

Tissues

- Groups of cells similar in structure and function
- The four types of tissues
 - Epithelial
 - Connective
 - Muscle
 - Nerve

Epithelial Tissue

- **Cellularity** – composed almost entirely of cells
- **Special contacts** – form continuous sheets held together by tight junctions and desmosomes
- **Polarity** – apical and basal surfaces
- **Supported by connective tissue** – reticular and basal laminae
- **Avascular but innervated** – contains no blood vessels but supplied by nerve fibers
- **Regenerative** – rapidly replaces lost cells by cell division

Classification of Epithelia

- Simple or stratified

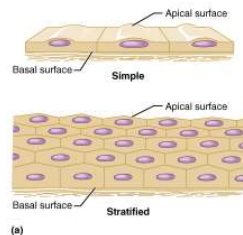


Figure 4.1a

Classification of Epithelia

- Squamous, cuboidal, or columnar

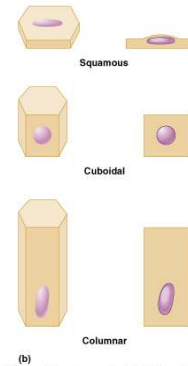


Figure 4.1b

Epithelia: Simple Squamous

- Single layer of flattened cells with disc-shaped nuclei and sparse cytoplasm
- Functions
 - Diffusion and filtration
 - Provide a slick, friction-reducing lining in lymphatic and cardiovascular systems
- Present in the kidney glomeruli, lining of heart, blood vessels, lymphatic vessels, and serosae

Epithelia: Simple Squamous

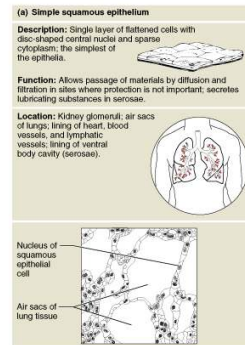


Figure 4.2a

Epithelia: Simple Cuboidal

- Single layer of cubelike cells with large, spherical central nuclei
- Function in secretion and absorption
- Present in kidney tubules, ducts and secretory portions of small glands, and ovary surface

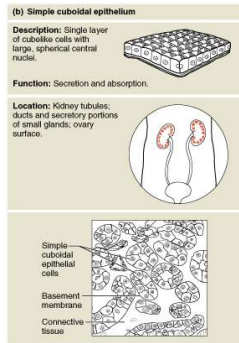


Figure 4.2b

Epithelia: Simple Columnar

- Single layer of tall cells with oval nuclei; many contain cilia
- Goblet cells are often found in this layer
- Function in absorption and secretion
- Nonciliated type line digestive tract and gallbladder
- Ciliated type line small bronchi, uterine tubes, and some regions of the uterus

Epithelia: Simple Columnar

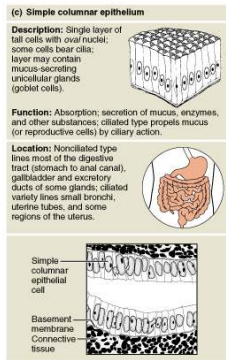


Figure 4.2c

Epithelia: Pseudostratified Columnar

- Single layer of cells with different heights; some do not reach the free surface
- Nuclei are seen at different layers
- Function in secretion and propulsion of mucus
- Present in the male sperm-carrying ducts (nonciliated) and trachea (ciliated)

Epithelia: Pseudostratified Columnar

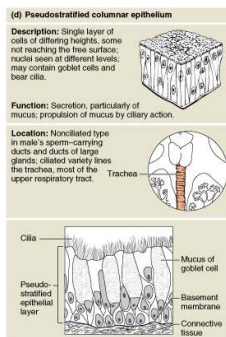


Figure 4.2d

Epithelia: Stratified Squamous

- Thick membrane composed of several layers of cells
- Function in protection of underlying areas subjected to abrasion
- Forms the external part of the skin's epidermis (keratinized cells), and linings of the esophagus, mouth, and vagina (nonkeratinized cells).

