

CHAPTER 5: TISSUES

OBJECTIVES:

1. Define the term *tissue*.
2. Name the four primary adult tissue types, and give a brief description of each.
3. Describe the functions and types of extracellular fluid (ECF).
4. Compare and contrast the structure and function of the three types of cell junctions.
5. Sketch a typical layer of epithelium. Label each structure and use this cell layer to discuss the characteristics of epithelia.
6. Explain how epithelia are nourished.
7. Discuss the classification scheme for epithelia.
8. For each of the following epithelial tissues, give a structural description (including any special features such as cilia, goblet cells, etc.), denote a key body location, and identify its function(s):
 - A. Simple Squamous ET
 - B. Simple Cuboidal ET
 - C. Simple Columnar ET
 - D. Pseudostratified Columnar ET
 - E. Transitional ET
 - F. Stratified Squamous ET (both keratinized and non-keratinized)
 - G. Glandular ET
9. Distinguish between merocrine, apocrine, and holocrine exocrine glands and give an example of each.
10. Define the term *carcinoma*.
11. Describe the general characteristics of connective tissues (CT) and discuss the major structural differences from ET's.
12. Explain how CT's are composed of cells plus an intercellular matrix composed of ground substance and fibers.

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13. Describe ground substance, list the three CT fiber types, and name the many types of cells that may compose CT.
14. For each of the following CT's, describe its structure, name a key body location, and identify its function(s):
 - A. Mesenchyme
 - B. Areolar CT
 - C. Adipose Tissue
 - D. Reticular CT
 - E. Dense Regular CT
 - F. Dense Irregular CT
 - G. Elastic CT
 - H. Hyaline Cartilage
 - I. Fibrocartilage
 - G. Elastic Cartilage
 - H. Bone
 - I. Blood
15. Explain why a CT may be either liquid (blood), semi-solid (fat), or very rigid (bone).
16. Define the term *epithelial membrane* and discuss the structure, location, and function of the three different types: cutaneous, mucous, and serous.
17. Explain why muscle cells are called fibers and define contractility.
18. Compare and contrast the three types of muscle tissue in terms of their structure, control, location in the human body, and function.
19. Identify the major cell within nervous tissue, denote the location of nervous tissue in the body, and discuss its function.

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I. INTRODUCTION

- A. A tissue is composed of similar cells that are specialized to perform a common function(s).
- B. **Four adult primary types** of tissues form the "fabric" of the human organism: See Table 5.1, page 136.
1. **epithelial** tissues (ET; covering/lining);
 2. **connective** tissues (CT; support);
 3. **muscle** tissues (MT; movement);
 4. **nervous** tissues (NT; control).
- C. The four primary tissue types are derived from three embryonic germ layers:
1. Ectoderm (outside) gives rise to ET and NT;
 2. Mesoderm (middle) gives rise to ET, CT and MT;
 3. Endoderm (inside) gives rise to ET.
- D. Surrounding all body cells is **Extracellular Fluid (ECF)**.
1. Functions are many:
 - a. medium to dissolve solutes;
 - b. transport;
 - c. site of chemical reactions.
 2. Two types of ECF:
 - a. **interstitial fluid** which fills the spaces between cells in tissues;
 - b. **plasma** which is the liquid portion of blood.

II. Cell Junctions: See Fig 3.8 and Fig 3.9 on page 69..

- A. Membrane (cell) Junctions = hold layers of cells together and...
- B. Three types:
1. **Tight Junctions** = tight, zipper-like junctions between cells; prevent intercellular passage of materials;
 2. **Desmosomes** = anchoring junctions that hold adjacent cells together;
 3. **Gap Junctions** = communicating (transport) channels between adjacent cells.

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III. EPITHELIAL TISSUES

A. General Characteristics:

1. Cellularity: Structure = tightly packed sheet of cells with little intercellular material between them.
2. Polarity:
 - a. ET always has a free surface ("apical surface") which opens to the outside or to an internal space (lumen);
 - b. This free surface may possess modifications.
 - microvilli or
 - cilia.
3. Basement Membrane:
 - a. The "basal surface" is anchored to underlying CT by a distinct **basement membrane**; composed of 2 layers:
 - basal lamina and
 - reticular lamina;
4. Specialized contacts:
 - a. tight junctions and
 - b. desmosomes.
5. Avascularity:
 - a. ET contain **no blood vessels**.
 - b. ET is nourished by nutrients which diffuse upward from underlying connective tissue.
6. Regeneration: high regeneration capacity.
7. Location:
 - a. **cover all body surfaces inside & out**
 - cover organs (i.e. visceral membranes),
 - line internal spaces (i.e. lumen of the intestine),
 - line body cavities (i.e. parietal membranes),
 - line ducts of exocrine glands (i.e. sweat glands),
 - cover body (i.e. epidermis).
8. Functions:
 - a. protection
 - b. absorption
 - c. secretion
 - d. excretion
 - e. filtration.

