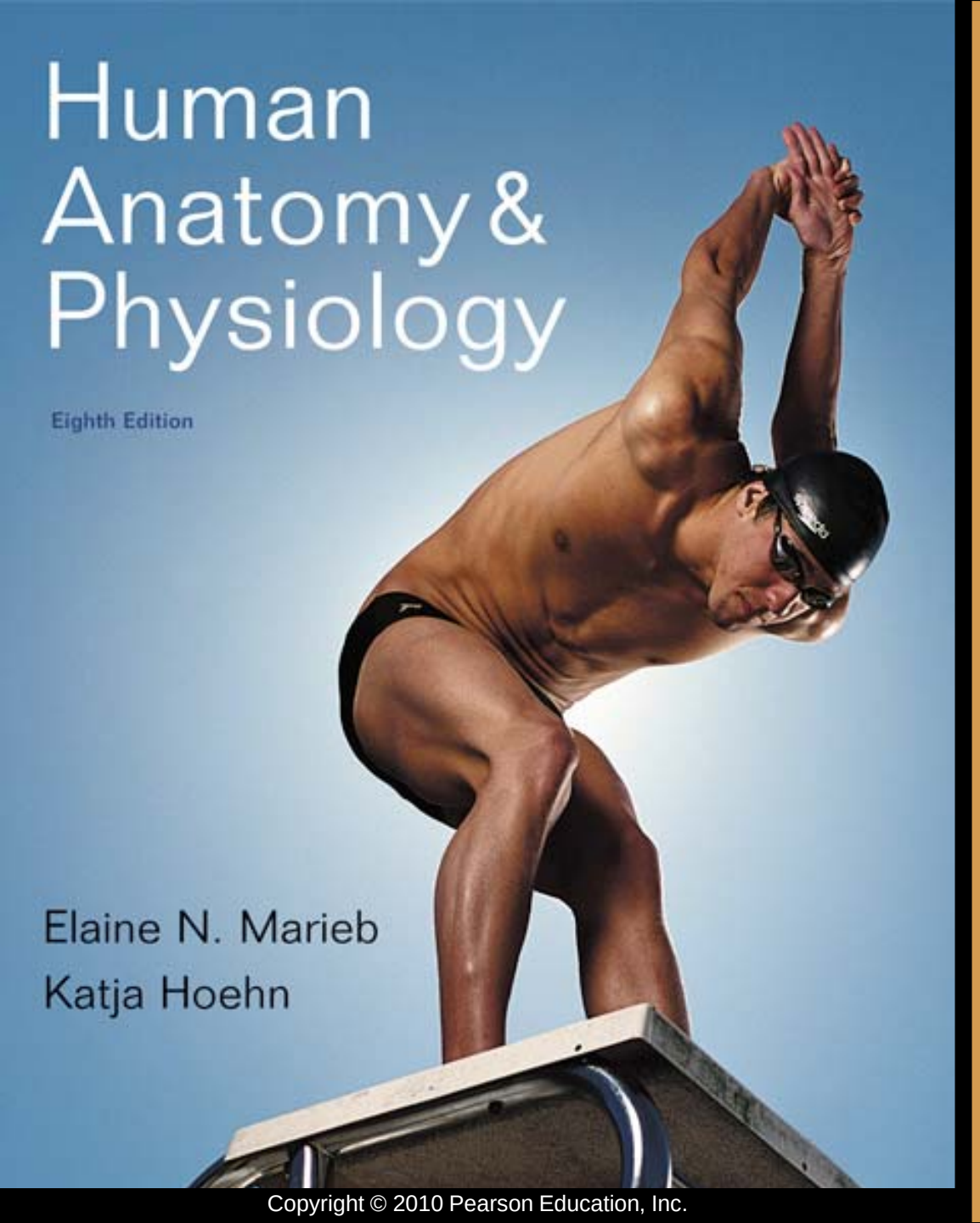

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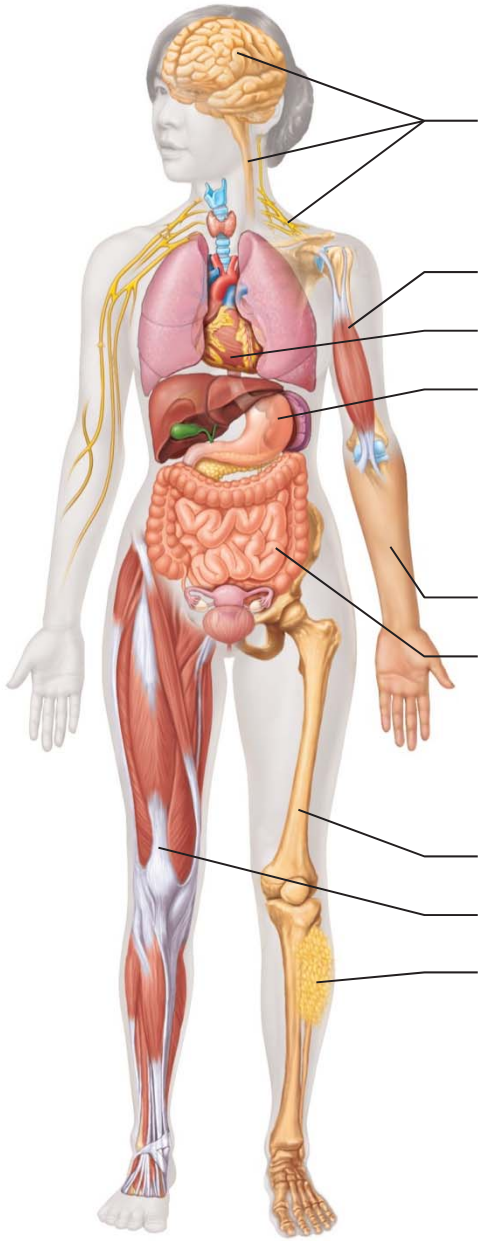
Janice Meeking,
Mount Royal College

CHAPTER 4

Tissue: The Living Fabric: Part A

Tissues

- Groups of cells similar in structure and function
- Types of tissues
  - Epithelial tissue
  - Connective tissue
  - Muscle tissue
  - Nerve tissue



Nervous tissue: **Internal communication**

- **Brain, spinal cord, and 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**

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

Connective tissue: **Supports, protects, binds other tissues together**

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

Figure 4.1

Epithelial Tissue (Epithelium)

- Two main types (by location):
  1. Covering and lining epithelia
     - On external and internal surfaces
  2. Glandular epithelia
     - Secretory tissue in glands

Characteristics of Epithelial Tissue

1. Cells have polarity—apical (upper, free) and basal (lower, attached) surfaces
   - Apical surfaces may bear microvilli (e.g., brush border of intestinal lining) or cilia (e.g., lining of trachea)
   - Noncellular basal lamina of glycoprotein and collagen lies adjacent to basal surface

Characteristics of Epithelial Tissue

2. Are composed of closely packed cells
    - Continuous sheets held together by tight junctions and desmosomes
3. Supported by a connective tissue reticular lamina (under the basal lamina)
4. Avascular but innervated
5. High rate of regeneration

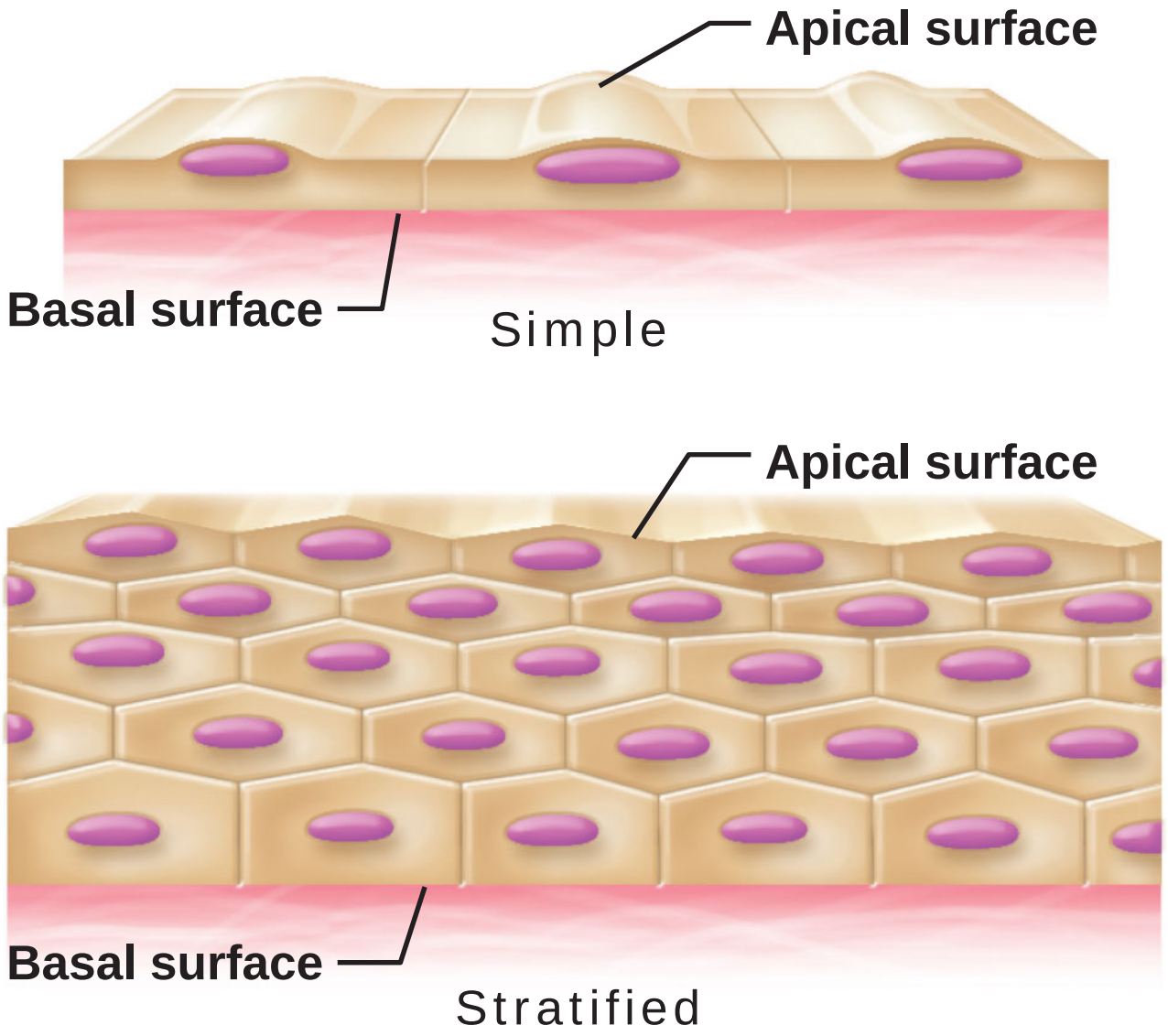
Classification of Epithelia

- Ask two questions:

1. How many layers?

   1 = simple epithelium

   >1 = stratified epithelium



(a) Classification based on number of cell layers.

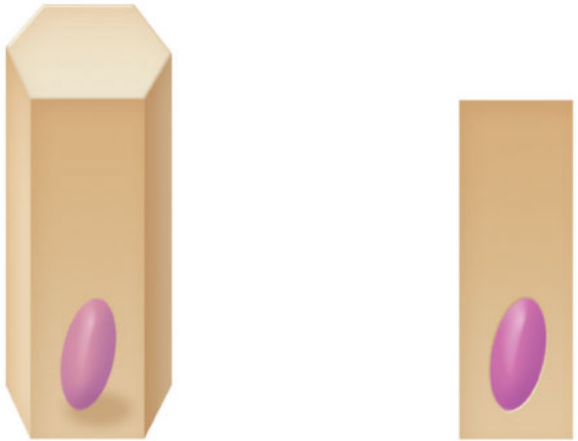
Figure 4.2a

Classification of Epithelia

2. What type of cell?
   - Squamous
   - Cuboidal
   - Columnar
- (If stratified, name according to apical layer of cells)

Squamous

Cuboidal



Columnar

(b) Classification based on cell shape.

Figure 4.2b

Overview of Epithelial Tissues

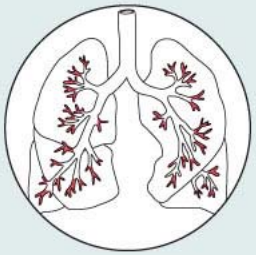
- For each of the following types of epithelia, note:
  - Description
  - Function
  - Location

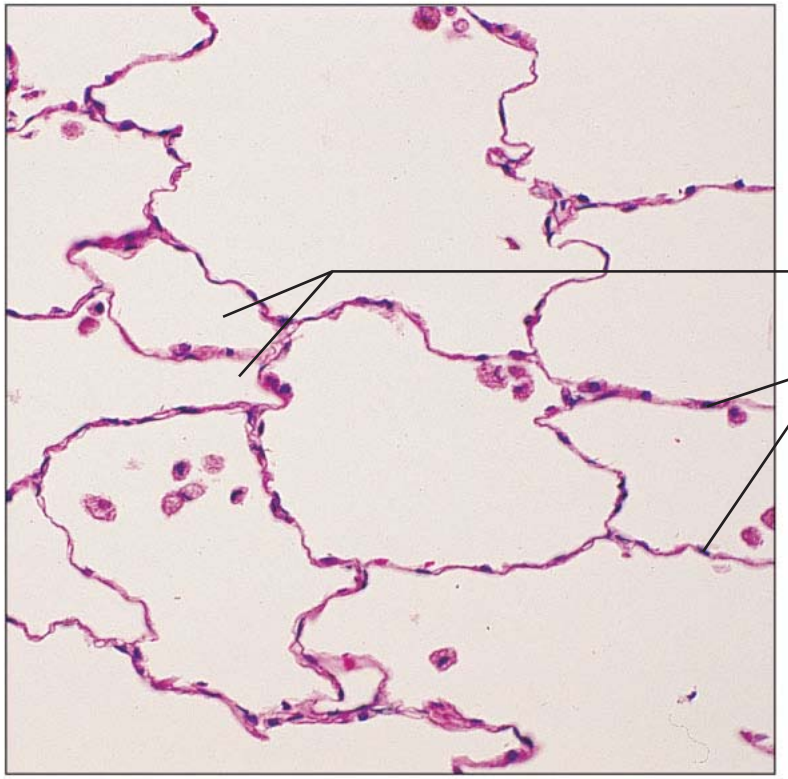
(a) Simple squamous epithelium

Description: **Single layer of flattened cells with disc-shaped central nuclei and sparse cytoplasm; the simplest of the epithelia.**