Epithelia: Stratified Squamous

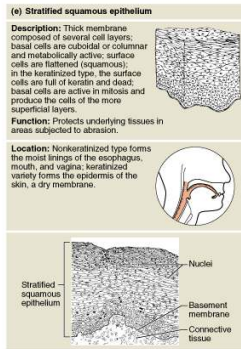


Figure 4.2e

Epithelia: Stratified Columnar

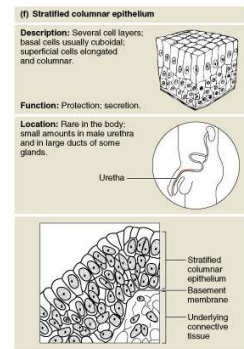


Figure 4.2f

- Several cell layers with cuboidal basal cells and columnar superficial cells
- Functions in protection and secretion
- Present in large ducts of some glands, and in portions of the male urethra

Epithelia: Transitional

- Several cell layers, basal cells are cuboidal, surface cells are dome shaped
- Stretches to permit the distension of the urinary bladder
- Lines the urinary bladder, ureters, and part of the urethra

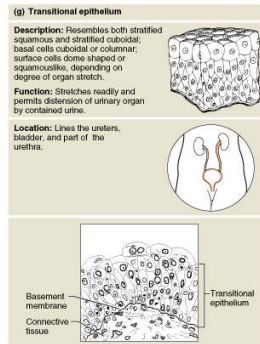


Figure 4.2g

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 or multicellular

Endocrine Glands

- Ductless glands that produce hormones
- Secretions include amino acids, proteins, glycoproteins, and steroids

Exocrine Glands

- More numerous than endocrine glands
- Secrete their products onto body surfaces (skin) or into body cavities
- Examples include mucous, sweat, oil, and salivary glands
- The only important unicellular gland is the goblet cell
- Multicellular exocrine glands are composed of a duct and secretory unit

Multicellular Exocrine Glands

- Classified according to:
 - Simple or compound duct type
 - Structure of their secretory units

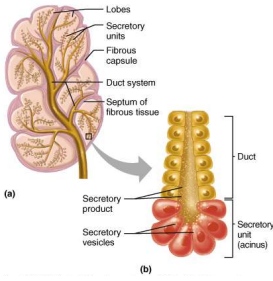


Figure 4.3

Structural Classification of Multicellular Exocrine Glands





| | Tubular secretory structure | | Alveolar secretory structure | |
|--|--|---|---|--|
| Simple duct structure (duct does not branch) |  (a) Simple tubular Example: intestinal glands |  (b) Simple branched tubular Example: stomach (gastric) glands |  (c) Simple alveolar Example: No important example in humans |  (d) Simple branched alveolar Example: sebaceous (oil) glands |
| Key: ■ = Surface epithelium ■ = Duct ■ = Secretory epithelium | | | | |

Figure 4.4a-d

Structural Classification of Multicellular Exocrine Glands




| | Tubular secretory structure | | Alveolar secretory structure | |
|--|---|---|--|--|
| Compound duct structure (duct branches) |  (e) Compound tubular Example: Brunner's glands of small intestine |  (f) Compound alveolar Example: mammary glands |  (g) Compound tubuloalveolar Example: salivary glands | |
| Key: ■ = Surface epithelium ■ = Duct ■ = Secretory epithelium | | | | |

Figure 4.4e-g

Modes of Secretion

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

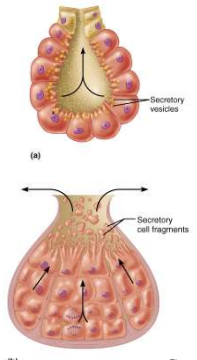


Figure 4.5

Connective Tissue

- Found throughout the body; most abundant and widely distributed in primary tissues
- Connective tissue proper
- Cartilage
- Bone
- Blood

Connective Tissue

| Common embryonic origin: | Mesenchyme | | | |
|--|--|---|--|---|
| Cellular descendants: | Fibroblast | Chondroblast | Osteoblast | Hematopoietic stem cell |
| | Fibrocyte | Chondrocyte | Osteocyte | Blood cells* (and macrophages) |
| Class of connective tissue resulting: | Connective tissue proper | Cartilage | Osseous (bone) | Blood |
| Subclasses: | 1. Loose connective tissue Types: Areolar, Adipose, Reticular 2. Dense connective tissue Types: Regular, Irregular, Elastic | 1. Hyaline cartilage 2. Fibrocartilage 3. Elastic cartilage | 1. Compact bone 2. Spongy (cancellous) bone | * Blood cell formation and differentiation are quite complex. Details are provided in Chapter 18. |

