adipose tissue = fat
- 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 /// also provides thermal insulation
- the quantity of stored triglyceride and the number of adipocytes are quite stable in a person
 - fat is recycled continuously to prevent stagnation
 - new triglycerides are constantly synthesized and stored
 - old triglycerides are hydrolyzed and released into circulation

Cartilage = Another Form of CT

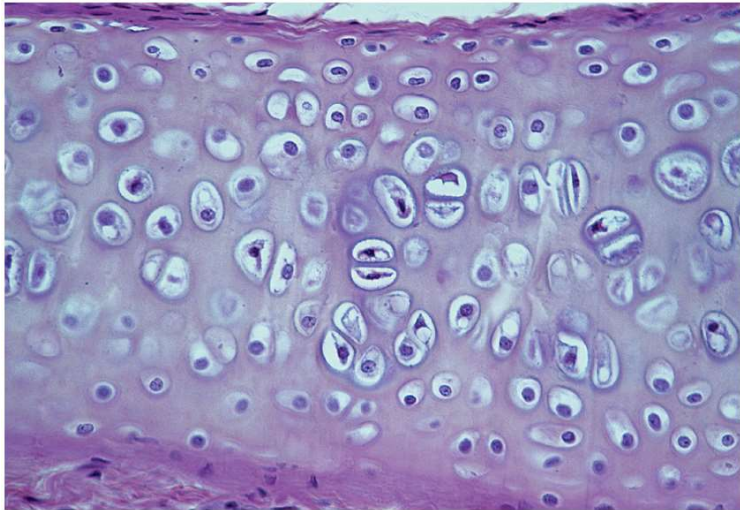


- produced by chondrocytes
- types of cartilage vary with fiber types
 - hyaline cartilage
 - fibrocartilage
 - elastic cartilage
- connective tissue matrix that supports tissue with flexible, rubbery matrix
- cartilage gives shape to ear, tip of nose, and larynx
- **no blood vessels = avascular** // diffusion brings nutrients and removes wastes // heals slowly

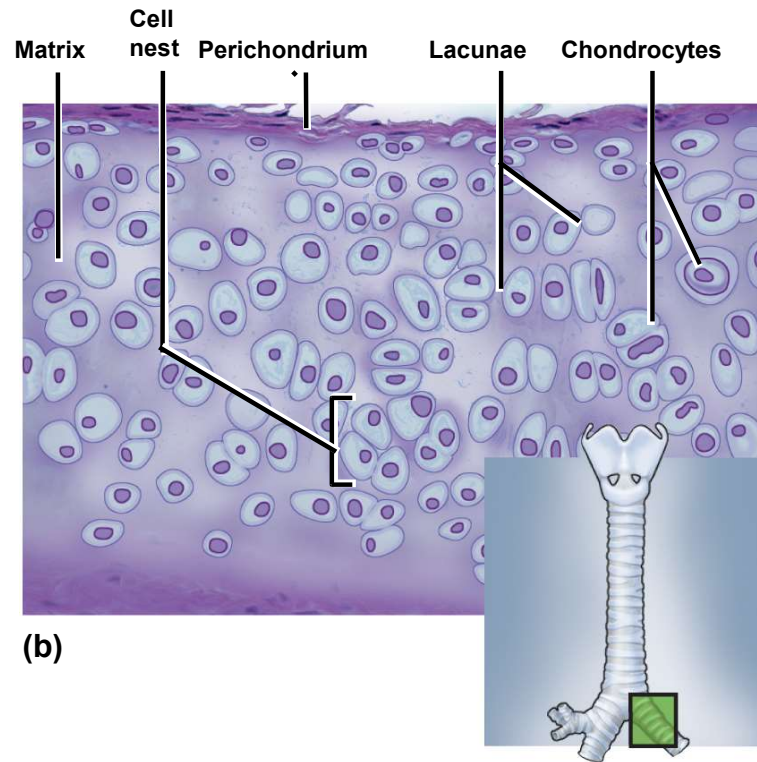
Cells of Cartilage

- **chondroblasts** produce matrix and surround themselves until they become trapped in little cavities (lacunae)
- **chondrocytes** – cartilage cells in lacunae
- **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
- matrix rich in **chondroitin sulfate** and contain **collagen fibers**

