

# INTRODUCTION TO HISTOLOGY

- Histology: study about the **structure of tissues** by aid of **microscope**.
- **What is significance of histology??**
  - When tissues malfunction, e.g. in certain disease states such as cancer or inflammation, there are often specific changes in the microscopic structure of the tissues.
    - The study of these changes is known as histopathology.
  - So, a sound knowledge of normal structure is essential for an understanding of pathology.

# HISTOLOGY

## Tissue :

- a group of cells and their products, with similar function.
- Cells + ECM

There are 4 types:

❖ Epithelial tissue

❖ Connective tissue

❖ Muscle tissue

❖ Nervous tissue

## Epi- tissue

- are originated from primary germ layers of embryo: endoderm, mesoderm and ectoderm

# EPITHELIAL TISSUE

## Functions:

- Protection: skin(protects mechanical/ chemical/bacterial)
- Absorption: digestive tract
- Filtration: kidneys(also do protection and absorption)
- Motion( movement): egg, zygote, mucous from upper respiratory tract move by aid of epithelial cells surface modification
- Secretion: specialty of glands

# Properties of ET

## Cellularity:

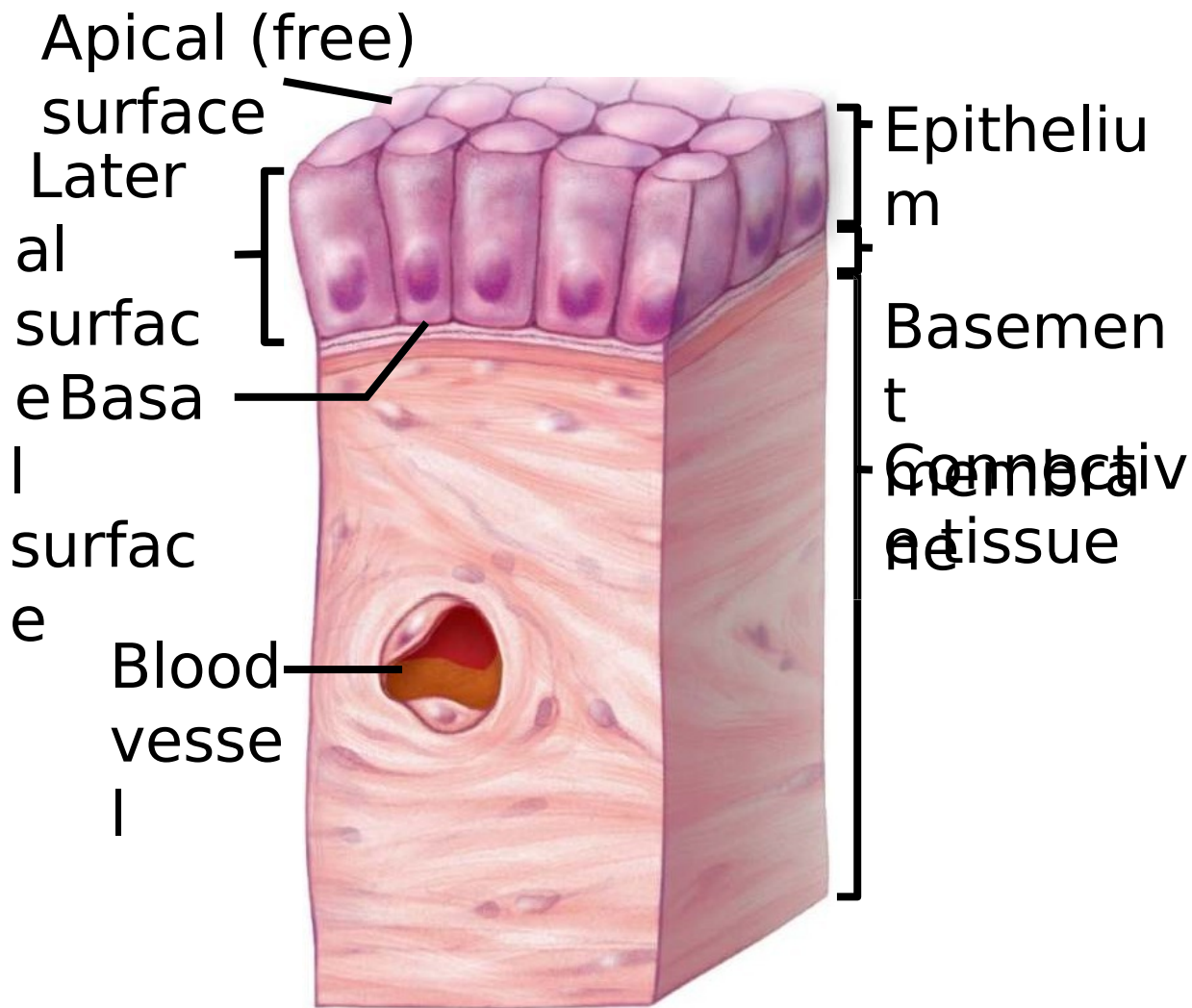
- Composed almost entirely of cells (closely packed).
- No gap b/n the cells and with little ECM
- Epithelial cells are arranged in continuous sheets, in single or multiple layers
- Cell junctions are located at lateral surface of epi-cells, that provide secure attachments among cells.

## Free apical surface:

- Portion of epithelium exposed to the **body exterior or the cavity of an internal organ**
- Some exposed surfaces are smooth, others exhibit modifications such as microvilli or cilia

# Properties of ET

- ❖ Cells **fit closely** together and connected with each other by **d/t cell** junction. No gap b/n adjacent(next) cells, due to this it has too little ECM.
- ❖ It **rests** on a **basement** membrane
- ❖ Epithelial cells are highly **regenerative** cells.
- ❖ It is **a vascular** (no blood and lymph vessels ).
  - ❖ It receives **nutrition** by **diffusion** from the underlying CT.
- ❖ Epithelial tissue is highly **innervated(sensory nerve supply)**.



## Epithelium-connective tissue junction

# Classification of Epithelium

- Classified into 2 based on:-

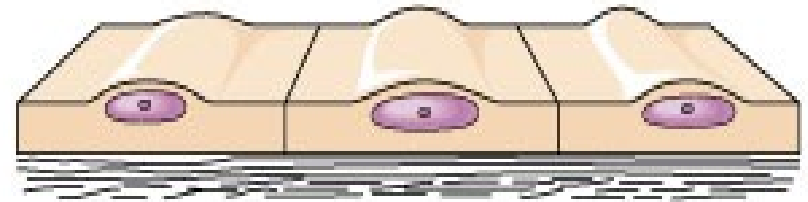
## 1. Number of cell layers(2)

☐ **Simple** – one layer.

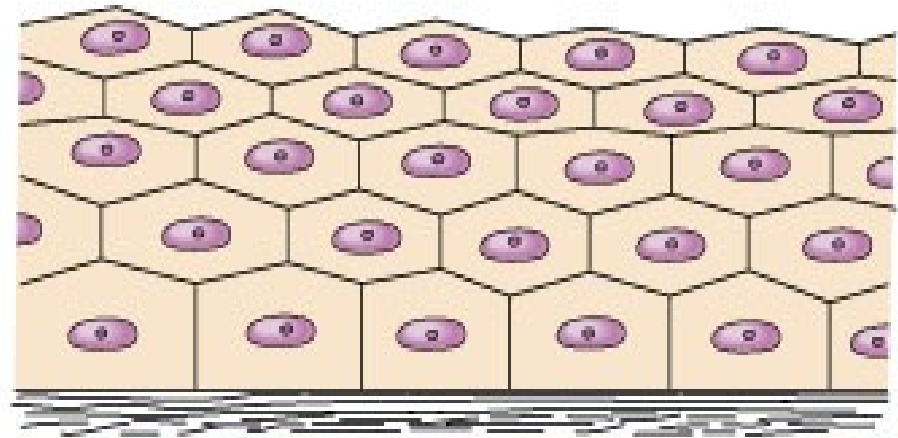
- ✓ All cells arise from basal surface

☐ **Stratified** – more than one layer.

- ✓ It named based on the top of cells but not based on the bottom of cells b/c all cells are not arise from basal surface



Simple

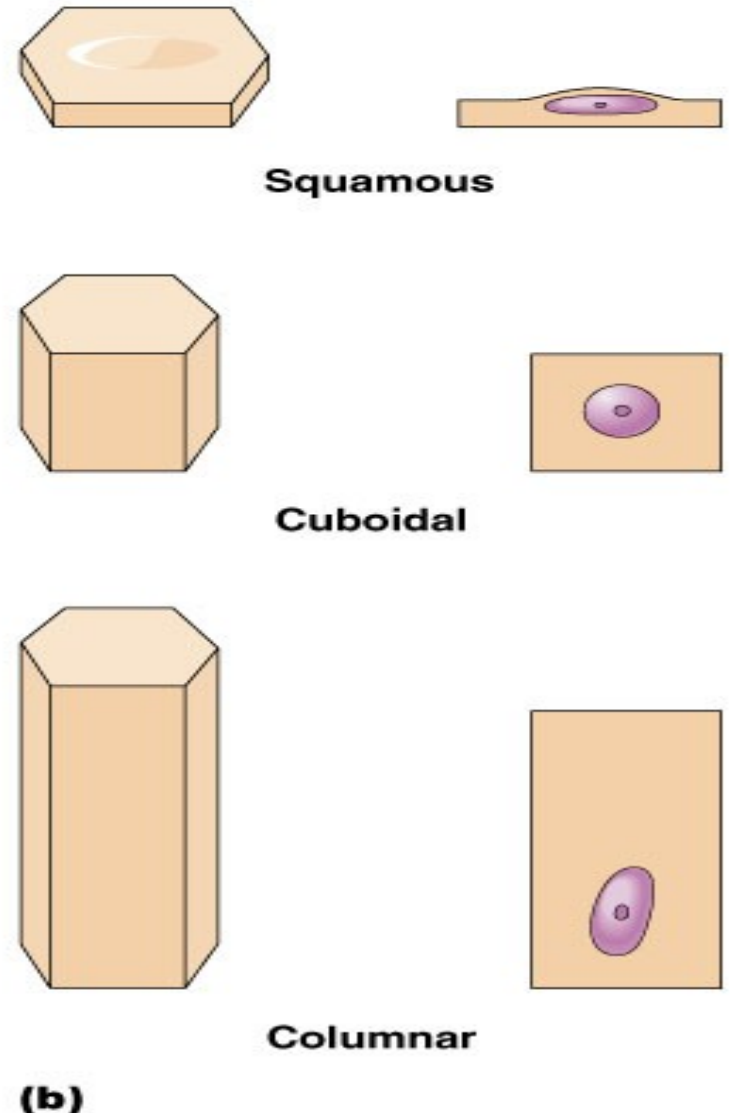


Stratified

(a)

## 2. Shape of cells(3)

- ❑ Squamous – flattened and thin
- ❑ Cuboidal – cube-shaped
  - approximately: length=width
  - nucleus located at center
- ❑ Columnar – column-like
  - length>width
  - nucleus at bottom



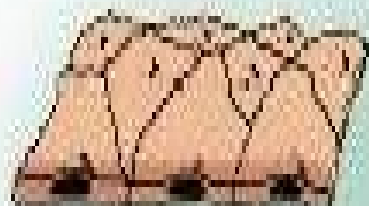
## **A- Simple epithelium**

- i. Simple squamous epith.
- ii. Simple cuboidal epith.
- iii. Simple columnar epith.
- iv. Pseudo stratified columnar epith.

## **B- Stratified**

- epithelium**
- i-Stratified squamous epith.
  - ii- Stratified cuboidal epith.
  - iii- Stratified columnar epith.
  - iv- Transitional epith.

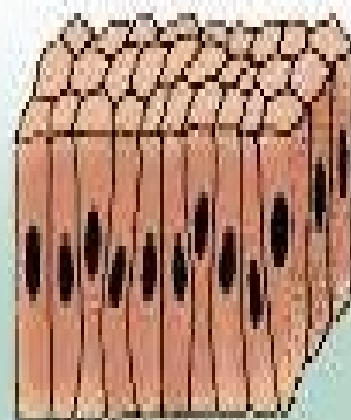
# Types of Epithelium



Simple squamous

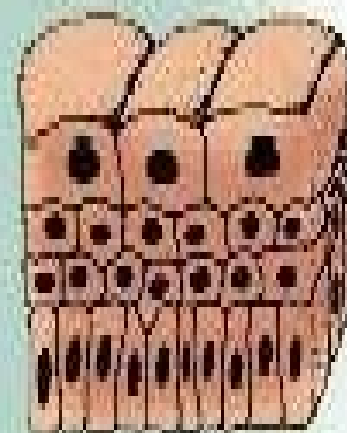
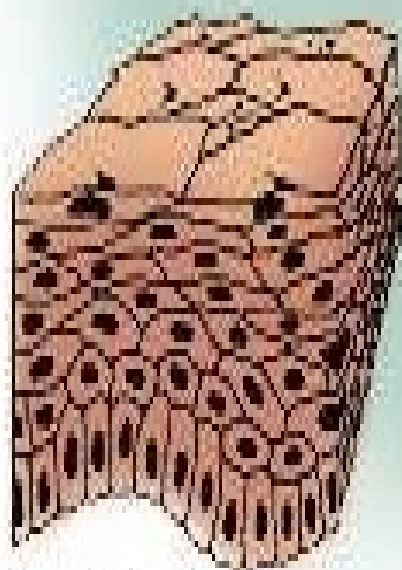


Simple cuboidal

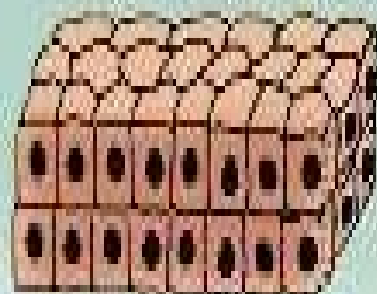


Simple columnar

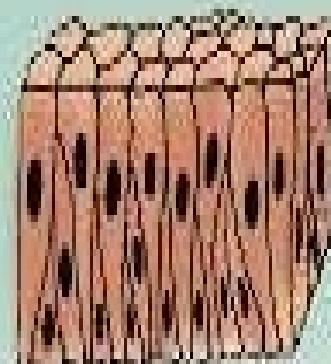
Transitional



Stratified squamous



Stratified cuboidal



Pseudostratified columnar

# EPITHELIAL TISSUE

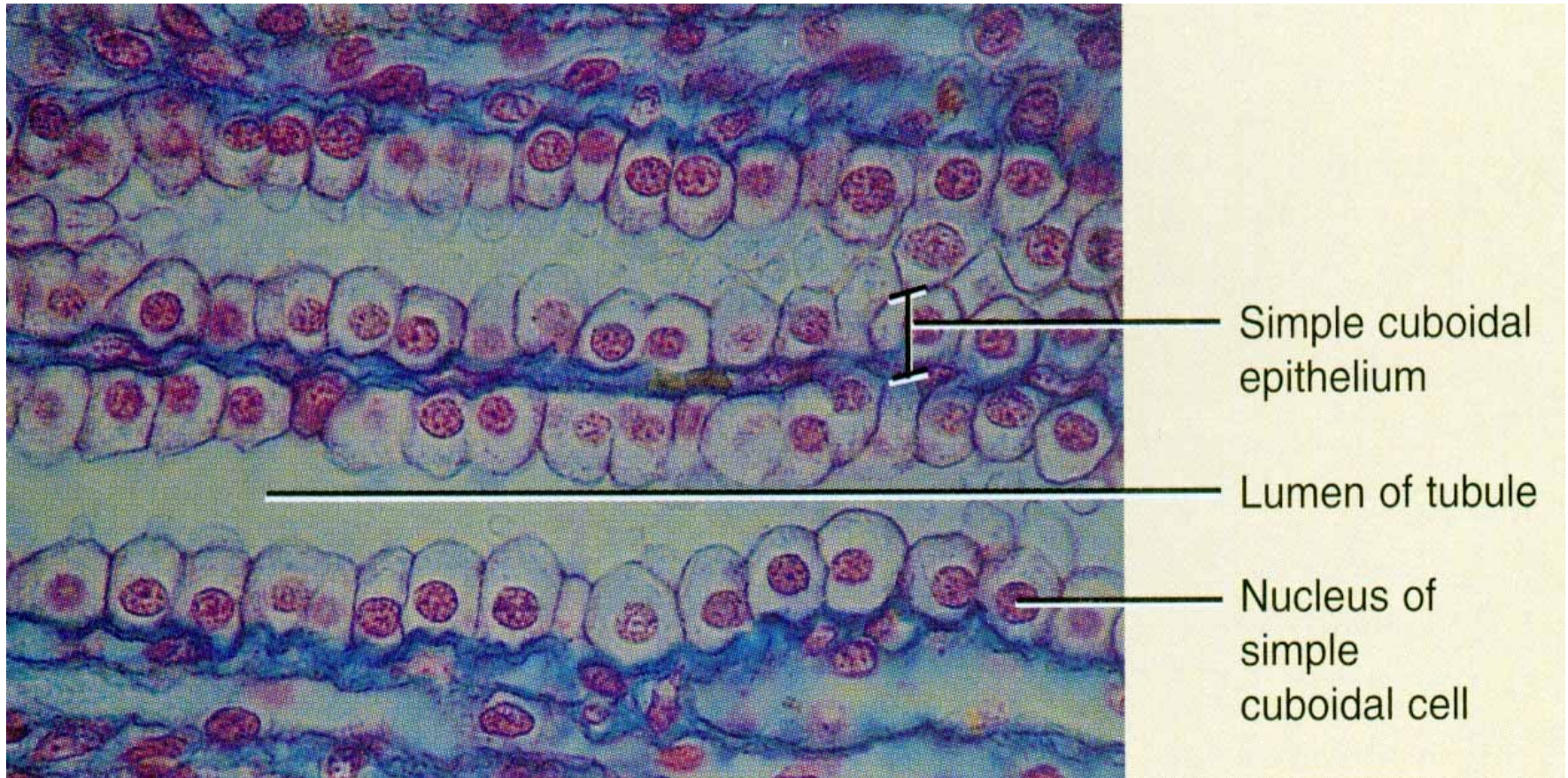
## Simple squamous

- Substance pass easily through them
- simple squamous epi-: lines blood vessels, lymphatic and heart called endothelium and body cavities called mesothelium.
- Also found in alveoli of lung, part of nephron of kidney.
- Function: diffusion, filtration, and secretion

