

Histology

- 50 trillion cells of 200 different cell types
- four broad categories of tissues
 - **epithelial tissue**
 - **connective tissue**
 - **nervous tissue**
 - **muscular tissue**
- **organ** - structure with discrete boundaries that is composed of two or more tissue types
- **histology** (microscopic anatomy) – the study of tissues and how they are arranged into organs

The Primary Tissue Classes

- **tissue** – a group of similar cells and cell products that arise from the same region of the embryo and work together to perform a specific structural or physiological role in an organ.
- **four primary tissues** differ from one another in the:
 - types and functions of their cells
 - the characteristics of the matrix (extracellular material)
 - the relative amount of space occupied by cells versus matrix
- **matrix** – (extracellular material) is composed of :
 - fibrous proteins
 - a clear gel known as **ground substance** , **tissue fluid**, **extracellular fluid (ECF)**, **interstitial fluid**, or **tissue gel**

Epithelial Tissue

- consists of a flat sheet of closely adhering cells
- one or more cells thick
- upper surface usually exposed to the environment or an internal space in the body
- covers body surface
- lines body cavities
- forms the external and internal linings of many organs
- constitutes most glands
- extracellular material is so thin it is not visible with a light microscope
- epithelia allows no room for blood vessels
- lie on a layer of loose connective tissue and depend on its blood vessels for nourishment and waste removal

Basement Membrane

- **basement membrane** – layer between an epithelium and the underlying connective tissue
 - anchors the epithelium to the connective tissue below it
- **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

Simple vs. Stratified Epithelia

- **Simple epithelium**

- contains one layer of cells
- named by shape 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 do not touch basement membrane

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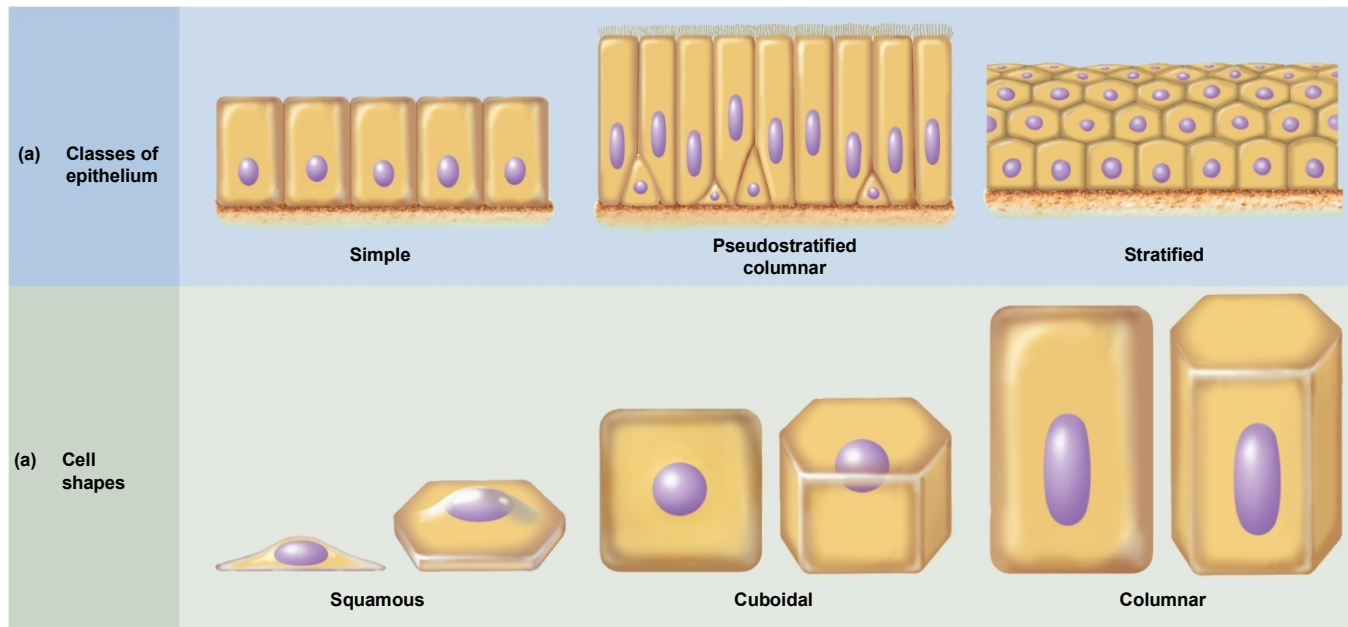


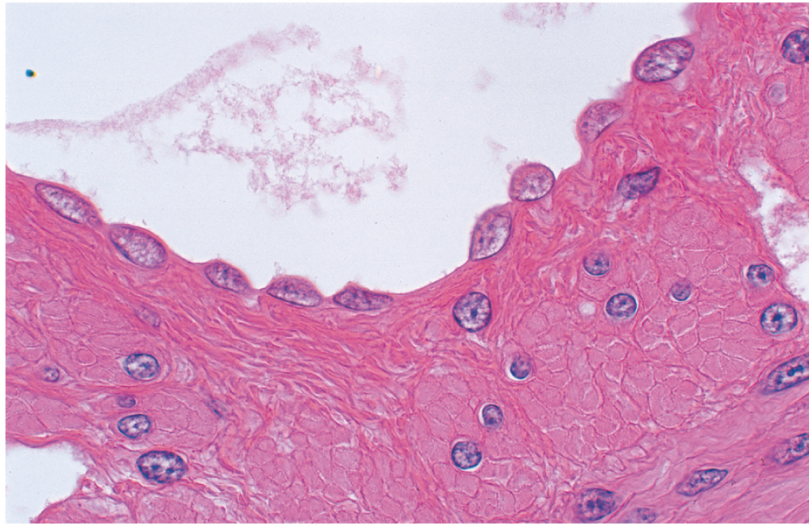
Figure 5.3

Simple Epithelia

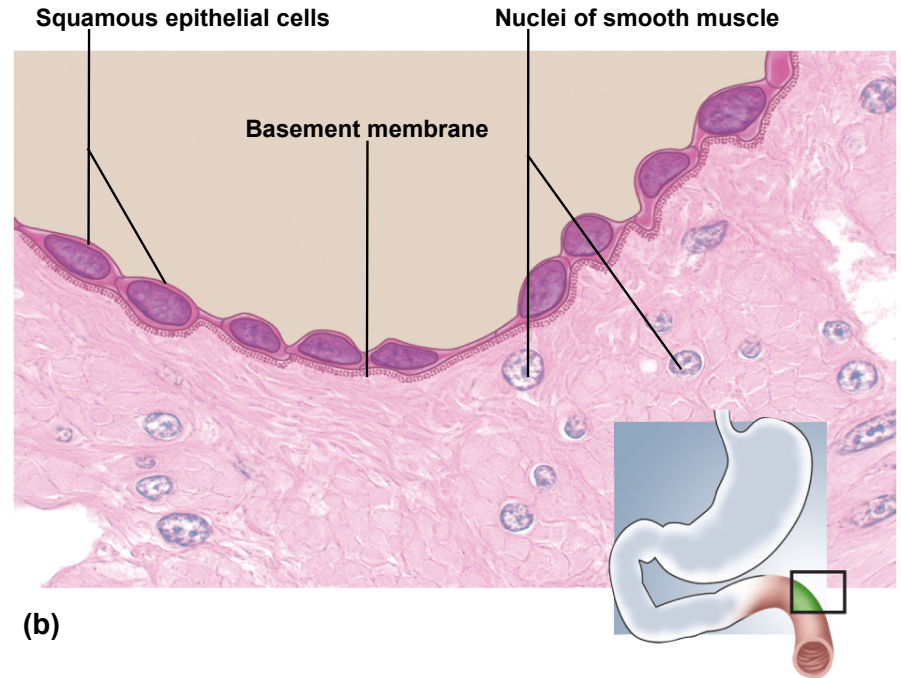
- **four types** of simple epithelia
- three named for their cell shapes
 - simple squamous (thin scaly cells)
 - simple cuboidal (square or round cells)
 - simple columnar (tall narrow cells)
- fourth type –
 - pseudostratified columnar
 - not all cells reach the free surface
 - shorter cells are covered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

Simple Squamous Epithelium

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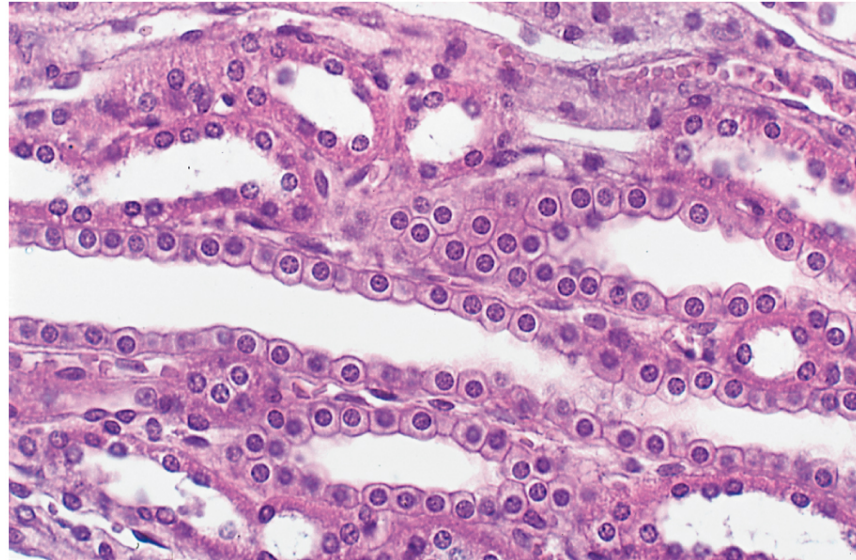
Figure 5.4a