Hyaline Cartilage



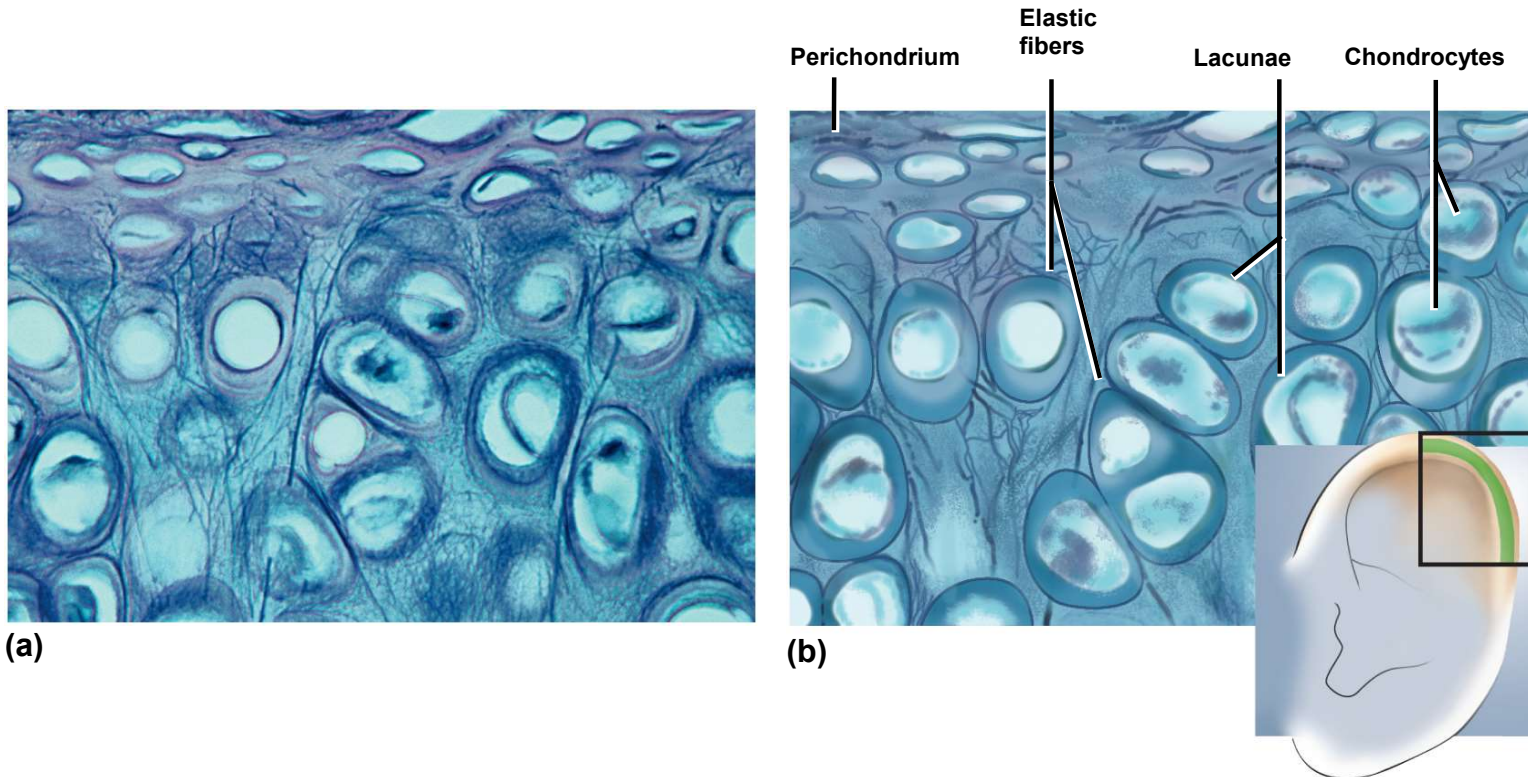
(a)



(b)