Function: **Allows passage of materials by diffusion and filtration in sites where protection is not important; secretes lubricating substances in serosae.**

Location: **Kidney glomeruli; air sacs of lungs; lining of heart, blood vessels, and lymphatic vessels; lining of ventral body cavity (serosae).**





Photomicrograph: **Simple squamous epithelium forming part of the alveolar (air sac) walls (125x).**

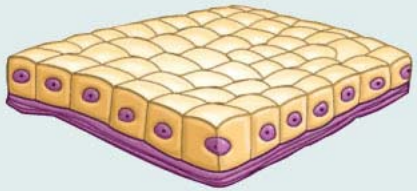
Figure 4.3a

Epithelia: Simple Squamous

- Two other locations
  - Endothelium
    - The lining of lymphatic vessels, blood vessels, and heart
  - Mesothelium
    - The epithelium of serous membranes in the ventral body cavity

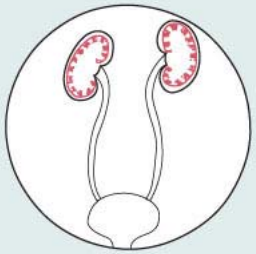
(b) Simple cuboidal epithelium

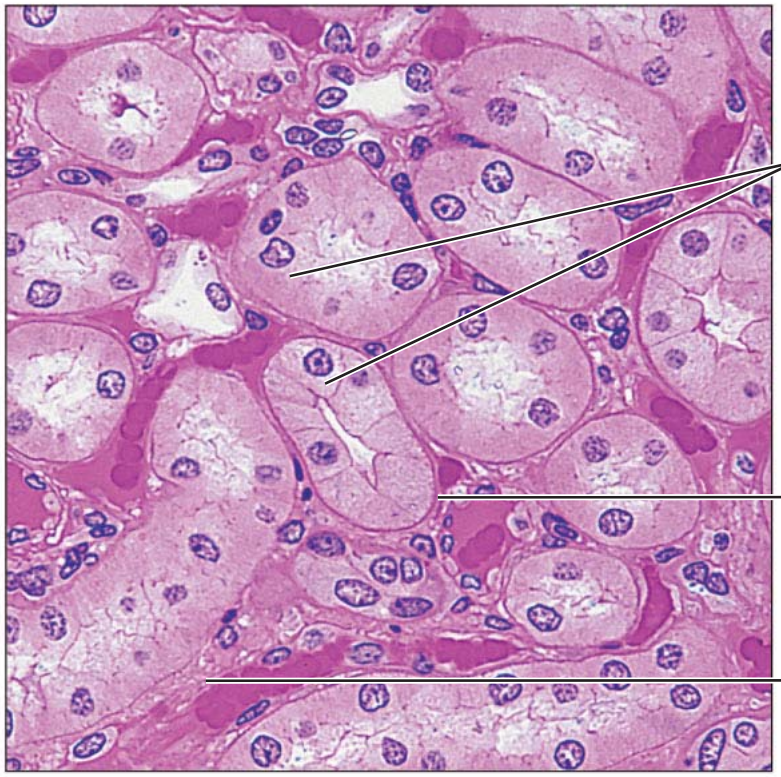
Description: **Single layer of cubelike cells with large, spherical central nuclei.**



Function: **Secretion and absorption.**

Location: **Kidney tubules; ducts and secretory portions of small glands; ovary surface.**



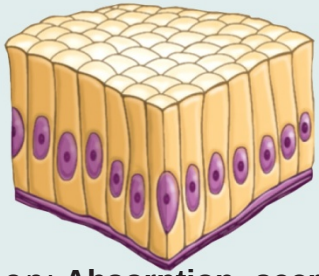


Photomicrograph: **Simple cuboidal epithelium in kidney tubules (430x).**

Figure 4.3b

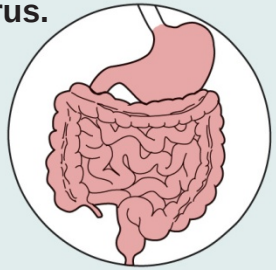
(c) Simple columnar epithelium

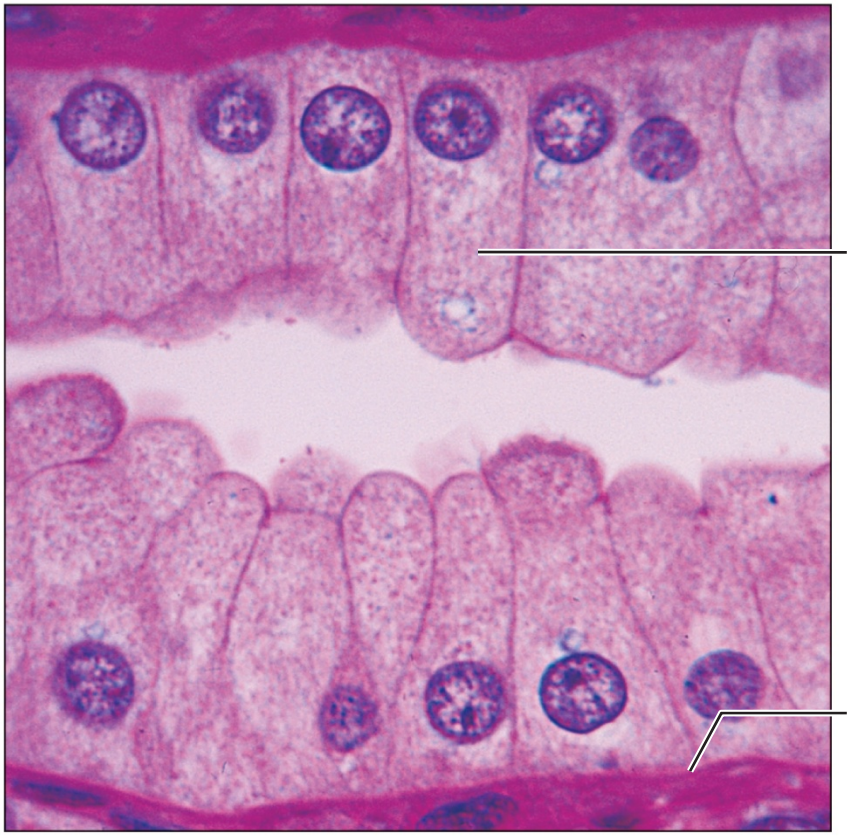
Description: **Single layer of tall cells with *round* to *oval* nuclei; some cells bear cilia; layer may contain mucus-secreting unicellular glands (goblet cells).**



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

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



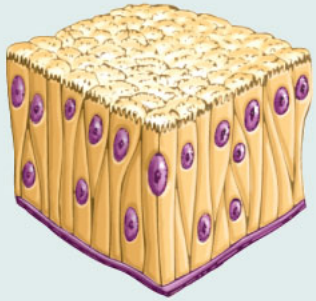


Photomicrograph: **Simple columnar epithelium of the stomach mucosa (860X).**

Figure 4.3c

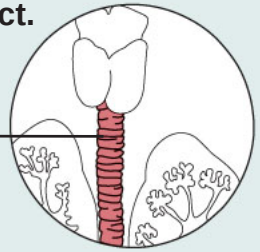
(d) Pseudostratified columnar epithelium

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



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

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

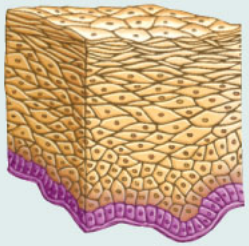


Photomicrograph: **Pseudostratified ciliated columnar epithelium lining the human trachea (570x).**

Figure 4.3d

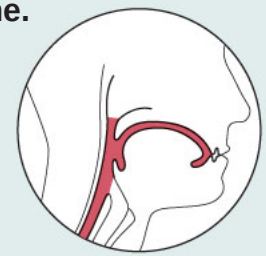
(e) Stratified squamous epithelium

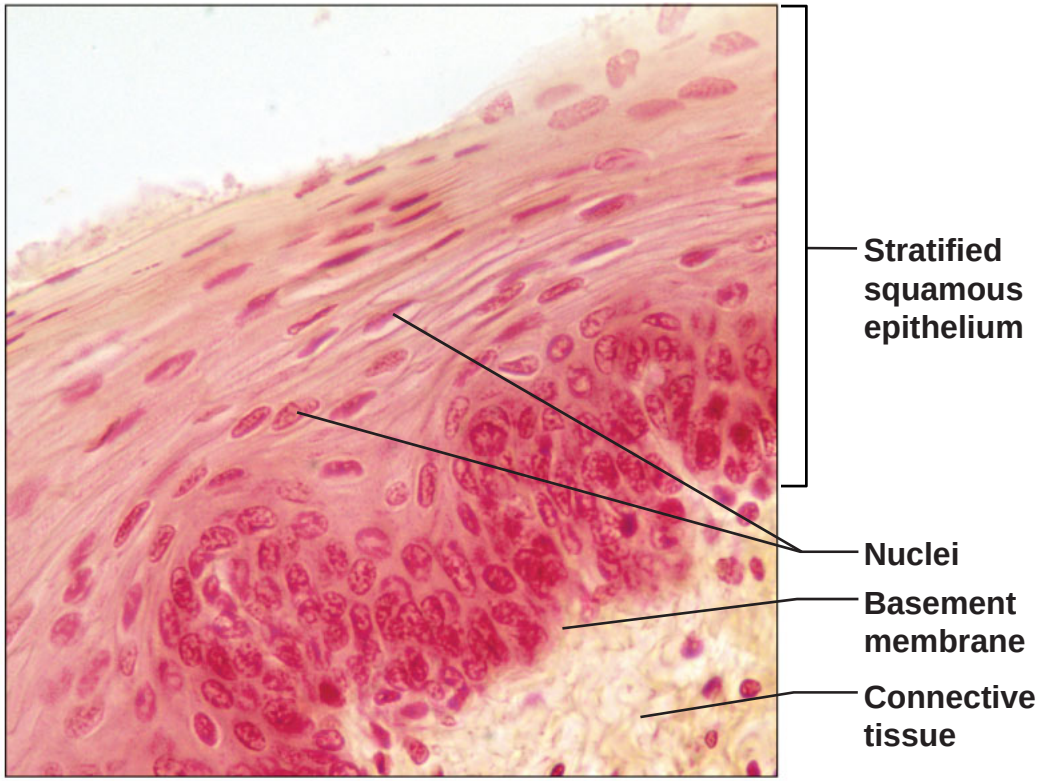
Description: **Thick membrane composed of several cell layers; basal cells are cuboidal or columnar and metabolically active; surface cells are flattened (squamous); in the keratinized type, the surface cells are full of keratin and dead; basal cells are active in mitosis and produce the cells of the more superficial layers.**



Function: **Protects underlying tissues in areas subjected to abrasion.**

Location: **Nonkeratinized type forms the moist linings of the esophagus, mouth, and vagina; keratinized variety forms the epidermis of the skin, a dry membrane.**





Photomicrograph: **Stratified squamous epithelium lining the esophagus (285x).**

Figure 4.3e

Epithelia: Stratified Cuboidal

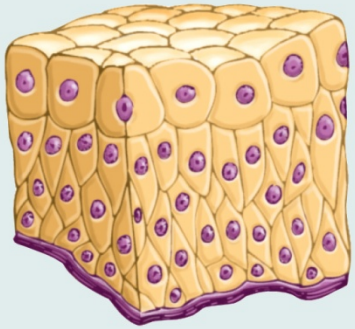
- Quite rare in body
- Found in some sweat and mammary glands
- Typically two cell layers thick

Epithelia: Stratified Columnar

- Limited distribution in body
- Small amounts in pharynx, male urethra, and lining some glandular ducts
- Also occurs at transition areas between two other types of epithelia

(f) Transitional epithelium

Description: **Resembles both stratified squamous and stratified cuboidal; basal cells cuboidal or columnar; surface cells dome shaped or squamouslike, depending on degree of organ stretch.**



Function: **Stretches readily and permits distension of urinary organ by contained urine.**

Location: **Lines the ureters, urinary bladder, and part of the urethra.**

Photomicrograph: **Transitional epithelium lining the urinary bladder, relaxed state (360X); note the bulbous, or rounded, appearance of the cells at the surface; these cells flatten and become elongated when the bladder is filled with urine.**

Figure 4.3f

Glandular Epithelia

- A gland is one or more cells that makes and secretes an aqueous fluid
- Classified by:
  - Site of product release—endocrine or exocrine
  - Relative number of cells forming the gland—unicellular (e.g., goblet cells) or multicellular

Endocrine Glands

- Ductless glands
- Secrete hormones that travel through lymph or blood to target organs

Exocrine Glands

- More numerous than endocrine glands
- Secrete products into ducts
- Secretions released onto body surfaces (skin) or into body cavities
- Examples include mucous, sweat, oil, and salivary glands