Figure 5.4b,i

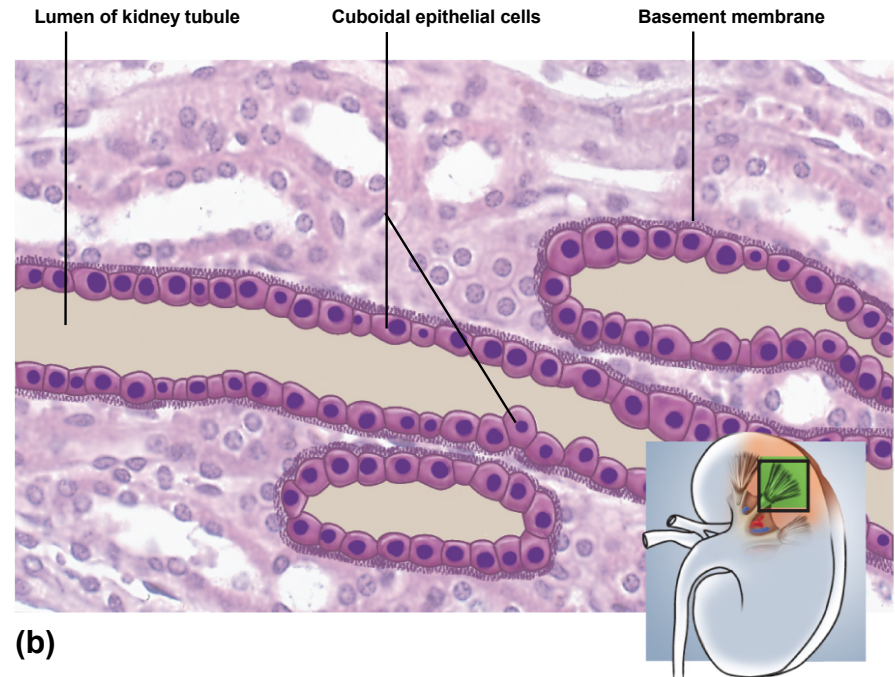
- single row of thin cells
- permits rapid diffusion or transport of substances
- secretes serous fluid
- alveoli, glomeruli, endothelium, and serosa

Simple Cuboidal Epithelium

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Figure 5.5a

Figure 5.5b,i

- 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

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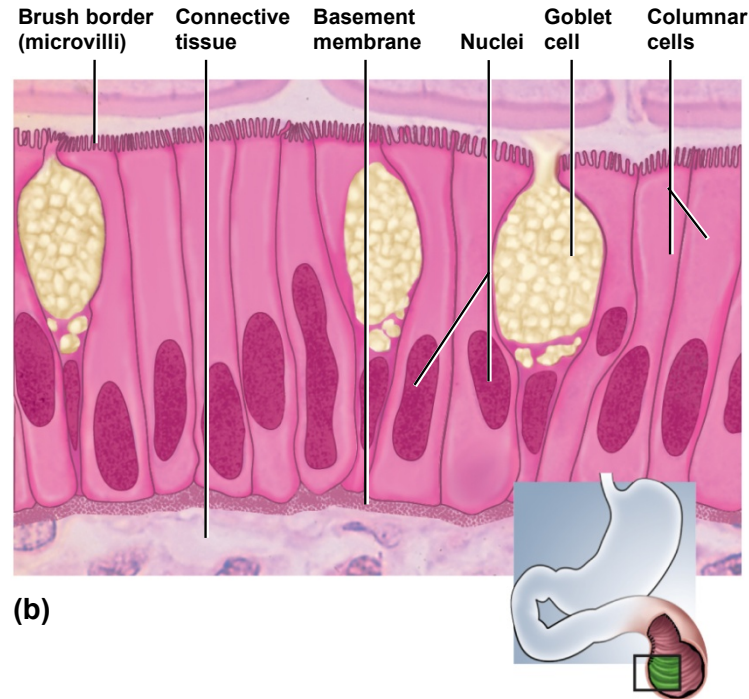
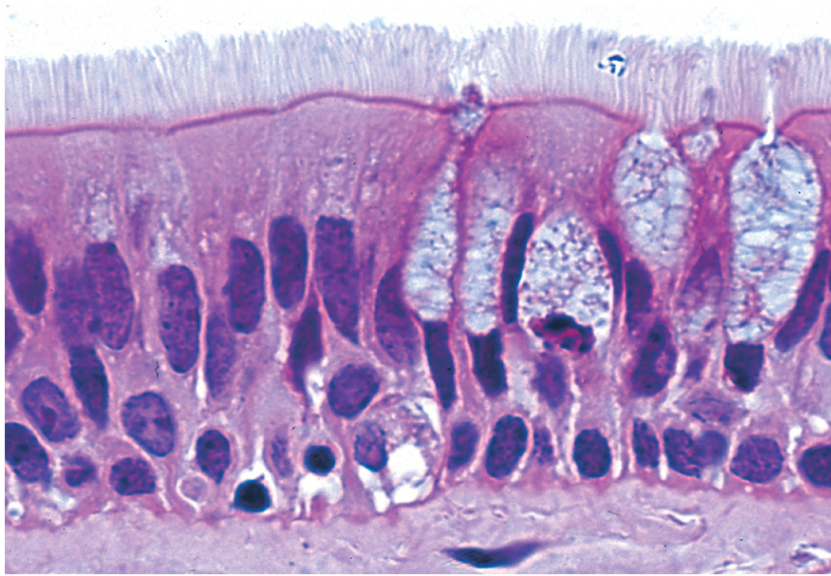


Figure 5.6b,i

- 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

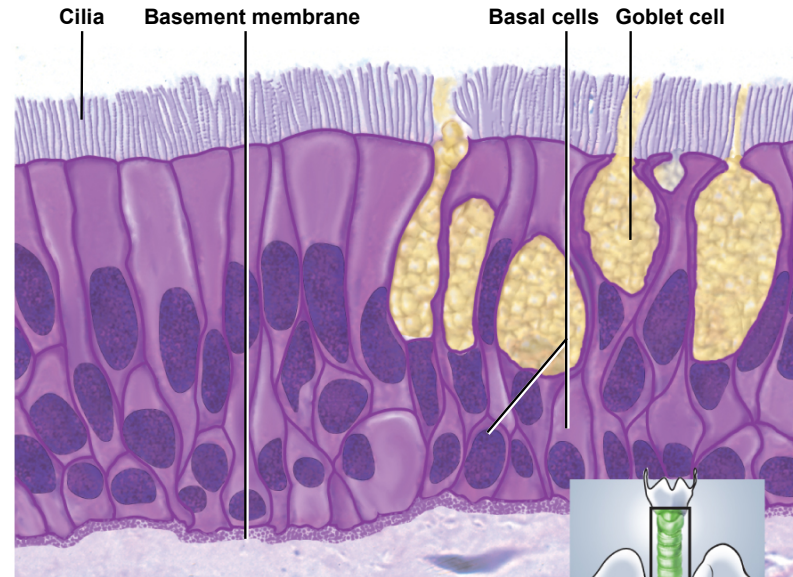
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Figure 5.7a



(b)

Figure 5.7b,i

- 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
- some cells resting directly on others
- 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

Keratinized Stratified Squamous

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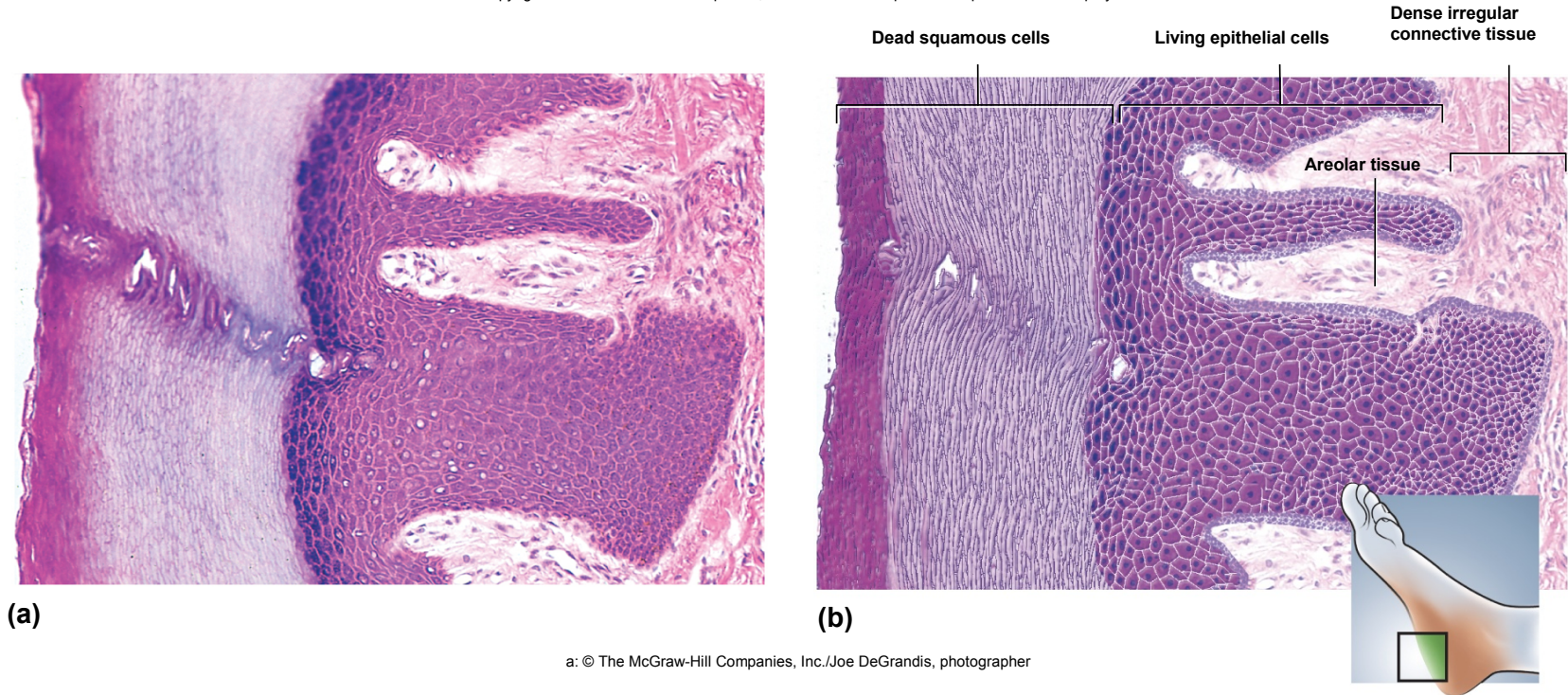