Figure 4.6

Functions of Connective Tissue

- Binding and support
- Protection
- Insulation
- Transportation

Characteristics of Connective Tissue

- Connective tissues have:
 - Mesenchyme as their common tissue of origin
 - Varying degrees of vascularity
 - Nonliving extracellular matrix, consisting of ground substance and fibers

Structural Elements of Connective Tissue

- Ground substance – unstructured material that fills the space between cells
- Fibers – collagen, elastic, or reticular
- Cells – fibroblasts, chondroblasts, osteoblasts, and hematopoietic stem cells

Ground Substance

- Interstitial (tissue) fluid
- Adhesion proteins – fibronectin and laminin
- Proteoglycans – glycosaminoglycans (GAGs)
- Functions as a molecular sieve through which nutrients diffuse between blood capillaries and cells

Fibers

- Collagen – tough; provides high tensile strength
- Elastic – long, thin fibers that allow for stretch
- Reticular – branched collagenous fibers that form delicate networks

Chapter 4

Tissue: The Living Fabric

Part C

Connective Tissue: Fundamental Cell Type

- Fibroblasts – connective tissue proper
- Chondroblasts – cartilage
- Osteoblasts – bone
- Hematopoietic stem cells – blood
- White blood cells (WBCs), plasma cells, macrophages, and mast cells

Connective Tissue (CT): Embryonic

- Mesenchyme – embryonic CT
 - Gel-like ground substance with fibers and star-shaped mesenchymal cells
 - Gives rise to all other connective tissues
 - Found in the embryo


Embryonic connective tissue

(a) Mesenchyme

Description: Embryonic connective tissue; gel-like ground substance containing fibers, star-shaped mesenchymal cells.

Function: Gives rise to all other connective tissue types.

Location: Primarily in embryo.



Mesenchymal cell
Ground substance
Fibers

Figure 4.8a

Connective Tissue Proper: Loose

- Areolar CT
 - Gel-like matrix with all three CT fibers
 - Fibroblasts, macrophages, mast cells, and some WBCs
 - Wraps and cushions organs
 - Widely distributed throughout the body

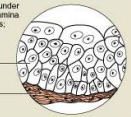
Connective tissue proper: Loose connective tissue (b to d)

(b) Areolar connective tissue

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 phagocytose 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.



Epithelium
Lamina propria
Fibroblast nuclei
Elastic fibers
Collagen fibers

Figure 4.8b

Connective Tissue Proper: Loose

- Adipose CT
 - Matrix similar to areolar CT with closely packed adipocytes
 - Reserve food stores, insulates against heat loss, and supports and protects
 - Found under skin, around kidneys, within abdomen, and in breasts


Loose connective tissue (continued)

(c) Adipose tissue

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; around kidneys and eyeballs; within abdomen; in breasts.



Blood vessel
Venucle containing fat droplet
Nuclei of fat cells

Figure 4.8c

Connective Tissue Proper: Loose

- Reticular CT
 - Loose ground substance with reticular fibers
 - Reticular cells lie in a fiber network
 - Forms a soft internal skeleton, or stroma, that supports other cell types
 - Found in lymph nodes, bone marrow, and the spleen

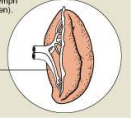
Loose connective tissue (continued)

(d) Reticular connective tissue

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.

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



Spleen
White blood cells
Reticular cell
Reticular fibers

Figure 4.8d

Connective Tissue Proper: Dense Regular

- Parallel collagen fibers with a few elastic fibers
- Major cell type is fibroblasts
- Attaches muscles to bone or to other muscles, and bone to bone
- Found in tendons, ligaments, and aponeuroses

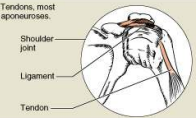
Connective tissue proper: Dense connective tissue (e and f)

(e) Dense regular connective tissue

Description: Primarily parallel collagen fibers; a few elastin 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.



Shoulder joint
Ligament
Tendon
Collagen fibers
Nuclei of fibroblasts

Figure 4.8e

Connective Tissue Proper: Dense Irregular

- Irregularly arranged collagen fibers with some elastic fibers
- Major cell type is fibroblasts

Dense connective tissue (continued)

(f) Dense irregular connective tissue

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: Dermis of the skin; submucosa of digestive tract; fibrous capsules of organs and of joints.