Unicellular Exocrine Glands

- The only important unicellular gland is the goblet cell

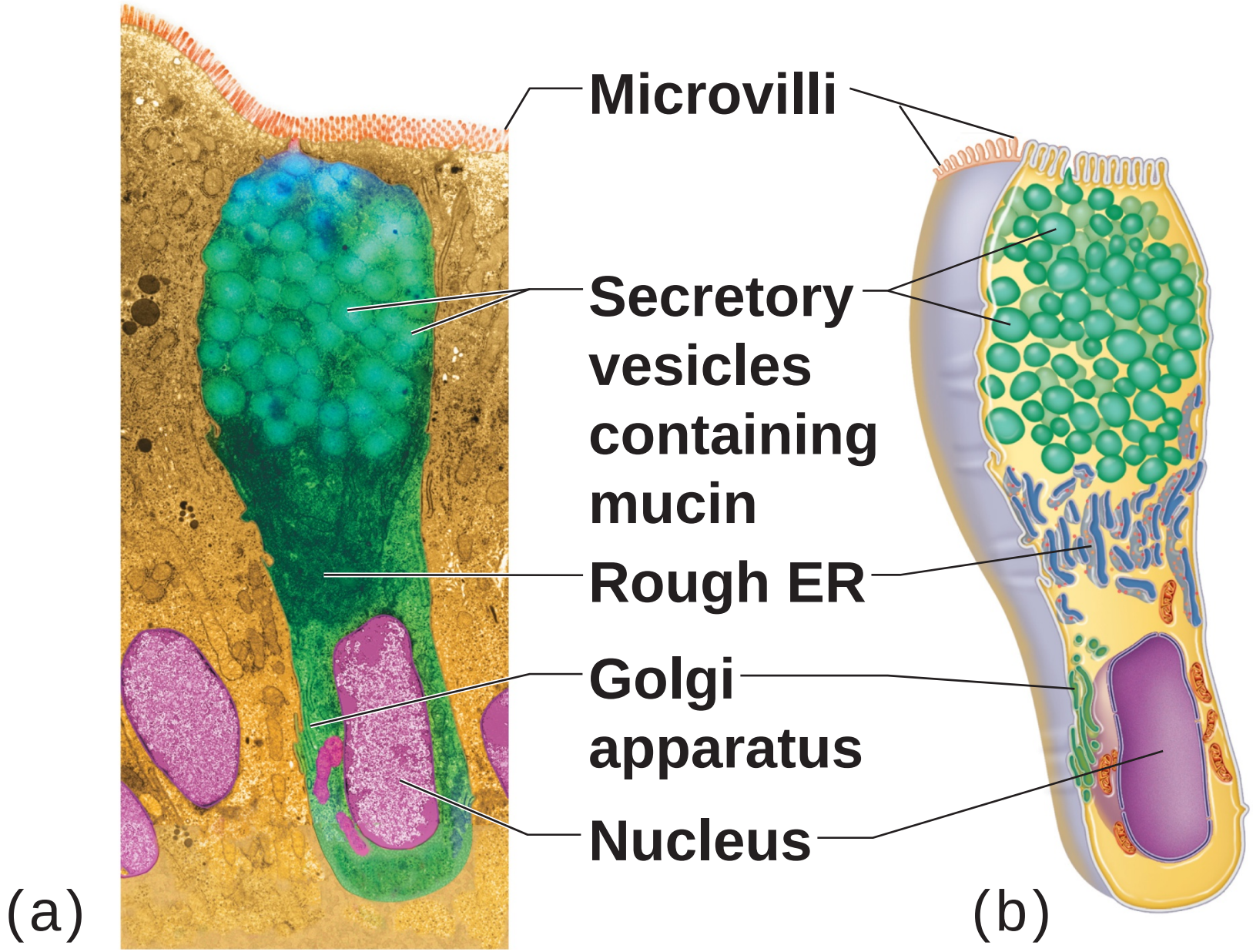
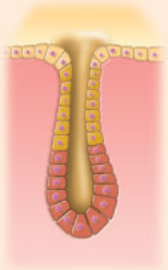
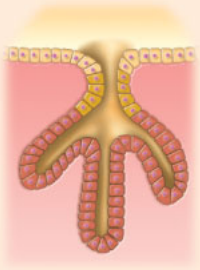
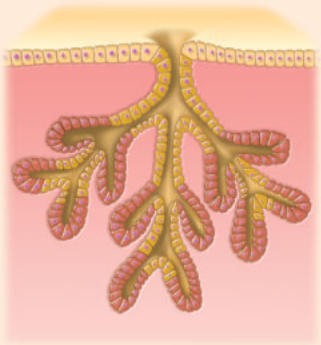
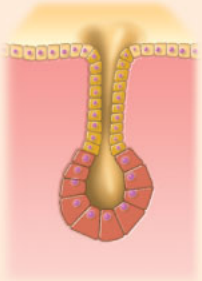
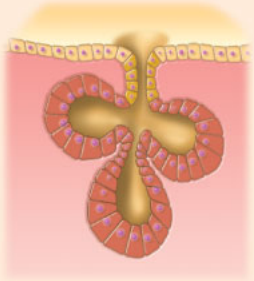
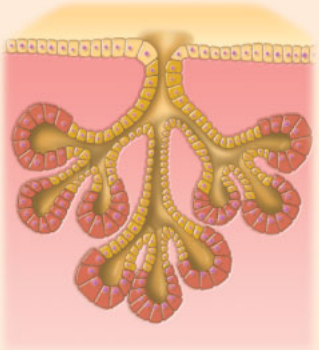
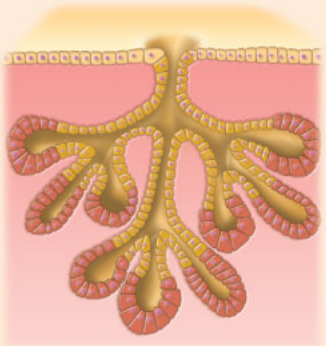


Figure 4.4

Multicellular Exocrine Glands

- Multicellular exocrine glands are composed of a duct and a secretory unit
- Classified according to:
  - Duct type (simple or compound)
  - Structure of their secretory units (tubular, alveolar, or tubuloalveolar)

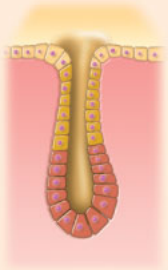
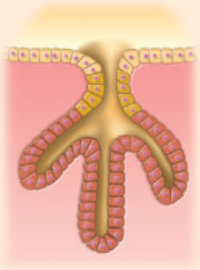
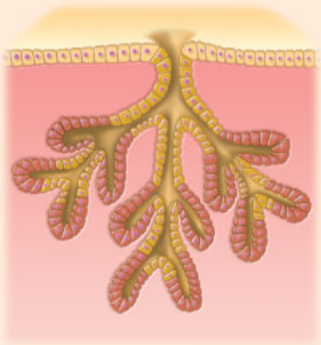
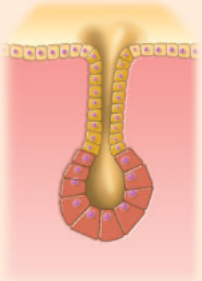
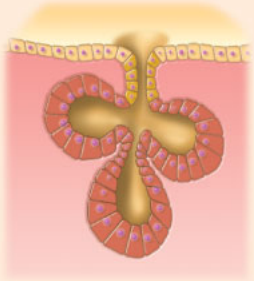
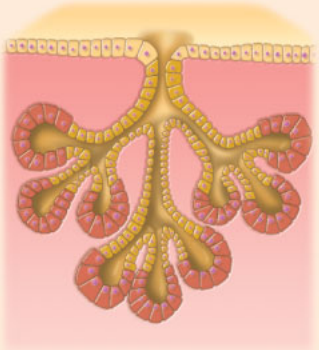
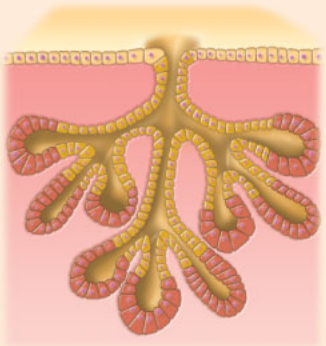
	Simple duct structure (duct does not branch)		Compound duct structure (duct branches)	
Tubular secretory structure	 Simple tubular *Example* **Intestinal glands**	 Simple branched tubular *Example* **Stomach (gastric) glands**	 Compound tubular *Example* **Duodenal glands of small intestine**	
Alveolar secretory structure	 Simple alveolar *Example* **No important example in humans**	 Simple branched alveolar *Example* **Sebaceous (oil) glands**	 Compound alveolar *Example* **Mammary glands**	 Compound tubuloalveolar *Example* **Salivary glands**

Surface epithelium **Duct** **Secretory epithelium**

Figure 4.5

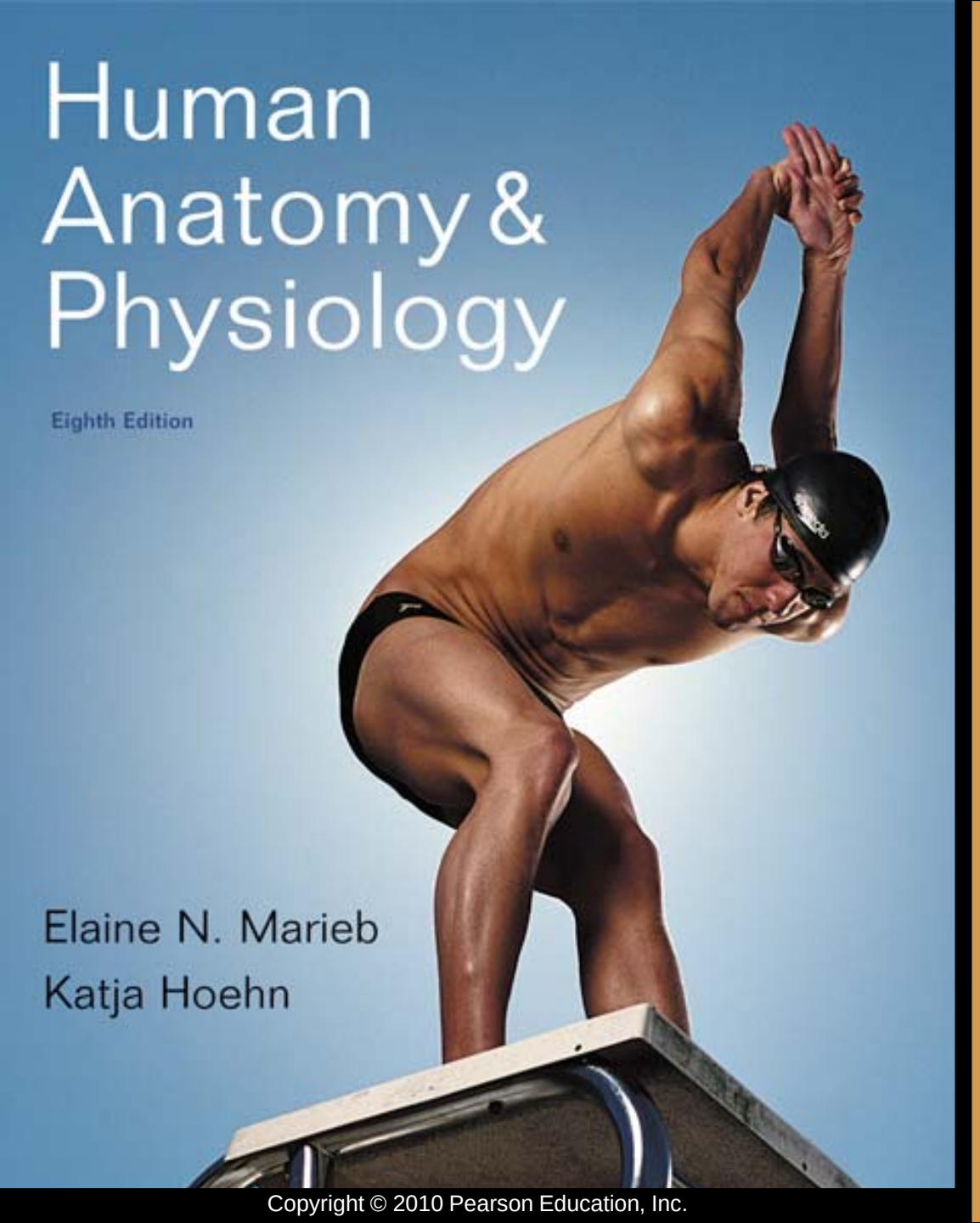
Modes of Secretion

- Merocrine
  - Products are secreted by exocytosis (e.g., pancreas, sweat and salivary glands)
- Holocrine
  - Products are secreted by rupture of gland cells (e.g., sebaceous glands)

	Simple duct structure (duct does not branch)		Compound duct structure (duct branches)	
Tubular secretory structure	 Simple tubular *Example* **Intestinal glands**	 Simple branched tubular *Example* **Stomach (gastric) glands**	 Compound tubular *Example* **Duodenal glands of small intestine**	
Alveolar secretory structure	 Simple alveolar *Example* **No important example in humans**	 Simple branched alveolar *Example* **Sebaceous (oil) glands**	 Compound alveolar *Example* **Mammary glands**	 Compound tubuloalveolar *Example* **Salivary glands**

Surface epithelium **Duct** **Secretory epithelium**

Figure 4.5



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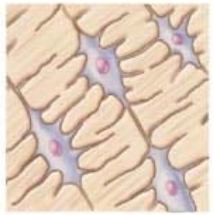
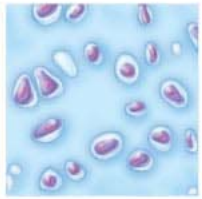
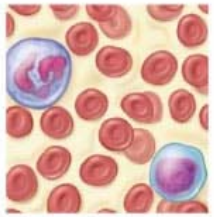
CHAPTER 4

Tissue: The Living Fabric: Part B

Connective Tissue

- Most abundant and widely distributed tissue type
- Four classes
  - Connective tissue proper
  - Cartilage
  - Bone tissue
  - Blood

TABLE 4.1 Comparison of Classes of Connective Tissues

TISSUE CLASS AND EXAMPLE	SUBCLASSES	TISSUE CLASS AND EXAMPLE	SUBCLASSES
Connective Tissue Proper  *Dense regular connective tissue*	1. Loose connective tissue ▪ Areolar ▪ Adipose ▪ Reticular 2. Dense connective tissue ▪ Regular ▪ Irregular ▪ Elastic	**Bone Tissue**  *Compact bone*	1. Compact bone 2. Spongy bone
Cartilage  *Hyaline cartilage*	1. Hyaline cartilage 2. Elastic cartilage 3. Fibrocartilage	**Blood** 	Blood cell formation and differentiation are quite complex. Details are provided in Chapter 17.