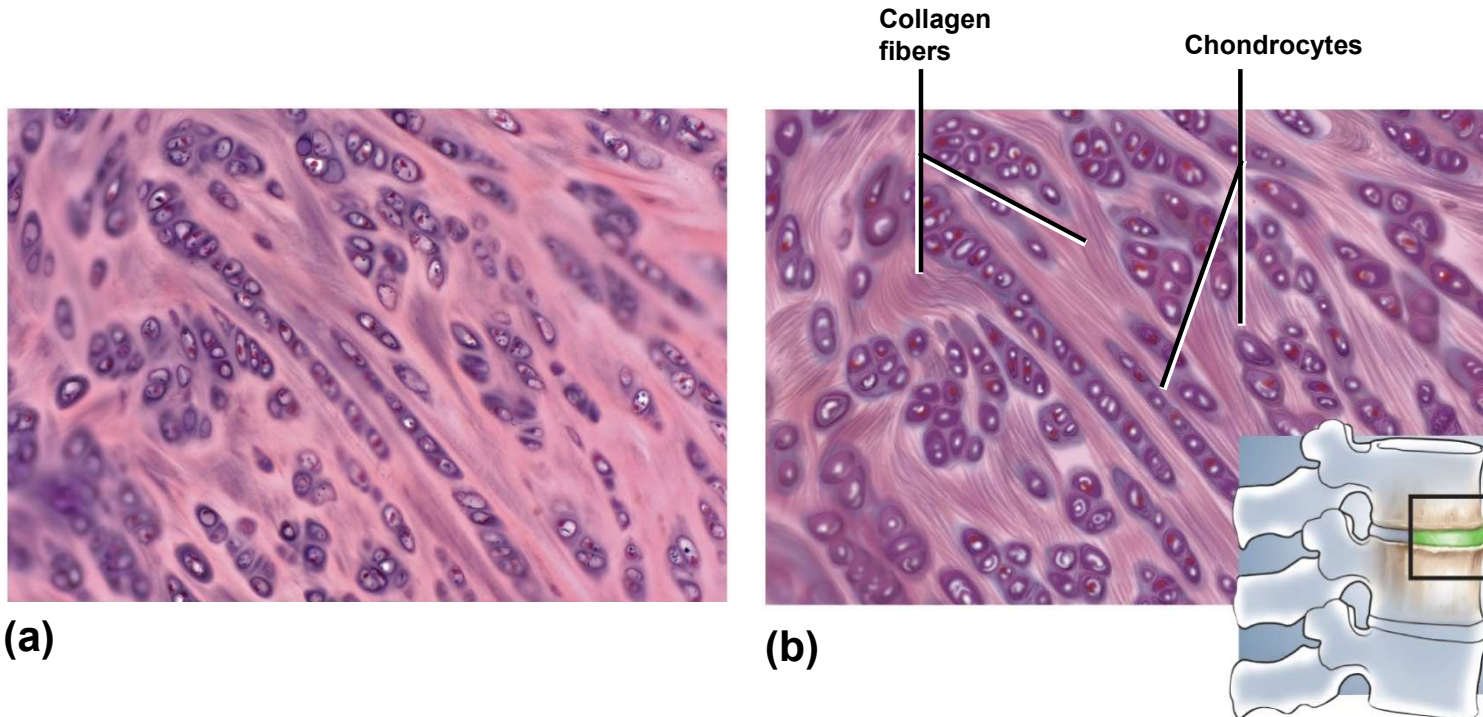
- clear, glassy microscopic appearance because of unusual fineness of the collagen fibers
- usually covered by perichondrium
- articular cartilage, costal cartilage, trachea, larynx, fetal skeleton
- eases joint movement, holds airway open, moves vocal cords during speech

Elastic Cartilage



- cartilage containing elastic fibers
- covered with perichondrium
- provides flexible, elastic support
 - external ear and epiglottis

Fibrocartilage



(a)

(b)

- cartilage containing large, coarse bundles of collagen fibers
- never has perichondrium
- resists compression and absorbs shock
 - pubic symphysis, menisci, and intervertebral discs