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III. EPITHELIAL TISSUES (continued)

B. **Classification of Epithelia** (plural); Epithelium (singular):

1. Many epithelial tissues are classified according to their **shape** and the number of **layers** they possess:
2. Some terms used to describe epithelia include:
 - a. **simple** = single layer of cells;
 - b. **stratified** = many layers of cells;
 - c. **squamous** = flattened cells;
 - d. **cuboidal** = square-shaped cells;
 - e. **columnar** = elongated cells (i.e. taller than wide);
3. Types of **Simple Epithelium**
 - a. **Simple squamous epithelium:**
 - a single layer of flattened cells;
 - generally allows for **easy passage (diffusion)** of substances;
 - Locations:
 1. linings of **air sacs** of lungs,
 2. lining of capillaries,
 3. lining of lymph vessels,
 4. lining of body cavities;
 - See Figure 5.1, page 137.
 - b. **Simple cuboidal epithelium:**
 - a single layer of square-shaped cells with centrally located nuclei;
 - Functions:
 1. **secretion**
 2. **absorption;**
 - Locations:
 1. lining of **kidney tubules**,
 2. ducts of glands,
 3. surface of ovary;
 - See Figure 5.2, page 138.

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III. Epithelial Tissues (continued)

3. Types of Simple Epithelium (continued)

c. **Simple columnar epithelium:**

- a single layer of elongated cells with basally located nuclei (near basement membrane);
- Functions:
 1. **protection,**
 2. **absorption,**
 3. **secretion;**
- Locations:
 1. lining of **digestive tract,**
 2. lining of uterus;
- Free Surface Modifications:
 1. microvilli (increase surface area); Fig 5.4, page 138.
 2. goblet cells (secrete protective mucus);
- See Figure 5.3, page 138.

d. **Pseudostratified columnar epithelium:**

- a single layer of elongated cells with scattered nuclei (i.e. look stratified but aren't);
- Functions:
 1. secretion,
 2. protection;
- Locations:
 1. lining of **respiratory tract,**
 2. lining of fallopian tube;
- Free surface modifications:
 1. **cilia** (trap debris and beat upward);
 2. goblet cells (mucus).
- See Figure 5.5, page 139.

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III. Epithelial Tissues (continued)

4. Types of **Stratified Epithelium**

a. **Stratified squamous epithelium:**

- many layers of flattened cells;
- Function = **protection**;
- locations:

Non-keratinized: See Figure 5.6, page 139;

1. lining of mouth,
2. lining of throat,
3. lining of vagina and
4. lining of anus.

Keratinized: Discussed in Chapter 6.

5. epidermis of **skin**.

b. **Transitional epithelium:**

- many layers of cells that change shape in response to tension;
- Function = distensibility (i.e. **stretches easily** to allow urine to fill bladder);
- Location = **urinary bladder**;
- See Figure 5.9, page 141.

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III. Epithelial Tissues (continued)

C. Glandular epithelium

1. usually simple cuboidal or columnar;
2. Function = **secretion**;
3. Two major types:
 - a. **Exocrine glands** secrete products into a duct which opens onto:
 - an external surface (i.e. sweat gland) or
 - an internal space (i.e. gastric gland);
 - b. Endocrine glands secrete hormones into the blood; these glands are ductless and will not be discussed here;
4. **Exocrine glandular secretions** are classified according to whether they consist of cellular products or portions of glandular cells:

See Fig 5.11, page 143 and Table 5.4, page 144.

- a. Three types of secretions.
 - **Merocrine**: secrete fluid through cell membrane into duct with no loss of glandular cells; Example = salivary glands.
 - **Apocrine**: lose small portion of cells with secretion; Example = mammary glands;
 - **Holocrine**: release entire cells as secretion; Example = sebaceous glands in skin (oil). Also see Fig 5.12, page 144.