Major Functions of Connective Tissue

- Binding and support
- Protection
- Insulation
- Transportation (blood)

Characteristics of Connective Tissue

- Connective tissues have:
  - Mesenchyme as their common tissue of origin
  - Varying degrees of vascularity
  - Cells separated by nonliving extracellular matrix (ground substance and fibers)

Structural Elements of Connective Tissue

- Ground substance
  - Medium through which solutes diffuse between blood capillaries and cells
  - Components:
    - Interstitial fluid
    - Adhesion proteins (“glue”)
    - Proteoglycans
      - Protein core + large polysaccharides (chrondroitin sulfate and hyaluronic acid)
      - Trap water in varying amounts, affecting the viscosity of the ground substance

Structural Elements of Connective Tissue

- Three types of fibers
  - Collagen (white fibers)
    - Strongest and most abundant type
    - Provides high tensile strength
  - Elastic
    - Networks of long, thin, elastin fibers that allow for stretch
  - Reticular
    - Short, fine, highly branched collagenous fibers

Structural Elements of Connective Tissue

- Cells
  - Mitotically active and secretory cells = “blasts”
  - Mature cells = “cytes”
    - Fibroblasts in connective tissue proper
    - Chondroblasts and chondrocytes in cartilage
    - Osteoblasts and osteocytes in bone
    - Hematopoietic stem cells in bone marrow
    - Fat cells, white blood cells, mast cells, and macrophages

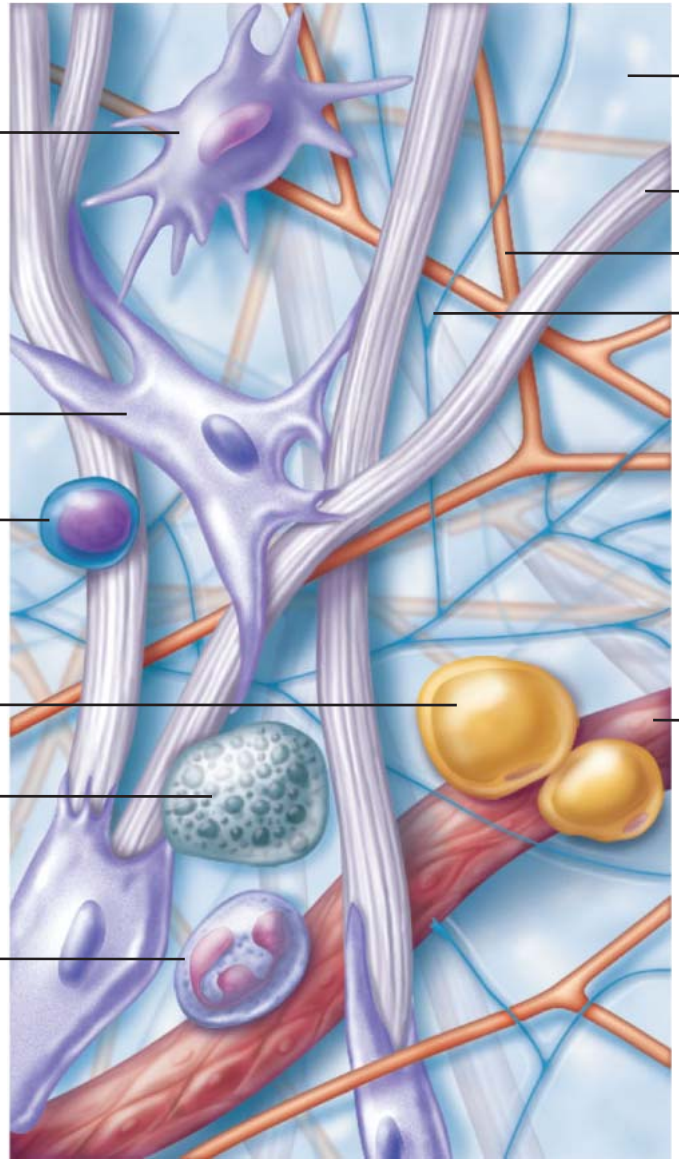


Figure 4.7

Connective Tissue: Embryonic

- Mesenchyme—embryonic connective tissue
  - Gives rise to all other connective tissues
  - Gel-like ground substance with fibers and star-shaped mesenchymal cells

Overview of Connective Tissues

- For each of the following examples of connective tissue, note:
  - Description
  - Function
  - Location

Connective Tissue Proper

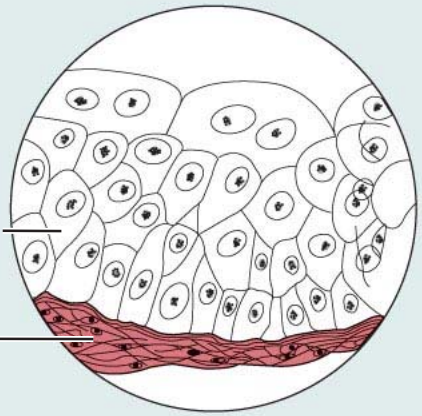
- Types:
  - Loose connective tissue
    - Areolar
    - Adipose
    - Reticular
  - Dense connective tissue
    - Dense regular
    - Dense irregular
    - Elastic

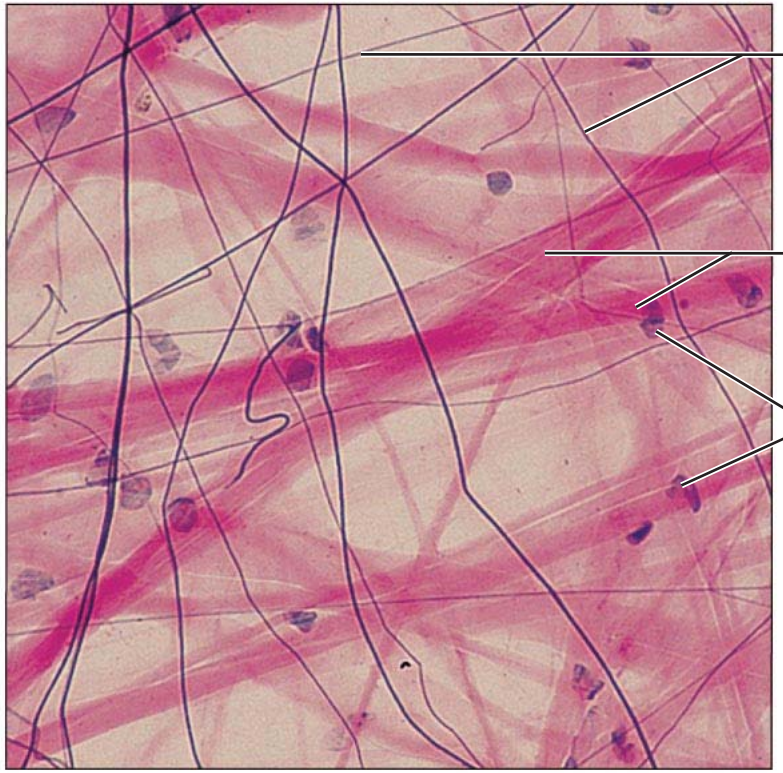
(a) Connective tissue proper: loose connective tissue, areolar

Description: **Gel-like matrix with all three fiber types; cells: fibroblasts, macrophages, mast cells, and some white blood cells.**

Function: **Wraps and cushions organs; its macrophages phagocytize bacteria; plays important role in inflammation; holds and conveys tissue fluid.**

Location: **Widely distributed under epithelia of body, e.g., forms lamina propria of mucous membranes; packages organs; surrounds capillaries.**





Photomicrograph: **Areolar connective tissue, a soft packaging tissue of the body (300x).**

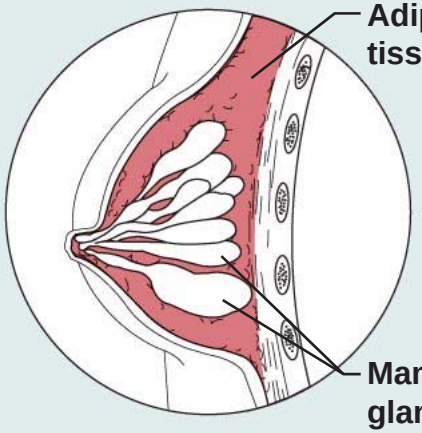
Figure 4.8a

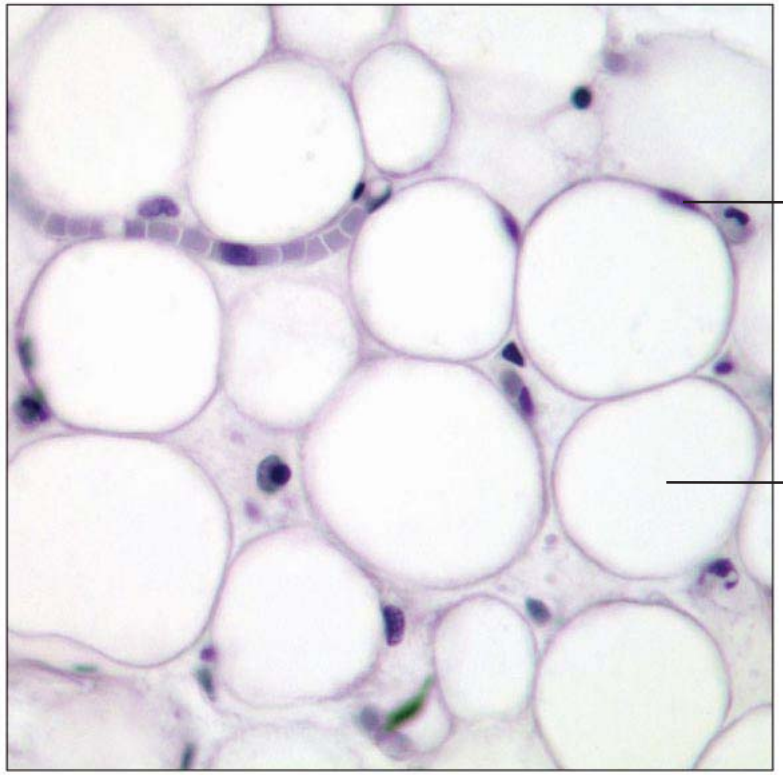
(b) Connective tissue proper: loose connective tissue, adipose

Description: **Matrix as in areolar, but very sparse; closely packed adipocytes, or fat cells, have nucleus pushed to the side by large fat droplet.**

Function: **Provides reserve food fuel; insulates against heat loss; supports and protects organs.**

Location: **Under skin in the hypodermis; around kidneys and eyeballs; within abdomen; in breasts.**





Photomicrograph: **Adipose tissue from the subcutaneous layer under the skin (350x).**

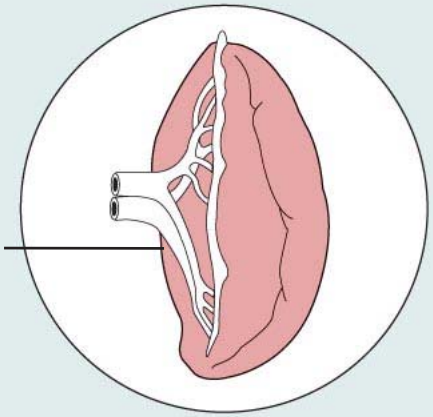
Figure 4.8b

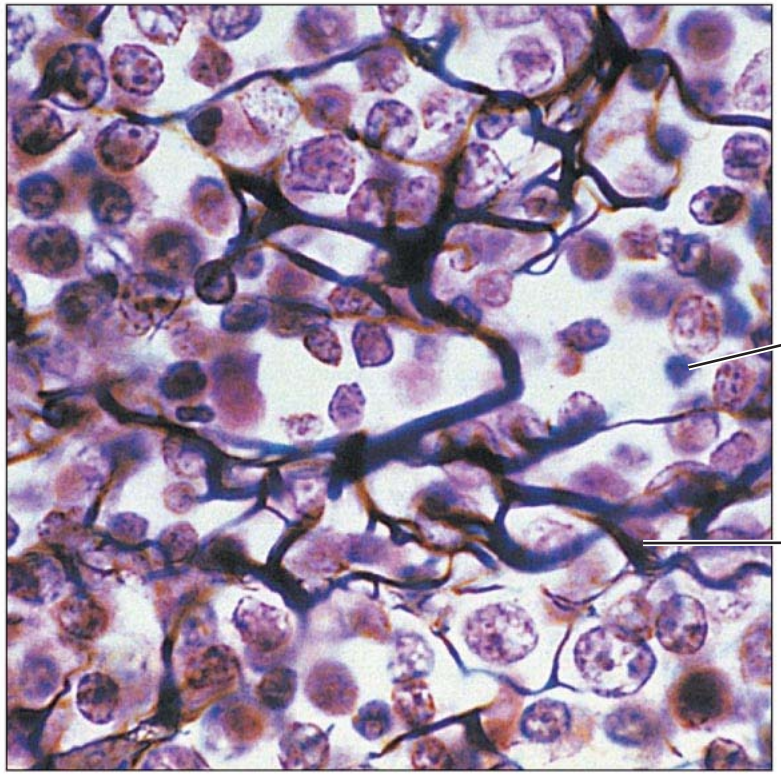
(c) Connective tissue proper: loose connective tissue, reticular

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

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

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





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

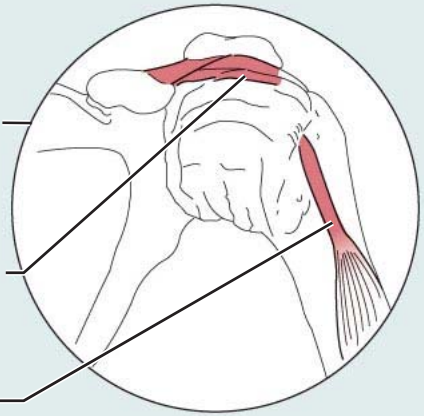
Figure 4.8c

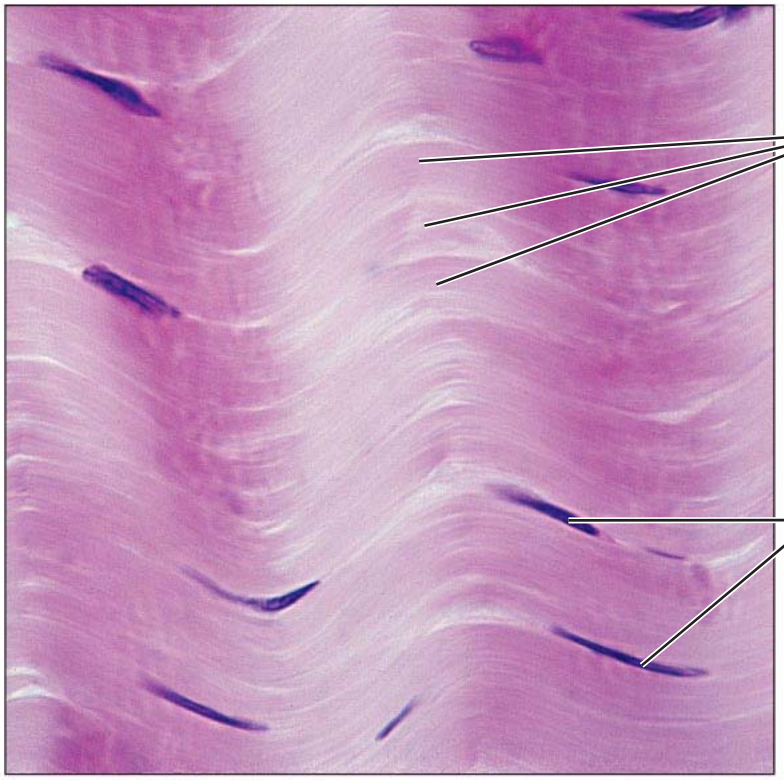
(d) Connective tissue proper: dense connective tissue, dense regular

