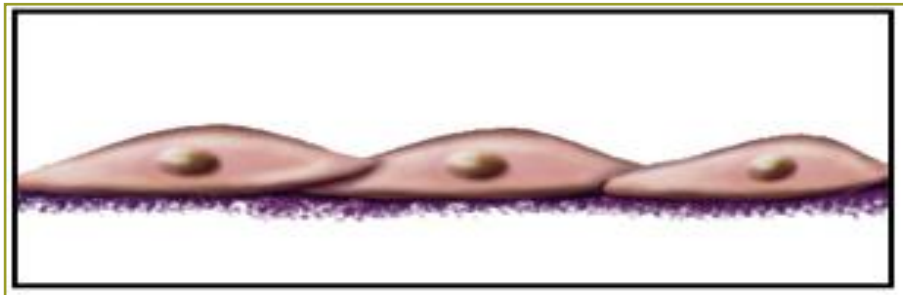
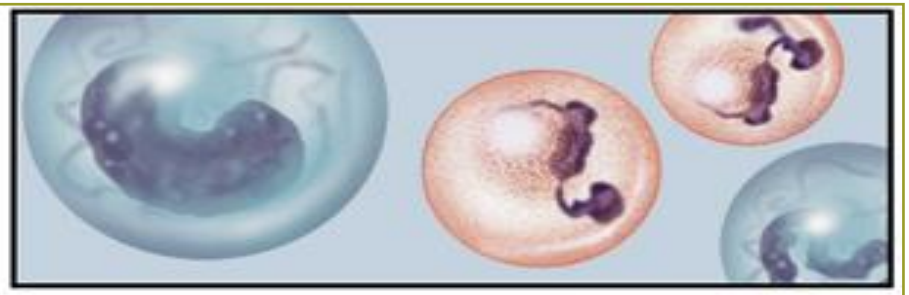
Animal Anatomy and Physiology 1

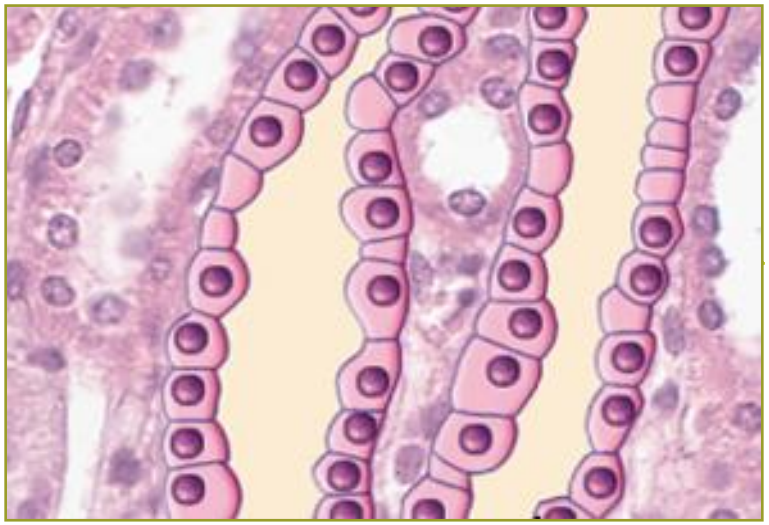
Webinar Chapter 4

Tissues





Tissues: Living Communities
Chapter 4



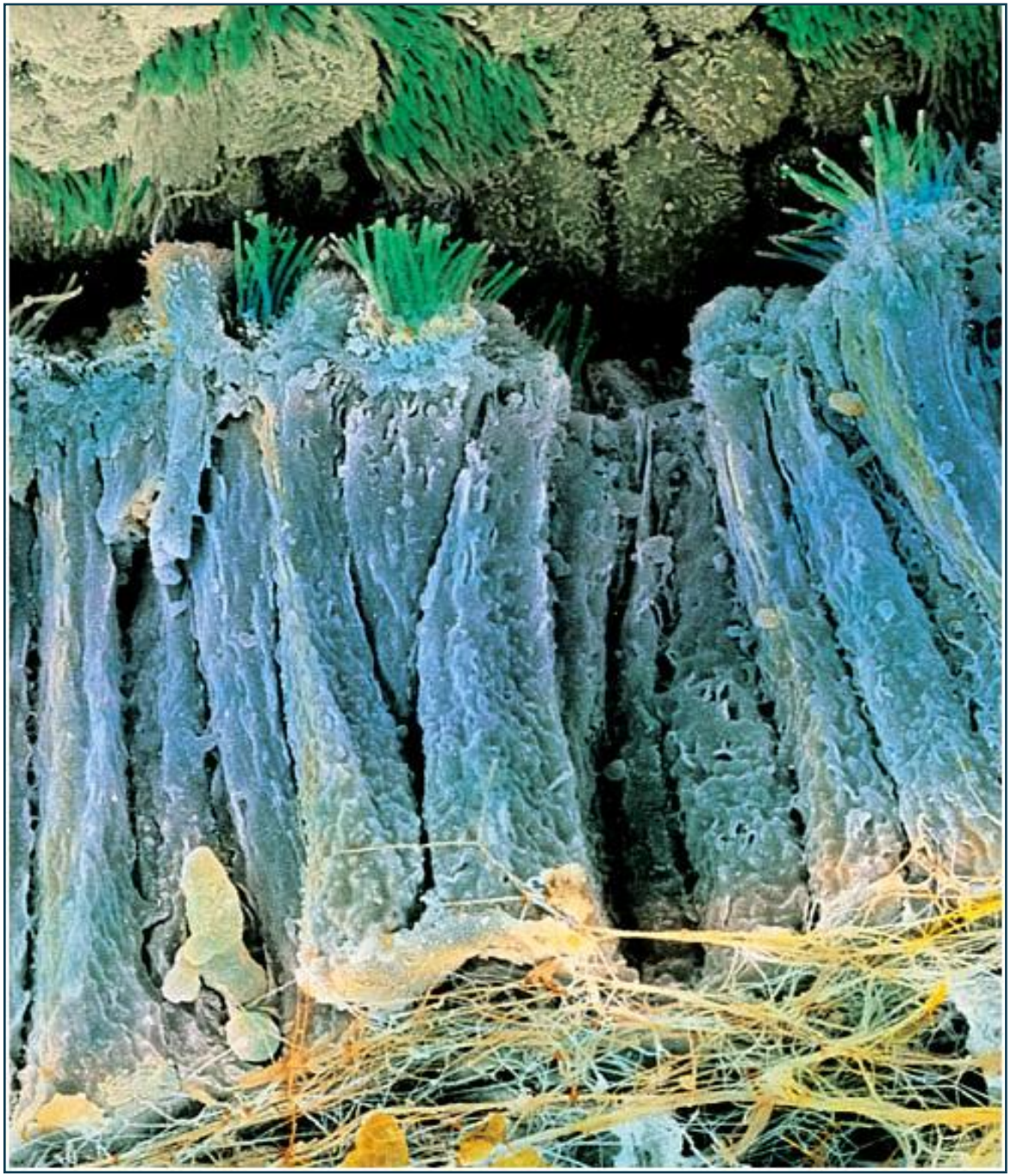
Pages 90-130

Textbook Learning Objectives

Chapter 4 – Page 90

- Describe the functions of epithelial tissues.
- Differentiate between the three major types of cellular junctions found between epithelial cells.
- Describe the structure of the basement membrane.
- List and describe the characteristics used to classify different epithelial tissues.
- List and describe the characteristics used to classify different glands.
- List and describe the components that make up connective tissues.
- Differentiate between areolar, adipose, and reticular connective tissues.
- Differentiate between dense regular, dense irregular, and elastic connective tissues.
- Differentiate between hyaline cartilage, elastic cartilage, and fibrocartilage.
- List and describe the components of bone.

What Tissue?



Types of Tissues

- Tissues are classified into the following four primary types:
  1. Epithelial tissue
  2. Connective tissue
  3. Muscle tissue
  4. Nervous tissue

1. Epithelial Tissue

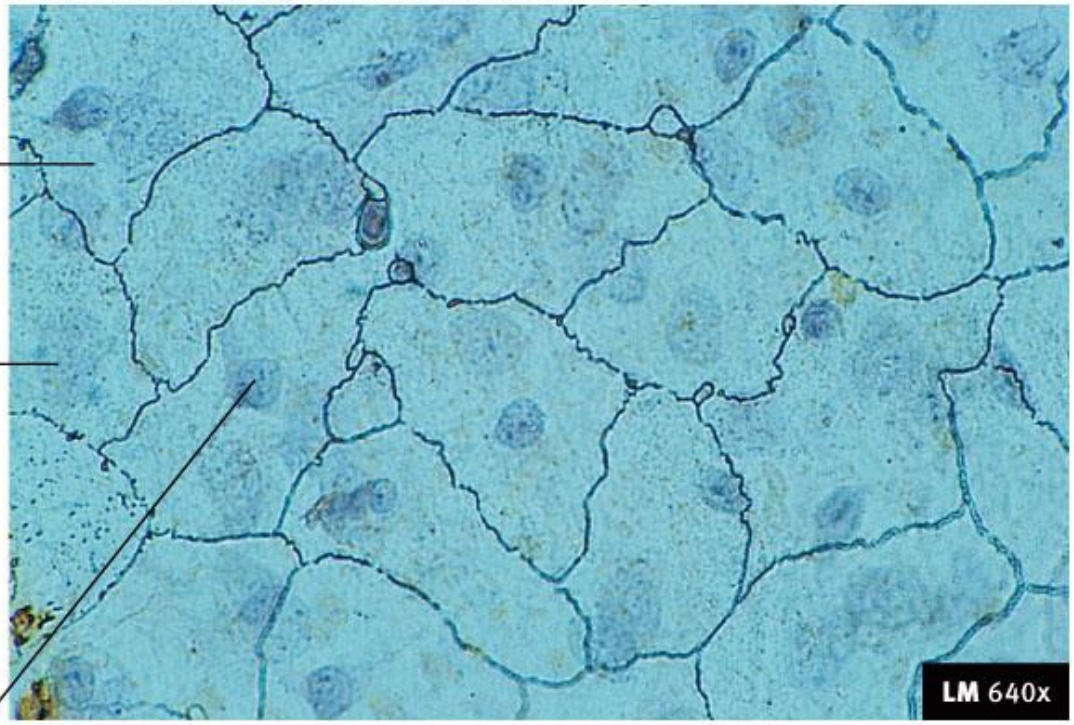
Sheetlike

Glandular

Epithelial Tissues

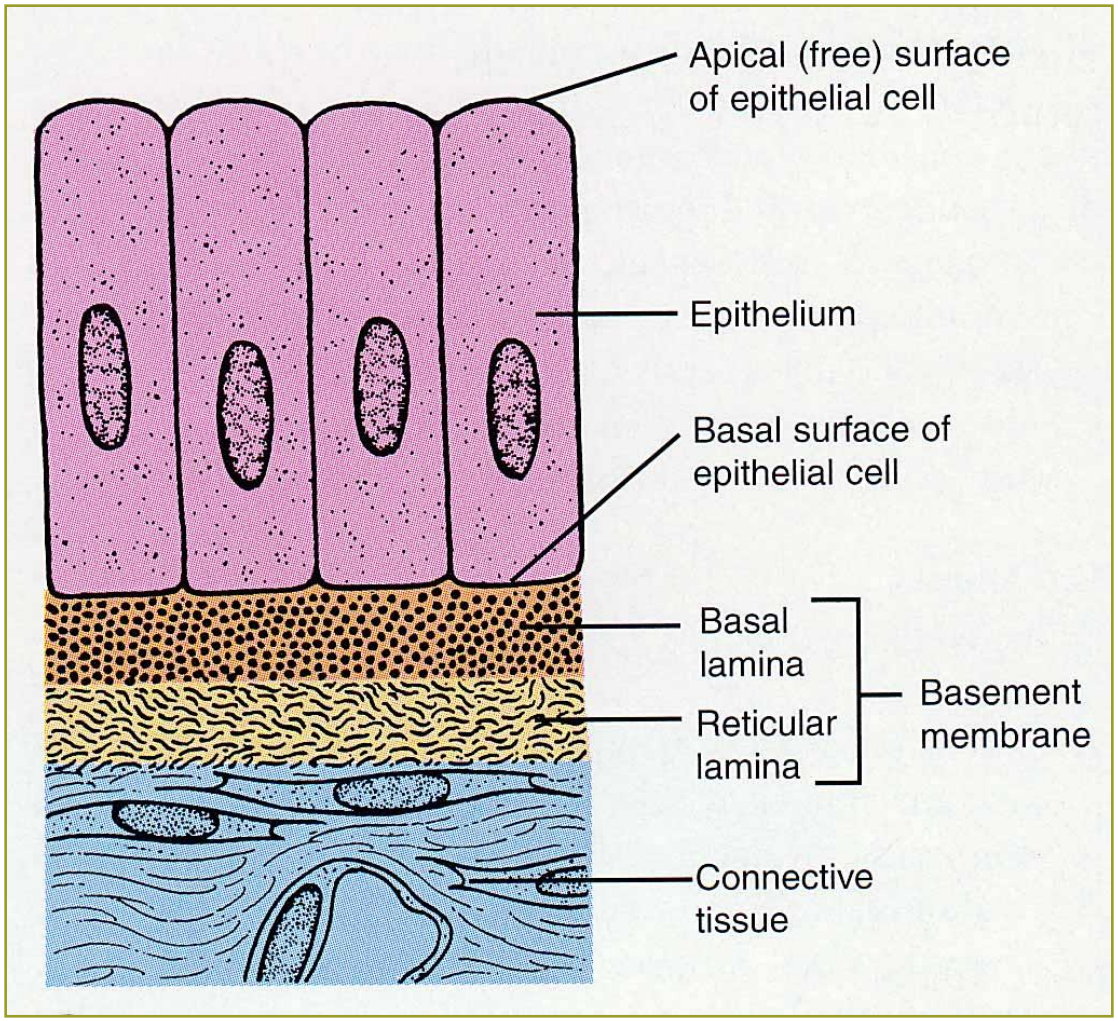
- **Sheets of cells** that cover and line other tissues
- Protect underlying tissues and may act to filter biochemical substances
- May absorb, secrete, or excrete biochemical substances
- May play a role in the **reception of sensory input**

Epithelial Tissue



Surface view

Anatomy of Epithelial Tissue



Characteristics of Epithelia

- Each epithelial cell has an **apical surface** and a **basal surface**
  - Apical surface faces the **lumen** or outside of the organ
  - Basal surface faces the basal lamina and blood vessels
- Lateral surfaces are connected to neighboring cells by junctional complexes.
- Epithelial cells are **avascular**
- Most epithelial cells are **innervated**

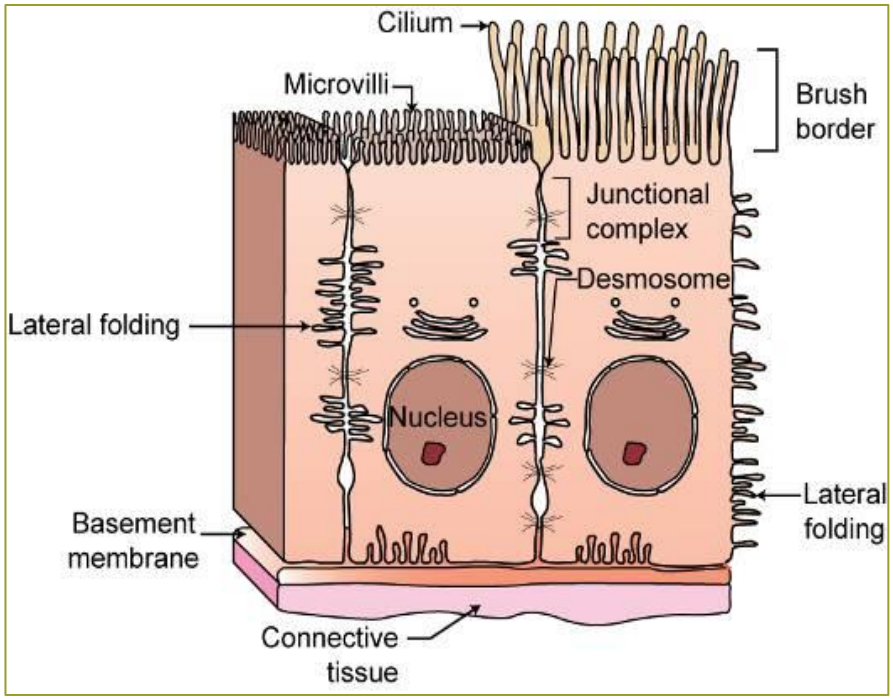
Basement Membrane

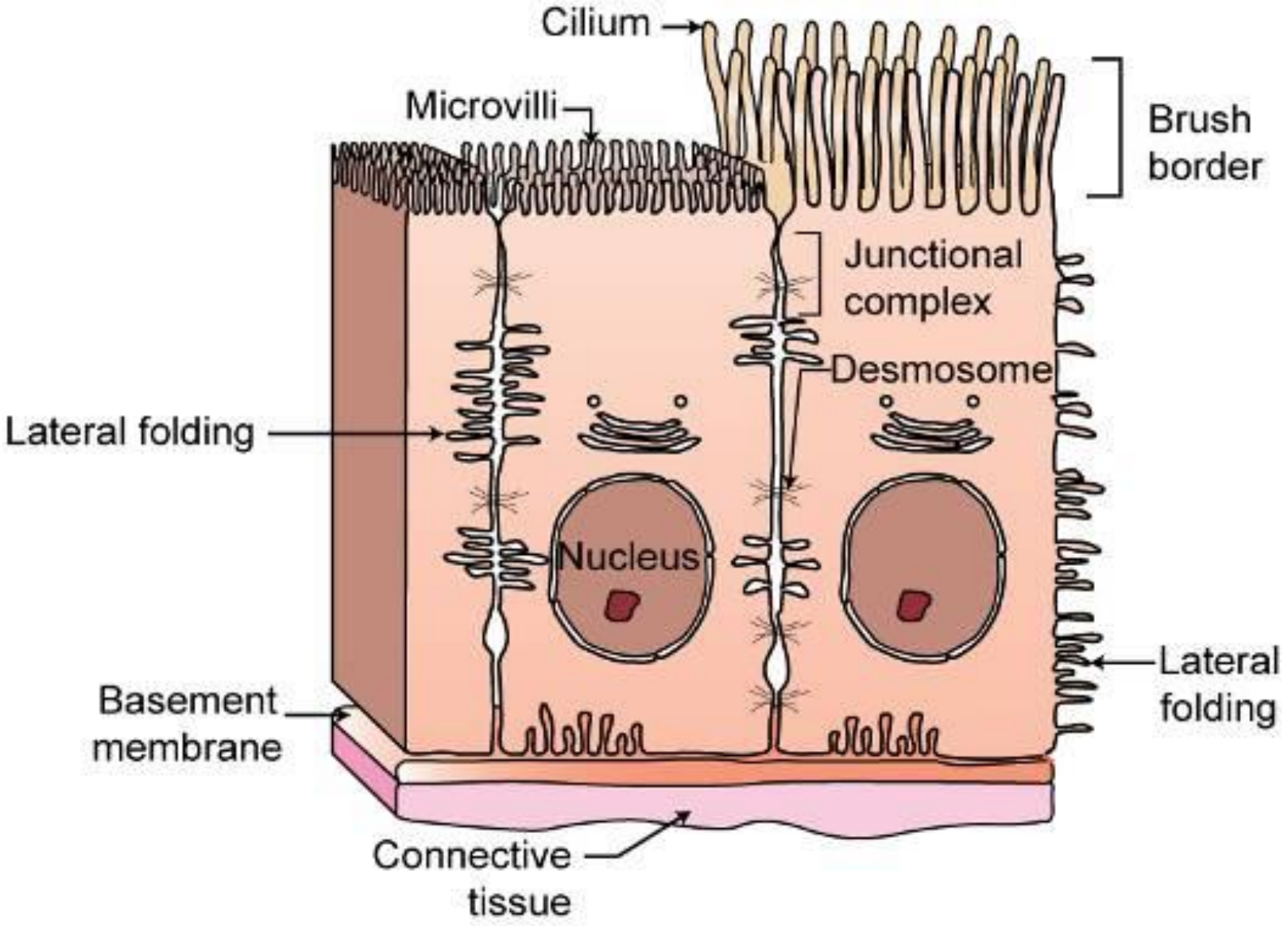
- Meshwork of fibers that cements the epithelial cell to the underlying connective tissue
- Also called *basal lamina*
- Varies in thickness
- Helps prevent the cell from being torn off by intraluminal pressures
- Acts as a partial barrier between the epithelial cell and the underlying connective tissue

Surface Specialization

Figure 4-2, Page 93

- Surfaces of epithelial cells vary depending on where they are located and what role they play in the function of the tissue
  - Smooth
  - **Microvilli** (brush border)
  - **Cilia**
  - Keratin

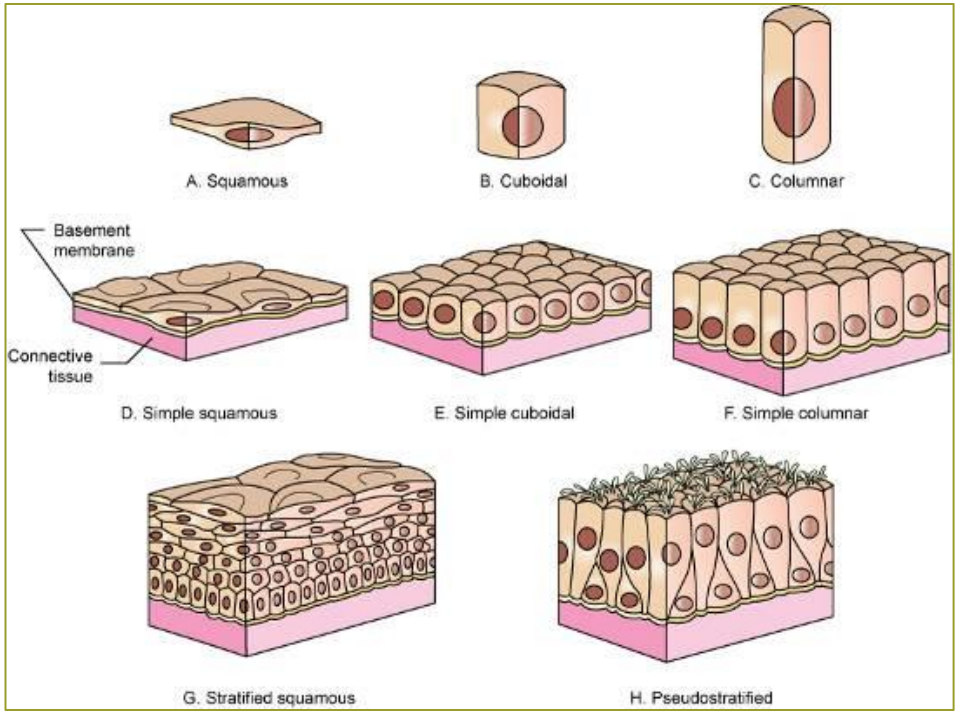



Cilium
Microvilli
Brush border
Junctional complex
Desmosome
Lateral folding
Nucleus
Lateral folding
Basement membrane
Connective tissue

Classification of Epithelial Tissue

Figure 4-3, Page 95

- **Number of layers** of cells: Simple or stratified
- **Shape** of the cells: Squamous, cuboidal, and columnar
- Presence of **surface specializations**: Cilia, keratin, etc.