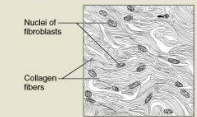



Figure 4.8f

Connective Tissue Proper: Dense Irregular

- Withstands tension in many directions providing structural strength
- Found in the dermis, submucosa of the digestive tract, and fibrous organ capsules

Dense connective tissue (continued)

(f) Dense irregular connective tissue

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: Dermis of the skin; submucosa of digestive tract; fibrous capsules of organs and of joints.

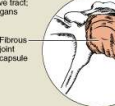
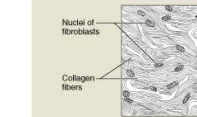



Figure 4.8f

Chapter 4

Tissue: The Living Fabric

Part D

Connective Tissue: Cartilage

- Hyaline cartilage
 - Amorphous, firm matrix with imperceptible network of collagen fibers
 - Chondrocytes lie in lacunae
 - Supports, reinforces, cushions, and resists compression

Cartilage: (g to i)

(g) Hyaline cartilage

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.

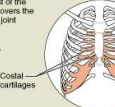
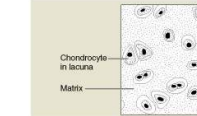



Figure 4.8g

Connective Tissue: Cartilage

- Forms the costal cartilage
- Found in: embryonic skeleton, the end of long bones, nose, trachea, and larynx

Cartilage: (g to i)

(g) Hyaline cartilage

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.


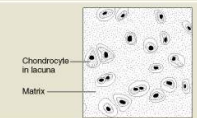



Figure 4.8g

Connective Tissue: Cartilage

- Elastic cartilage
 - Similar to hyaline cartilage but with more elastic fibers
 - Maintains shape and structure while allowing flexibility
 - Supports external ear (pinna) and the epiglottis

Cartilage (continued)

(h) Elastic cartilage

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.


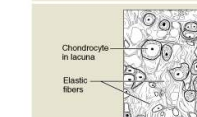



Figure 4.8h

Connective Tissue: Cartilage

- Fibrocartilage
 - Matrix similar to hyaline cartilage but less firm with thick collagen fibers
 - Provides tensile strength and absorbs compression shock
 - Found in intervertebral discs, the pubic symphysis, and in discs of the knee joint


Cartilage (continued)

(f) Fibrocartilage

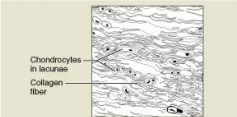
Description: Matrix similar but less firm than in hyaline cartilage; thick collagen fibers predominate.

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

Location: Intervertebral discs, pubic symphysis, discs of knee joint.



Intervertebral discs



Chondrocytes in lacunae
Collagen fiber

Figure 4.8i

Connective Tissue: Bone (Osseous Tissue)

- Osseous tissue
 - Hard, calcified matrix with collagen fibers found in bone
 - Osteocytes are found in lacunae and are well vascularized

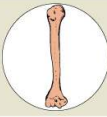
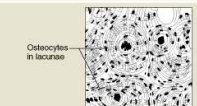
Others: (j and k)

(j) 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

Osteocytes in lacunae

Figure 4.8j

Connective Tissue: Bone (Osseous Tissue)

- Supports, protects, and provides levers for muscular action
- Stores calcium, minerals, and fat
- Marrow inside bones is the site of hematopoiesis

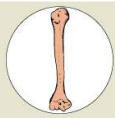
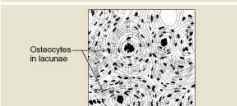
Others: (j and k)

(j) 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

Osteocytes in lacunae

Figure 4.8j

Connective Tissue: Blood

- Blood
 - Red and white cells in a fluid matrix (plasma)
 - Contained within blood vessels
 - Functions in the transport of respiratory gases, nutrients, and wastes


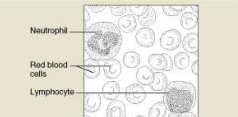
Others: (continued)

(k) 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.