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

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

Location: **Tendons, most ligaments, aponeuroses.**





Photomicrograph: **Dense regular connective tissue from a tendon (500x).**

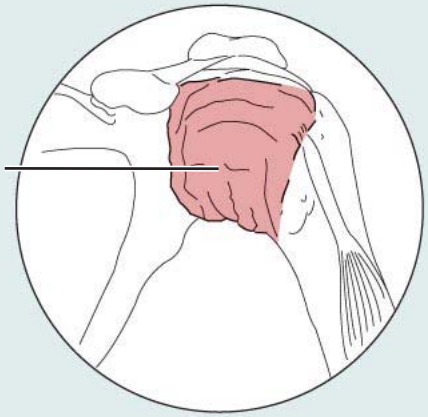
Figure 4.8d

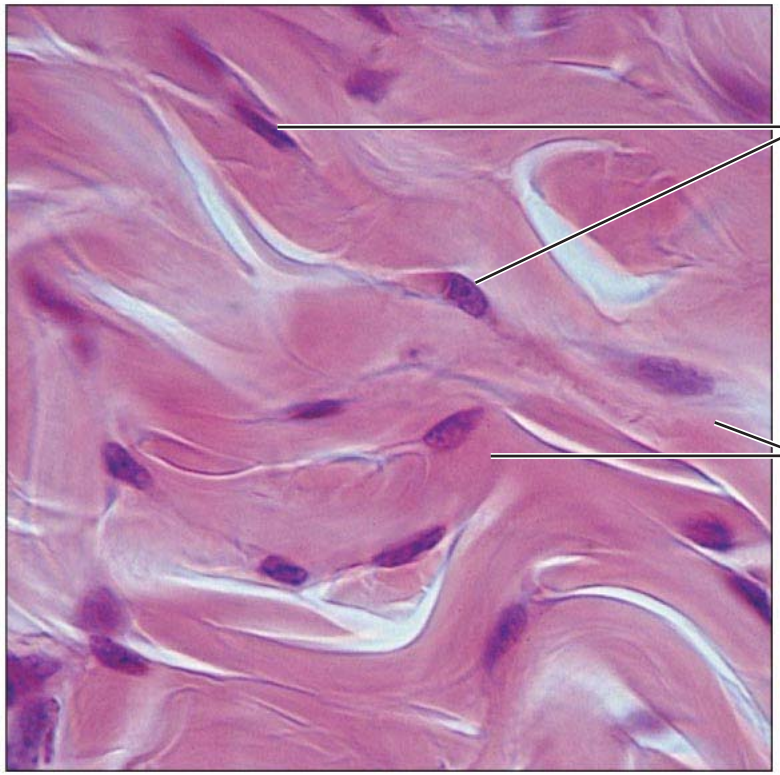
(e) Connective tissue proper: dense connective tissue, dense irregular

Description: **Primarily irregularly arranged collagen fibers; some elastic fibers; major cell type is the fibroblast.**

Function: **Able to withstand tension exerted in many directions; provides structural strength.**

Location: **Fibrous capsules of organs and of joints; dermis of the skin; submucosa of digestive tract.**





Photomicrograph: **Dense irregular connective tissue from the dermis of the skin (400x).**

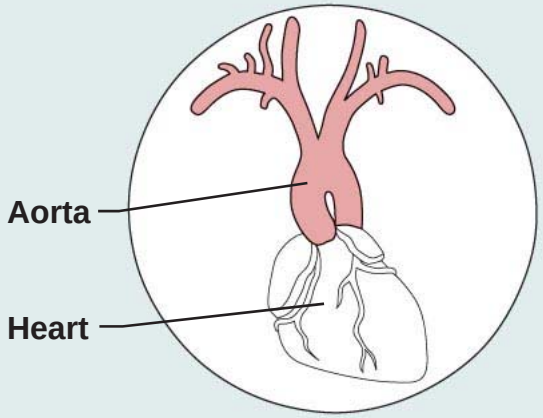
Figure 4.8e

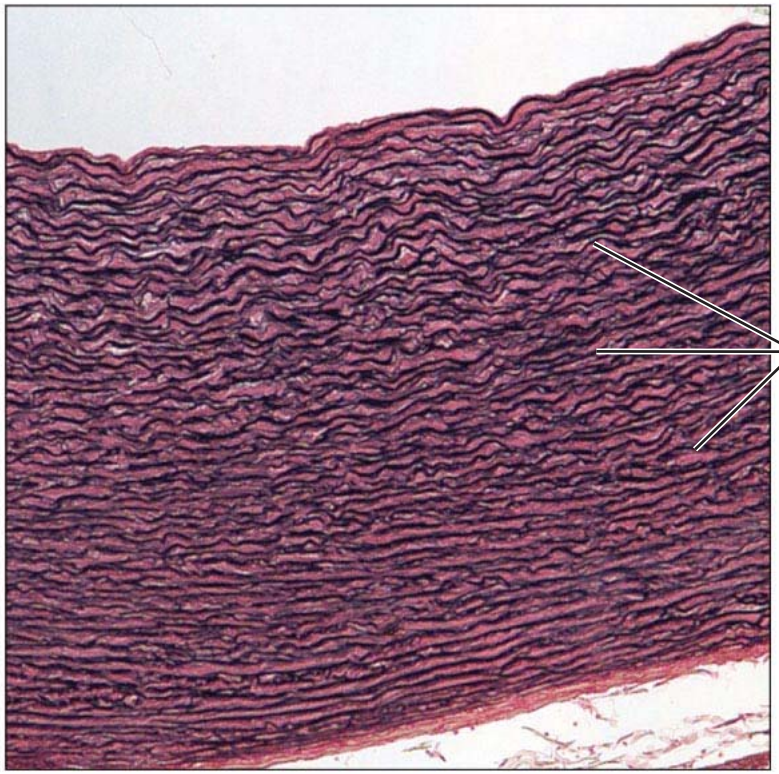
(f) Connective tissue proper: dense connective tissue, elastic

Description: **Dense regular connective tissue containing a high proportion of elastic fibers.**

Function: **Allows recoil of tissue following stretching; maintains pulsatile flow of blood through arteries; aids passive recoil of lungs following inspiration.**

Location: **Walls of large arteries; within certain ligaments associated with the vertebral column; within the walls of the bronchial tubes.**





Photomicrograph: **Elastic connective tissue in the wall of the aorta (250x).**

Figure 4.8f

Connective Tissue: Cartilage

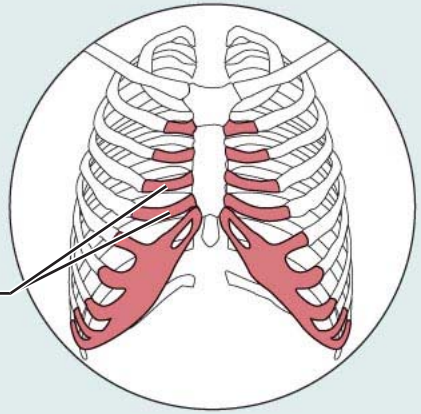
- Three types of cartilage:
  - Hyaline cartilage
  - Elastic cartilage
  - Fibrocartilage

(g) Cartilage: hyaline

Description: **Amorphous but firm matrix; collagen fibers form an imperceptible network; chondroblasts produce the matrix and when mature (chondrocytes) lie in lacunae.**

Function: **Supports and reinforces; has resilient cushioning properties; resists compressive stress.**

Location: **Forms most of the embryonic skeleton; covers the ends of long bones in joint cavities; forms costal cartilages of the ribs; cartilages of the nose, trachea, and larynx.**



Costal cartilages

Chondrocyte in lacuna

Matrix

Photomicrograph: **Hyaline cartilage from the trachea (750x).**

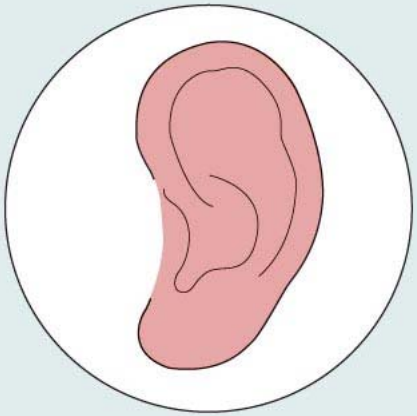
Figure 4.8g

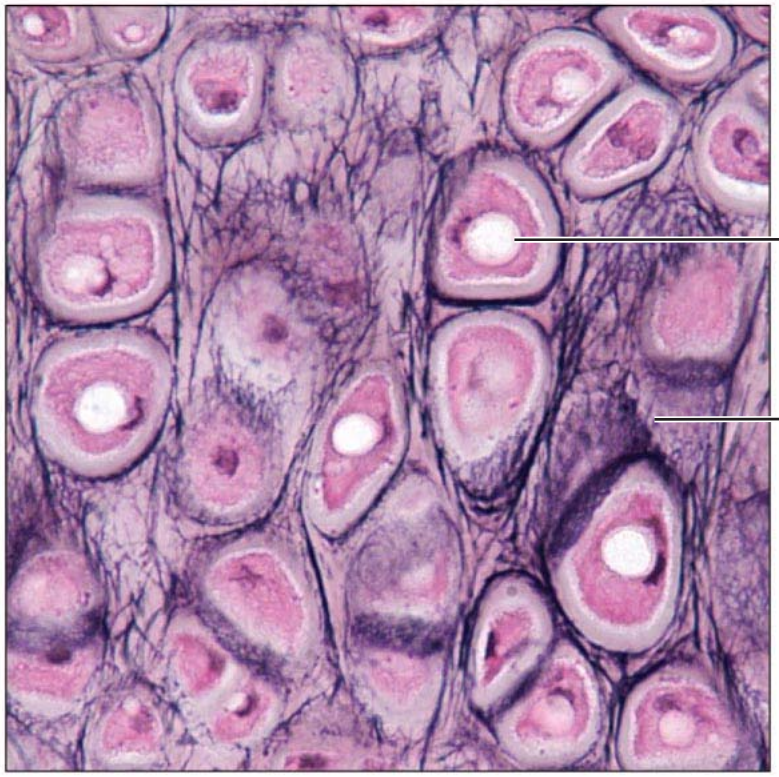
(h) Cartilage: elastic

Description: **Similar to hyaline cartilage, but more elastic fibers in matrix.**

Function: **Maintains the shape of a structure while allowing great flexibility.**

Location: **Supports the external ear (pinna); epiglottis.**





Photomicrograph: **Elastic cartilage from the human ear pinna; forms the flexible skeleton of the ear (800x).**

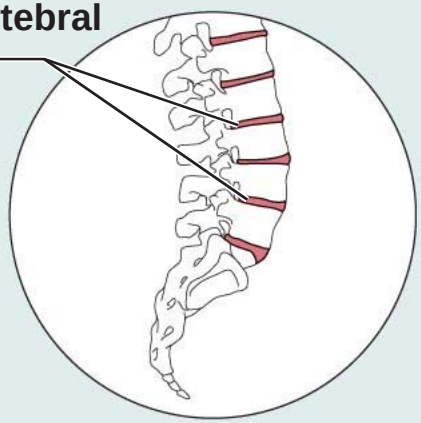
Figure 4.8h

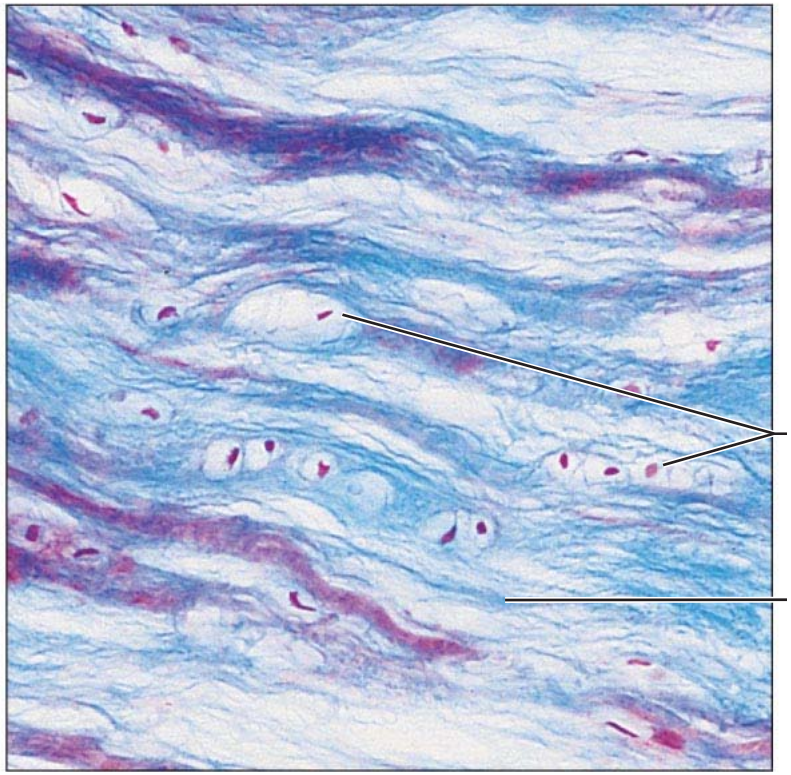
(i) Cartilage: fibrocartilage

Description: **Matrix similar to but less firm than that in hyaline cartilage; thick collagen fibers predominate.**

Function: **Tensile strength with the ability to absorb compressive shock.**

Location: **Intervertebral discs; pubic symphysis; discs of knee joint.**





Photomicrograph: **Fibrocartilage of an intervertebral disc (125x). Special staining produced the blue color seen.**

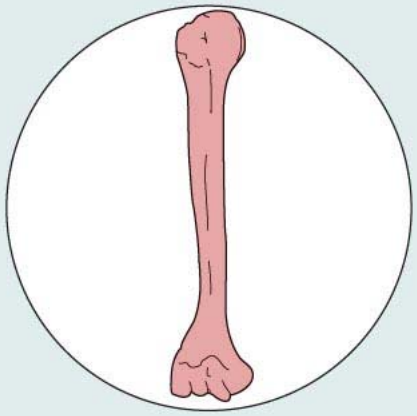
Figure 4.8i

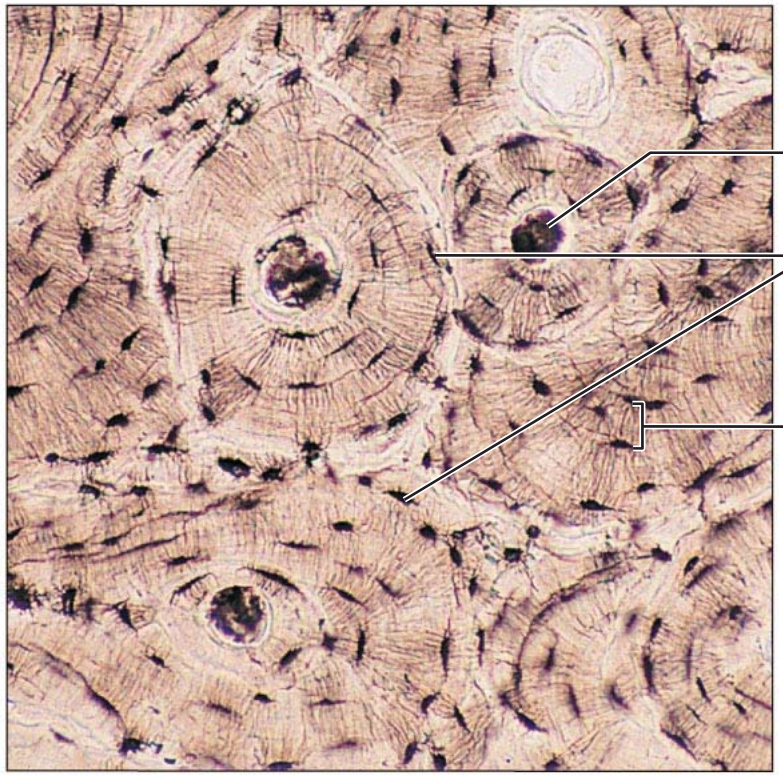
(j) Others: bone (osseous tissue)