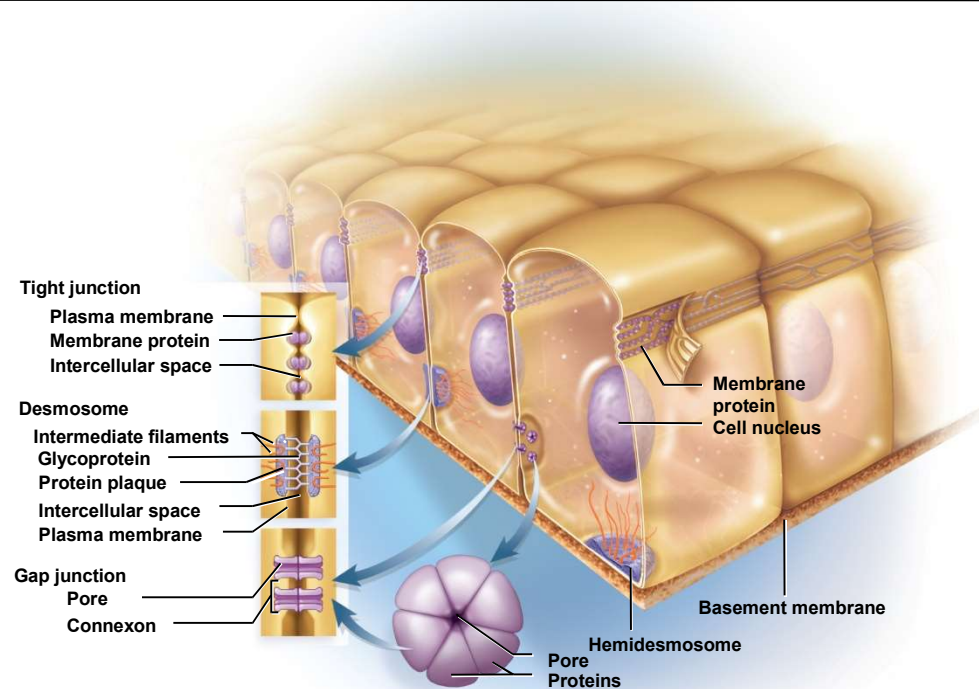
Other Tissues

- Blood // a type of connective tissue – covered in Chapter 19
- Bone // a type of connective tissue – covered in Chapter 6
- Muscle // cardiac – smooth – skeletal /// excitable tissue /// covered in Chapter 10
- Nervous tissue // excitable tissue /// covered in Chapter 12