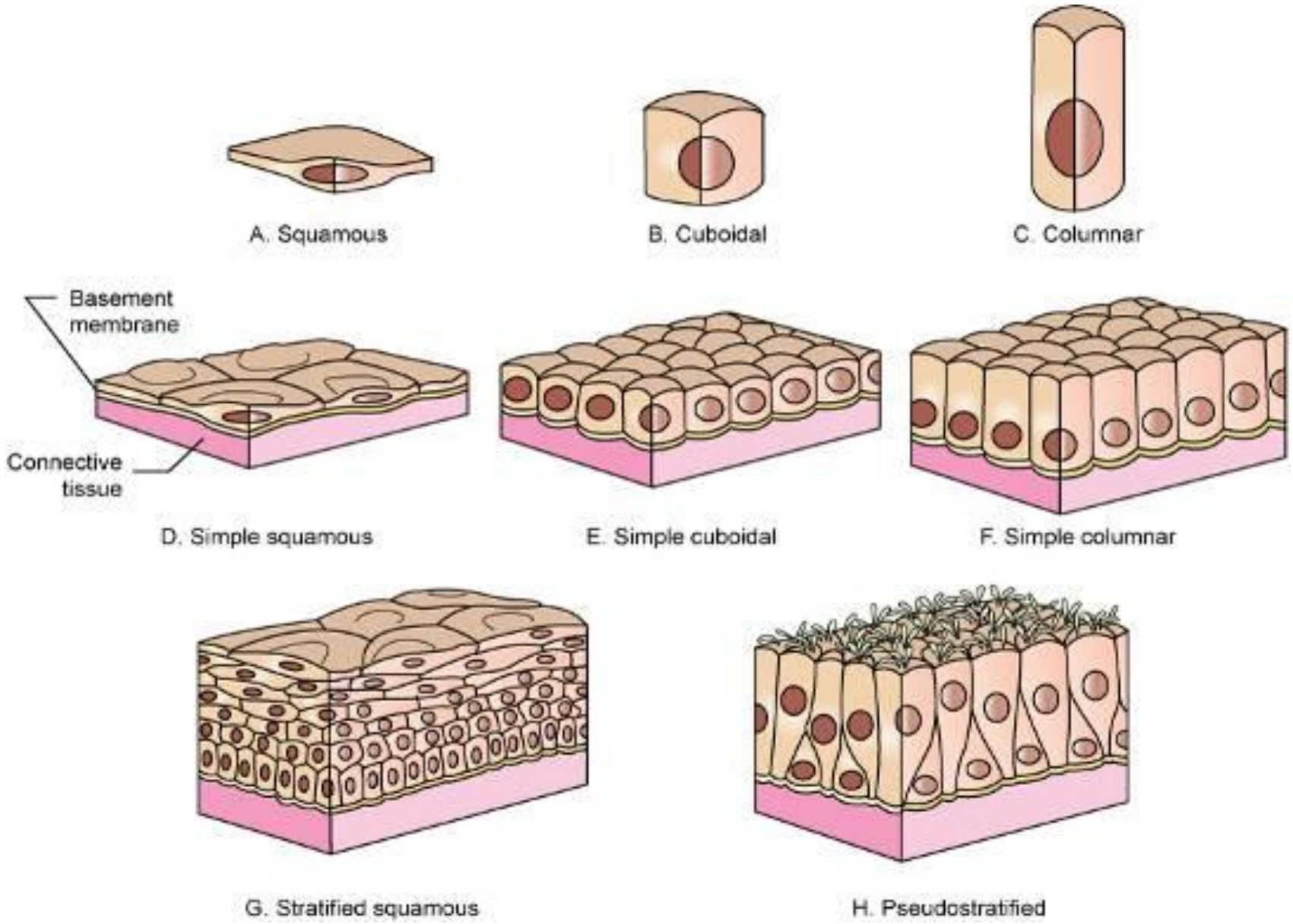

A. Squamous
B. Cuboidal
C. Columnar
Basement membrane
Connective tissue
D. Simple squamous
E. Simple cuboidal
F. Simple columnar
G. Stratified squamous
H. Pseudostratified

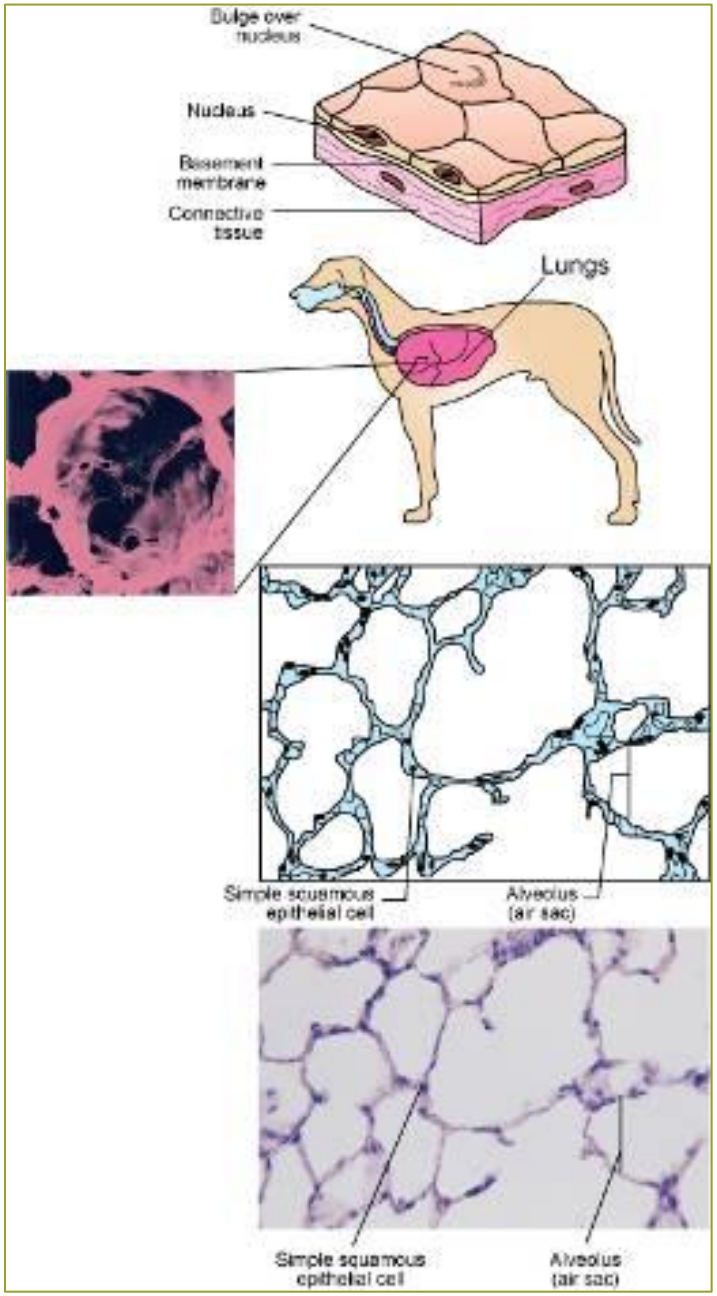
Table 4.1 Classification of Epithelia

Number of Layers	Cell Shape
Simple (one layer)	Squamous Cuboidal Columnar
Pseudostratified (a modified form of simple epithelium)	Columnar
Stratified (more than one layer)	Squamous Keratinized Nonkeratinized (moist)
Transitional (a type of stratified epithelium)	Roughly cuboidal to columnar when not stretched and squamouslike when stretched

Simple Squamous Epithelium

Figure 4-4, Page 96

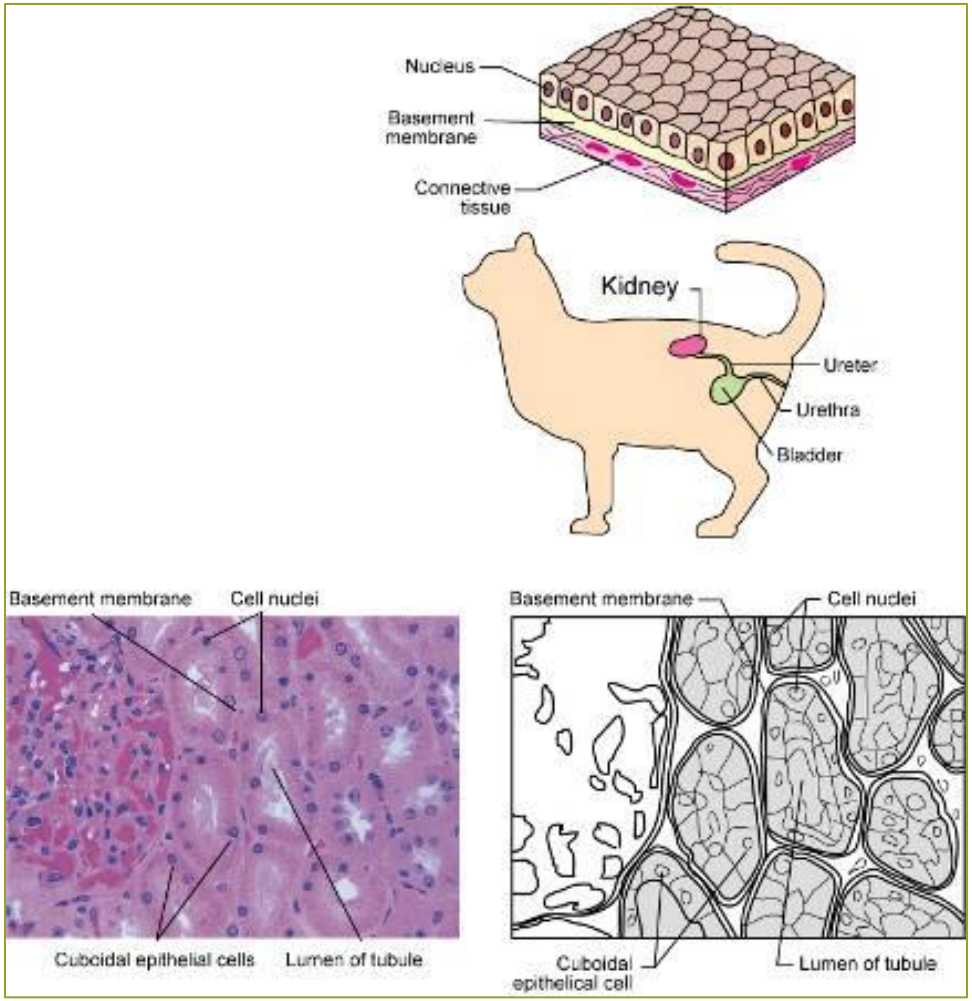
- Fragile and thin
- Found lining surfaces involved in the passage of either **gas** or **liquid**
- Flat and smooth



Simple Cuboidal Epithelium

Figure 4-5, Page 97

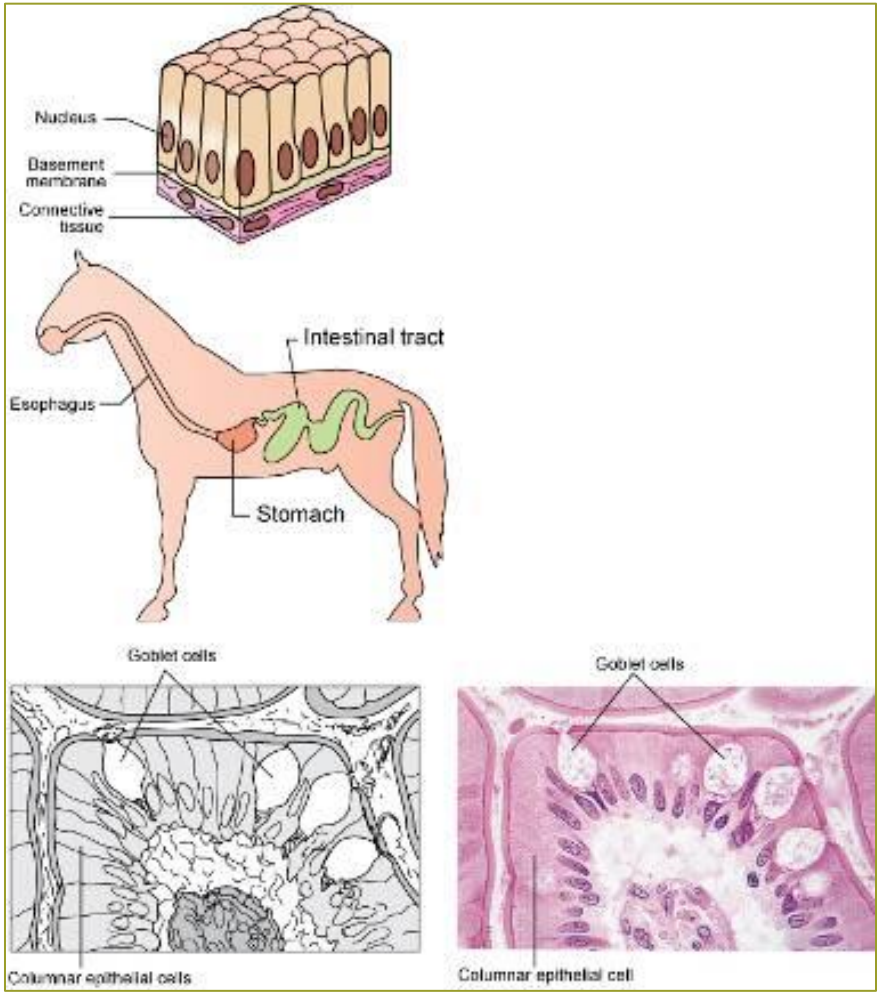
- Single layer of cube-shaped cells
- Round, dark-staining nuclei aligned in a single row
- Occurs in areas of the body where secretion and absorption take place



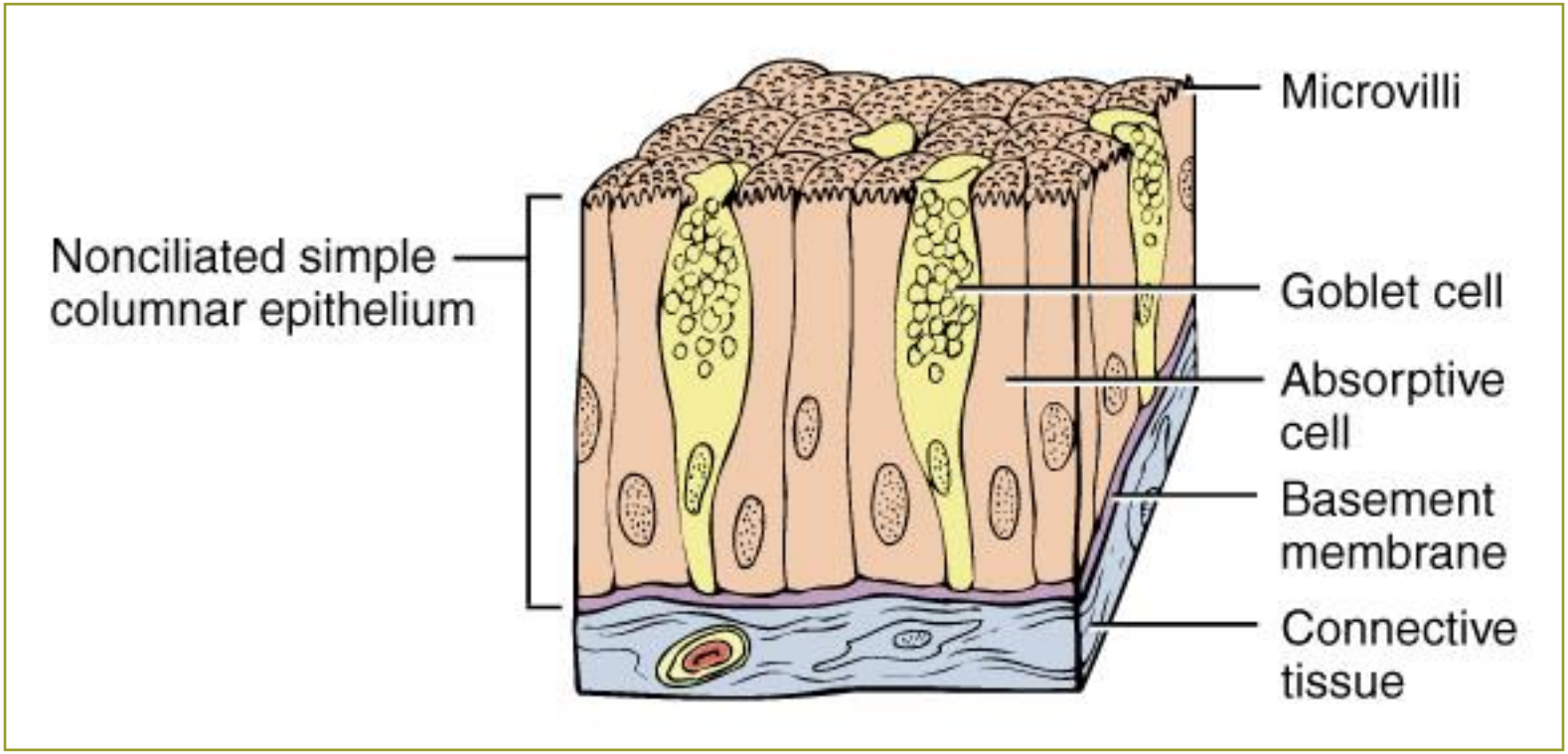
Simple Columnar Epithelium

Figure 4-6, Page 98

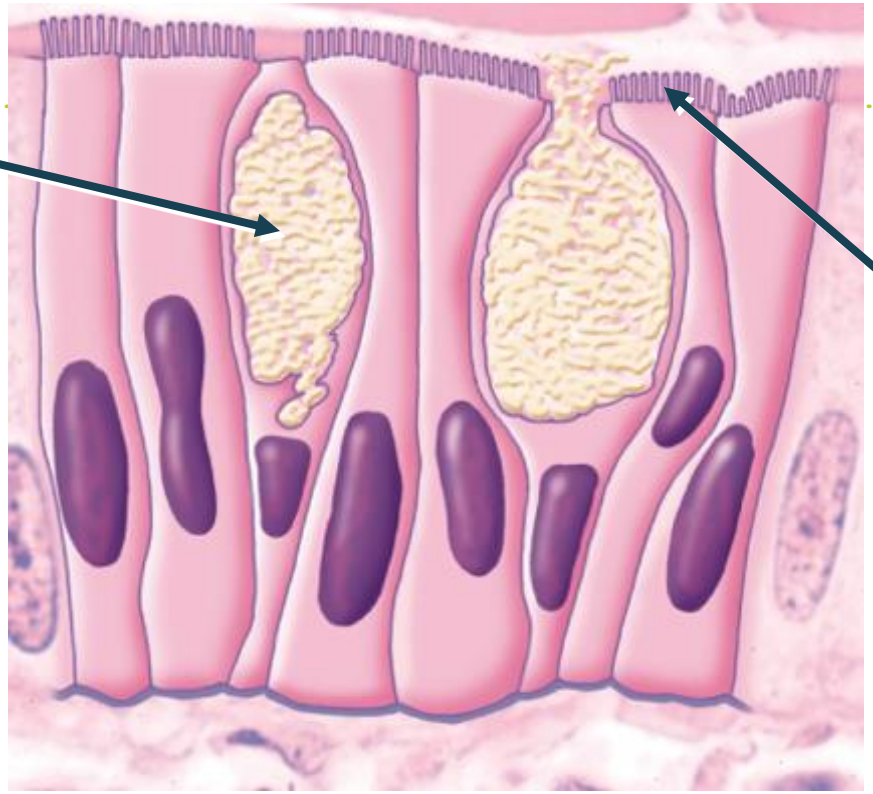
- Elongated and closely packed together
- Nuclei aligned in a row at the base of the cell near the basement membrane
- Found in many excretory ducts as well as in the digestive tract



Simple Columnar Epithelium

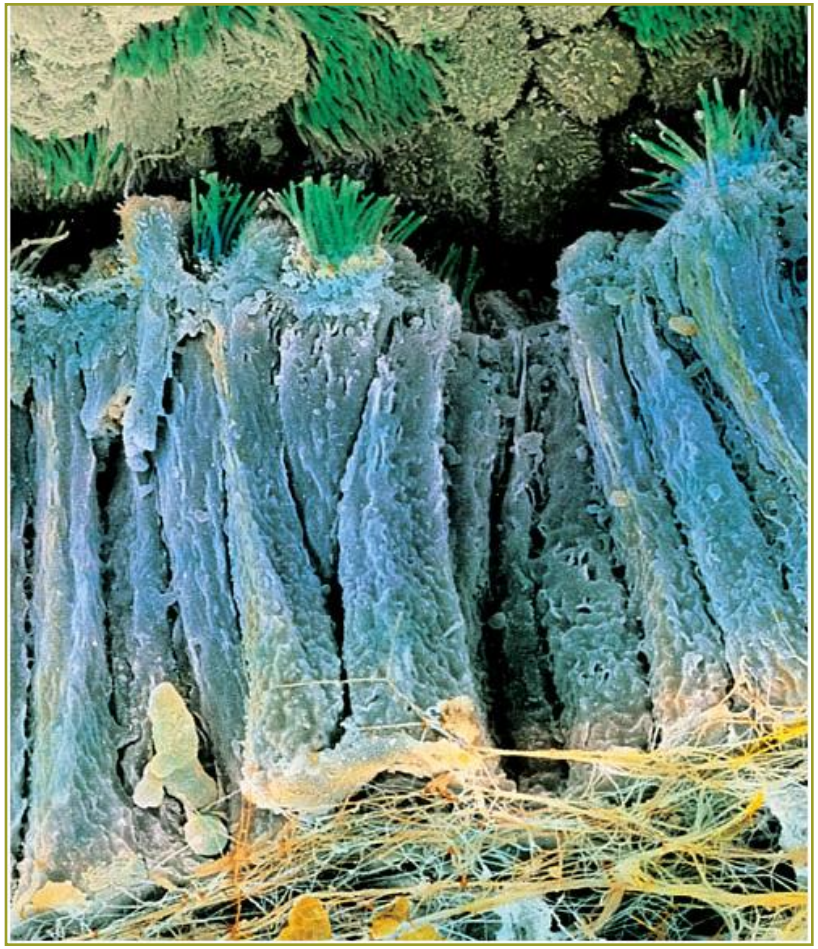


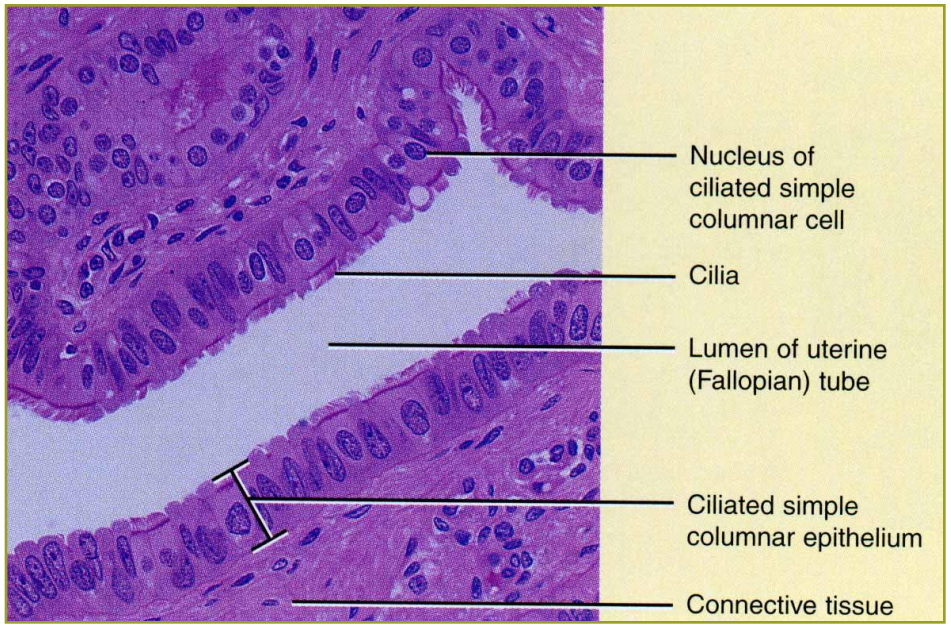
Simple Columnar Epithelium



- Digestive System

Oviduct (Uterine Tube)

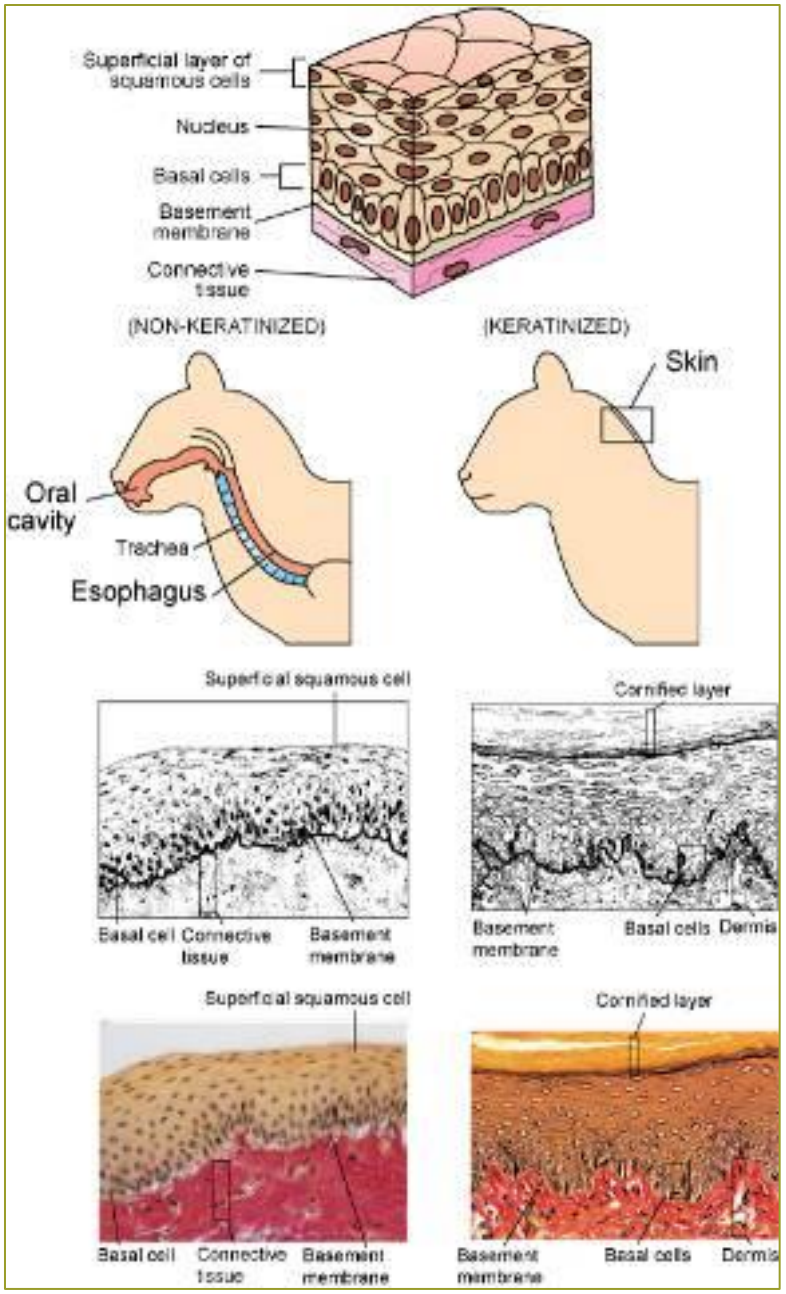




Stratified Squamous Epithelium

Figure 4-7, Page 99

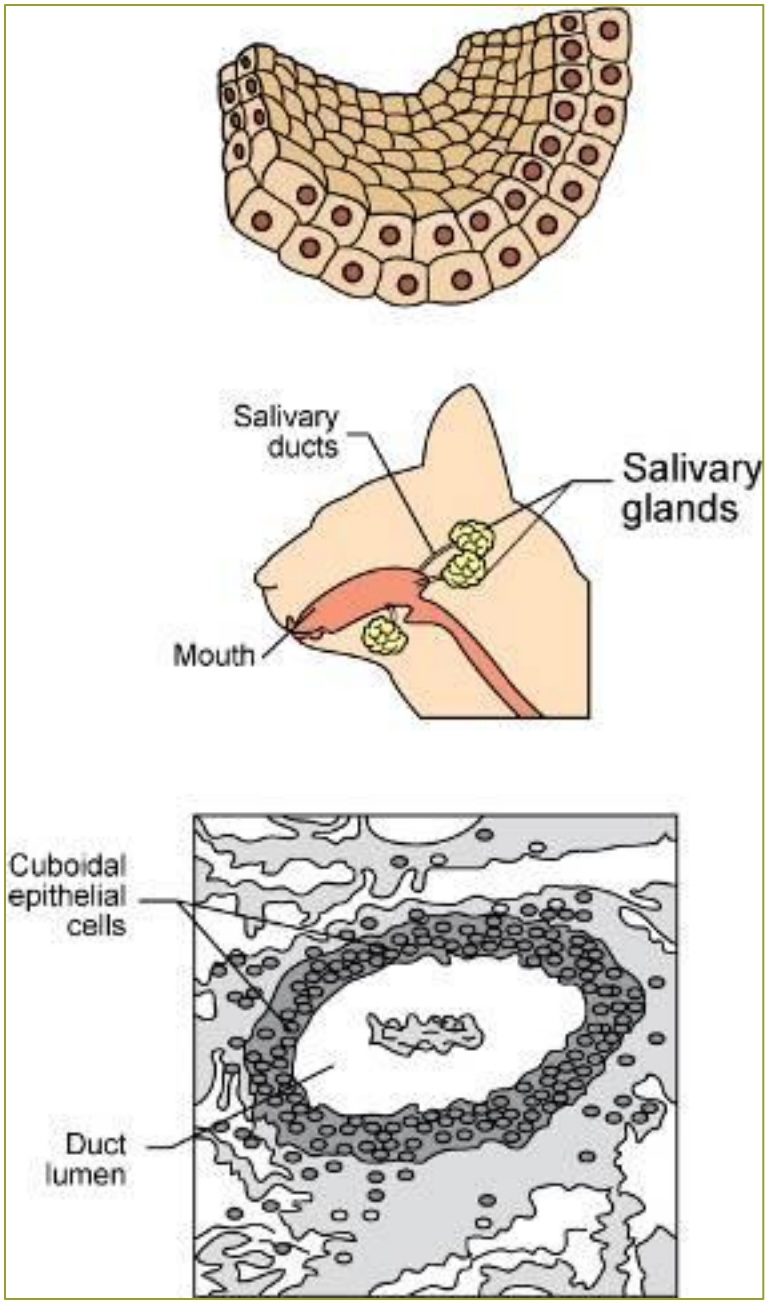
- Multilayered
- Occur in areas of the body subject to mechanical and chemical stresses
- Protect underlying tissues