## Simple cuboidal

- Common in glands and their ducts
- Lines walls of kidney tubules, Covers the ovaries and Pancreas
- **Function:** secretion & absorption

# Example of simple cuboidal

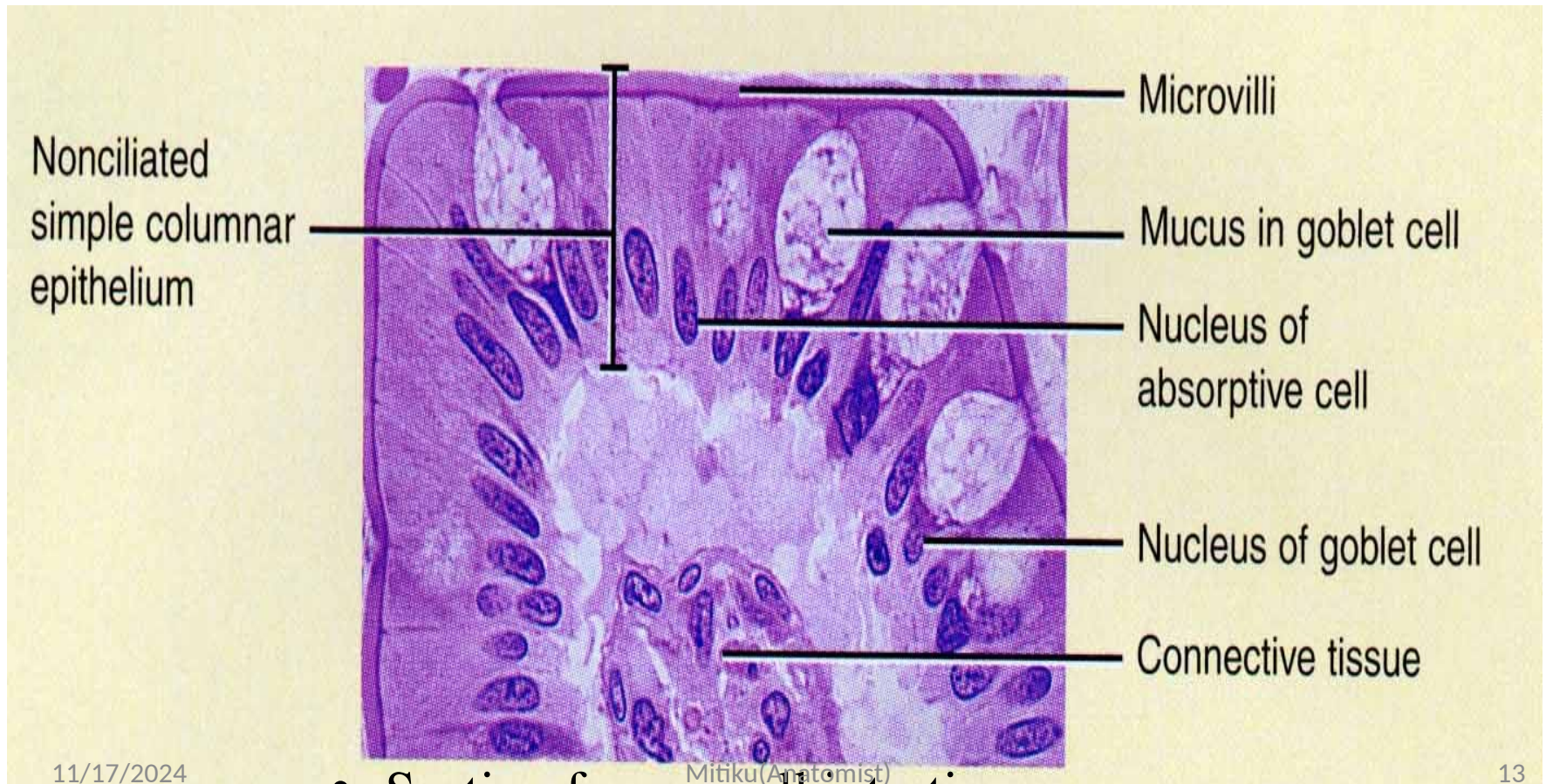


- Sectional view of kidney tubules

# EPITHELIAL TISSUE

## Simple columnar ( non ciliated)

- Often includes goblet cells, which produce mucous
- Lines digestive tract and used for **secretion**

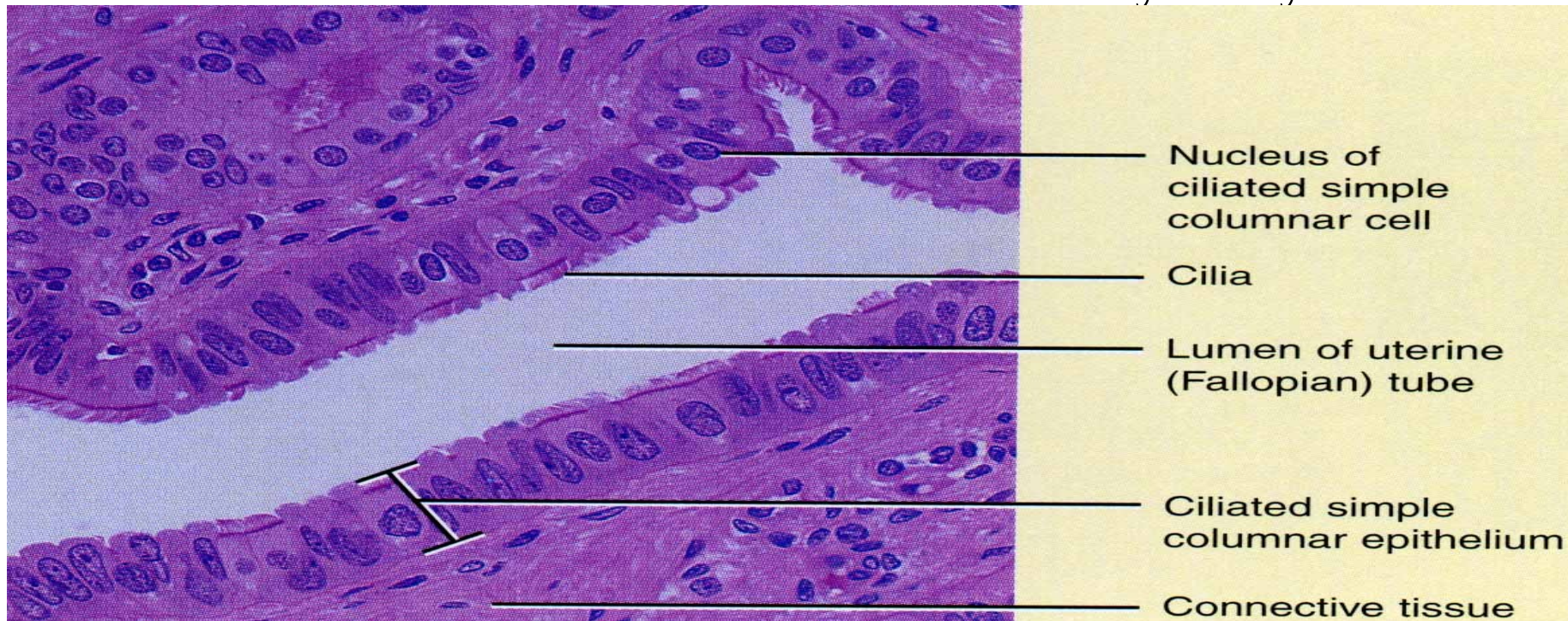


- Section from small intestine

# EPITHELIAL TISSUE

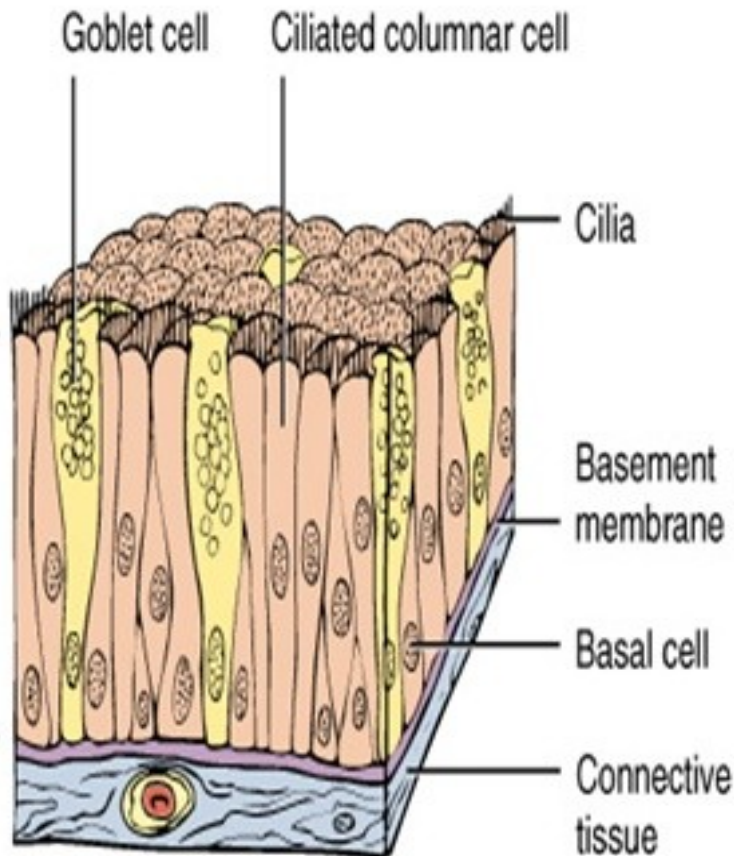
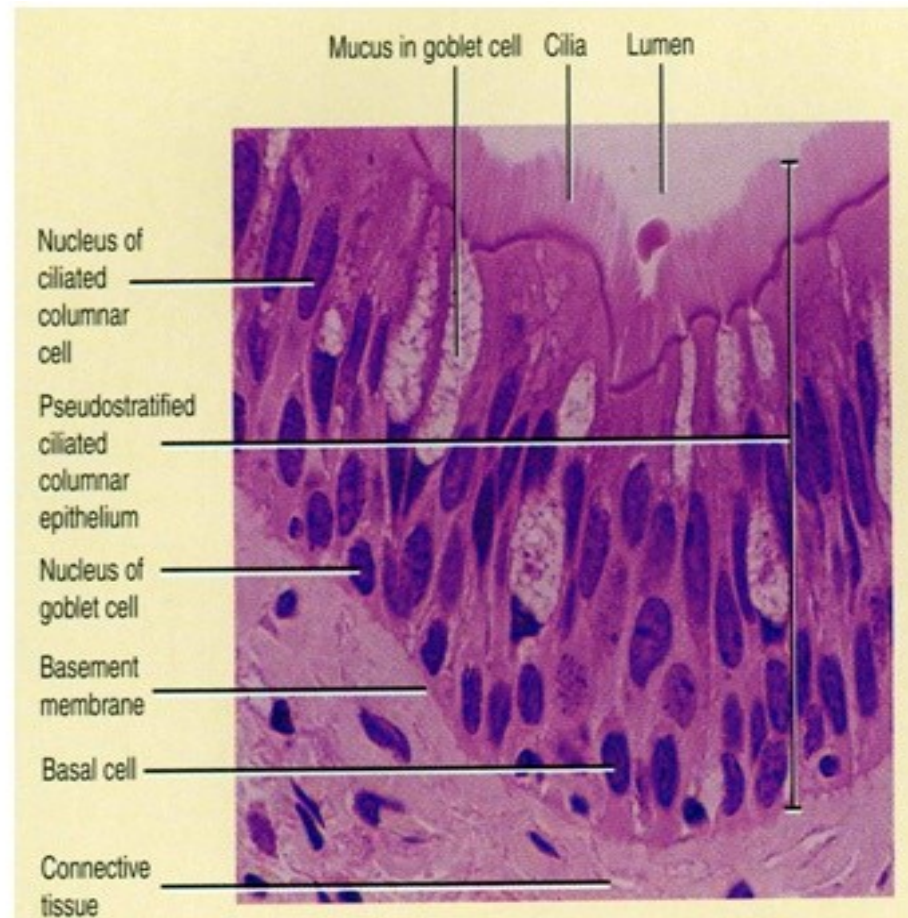
## Simple columnar (ciliated)

- The nucleus at the base
- It may contain the mucus
- Location : upper respiratory tract, uterine tube ,uterus
- Function : **movement** of mucus and other substances by ciliary action



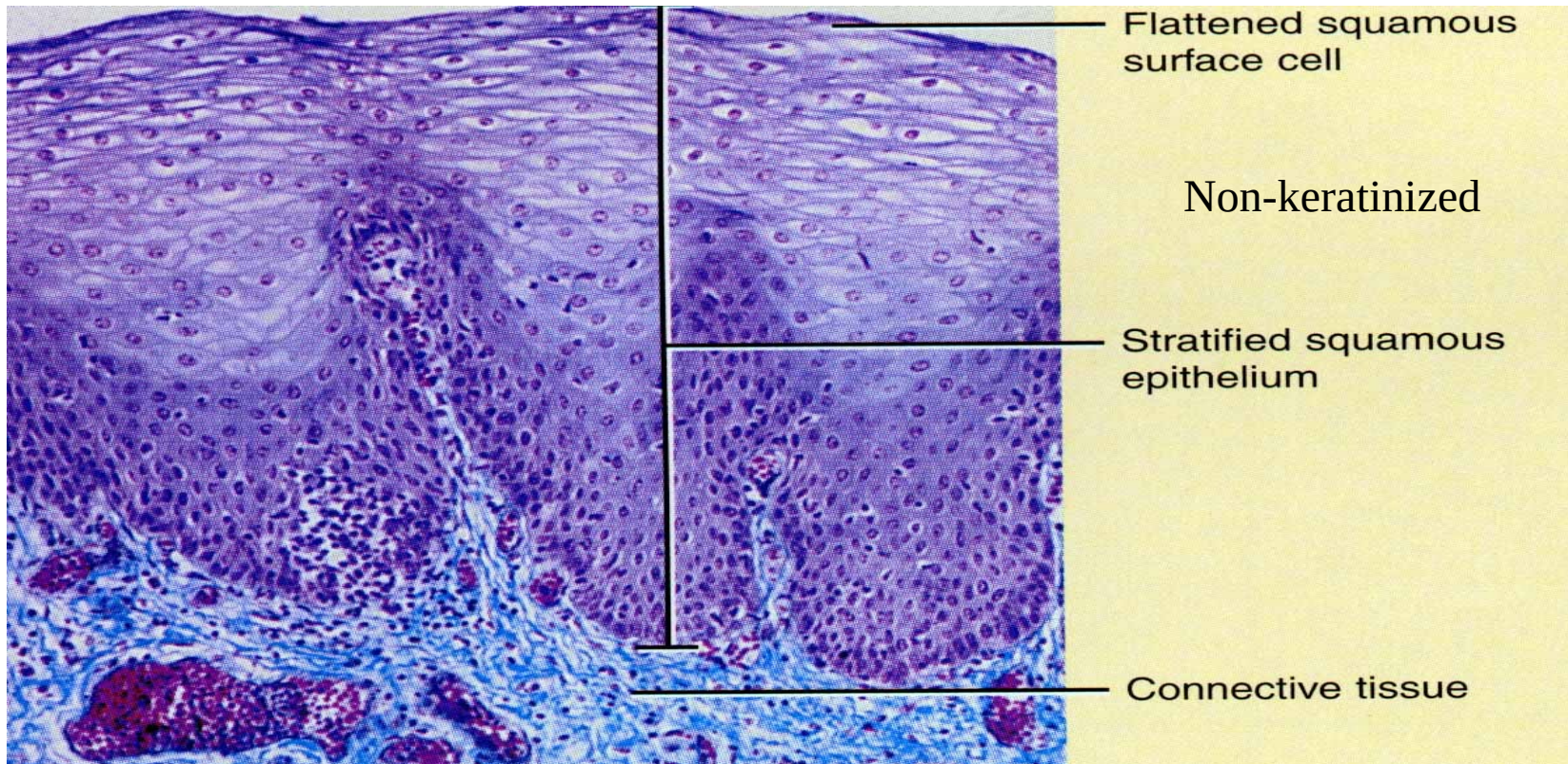
## Pseudostratified columnar(ciliated)