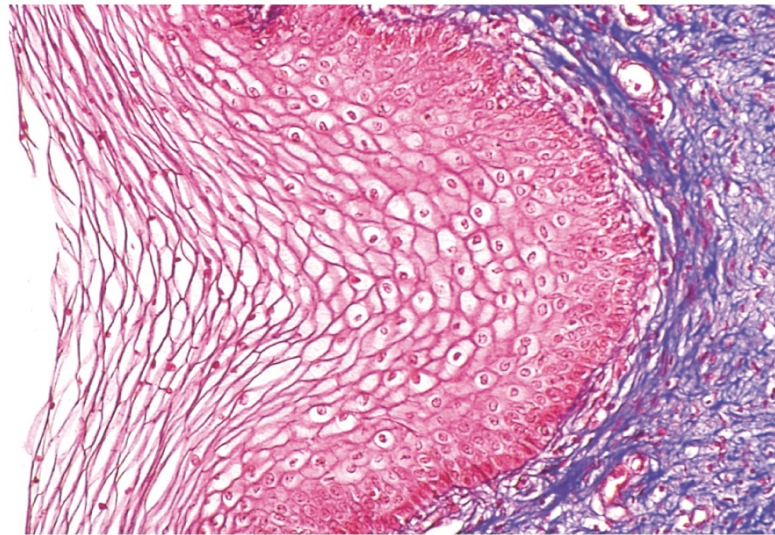
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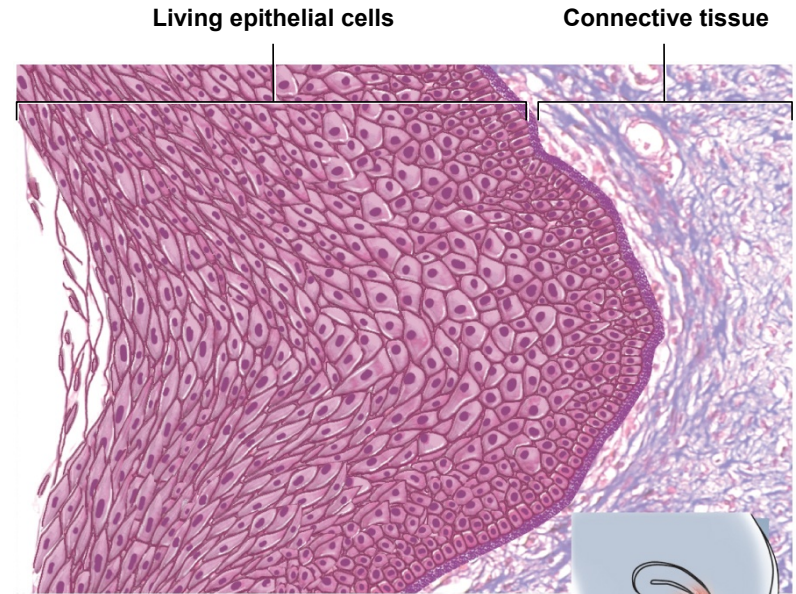
- multiple cell layers with cells becoming flat and scaly toward surface
- epidermis; palms and soles heavily keratinized
- resists abrasion; retards water loss through skin; resists penetration by pathogenic organisms

Nonkeratinized Stratified Squamous

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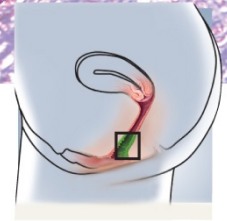


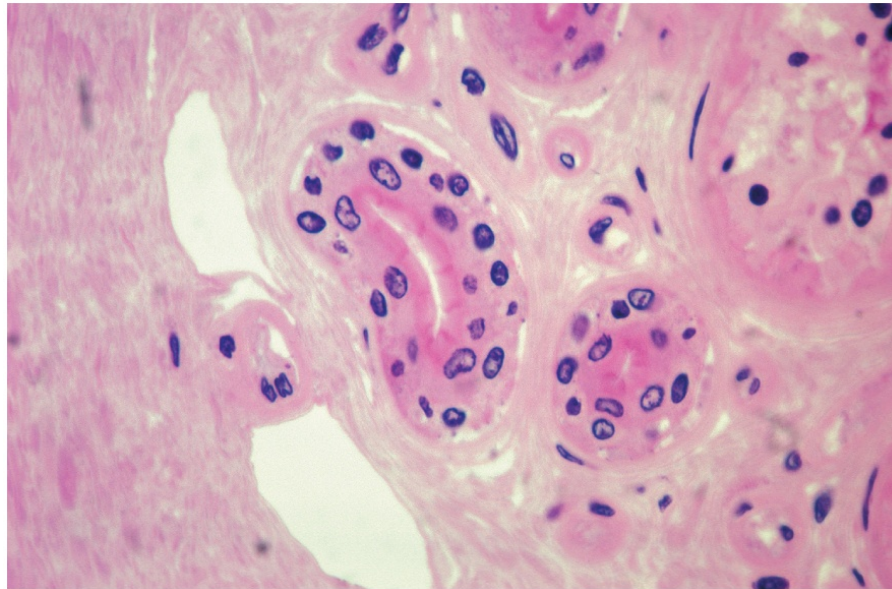
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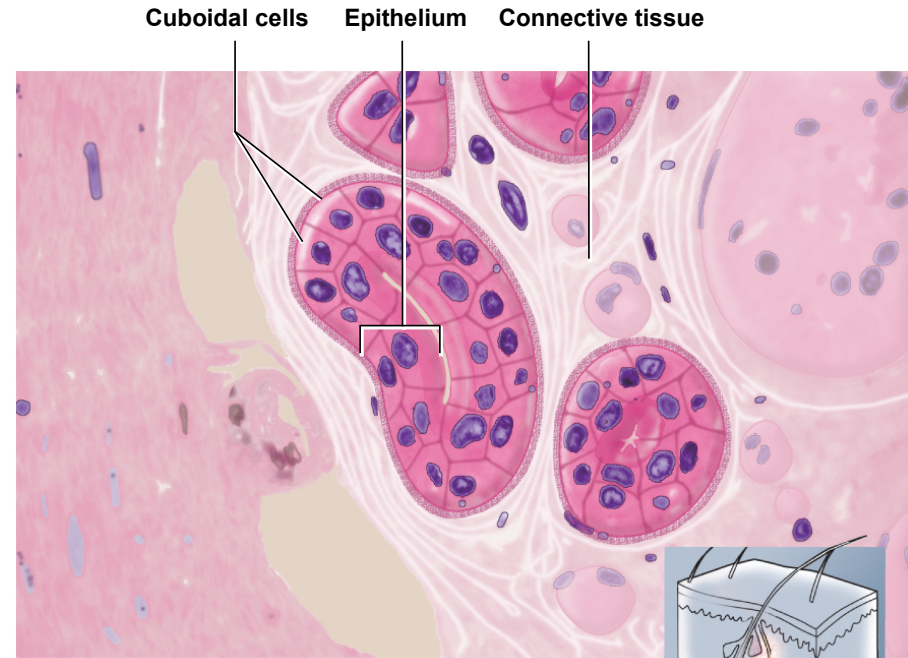
- same as keratinized epithelium without the surface layer of dead cells
- tongue, oral mucosa, esophagus and vagina
- resists abrasion and penetration of pathogens

Stratified Cuboidal Epithelium

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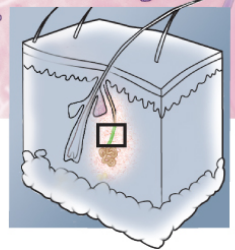


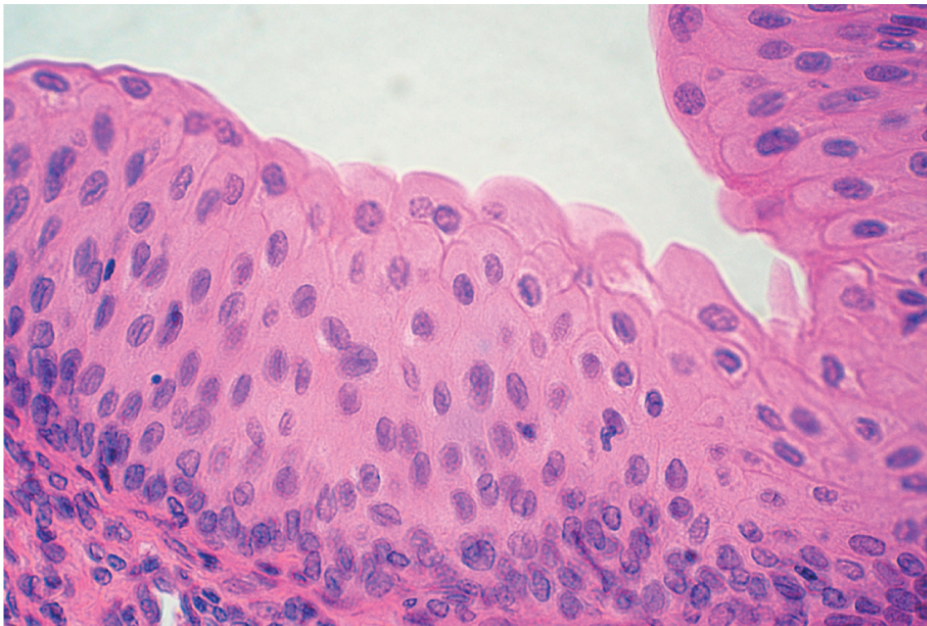
Figure 5.10a

Figure 5.10b,i

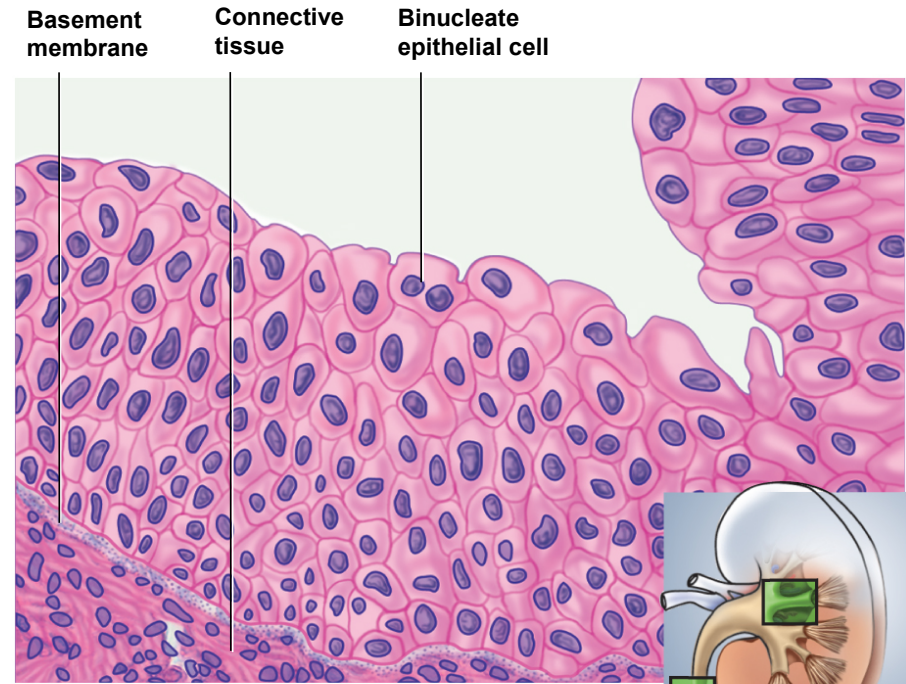
- two or more cell layers; surface cells square or round
- secretes sweat; sperm production and produces ovarian hormones
- sweat gland ducts; ovarian follicles and seminiferous tubules

Transitional Epithelium

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(a)