Stratified Cuboidal Epithelium

Figure 4-8, Page 100

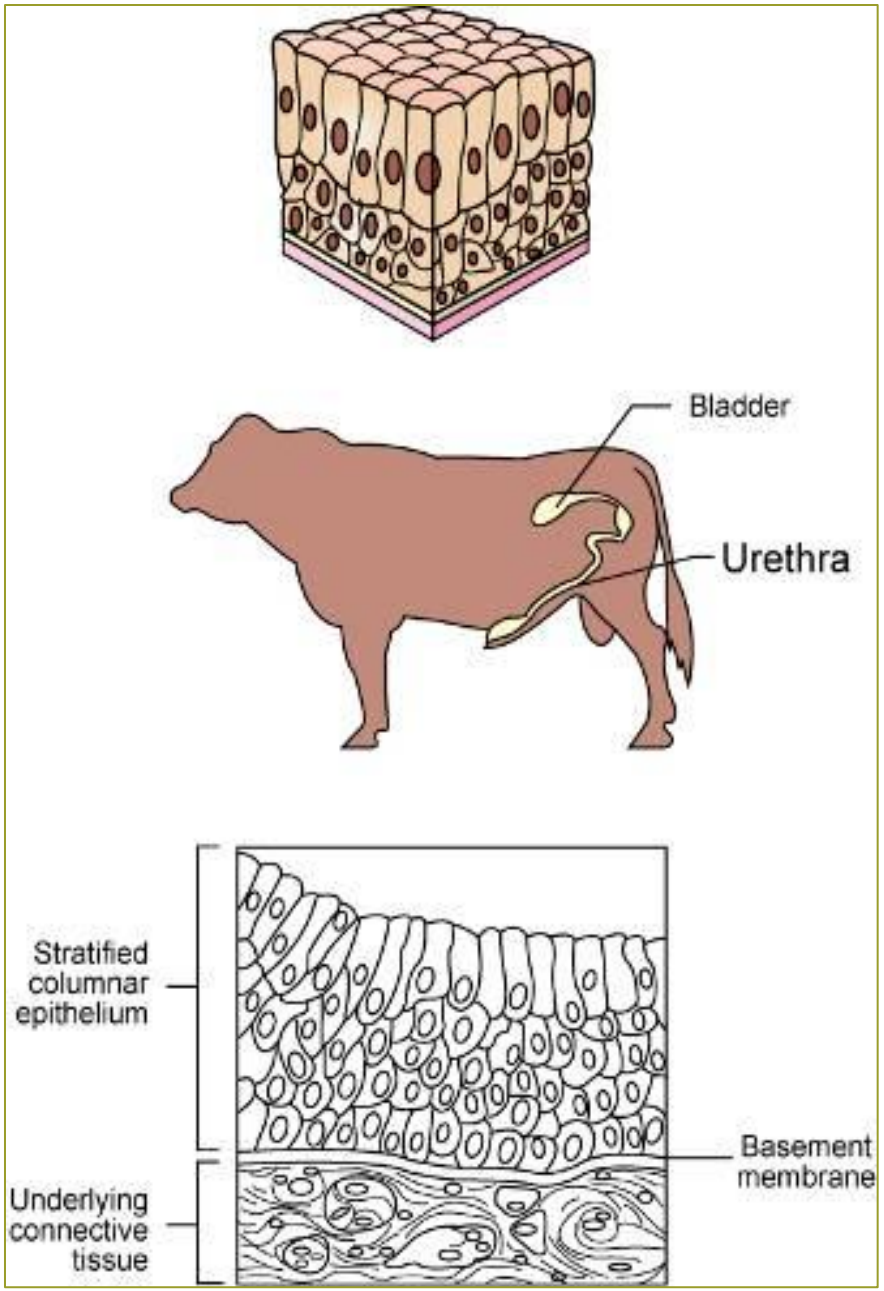
- Usually two layers of cuboidal cells
- Found primarily along large excretory ducts
- Protects underlying tissues



Stratified Columnar Epithelium

Figure 4-9, Page 100

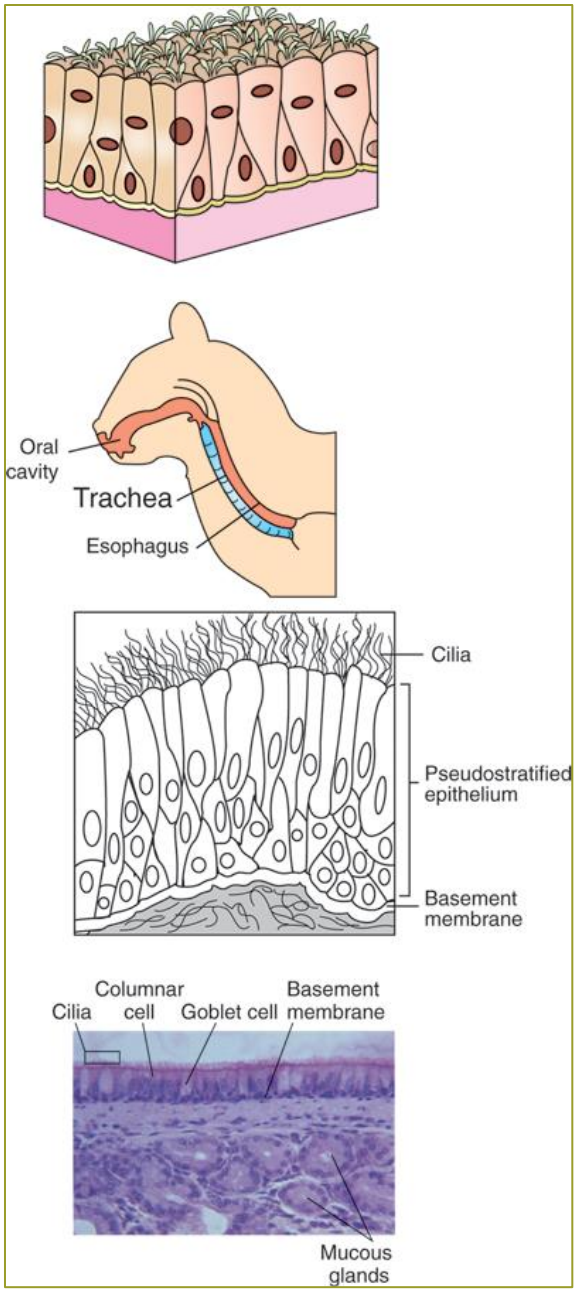
- Found only in select parts of the respiratory, digestive, reproductive systems and along some excretory ducts
- Function in secretion and protection



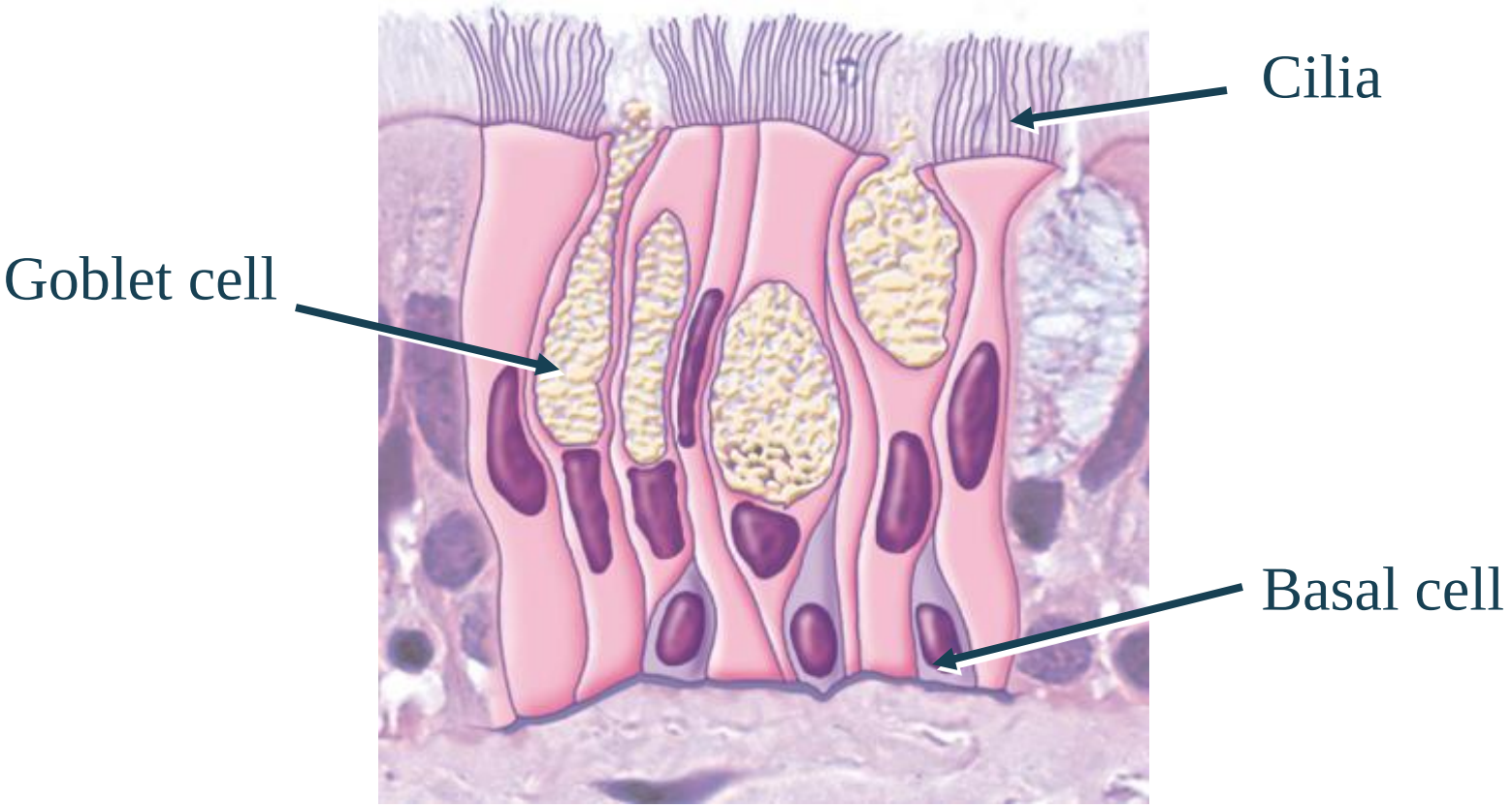
Pseudostratified Columnar Epithelium

Figure 4-10, Page 101

- Cell nuclei are found at different levels across the length of the tissue
- Some cells do not reach the luminal surface
- Found in **respiratory tract** and in portions of the male reproductive tract



Pseudostratified Epithelium

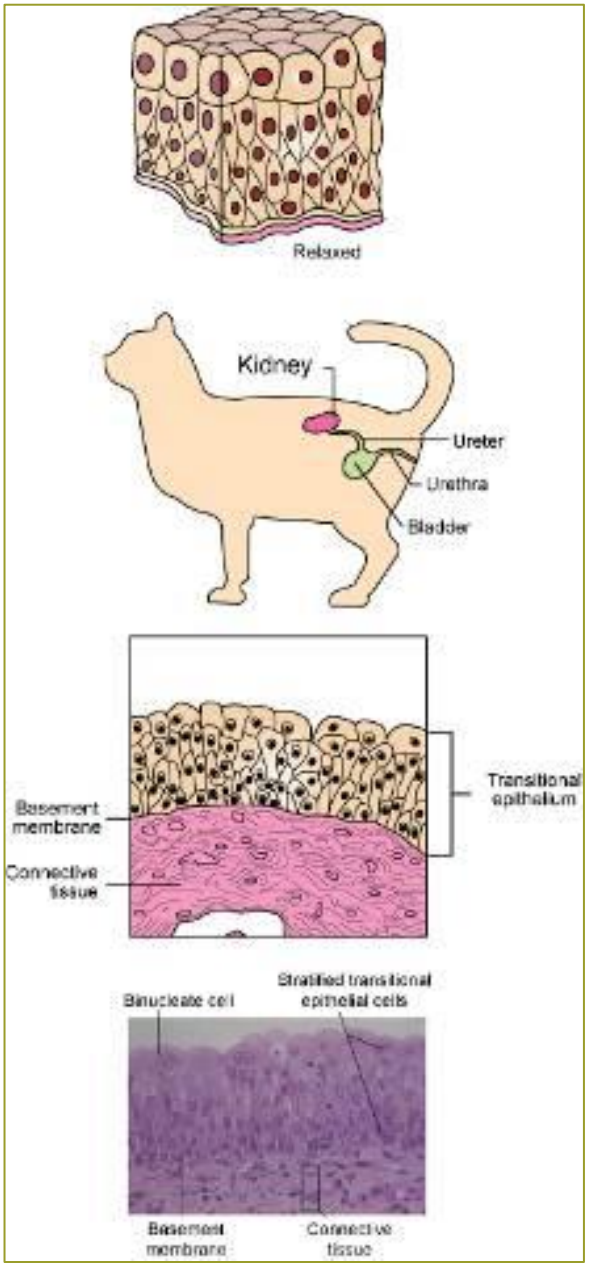


- Respiratory System

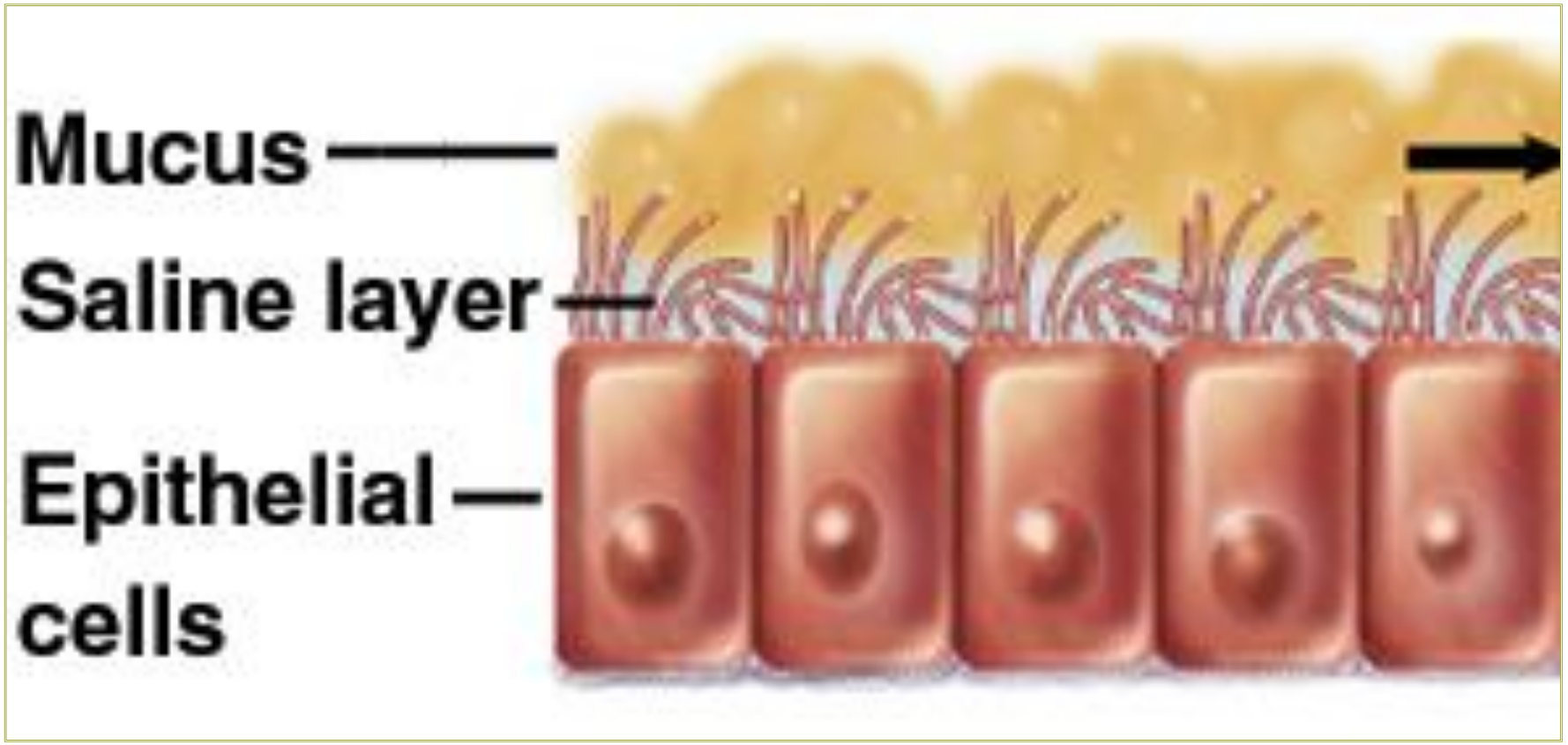
Transitional Epithelium

Figure 4-11, Page 102

- Stratified epithelium with a basal layer of cuboidal or columnar cells and a superficial layer of cuboidal or squamous cells
- Found in areas of the body required to expand and contract as part of their normal function – urinary tract



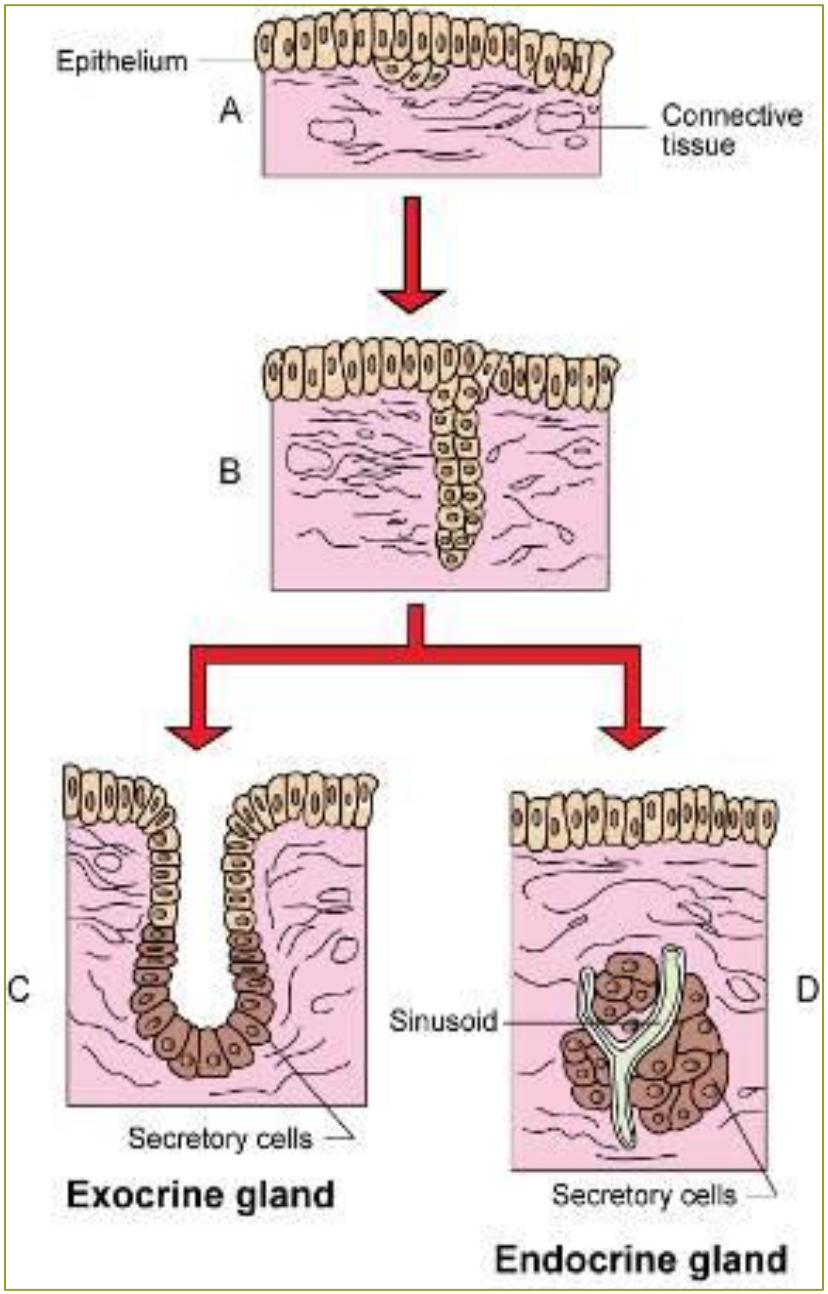
Mucosal Layer of Tracts



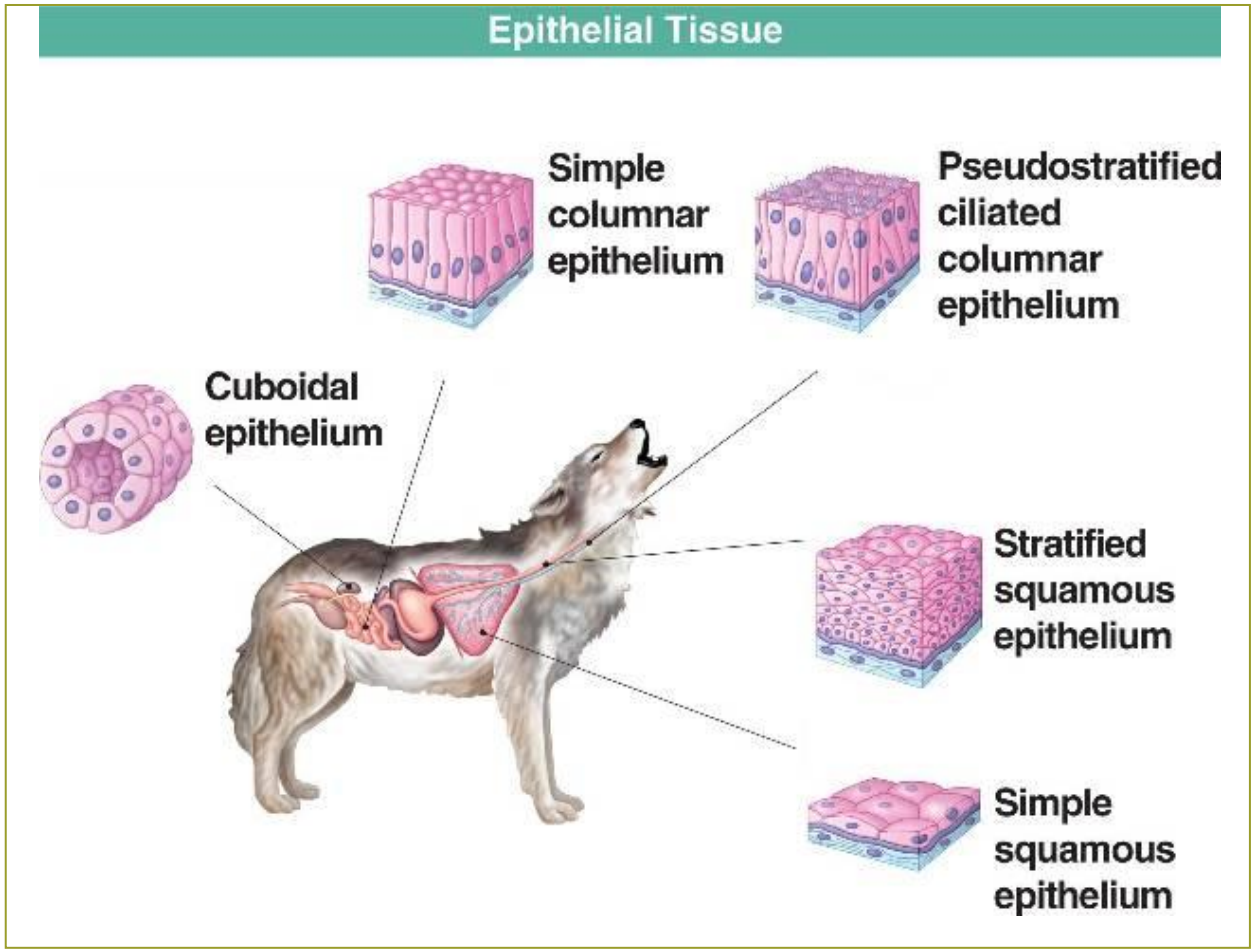
Glandular Epithelium

Figure 4-12, Page 103

- Groups of cells that manufacture and discharge a secretion
- Classification of glands
  1. Presence or absence of ducts
  2. Number of cells that compose them
  3. Shape of the secreting ducts
  4. Complexity of the glandular structure
  5. Type of secretion they produce
  6. Manner in which the secretion is stored and discharged



Epithelial Tissue Summary ☺



Endocrine Glands

- Glands that **do not have ducts** or tubules and whose secretions are distributed throughout the body
- Produce and secrete **hormones** into the bloodstream or the lymphatic system
- Part of a complex, biochemical network known as the **endocrine system**