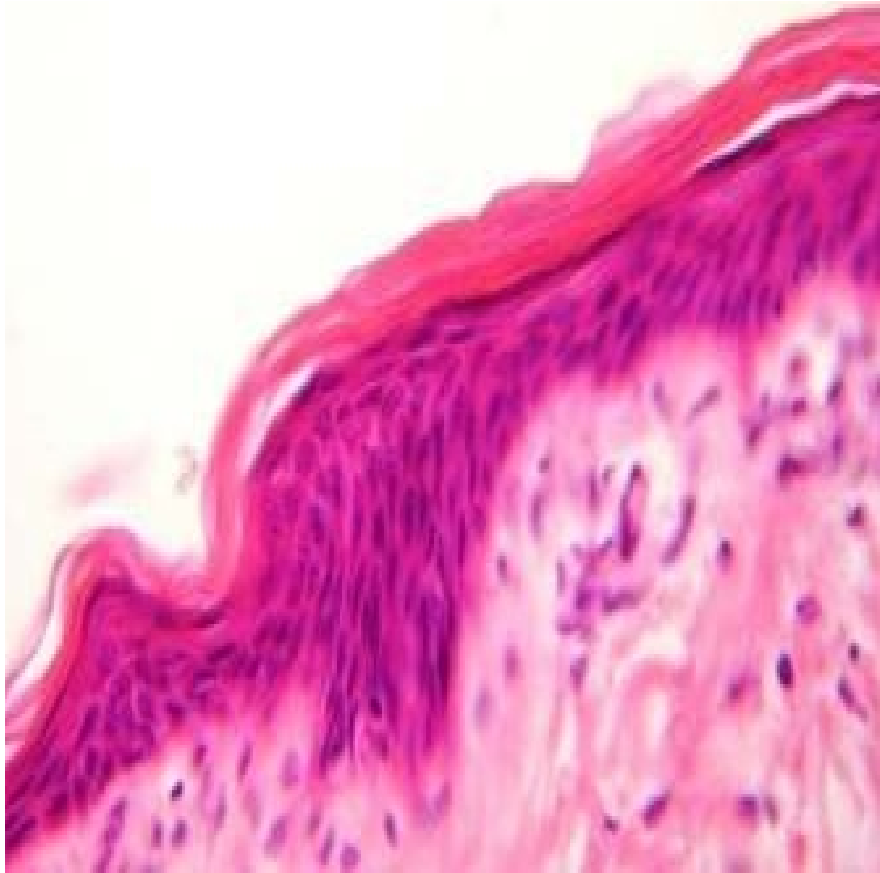
- Single cell layer
- All cells attach to basement membrane but not all reach free surface, nucleus at d/t level w/c make false strata
- Respiratory system, male urethra & epididymis



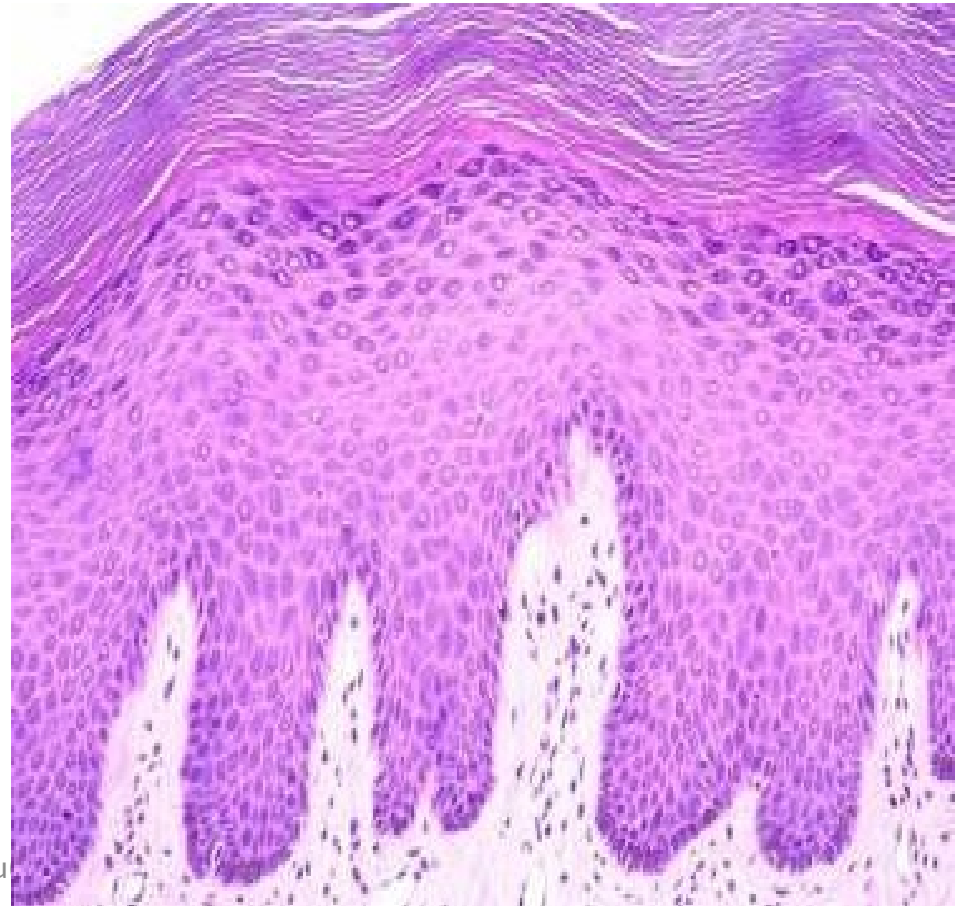
# Stratified squamous

- Found as a protective covering where friction is common . Divide in to keratinized = surface cells dead and filled with keratin in skin (epidermis) and nonkeratinized = no keratin in moist living cells at surface- in mouth, vagina, Esophagus
- Function: protection





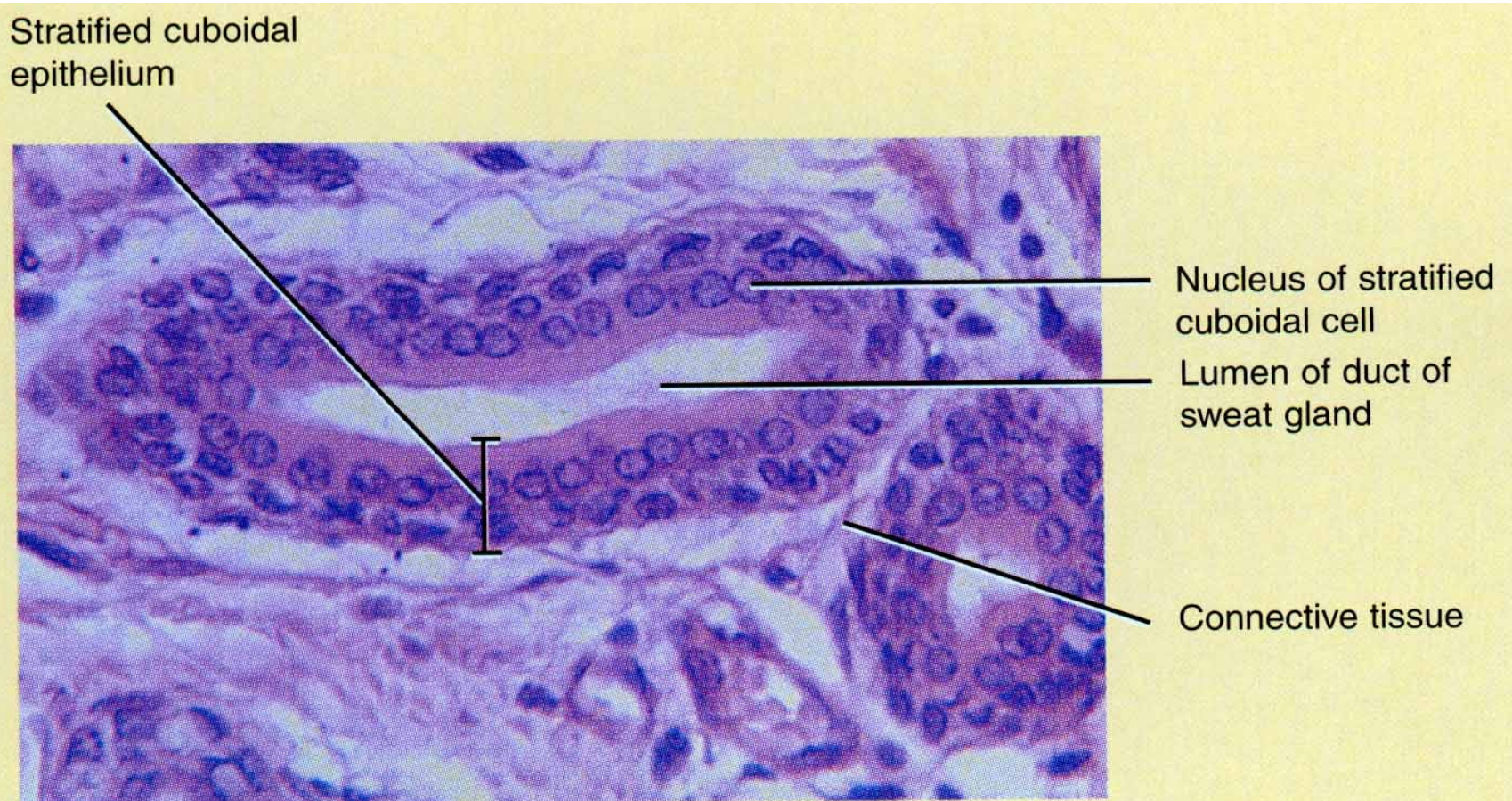
**Keratinized**



# EPITHELIAL TISSUE

## Stratified cuboidal

- Location: Largest ducts of sweat glands, mammary glands, and salivary glands.
- Function: protection and limited secretion



# EPITHELIAL TISSUE

## Stratified columnar

- basal cells usually cuboidal; superficial cells elongated and columnar.
- Location: Rare in the body; small amounts in male urethra and in large ducts of some glands.
- Function: Protection; rare secretion

## Transitional Epithelium called urothelium

- Surface cells varying in shape from round to flat if stretched
- Lines hollow organs that expand from within (urinary bladder, ureter and urethra)
- Function distension

# EPITHELIAL TISSUE

## Glandular Epithelium

- Form the glands of the body
- Usually found deep to the covering and lining epithelium
- Two types
  - ✓ Endocrine glandular epithelium
  - ✓ Exocrine glandular epithelium

# EPITHELIAL TISSUE

## Endocrine glandular epithelium

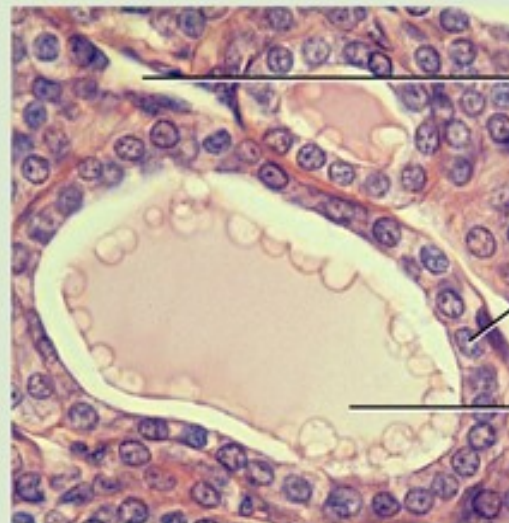
- Ductless and secrete hormones into the bloodstream
- Hormones diffuse into blood after passing through interstitial fluid

### H. Endocrine Glands

*Description:* Secretory products (hormones) diffuse into blood after passing through interstitial fluid.

*Locations:* Examples include pituitary gland, thyroid gland, adrenal gland, pancreas, ovaries, testes.

*Function:* Produce hormones that regulate various body activities.

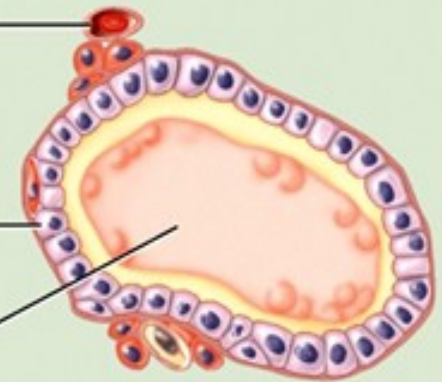


LM 500x

Blood vessel

Hormone-producing  
(epithelial) cell

Stored precursor  
of hormone



Endocrine gland  
(thyroid gland)

# EPITHELIAL TISSUE

## Exocrine glandular epithelium

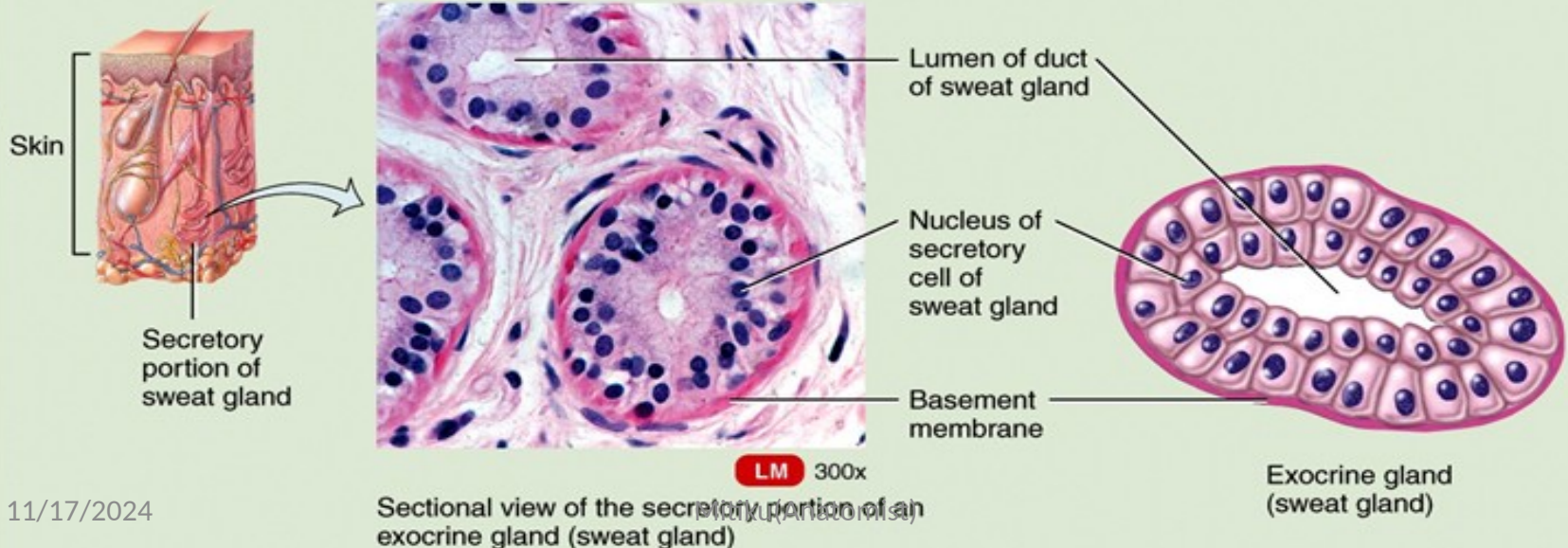
- Have ducts, connected to the epithelial surface by tubes (ducts)
- Include sweat and oil glands, salivary glands, liver, pancreas, mammary glands, mucous glands, etc.
- Secrete---sweat, ear wax, saliva, digestive enzymes onto free surface of epithelial layer

### I. Exocrine Glands

*Description:* Secretory products released into ducts.

*Locations:* Sweat, oil, and earwax glands of the skin; salivary glands, which secrete into mouth cavity; and pancreas, which secretes into the small intestine.

*Function:* Produce substances such as sweat, oil, earwax, saliva, or digestive enzymes.