Intercellular Junctions

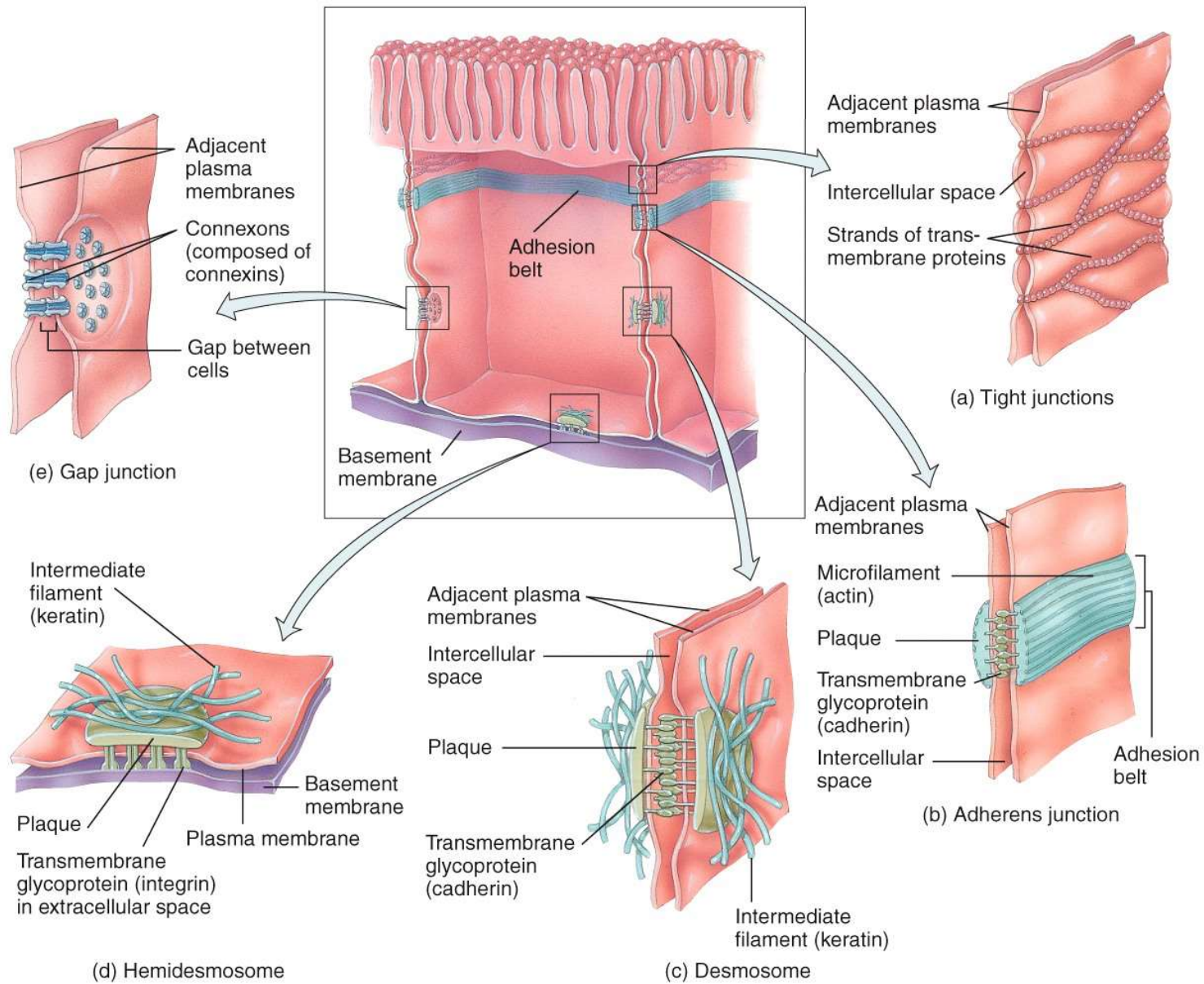


(Junctions associated with epithelial tissue and some muscle tissues.)



- **inter-cellular junctions** – connections between cells
- all cells (except blood cells and malignant cancer cells) are anchored to each other or anchored to their matrix by inter-cellular junctions
- resist force of stress and/or contribute to communication between cells

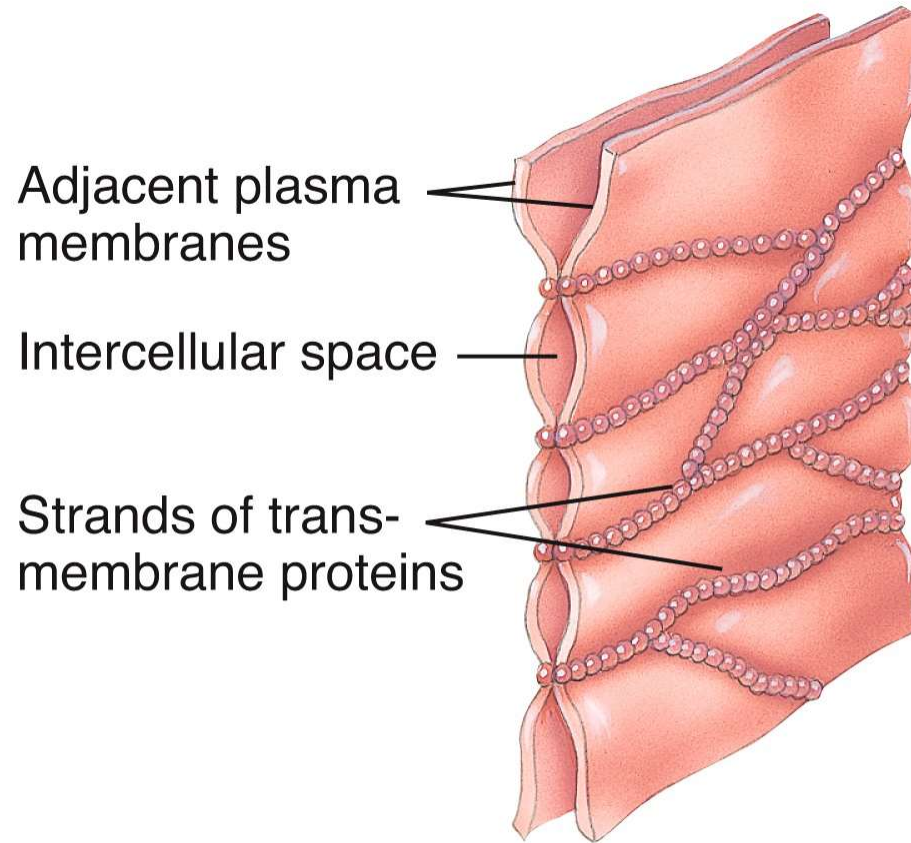
Five Type of Junctions



Tight Junctions



- a region in which adjacent cells are bound together by fusion of the **outer phospholipid layer of their plasma membranes**.
 - in epithelia, forms a zone that complete encircles each cell **near its apical pole**
 - seals off intercellular space
 - makes it **impossible for solvent & solute to pass between cells**
 - Stomach, intestines, urinary bladder



