

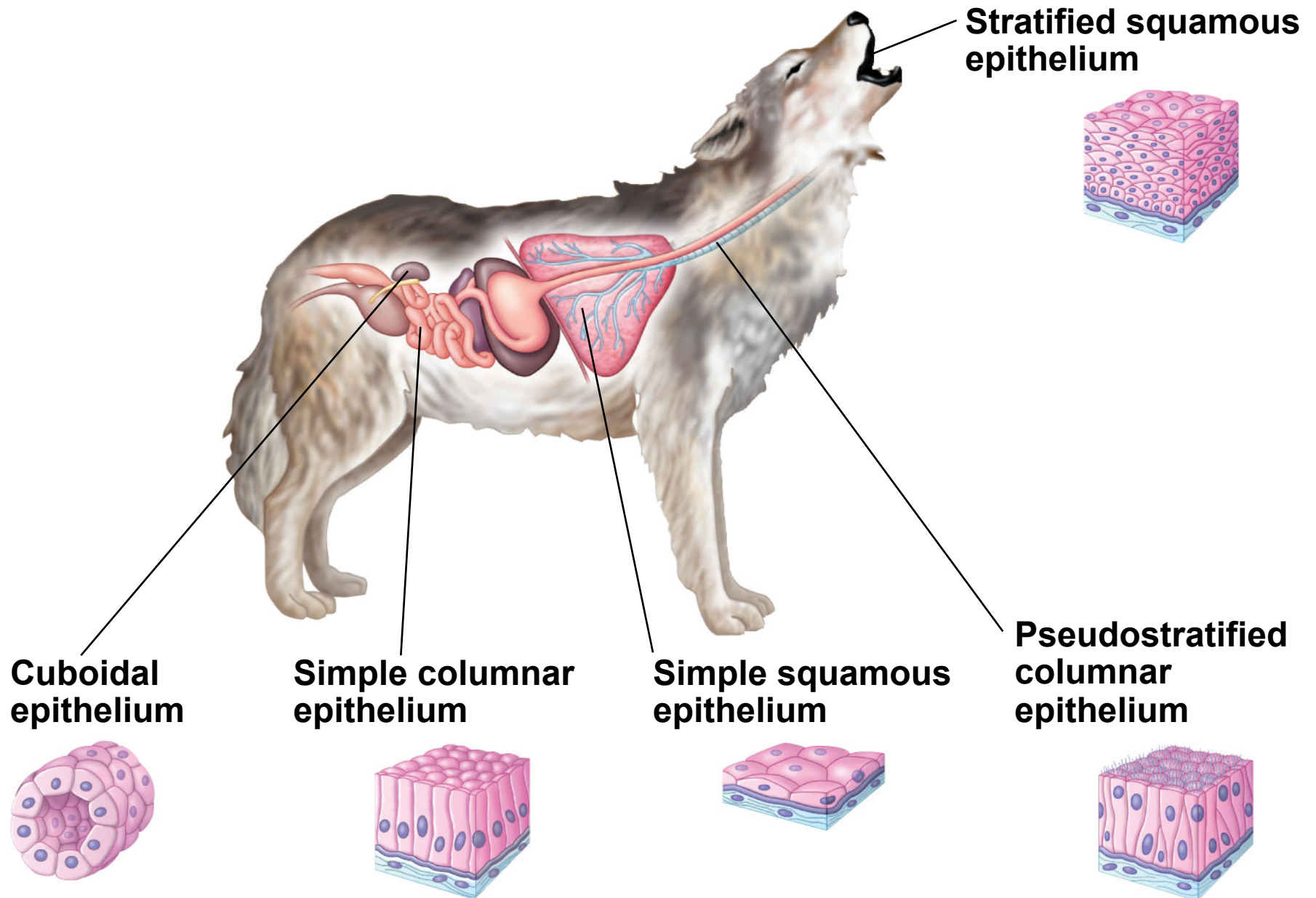
# Types of Tissue

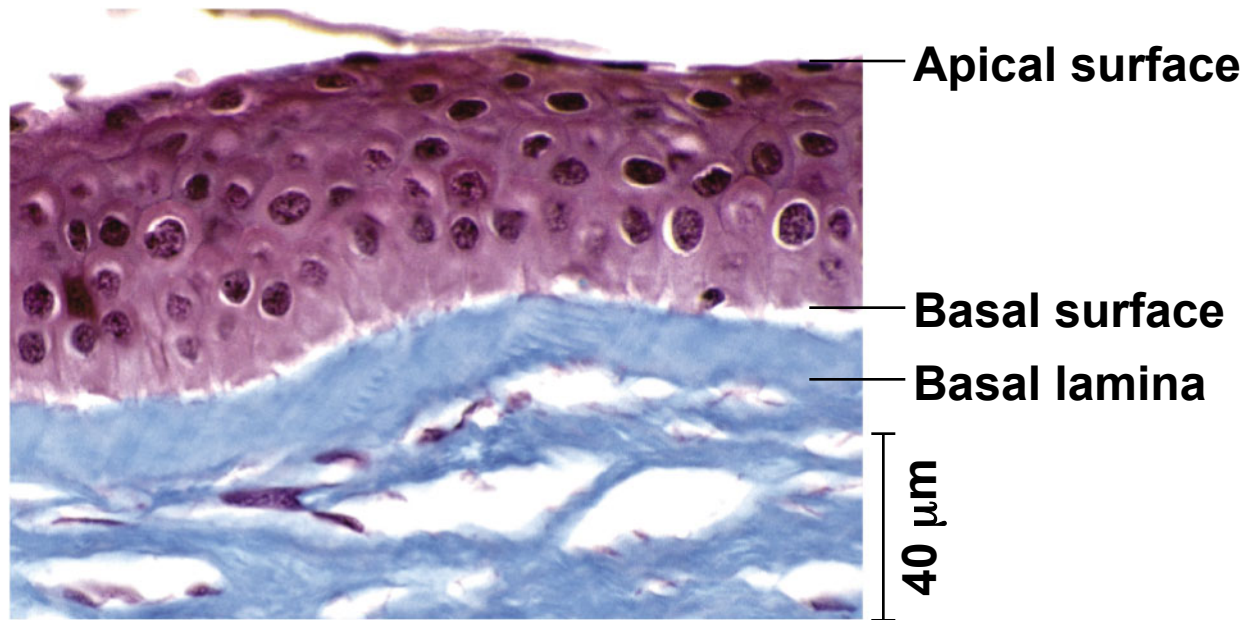
- **Epithelial Tissue**
- **Connective Tissue**
- **Muscle Tissue**
- **Nervous Tissue**

# Properties of Epithelia

- **Cellularity**
- **Polarity**
- **Avascularity**
- **Regeneration**

# Epithelial Tissue





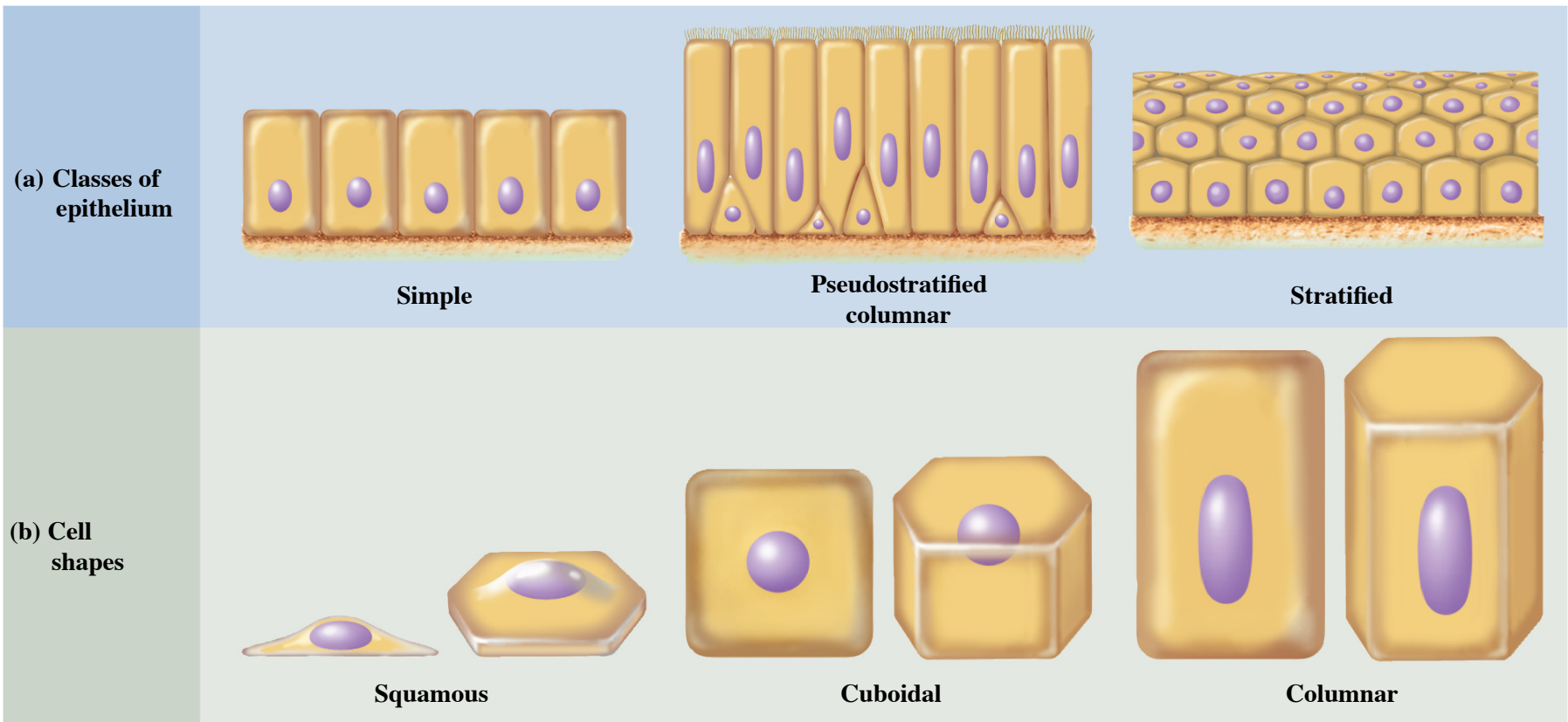
## Polarity of epithelia

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**TABLE 4.1**      **Classification of Epithelium**

Number of Layers or Category	Shape of Cells
Simple (single layer of cells)	Squamous Cuboidal Columnar
Stratified (more than one layer of cells)	Squamous Nonkeratinized (moist) Keratinized Cuboidal (very rare) Columnar (very rare)
Pseudostratified (modification of simple epithelium)	Columnar
Transitional (modification of stratified epithelium)	Roughly cuboidal to columnar when not stretched and squamouslike when stretched

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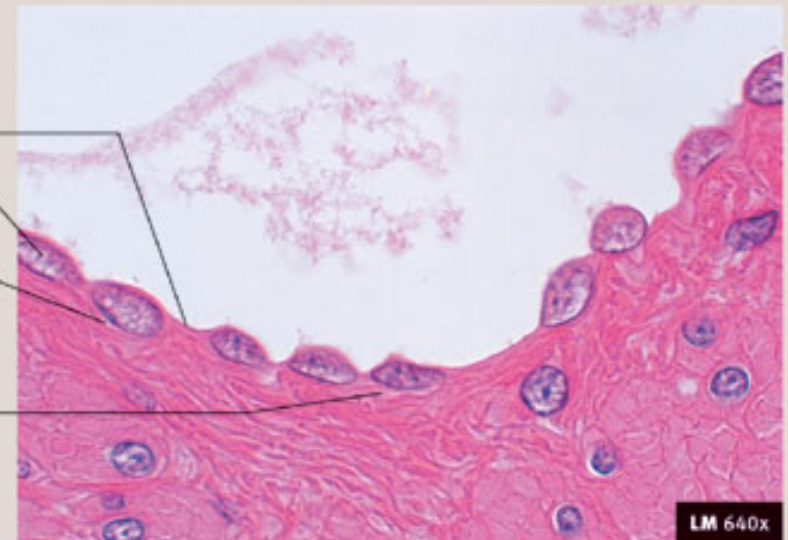
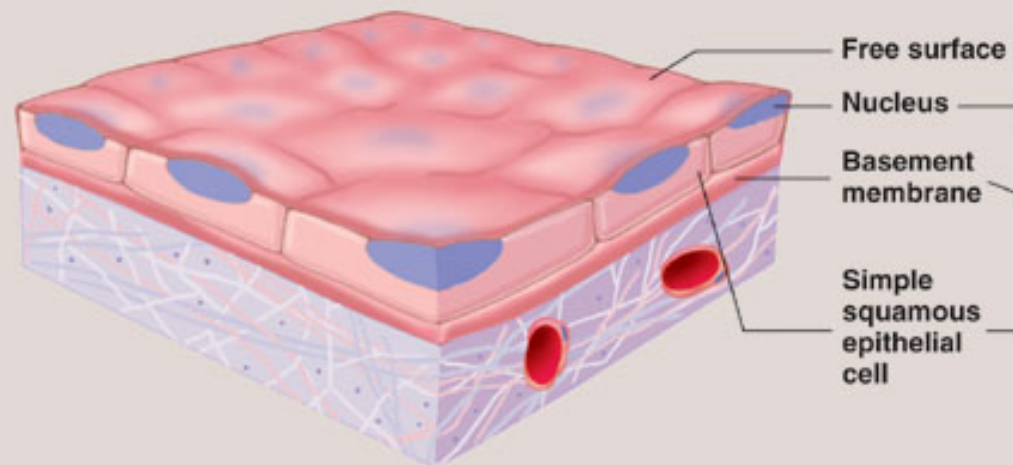
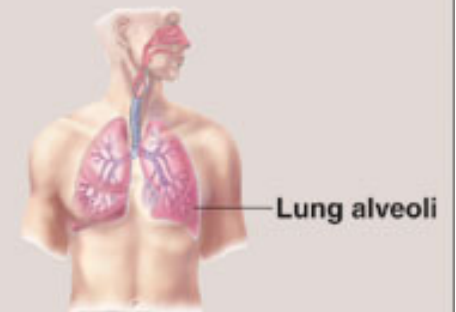
## Table 4.2 Simple Epithelium

### (a) Simple Squamous Epithelium

**Structure:** Single layer of flat, often hexagonal cells. The nuclei appear as bumps when viewed as a cross section because the cells are so flat.