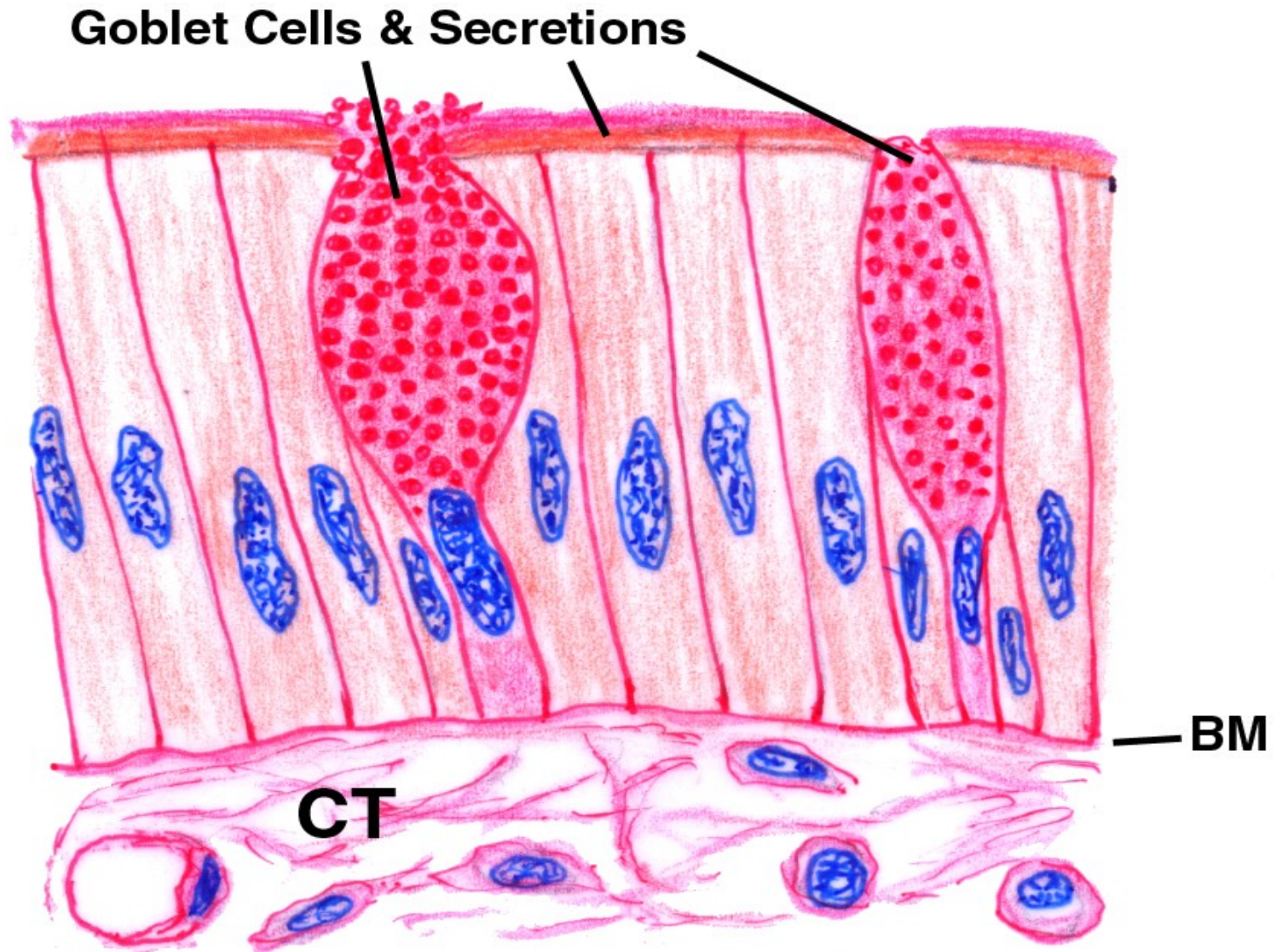
# EPITHELIAL TISSUE

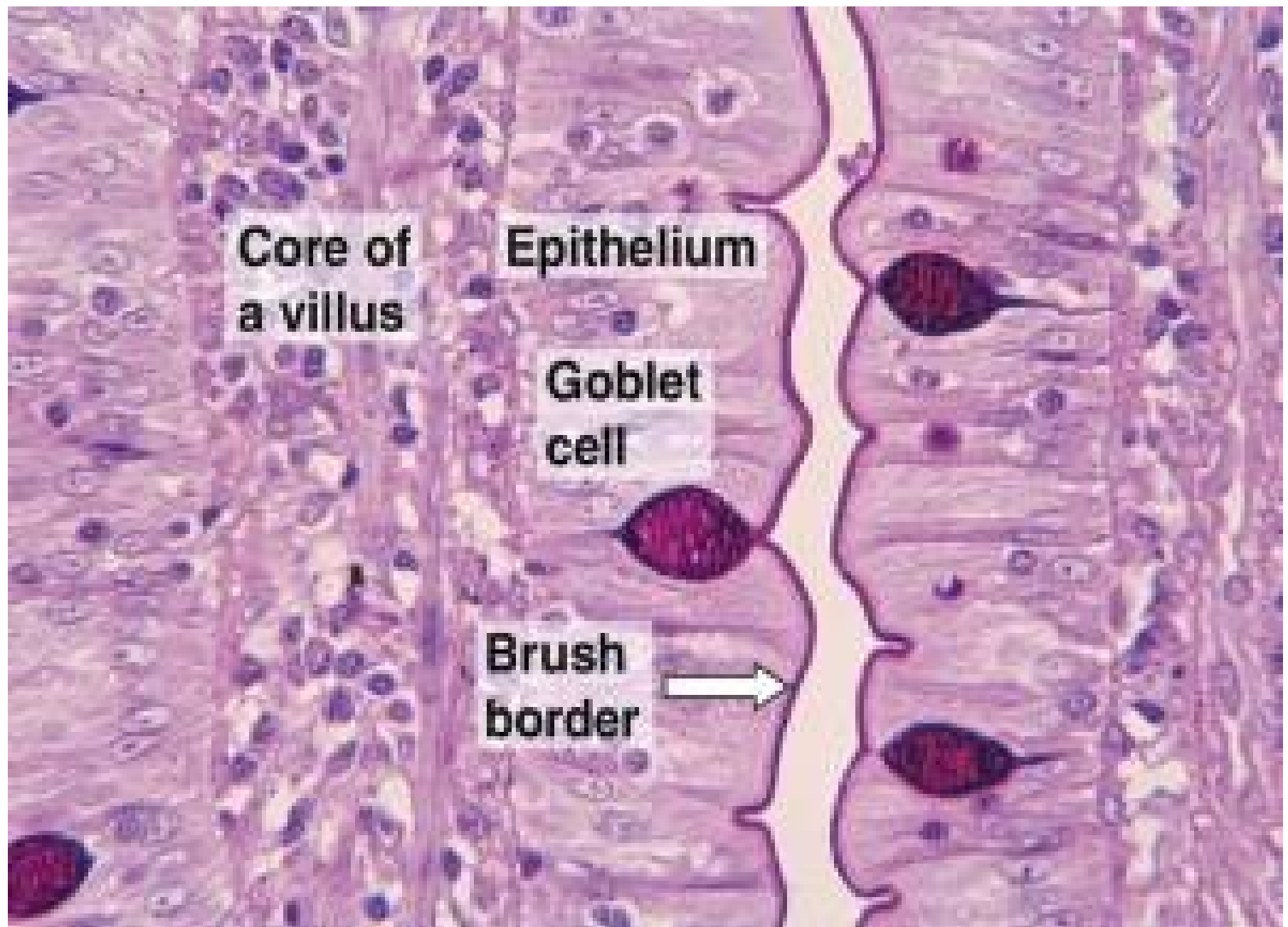
## Classification of Exocrine Glands

### Based on the numbers of cells:

- Unicellular- secrete mucous
- ✓ Found on digestive tract and portion of respiratory tract  
e.g. goblet cells
- Multicellular- form clusters of cells. e. g. Sweat and salivary gland

# EPITHELIAL TISSUE





## **According to the shape of secretory part and branching of ducts:**

### **1 Simple gland (single duct and unbranched end-pieces):**

- Simple **tubular** as the **intestinal** glands.
- Simple **alveolar** as **sebaceous** gland.
- Simple **tubulo-alveolar** as small **salivary** glands.
- Simple **coiled** tubular as **sweat** gland.

### **2- Branched glands (single duct and branched end-pieces):**

- Branched **tubular** as **gastric** glands.
- Branched **alveolar** as **tarsal** glands.
- Branched **tubulo-alveolar/acinar** as **prostate**.

Alvolar = acinar : part of gland is flask shape

Tubular – part of gland is straight

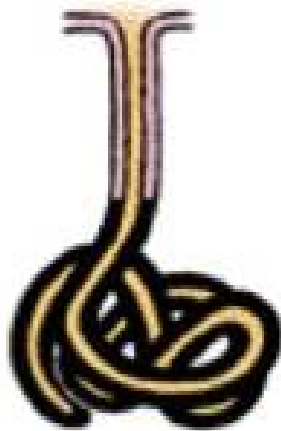
# EPITHELIAL TISSUE

Based on structure of the duct system:

- Simple and compound



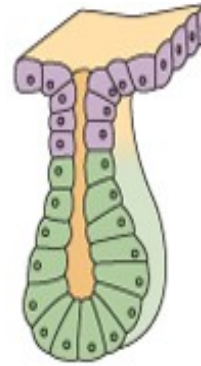
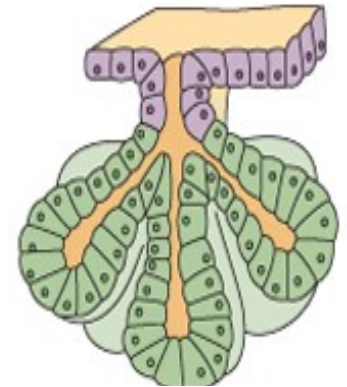
Simple tubular



Simple coiled tubular



Simple branched tubular



Simple branched acinar

### 3- Compound glands (branched duct and branched end-pieces):

- Compound **tubular** as **kidney** and **liver**.
- Compound **alveolar/acinar** as **mammary** gland.
- Compound **tubulo-alveolar** as **pancreas**.

**End pieces:** secretory portion of gland.

**Duct part:** carry out secreted product.

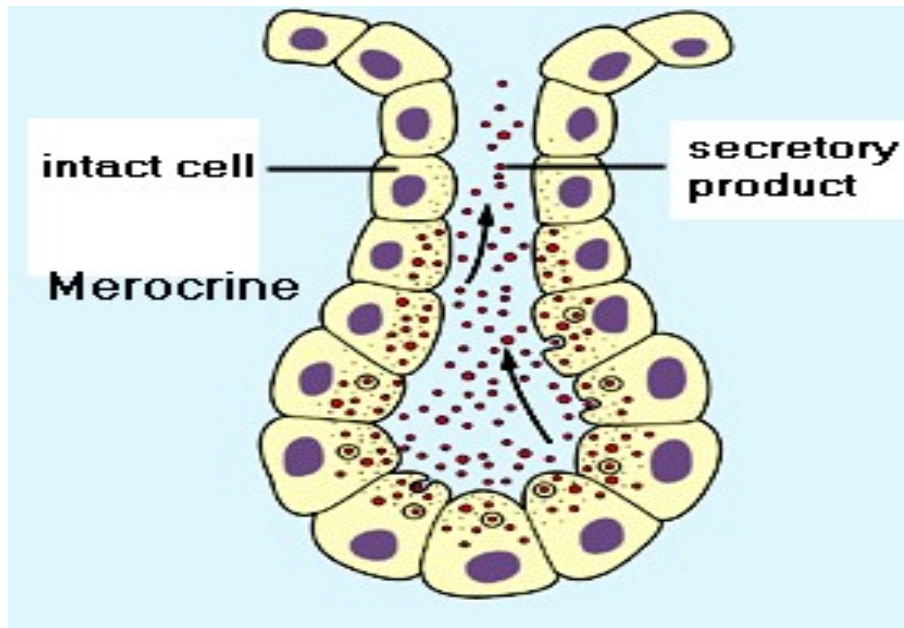
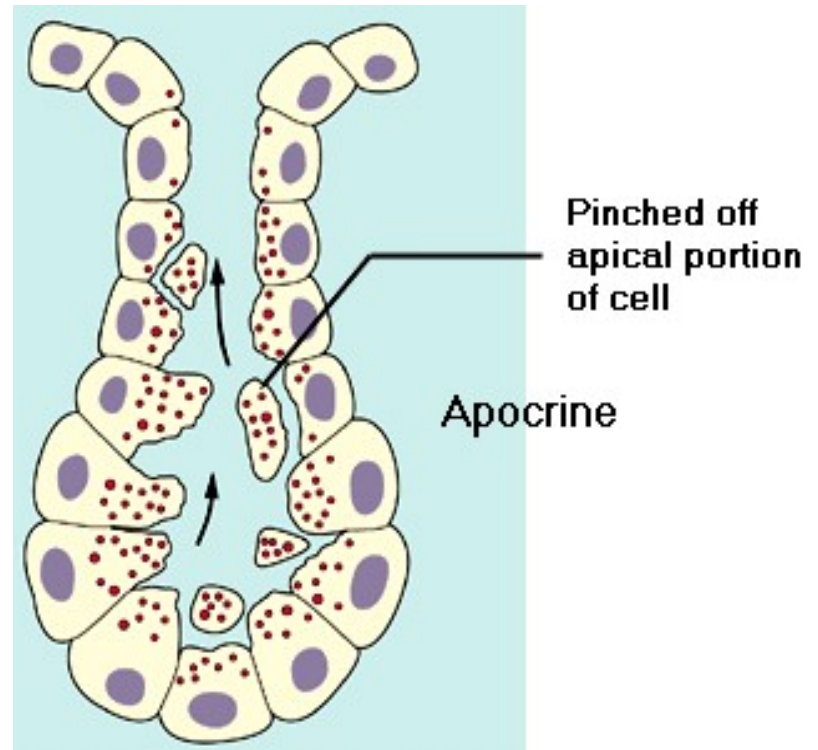
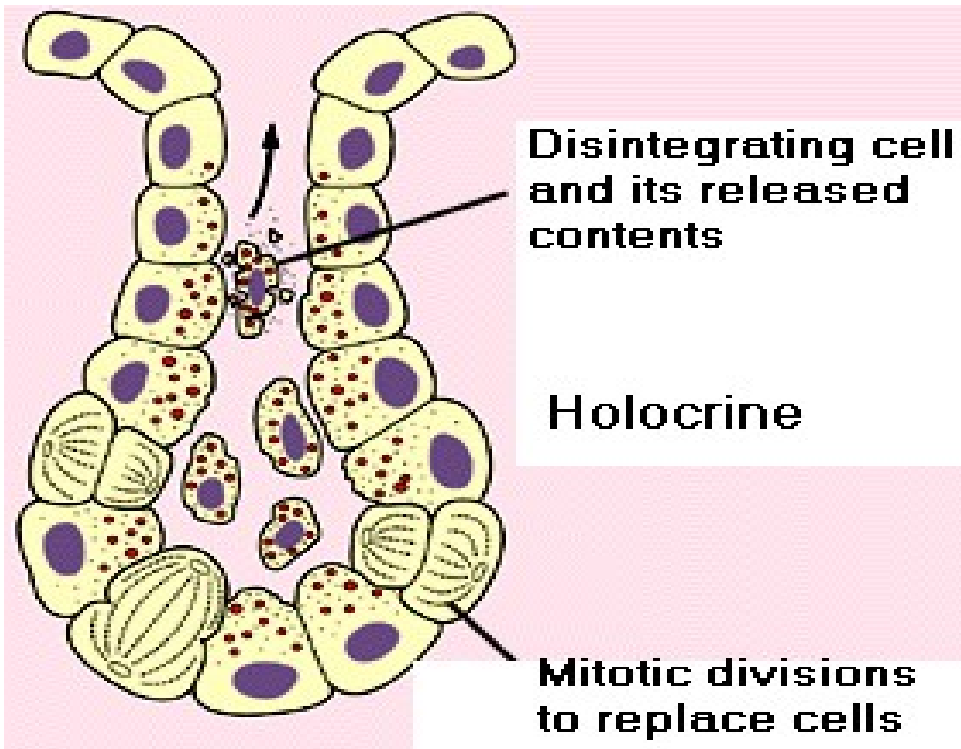
# EPITHELIAL TISSUE

**Based on the mechanism /way of secretion:**

**Apocrine:** Secretions discharged with part of apical cytoplasm  
E.g. mammary glands

**Holocrine :** Secretion is shed with the whole cell (cell lysis)  
– entire secretory cell & with its content is released  
E.g. sebaceous gland

**Merocrine :** Secretions leave the cell by exocytosis  
- Most exocrine glands are merocrine  
E.g. salivary glands, pancreas, parotid



# EPITHELIAL TISSUE

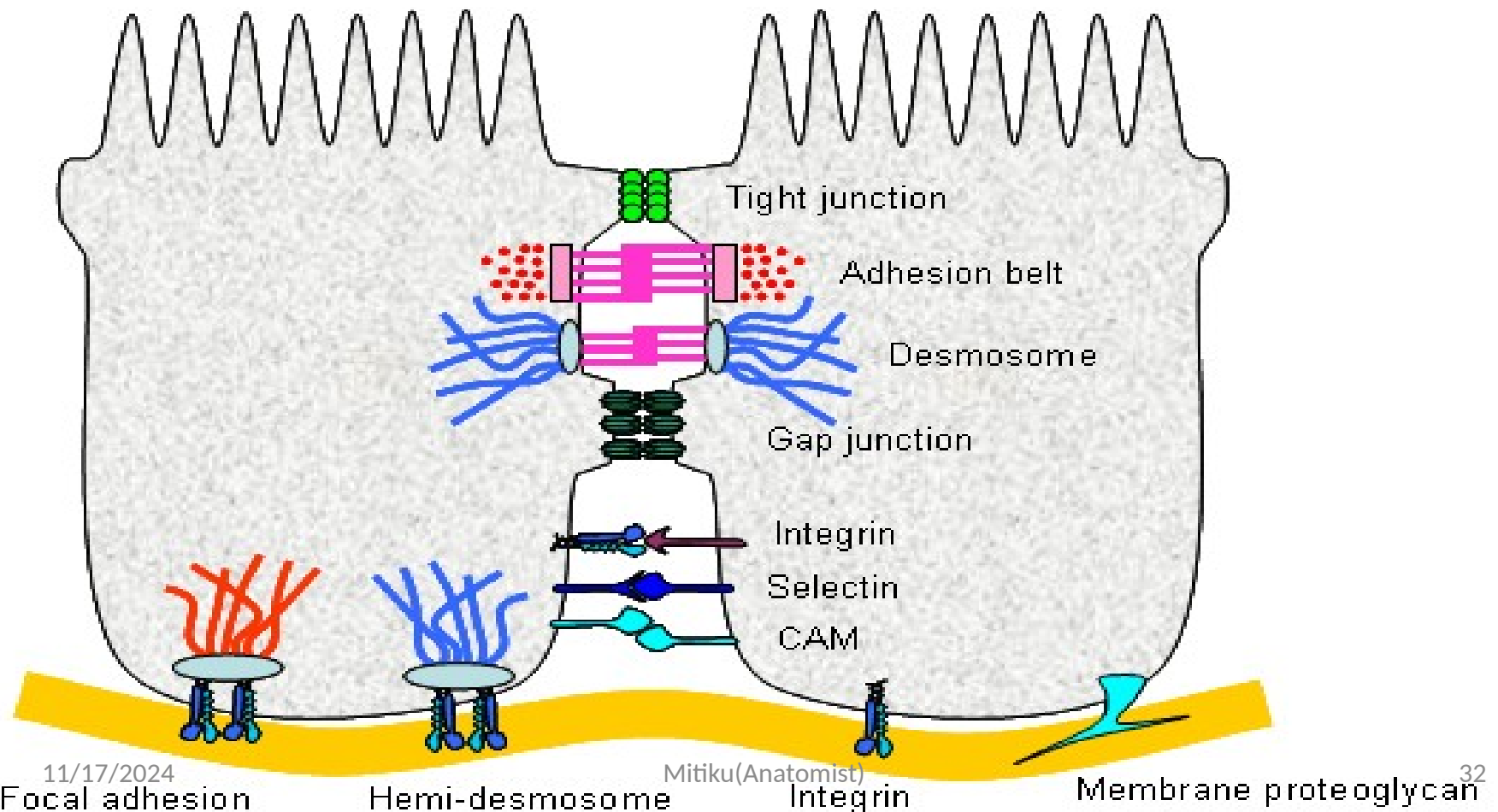
## Based on nature of secretion:

- ✓ Mucous-thick jelly like secretion e.g. goblet cell
- ✓ Serous secretion-water rich enzyme, e.g. salivary ,parotid gland and lacrimal gland

# EPITHELIAL TISSUE

## Epithelial surface specialization:

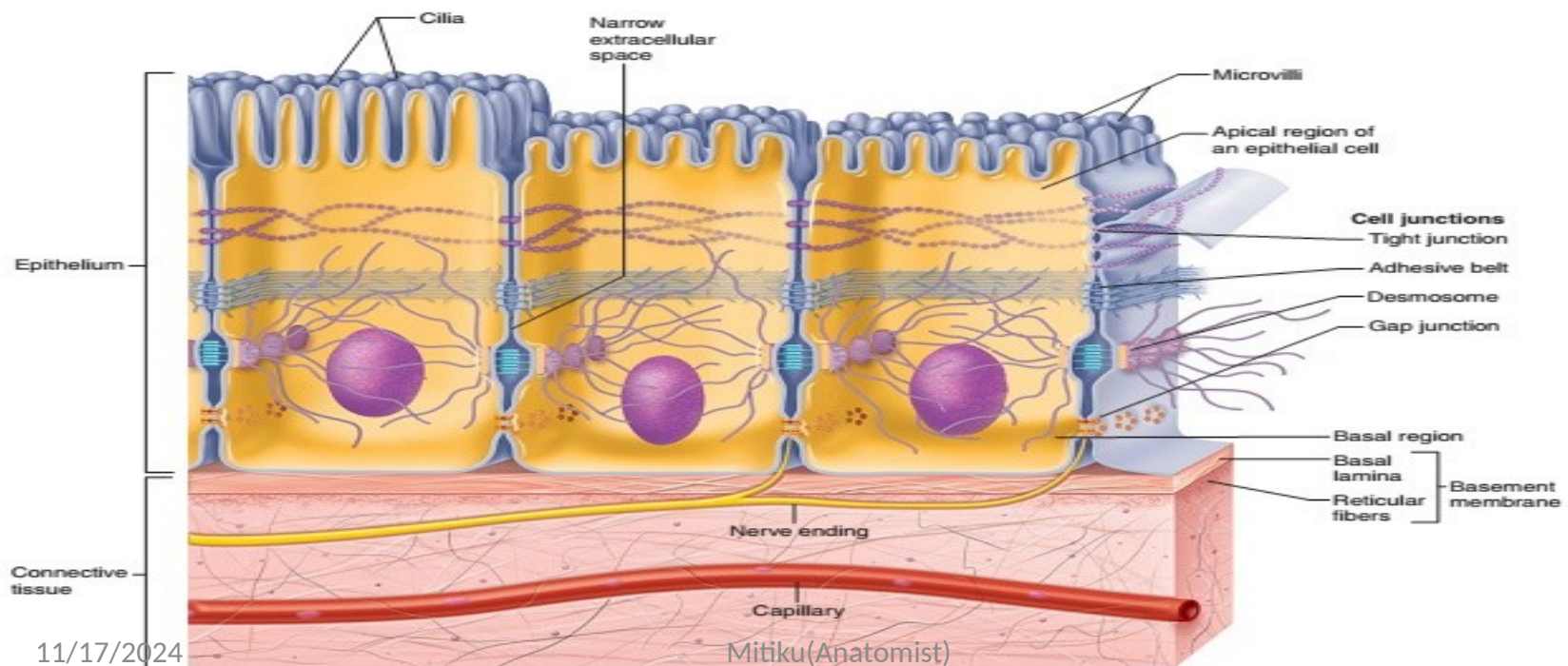
- Shows different modification on their apical, lateral and basal surface



# EPITHELIAL TISSUE

**Lateral surface:** modified into intercellular junctions

- ✓ Tight Junctions(zonula Occludens)
- ✓ Adhesive Belt Junctions(zonula adherens)
- ✓ Macula adherens(desmosome)
- ✓ Gap Junctions(nexus)

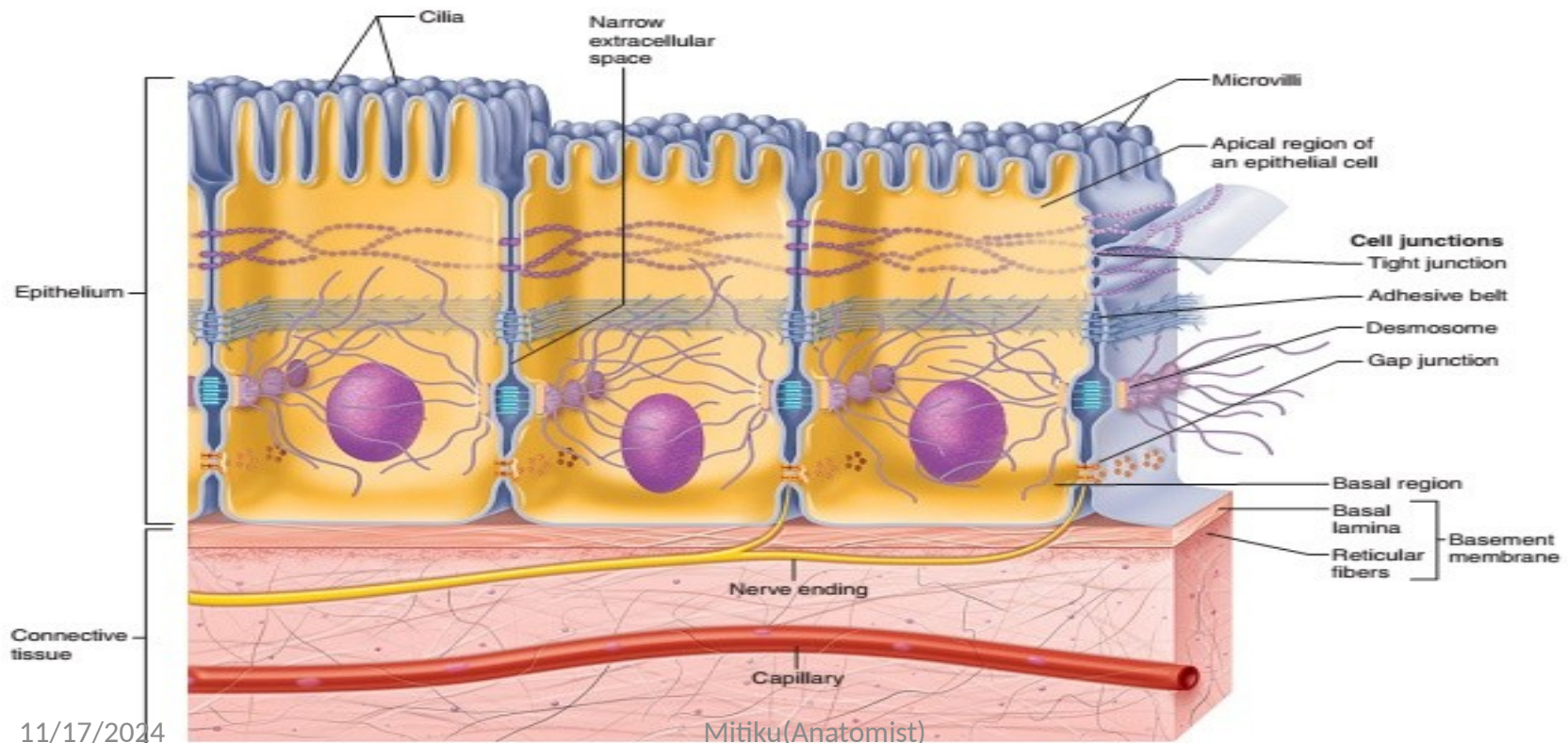


Special characteristics of epithelium.

# EPITHELIAL TISSUE

## Tight Junctions(zonula Occludens)

- In the apical region.
- Close the adjacent cells
  - ✓ prevent molecules from passing between the cells of epithelial tissue.

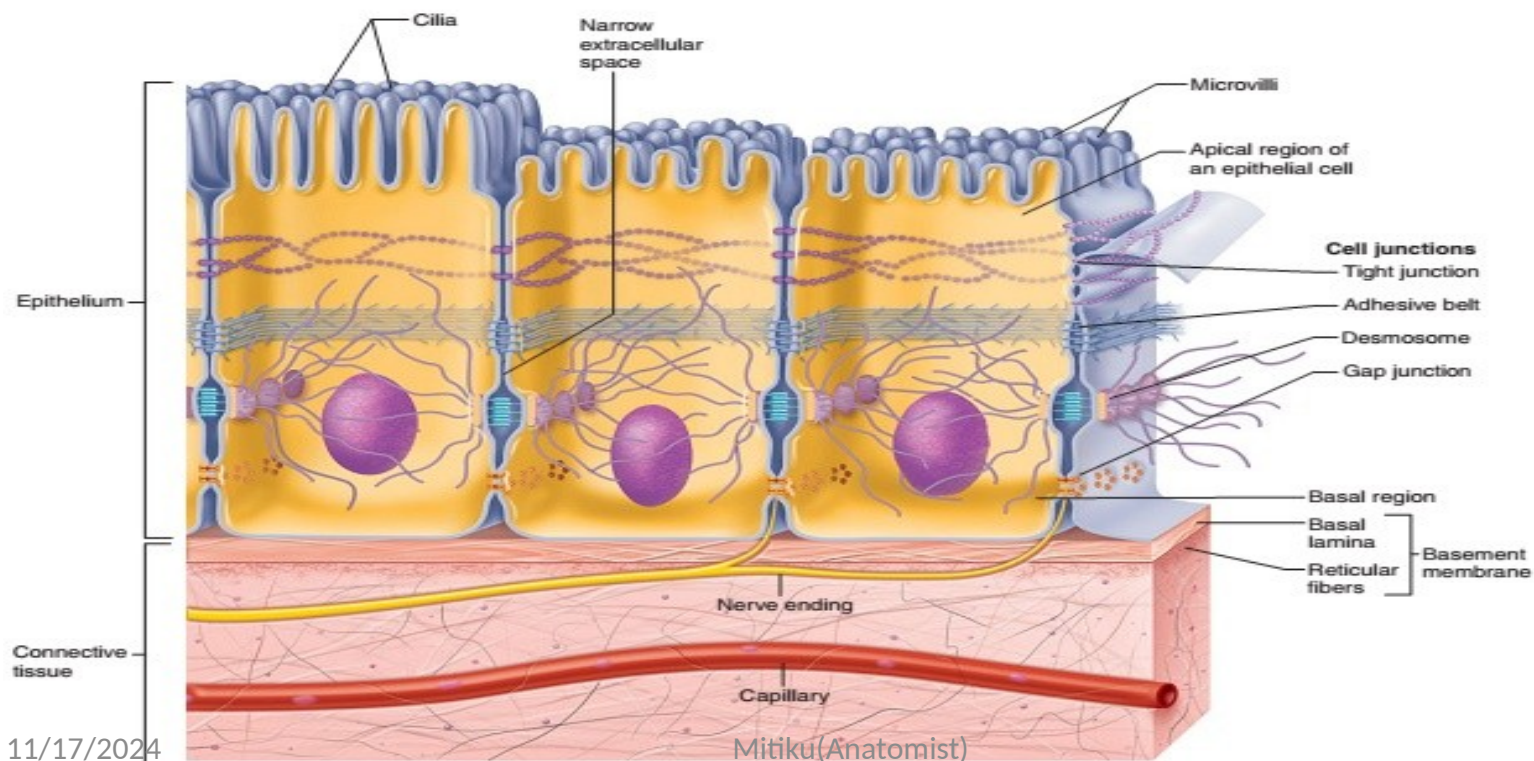


Special characteristics of epithelium.

# EPITHELIAL TISSUE

## Adhesive Belt Junctions(zonula adherens)

- Just below the tight junctions
- Mainly by microfillament and it stabilize tissue
- The opposing plasma membranes are separated by a gap of 20 nm wide.

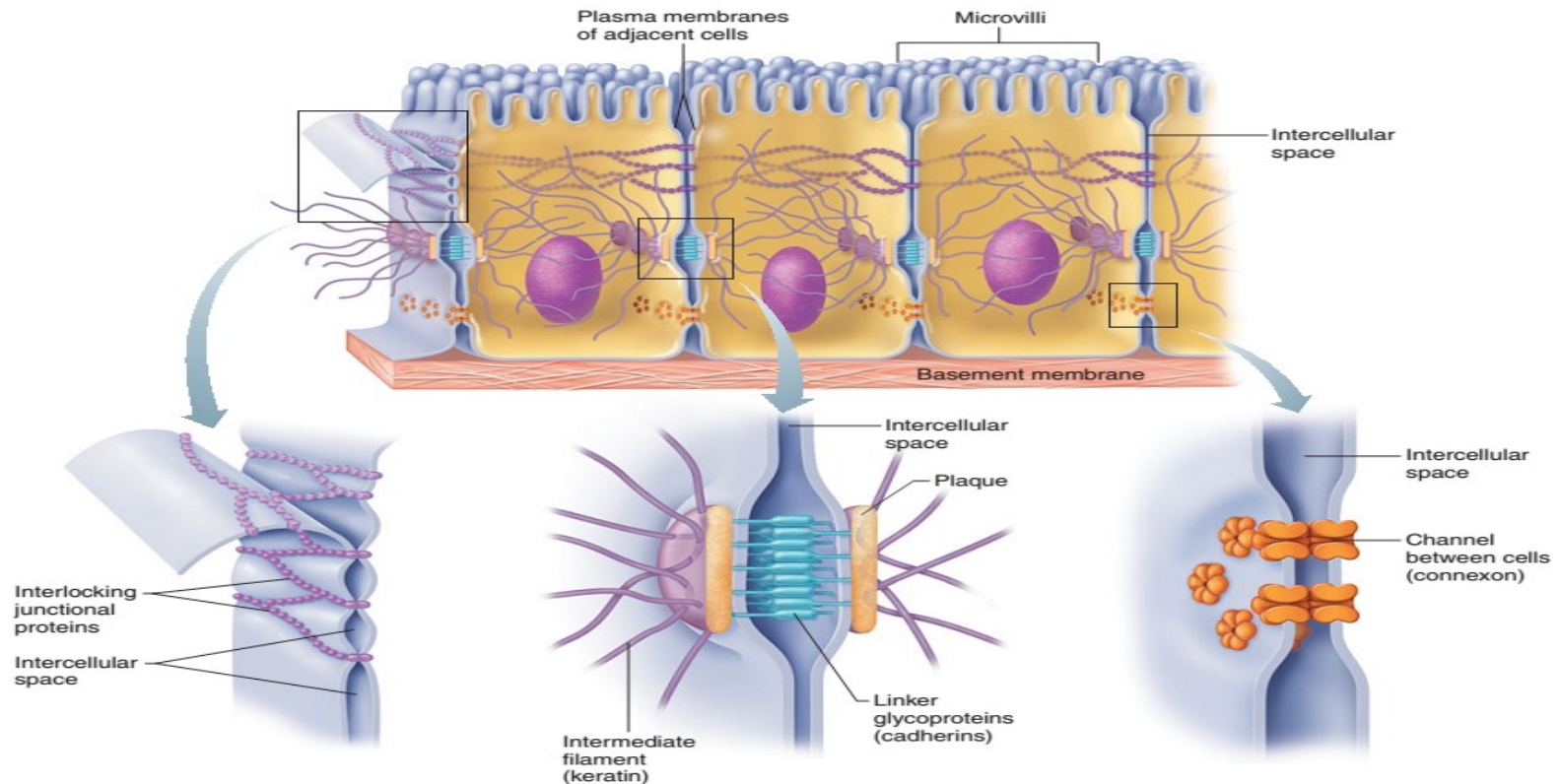


Special characteristics of epithelium.