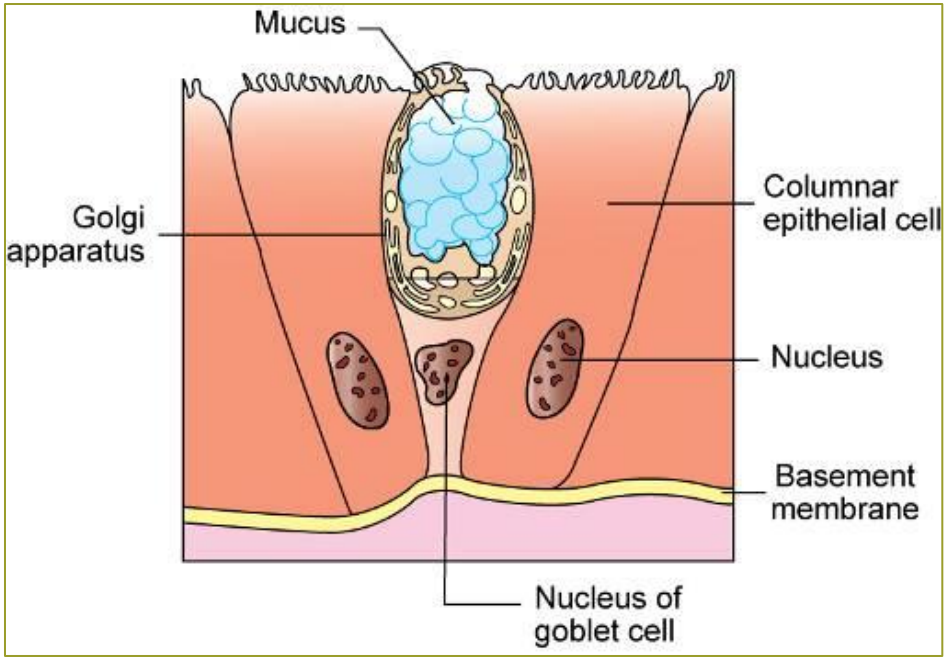
Exocrine Glands

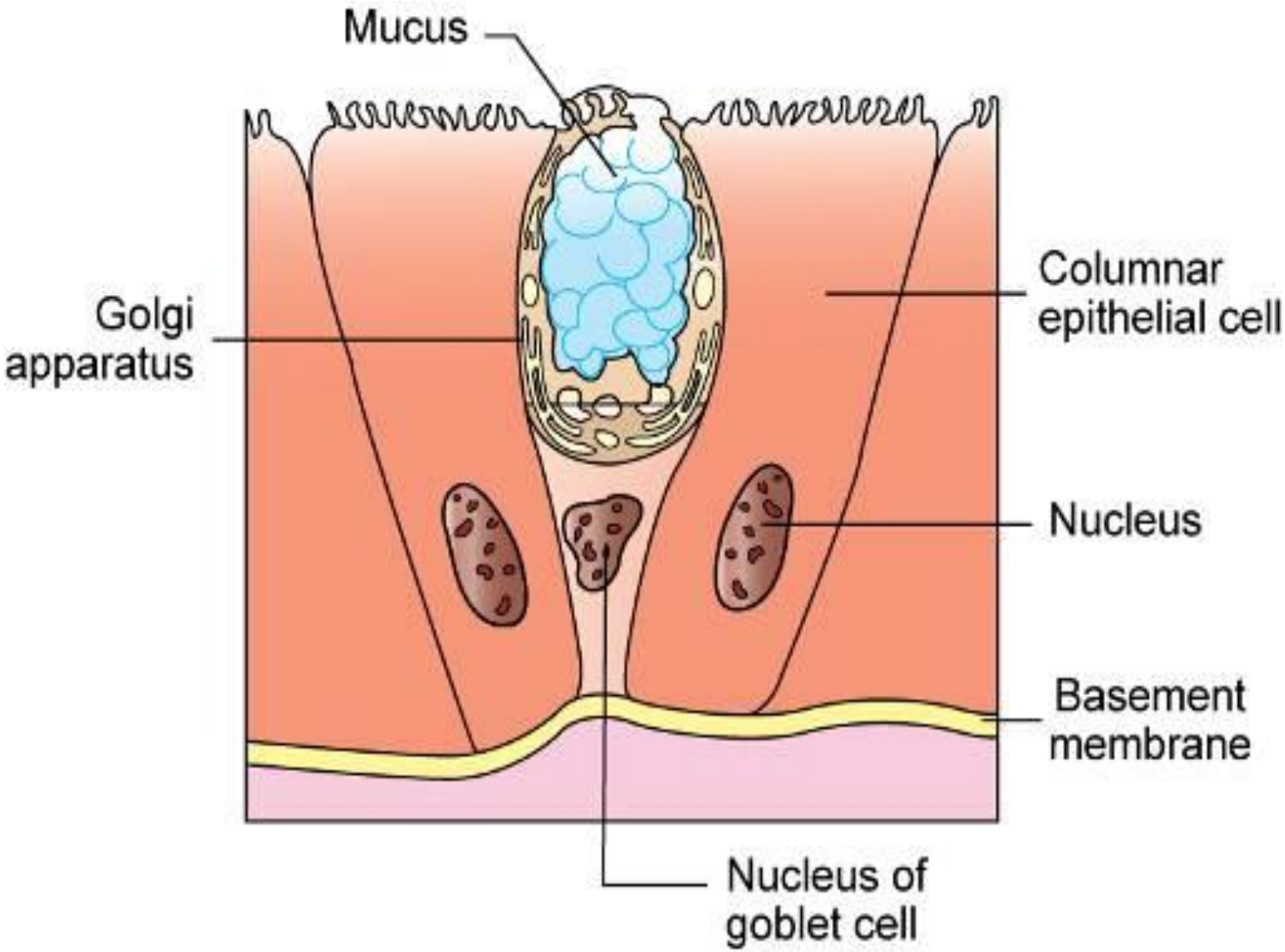
- **Discharge secretions via ducts** directly into local areas (except for **goblet cell**)
- Unicellular or multicellular

Goblet Cell

Figure 4-13, Page 104

- Unicellular exocrine gland
- Ductless and composed of modified columnar epithelial cell
- Found among columnar cells of the respiratory and digestive tracts and the conjunctiva of the eye
- Secretes mucin




Mucus
Golgi apparatus
Columnar epithelial cell
Nucleus
Basement membrane
Nucleus of goblet cell

Multicellular Exocrine Glands

Table 4-1, Page 105

- Composed of a secretory unit and a **duct**
- Secretory unit is usually surrounded by connective tissue rich in blood vessels and nerve fibers
- May be surrounded by myoepithelial cells that assist with the discharge of secretions into the glandular duct

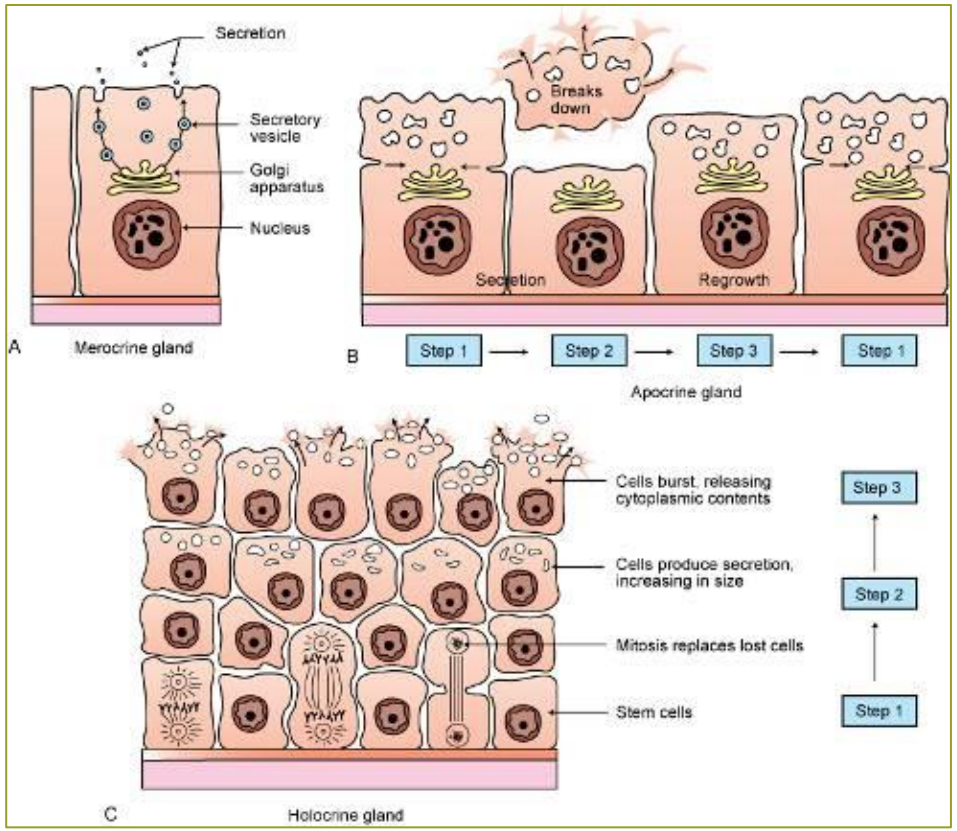
Classification of Exocrine Glands

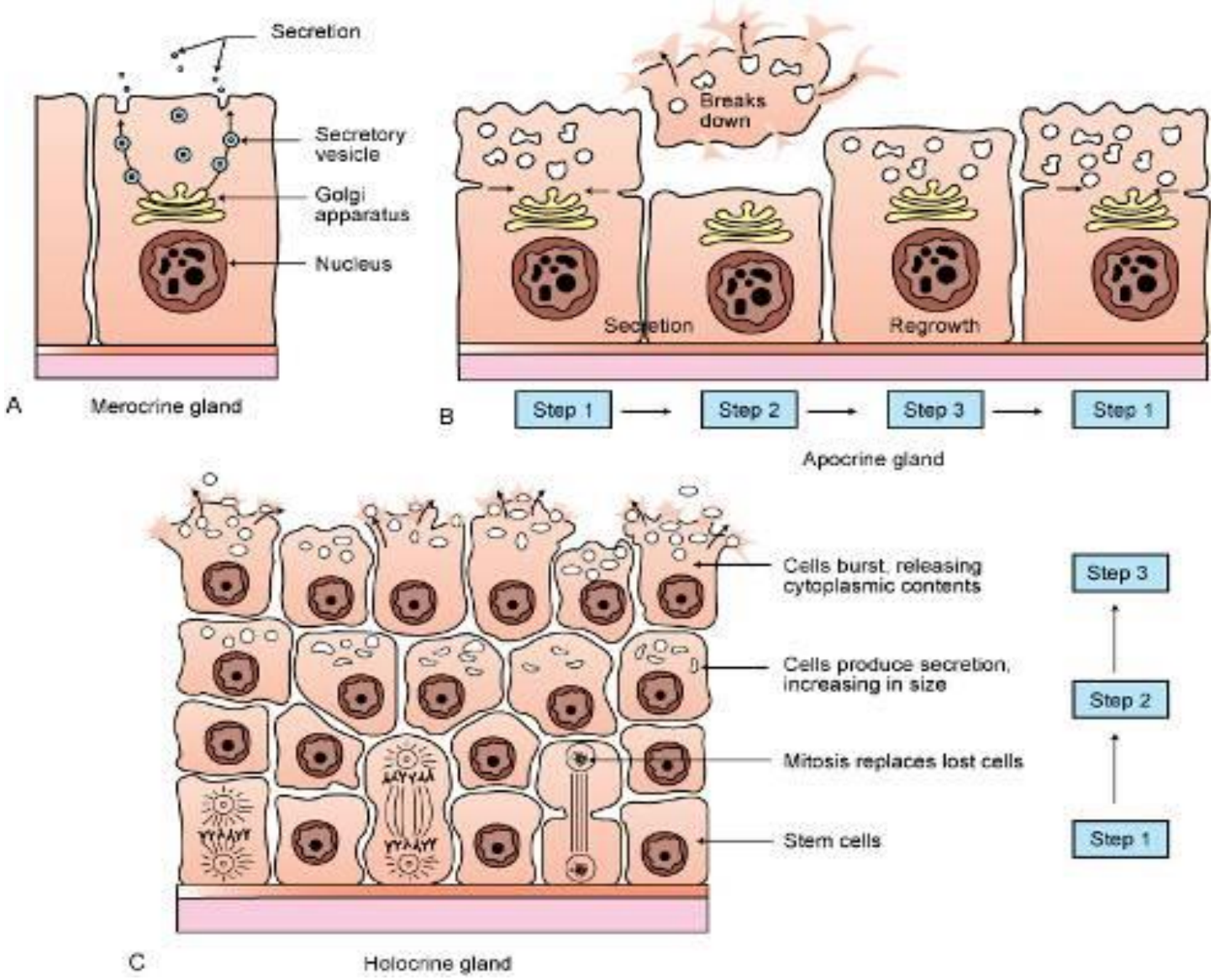
- **Ducts**:
  - Simple: main duct is unbranched
  - Compound: main duct is branched
- **Shape** of secretory portions
  - Tubular: secretory cells form a long channel of even width
  - Alveolar or acinar: secretory unit forms a rounded sac
  - Tubuloalveolar, or tubuloacinar: secretory units possess both tubular and alveolar qualities

Classification of Exocrine Glands

Figure 4-15, Page 106

- Merocrine glands package their secretions and release them via exocytosis as they are manufactured
- Apocrine glands store their secretions and then release the top part of the cell into the duct system
- Holocrine glands store their secretions and then release the entire contents of the cell




Secretion
Secretory vesicle
Golgi apparatus
Nucleus
A
Merocrine gland
Breaks down
Secretion
Regrowth
B
Step 1
Step 2
Step 3
Step 1
Apocrine gland
Cells burst, releasing cytoplasmic contents
Cells produce secretion, increasing in size
Mitosis replaces lost cells
Stem cells
Step 3
Step 2
Step 1
C
Holocrine gland

Classification of Exocrine Glands

Type of secretion produced

- **Serous** secretions
  - Watery
  - Contain a high concentration of enzymes
- **Mucous** secretions
  - Thick, viscous
  - Composed of glycoproteins
- Mixed exocrine glands contain both mucous and serous components

2. Connective Tissue

Few Cells

Matrix in between

Connective Tissue Functions

- Forms metabolic and structural connections between other tissues
- Forms a protective sheath around organs and helps insulate the body
- Acts as a reserve for energy
- Provides the frame that supports the body
- Composes the medium that transports substances from one region of the body to another
- Plays a role in the healing process and in the control of invading microorganisms

Connective Tissue Components

- Extracellular matrix
  - Extracellular fibers
  - Ground substance
- Cells

Ground Substance

- Medium through which cells exchange nutrients and waste with the bloodstream
- Amorphous, homogeneous material
- Ranges in texture from a liquid or gel to a calcified solid
- Acts to protect the more delicate cells it envelopes
- Serves as an effective obstacle for invading microorganisms

Extracellular Fibers

- Collagenous fibers
  - Strong, thick strands of collagen
  - Found in **tendons** and **ligaments**
- Reticular fibers
  - Thin, delicate, branched networks of collagen
  - Found around blood vessels, nerves, muscle fibers, and capillaries
- Elastic fibers
  - Branched networks composed primarily of the protein elastin
  - Occur in tissues commonly subjected to stretching (vocal cords, lungs, skin, and walls of blood vessels)

Cell Types

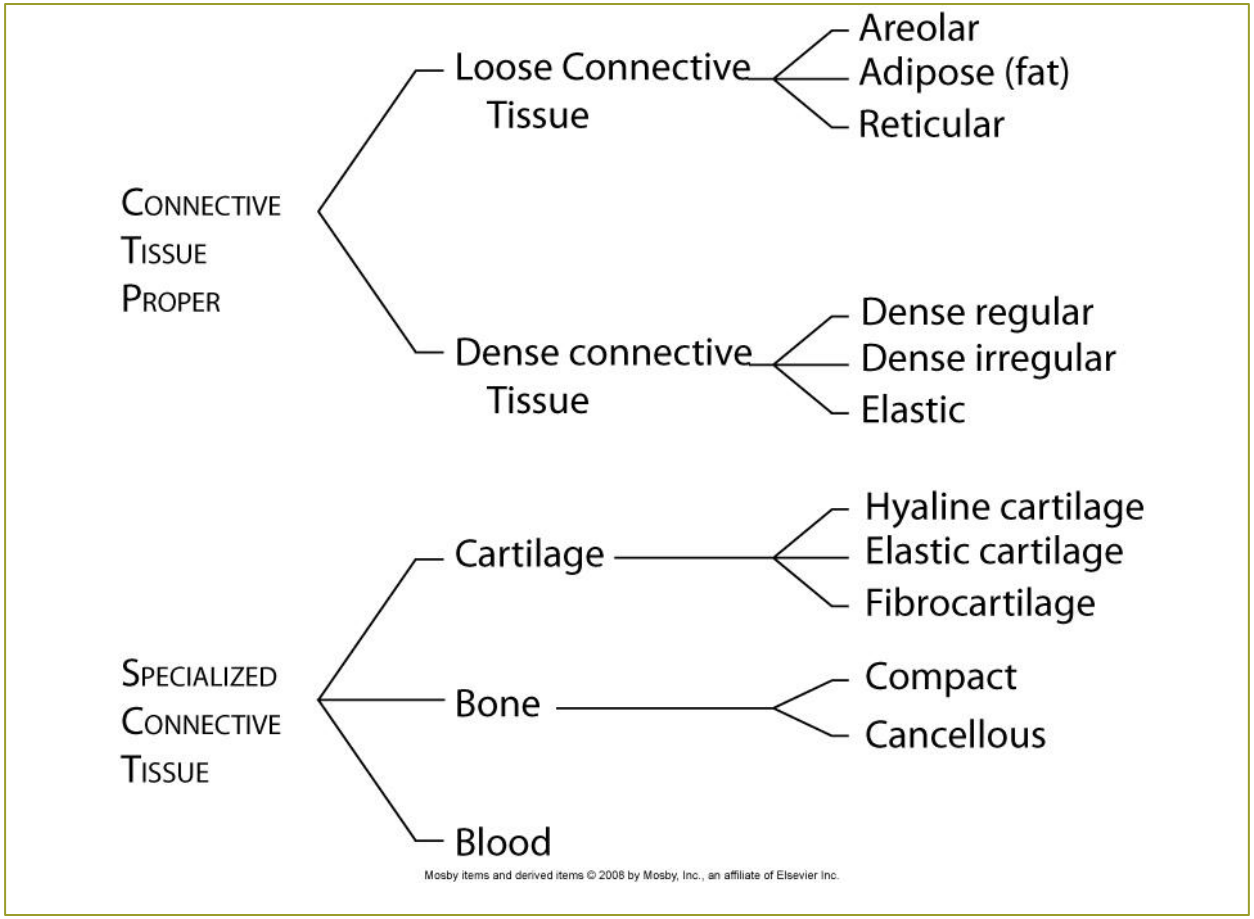
- **Fixed Cells**: involved in production and maintenance of the matrix
  - Fibro**blasts**, chondroblasts, osteoblasts, adipocytes, reticular cells
- **Transient Cells**: involved in the repair and protection of tissues
  - Leukocytes, mast cells, macrophages **(the army, police!)**

Table 4.4 Classification of Connective Tissues

- Loose (areolar) connective tissue
- Adipose tissue
- Dense connective tissue
  - Dense collagenous connective tissue
    - Collagen fibers arranged in the same direction
    - Collagen fibers arranged in many directions
  - Dense elastic connective tissue
    - Elastic fibers arranged in the same direction
    - Elastic fibers arranged in many directions
- Cartilage
  - Hyaline cartilage
  - Fibrocartilage
  - Elastic cartilage
- Bone
- Blood

Connective Tissue Types

Box 4-2, Page 117



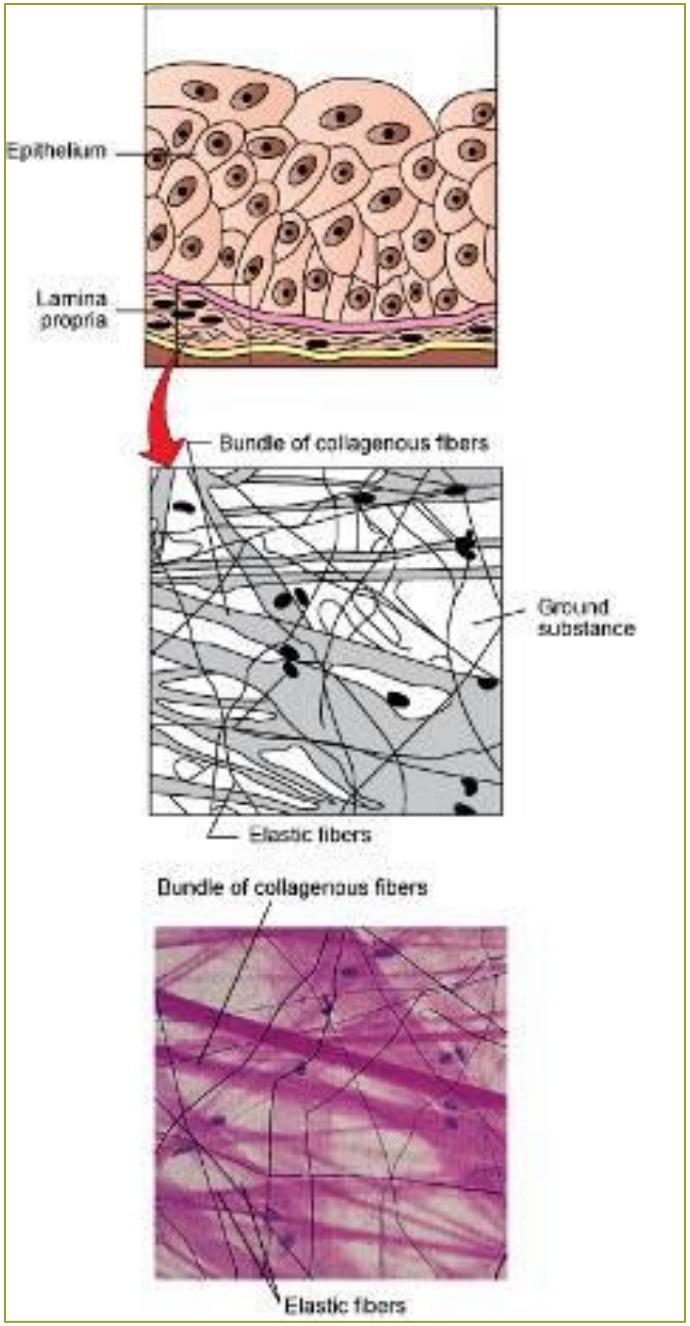
Connective Tissue Proper

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

Areolar Connective Tissue

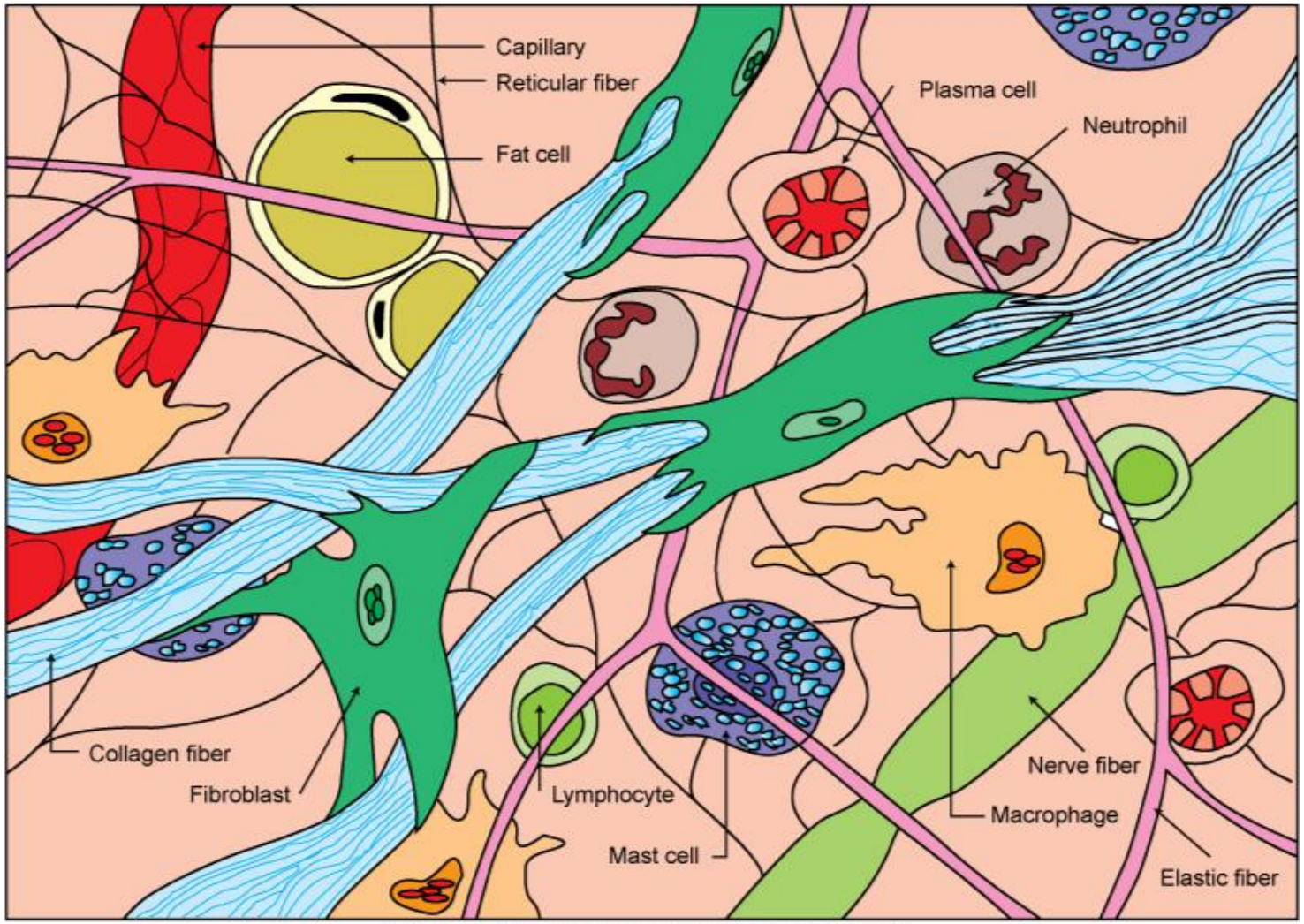
Figure 4-17, Page 110

- Loose connective tissue
- Fibers and cells suspended in a thick, translucent ground substance
- Predominant cell is the fibroblast
  - Manufactures the elastic, reticular, and collagenous fibers
- Surrounds every organ; forms the SQ layer that connects skin to muscle; envelopes blood vessels, nerves, and lymph nodes; present in all mucous membranes