**Function:** Diffusion, filtration, some protection against friction, secretion, and absorption.

**Location:** Lining of blood and lymphatic vessels (endothelium) and small ducts, alveoli of the lungs, loop of Henle in kidney tubules, lining of serous membranes (mesothelium), and inner surface of the eardrum.





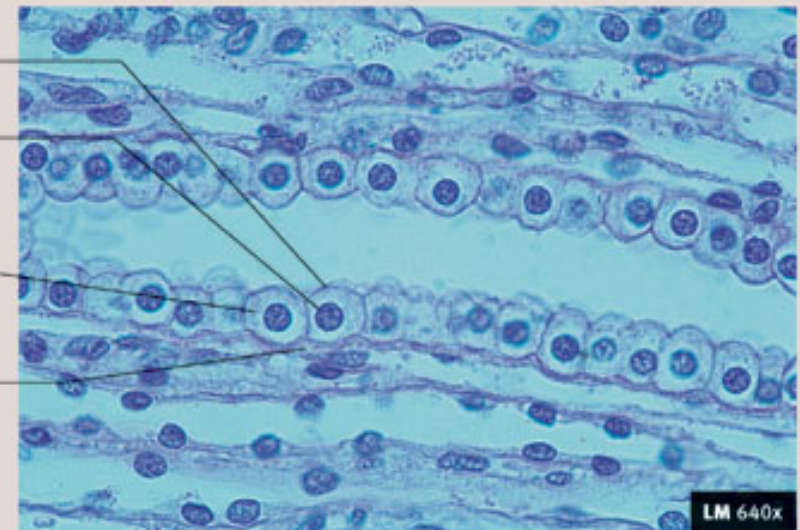
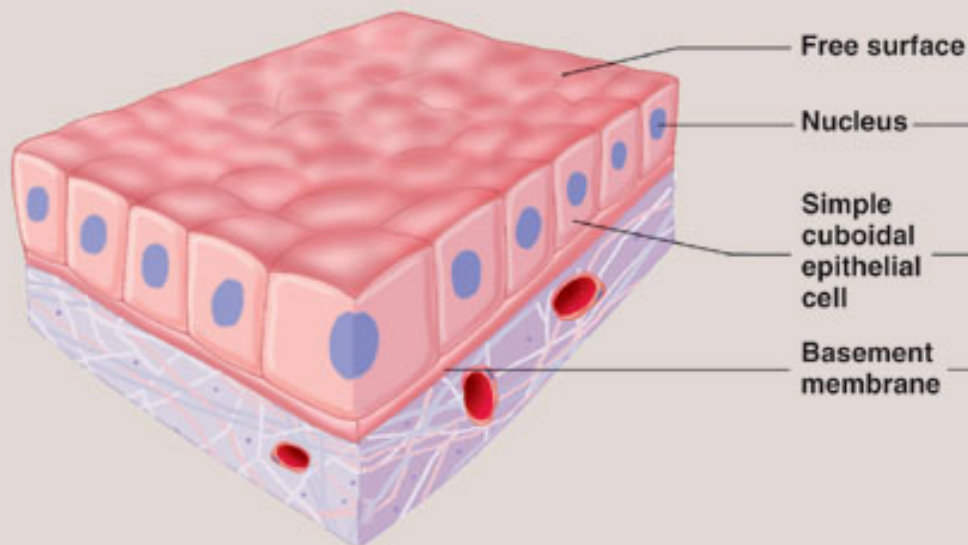
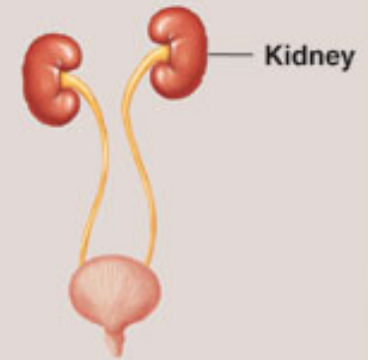
## Table 4.2 Simple Epithelium – Continued

### (b) Simple Cuboidal Epithelium

**Structure:** Single layer of cube-shaped cells; some cells have microvilli (kidney tubules) or cilia (terminal bronchioles of the lungs).

**Function:** Active transport and facilitated diffusion result in secretion and absorption by cells of the kidney tubules; secretion by cells of glands and choroid plexus; movement of particles embedded in mucus out of the terminal bronchioles by ciliated cells.

**Location:** Kidney tubules, glands and their ducts, choroid plexus of the brain, lining of terminal bronchioles of the lungs, and surface of the ovaries.





## Table 4.2 Simple Epithelium – Continued

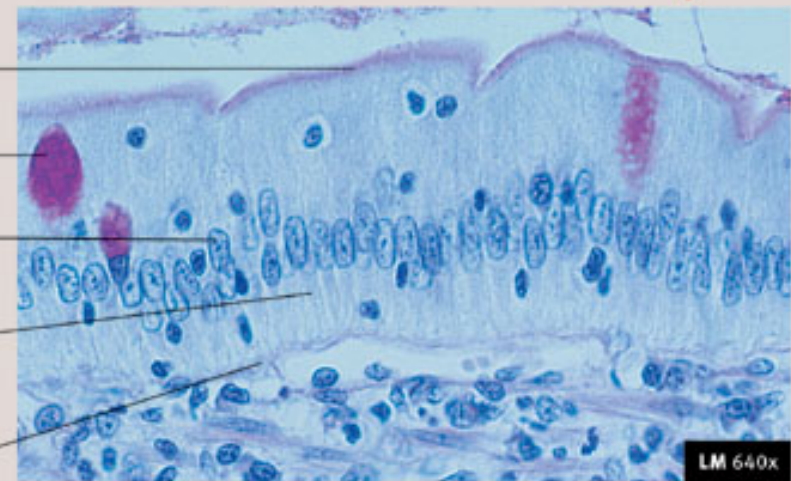
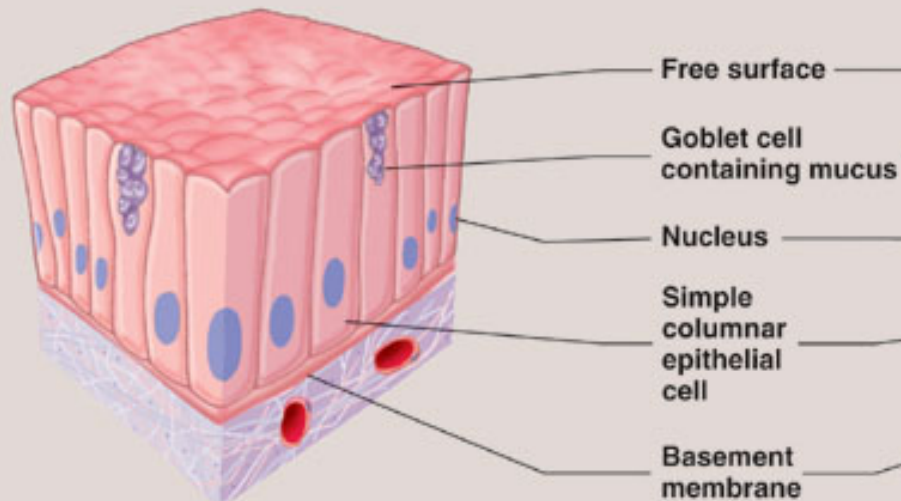
### (c) Simple Columnar Epithelium

**Structure:** Single layer of tall, narrow cells. Some cells have cilia (bronchioles of lungs, auditory tubes, uterine tubes, and uterus) or microvilli (intestines).

**Function:** Movement of particles out of the bronchioles of the lungs by ciliated cells; partially responsible for the movement of the oocyte through the uterine tubes by ciliated cells. Secretion by cells of the glands, the stomach, and the intestine. Absorption by cells of the intestine.

**Location:** Glands and some ducts, bronchioles of lungs, auditory tubes, uterus, uterine tubes, stomach, intestines, gallbladder, bile ducts, and ventricles of the brain.

**Lining of stomach and intestines**



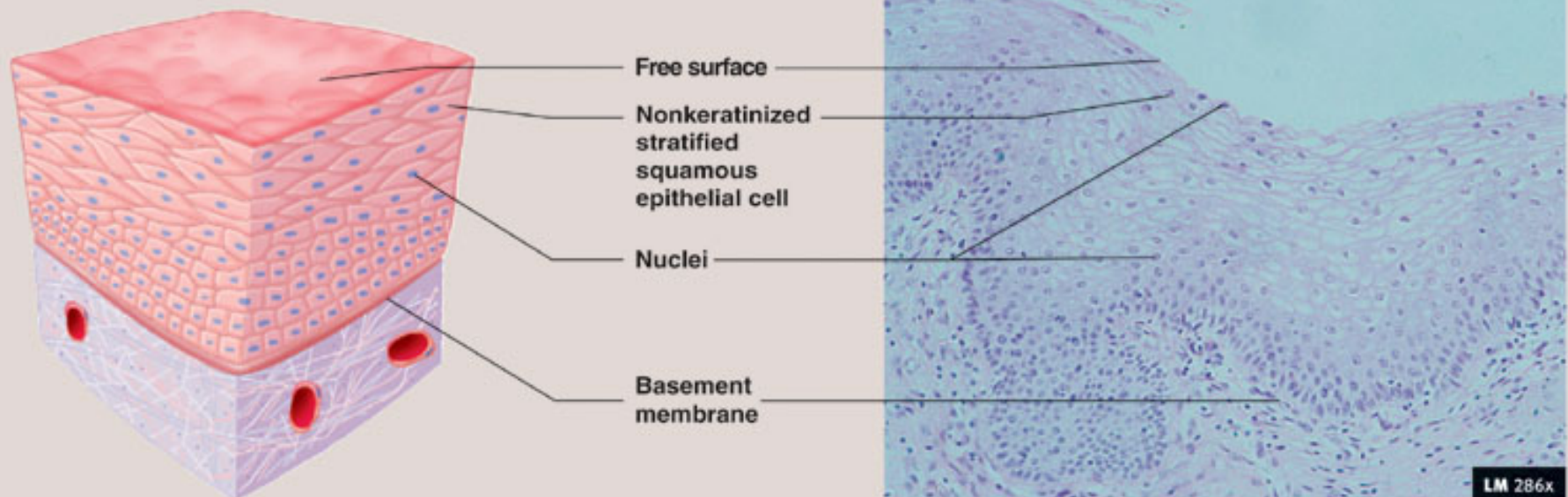
## Table 4.3 Stratified Epithelium

### (a) Stratified Squamous Epithelium

**Structure:** Multiple layers of cells that are cuboidal in the basal layer and progressively flattened toward the surface. The epithelium can be nonkeratinized or keratinized. In nonkeratinized stratified squamous epithelium the surface cells retain a nucleus and cytoplasm. In keratinized stratified epithelium, the cytoplasm of cells at the surface is replaced by a protein called keratin, and the cells are dead.

**Function:** Protection against abrasion, barrier against infection, and prevents loss of water from the body.

**Location:** Keratinized—skin. Nonkeratinized—mouth, throat, larynx, esophagus, anus, vagina, inferior urethra, and cornea.