# EPITHELIAL TISSUE

## Macula adherens(desmosome):

- Main junction
- By desmosome, adheres neighboring intermediate filaments of cells
- Plasma membranes are separated by a gap of 30 nm and is bridged by transmembrane proteins

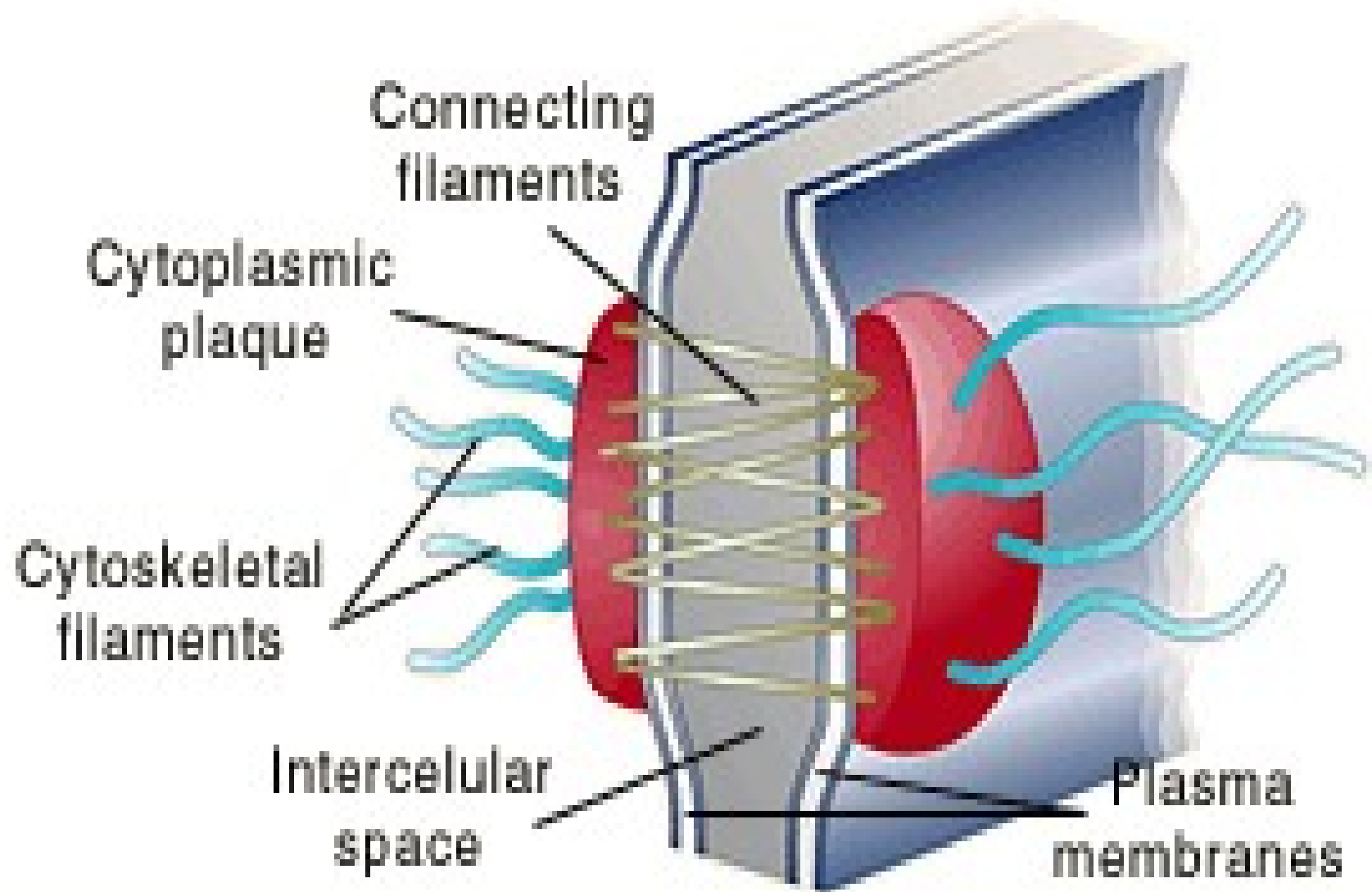


11/17/2014  
**(a) Tight junctions:** Impermeable junctions prevent molecules from passing through the intercellular space.

**(b) Desmosomes:** Anchoring junctions bind adjacent cells together and help form an internal tension-reducing network of fibers.

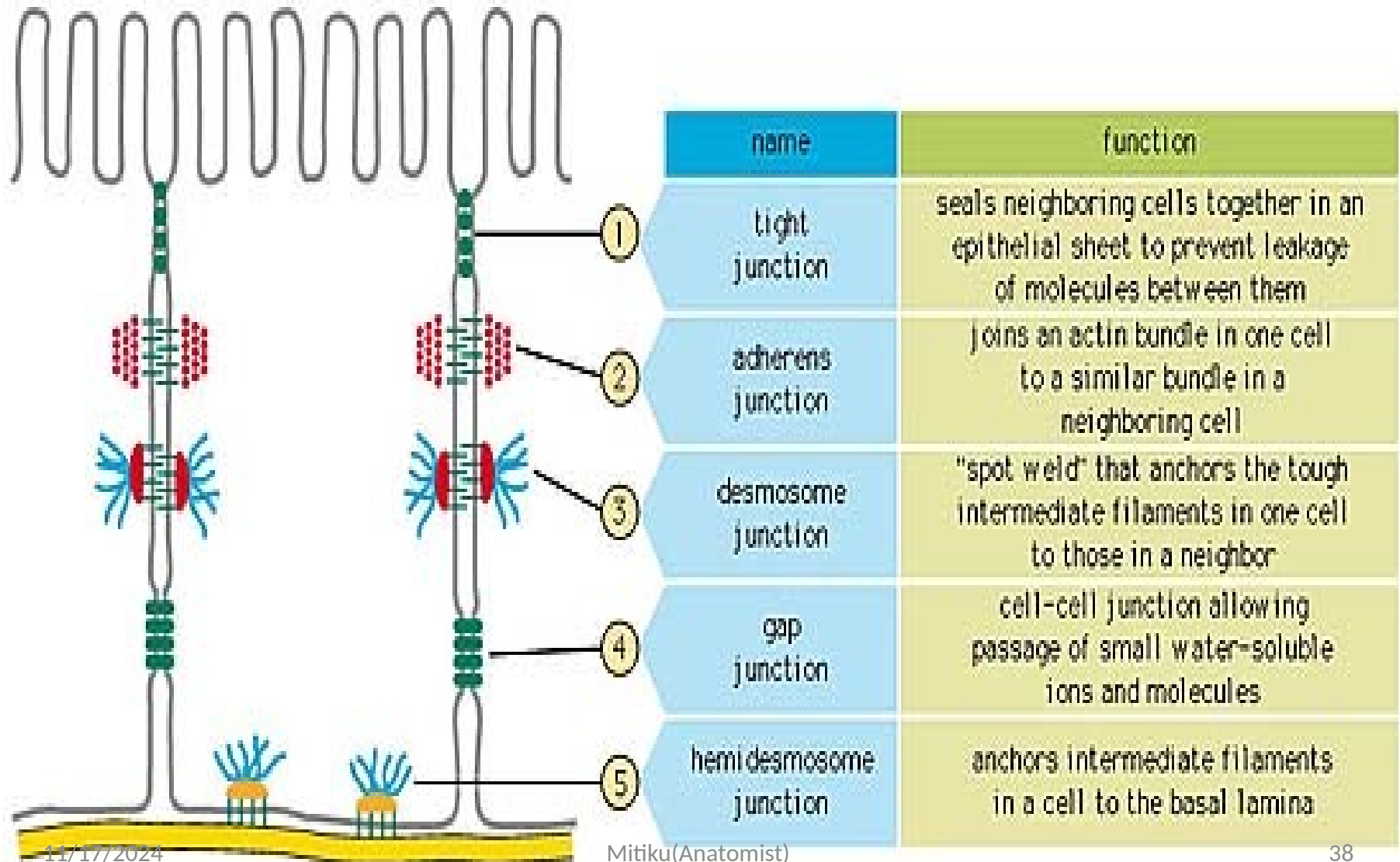
**(c) Gap junctions:** Communicating junctions allow ions and small molecules to pass from one cell to the next for intercellular communication.

# Desmosomes



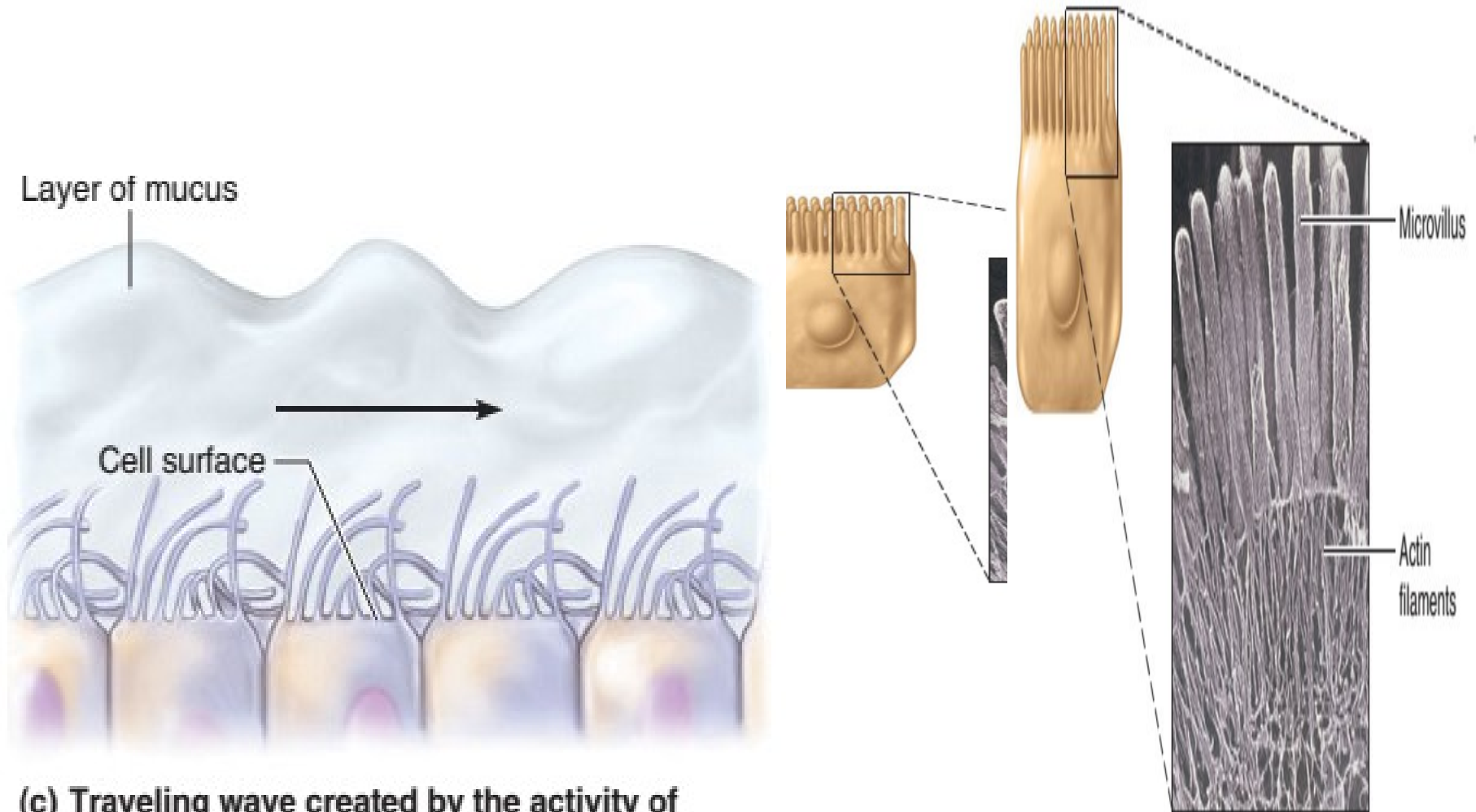
# EPITHELIAL TISSUE

**Gap Junctions(nexus):** allows passage of molecules



# EPITHELIAL TISSUE

**Apical surface:** modified in to cilia and microvilli



**(c) Traveling wave created by the activity of many cilia acting together propels mucus across cell surfaces.**

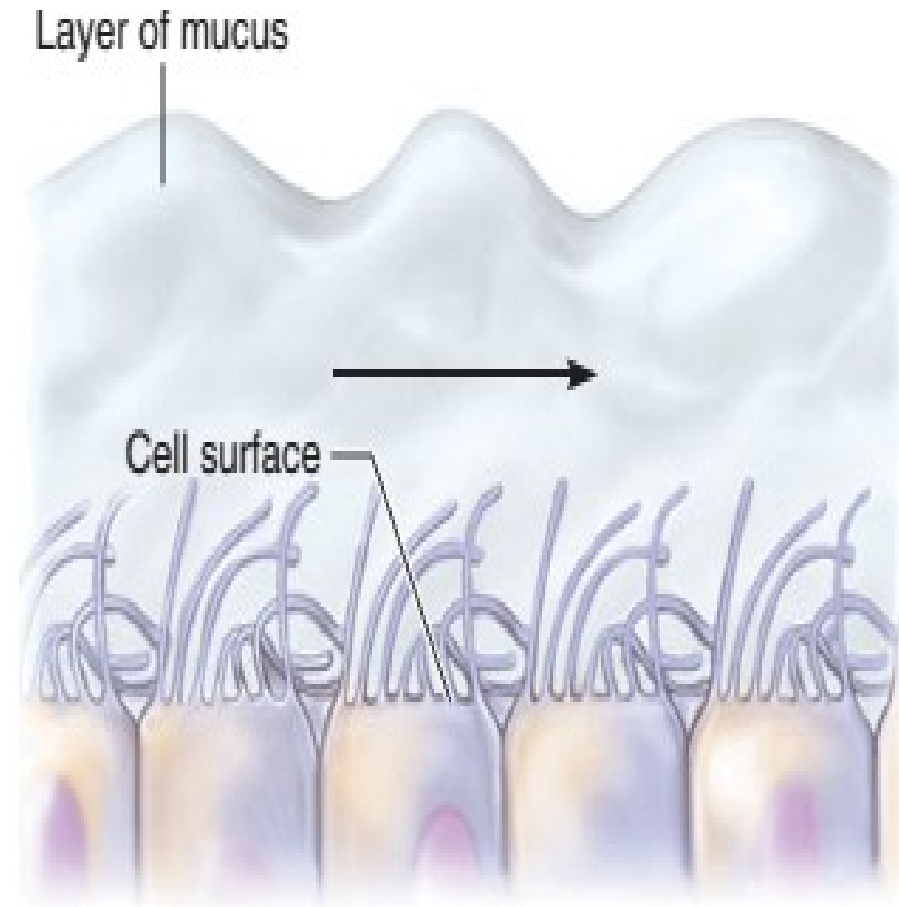
# EPITHELIAL TISSUE

## Cilia

- Large motile cytoplasmic extensions of the apical surface
- Consistes of mirotubules
- Located on repiratory tracts, oliphactory epithelium

## Function

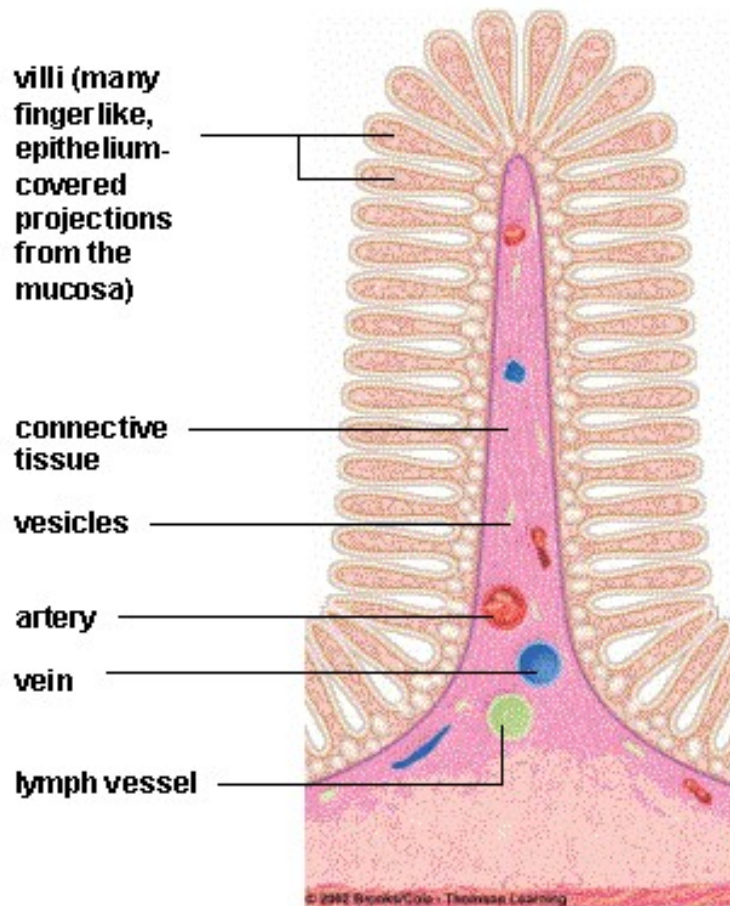
- ✓ Propel mucous
- ✓ Move fertilied egg to uterus
- ✓ chemoreceptors



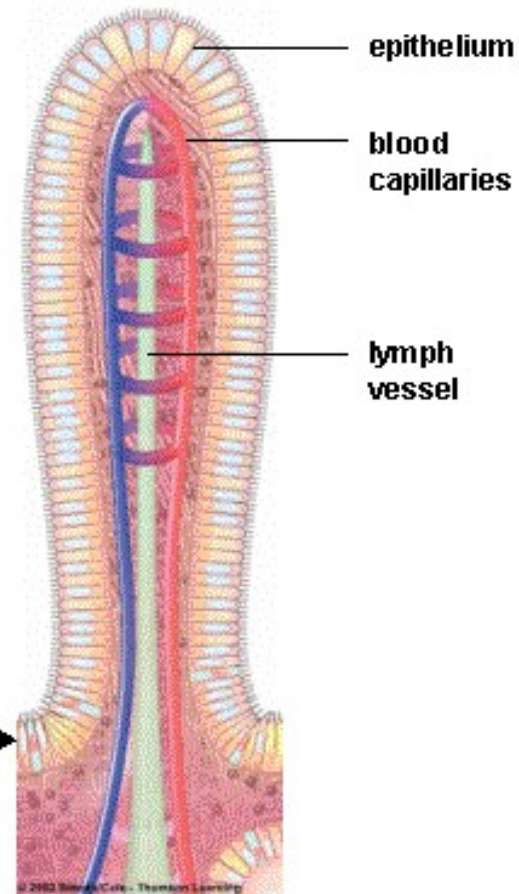
(c) Traveling wave created by the activity of many cilia acting together propels mucus across cell surfaces.