Areolar Connective Tissue

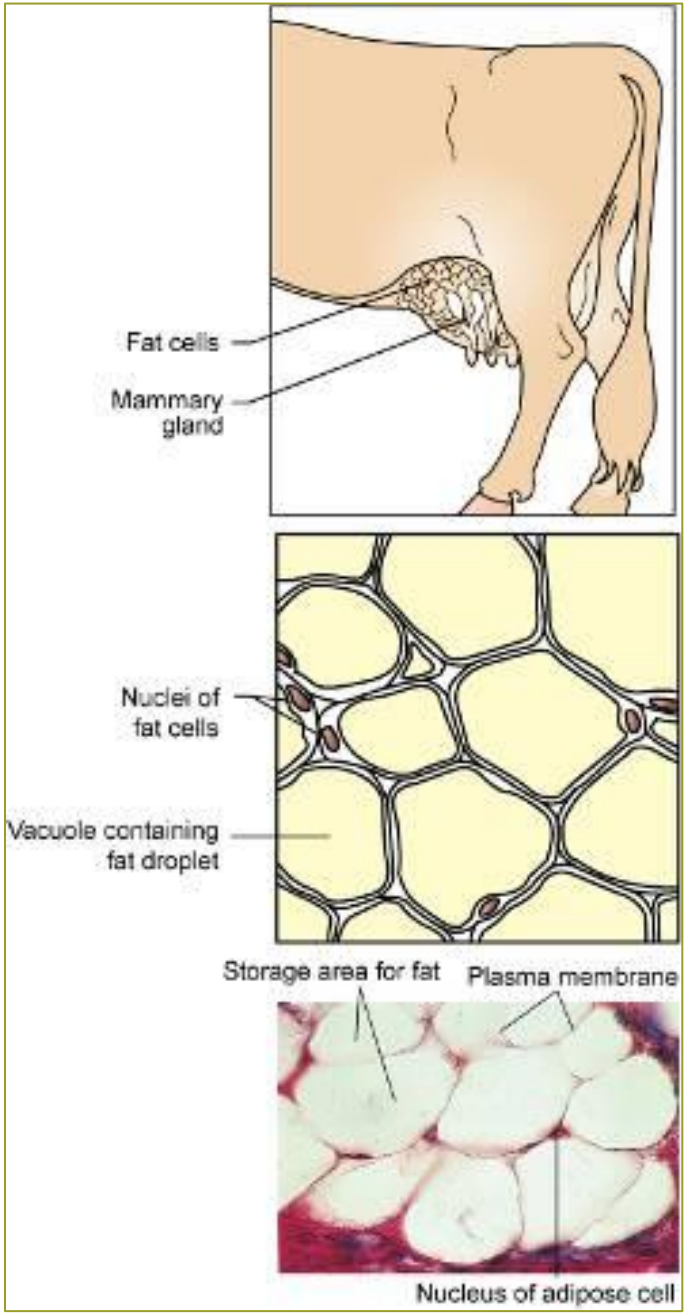
Figure 4-16, Page 107



Adipose Tissue

Figure 4-18, Page 111

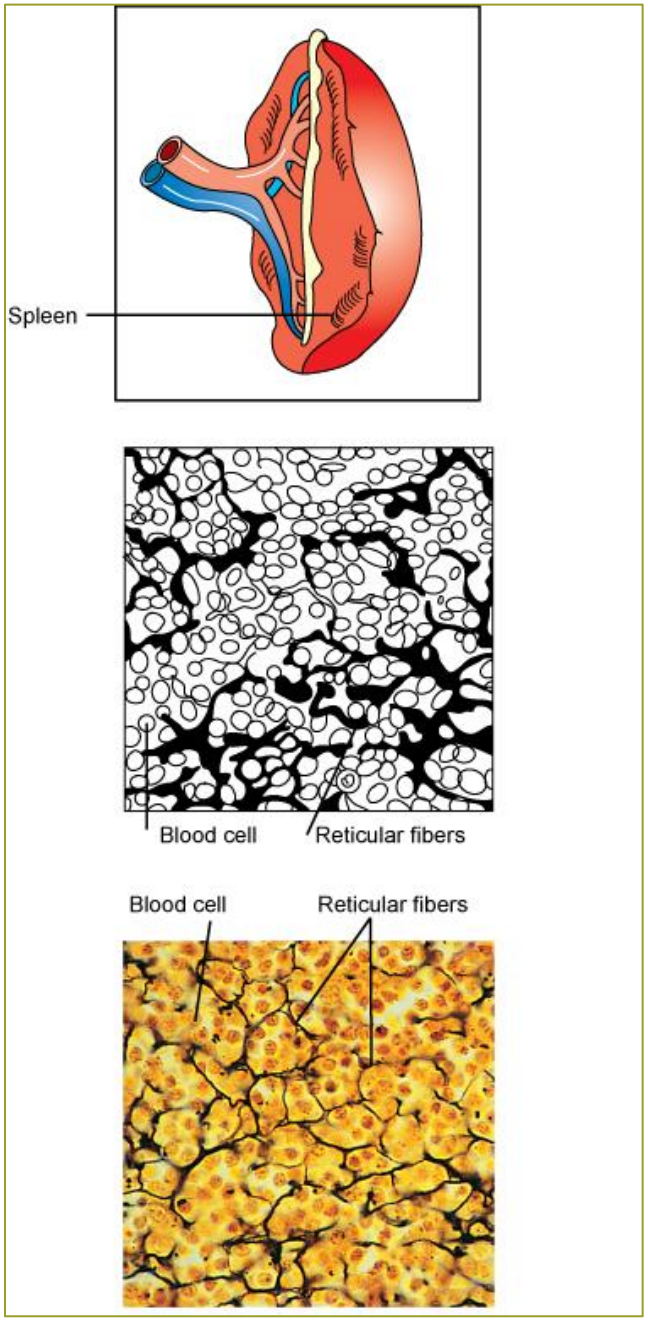
- Loose connective tissue
- Areolar tissue in which adipocytes predominate
- **Highly vascular**
- Acts as an energy storehouse and a thermal insulator



Reticular Connective Tissue

Figure 4-19, Page 112

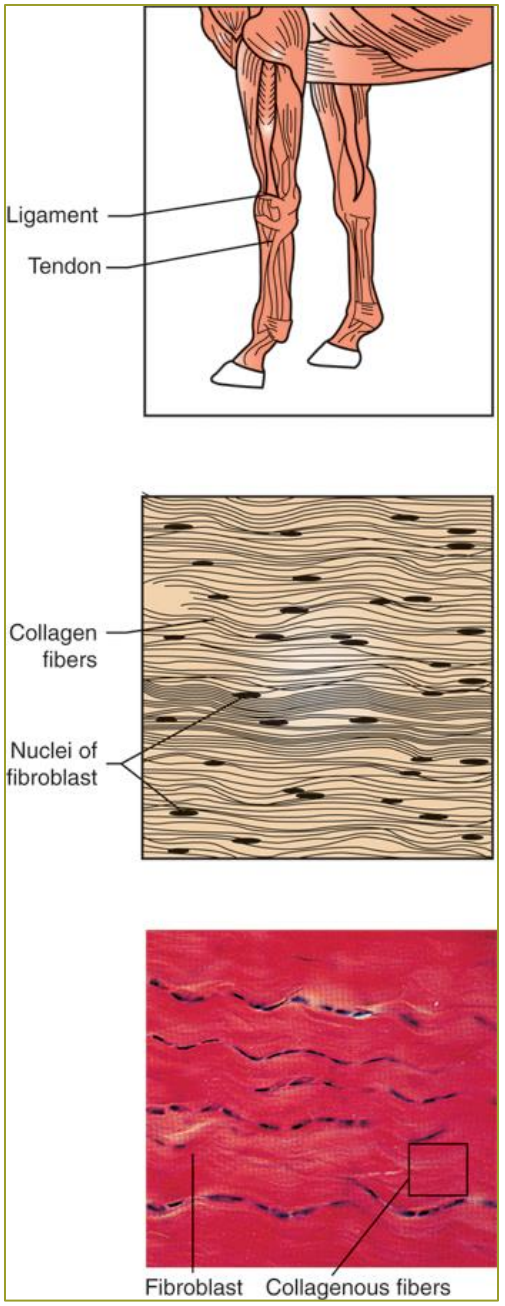
- Loose connective tissue
- Network of thin reticular fibers.
- Contains loosely arranged fibers and many fibroblasts suspended in a supportive ground substance
- Forms the stroma (framework of several organs)



Dense Regular Connective Tissue

Figure 4-20, Page 113

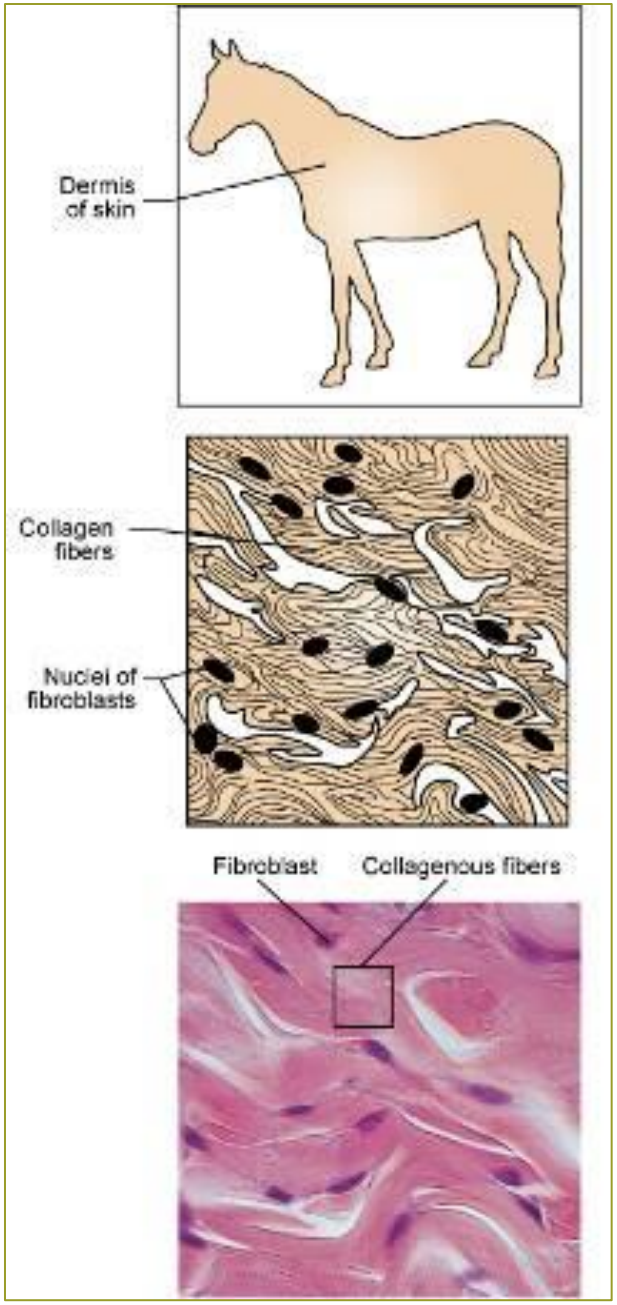
- Composed of tightly packed, parallel collagen fibers
- Relatively **avascular**
- Makes up the **tendons** and **ligaments**
- Can be found in fascial sheets that cover muscles



Dense Irregular Connective Tissue

Figure 4-21, Page 113

- Composed primarily of collagen fibers arranged in thick bundles
- Fibers are interwoven to form a single sheet
- Found in the dermis of the skin and in the fibrous coverings of many organs
- Forms the tough capsule of joints



Elastic Connective Tissue

- Primarily composed of **elastic** fibers
- Fibers may be arranged parallel or in interwoven patterns with fibroblasts and collagenous fibers interspersed
- Found in spaces between vertebrae and in areas of the body that require stretching (walls of arteries, stomach, bronchi, bladder, etc.)

Specialized Connective Tissues

- Cartilage
  - Hyaline cartilage
  - Elastic cartilage
  - Fibrocartilage
- Bone
- Blood

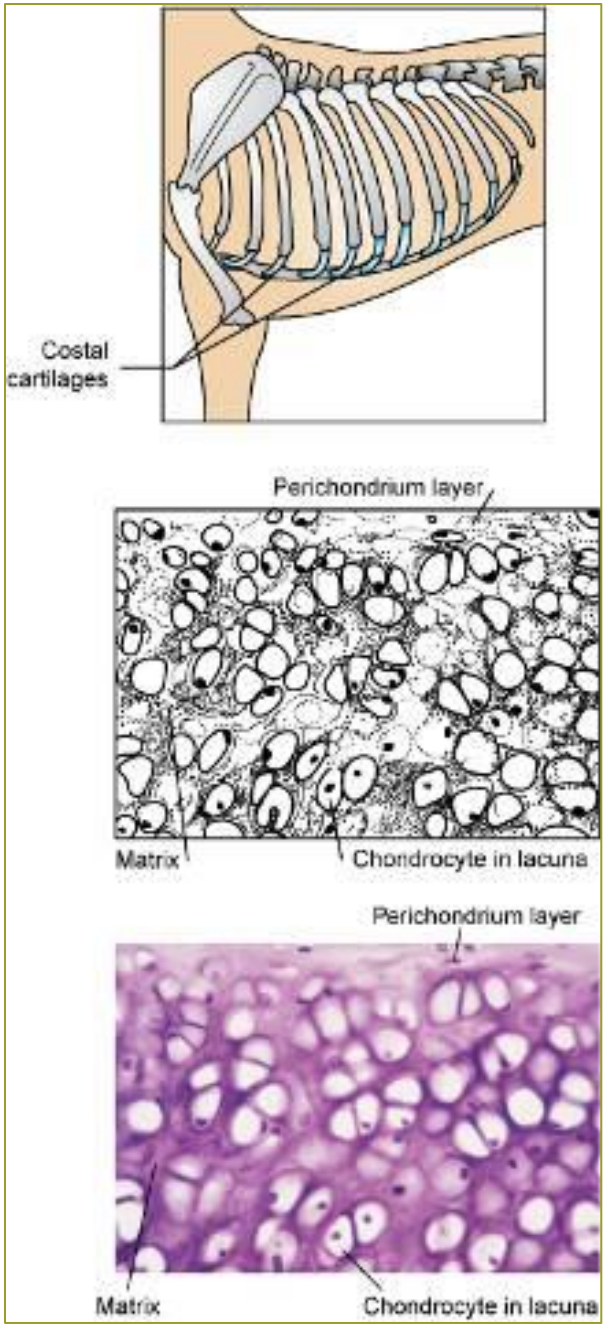
Cartilage

- **Found in joints** and in the **ear**, **nose**, and **vocal cords**
- Forms a **framework** on which bone is formed
- No innervation; **avascular**
- Cells:
  - Chondrocytes: live in hollowed-out pockets in the matrix called *lacunae*
- Matrix:
  - Ground substance: gel of chondroitin sulfate, **hyaluronic acid**, and chondronectin
  - Collagen fibers are most commonly found in the matrix, but elastic fibers are also present in varying amounts

Hyaline (Smooth) Cartilage

Figure 4-22, Page 114

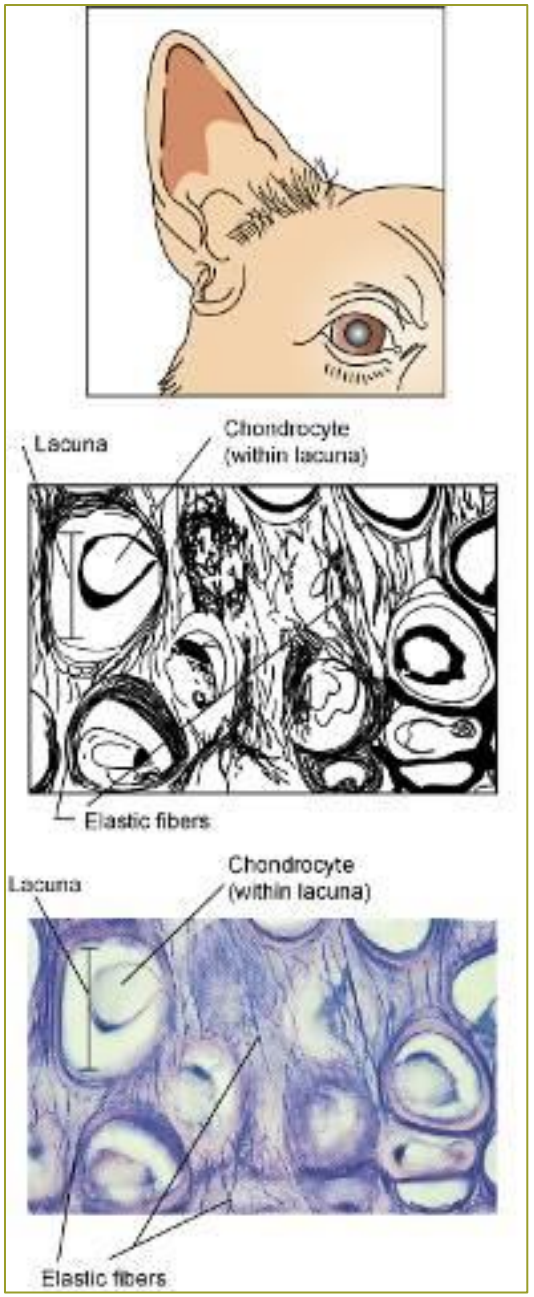
- **Most common type of cartilage found in the animal body**
- Composed of closely packed collagen
- Found in joints at the ends of long bones, growth plates of long bones, tracheal rings, and connections of the ribs to the sternum
- **Composes most of the embryonic skeleton**



Elastic Cartilage

Figure 4-23, Page 115

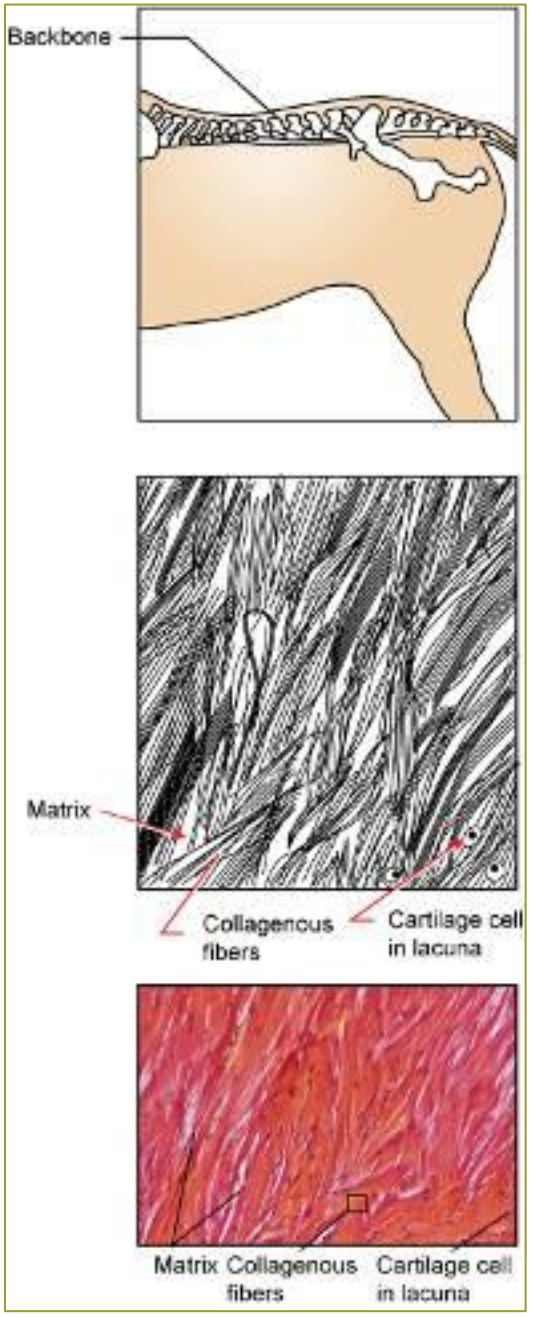
- Contains elastic fibers in dense branching bundles
- Flexible: can withstand repeated bending
- Found in the **epiglottis** of the larynx and in **pinnae** of ears of animals



Fibrocartilage

Figure 4-24, Page 116

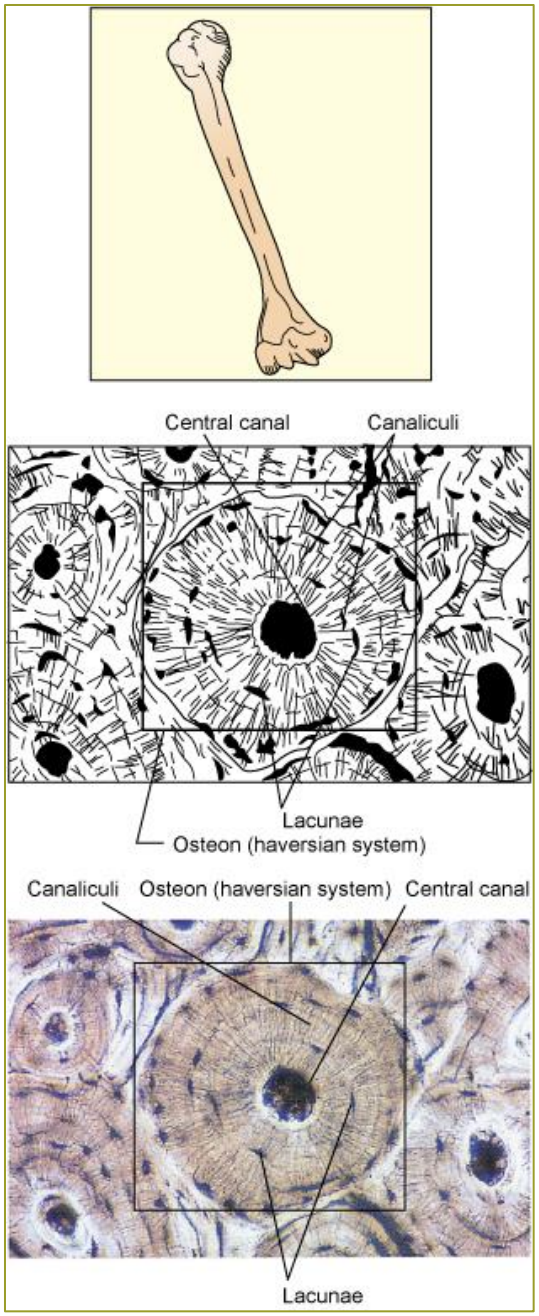
- Usually found merged with hyaline cartilage and dense connective tissue
- Contains thick bundles of collagen fibers with fewer chondrocytes than hyaline cartilage
- Lacks a perichondrium
- Found in **spaces between vertebrae** of the spine, between bones in the pelvic girdle, and in the knee joint



Bone

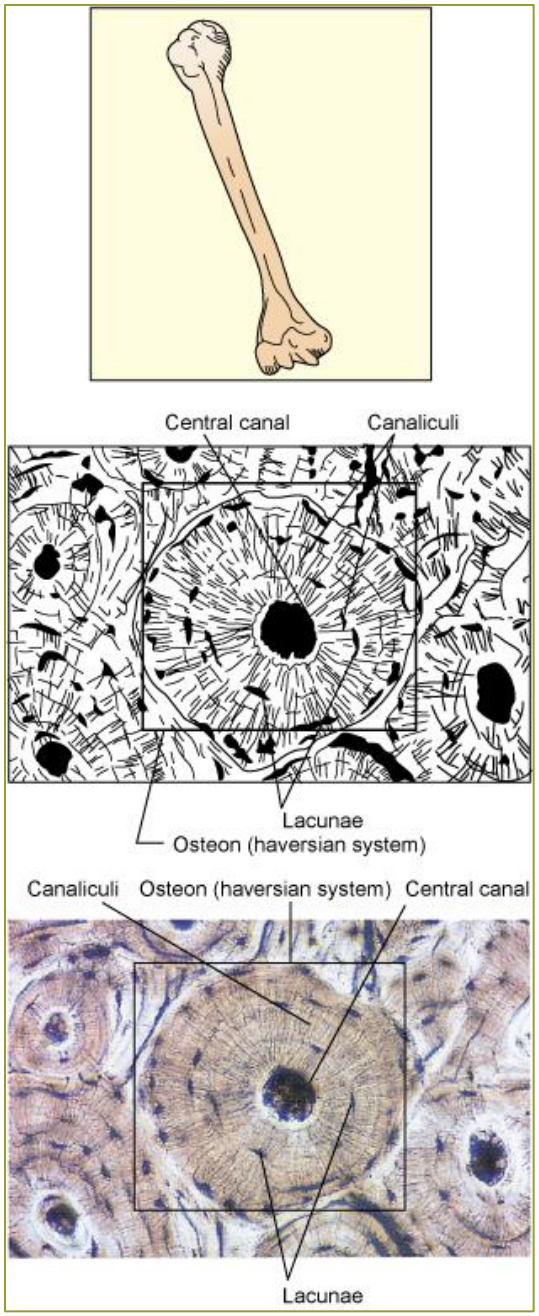
Figure 4-25, Page 116

- **Matrix** is a combination of **organic** collagen fibers and **inorganic** calcium salts
- **Well vascularized**
- **Haversian canal** contains both a vascular and a nerve supply
- **Canaliculi**: channels within the matrix support passage of blood vessels into deeper portions of tissue



Bone Cells

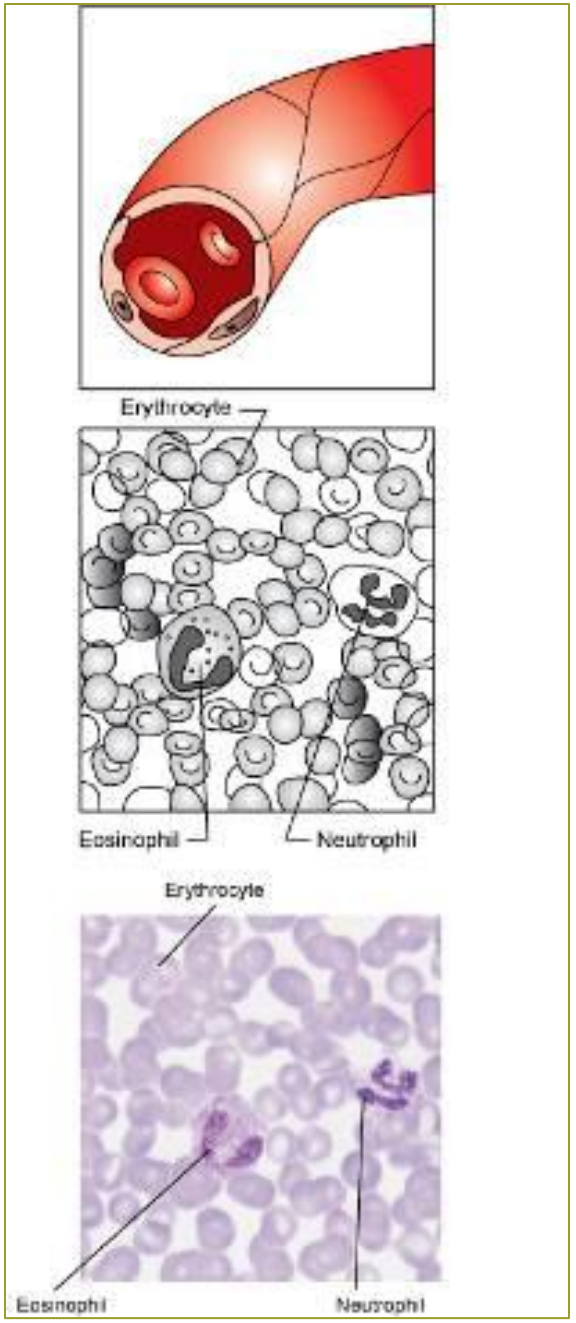
- Osteo**blasts**: manufacture the fibers that are part of the matrix
  - Lacunae and canaliculi are created as the osteoblasts manufacture the bony matrix
- **Osteocytes** reside in lacunae
  - Cellular extensions pass through the canaliculi