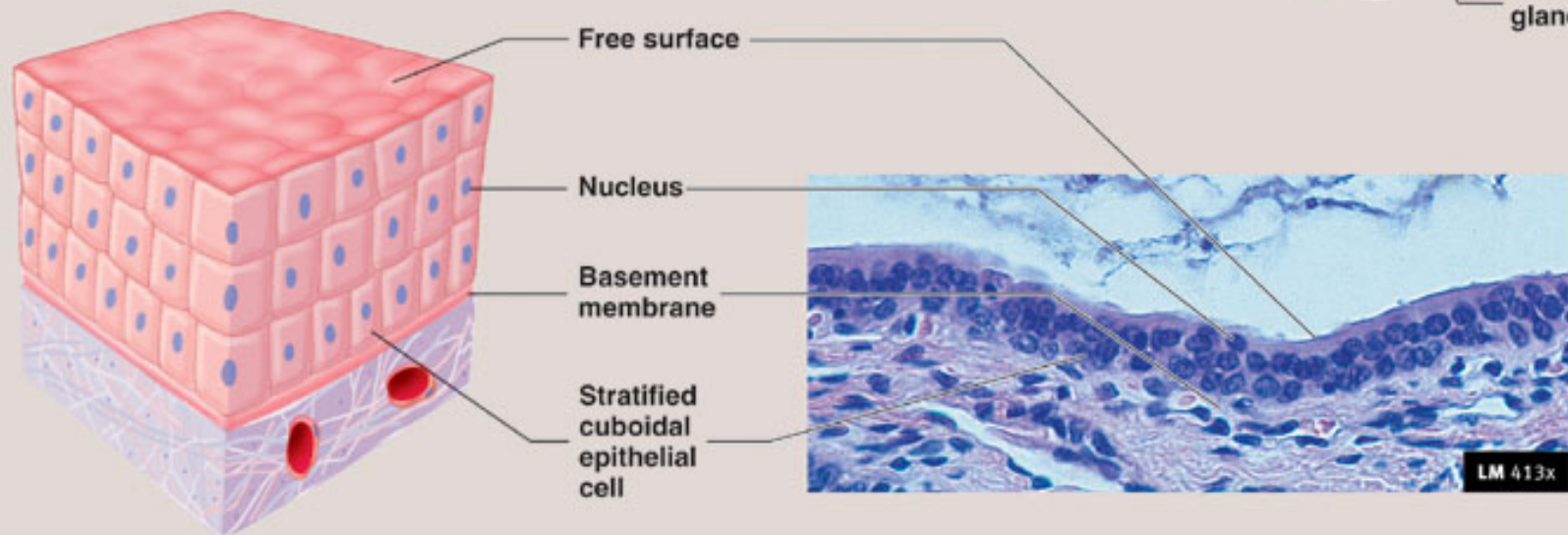
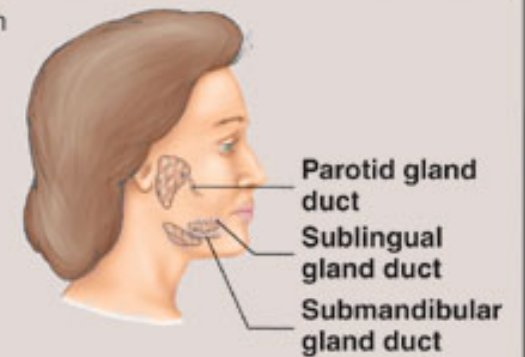
## Table 4.3 Stratified Epithelium – Continued

### (b) Stratified Cuboidal Epithelium

**Structure:** Multiple layers of somewhat cube-shaped cells.

**Function:** Secretion, absorption, and protection against infection.

**Location:** Sweat gland ducts, ovarian follicular cells, and salivary gland ducts.





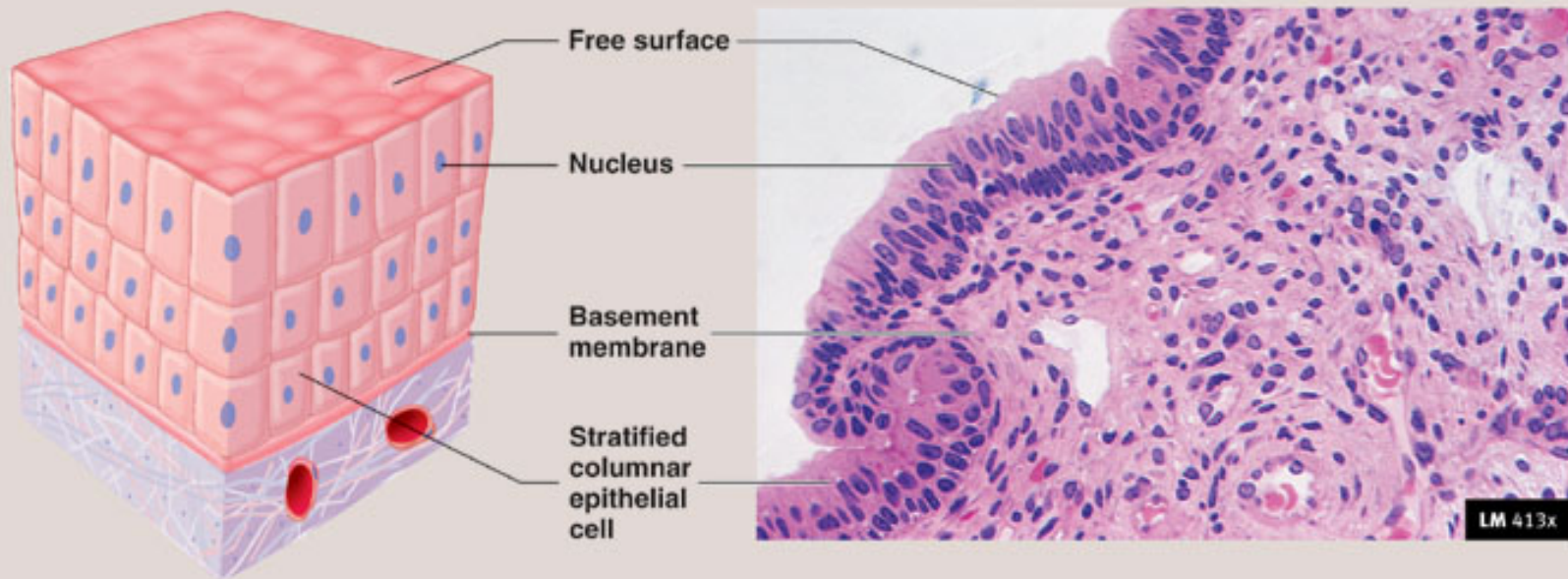
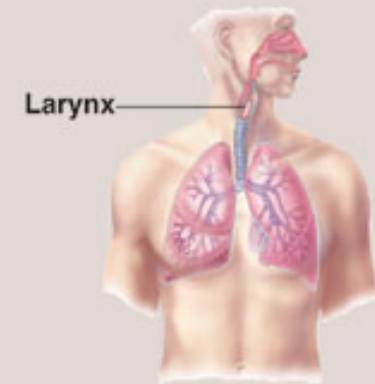
## Table 4.3 Stratified Epithelium – Continued

### (c) Stratified Columnar Epithelium

**Structure:** Multiple layers of cells, with tall, thin cells resting on layers of more cuboidal cells. The cells are ciliated in the larynx.

**Function:** Protection and secretion.

**Location:** Mammary gland duct, larynx, and a portion of the male urethra.



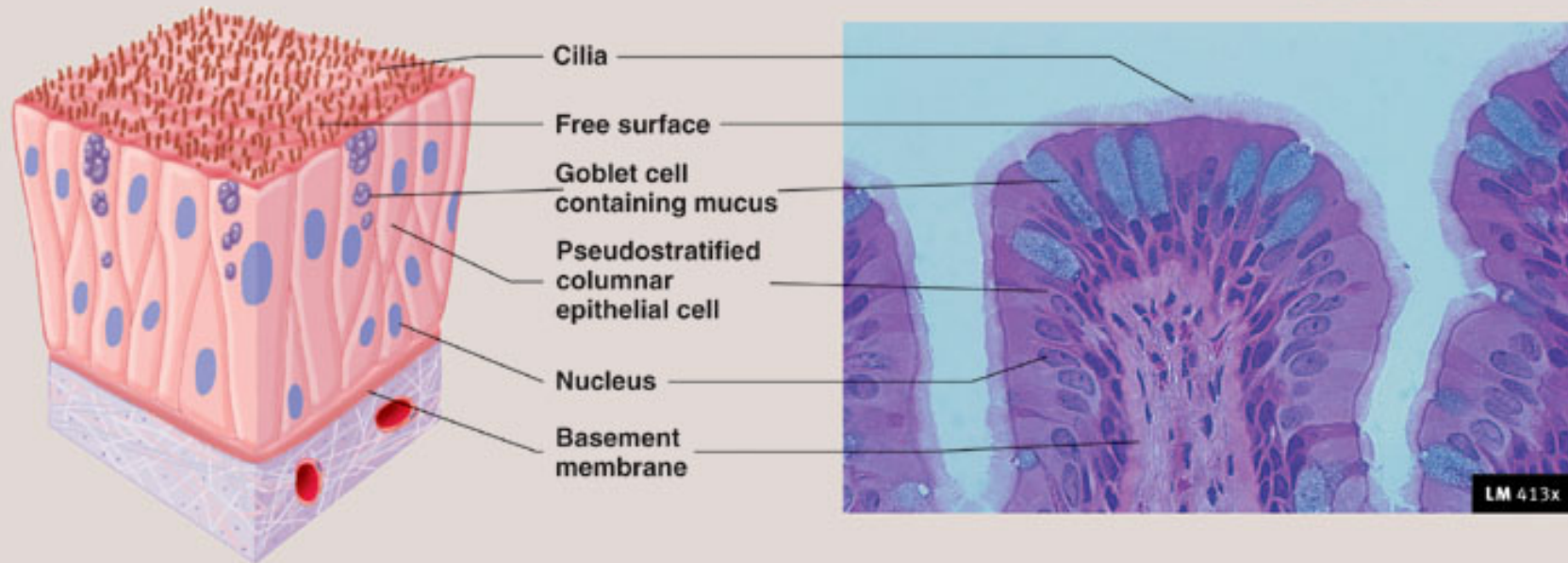
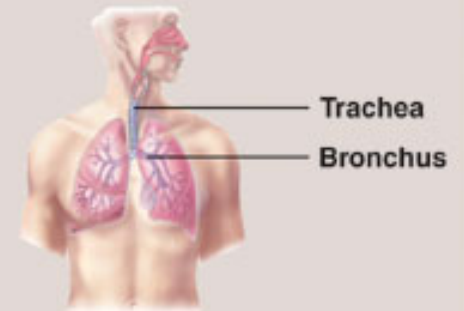
## Table 4.4 Pseudostratified Columnar Epithelium and Transitional Epithelium

### (a) Pseudostratified Columnar Epithelium

**Structure:** Single layer of cells; some cells are tall and thin and reach the free surface, and others do not; the nuclei of these cells are at different levels and appear stratified; the cells are almost always ciliated and are associated with goblet cells that secrete mucus onto the free surface.

**Function:** Synthesize and secrete mucus onto the free surface and move mucus (or fluid) that contains foreign particles over the surface of the free surface and from passages.

**Location:** Lining of nasal cavity, nasal sinuses, auditory tubes, pharynx, trachea, and bronchi of lungs.





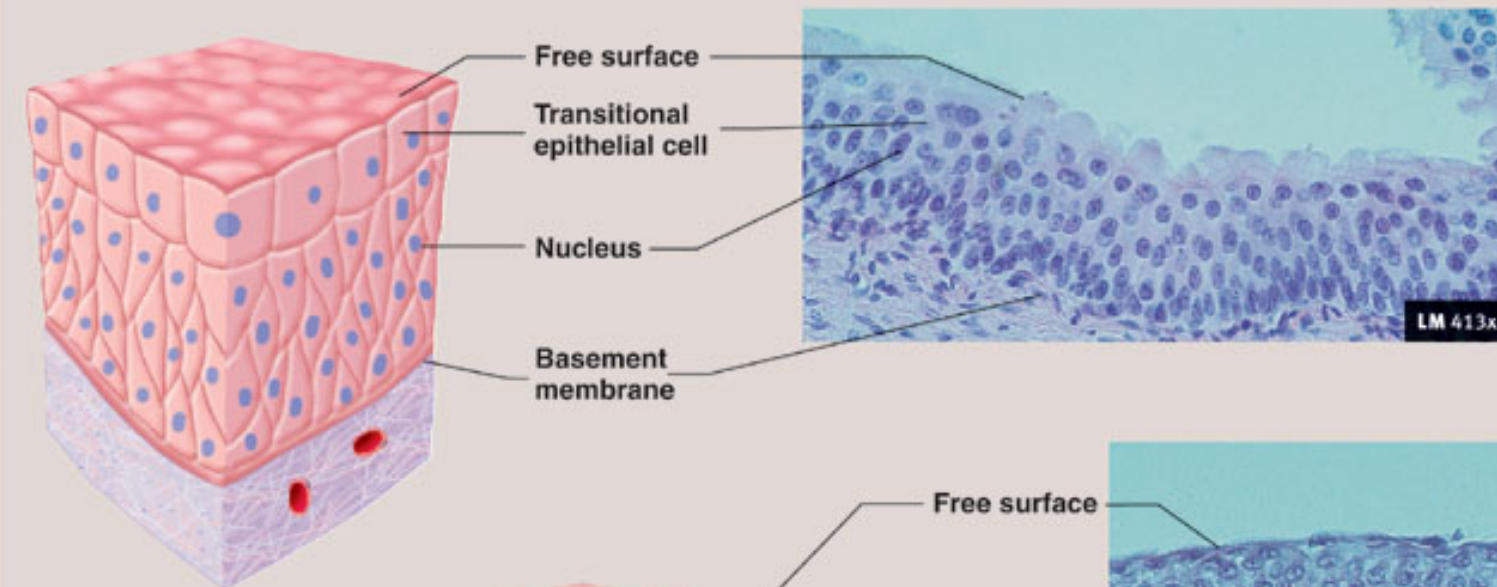
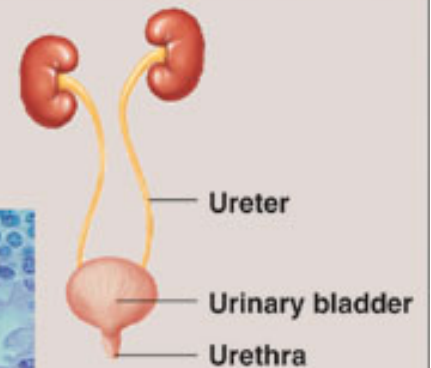
## Table 4.4 Pseudostratified Columnar Epithelium and Transitional Epithelium – Continued

### (b) Transitional Epithelium

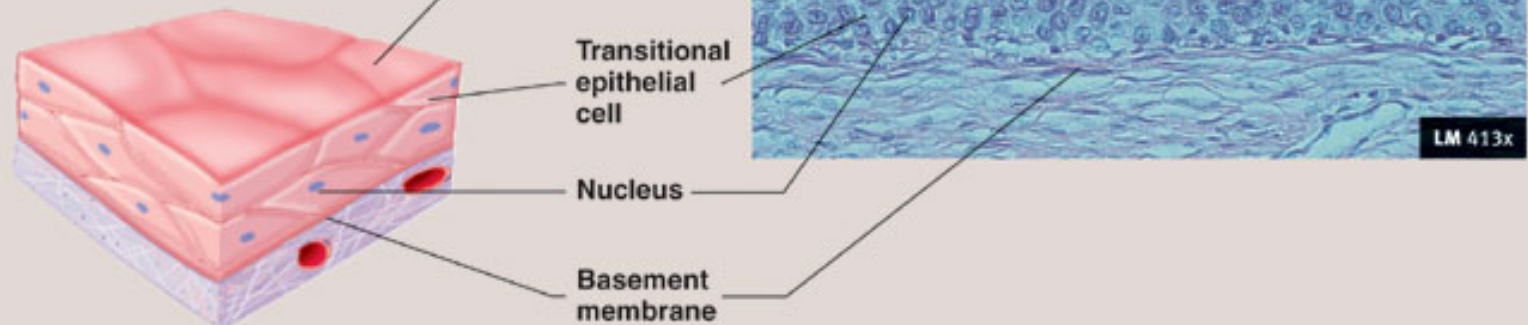
**Structure:** Stratified cells that appear cuboidal when the organ or tube is not stretched and squamous when the organ or tube is stretched by fluid.