(a) Tight junctions

Adherens Junctions

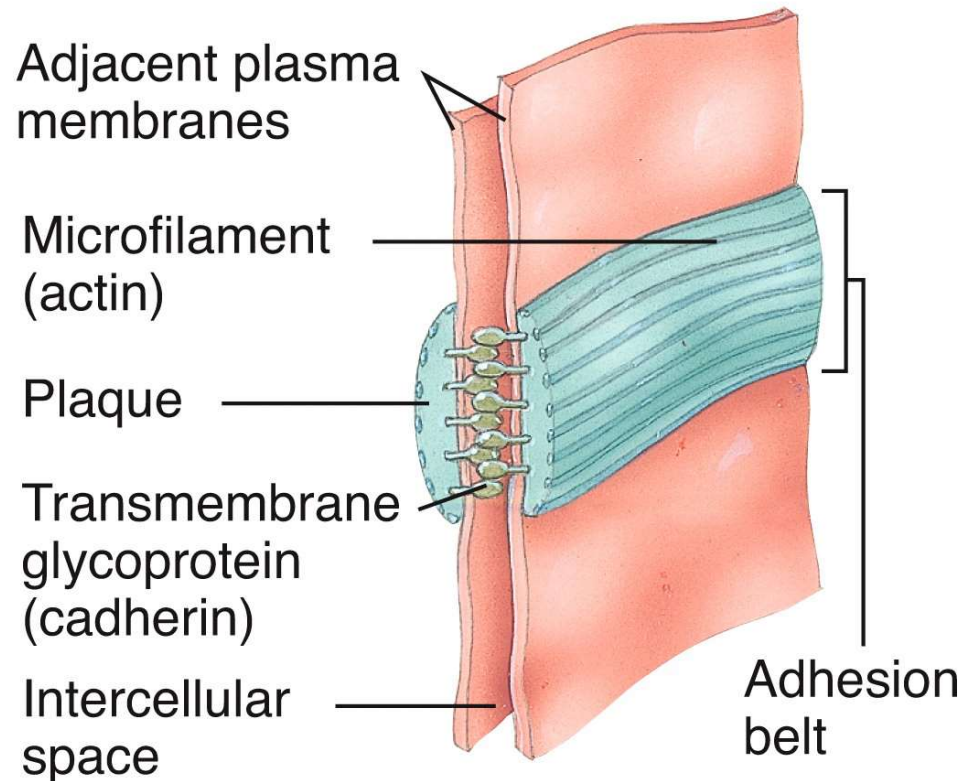


Plaques on inside of cell membrane

Plaques attached to intermediate fibers

Transmembrane glycoprotein connect adjacent cells

Associated with epithelial cells / **prevent cells from being pulled apart**

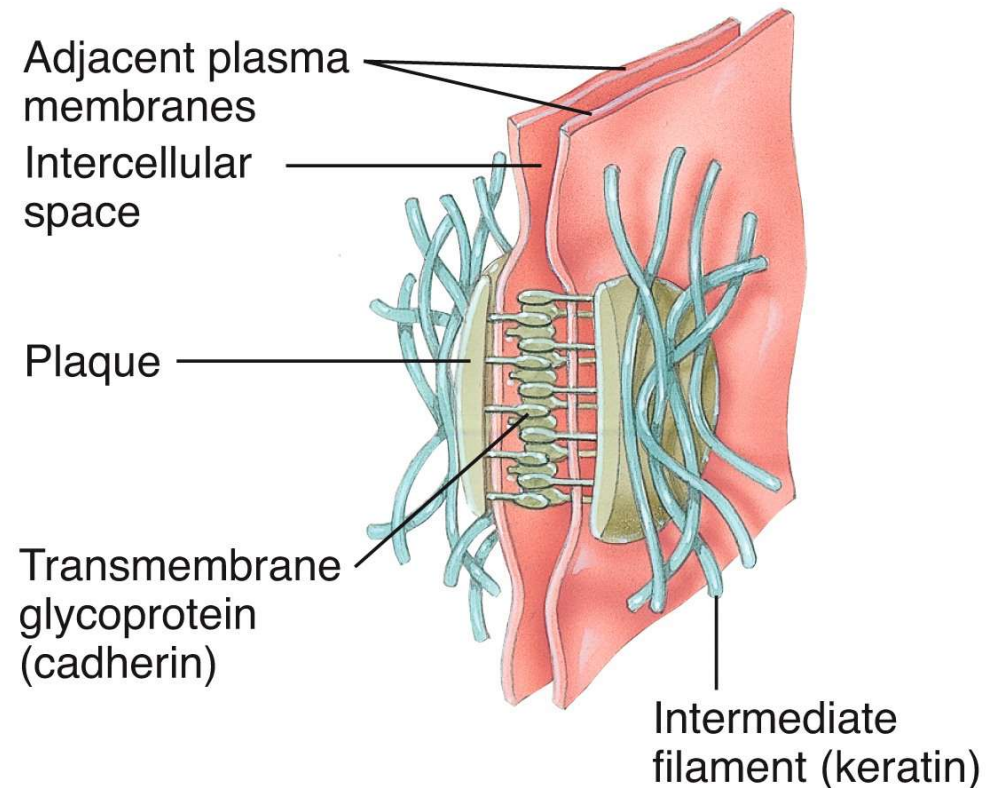


(b) Adherens junction

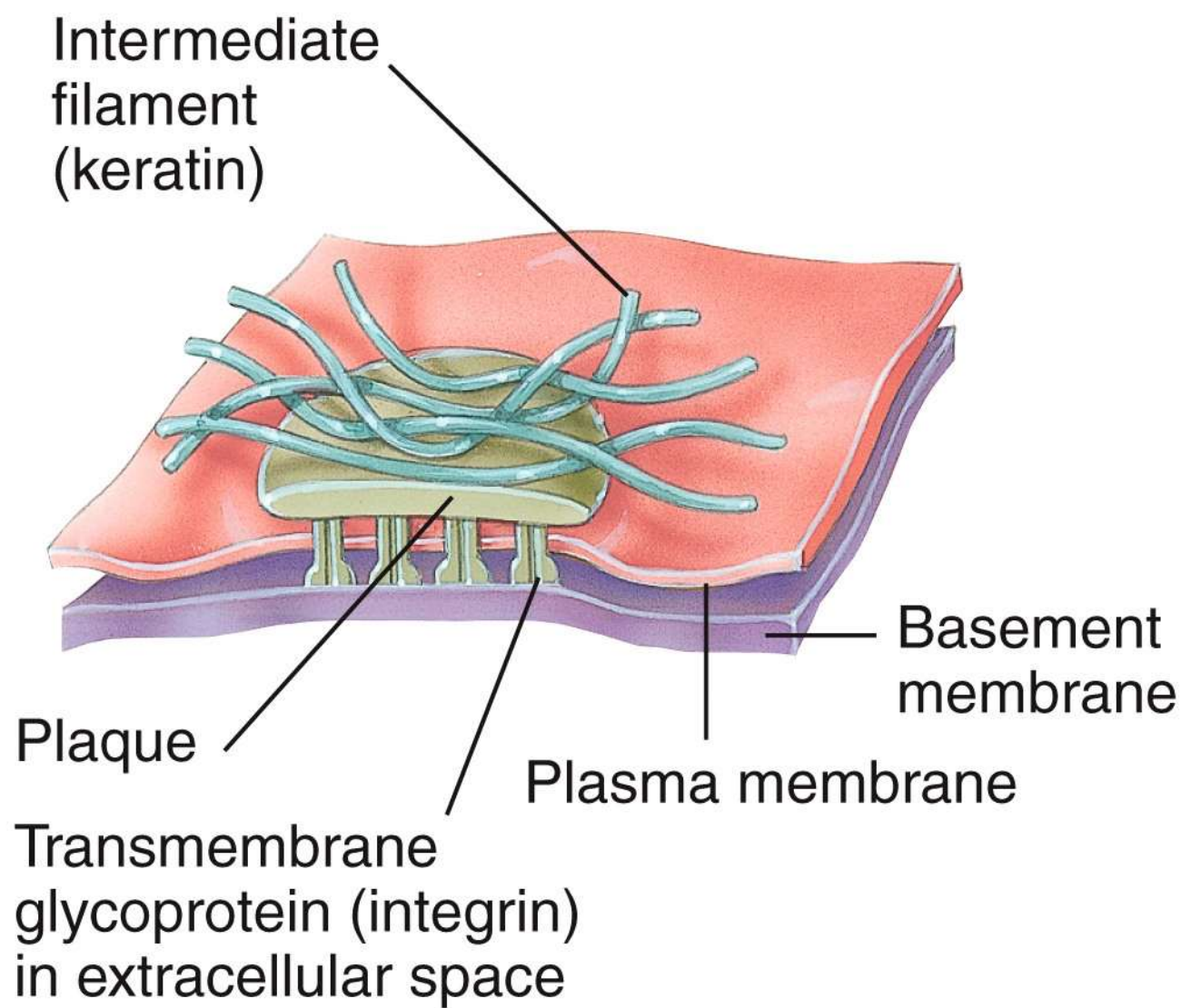
Desmosomes & Hemidesmosomes



- patch that holds cells together (like a clothing snap or button)
