

## CHAPTER 5: TISSUES

### 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:
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. Four types of ECF:
    - a. **interstitial fluid** which fills the spaces between cells in tissues;
    - b. **plasma** which is the liquid portion of blood.
    - c. **Lymph** which is in lymphatic vessels
    - d. **Transcellular fluid** which includes cerebrospinal fluid, synovial fluid, humors of the eye, serous fluid and exocrine secretions

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### II. EPITHELIAL TISSUES

#### A. General Structural Characteristics:

1. Cellularity: ETs are composed of tightly packed sheet(s) of cells with little intercellular material between them.
2. Polarity:
  - a. ETs exhibit polarity and always have a free surface ("apical surface") which opens to the outside or to an internal space (lumen);
  - b. This free surface may possess modifications.
    - microvilli (increases membrane surface);
    - cilia (aid in movement of a substance across the layer).
3. Basement Membrane:
  - a. The "basal surface" of ETs are anchored to underlying CT by a distinct **basement membrane**
4. Specialized contacts that ETs may possess include:
  - a. tight junctions (zipper-like junctions that prevent intercellular leakage);
  - b. desmosomes (hold adjacent cells, and therefore the layer of cells, together).
5. Avascularity:
  - a. ETs contain **no blood vessels**.
  - b. ET is nourished by nutrients which diffuse upward from underlying connective tissue through the basement membrane.
6. Regeneration: high regeneration capacity, due to rapid cell division
7. **Locations: ETs cover us and line us:**
  - a. coverings:
    - body (i.e. epidermis) and
    - ventral cavity organs (i.e. visceral serous membranes)
  - b. linings
    - internal spaces (i.e. lumen of the intestine),
    - line body cavities (i.e. parietal membranes),
    - line ducts of exocrine glands (i.e. sweat glands).
8. **Functions:**
  - a. protection (i.e. epidermis)
  - b. absorption (i.e. lining of intestine)
  - c. secretion (i.e. ducts of glands)
  - d. excretion (i.e. epidermis and lining of kidney capillaries)
  - e. filtration. (i.e. lining of kidney capillaries)

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### II. EPITHELIAL TISSUES

#### 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. lining **air sacs** of lungs,
      2. lining capillaries,
      3. lining body cavities,
      4. covering ventral organs;
  - b. **Simple cuboidal epithelium:**
    - a single layer of square-shaped cells with large centrally located nuclei;
    - Functions:
      1. **secretion**
      2. **absorption;**
    - Locations:
      1. lining **kidney tubules,**
      2. lining ducts of glands,
      3. covering surface of ovary;

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### II. EPITHELIAL TISSUES

#### B. Classification of Epithelia

##### 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 **small intestine,**
  2. lining uterus;
- Free Surface Modifications:
  1. microvilli (increase surface area);
  2. goblet cells (secrete protective mucus);

###### d. **Pseudostratified columnar epithelium:**

- a single layer of elongated cells with scattered nuclei (i.e. look stratified but are not); all cells touch the basement membrane
- Functions:
  1. secretion,
  2. protection;
- Locations:
  1. lining **trachea,**
  2. lining fallopian tube;
- Free surface modifications:
  1. **cilia** (trap debris and aid in passage of mucus up and out of airway);
  2. goblet cells (produce mucus which coats cilia and helps trap debris).

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### II. EPITHELIAL TISSUES

#### B. Classification of Epithelia

##### 4. Types of Stratified Epithelium

###### a. Stratified squamous epithelium:

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

Non-keratinized:

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

Keratinized: Discussed in more detail with skin

1. epidermis of **skin**.

###### b. Stratified Cuboidal epithelium:

- 2-3 layers of cuboidal cells
- Locations
  1. mammary glands
  2. sweat glands
  3. salivary glands
  4. pancreas

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### II. EPITHELIAL TISSUES

#### B. Classification of Epithelia

##### 4. Types of Stratified Epithelium

###### c. **Stratified columnar epithelium:**

- 2-3 layers of elongated cells
- Locations
  1. vas deferens
  2. part of male urethra

###### d. **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 = lining **urinary bladder** and ureters.

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### II. EPITHELIAL TISSUES

#### B. Classification of Epithelia

##### 5. Glandular epithelium

- a. usually simple cuboidal or columnar ET;
- b. Function = **secretion**;
- c. two major types:
  - **Exocrine glands** secrete products into a duct, which opens onto:
    - an external surface (i.e sweat gland) or
    - an internal space/lumen (i.e. gastric gland);
  - **Endocrine glands** secrete hormones into the blood. These glands are ductless and will be discussed later.
- d. Exocrine glands structure varies tremendously
  - Single cells (unicellular) – goblet cells
  - Many cells (multicellular)
    - Simple – unbranched
    - Compound – branched
    - Tubular – tube-like
    - Alveolar – sac-like
- e. **Exocrine glandular secretions** are classified according to whether they consist of cellular products or portions of glandular cells:

Three types of secretions.