**Function:** Accommodates fluctuations in the volume of fluid in an organ or tube; protection against the caustic effects of urine.

**Location:** Lining of urinary bladder, ureters, and superior urethra.



Tissue not stretched



Tissue stretched

# **Constituents of Connective Tissues**

## **1. Cells**

**A. Blasts**

**B. Cytes**

**C. Clasts**

## **2. Extracellular Matrix**

**A. Ground Substance**

**B. Fibers**

**I. Collagenous**

**II. Elastic**

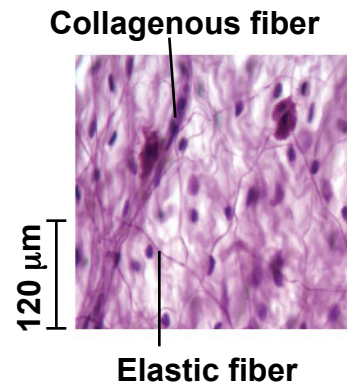
**III. Reticular**

**TABLE 4.6**      **Classification of Connective Tissue**

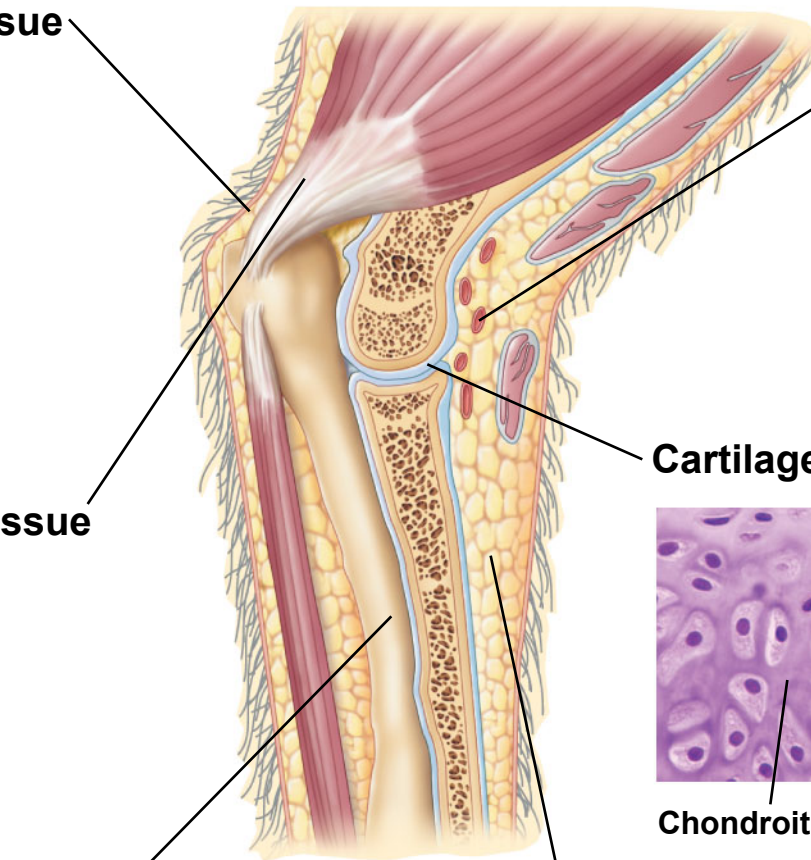
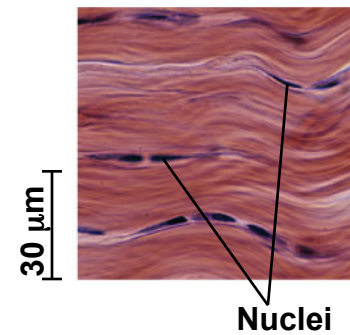
- A. Embryonic connective tissue
  - 1. Mesenchyme
  - 2. Mucous
- B. Adult connective tissue
  - 1. Loose (areolar)
  - 2. Dense
    - a. Dense, regular collagenous
    - b. Dense, regular elastic
    - c. Dense, irregular collagenous
    - d. Dense, irregular elastic
  - 3. Special properties
    - a. Adipose
    - b. Reticular
  - 4. Cartilage
    - a. Hyaline
    - b. Fibrocartilage
    - c. Elastic
  - 5. Bone
    - a. Cancellous
    - b. Compact
  - 6. Blood and hemopoietic tissue

# Connective Tissue

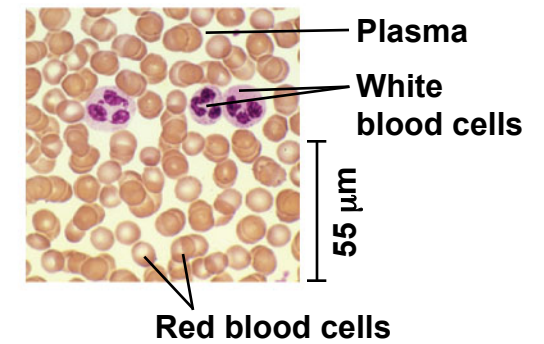
## Loose connective tissue



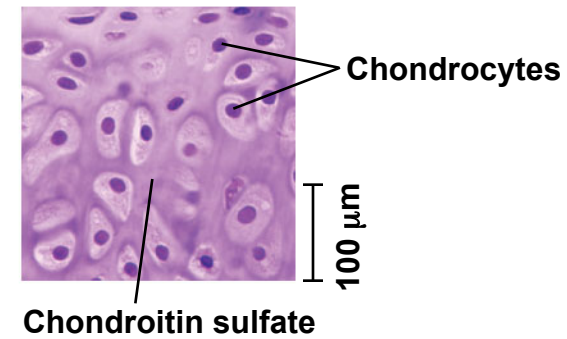
## Fibrous connective tissue



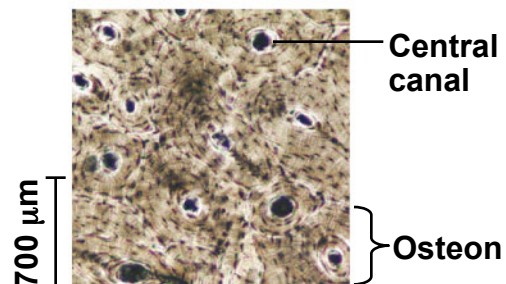
## Blood



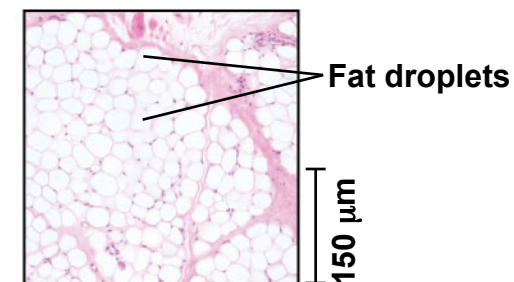
## Cartilage



## Bone



## Adipose tissue





## Table 4.7 Embryonic Connective Tissue

### (a) Mesenchyme

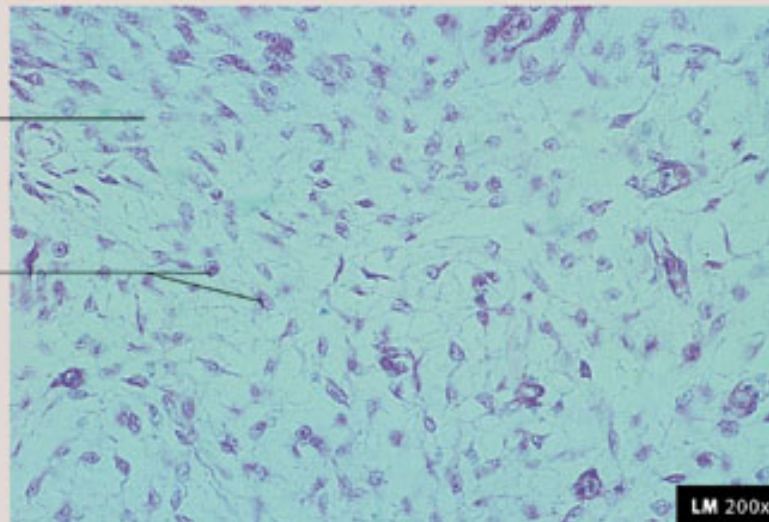
**Structure:** The mesenchymal cells are irregularly shaped. The extracellular matrix is abundant and contains scattered reticular fibers.

**Location:** Mesenchyme is the embryonic tissue from which connective tissues, as well as other tissues, arise.



Intercellular  
matrix

Nuclei of  
mesenchyme  
cells



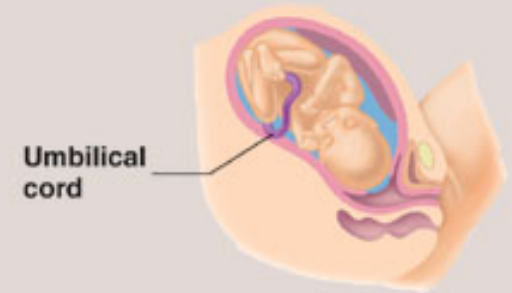


## Table 4.7 Embryonic Connective Tissue – Continued

### (b) Mucous Connective Tissue

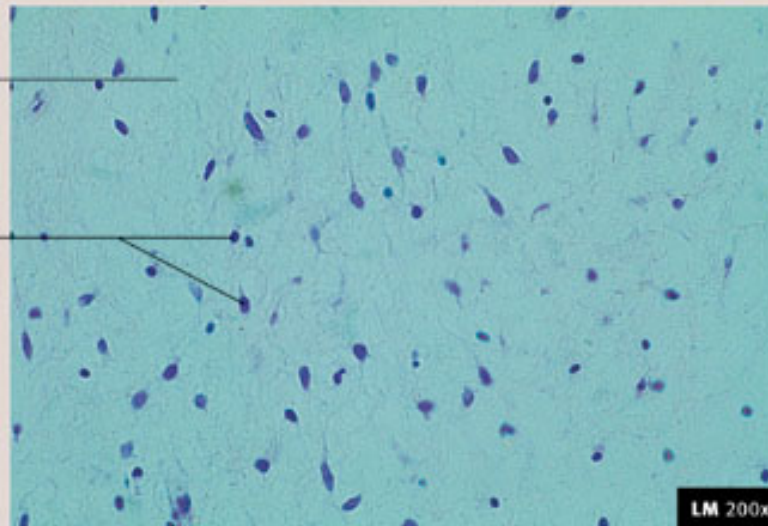
**Structure:** Mucous tissue is mesenchymal tissue that remains unspecialized. The cells are irregularly shaped. The extracellular matrix is abundant and contains scattered reticular fibers.