# Walls of Small Intestine

Projections into the intestinal lumen increase the surface area available for absorption



**Villi on one of the folds,  
longitudinal section**



**One villus**

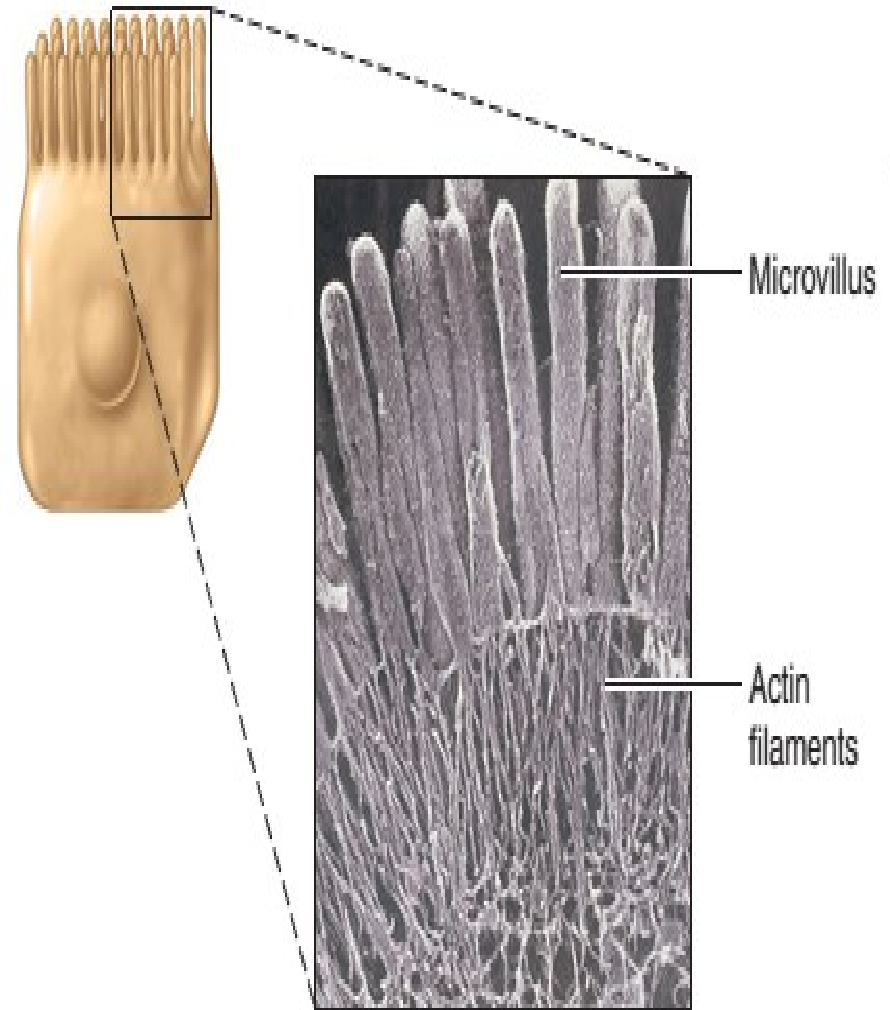
# EPITHELIAL TISSUE

## Microvillie

- Finger like extentions of the plasma membrane
- Made from micro filaments
- Located on small intestine and kidney

## Function:

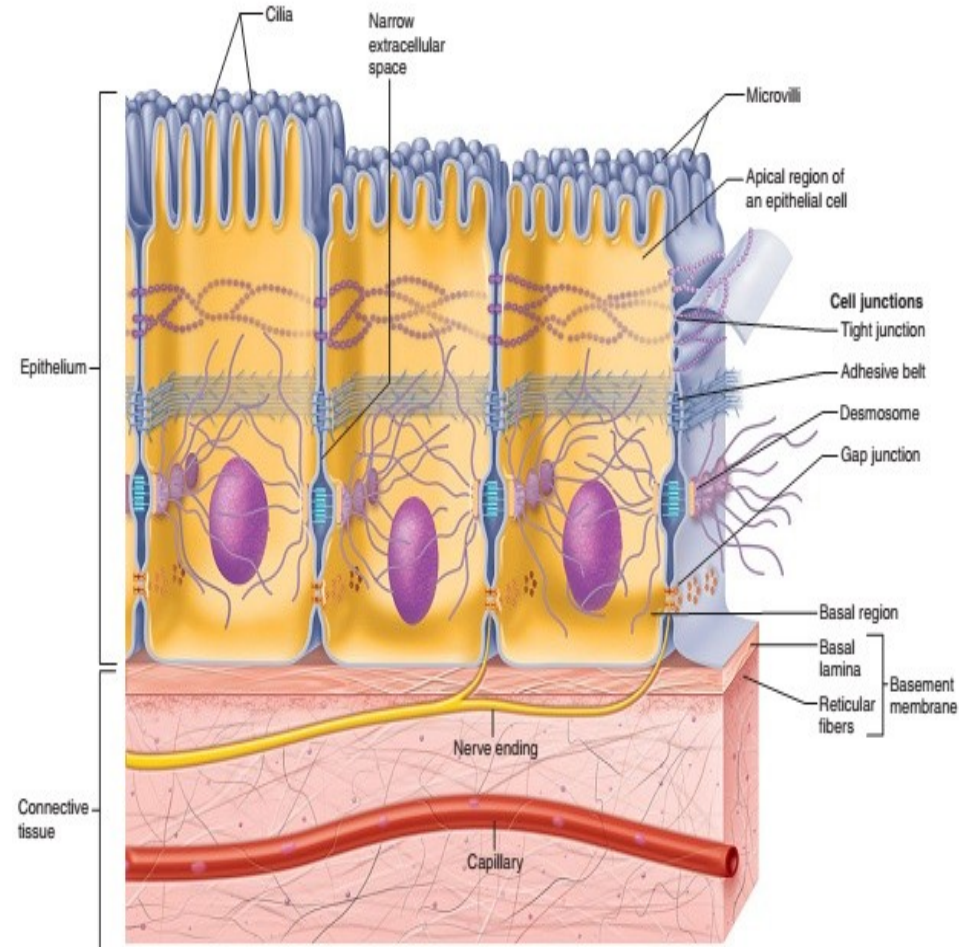
- ✓ Increase surface area
- ✓ Absorption
- ✓ Ion transport



# EPITHELIAL TISSUE

## Basal surface- basal lamina

- Upper part of basement membrane
- None cellular adhesive material
- Formed by glycoprotein
- Function selectively filter
- Adhere epithelial tissue with connective tissue



Special characteristics of epithelium.

# CONNECTIVE TISSUE

- Most abundant and widely distributed tissues in the body.

## Functions:

- It binds, supports, and protects other body tissues;
- Store energy
- Form stroma of the body (structural part)
- Transport substances
- Protect against diseases
- Blood cell formation

# CONNECTIVE TISSUE

## Common features of CT

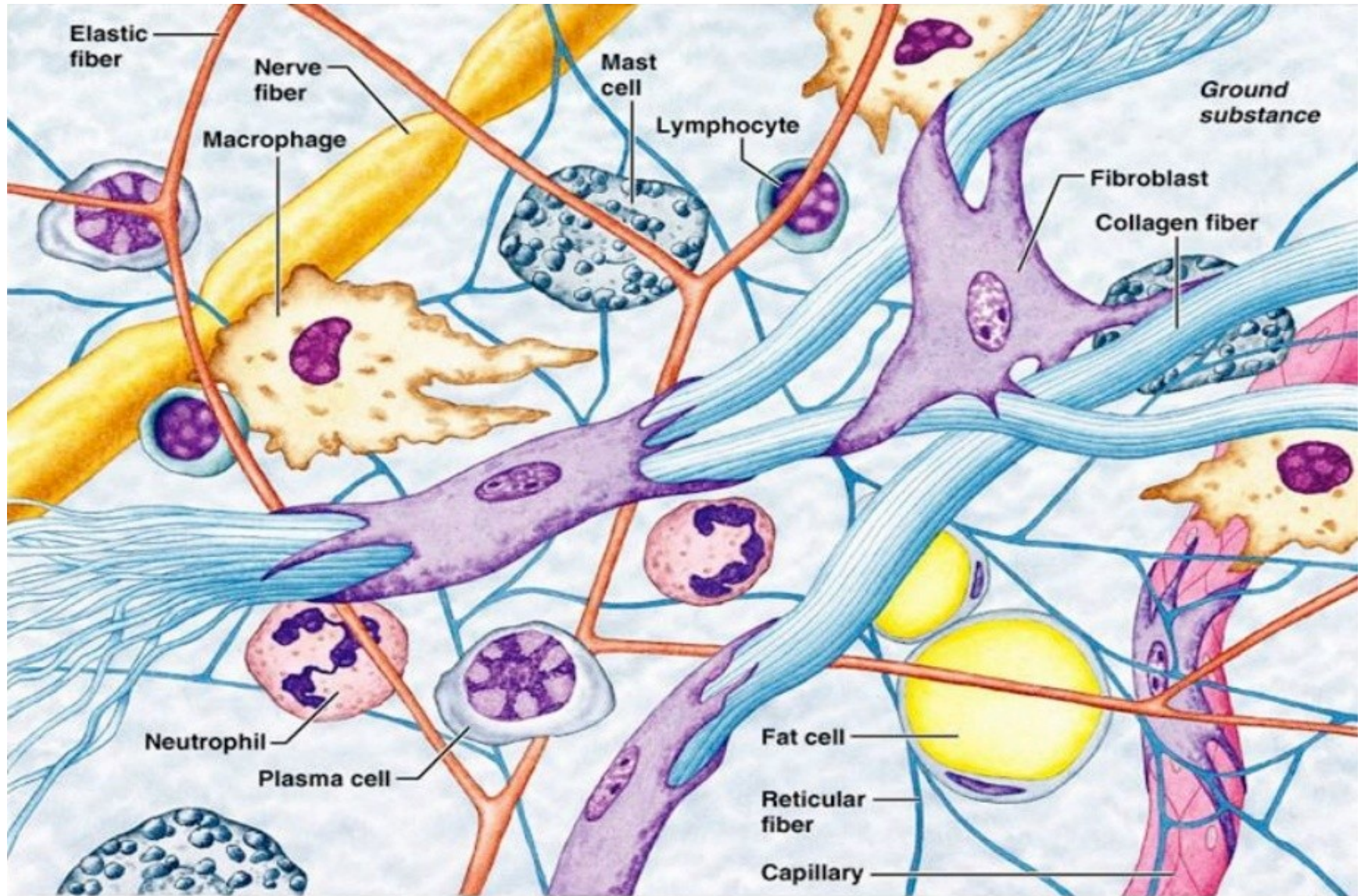
- Few cells, and **lots of extracellular matrix.**
- Most connective tissues originate from mesoderm, where multipotential cells of the embryo, the mesenchyme, develop
- Mesenchyme as their common tissue of origin
- Is highly vascular
- Exceptions: cartilage - avascular and tendons - have scanty blood supply

# CONNECTIVE TISSUE

## Structural elements of CT.

- Any connective tissue is made up of three elements:
- CT= cells + ECM. ECM = fibers + ground substance
- Cells – fibroblasts, chondroblasts, osteoblasts, and hematopoietic stem cells
- Fibers-
  - Collagen: thick
  - Elastic
  - Reticular : thin
- Ground substance: glycosaminoglycans, proteoglycans, and glycoproteins.

# CONNECTIVE TISSUE



## **Collagen type I**

- large banded fibers and bundles
- bone, dentin, skin, tendons, ligaments, cornea, fibrocartilage, internal organs(~90% of body collagen)
- fibroblast, osteoblast, odontoblast

## **Collagen type II**

- Fibrils (50 nm thick)
- cartilage (hyaline and elastic), and nucleus pulposus of IVDs
- chondroblast

## **Collagen type III**

- Fibrils and small banded fibers
- internal organs (e.g., reticular fibers in lymph nodes, spleen, liver, blood vessels, skin)
- fibroblast, reticular cell, smooth muscle cell, hepatocyte

# CONNECTIVE TISSUE

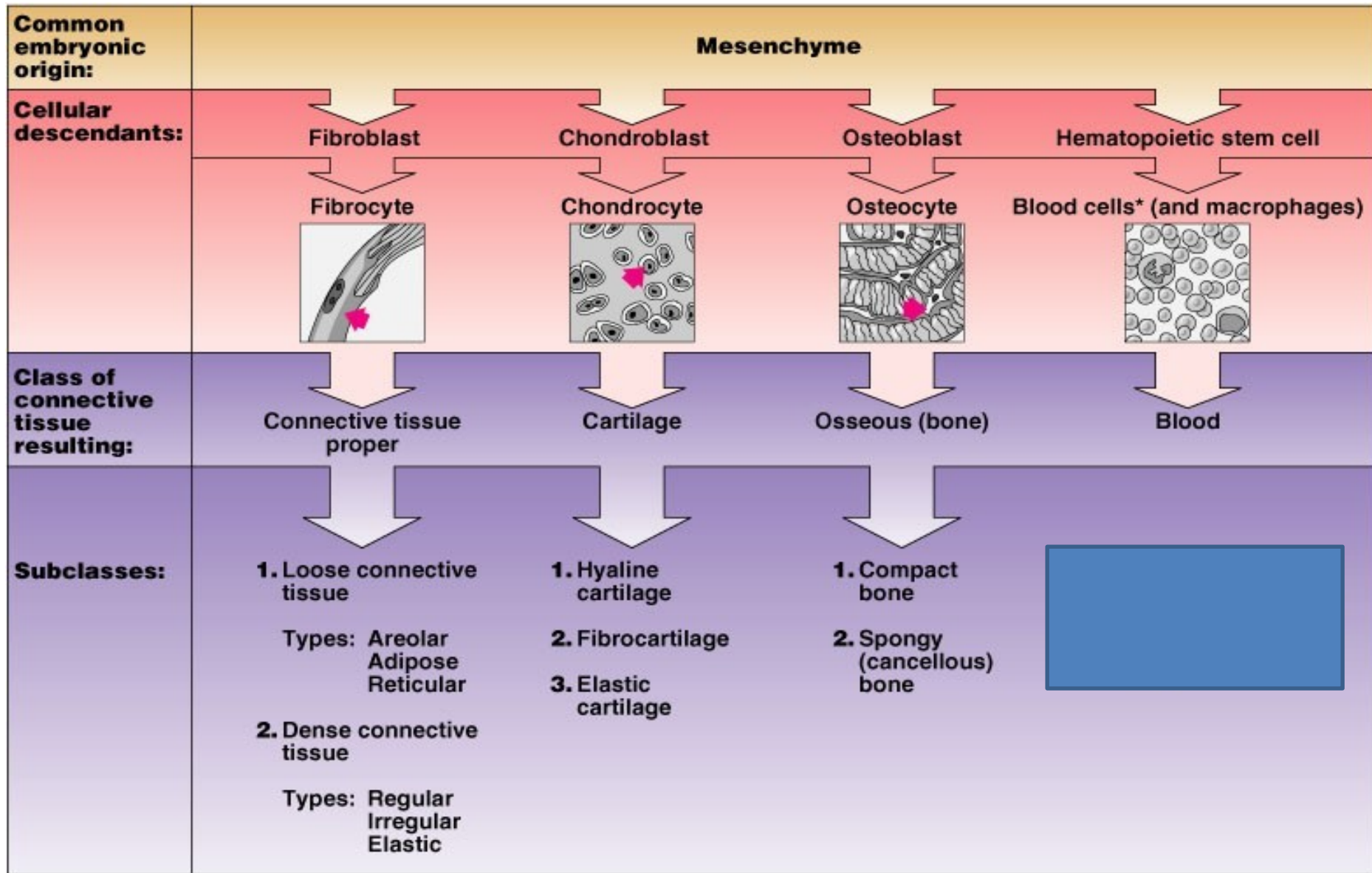
## Cells of CT.

- They are important to produce ECM.
- These cells are divided into **resident cells and migratory cell.**

**Resident connective tissue cells(internsic)** include fibroblasts, pericytes, adipose cells, mast cells, and "fixed" macrophages.

- **Cells of migratory(externsic cells)** arise are short lived and originated from hematopoietic stem cells in the bone marrow and migrated into the tissue from the blood in response to specific stimuli.