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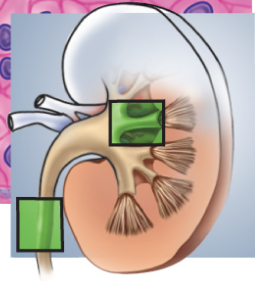


Figure 5.11a

Figure 5.11b,i

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

Connective Tissue

- **connective tissue** – a type of tissue in which 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
 - separated by extracellular material
- **highly vascular** – richly supplied with blood vessels
- most abundant, widely distributed, and histologically variable of the primary tissues

Functions of Connective Tissue

- **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

Components of Fibrous Connective Tissue

- **cells**
 - **fibroblasts** produce fibers and ground substance
 - **Immune system cells**
 - **adipocytes** store triglycerides (fat molecules)

Components of Fibrous Connective Tissue

- **fibers**
 - **collagenous fibers**
 - most abundant of the body's proteins – 25%
 - tough, flexible, and resist stretching
 - tendons, ligaments, and deep layer of the skin are mostly collagen
 - less visible in matrix of cartilage and bone
 - **reticular fibers**
 - thin collagen fibers coated with glycoprotein
 - form framework of such organs as spleen and lymph nodes
 - **elastic fibers**
 - thinner than collagenous fibers
 - made of protein called **elastin**
 - allows stretch and recoil

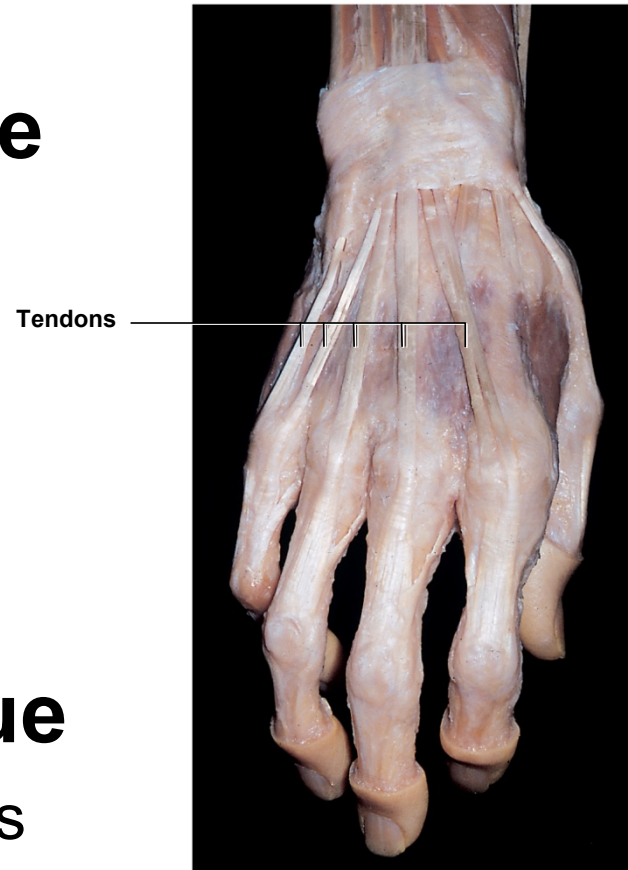
Components of Fibrous Connective Tissue

- **ground substance**
 - usually a gelatinous to rubbery consistency resulting from three classes of large molecules
 - **glycosaminoglycans (GAG)**
 - long polysaccharide
 - **proteoglycan**
 - gigantic molecule
 - **adhesive glycoproteins** – bind components of tissues together

Types of Fibrous Connective Tissue

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- **loose connective tissue**
 - much gel-like ground substance between cells
 - types
 - areolar
 - reticular
- **dense connective tissue**
 - fibers fill spaces between cells
 - types vary in fiber orientation
 - dense regular connective tissue
 - dense irregular connective tissue



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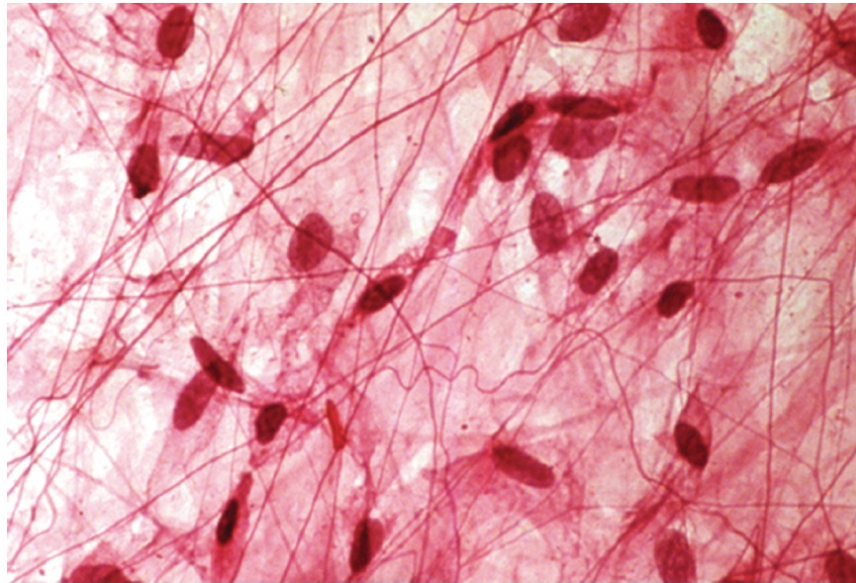
Figure 5.13

Areolar Tissue

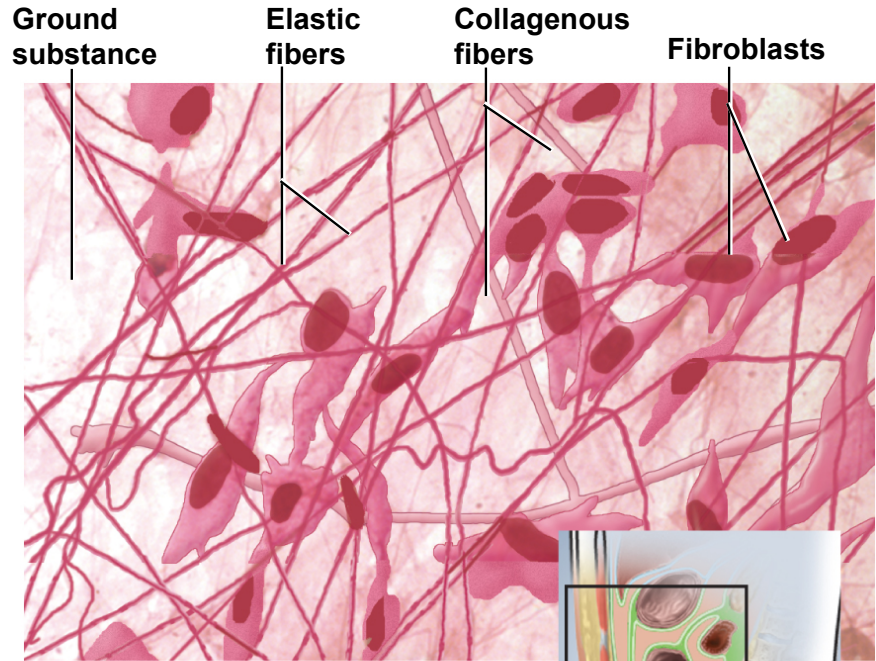
- loosely organized fibers, abundant blood vessels, and a lot of seemingly empty space
- fibers run in random directions
 - mostly collagenous, but elastic and reticular also present
- found in tissue sections from almost every part of the body
 - surrounds blood vessels and nerves
- nearly every epithelium rests on a layer of areolar tissue
 - blood vessels provide nutrition to epithelium and waste removal
 - ready supply of infection fighting leukocytes that move about freely in areolar tissue

Areolar Tissue

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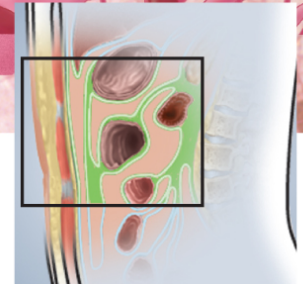


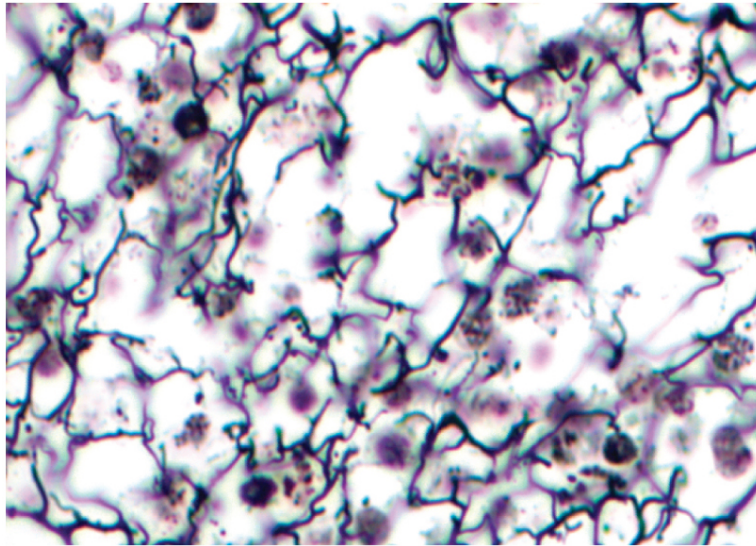
Figure 5.14a

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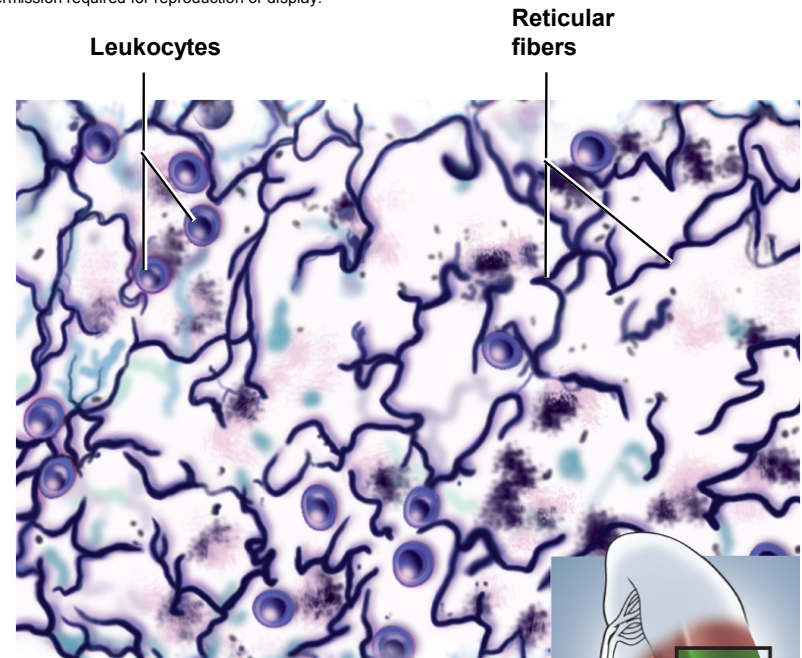
- loosely organized fibers, abundant blood vessels, and a lot of seemingly empty space
- underlies all epithelia, in serous membranes, between muscles, passageways for nerves and blood vessels