Description: **Hard, calcified matrix containing many collagen fibers; osteocytes lie in lacunae. Very well vascularized.**

Function: **Bone supports and protects (by enclosing); provides levers for the muscles to act on; stores calcium and other minerals and fat; marrow inside bones is the site for blood cell formation (hematopoiesis).**

Location: **Bones**





Photomicrograph: **Cross-sectional view of bone (125x).**

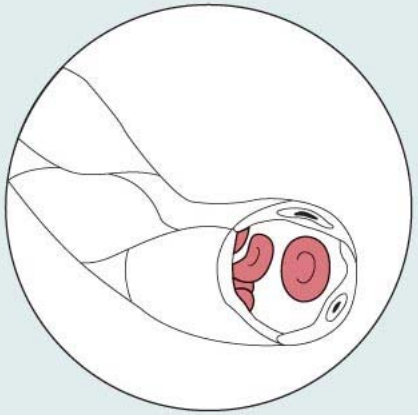
Figure 4.8j

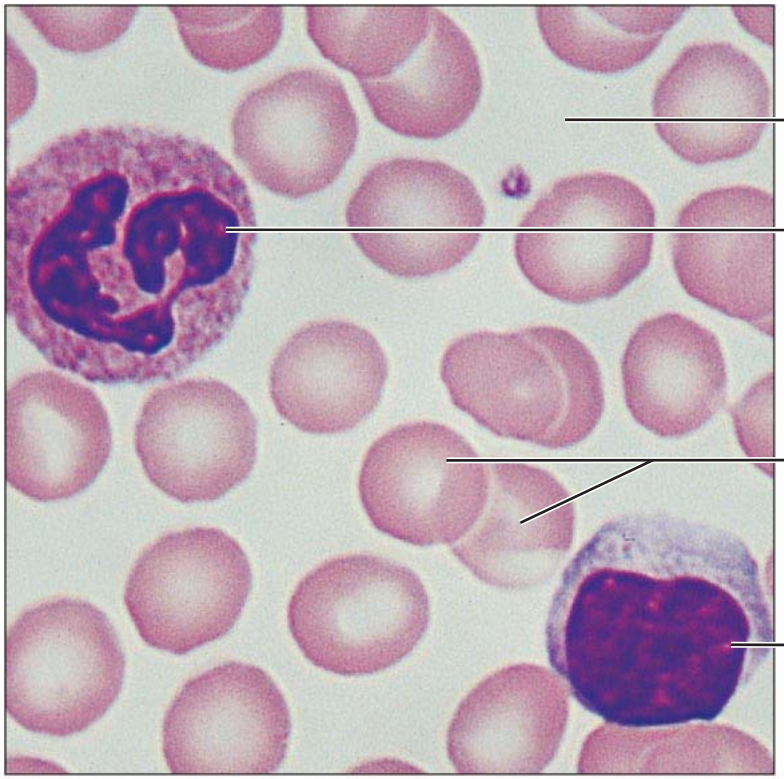
(k) Others: blood

Description: **Red and white blood cells in a fluid matrix (plasma).**

Function: **Transport of respiratory gases, nutrients, wastes, and other substances.**

Location: **Contained within blood vessels.**





Photomicrograph: **Smear of human blood (1860x); two white blood cells (neutrophil in upper left and lymphocyte in lower right) are seen surrounded by red blood cells.**

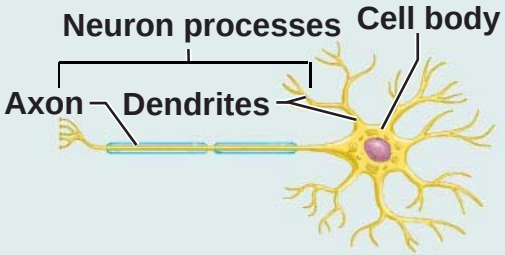
Figure 4.8k

Nervous Tissue

- Nervous system (more detail with the Nervous System, Chapter 11)

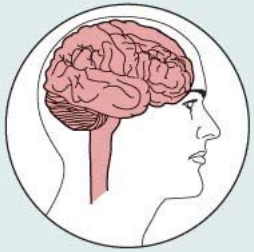
Nervous tissue

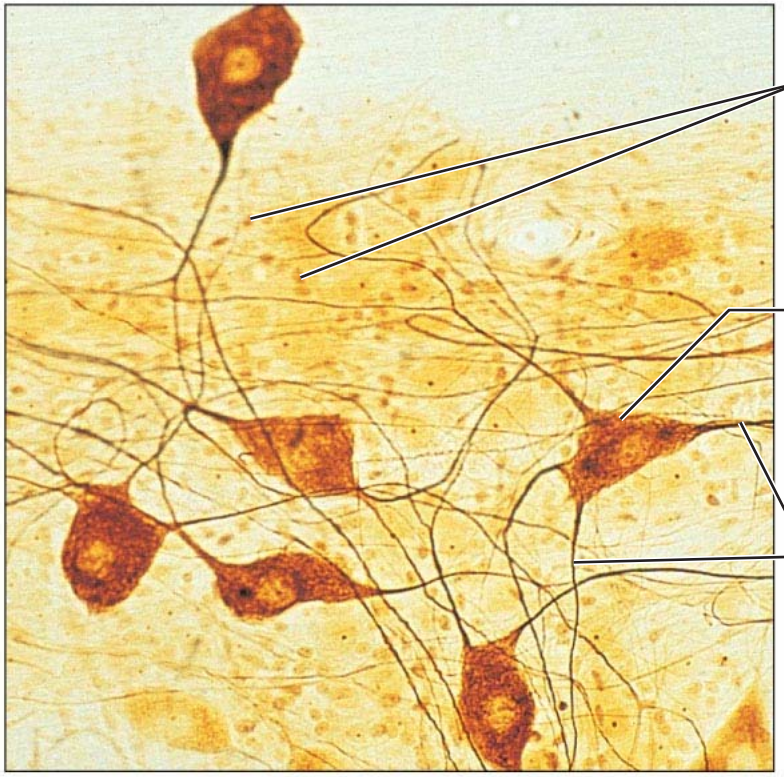
Description: **Neurons are branching cells; cell processes that may be quite long extend from the nucleus-containing cell body; also contributing to nervous tissue are nonirritable supporting cells (not illustrated).**



Function: **Transmit electrical signals from sensory receptors and to effectors (muscles and glands) which control their activity.**

Location: **Brain, spinal cord, and nerves.**





Photomicrograph: **Neurons (350x)**

Figure 4.9

Muscle Tissue

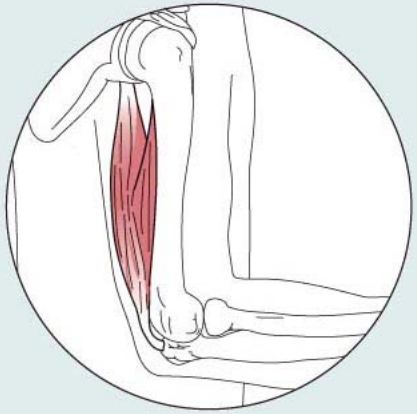
- Skeletal muscle (more detail with the Muscular System, Chapter 10)

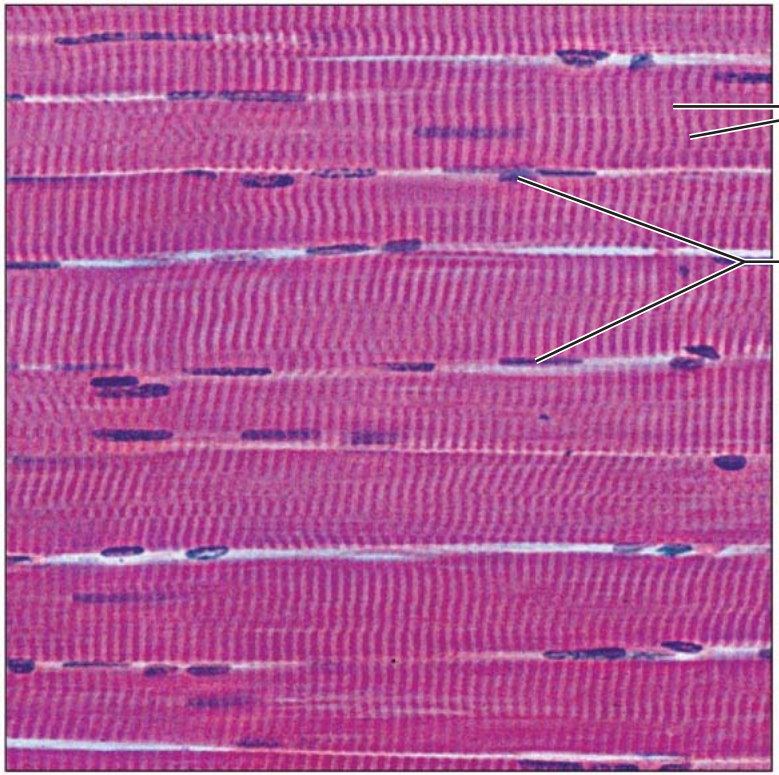
(a) Skeletal muscle

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

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

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





Photomicrograph: **Skeletal muscle (approx. 460x). Notice the obvious banding pattern and the fact that these large cells are multinucleate.**

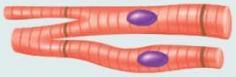
Figure 4.10a

Muscle Tissue

- Cardiac muscle (more detail with the Cardiovascular System, Chapters 18 and 19)

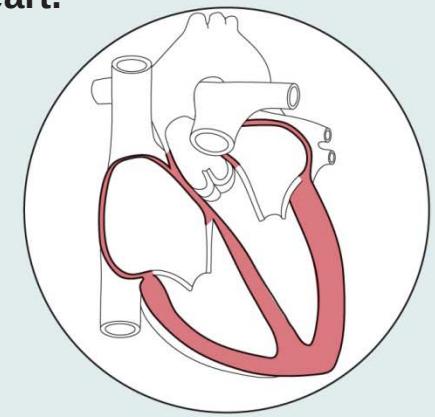
(b) Cardiac muscle

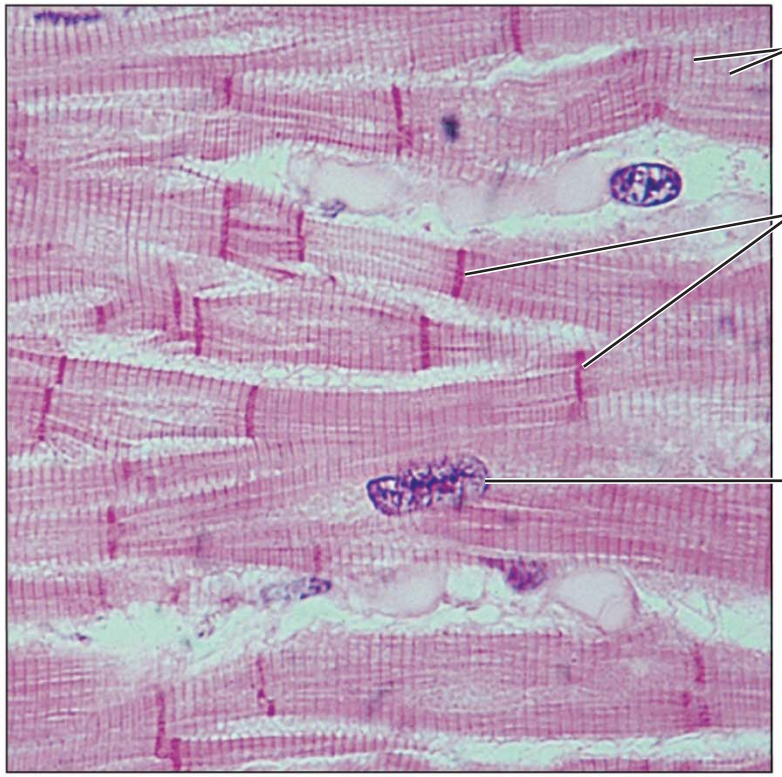
Description: **Branching, striated, generally uninucleate cells that interdigitate at specialized junctions (intercalated discs).**



Function: **As it contracts, it propels blood into the circulation; involuntary control.**

Location: **The walls of the heart.**





Photomicrograph: **Cardiac muscle (500X); notice the striations, branching of cells, and the intercalated discs.**