- Merocrine:** secrete fluid through cell membranes into a 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 into secretion.  
Example = sebaceous glands in skin (oil).
- f. **Carcinoma** = a tumor (cancer) originating from epithelial tissue.

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**EPITHELIA SUMMARY TABLE** (Keyed at the end of this outline)

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

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### III. CONNECTIVE TISSUES

#### A. General Characteristics:

1. Common Origin: from mesenchyme (mesoderm).
2. Wide Range of Vascularity: from cartilage, which is avascular, to bone, which has a rich blood supply.
3. Structural Elements: cells plus extracellular matrix (ground substance plus fibers).
4. **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.

#### B. Major Cell Types:

1. **fixed cell** in each CT type: maintains constant numbers
  - a. fibroblasts in CT proper
  - b. osteocyte in bone,
  - c. chondrocyte in cartilage.
  - d. **blast cells** = undifferentiated cells that secrete matrix;
    - fibroblast in CT proper.
    - chondroblast in cartilage;
    - osteoblast in bone;

\* Once the matrix has been formed, these "blast" cells assume their less active role as "-cytes" (but they can be reactivated if needed);
2. **wandering cells;** are not always there
  - a. **migrating white blood cells** that respond to tissue damage (i.e. inflammation) ; 2 types:
    - **mast cells:**
      - Secrete heparin to prevent excessive blood clotting
      - Secrete histamine to promote inflammation
    - **macrophages** or phagocytes:
      - Eat foreign material

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### III. CONNECTIVE TISSUES

#### C. **Connective Tissue Fibers** = 3 types:

1. **Collagen fibers** are composed of the protein collagen.
  - a. provide high tensile strength to matrix;
  - b. stain pink.
  
2. **Elastic fibers** are composed of the protein elastin.
  - a. provide rubbery resiliency to matrix;
  - b. stain purple;
  - c. found in skin, lungs, and blood vessels.
  
3. **Reticular fibers** are fine collagenous fibers.
  - a. form delicate networks;
  - b. found in basement membranes;
  - c. stain purple.

#### D. **Categories of Connective Tissues**

1. **Embryonic CT = mesenchyme:** from mesoderm
  - a. Location = embryo;
  - b. Function = gives rise to all other types of CT;
  
2. **Connective Tissue Proper** – All CT with a semi-fluid ground substance
  - a. **Loose Areolar CT:**
    - gel-like matrix with **fibroblasts**, macrophages, mast cells and **collagen** and **elastic fibers**;
    - Location = beneath epithelium, covering ventral organs;
    - Functions = diffusion of nutrients and gases; wraps & cushions organs.

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### III. CONNECTIVE TISSUES

#### D. Categories of Connective Tissues

##### 2. Connective Tissue Proper

##### b. Adipose Tissue:

- closely packed adipocytes (**fat-cells**) with nuclei pushed to one side within matrix (resemble signet rings);
- Location = **under skin** (as subcutaneous layer), around kidneys and eyeballs, breasts;
- Functions = **energy store**, insulation, protection;

##### c. Reticular CT:

- network of **reticular fibers** within loose ground substance and reticulocytes;
- Location = **basement membranes** and lymphatic organs (i.e. lymph nodes, thymus, spleen);
- Function = support;

##### d. 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;

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### III. CONNECTIVE TISSUES

#### D. Categories of Connective Tissues

##### 2. Connective Tissue Proper

##### e. **Dense Irregular CT:**

- primarily collagen fibers randomly arranged;
- Location = dermis of skin, heart valves;
- Function = provides tensile strength;
- (located below stratified squamous ET in skin)

##### f. **Elastic CT:**

- primarily **elastin fibers** (purple);
- Location = lung tissue, wall of aorta;
- Function = durability with stretch;

##### 3. Special Connective Tissues

##### a. **Hyaline cartilage:**

- amorphous (chondroitin and glucosamine) matrix that surrounds cells = **chondrocytes** (within lacunae);
- Locations = embryonic skeleton, costal cartilages, cartilage of the nose, trachea, and larynx;
- Function = support;
- Avascular = no healing;

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### III. CONNECTIVE TISSUES

#### D. Categories of Connective Tissues

##### 3. Special Connective Tissues

##### b. Elastic cartilage:

- same as above plus elastic fibers (purple);
- Locations = external ear, epiglottis;
- Functions = maintenance of shape plus flexibility;

##### c. Fibrocartilage:

- less firm than above;
- Locations = intervertebral discs, pubic symphysis;
- Functions = tensile strength plus shock absorber;

##### d. Bone:

- hard, calcified matrix ( $[\text{Ca}_3(\text{PO}_4)_2(\text{OH})_2]$  = rigidity), with collagen fibers (tensile strength) and cells = **osteocytes** (within lacunae);
- Location = bones of the skeleton;
- Functions = protection, support, movement, calcium store and hematopoiesis;
- Highly vascular = fast healing;
- Note **concentric circles** of compact bone.