**Location:** Umbilical cord of newborn.



Intercellular matrix

Nuclei of mucous connective tissue cells

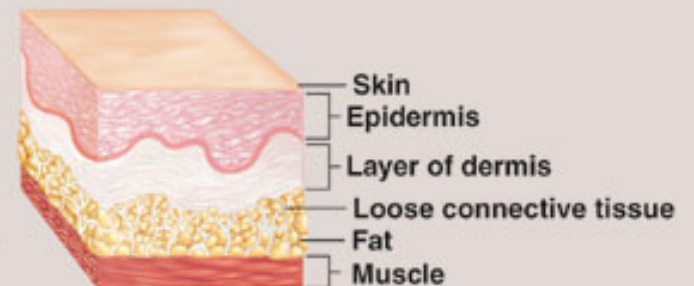
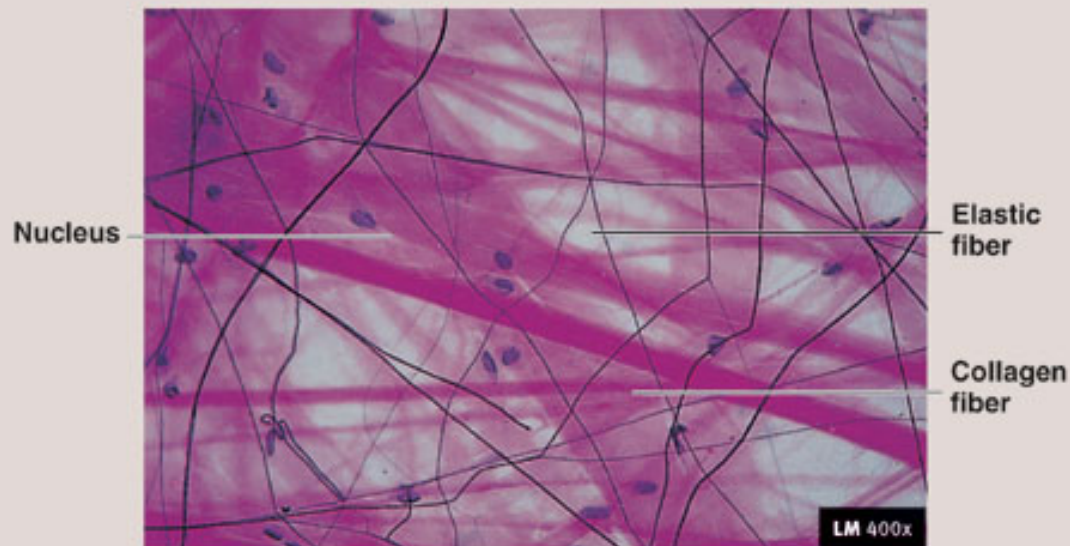


## Table 4.8 Loose Connective Tissue

**Structure:** Cells (e.g., fibroblasts, macrophages, and lymphocytes) within a fine network of mostly collagen fibers. Often merges with denser connective tissue.

**Function:** Loose packing, support, and nourishment for the structures with which it is associated.

**Location:** Widely distributed throughout the body; substance on which epithelial basement membranes rest; packing between glands, muscles, and nerves. Attaches the skin to underlying tissues.



## Table 4.9 Dense Connective Tissue

### (a) Dense Regular Collagenous Connective Tissue

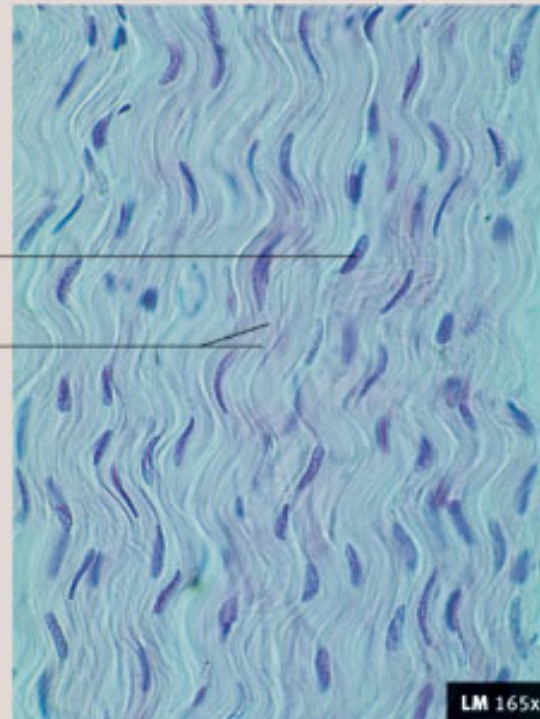
**Structure:** Matrix composed of collagen fibers running in somewhat the same direction.

**Function:** Ability to withstand great pulling forces exerted in the direction of fiber orientation, great tensile strength, and stretch resistance.

**Location:** Tendons (attach muscle to bone) and ligaments (attach bones to each other).

Nucleus of fibroblast

Collagen fibers



Ligament

Tendon



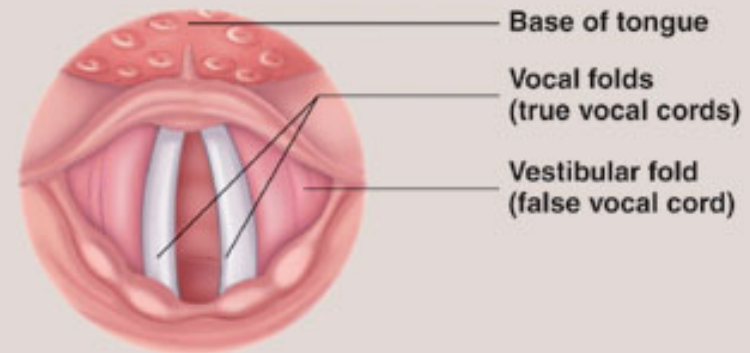
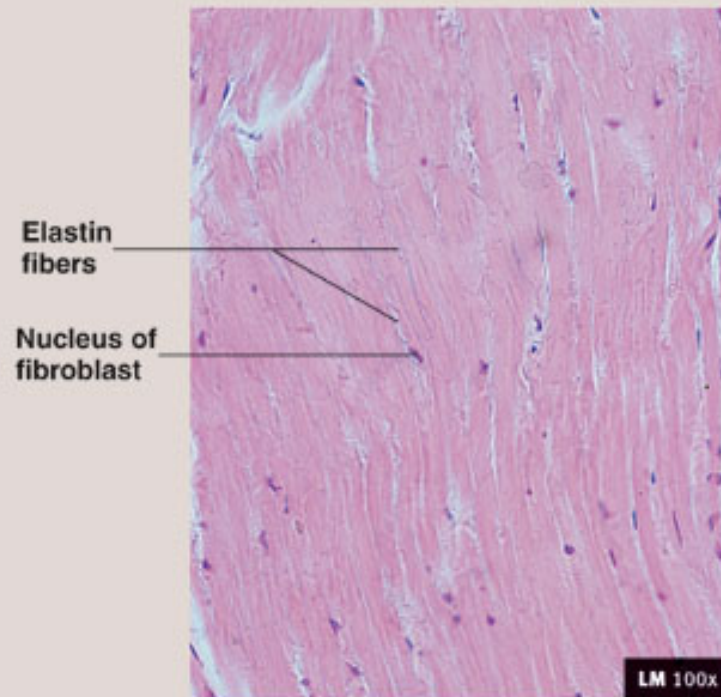
## Table 4.9 Dense Connective Tissue – Continued

### (b) Dense Regular Elastic Connective Tissue

**Structure:** Matrix composed of regularly arranged collagen fibers and elastin fibers.

**Function:** Capable of stretching and recoiling like a rubber band with strength in the direction of fiber orientation.

**Location:** Ligaments between the vertebrae and along the dorsal aspect of the neck (nucha) and in the vocal cords.





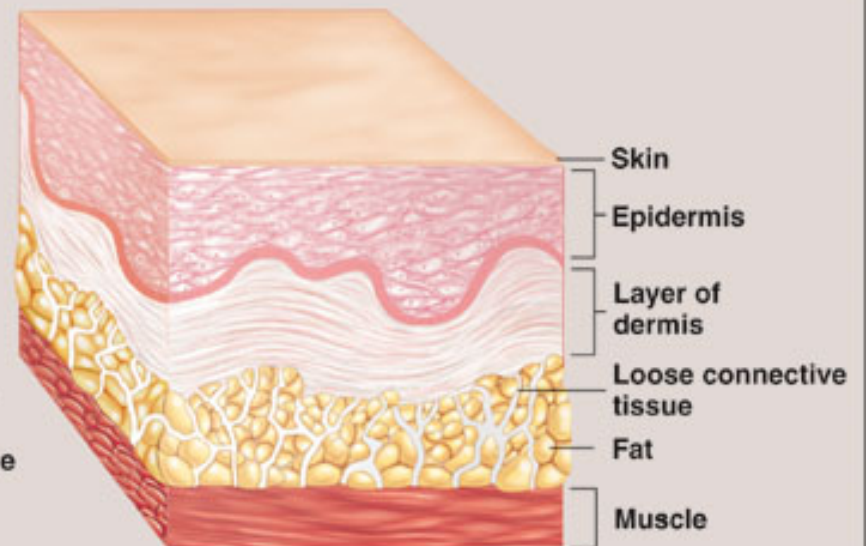
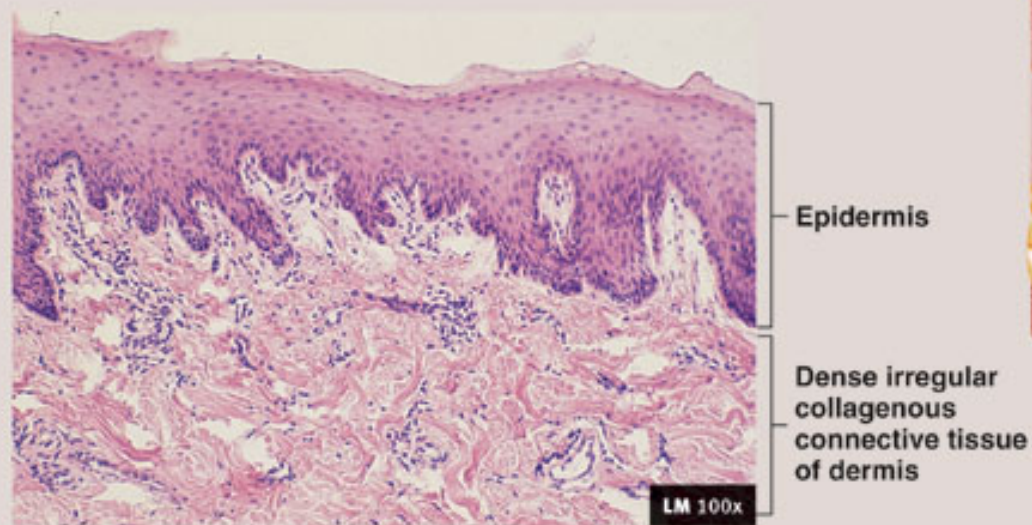
## Table 4.9 Dense Connective Tissue – Continued

### (c) Dense Irregular Collagenous Connective Tissue

**Structure:** Matrix composed of collagen fibers that run in all directions or in alternating planes of fibers oriented in a somewhat single direction.

**Function:** Tensile strength capable of withstanding stretching in all directions.

**Location:** Sheaths; most of the dermis of the skin; organ capsules and septa; outer covering of body tubes.





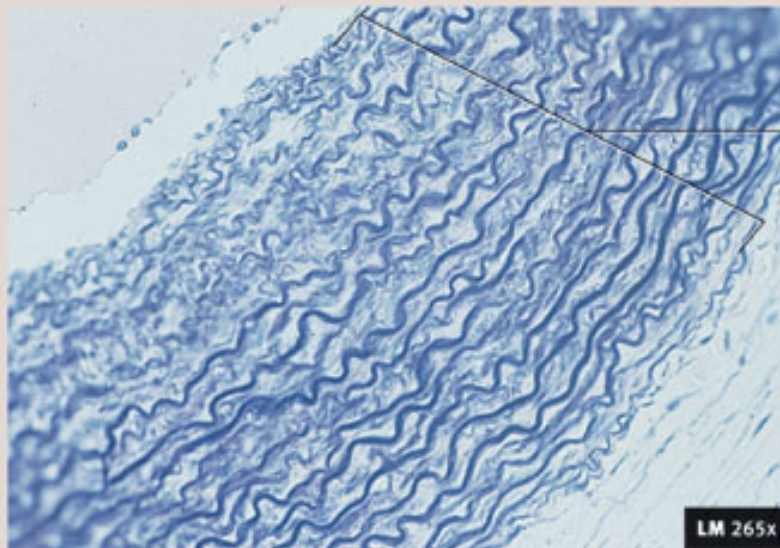
## Table 4.9 Dense Connective Tissue – Continued

### (d) Dense Irregular Elastic Connective Tissue

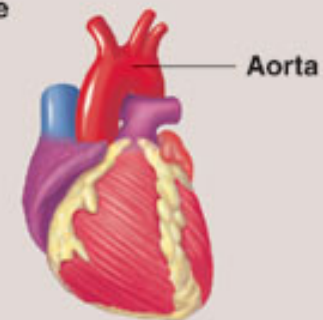
**Structure:** Matrix composed of bundles and sheets of collagenous and elastin fibers oriented in multiple directions.

**Function:** Capable of strength with stretching and recoil in several directions.

**Location:** Elastic arteries.



Dense irregular elastic connective tissue



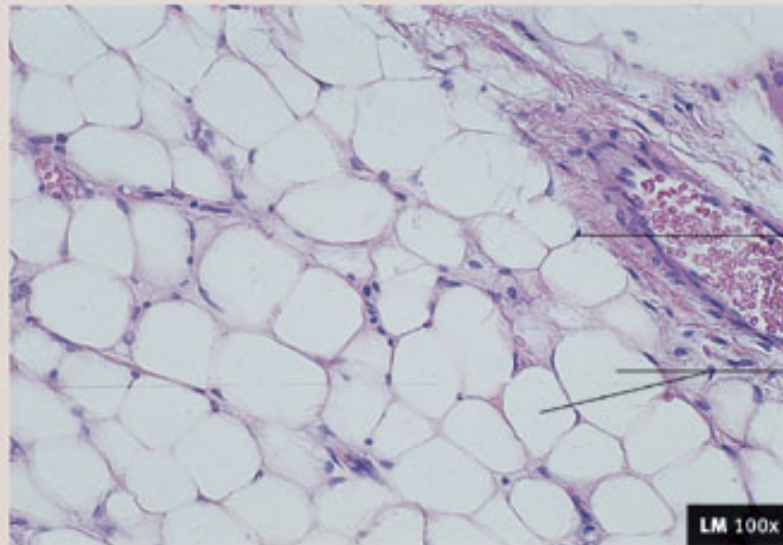
## Table 4.10 Connective Tissue with Special Properties

### (a) Adipose Tissue

**Structure:** Little extracellular matrix surrounding cells. The adipocytes, or fat cells, are so full of lipid that the cytoplasm is pushed to the periphery of the cell.