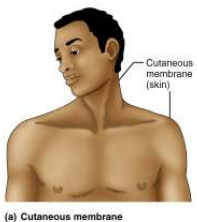



Neutrophil
Red blood cells
Lymphocyte

Figure 4.8k

Epithelial Membranes

- Cutaneous – skin



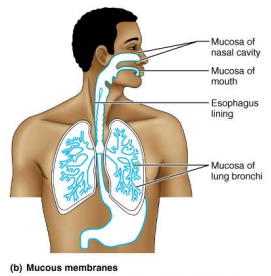
Cutaneous membrane (skin)

(a) Cutaneous membrane

Figure 4.9a

Epithelial Membranes

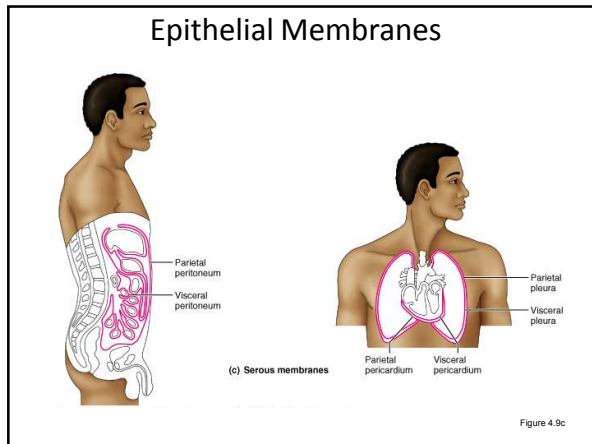
- Mucous – lines body cavities open to the exterior (e.g., digestive and respiratory tracts)
- Serous – moist membranes found in closed ventral body cavity



Mucosa of nasal cavity
Mucosa of mouth
Esophagus lining
Mucosa of lung bronchi

(b) Mucous membranes

Figure 4.9b



Chapter 4

Tissue: The Living Fabric

Part E

Nervous Tissue

- Branched neurons with long cellular processes and support cells
- Transmits electrical signals from sensory receptors to effectors
- Found in the brain, spinal cord, and peripheral nerves

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 nonreversible 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.

Figure 4.10

Muscle Tissue: Skeletal

- Long, cylindrical, multinucleate cells with obvious striations
- Initiates and controls voluntary movement
- Found in skeletal muscles that attach to bones or skin

(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.

Figure 4.11a

Muscle Tissue: Cardiac

- Branching, striated, uninucleate cells interdigitating at intercalated discs
- Propels blood into the circulation
- Found in the walls of the heart

(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.

Figure 4.11b

Muscle Tissue: Smooth

- Sheets of spindle-shaped cells with central nuclei that have no striations
- Propels substances along internal passageways (i.e., peristalsis)
- Found in the walls of hollow organs

(c) Smooth muscle

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

Function: Propels substances or objects (foodstuffs, urine, a baby) along internal passageways; involuntary control.

Location: Mostly in the walls of hollow organs.

Figure 4.11c

Tissue Trauma

- Causes inflammation, characterized by:
 - Dilation of blood vessels
 - Increase in vessel permeability
 - Redness, heat, swelling, and pain

Tissue Repair

- Organization and restored blood supply
 - The blood clot is replaced with granulation tissue
- Regeneration and fibrosis
 - Surface epithelium regenerates and the scab detaches

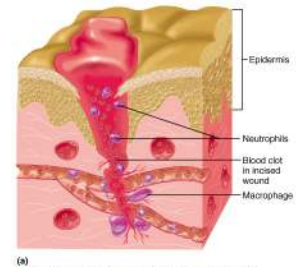


Figure 4.12a

Tissue Repair

- Fibrous tissue matures and begins to resemble the adjacent tissue

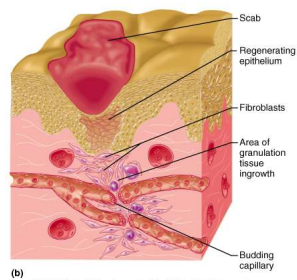


Figure 4.12b

Tissue Repair

- Results in a fully regenerated epithelium with underlying scar tissue

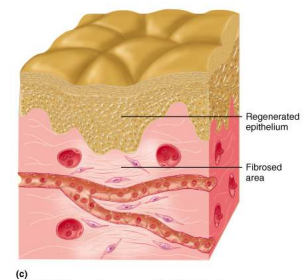


Figure 4.12c