##### e. Blood:

- red cells (erythrocytes), white cells (leukocytes), and platelets (thrombocytes) in a fluid matrix called plasma;
- Location = within heart and blood vessels;
- Function = transport of gases, nutrients, wastes;

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### CONNECTIVE TISSUE SUMMARY TABLE (Keyed at the end 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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### IV. 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.

##### 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

##### 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;  
attached to hair follicles in the dermis
- c. Function: movement of food through digestive tract;  
vasoconstriction;
- d. Control: **involuntary** = unconscious;

## CHAPTER 5: TISSUES

MUSCLE TISSUE SUMMARY TABLE (Keyed at the end 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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### V. NERVOUS TISSUE

#### A. Structure:

1. Primary cells = **neurons** which respond to changes in their surroundings (stimuli);
2. neurons are surrounded by **neuroglia** (supporting cells);

#### B. Locations:

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

#### C. Function:

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

#### D. **No reproduction** of neurons, only neuroglia can divide.

### VI. 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:**

- a. **skin;**
- b. consists of keratinized stratified squamous ET firmly attached to a thick layer of dense irregular CT.

##### 2. **Mucous Membranes** (mucosae):

- 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 mucus);
- d. consist of a layer of epithelium (varies depending upon location) firmly attached to a layer of loose areolar CT.

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### VI. EPITHELIAL MEMBRANES

#### B. Three Common Types:

3. **Serous Membranes** (serosae):
  - a. are found in closed **ventral body cavities**;
  - b. consist of two layers with a potential space (cavity) between them:
    - visceral membrane surrounds an organ;
    - 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 layer of simple squamous ET resting on a thin layer of areolar (loose) CT;
  - e. are named for the organs that occupy each cavity:
    - pleural = lungs;
    - pericardial = heart;
    - 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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**EPITHELIA SUMMARY TABLE**

<b>NAME OF ET</b>	<b>DESCRIPTION STRUCTURE</b>	<b>LOCATION</b>	<b>FUNCTION</b>	<b>TYPICAL SKETCH</b>
SIMPLE SQUAMOUS	a single layer of flattened cells	linings of air sacs, capillaries, lymph vessels, body cavities; covering ventral organs	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 intestine	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	

## CHAPTER 5: TISSUES

### CONNECTIVE TISSUE SUMMARY TABLE

NAME OF CT	DESCRIPTION	LOCATION	FUNCTION	SKETCH
<b>MESENCHYME</b>		Embryo	gives rise to all other CT's	
<b>AREOLAR</b>	gel-like matrix with fibroblasts, collagen and elastic fibers	beneath ET (serous membranes around organs & lining cavities)	diffusion, cushioning organs	
<b>ADIPOSE</b>	closely packed adipocytes with nuclei pushed to one side	beneath skin, breasts, around kidneys & eyeballs	insulation, energy store, protection	
<b>RETICULAR</b>	network of ret. fibers in loose matrix	basement membranes, lymphatic organs	Support	
<b>DENSE REGULAR</b>	dense matrix of collagen fibers	tendons, ligaments	attachment (high tensile strength)	
<b>DENSE IRREGULAR</b>	loose matrix of collagen fibers	dermis of skin	tensile strength	
<b>ELASTIC</b>	matrix of elastic fibers	lung tissue, wall of aorta	durability with stretch	
<b>HYALINE CARTILAGE</b>	chondrocytes in lacunae in amorphous matrix	embryonic. skeleton, costal cart, tip of nose, trachea, larynx	support	
<b>FIBRO-CARTILAGE</b>	less firm than above	intervertebral discs, pubic symphysis	tensile strength, shock absorber	
<b>ELASTIC CARTILAGE</b>	above plus elastic fibers	external ear, epiglottis	shape maintenance plus flexibility	
<b>BONE</b>	concentric circles of calcified matrix	Bones	support, protection, movement, Ca <sup>++</sup> store, hematopoiesis	
<b>BLOOD</b>	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**

<b>NAME OF MUSCLE TISSUE</b>	<b>DESCRIPTION OF STRUCTURE</b>	<b>TYPE OF CONTROL</b>	<b>LOCATION</b>	<b>FUNCTION</b>	<b>SKETCH</b>
<b>SKELETAL MUSCLE</b>	long, thin fibers with many nuclei and striations	Voluntary	attached to bones	to move bones	
<b>SMOOTH MUSCLE</b>	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.	
<b>CARDIAC MUSCLE</b>	a network of striated cells with one centrally located nucleus attached by intercalated discs	Involuntary	heart	pump blood to lungs and body	