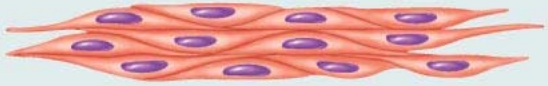
Figure 4.10b

Muscle Tissue

- Smooth muscle

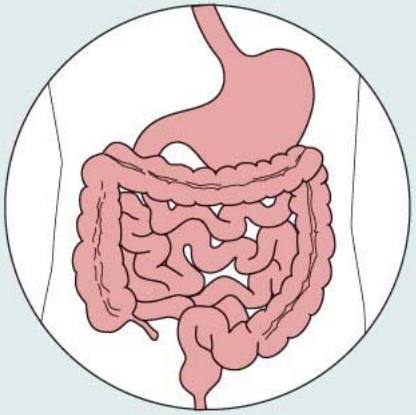
(c) Smooth muscle

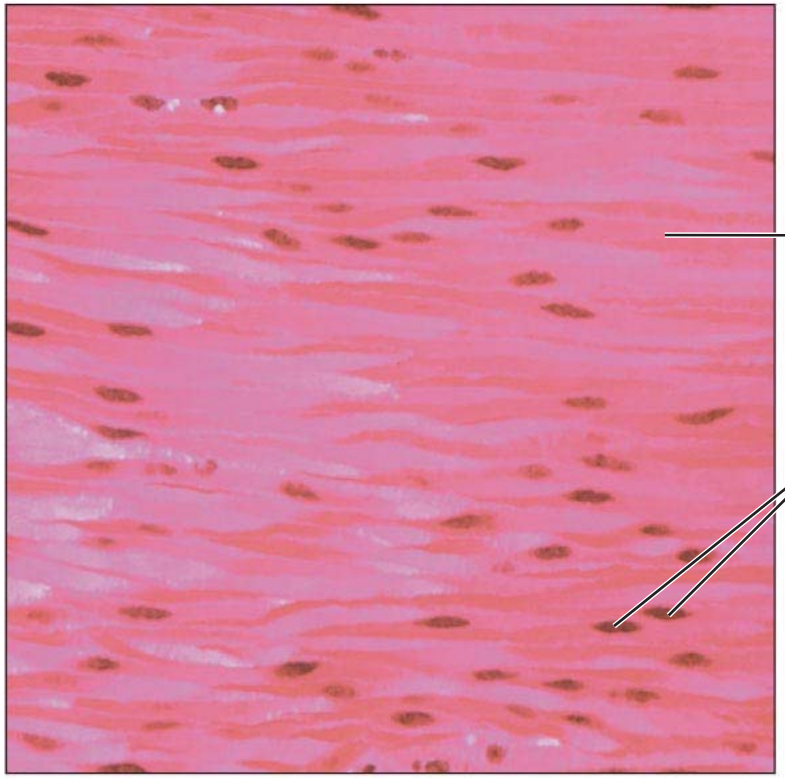
Description: **Spindle-shaped cells with central nuclei; no striations; cells arranged closely to form sheets.**



Function: **Propels substances or objects (foodstuffs, urine, a baby) along internal passage-ways; involuntary control.**

Location: **Mostly in the walls of hollow organs.**



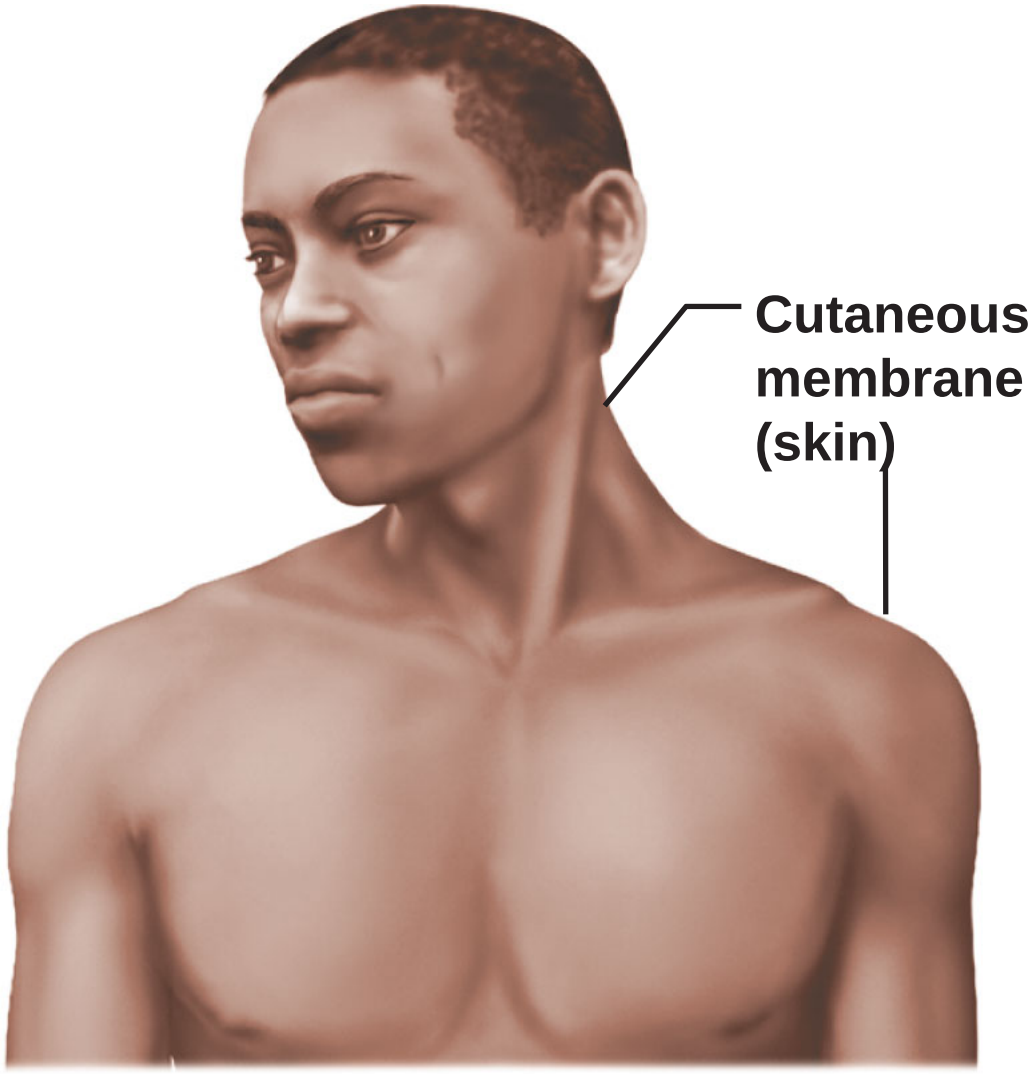


Photomicrograph: **Sheet of smooth muscle (200x).**

Figure 4.10c

Epithelial Membranes

- Cutaneous membrane (skin) (More detail with the Integumentary System, Chapter 5)

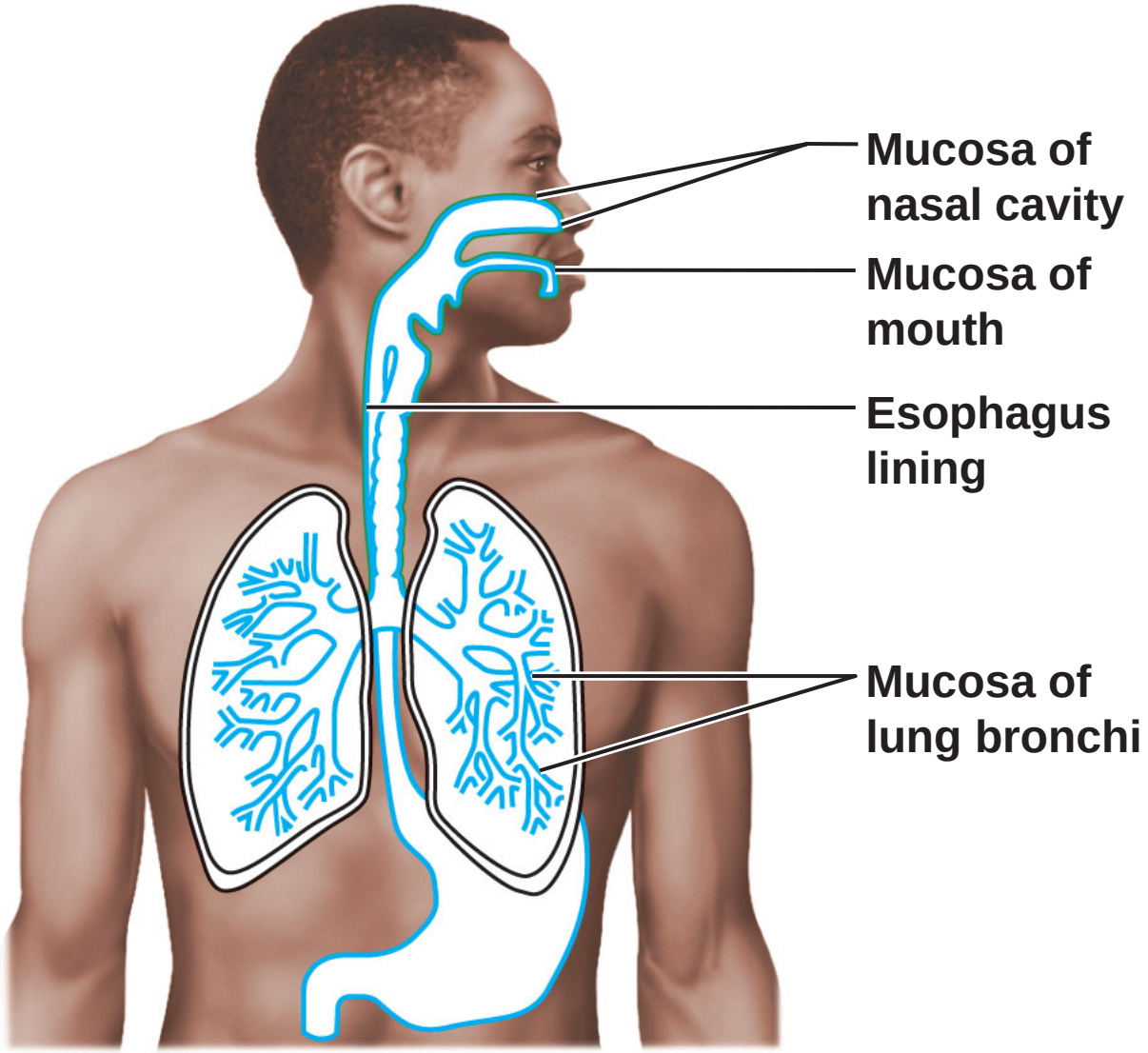


(a) Cutaneous membrane (the skin) covers the body surface.

Figure 4.11a

Epithelial Membranes

- Mucous membranes
  - Mucosae
    - Line body cavities open to the exterior (e.g., digestive and respiratory tracts)

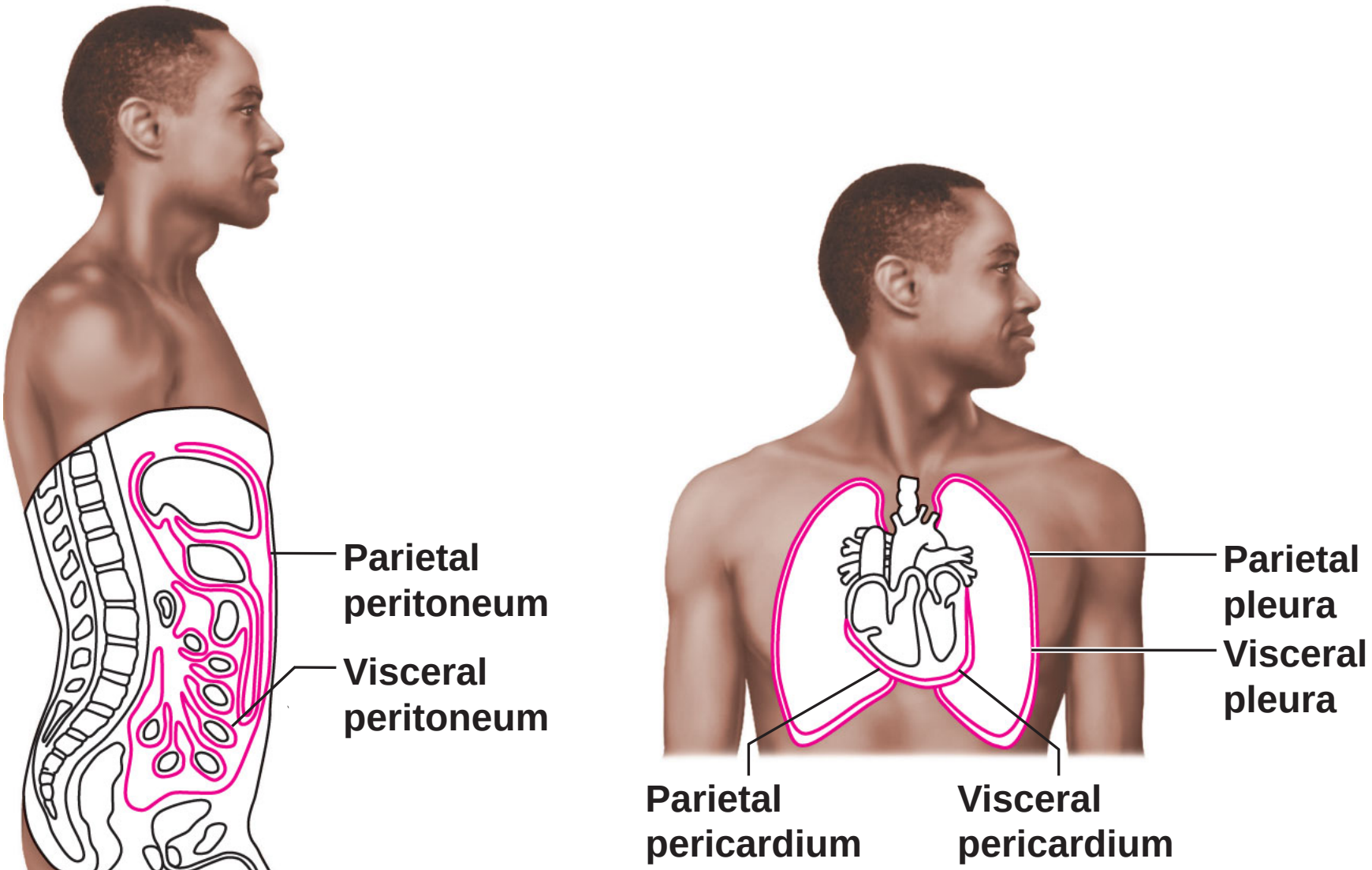


(b) Mucous membranes line body cavities open to the exterior.