**Function:** Packing material, thermal insulator, energy storage, and protection of organs against injury from being bumped or jarred.

**Location:** Predominantly in subcutaneous areas, mesenteries, renal pelvis, around kidneys, attached to the surface of the colon, mammary glands, and in loose connective tissue that penetrates into spaces and crevices.

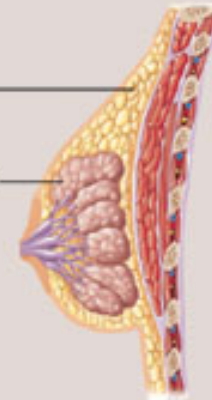


Nucleus

Adipocytes  
or fat cells

Adipose  
tissue

Mammary  
gland



## Table 4.10 Connective Tissue with Special Properties – Continued

### (b) Reticular Tissue

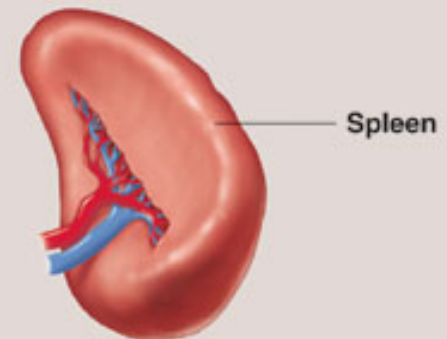
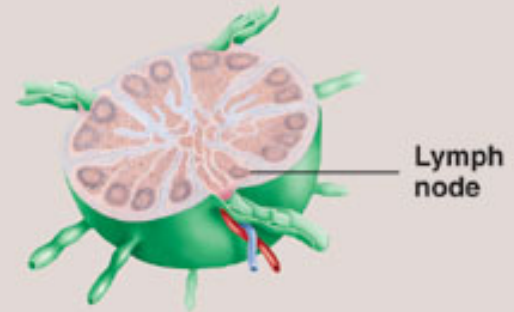
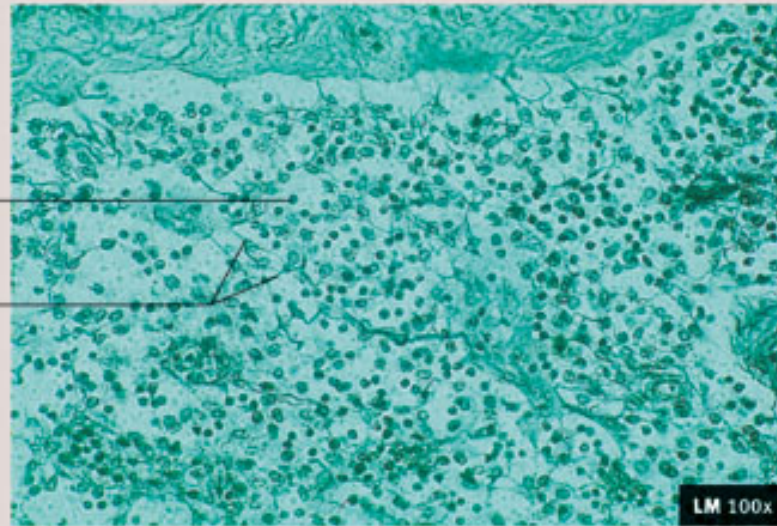
**Structure:** Fine network of reticular fibers irregularly arranged.

**Function:** Provides a superstructure for the lymphatic and hemopoietic tissues.

**Location:** Within the lymph nodes, spleen, and bone marrow.

Nucleus of lymphocyte

Reticular fibers





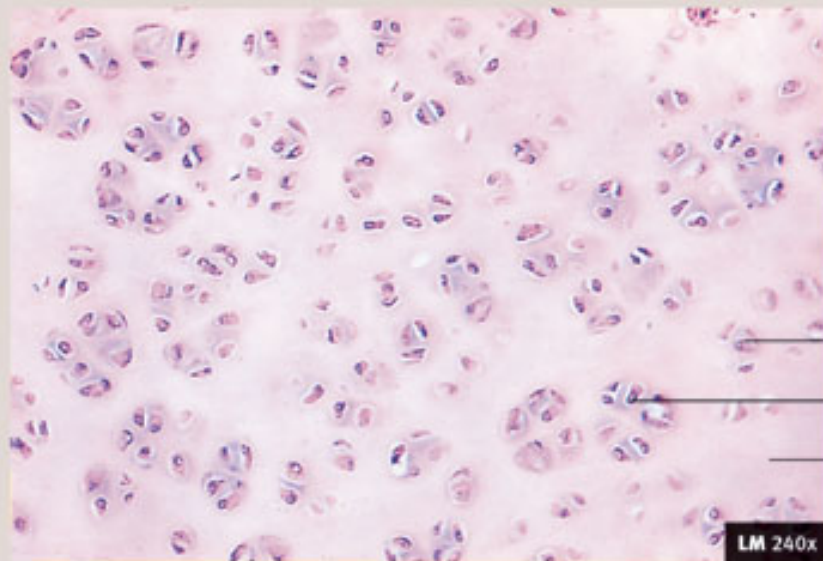
## Table 4.11 Connective Tissue: Cartilage

### (a) Hyaline Cartilage

**Structure:** Collagen fibers are small and evenly dispersed in the matrix, making the matrix appear transparent. The cartilage cells, or chondrocytes, are found in spaces, or lacunae, within the firm but flexible matrix.

**Function:** Allows growth of long bones. Provides rigidity with some flexibility in the trachea, bronchi, ribs, and nose. Forms rugged, smooth, yet somewhat flexible articulating surfaces. Forms the embryonic skeleton.

**Location:** Growing long bones, cartilage rings of the respiratory system, costal cartilage of ribs, nasal cartilage, articulating surface of bones, and the embryonic skeleton.



## Table 4.11 Connective Tissue: Cartilage – Continued

### (b) Fibrocartilage

**Structure:** Collagenous fibers similar to those in hyaline cartilage. The fibers are more numerous than in other cartilages and are arranged in thick bundles

**Function:** Somewhat flexible and capable of withstanding considerable pressure. Connects structures subjected to great pressure.

**Location:** Intervertebral disks, symphysis pubis, articular disks (e.g., knee and temporomandibular [jaw] joints).

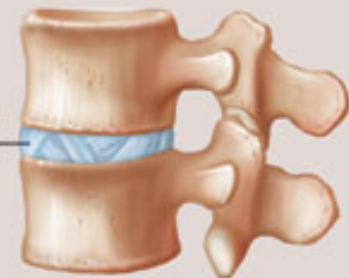


Chondrocyte  
in lacuna

Nucleus

Collagen fibers  
in matrix

Intervertebral  
disk





## Table 4.11 Connective Tissue: Cartilage – Continued

### (c) Elastic Cartilage

**Structure:** Similar to hyaline cartilage, but matrix also contains elastin fibers.

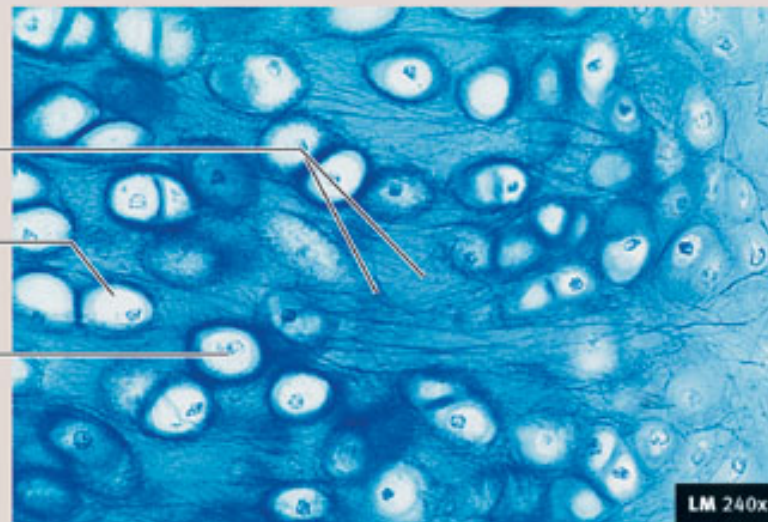
**Function:** Provides rigidity with even more flexibility than hyaline cartilage because elastic fibers return to their original shape after being stretched.

**Location:** External ear, epiglottis, and auditory tubes.

Elastic fibers  
in matrix

Chondrocytes  
in lacunae

Nucleus



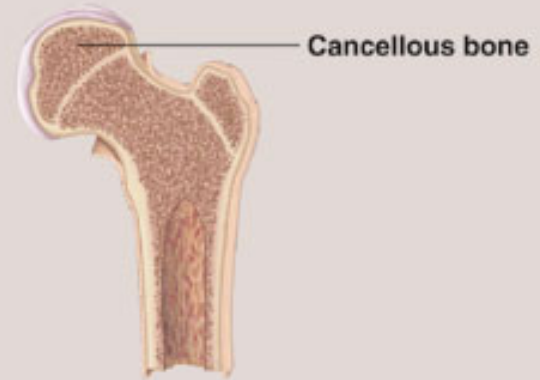
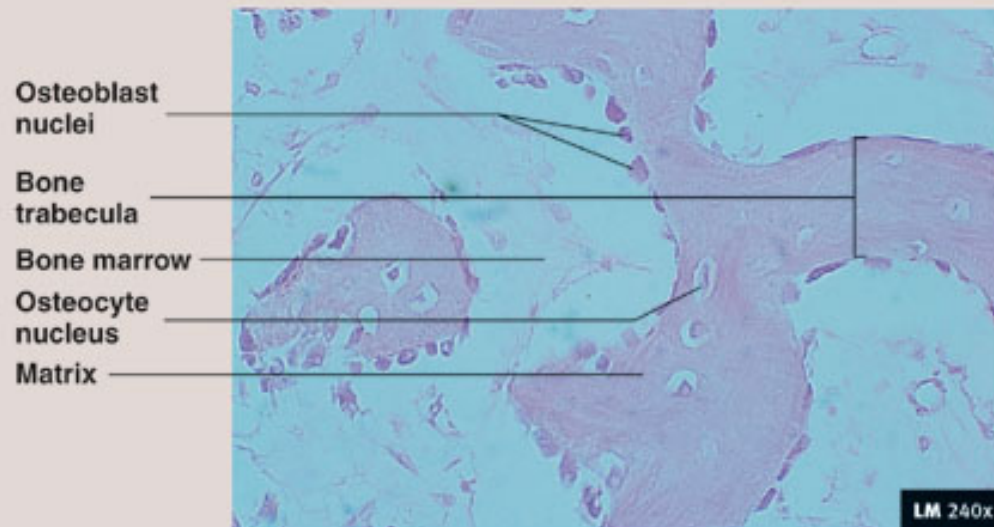
## Table 4.12 Connective Tissue: Bones

### (a) Cancellous Bone

**Structure:** Latticelike network of scaffolding characterized by trabeculae with large spaces between them filled with hemopoietic tissue. The osteocytes, or bone cells, are located within lacunae in the trabeculae.

**Function:** Acts as a scaffolding to provide strength and support without the greater weight of compact bone.

**Location:** In the interior of the bones of the skull, vertebrae, sternum, and pelvis; also found in the ends of the long bones.



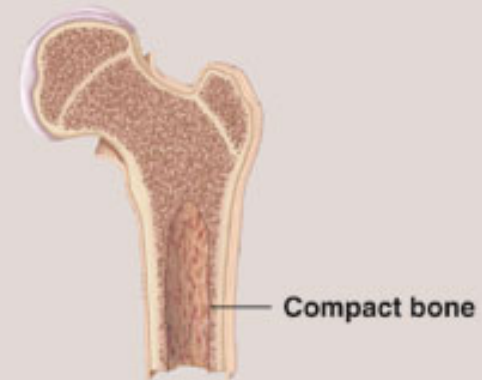
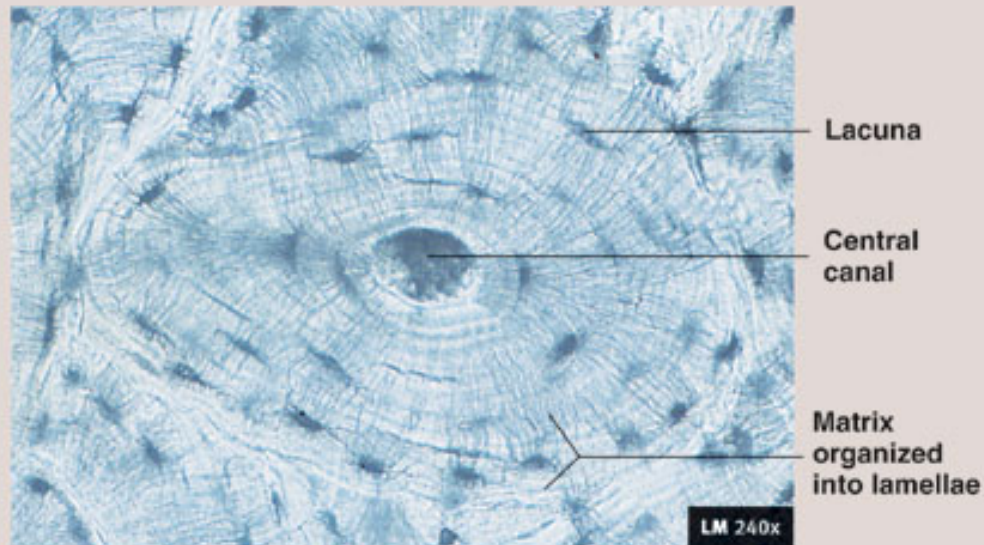
## Table 4.12    Connective Tissue: Bones – Continued

### (b) Compact Bone

**Structure:** Hard, bony matrix predominates. Many osteocytes (not seen in this bone preparation) are located within lacunae that are distributed in a circular fashion around the central canals. Small passageways connect adjacent lacunae.