D. **Carcinoma** = a tumor (cancer) originating from epithelial tissue.

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EPITHELIA SUMMARY TABLE (Keyed on page 103 of this outline)

NAME OF ET	DESCRIPTION STRUCTURE	LOCATION	FUNCTION	TYPICAL SKETCH
SIMPLE SQUAMOUS				
SIMPLE CUBOIDAL				
SIMPLE COLUMNAR				
PSEUDO- STRATIFIED COLUMNAR				
STRATIFIED SQUAMOUS				
TRANSI- TIONAL				
GLANDULAR				

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IV. CONNECTIVE TISSUES

A. General Characteristics:

1. Common Origin: from mesenchyme;
2. Wide Range of Vascularity: from cartilage which is avascular to bone which has a rich blood supply;
3. Structural Elements: cells plus intercellular matrix (ground substance plus fibers).

B. Structural Elements:

Types of CT vary in their proportions of cells: fibers: ground substance. Accordingly they represent a diverse group of tissues.

1. Ground Substance:

- a. amorphous material that fills the space between cells and fibers;
- b. Functions as a molecular "sieve" through which nutrients and gases can diffuse between cells and blood capillaries.

2. Fibers = 3 types: See Figure 5.16, page 145.

a. Collagen fibers are composed of the protein collagen.

- provide high tensile strength to matrix;
- stain pink.

b. Elastic fibers are composed of the protein elastin.

- provide rubbery resiliency to matrix;
- stain purple;
- found in skin, lungs, and blood vessels;

c. Reticular fibers are fine collagenous fibers.

- form delicate networks;
- found in basement membranes;
- stain purple.

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IV. B. CT Structural Elements (continued)

3. Cells:

a. **fundamental cell** in each CT type:

- osteocyte in bone,
- chondrocyte in cartilage.

b. **"blast" cells** = undifferentiated cells that secrete matrix; 4 primary types:

- fibroblast in CT proper; Fig 5.13, page 145;
- chondroblast in cartilage;
- osteoblast in bone;
- hemocytoblast in blood.

*Once the matrix has been formed, these "blast" cells assume their less active role as "-cytes" (but they can be reactivated if needed);

c. **migrating white blood cells** that respond to tissue damage (i.e. inflammation) ; 2 types:

- mast cells (See Fig 5.15, page 145) and
- **macrophages** or phagocytes (See Fig 5.14, page 145).

* See Components of Connective Tissues Summary Table 5.6, page 147.

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IV. CONNECTIVE TISSUES (continued)

C. Types of Connective Tissues

1. Embryonic CT = mesenchyme:

- a. Location = embryo;
- b. Function = gives rise to all other types of CT;

2. Mature CT's: **Loose Connective Tissue:**

a. **Loose Fibrous (Areolar) CT:**

1. gel-like matrix with **fibroblasts**, macrophages, mast cells and **collagen** and **elastic fibers**;
2. Location = beneath epithelium, surrounds organs;
3. Functions = wraps & cushions organs, inflammation, diffusion of nutrients and gases;
4. See page Fig 5.18, page 147.

b. **Adipose Tissue:**

1. closely packed adipocytes (**fat-cells**) with nuclei pushed to one side within areolar matrix (resemble signet rings);
2. Location = **under skin**, around kidneys & eyeballs, breasts;
3. Functions = energy store, **insulation**, protection;
4. See Figure 5.19, page 148.

c. **Reticular CT:**

1. network of **reticular fibers** within loose ground substance and reticulocytes;
2. Location = basement membranes, **lymph nodes, thymus, spleen**;
3. Function = support;
4. See Figure 5.20, page 148.

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IV. C. Types of Connective Tissues (continued)

3. Mature CT's: **Dense Connective Tissue:**

a. **Dense Regular CT (White Fibrous CT):**

- primarily **collagen fibers** (pink) with few fibroblasts (you can only see nuclei!);
- Location = **tendons, ligaments;**
- Functions = **attachment**, tensile strength;
- Poor blood supply = slow to no healing;
- See Fig 5.21, page 149.

b. **Dense Irregular CT:**

- primarily collagen fibers randomly arranged;
- Location = dermis of skin, heart valves;
- Function = provides tensile strength;
- See Figure 6.2, page 162 (where it is located below stratified squamous ET in skin)

c. **Elastic CT:**

- primarily **elastin fibers** (purple);
- Location = lung tissue, wall of aorta;
- Function = durability with stretch;
- See Figure 5.22, page 149.

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IV. Connective Tissues (continued)

C. Types of CT (continued)

4. **Cartilage:**

a. **Hyaline cartilage:**

- amorphous matrix that surrounds cells = chondrocytes (within lacunae);
- Locations = embryonic skeleton, costal cartilages, cartilage of the nose, trachea, and larynx;
- Function = support;
- Avascular = no healing;
- See Figure 5.23, page 150.

b. **Fibrocartilage:**

- less firm than above;
- Locations = intervertebral discs, pubic symphysis;
- Functions = tensile strength plus shock absorber;
- See Figure 5.25, page 151.

c. **Elastic cartilage:**

- same as above plus elastic fibers (purple);
- Locations = external ear, epiglottis;
- Functions = maintenance of shape plus flexibility;
- See Figure 5.24, page 150.