Reticular Tissue

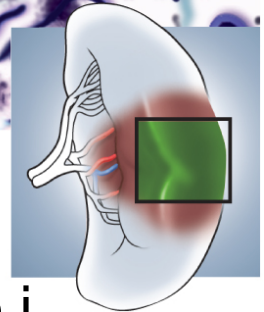
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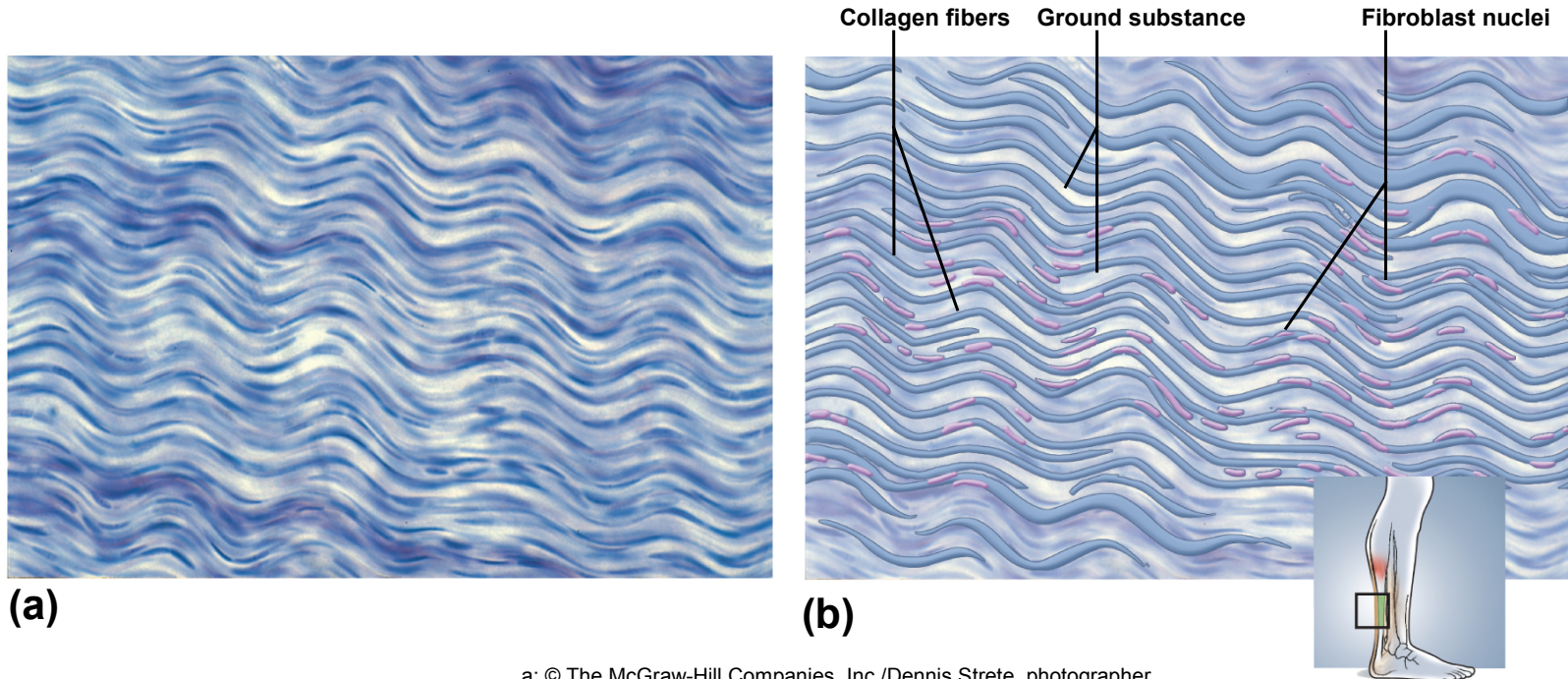
Figure 5.15a

Figure 5.15b,i

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

Dense Regular Connective Tissue

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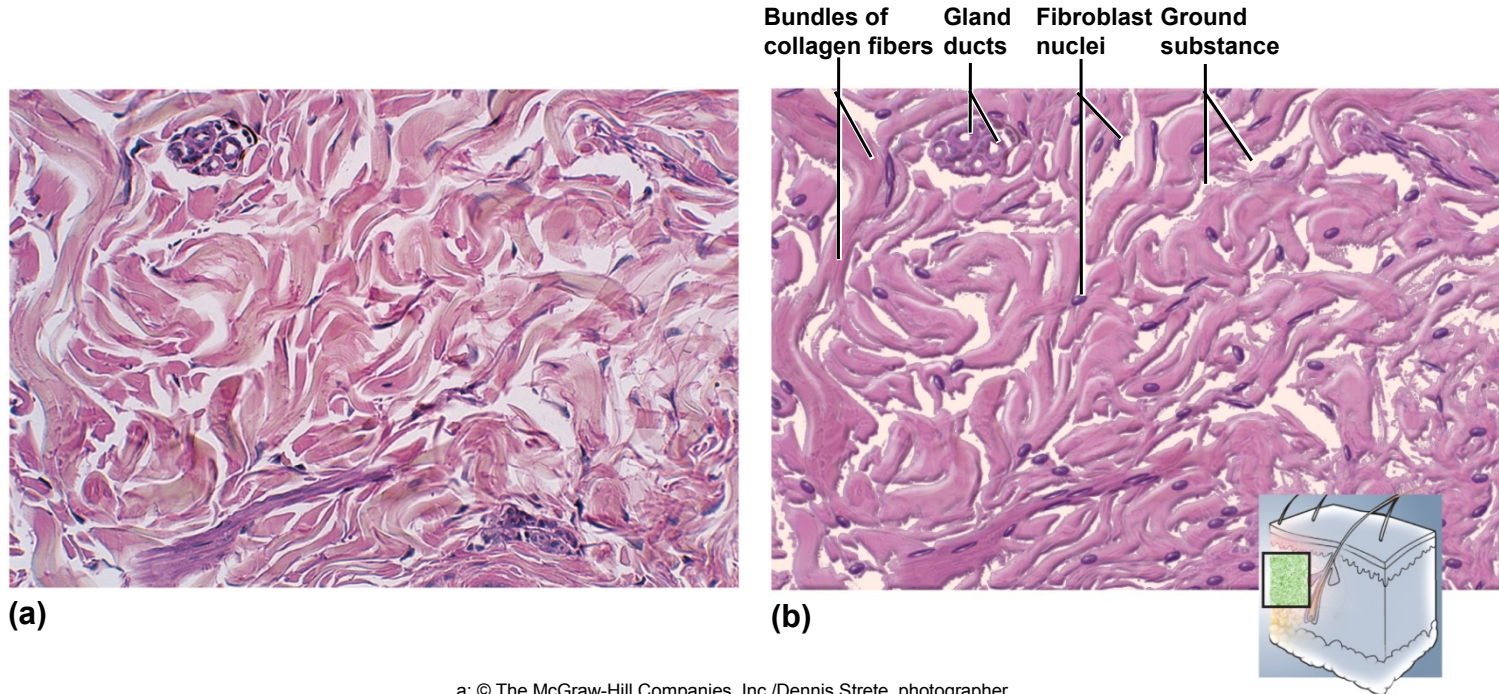
Figure 5.16a

Figure 5.16b,i

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

Dense Irregular Connective Tissue

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Figure 5.17a

Figure 5.17b,i

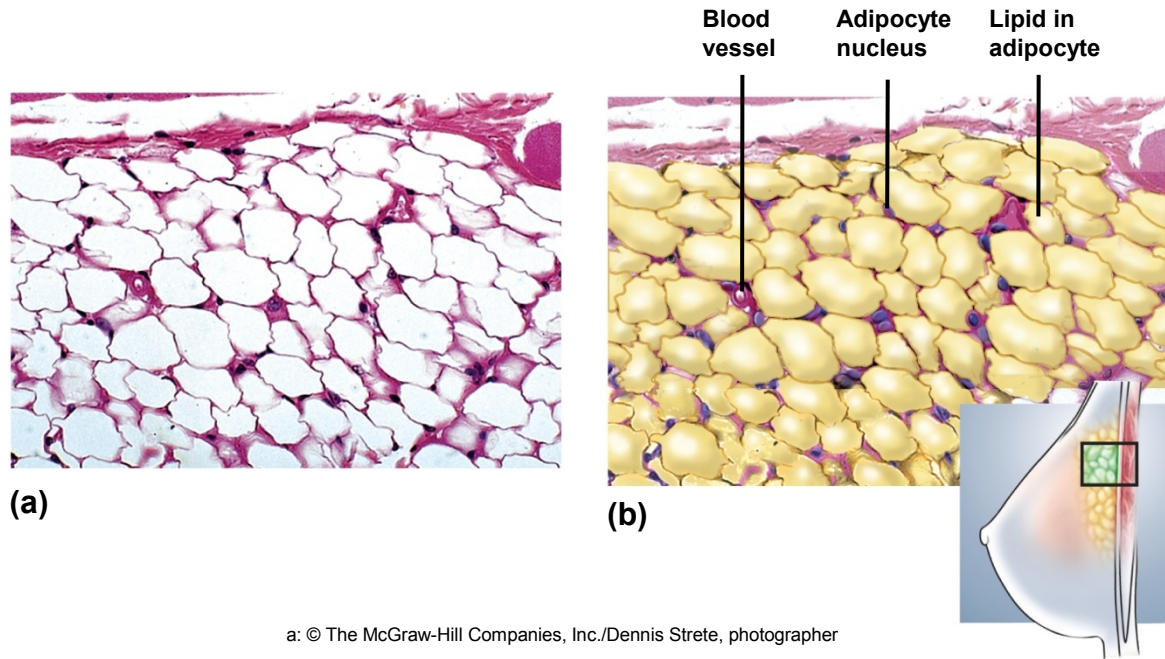
- densely packed, randomly arranged, collagen fibers and few visible cells
 - withstands unpredictable stresses
 - deeper layer of skin; capsules around organs

Adipose Tissue

- **adipose tissue (fat)** – tissue in which **adipocytes** are the dominant cell type
- space between adipocytes is occupied by areolar tissue, reticular tissue, and blood capillaries
- **fat** is the body's primary energy reservoir
- provides **thermal insulation**
- **anchors and cushions organs** such as eyeball, kidneys
- most adult fat is called **white fat**
- **brown fat** – in fetuses, infants, children – a heat generating tissue