**Function:** Provides great strength and support. Forms a solid outer shell on bones that keeps them from being easily broken or punctured.

**Location:** Outer portions of all bones and the shafts of long bones.



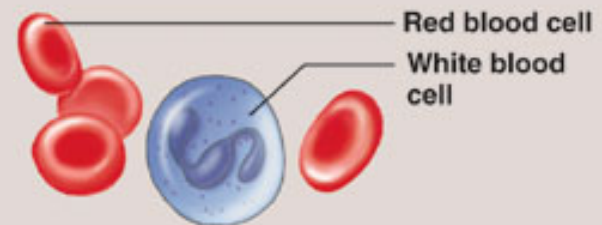
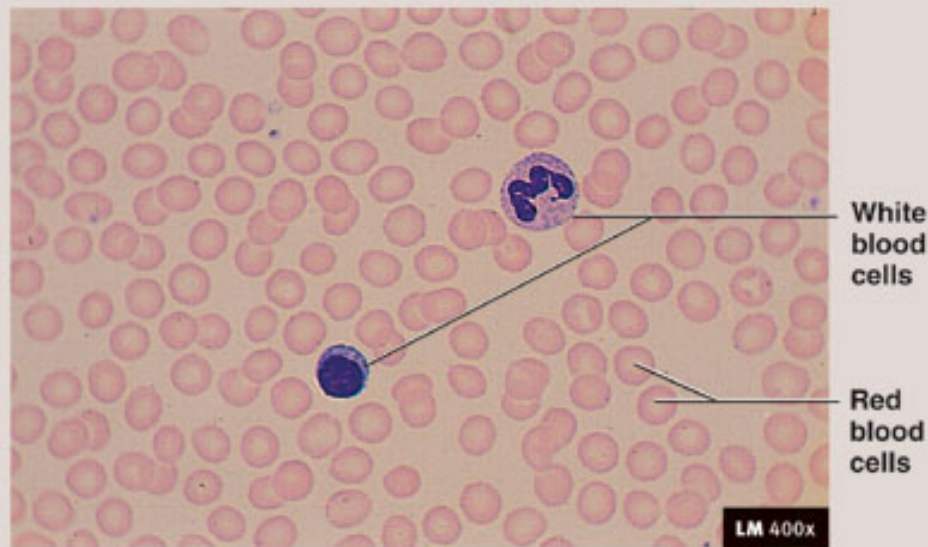
## Table 4.13 Connective Tissue: Blood and Hemopoietic Tissue

### (a) Blood

**Structure:** Blood cells and a fluid matrix.

**Function:** Transports oxygen, carbon dioxide, hormones, nutrients, waste products, and other substances. Protects the body from infections and is involved in temperature regulation.

**Location:** Within the blood vessels. Produced by the hemopoietic tissues. White blood cells frequently leave the blood vessels and enter the interstitial spaces.





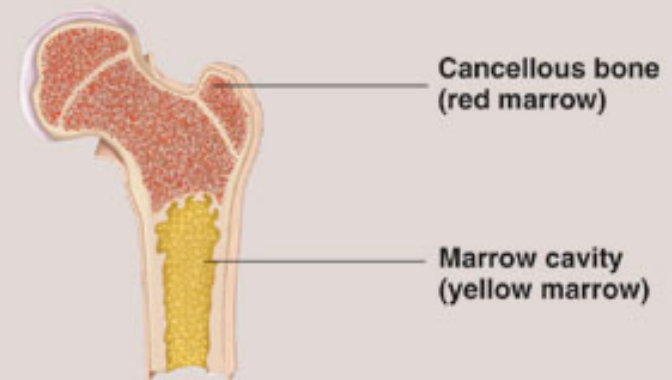
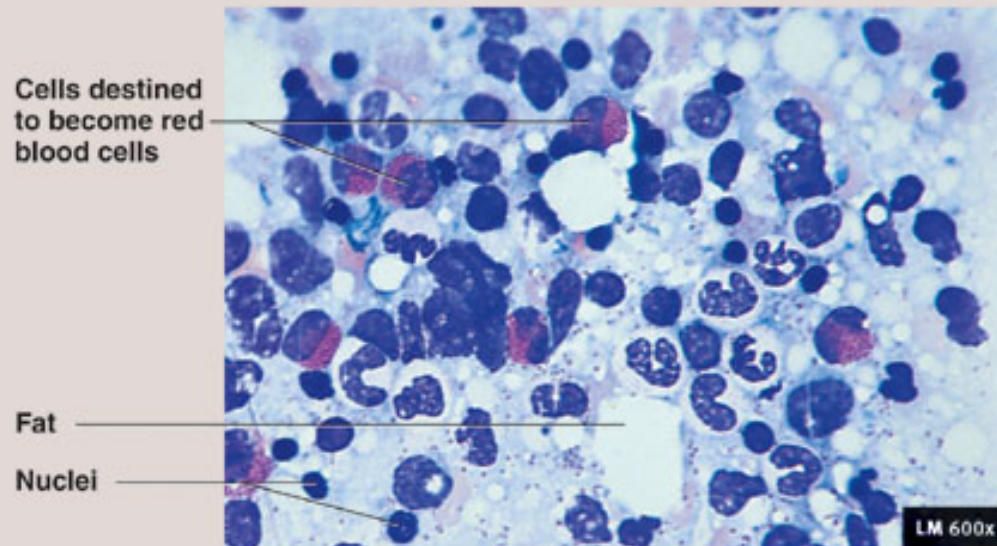
## Table 4.13 Connective Tissue: Blood and Hemopoietic Tissue – Continued

### (b) Bone Marrow

**Structure:** Reticular framework with numerous blood-forming cells (red marrow).

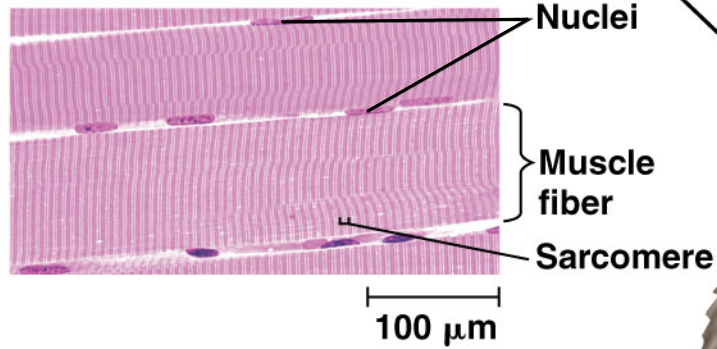
**Function:** Production of new blood cells (red marrow); lipid storage (yellow marrow).

**Location:** Within marrow cavities of bone. Two types: yellow marrow (mostly adipose tissue) in the shafts of long bones; and red marrow (hemopoietic or blood-forming tissue) in the ends of long bones and in short, flat, and irregularly shaped bones.