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IV. Connective Tissues (continued)

C. Types of CT (continued)

5. **Bone:**

- a. hard, calcified matrix ($[\text{Ca}_3(\text{PO}_4)_2(\text{OH})_2]$ = rigidity), with collagen fibers (tensile strength) and cells = **osteocytes** (within lacunae);
- b. Location = bones;
- c. Functions = protection, support, movement, calcium store and hematopoiesis;
- d. Highly vascular = fast healing;
- e. See Figure 5.26, page 151. Note **concentric circles**.

6. **Blood:**

- a. red cells, white cells, and platelets in a fluid matrix called plasma;
- b. Location = within blood vessels;
- c. Function = transport of gases, nutrients, wastes;
- d. See Figure 5.27, page 152.

* See Table 5.7, page 152 for a Summary of Connective Tissues.

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CONNECTIVE TISSUE SUMMARY TABLE (Keyed on page 104 of this outline)

NAME OF CT	DESCRIPTION	LOCATION	FUNCTION	SKETCH
MESENCHYME				
AREOLAR				
ADIPOSE				
RETICULAR				
DENSE REGULAR				
DENSE IRREGULAR				
ELASTIC				
HYALINE CARTILAGE				
FIBRO- CARTILAGE				
ELASTIC CARTILAGE				
BONE				
BLOOD				

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V. Epithelial Membranes

- A. DEFINITION: An epithelial membrane is a continuous multicellular sheet composed of at least two primary types of tissue: an **epithelium bound to a discrete underlying CT tissue**.
- B. Three Common Types:
1. **Cutaneous Membrane:** See Fig 6.2, page 162.
 - a. **skin;**
 - b. consists of keratinized stratified squamous epithelium firmly attached to a thick layer of dense irregular CT.
 2. **Mucous Membranes** (mucosae): See Fig
 - a. line body cavities that open to the outside;
 - b. include lining of digestive, respiratory and urinary tract;
 - c. are "wet" or **moist membranes** (through secretions of mucous);
 - d. consist of a layer of epithelium (usually stratified squamous or simple columnar) firmly attached to a layer of loose areolar CT.
 3. **Serous Membranes** (serosae): See page 7 of this outline.
 - a. are found in closed **ventral body cavities**;
 - b. consist of two layers with a potential space (cavity) between them:
 1. visceral membrane surrounds an organ;
 2. parietal membrane lines a body cavity;
 - c. secrete a thin watery fluid called **serous fluid** into the cavity between the membranes; function = **lubrication**;
 - d. each membrane consists of a thin simple squamous epithelial layer resting on a thin layer of areolar (loose) CT;
 - e. are named for the organs that occupy each cavity:
 1. pleural = lungs;
 2. pericardial = heart;
 3. peritoneal = abdominal organs.

Note: Synovial Membranes (those that line the cavities of freely movable joints) are NOT epithelial membranes, and will not be discussed here.

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VI. MUSCLE TISSUES

A. General Characteristics:

1. All muscle cells are elongated = muscle fibers;
2. Muscle fibers are **contractile** (i.e. they change their shape (shorten) to cause their attachments to move).

B. Types of Muscle Tissue:

1. Skeletal Muscle Tissue

- a. Structure: long thin cells (fibers) with many nuclei; alternating areas of light & dark (**striations**);
- b. Location: attached to bones;
- c. Function: move bones of skeleton;
- d. Control: **voluntary** = conscious.
- e. See Figure 5.28, page 153.

2. Cardiac Muscle Tissue

- a. Structure: network of cells with one centrally located nucleus; **intercalated discs** (where 2 cells meet); striations;
- b. Location: **heart**;
- c. Function: to pump blood from heart ----> lungs;
to pump blood from heart ----> body;
- d. Control: **involuntary** = unconscious
- e. See Figure 5.30, page 154.

3. Smooth Muscle Tissue

- a. Structure: spindle-shaped cells with one centrally located nucleus; no striations;
- b. Location: walls of hollow visceral organs;
walls of blood vessels;
- c. Function: moving food through digestive tract; expelling urine;
constricting blood vessels;
- d. Control: **involuntary** = unconscious;
- e. See Figure 5.29, page 154.