- serves to **keep cells from pulling apart** – resists mechanical stress
- hooklike J-shaped proteins arise from cytoskeleton /// **integrated into adjacent cell's cytoskeleton**
 - approach cells surface
 - penetrate into thick protein plaques linked to transmembrane proteins
- **hemidesmosomes** – anchor the basal cells of epithelium to the underlying basement membrane
 - epithelium can not easily peel away from underlying tissues (see next slide)



(c) Desmosome

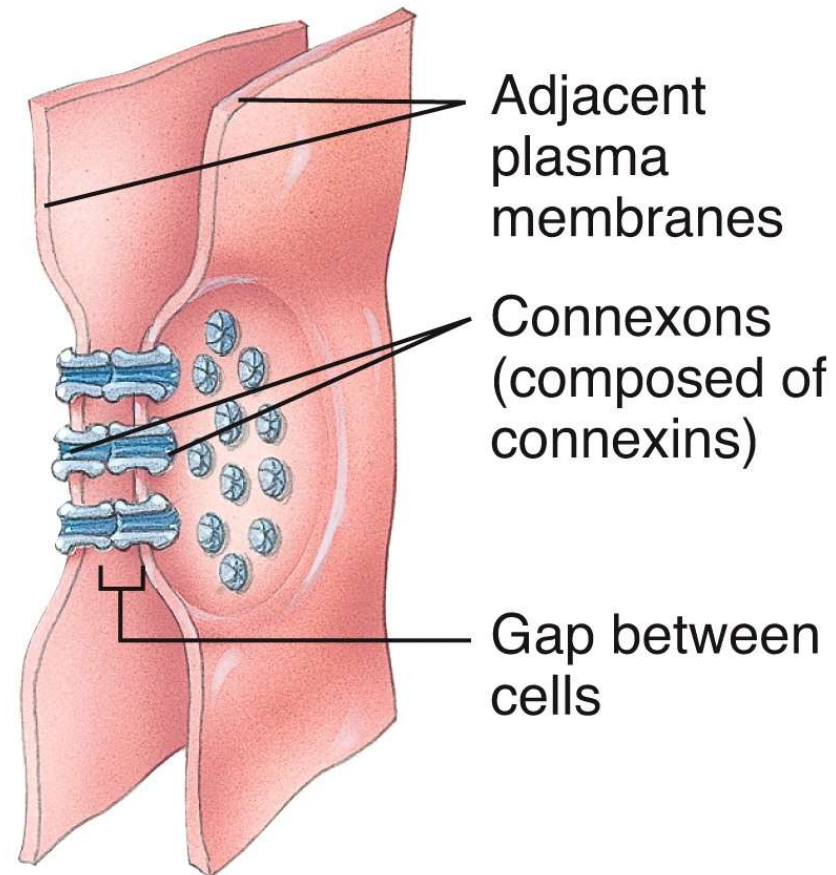


(d) Hemidesmosome

Gap Junctions



- formed by a ringlike connexon
- communicating junction
- consists of six transmembrane proteins arranged like segments of an orange
- surrounding a water-filled pores
- ions, glucose, amino acids and other solutes pass from one cell to the next
-
- Important in embryonic development, heart function, epithelial tissue, smooth muscle



(e) Gap junction