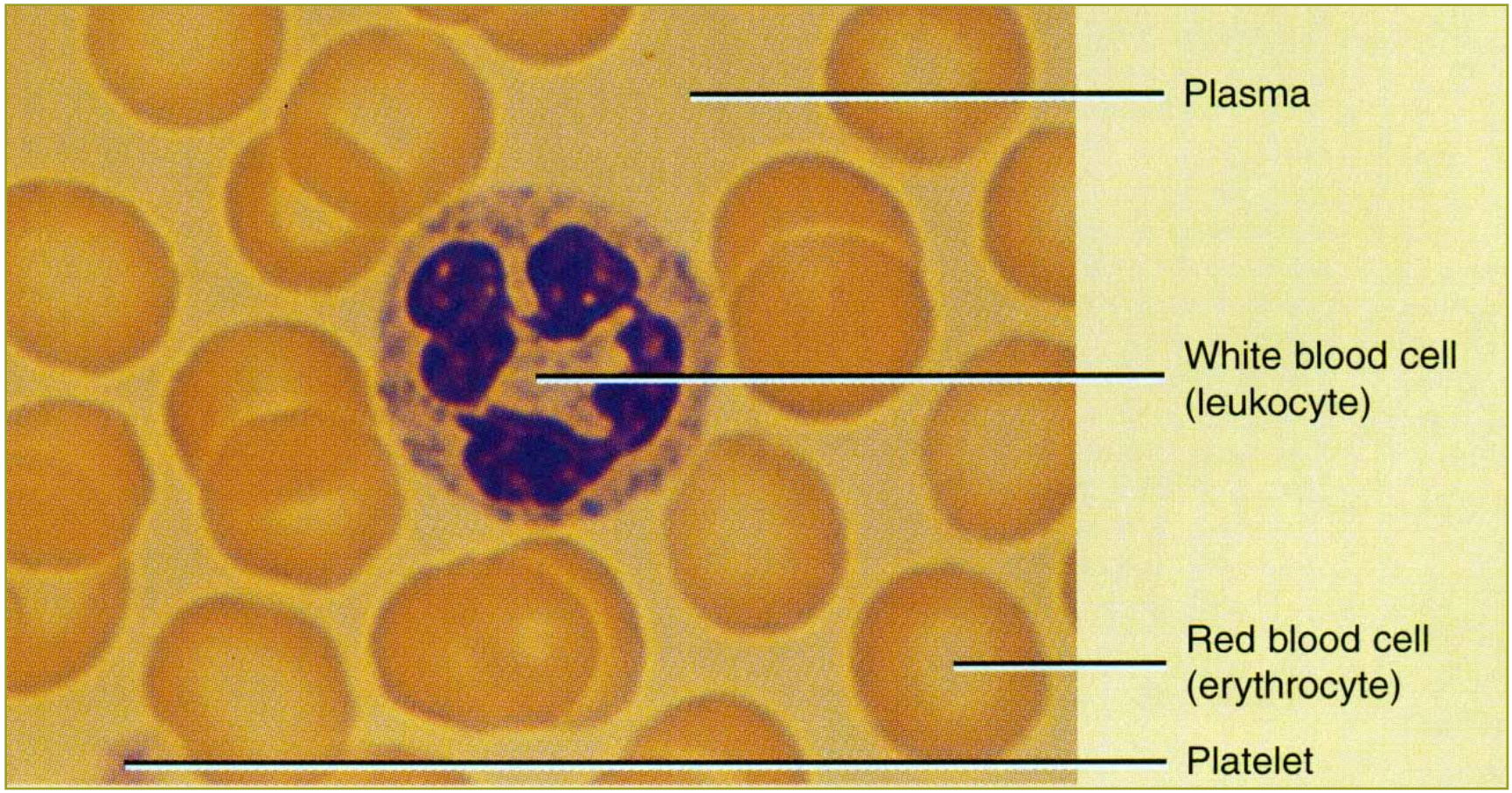
Blood

Figure 4-26, Page 117

- Matrix:
  - Ground substance: plasma
  - fibrous component: protein
- Cells
  - Erythrocytes
  - Leukocytes
  - Thrombocytes



Blood Tissue



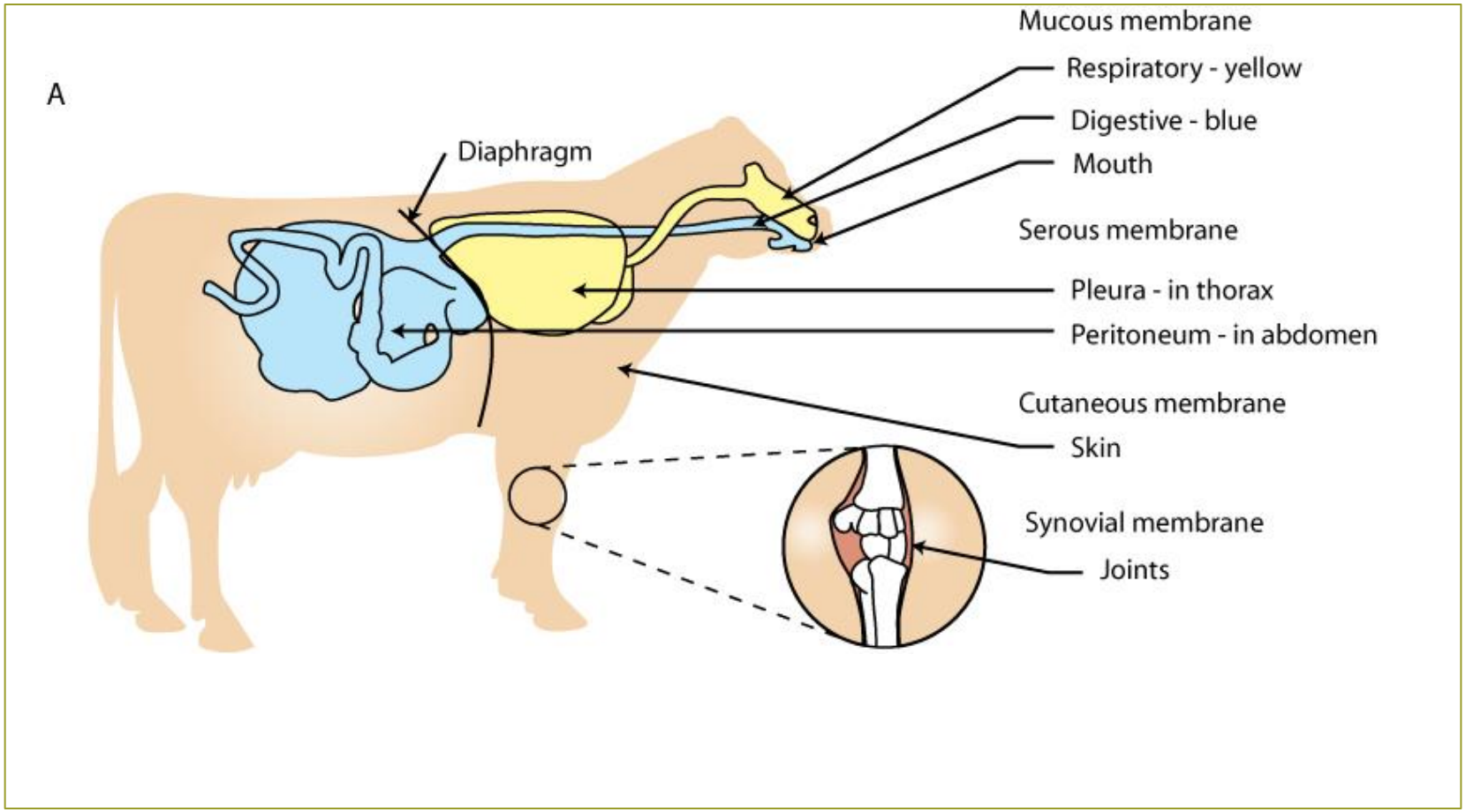
Membranes

Epithelial Tissue

Connective Tissue

Mucous Membranes

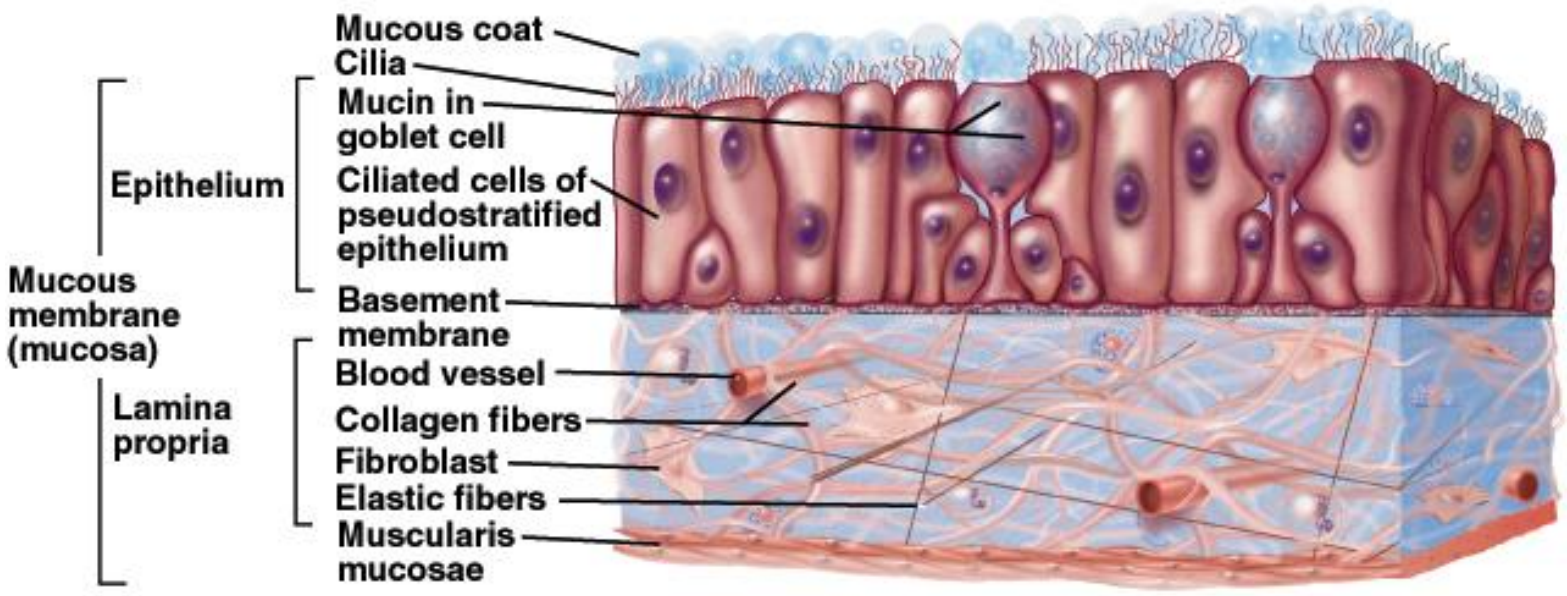
Figure 4-27A, Page 118



Mucous Membranes (Mucosae)

- Line organs with connections to the outside environment (mouth, intestines, nasal passages, etc.)
- Usually composed of either stratified squamous or simple columnar epithelium covering a layer of loose connective tissue
- May contain goblet cells or multicellular glands
  - Can produce large quantities of mucus
- Some mucosae also can absorb (e.g., the epithelial layer in the intestine)

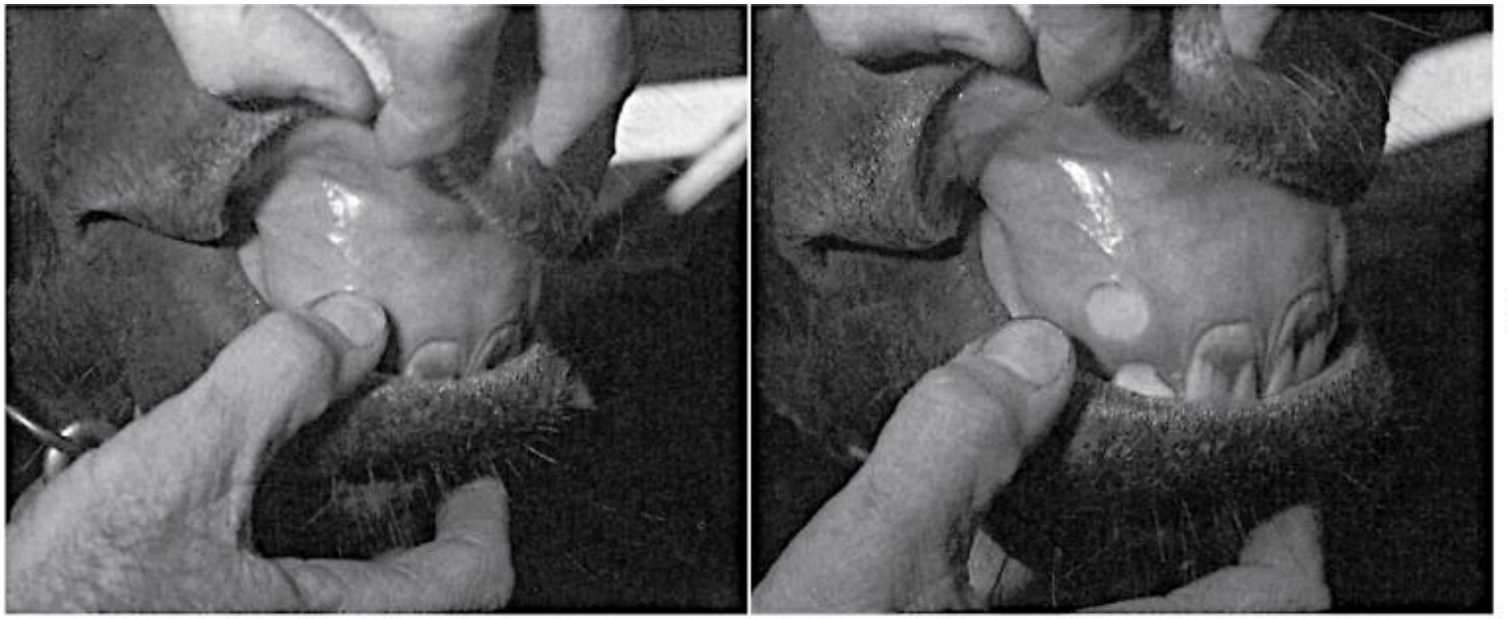
Mucous Membranes (Mucosa)



Mucous Membrane Color & Capillary Refill Time (CRT)

Clinical Application, Page 119

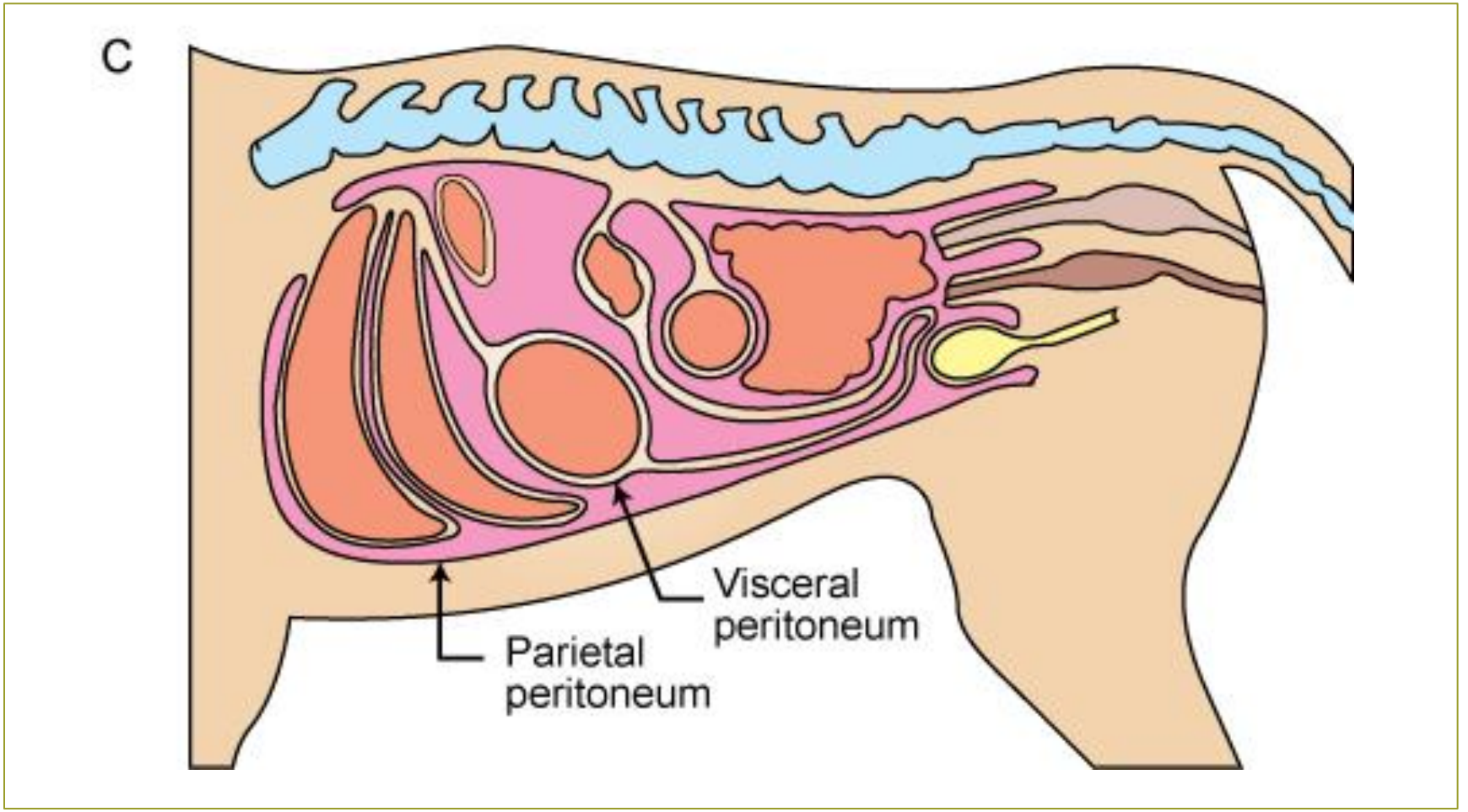
A



B

Serous Membranes

Figure 4-27C, Page 118



Serous Membranes (Serosae)

- Line walls and cover organs of body cavities (e.g., thorax and abdominopelvic cavities)
- Consist of a continuous sheet **doubled over** on itself to form **two layers**
- The portion of the membrane that lines the cavity wall is called the **parietal layer**
- The portion of the membrane that covers the outer surface of organs is called the **visceral layer**
- In abdominopelvic cavity, visceral layers of serosa merge to form **mesenteries**

Cutaneous Membrane (Skin)

- Also called **integument** (or, more simply, **skin**)
- Composed of an outer keratinized stratified squamous epithelium, or **epidermis**
- Epidermis is attached to an underlying layer of dense irregular connective tissue called the **dermis**
- Dermis contains collagenous, reticular, and elastic fibers which enable skin to be both strong and elastic

Synovial Membranes

- Line the cavities of joints
- Composed of loose connective tissue and adipose tissue covered by a layer of collagen fibers and fibroblasts
- Manufacture the **synovial fluid** that fills the joint spaces

3. Muscle Tissue

Skeletal

Smooth

Cardiac

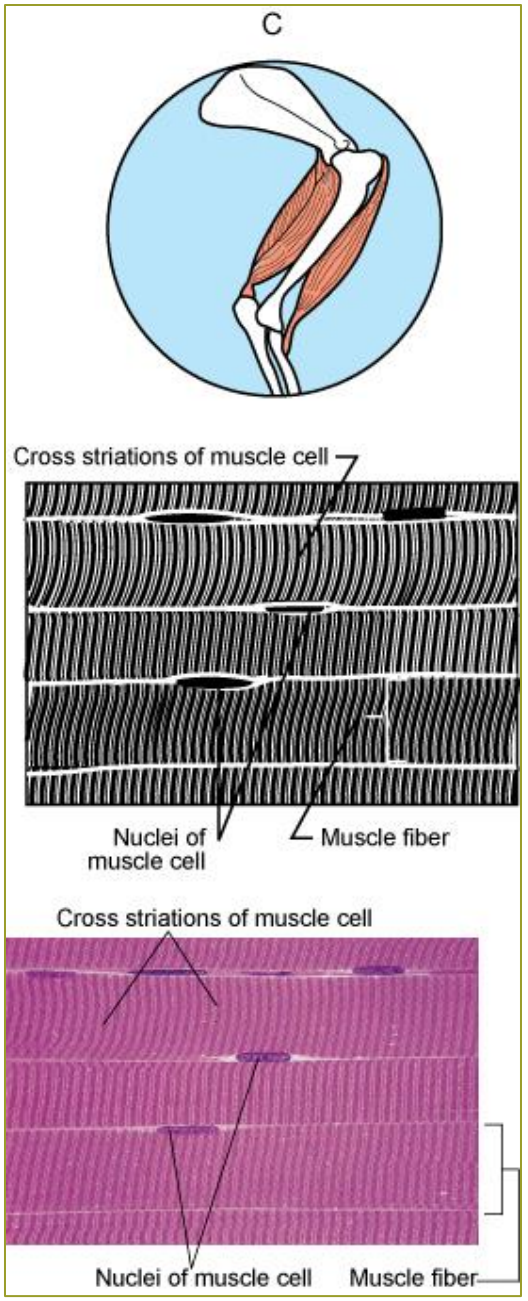
Table 7.2 Comparison of Muscle Types

Feature	Skeletal Muscle	Cardiac Muscle	Smooth Muscle
			
Location	Attached to bone	Heart	Wall of hollow organs, blood vessels, and glands
Appearance			
Cell shape	Long, cylindrical	Branched	Spindle-shaped
Nucleus	Multiple, peripheral	Usually single, central	Single, central
Special features		Intercalated disks	Cell–cell attachments
Striations	Yes	Yes	No
Autorhythmic	No	Yes	Yes
Control	Voluntary	Involuntary	Involuntary
Function	Move the whole body	Heart contraction to propel blood through the body	Compression of organs, ducts, tubes, etc.

Skeletal Muscle

Figure 4-28-C, Page 126

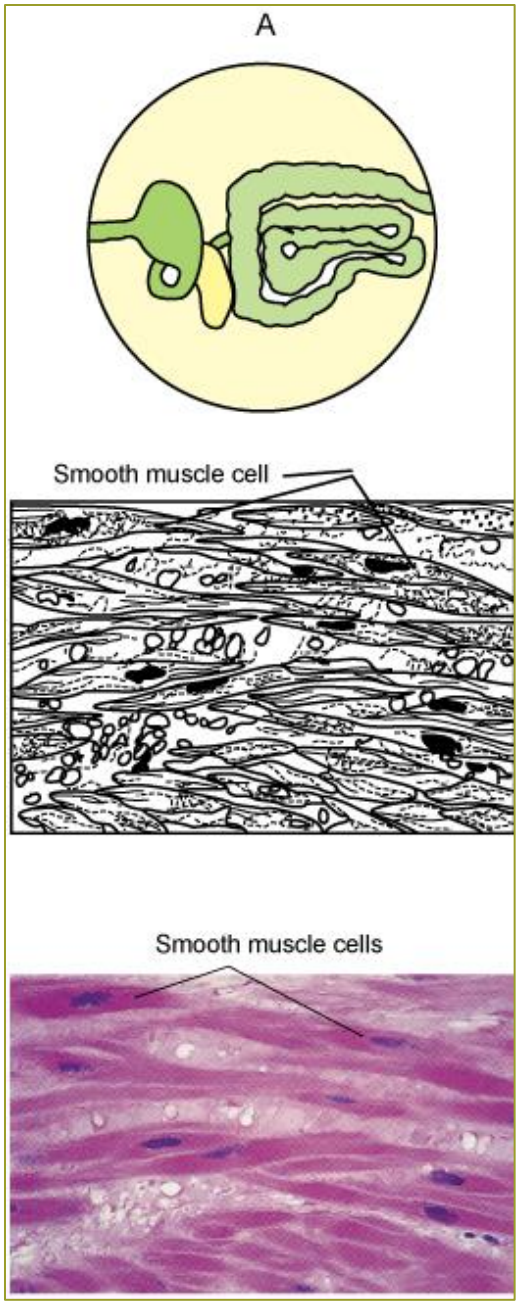
- Large cells that contain **hundreds of nuclei and mitochondria**
- Usually controlled through conscious efforts (**voluntary** muscle)
- Skeletal muscle cells are **striated**
- The collagen fibers that surround the cells merge with the collagen fibers in tendons



Smooth Muscle

Figure 4-28-A, Page 126

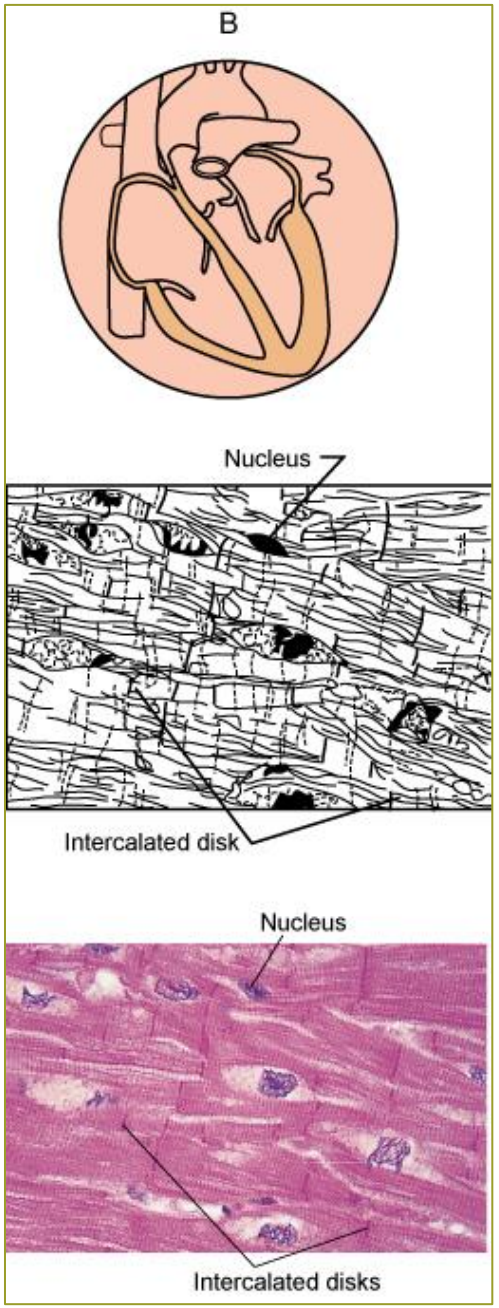
- Small cells that **lack striations**
- Muscle contractions cannot be consciously controlled (**non-striated involuntary muscle**)
- Found in the **walls of hollow organs**, in exocrine glands, and along the respiratory tract
  - Responsible for **peristalsis** in gastrointestinal tract, constriction of blood vessels, and emptying of urinary bladder



Cardiac Muscle

Figure 4-28-B, Page 126

- Found **only in the heart**
- Contains **specialized pacemaker cells** that supply signal for heart to contract at regular intervals
- Entirely **involuntary** and **striated**
- Cardiac muscle cells connected to one another via **intercalated disks**