Adipose Tissue

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Figure 5.18a

Figure 5.18b,i

- empty-looking cells with thin margins; nucleus pressed against cell membrane
- energy storage, insulation, cushioning
 - subcutaneous fat and organ packing
 - brown fat (hibernating animals) produces heat

Cartilage

- supportive connective tissue with flexible, rubbery matrix
- gives shape to ear, tip of nose, and larynx
- **chondroblasts** produce matrix and surround themselves until they become trapped in little cavities (lacunae)
- **chondrocytes** – cartilage cells in lacunae
- No blood vessels
 - diffusion brings nutrients and removes wastes
 - heals slowly
- matrix rich in **chondroitin sulfate** and contain **collagen fibers**

Hyaline Cartilage

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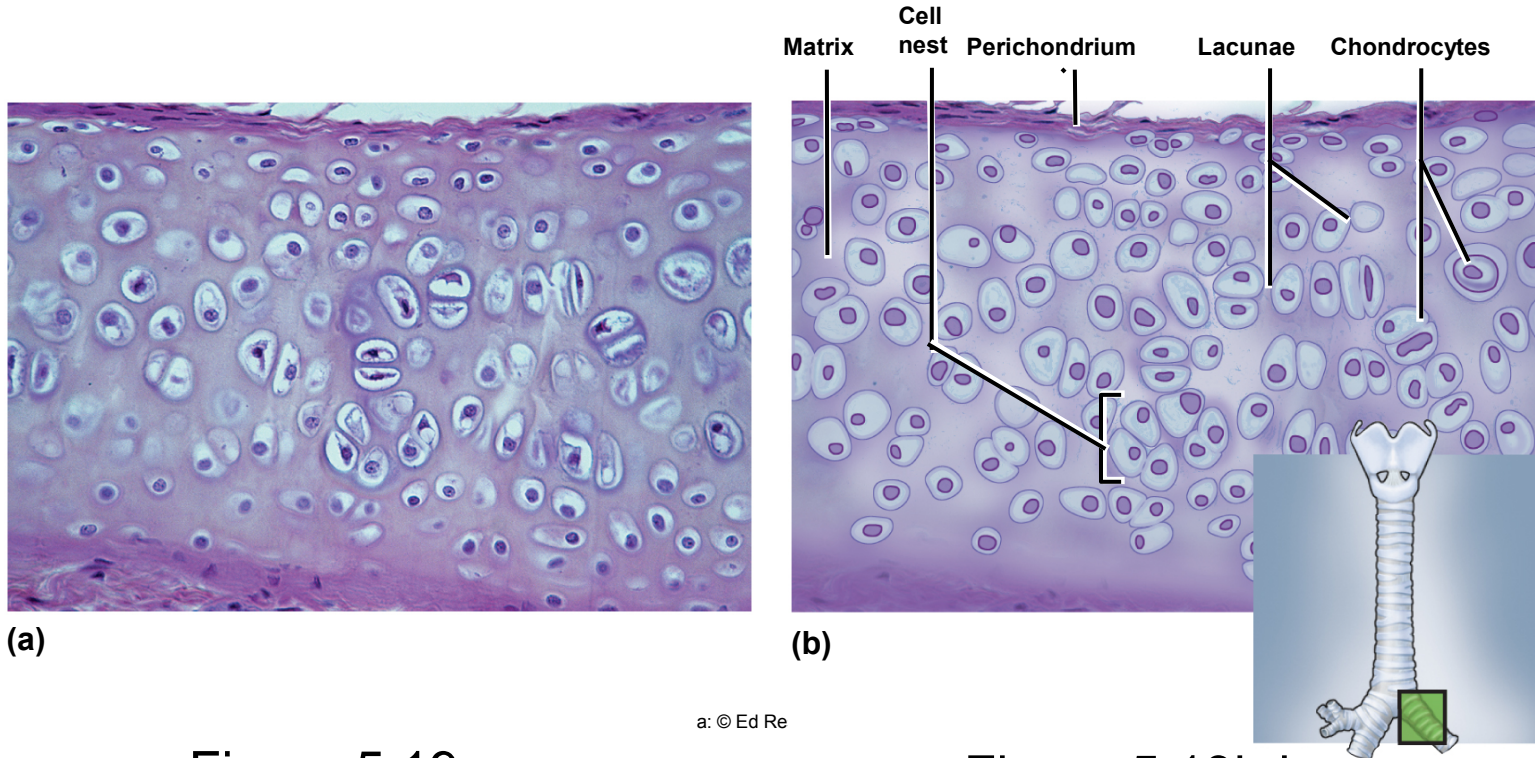


Figure 5.19a

Figure 5.19b,i

- 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

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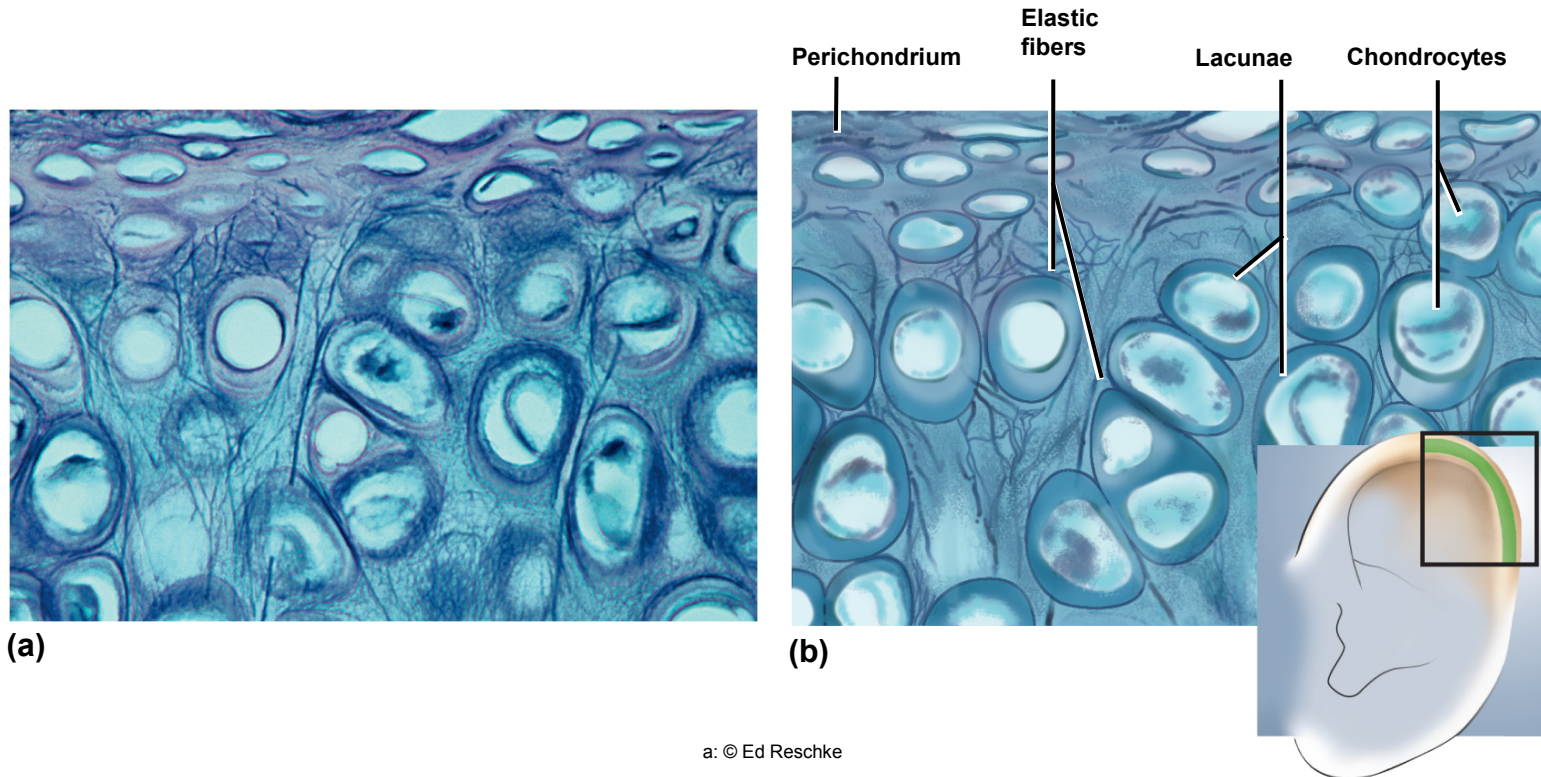