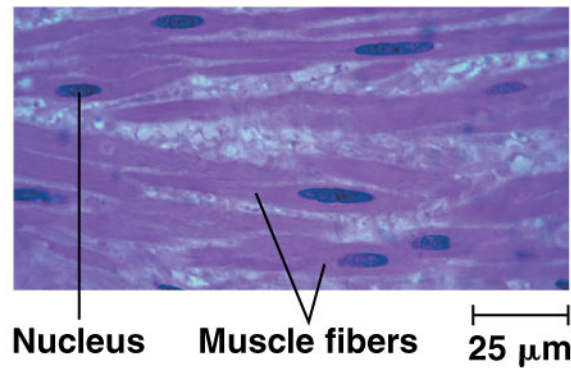


# Muscle Tissue

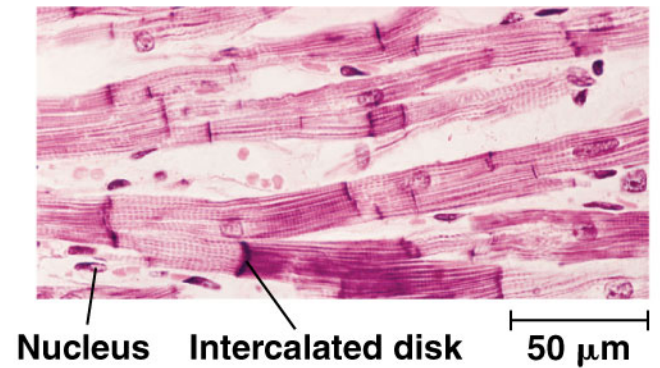
## Skeletal muscle



## Smooth muscle



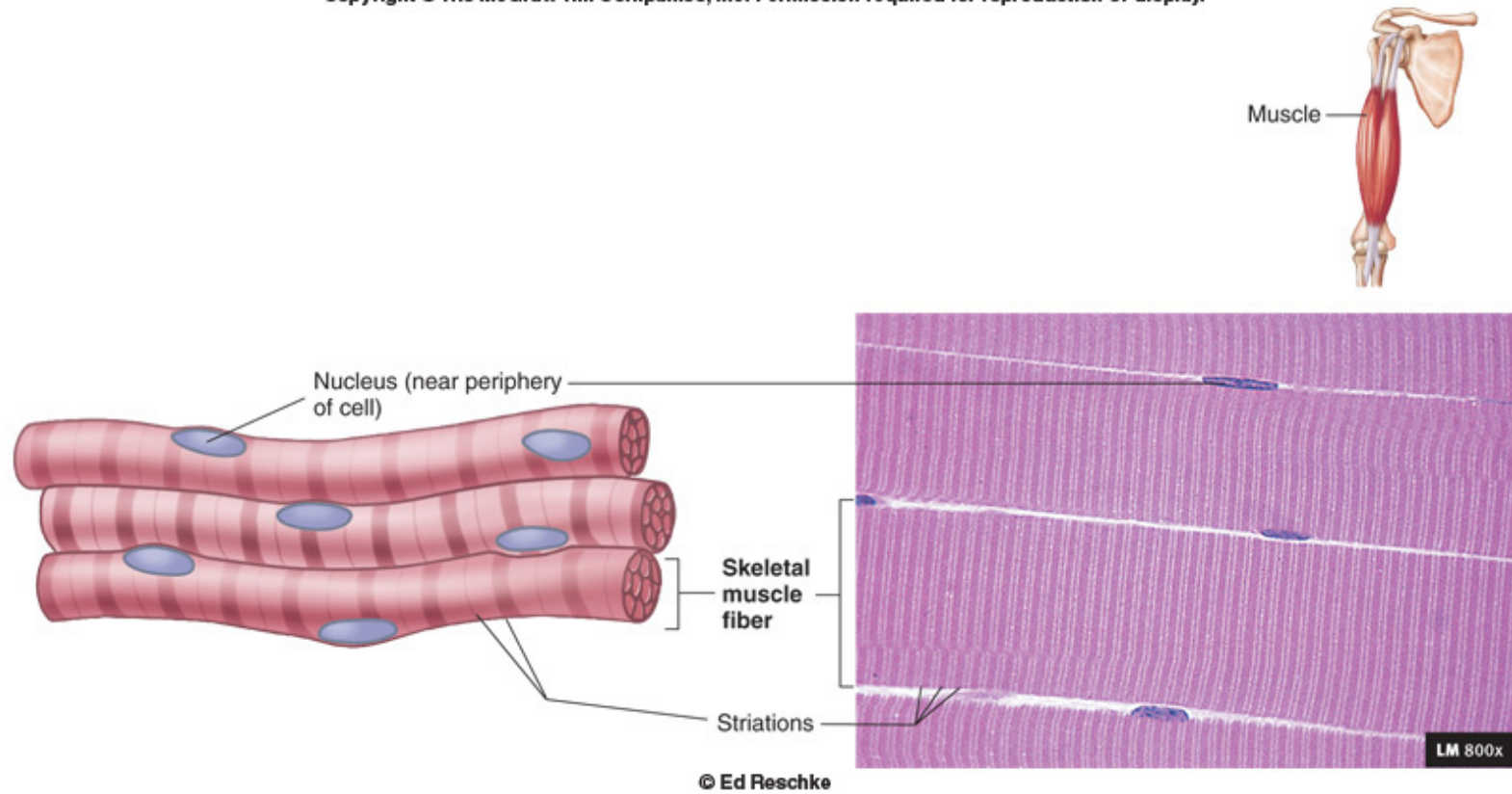
## Cardiac muscle



**TABLE 4.14** Comparison of Muscle Types

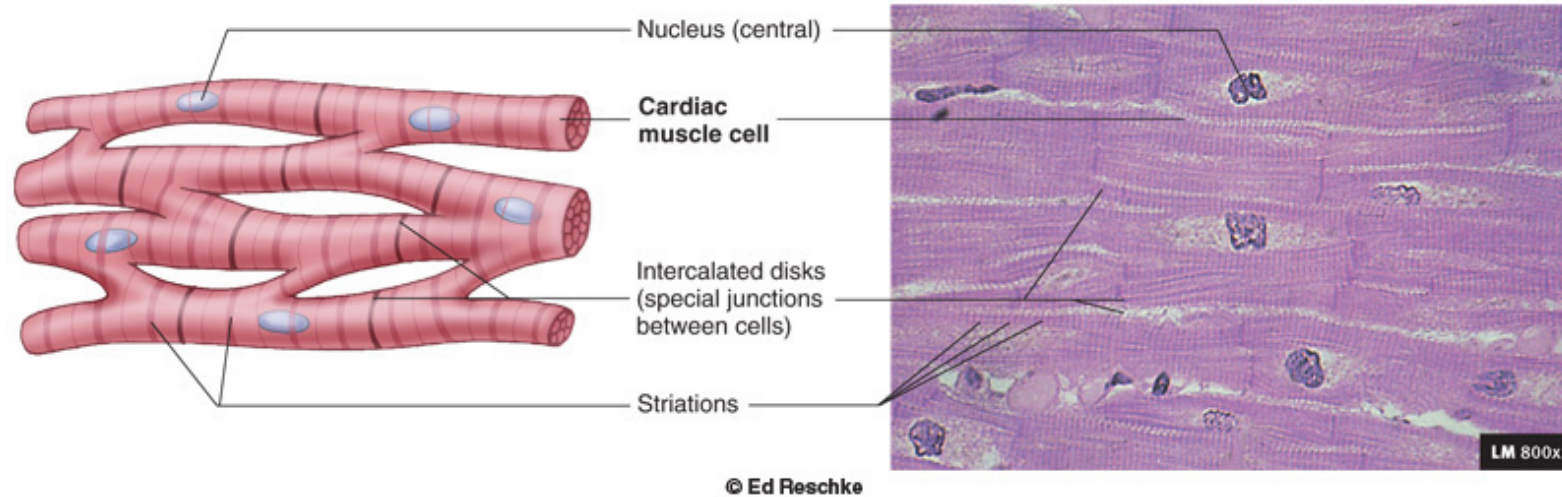
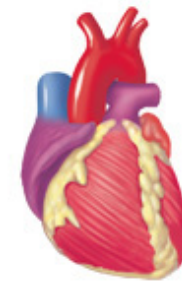
	Skeletal Muscle	Cardiac Muscle	Smooth Muscle
<b>Location</b>	Attached to bones	Heart	Walls of hollow organs, blood vessels, eyes, glands, skin
<b>Cell Shape</b>	Very long, cylindrical cells (1–4 cm and may extend the entire length of the muscle; 10–100 $\mu\text{m}$ in diameter)	Cylindrical cells that branch (100–500 $\mu\text{m}$ in length; 12–20 $\mu\text{m}$ in diameter)	Spindle-shaped cells (15–200 $\mu\text{m}$ in length; 5–8 $\mu\text{m}$ in diameter)
<b>Nucleus</b>	Multinucleated, peripherally located	Single, centrally located	Single, centrally located
<b>Striations</b>	Yes	Yes	No
<b>Control</b>	Voluntary (conscious)	Involuntary (unconscious)	Involuntary (unconscious)
<b>Ability to Contract Spontaneously</b>	No	Yes	Yes
<b>Function</b>	Body movement	Contraction provides the major force for moving blood through the blood vessels.	Movement of food through the digestive tract, emptying of the urinary bladder, regulation of blood vessel diameter, change in pupil size, contraction of many gland ducts, movement of hair, and many more functions
<b>Special Features</b>		Branching fibers, intercalated disks containing gap junctions joining the cells to each other	Gap junctions

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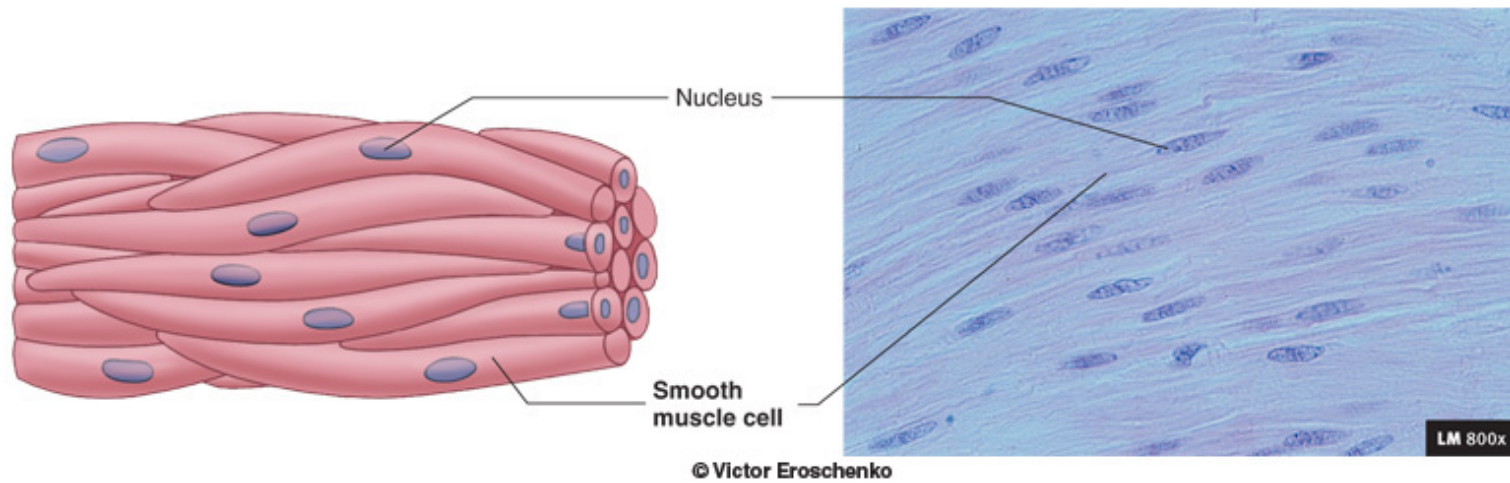
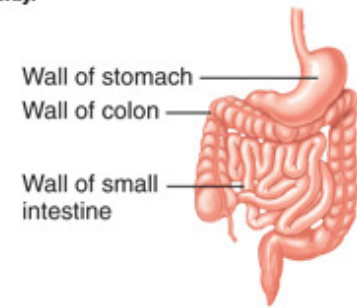




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# Nervous Tissue

## Neurons

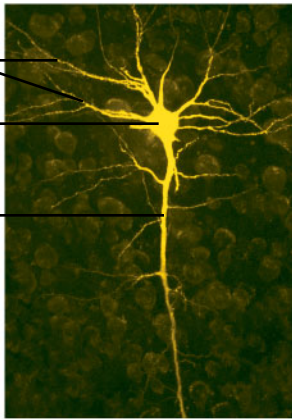
Neuron:

Dendrites

Cell body

Axon

40  $\mu\text{m}$



(Fluorescent LM)



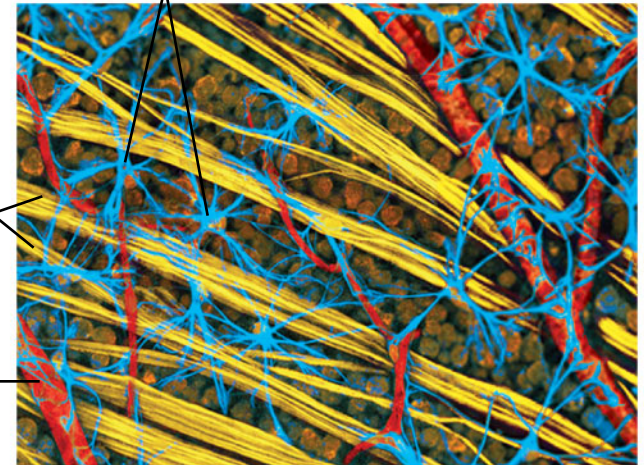
## Glia

Glia

15  $\mu\text{m}$

Axons of neurons

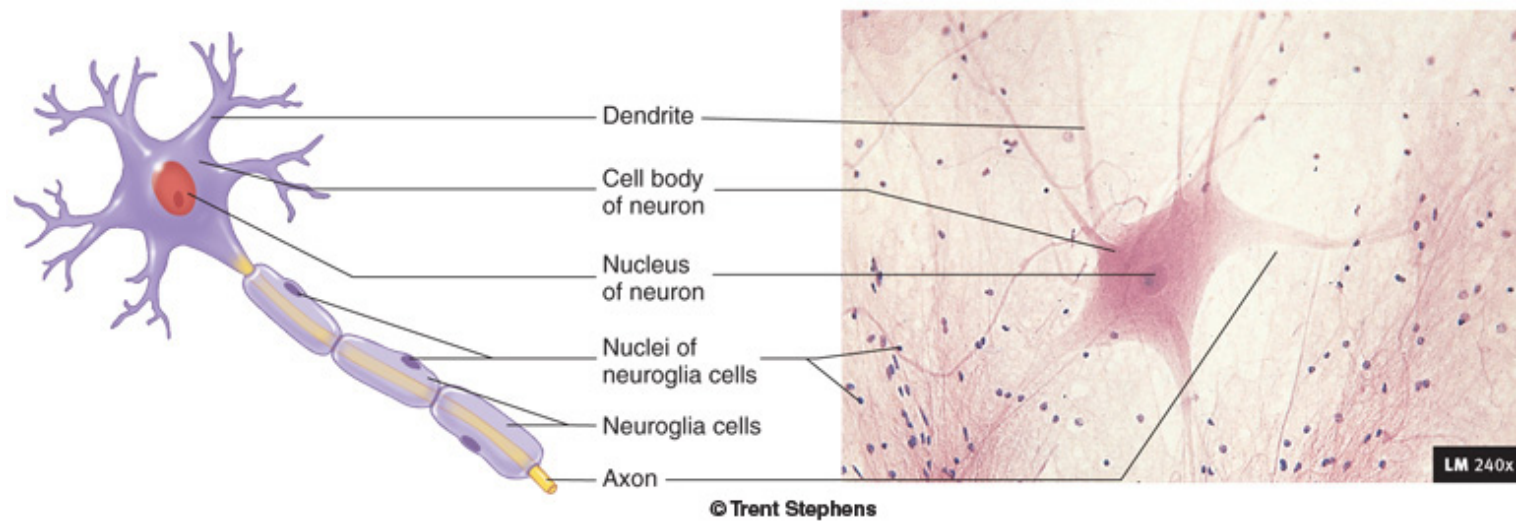
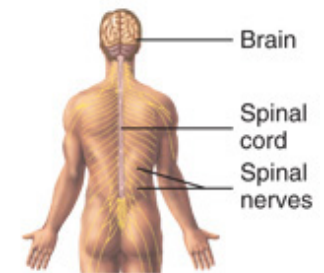
Blood vessel



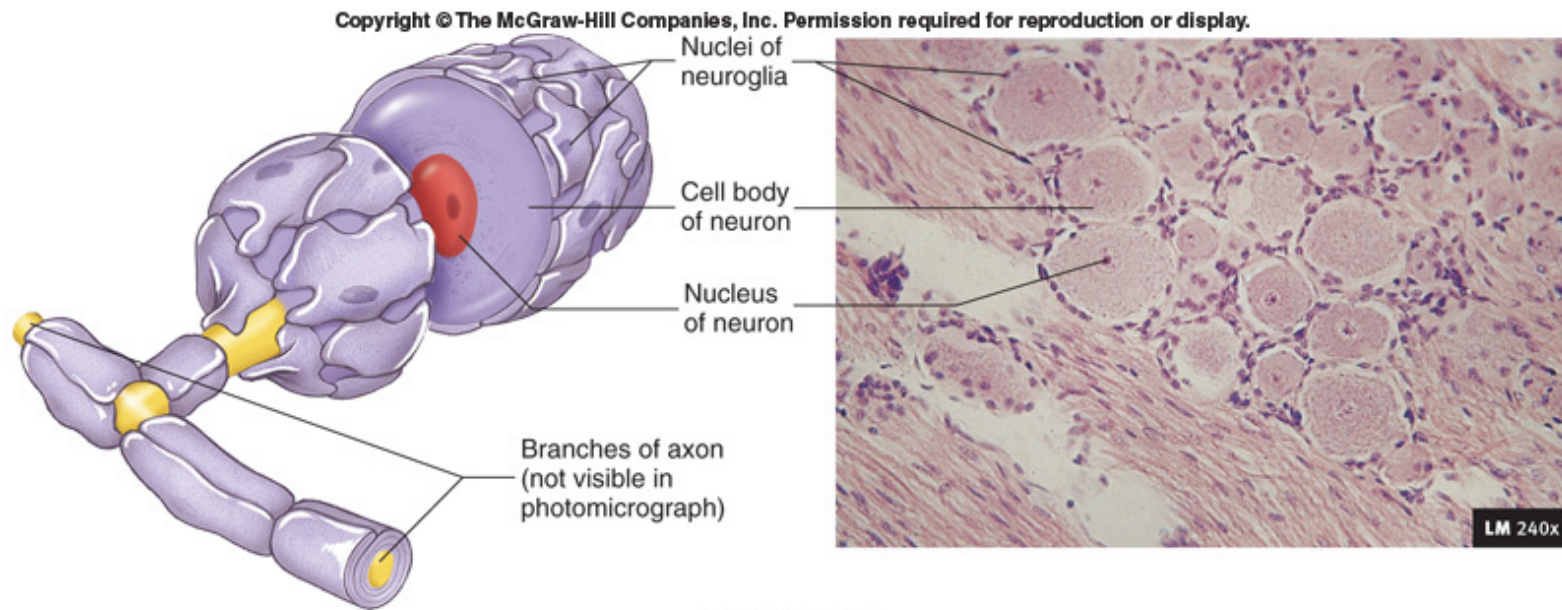
(Confocal LM)

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