4. Nervous Tissue

Neurons

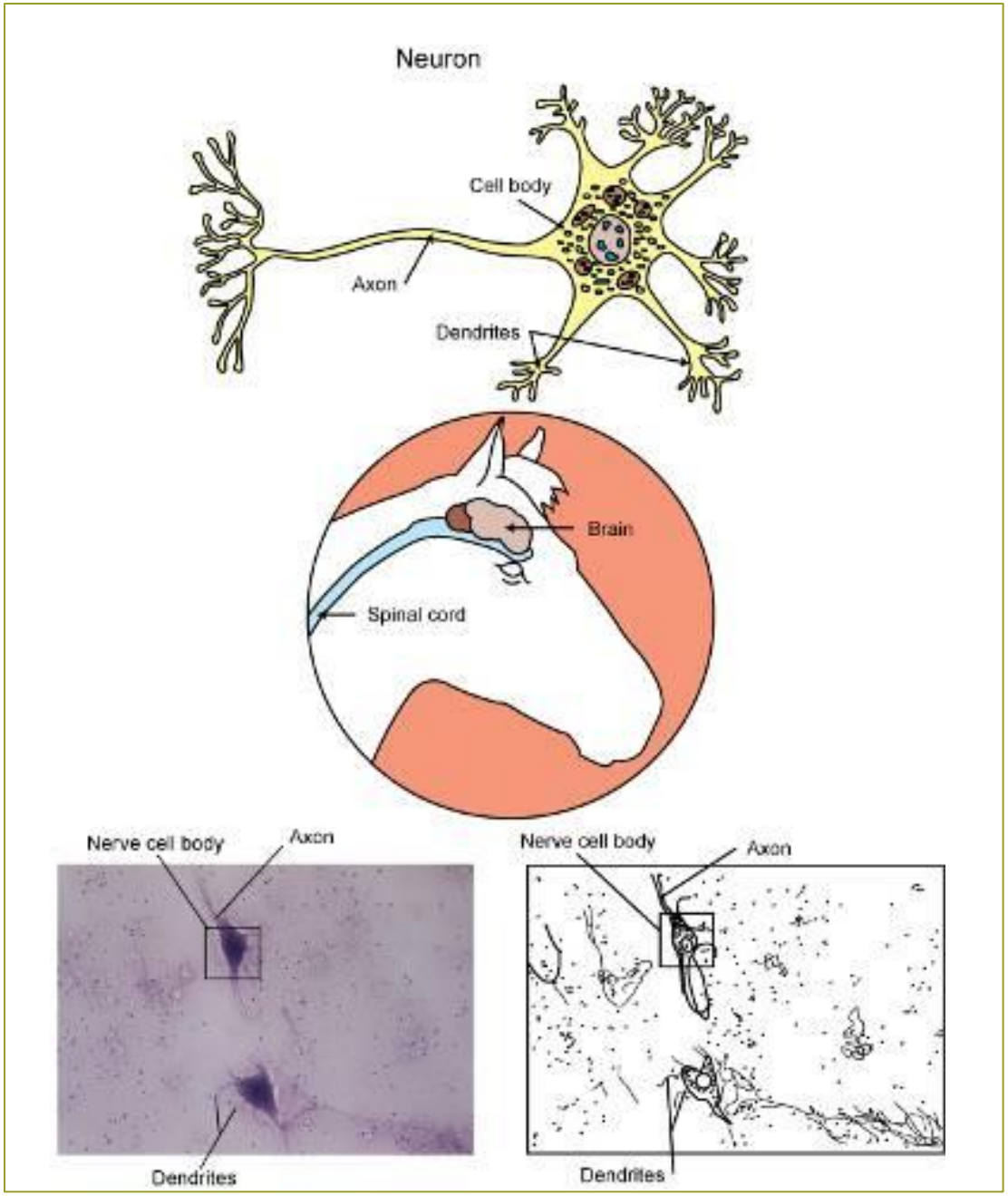
Neuroglial Cells

Nervous Tissue

- Designed to **receive and transmit electrical and chemical signals** throughout the body
  - **Most specialized cells in animal's body**
  - **Longest cells** in animal's body
- Found in the **brain**, **spinal cord**, and **peripheral nerves**
- Composed of two general cell types:
  - **Neurons**
  - **Supporting neuroglial cells**

Nervous Tissue

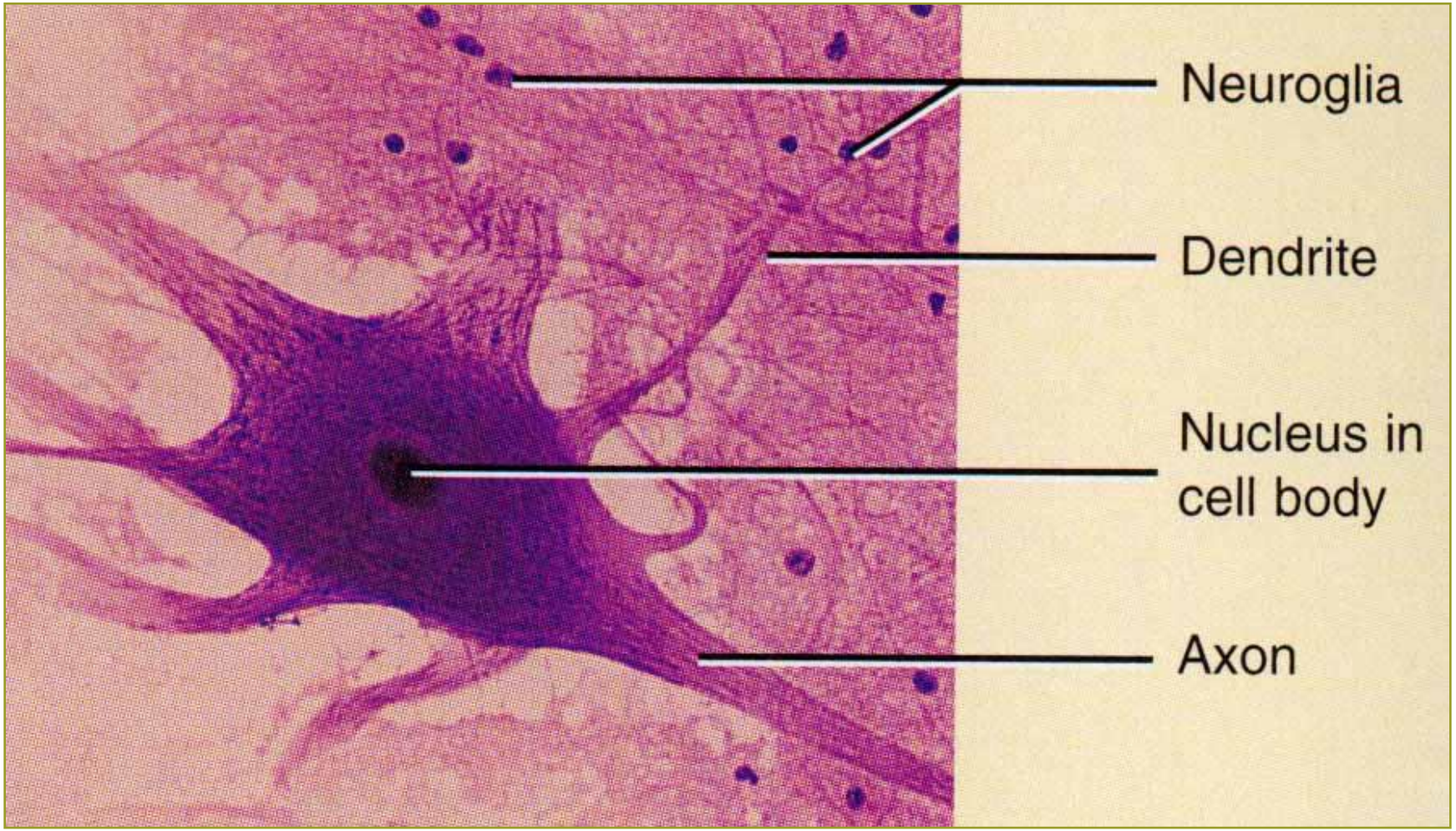
Figure 4-29, Page 127



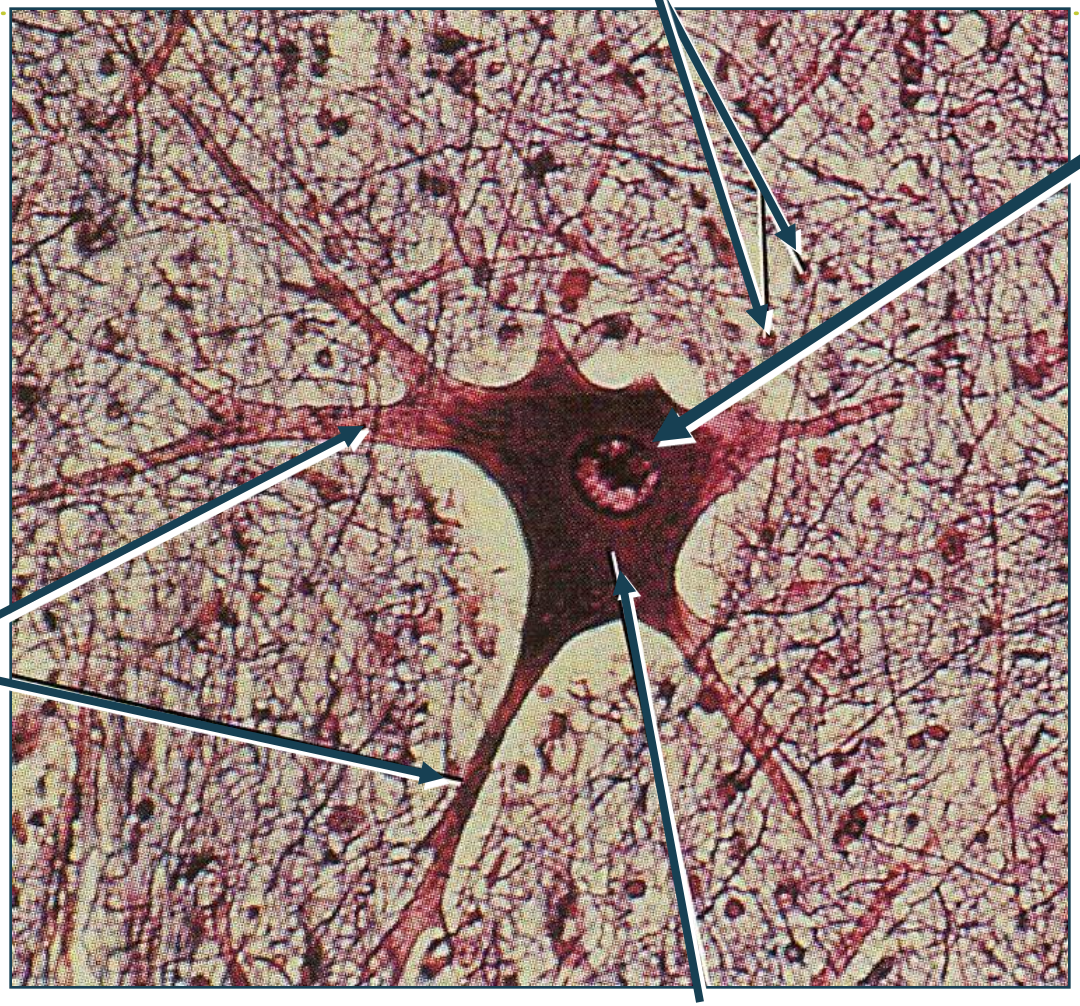
Nervous Tissue Cells

- **Neurons – longest cells** in the animal body; three primary parts:
  - **Perikaryon** – the **cell body**; contains the nucleus
  - **Dendrites** – short cytoplasmic extensions; receives impulses
  - **Axons** – long, single extension; conducts impulses away from the cell body
- **Neuroglial cells**
  - Support the neurons

Parts of a Neuron

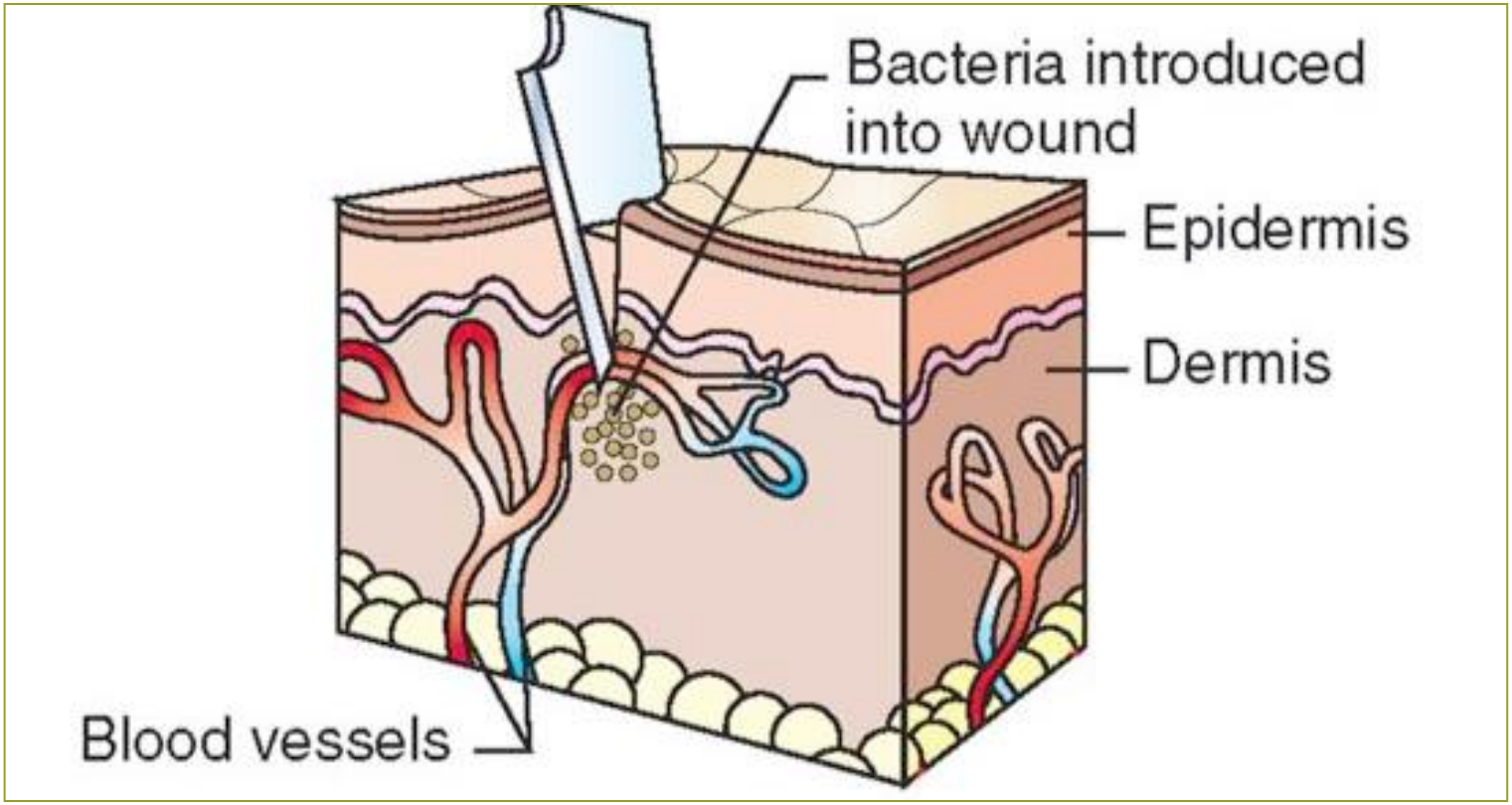


Parts of a Neuron



Topic 19

Describe the steps of wound healing in an animal body

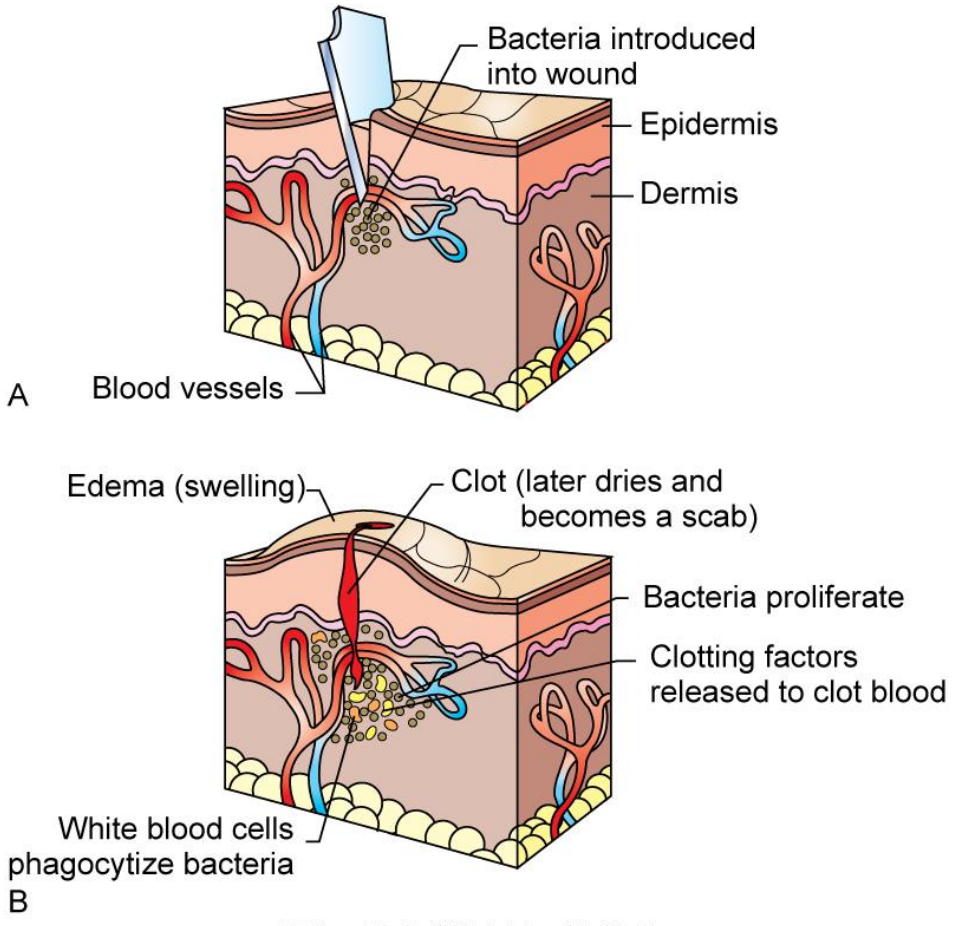


Tissue Healing and Repair

- **Inflammation**: initial response to injuries
  - Goal: limit further damage and eliminate any harmful agents
- **Repair**: involves organization of granulation tissue and regeneration of lost tissue or formation of scar tissue

Tissue Repair

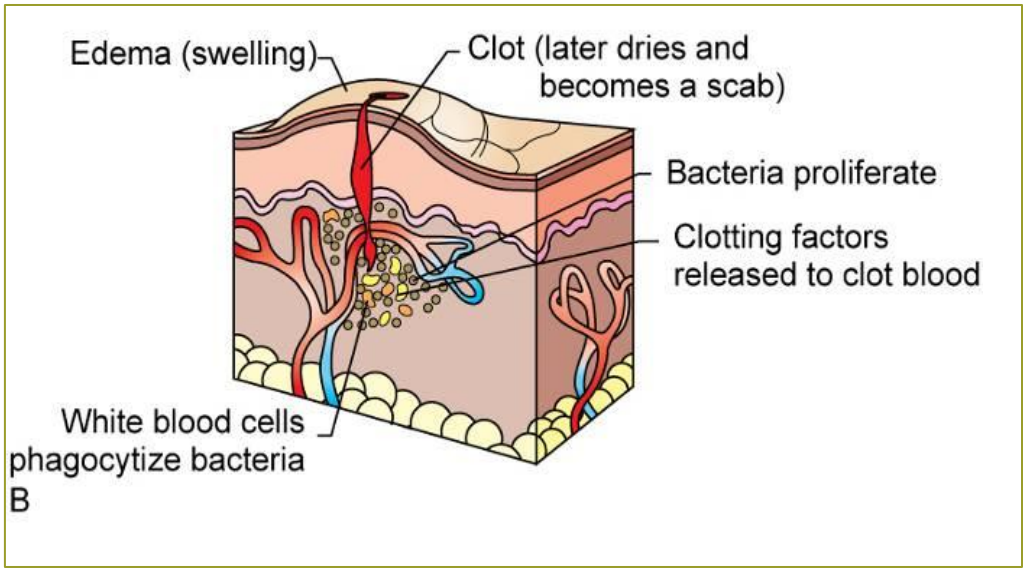
Figure 4-30A&B, Page 128



Inflammation

Figure 4-30B, Page 128

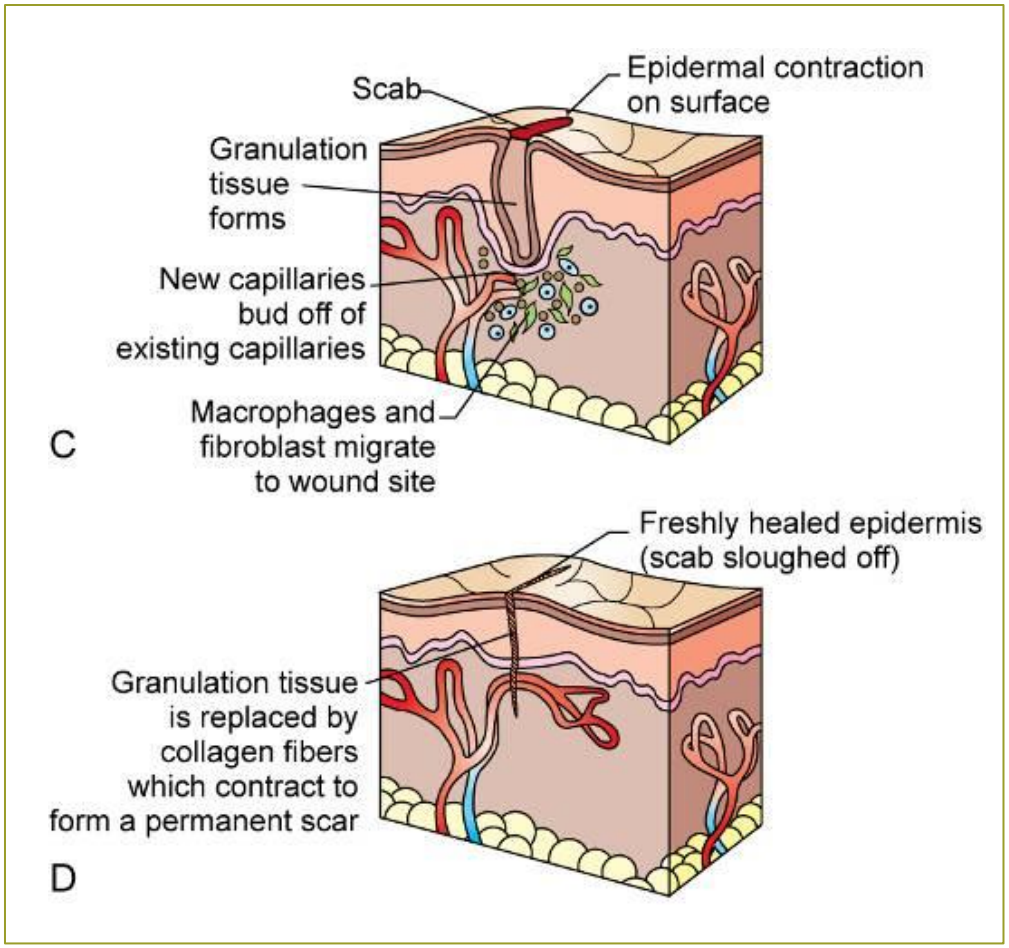
- **Nonspecific reaction** to injury or disease
- Steps
  1. Vasodilation
  2. Swelling
  3. Clot formation
  4. Phagocytosis
  5. Capillaries return to normal size, blood flow and fluid leakage into the affected area abate



Formation of Granulation Tissue and Epithelialization

Figure 4-28-C & D, Page 128

- Tissue that forms beneath the overlying blood clot or scab
- Composed of a layer of collagen fibers infiltrated with capillaries (that have branched off existing capillaries in deeper layers of damaged tissue)
- Granulation tissue is slowly replaced by fibrous scar tissue

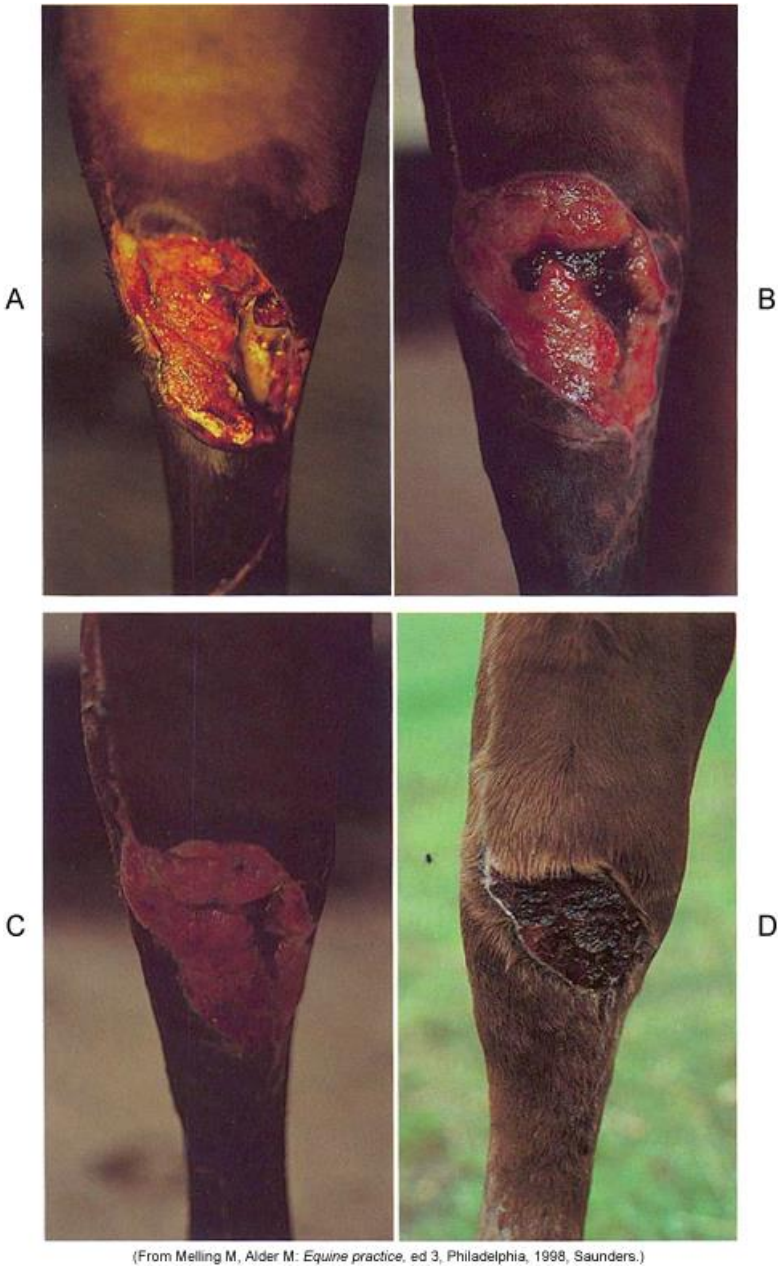


Classification of Wound Healing

- **First intention**:
  - Edges of wound held in close apposition
  - Skin forms a primary union without formation of granulation tissue or significant scarring
- **Second intention**:
  - Edges of wound separated from each another
  - Granulation tissue forms to close gap; scarring results
- **Third intention**:
  - Contaminated wound left open until contamination is reduced and inflammation subsides; later closed by **first intention**; also called *delayed primary closure*