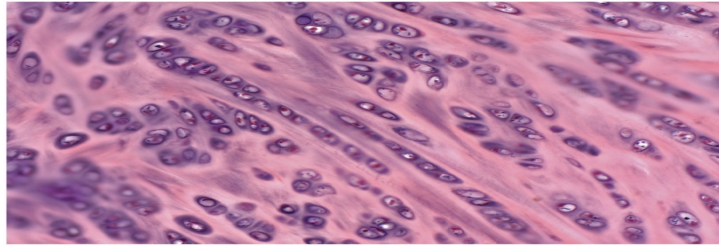
Figure 5.20a

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

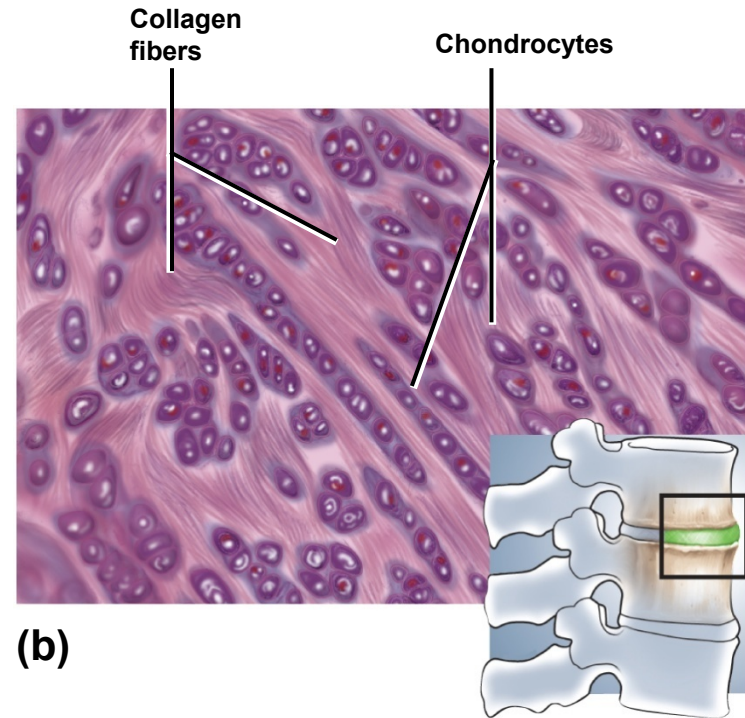
Figure 5.20b,i

Fibrocartilage

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a: Dr. Alvin Ieiser

Figure 5.21a

Figure 5.21b,i

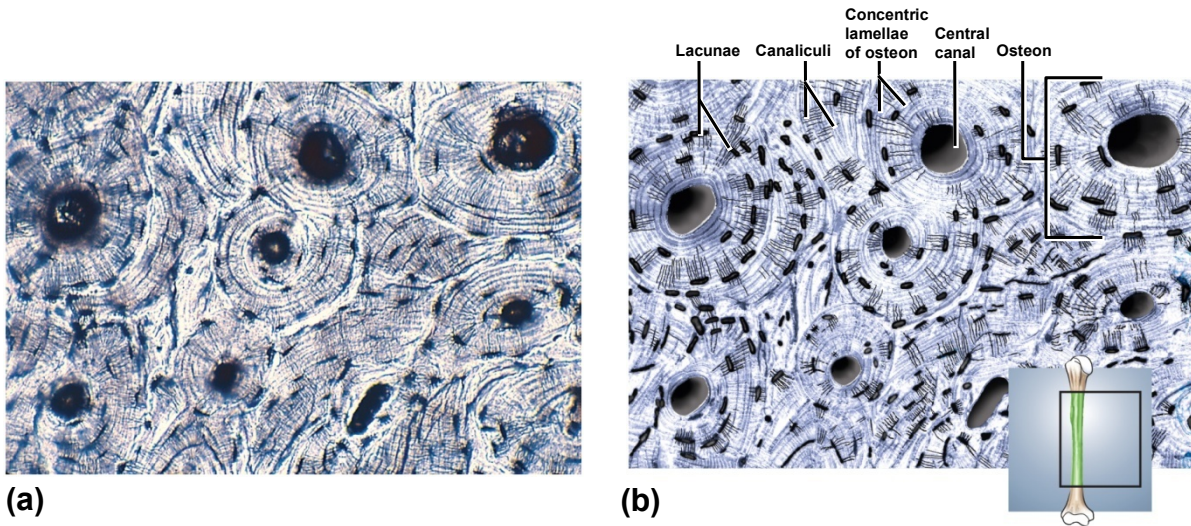
- cartilage containing large, coarse bundles of collagen fibers
- never has perichondrium
- resists compression and absorbs shock
 - pubic symphysis, menisci, and intervertebral discs

Bone

- two forms of osseous tissue
 - **spongy bone** - spongy in appearance
 - delicate struts of bone - **trabeculae**
 - covered by compact bone
 - found in heads of long bones and in middle of flat bones such as the sternum
 - **compact bone** – denser calcified tissue with no visible spaces
 - more complex arrangement
 - cells and matrix surround vertically oriented blood vessels in long bones

Bone Tissue (compact bone)

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Figure 5.22a

Figure 5.22b,i

- most compact bone is arranged in cylinders that surround **central (haversian or osteonic) canals** that run longitudinally through shafts of long bones
 - blood vessels and nerves travel through central canal
- bone matrix deposited in **concentric lamella**
 - onionlike layers around each central canal
- **osteon** – central canal and its surrounding lamellae
- **osteocytes** – mature bone cells that occupy the **lacunae**
- **canaliculi** – delicate canals that radiate from each lacuna to its neighbors, and allows osteocytes to contact each other
- **periosteum** – tough fibrous connective tissue covering of the bone as a whole

Blood

- fluid connective tissue
- transports cells and dissolved matter from place to place
- **plasma** – blood's liquid ground substance
- **formed elements** – cells and cell fragments
 - **erythrocytes** – red blood cells – transport O₂ and CO₂
 - **leukocytes** – white blood cells – defense against infection and other diseases
 - **platelets** – cell fragments involved in clotting and other mechanisms

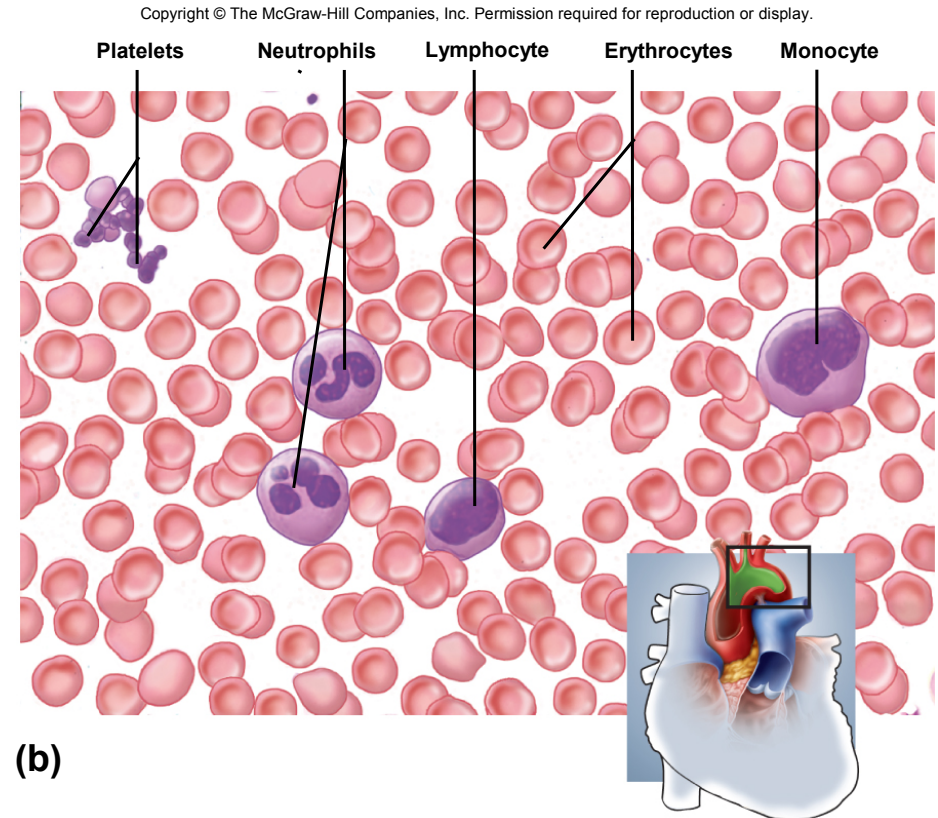


Figure 5.23b,i

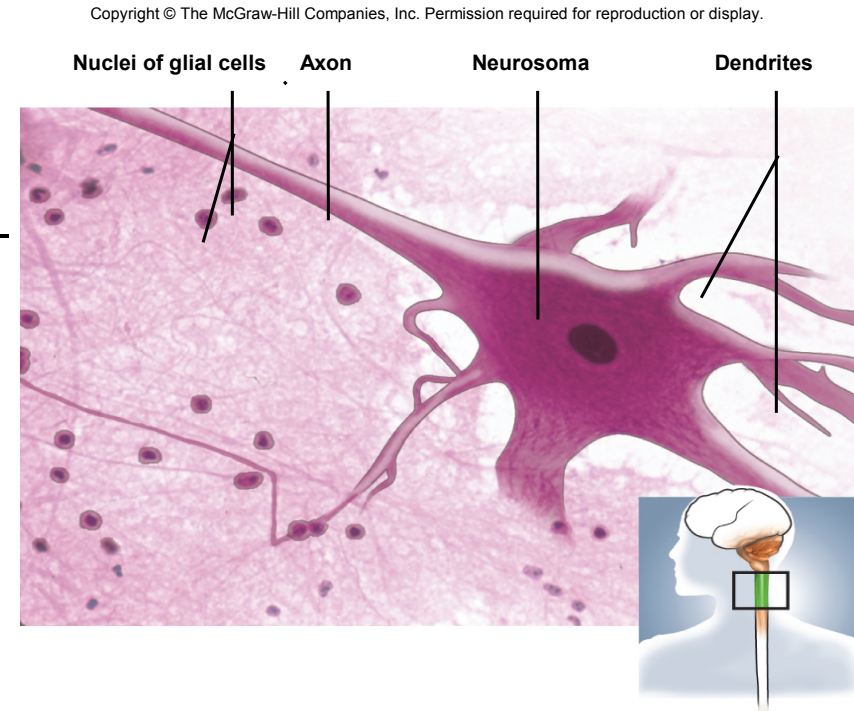
Excitable Tissues

Muscular & Nervous Tissue

- **excitability** – a characteristic of all living cells
 - developed to highest degree in nervous and muscular tissues
- **membrane potential** – electrical charge difference (voltage) that occurs across the plasma membranes is the basis for their excitation
 - respond quickly to outside **stimulus** by means of changes in membrane potential
 - **nerves** – changes result in rapid transmission of signals to other cells
 - **muscles** – changes result in contraction, shortening of the cell

Nervous Tissue

- **nervous tissue** – specialized for communication by **electrical and chemical signals**
- consists of **neurons (nerve cells)** –
 - detect stimuli
 - respond quickly
 - transmit coded information rapidly to other cells
- and **neuroglia (glial)**
 - protect and assist neurons
 - ‘housekeepers’ of nervous system
- **neuron parts**
 - **neurosoma (cell body)**
 - houses nucleus and other organelles
 - cell’s center of genetic control and protein synthesis
 - **dendrites**
 - multiple short, branched processes
 - receive signals from other cells
 - transmit messages to neurosoma
 - **axon (nerve fiber)**
 - sends outgoing signals to other cells
 - can be more than a meter long



(b)

Figure 5.24b,i

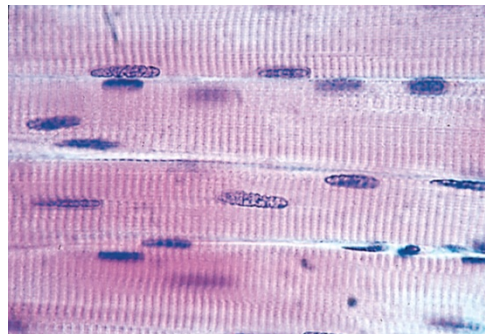
Muscular Tissue

- **muscular tissue** – elongated cells that are specialized to contract in response to stimulation
- primary job is to **exert physical force** on other tissues and organs
- **creates movements** involved in body and limb movement, digestion, waste elimination, breathing, speech, and blood circulation
- important source of **body heat**
- three types of muscle: **skeletal, cardiac, and smooth**