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MUSCLE TISSUE SUMMARY TABLE (Keyed on page 105 of this outline)

NAME OF MUSCLE TISSUE	DESCRIPTION OF STRUCTURE	TYPE OF CONTROL	LOCATION	FUNCTION	SKETCH
SKELETAL MUSCLE					
SMOOTH MUSCLE					
CARDIAC MUSCLE					

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VII. NERVOUS TISSUE

A. Structure:

1. Primary cell = **neuron** which responds to changes in their surroundings (stimuli);
 - a. possess many extensions (axons & dendrites);
 - b. neurons are surrounded by neuroglia (support cells);

B. Locations:

1. **Brain**
2. **Spinal Cord**
3. **Nerves**

C. Function:

1. **Coordination** of body parts (i.e. to transmit signals from body parts to brain and from brain back to body parts);

D. **No reproduction** of cells!

E. See Figure 5.31, page 155.

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EPITHELIA SUMMARY TABLE (outline page 92)

NAME OF ET	DESCRIPTION STRUCTURE	LOCATION	FUNCTION	TYPICAL SKETCH
SIMPLE SQUAMOUS	a single layer of flattened cells	linings of air sacs, capillaries, lymph vessels, & body cavities	diffusion, cushioning	
SIMPLE CUBOIDAL	a single layer of cube-shaped cells with large centrally located nuclei	linings of kidney tubules, ducts of glands	absorption, secretion	
SIMPLE COLUMNAR	a single layer of tall cells with basally located nuclei, goblet cells, & mucrovilli	lining of digestive tract	protection, absorption, secretion	
PSEUDO-STRATIFIED COLUMNAR	a single layer of tall cells with scattered nuclei, cilia, & goblet cells	lining of trachea, lining of fallopian tube	protection, secretion	
STRATIFIED SQUAMOUS	many layers of flattened cells	keratinized = epidermis; non-keratinized = lining of vagina, anus, throat, mouth	protection	
TRANSITIONAL	several layers of cells that change shape under pressure	lining OF urinary bladder and ureters	distensibility	
GLANDULAR	simple cuboidal	lining the ducts of glands	secretion	

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CONNECTIVE TISSUE SUMMARY TABLE (outline page 99)

NAME OF CT	DESCRIPTION	LOCATION	FUNCTION	SKETCH
MESENCHYME		embryo	gives rise to all other CT's	
AREOLAR	gel-like matrix with fibroblasts, collagen and elastic fibers	beneath ET (serous membranes around organs & lining cavities)	cushions, diffusion, inflammation	
ADIPOSE	closely packed adipocytes with nuclei pushed to one side	beneath skin, breasts, around kidneys & eyeballs	insulation, energy store, protection	
RETICULAR	network of ret. fibers in loose matrix	basement memb, lymph organs	support	
DENSE REGULAR	dense matrix of collagen fibers	tendons, ligaments	attachment (high tensile strength)	
DENSE IRREGULAR	loose matrix of collagen fibers	dermis of skin	tensile strength	
ELASTIC	matrix of elastic fibers	lung tissue, wall of aorta	durability with stretch	
HYALINE CARTILAGE	chondrocytes in lacunae in amorphous matrix	emb. skeleton, costal cart, tip of nose, trachea, larynx	support	
FIBRO-CARTILAGE	less firm than above	intervertebral discs, pubic symphysis	tensile strength, shock absorber	
ELASTIC CARTILAGE	above plus elastic fibers	external ear, epiglottis	shape maintenance plus flexibility	
BONE	concentric circles of calcified matrix	bones	support, protection, movement, Ca ⁺⁺ store, hematopoiesis	
BLOOD	red cells, white cells and platelets in liquid plasma	in heart, and blood vessels	transport of nutrients, wastes & gases	

CHAPTER 5: TISSUES**MUSCLE TISSUE SUMMARY TABLE (outline page 102)**

NAME OF MUSCLE TISSUE	DESCRIPTION OF STRUCTURE	TYPE OF CONTROL	LOCATION	FUNCTION	SKETCH
SKELE-TAL MUSCLE	long, thin fibers with many nuclei and striations	voluntary	attached to bones	to move bones	
SMOOTH MUSCLE	spindle shaped cells with one centrally located nucleus, lacking striations	involuntary	walls of visceral hollow organs, irises of eyes, walls of blood vessels	to move substances through passageways (i.e. food, urine, semen), constrict blood vessels, etc	
CARDIAC MUSCLE	a network of striated cells with one centrally located nucleus attached by intercalated discs	involuntary	heart	pump blood to lungs and body	