Figure 4.11b

Epithelial Membranes

- Serous Membranes
  - Serosae—membranes (mesothelium + areolar tissue) in a closed ventral body cavity
  - Parietal serosae line internal body walls
  - Visceral serosae cover internal organs

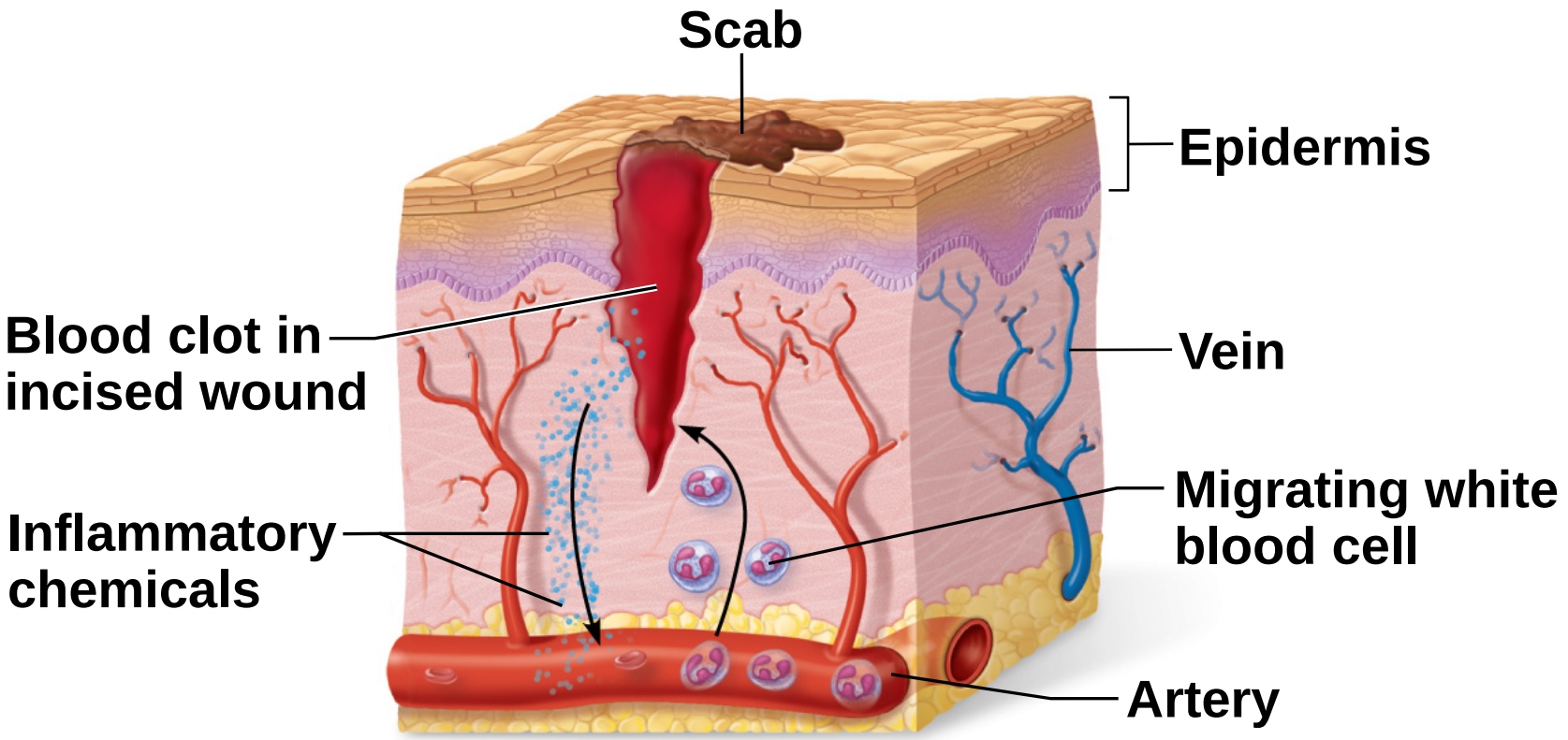


(c) Serous membranes line body cavities closed to the exterior.

Figure 4.11c

Steps in Tissue Repair

- Inflammation
  - Release of inflammatory chemicals
  - Dilation of blood vessels
  - Increase in vessel permeability
  - Clotting occurs



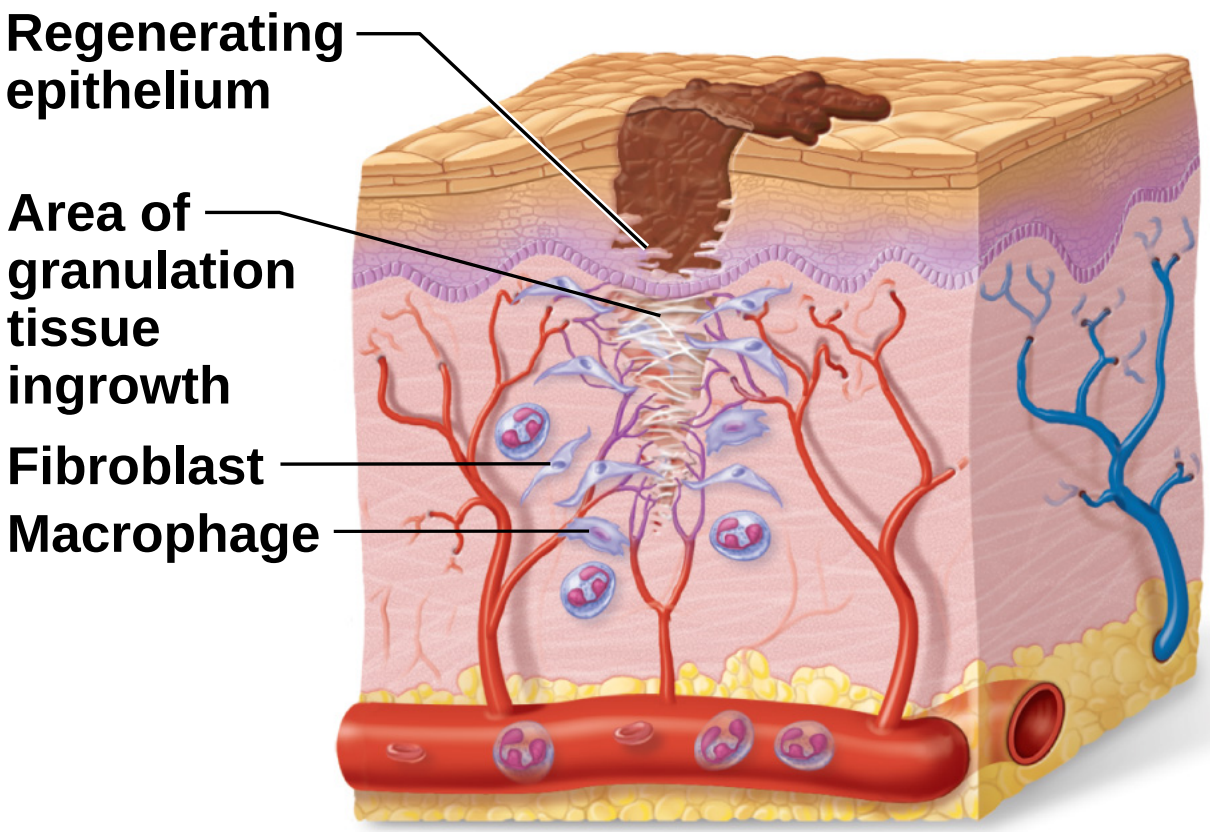
① Inflammation sets the stage:

- **Severed blood vessels bleed and inflammatory chemicals are released.**
- **Local blood vessels become more permeable, allowing white blood cells, fluid, clotting proteins and other plasma proteins to seep into the injured area.**
- **Clotting occurs; surface dries and forms a scab.**

Figure 4.12, step 1

Steps in Tissue Repair

- Organization and restored blood supply
  - The blood clot is replaced with granulation tissue
  - Epithelium begins to regenerate
  - Fibroblasts produce collagen fibers to bridge the gap
  - Debris is phagocytized



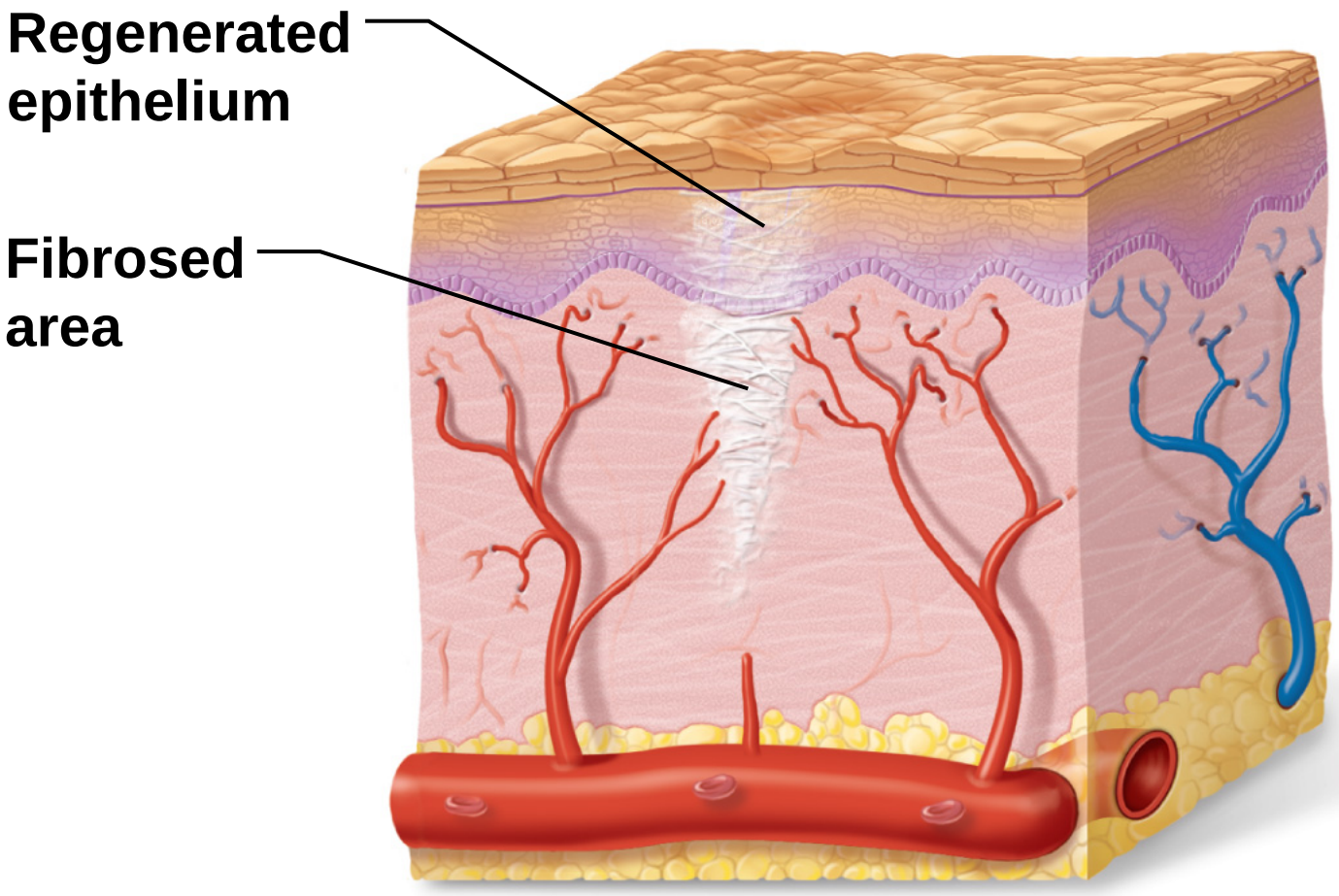
② Organization restores the blood supply:

- **The clot is replaced by granulation tissue, which restores the vascular supply.**
- **Fibroblasts produce collagen fibers that bridge the gap.**
- **Macrophages phagocytize cell debris.**
- **Surface epithelial cells multiply and migrate over the granulation tissue.**

Figure 4.12, step 2

Steps in Tissue Repair

- Regeneration and fibrosis
  - The scab detaches
  - Fibrous tissue matures; epithelium thickens and begins to resemble adjacent tissue
  - Results in a fully regenerated epithelium with underlying scar tissue



③ Regeneration and fibrosis effect permanent repair:

- **The fibrosed area matures and contracts; the epithelium thickens.**
- **A fully regenerated epithelium with an underlying area of scar tissue results.**

Figure 4.12, step 3

Developmental Aspects

- Primary germ layers: ectoderm, mesoderm, and endoderm
  - Formed early in embryonic development
  - Specialize to form the four primary tissues
    - Nerve tissue arises from ectoderm
    - Muscle and connective tissues arise from mesoderm
    - Epithelial tissues arise from all three germ layers

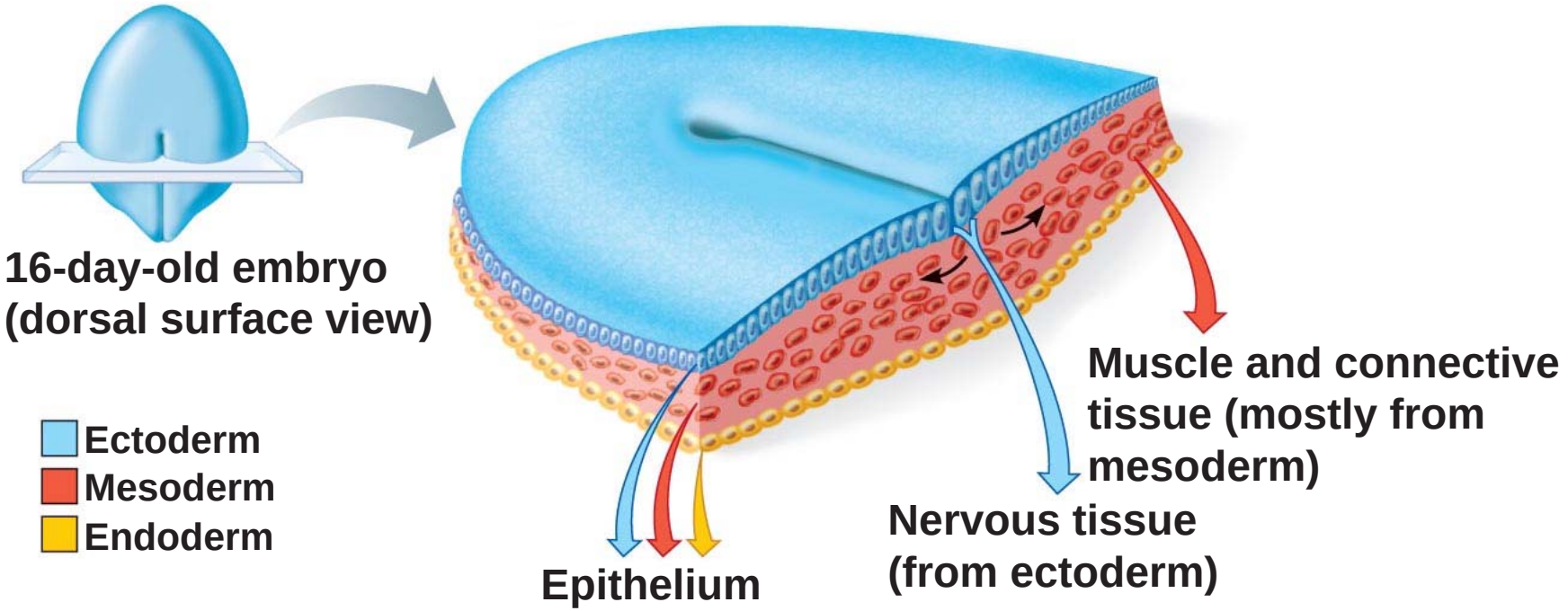


Figure 4.13