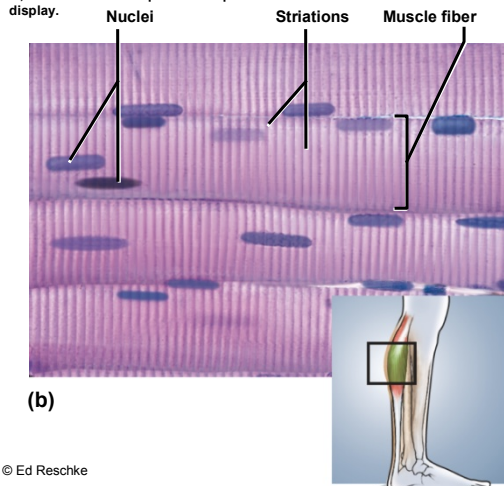
Skeletal Muscle

- long, threadlike cells – muscle fibers
- most attach to bone
- exceptions – in tongue, upper esophagus, facial muscles, some **sphincter muscles** – (ringlike or cufflike muscles that open and close body passages)
- contains **multiple nuclei** adjacent to plasma membrane
- **striations** – alternating dark and light bands
- **voluntary** – conscious control over skeletal muscles

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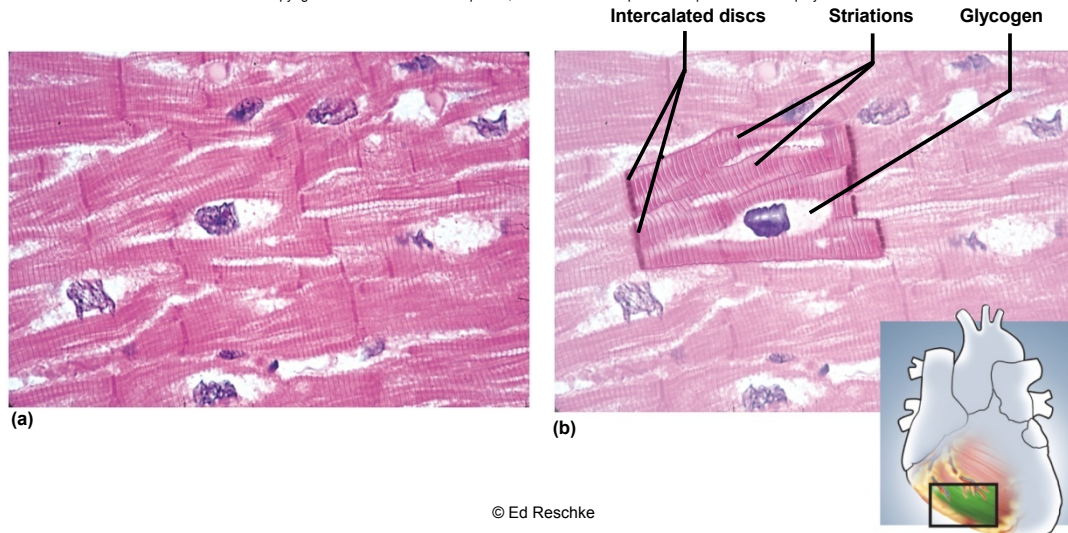
Figure 5.25a

Figure 5.25b,i

Cardiac Muscle

- limited to the heart
- **myocytes** or **cardiocytes** are much shorter, branched, and notched at ends
- contain **one centrally located nucleus** surrounded by light staining glycogen
- **intercalated discs** join cardiocytes end to end
 - provide electrical and mechanical connection
- **striated**, and **involuntary** (not under conscious control)

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Figure 5.26a

Figure 5.26b,i

Smooth Muscle

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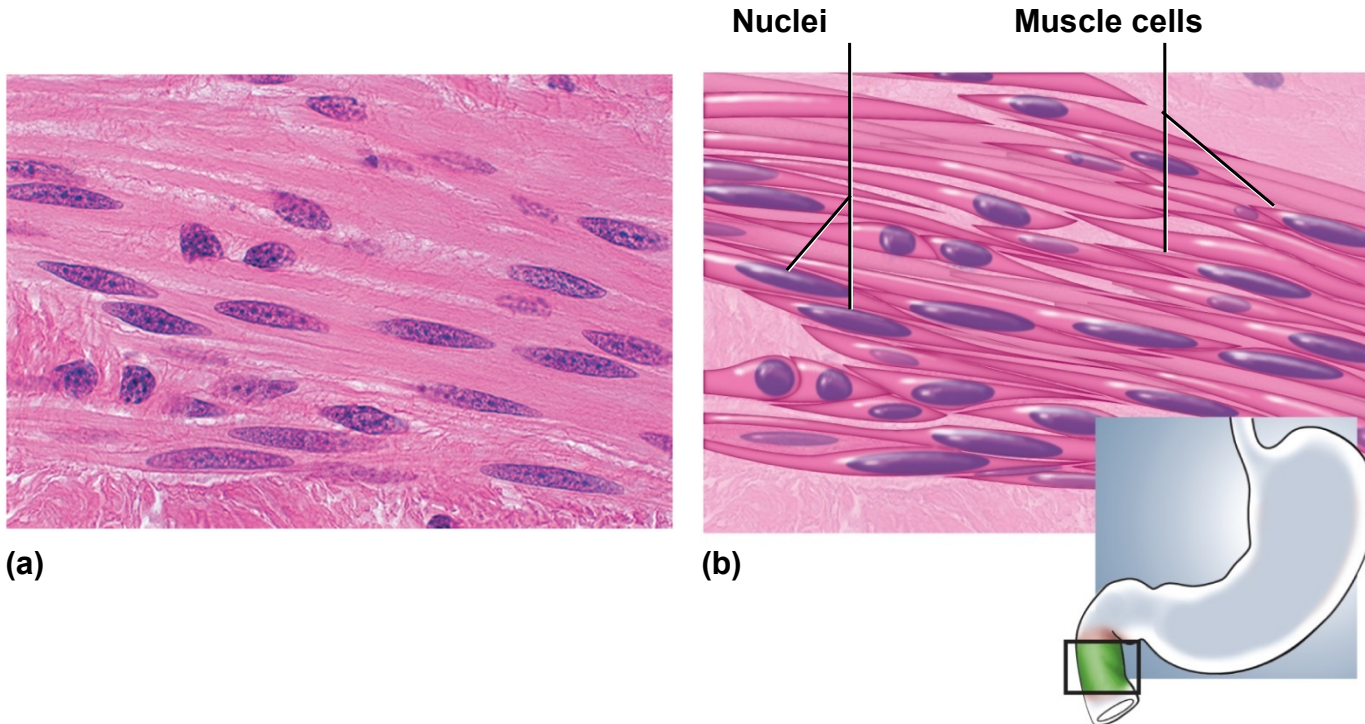


Figure 5.27a

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Figure 5.27b,i

- **lacks striations** and is **involuntary**
- relatively short, **fusiform cells** (thick in middle, tapered at ends)
- **one centrally located nucleus**
- **visceral muscle** – forms layers of digestive, respiratory, and urinary tract: blood vessels, uterus and other viscera
- propels contents through an organ, regulates diameter of blood vessels

Membranes

- **membranes** – line body cavities and cover their viscera
- **cutaneous membrane** - the skin – largest membrane in the body
 - stratified squamous epithelium (epidermis) over connective tissue (dermis)
 - relatively dry layer serves protective function
- **mucous membrane (mucosa)** – lines passageways open to the external environment
- **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)
- **synovial membrane** - lines joint cavities
 - connective tissue layer only, secretes synovial fluid

Mucous Membranes (Mucosa)

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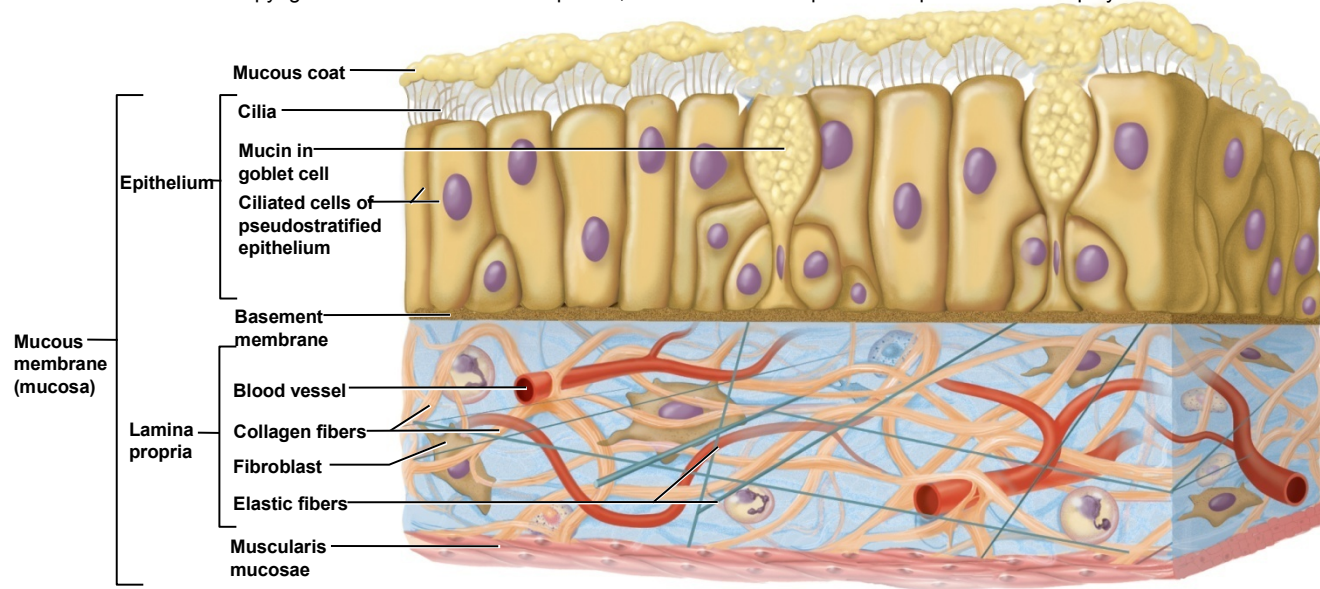


Figure 5.32

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

Tissue Growth

- **tissue growth** – increasing the number of cells or the existing cells grow larger
- **hyperplasia** - tissue growth through cell multiplication
- **hypertrophy** - enlargement of preexisting cells
 - muscle grow through exercise
 - accumulation of body fat
- **neoplasia** – development of a tumor (**neoplasm**)
 - benign or malignant
 - composed of abnormal, nonfunctional tissue

Tissue Repair

- **regeneration** - replacement of dead or damaged cells by the same type of cell as before
 - restores normal function
 - skin injuries and liver regenerate
- **fibrosis** - replacement of damaged cells with scar tissue
 - holds organs together
 - does not restore normal function
 - severe cuts and burns, healing of muscle injuries, scarring of lungs in tuberculosis