Second Intention Wound Healing

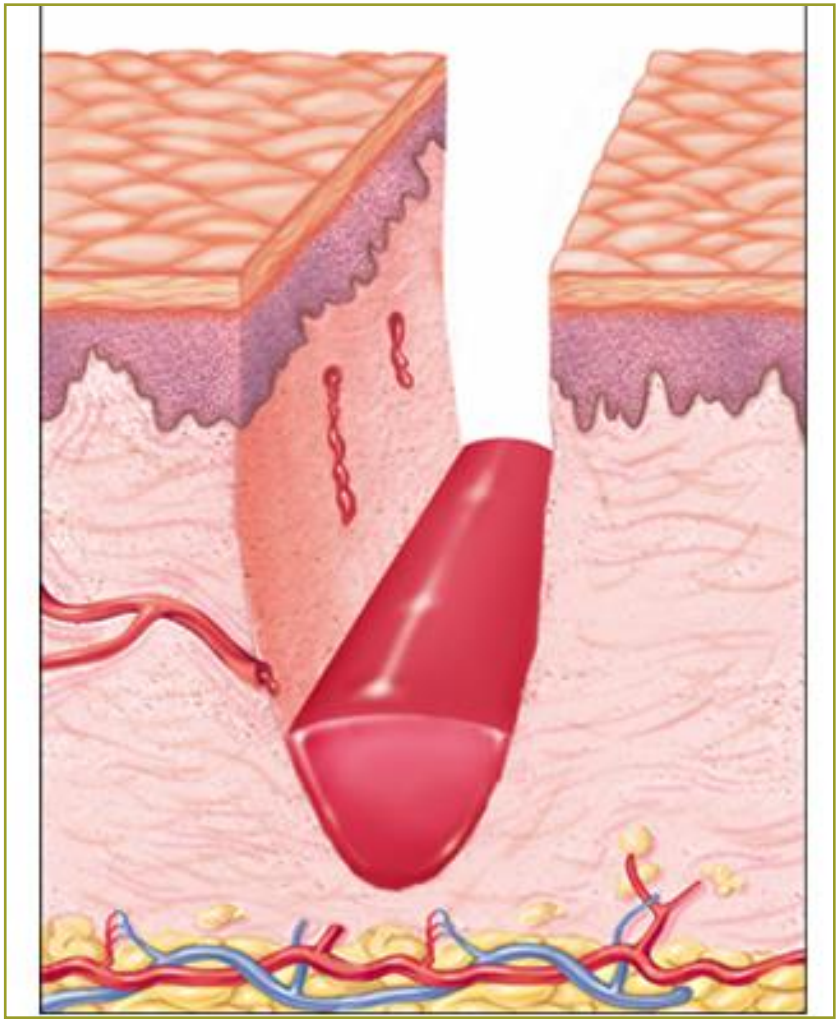
Figure 4-31, Page 130



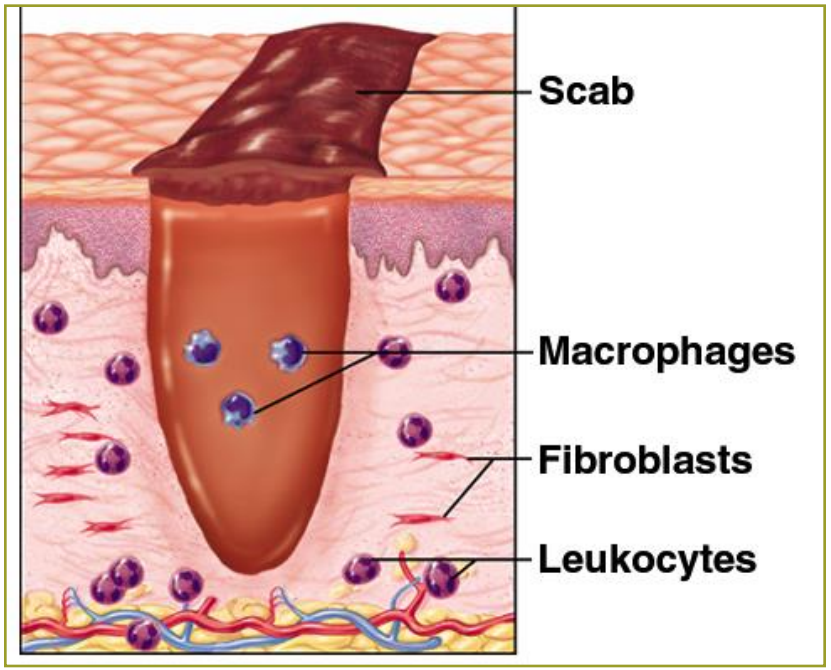
(From Melling M, Alder M: *Equine practice*, ed 3, Philadelphia, 1998, Saunders.)

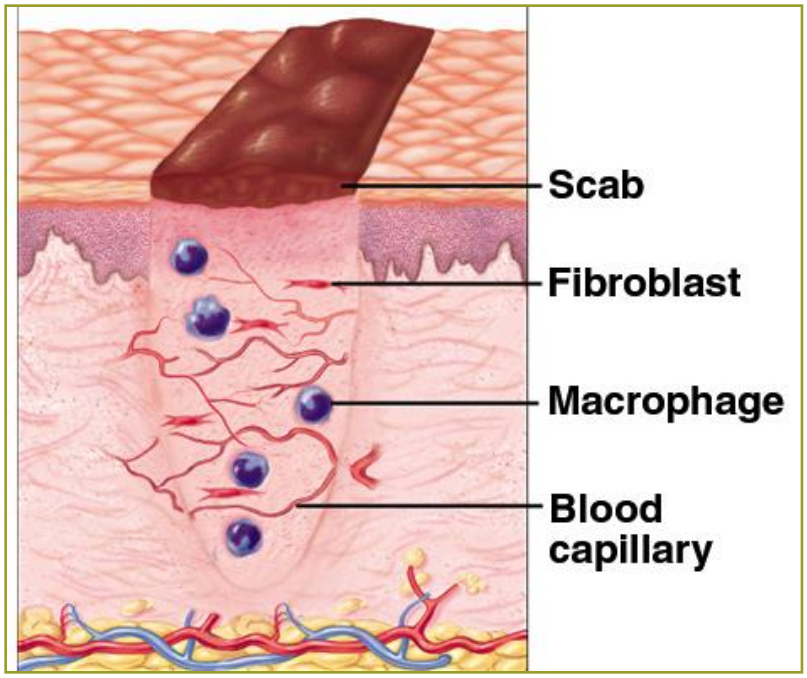
Review – Tissue Healing & Repair

- Injury to tissue
- Inflammation
- Formation of granulation tissue
- Regeneration (new tissue) or fibrosis (scar tissue)



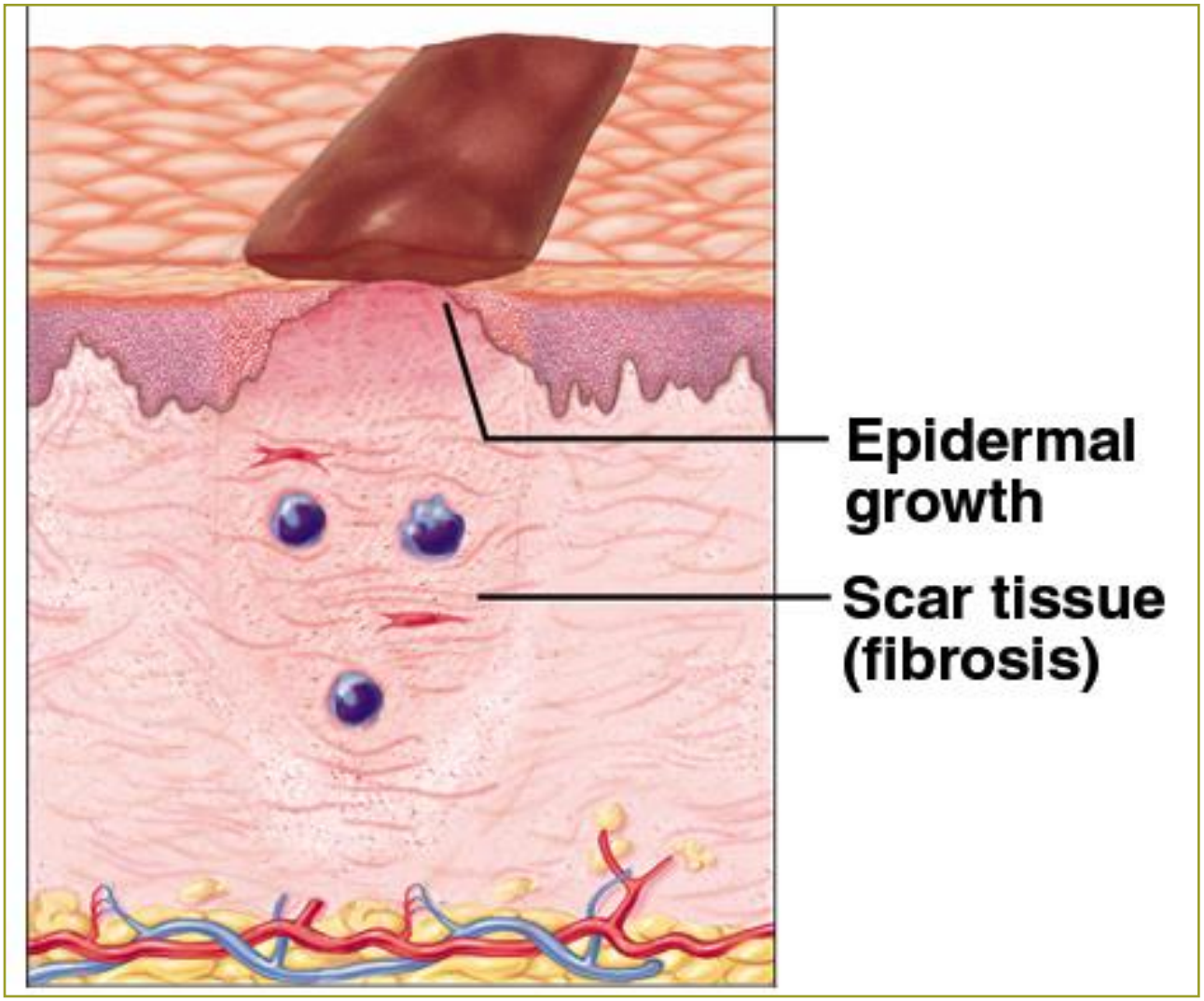
Steps of Wound Healing



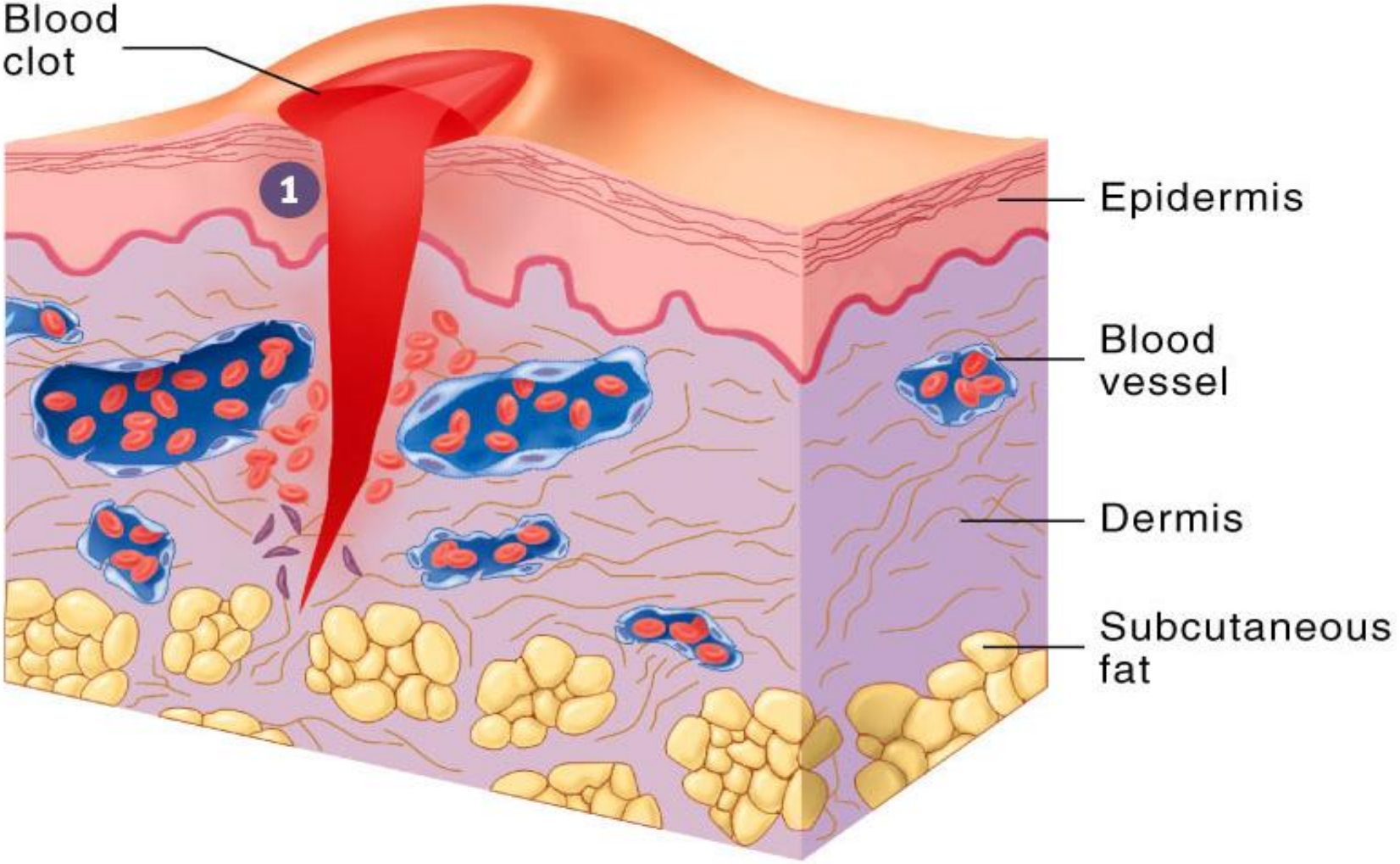


Scab formation

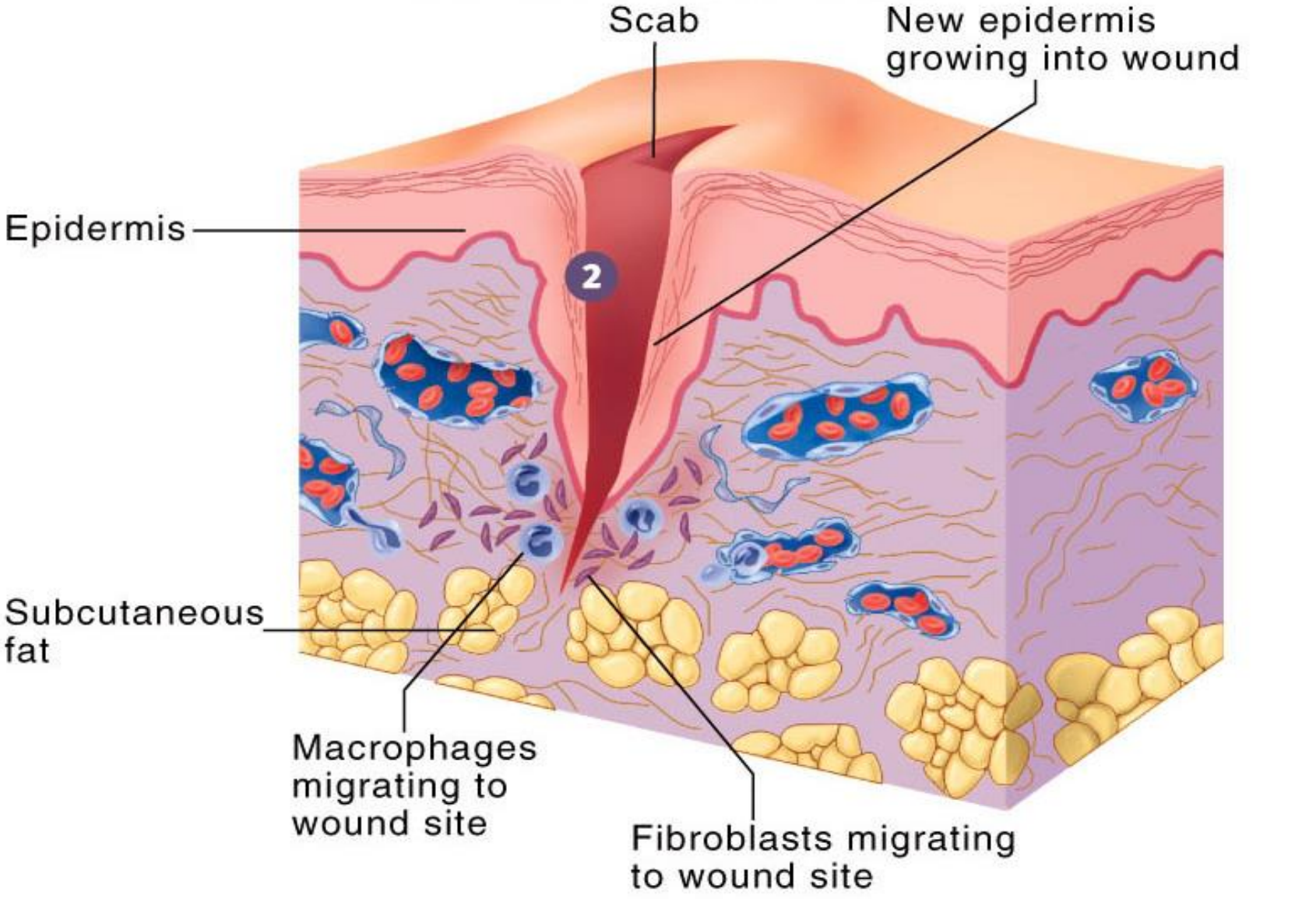
Formation of granulation tissue



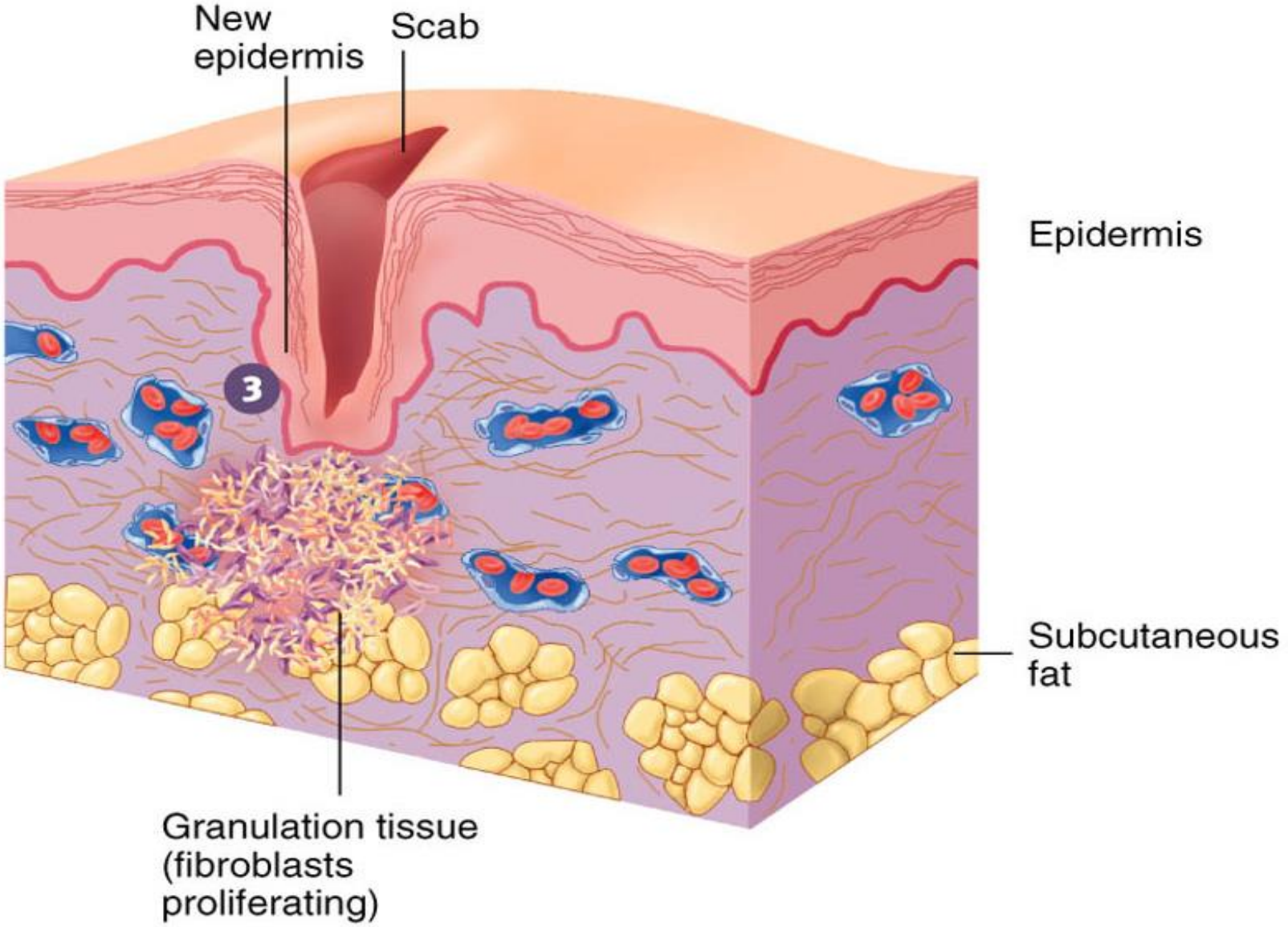
Epithelial regeneration & connective tissue fibrosis



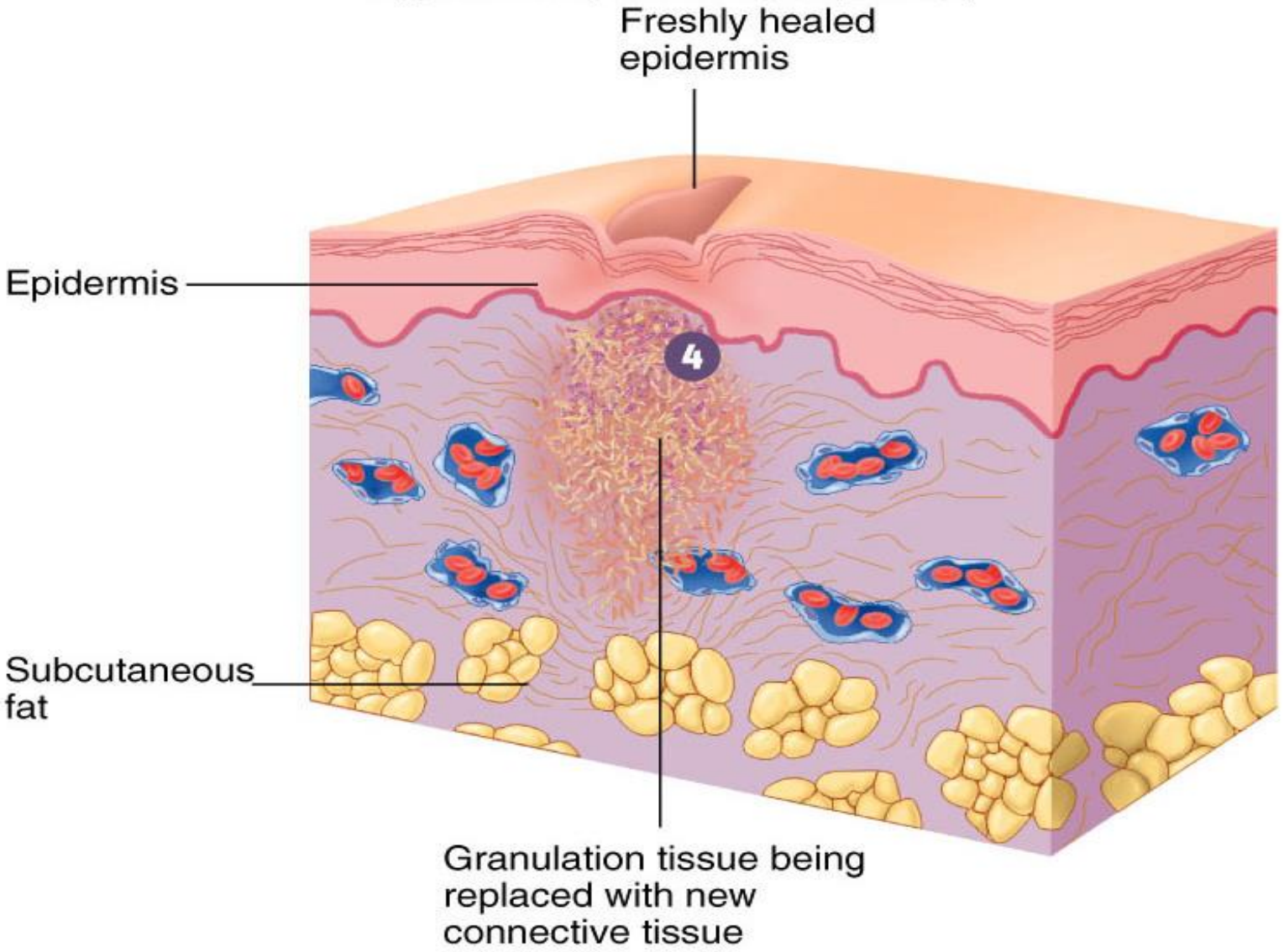
1. Fresh wound cuts through the epithelium (epidermis) and underlying connective tissue (dermis), and a clot forms.



2. Approximately 1 week after the injury, a scab is present, and epithelium (new epidermis) is growing into the wound.



3. Approximately 2 weeks after the injury, the epithelium has grown completely into the wound, and fibroblasts have formed granulation tissue.



4. Approximately 1 month after the injury, the wound has completely closed, the scab has been sloughed, and the granulation tissue is being replaced by new connective tissue.

Test Yourself

KNOW THESE IN EVERY CHAPTER!

Pages 93, 102, 107, 109, 117, 125, 130

Clinical Applications

Pages 94, 119, 121-124, 130