# Connective Tissue



# Structural Elements of Connective Tissue

- All connective tissues share similar structural elements which are listed below
  - 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

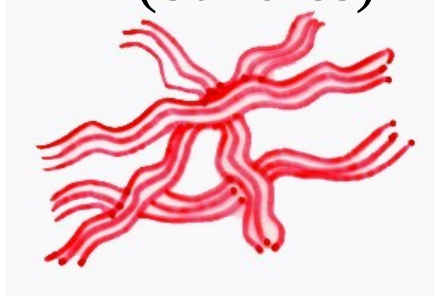
- Interstitial (tissue) fluid
- Adhesion proteins – fibronectin and laminin
- Proteoglycans – glycosaminoglycans (GAGs)
- Functions as a molecular sieve through which nutrients diffuse between blood capillaries and cells

# Fibers

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

# CONNECTIVE TISSUE FIBERS

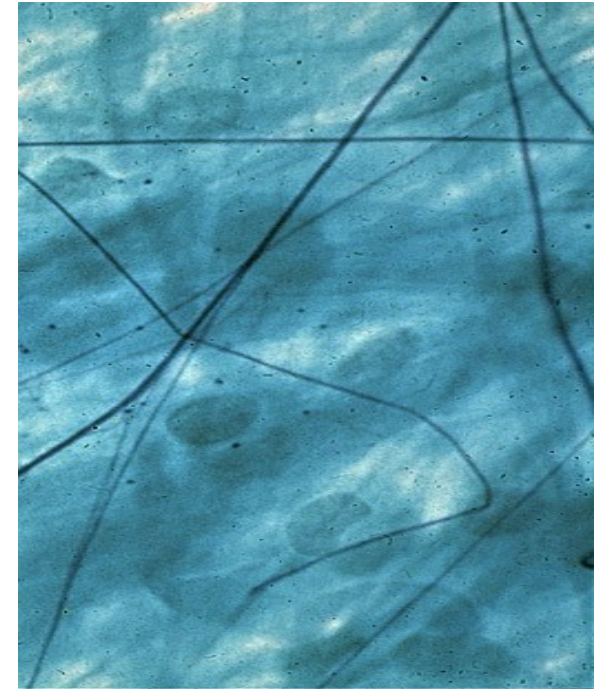
Collagenous Fibers  
(bundles)



Reticular Fibers  
(networks)



Elastic Fibers  
(anastomosing bundles)



# Cells

- Each Type of connective tissue has to be made by a certain cell type. In an immature stage each cell below secretes the fibers needed for its connective tissue.
- Fibroblasts – connective tissue proper
- Chondroblasts – cartilage
- Osteoblasts – bone
- Hematopoietic stem cells – blood ( White blood cells, plasma cells, macrophages, and mast cells )

# Connective Tissue: Embryonic

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

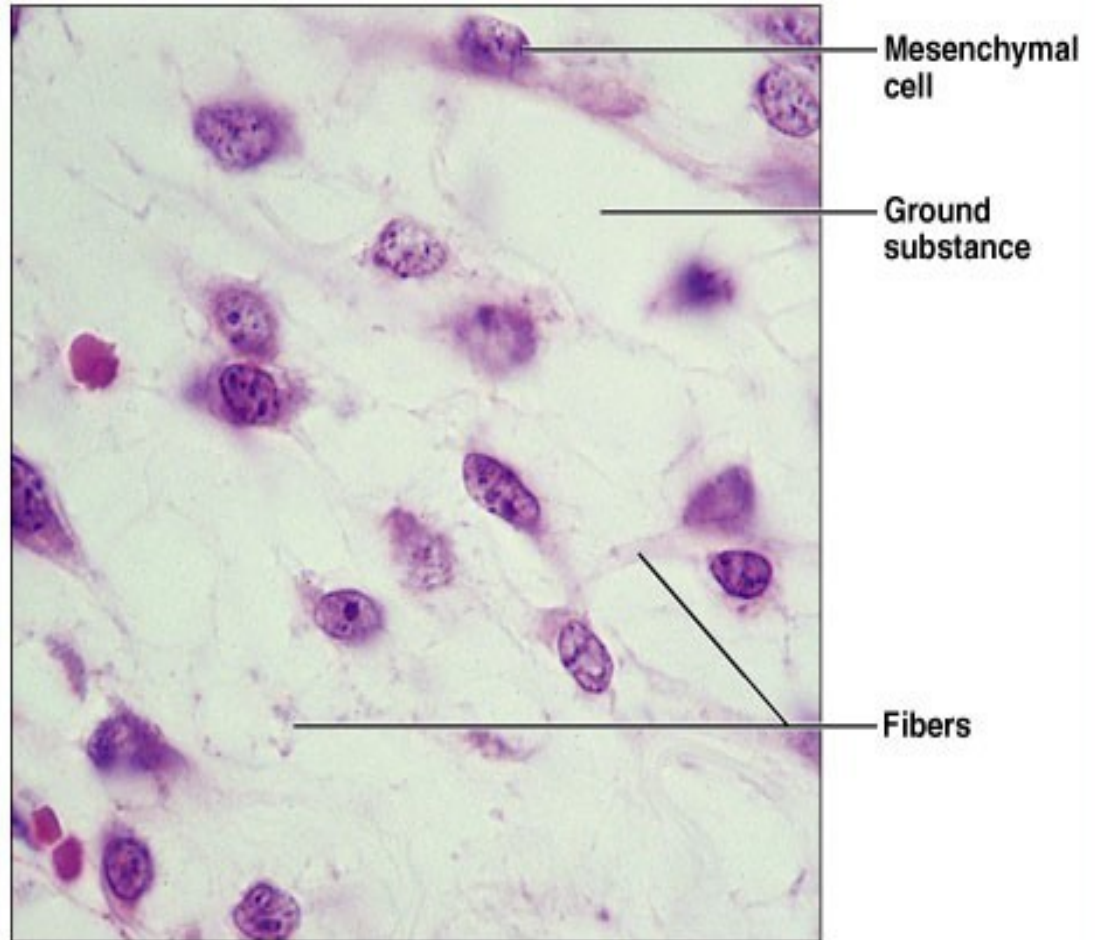
# Connective Tissue: Embryonic

## (a) Embryonic connective tissue: mesenchyme

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

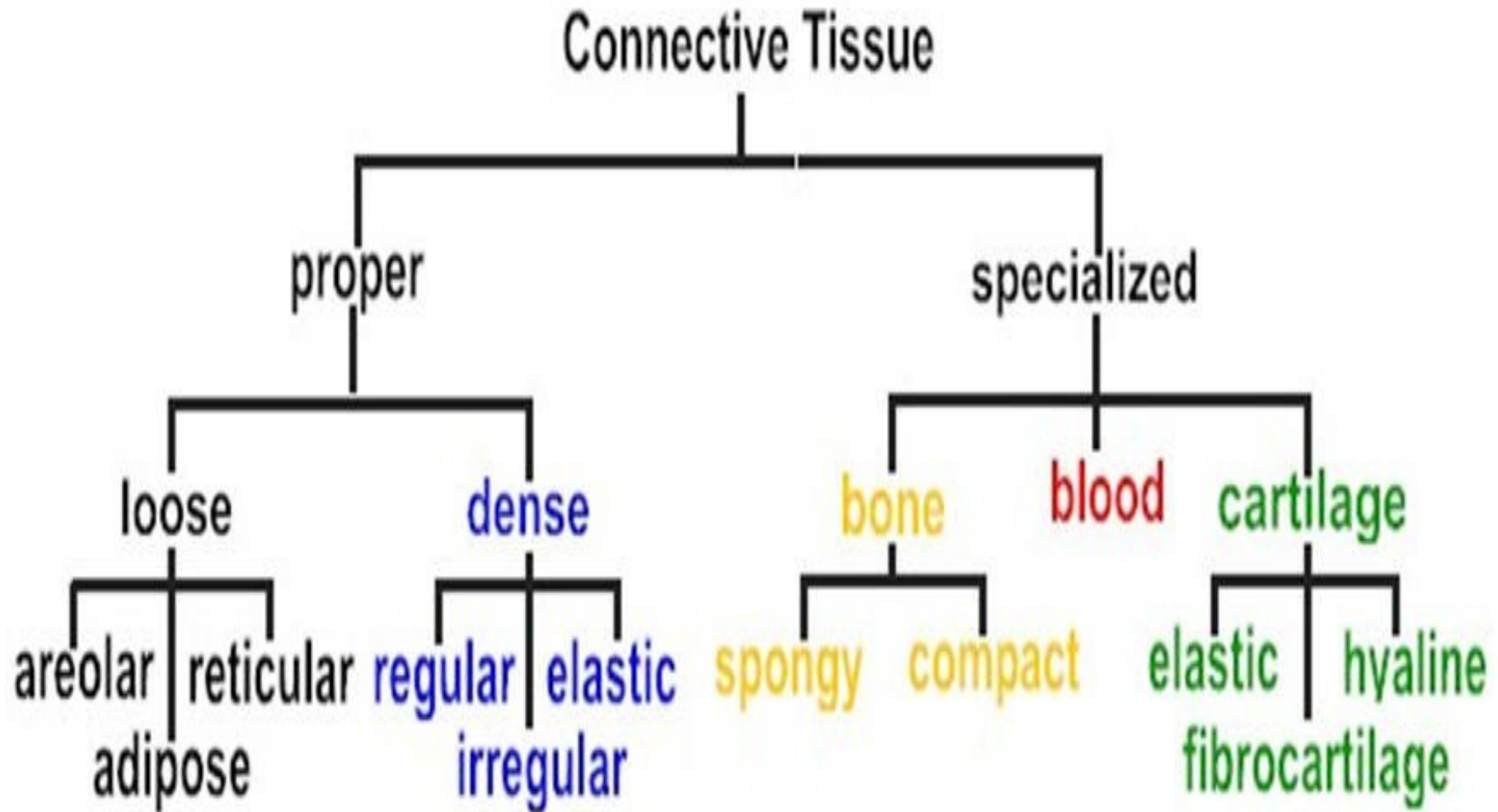
**Function:** Gives rise to all other connective tissue types.

**Location:** Primarily in embryo.



**Photomicrograph:** Mesenchymal tissue, an embryonic connective tissue (400x); the clear-appearing background is the fluid ground substance of the matrix; notice the fine, sparse fibers.

# TYPES OF CONNECTIVE TISSUE



# Connective Tissue Proper: Loose

- **Areolar connective tissue**
  - Gel-like matrix with all three connective tissue fibers
  - Fibroblasts, macrophages, mast cells, and some white blood cells
  - Wraps and cushions organs
  - Widely distributed throughout the body

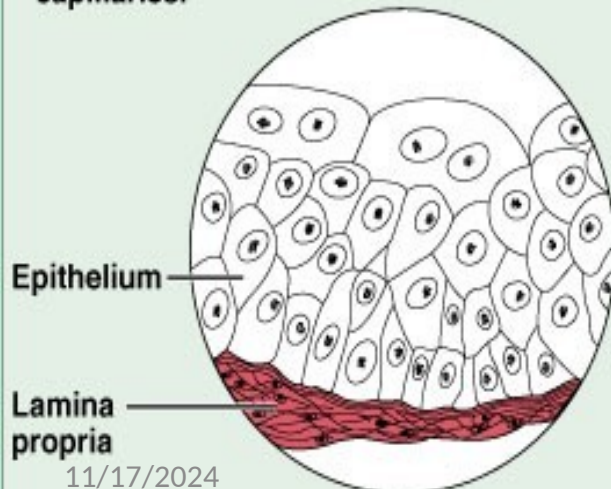
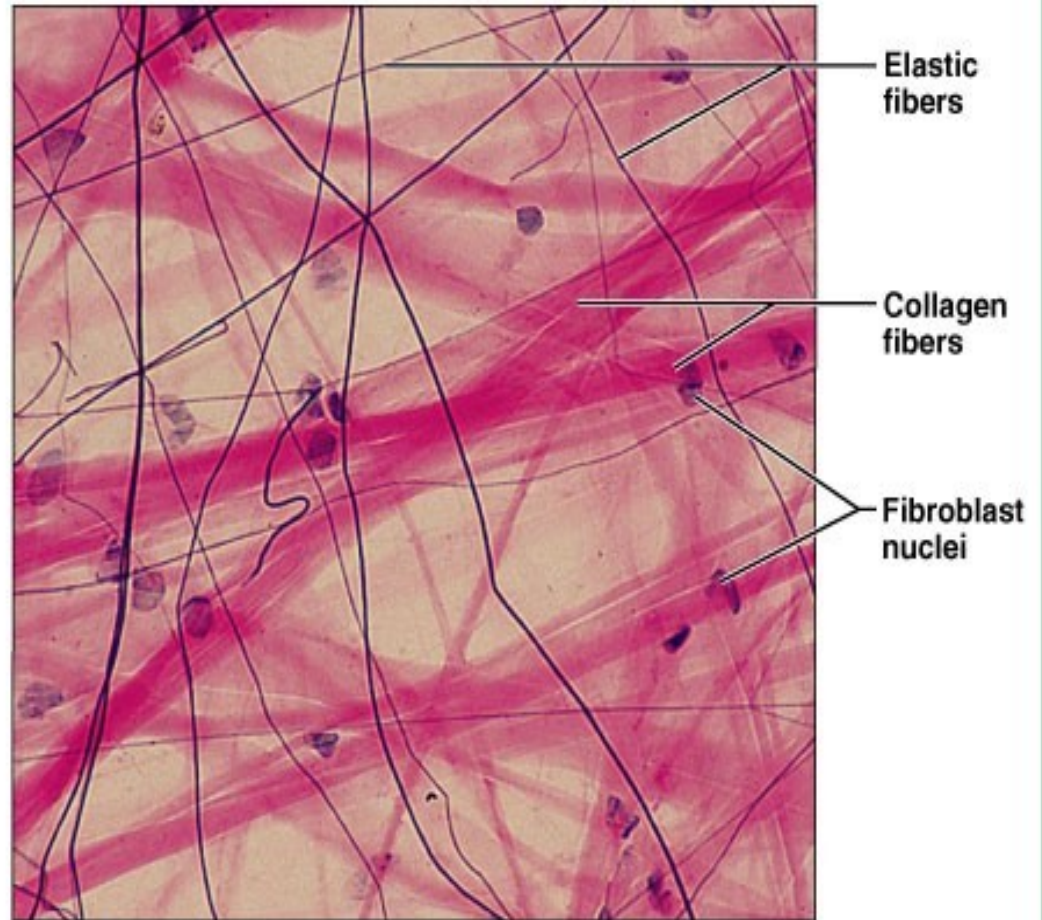
# Connective Tissue Proper: Loose

## (b) Connective tissue proper: loose connective tissue, areolar

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

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

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



**Photomicrograph:** Areolar connective tissue, a soft packaging tissue of the body (400 $\times$ ).

# Connective Tissue Proper: Loose

## ■ **Adipose connective tissue**

- Matrix similar to areolar connective tissue with closely packed **adipocytes**
- Reserves food stores, insulates against heat loss, supports and protects
- Found under skin, around kidneys, within abdomen, and in breasts
- Local fat deposits serve nutrient needs of highly active organs

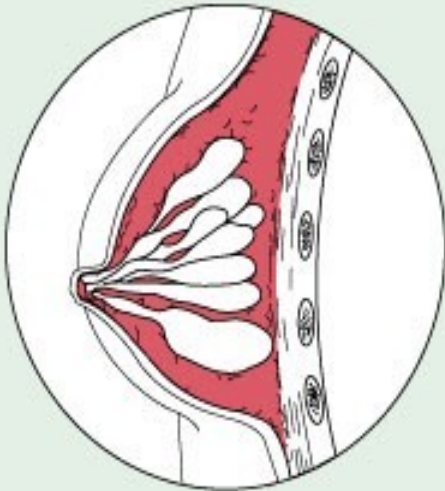
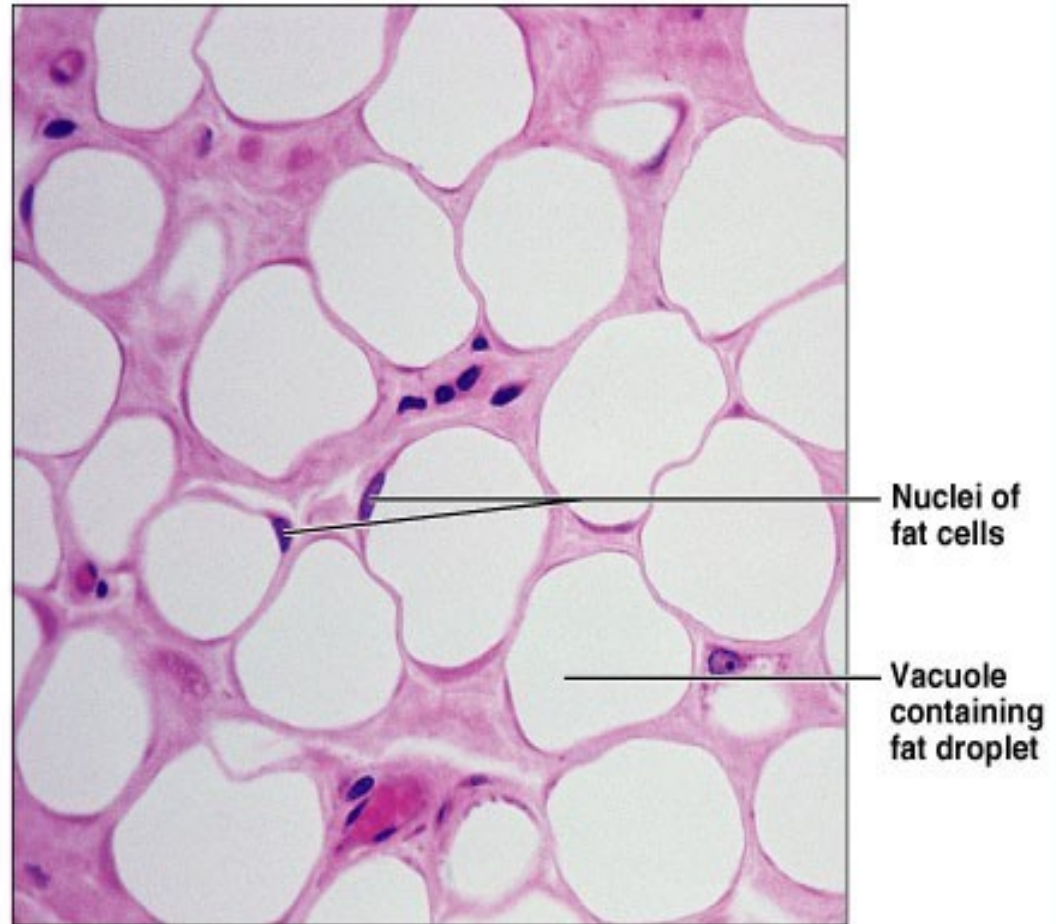
# Connective Tissue Proper: Loose

## (c) Connective tissue proper: loose connective tissue, adipose

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

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

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



**Photomicrograph:** Adipose tissue from the subcutaneous layer under the skin (600 $\times$ ).

- Two types of adipose tissue, which derive their names from the color of the tissue (white or brown) and/or the number of lipid droplets found in the adipocytes.

### Yellow adipocyte

- Big round cell
- Single lipid droplet
- Flat peripheral nucleus
- Few mitochondria
- Found in adults
- Energy storage

### Brown adipocyte

- Small polygonal cell
- Many lipid droplets
- Spherical central nucleus
- Many mitochondria
- Found in embryo, fetus, newborn
- Help in heat production

# Connective Tissue Proper: Loose

- **Reticular connective tissue**

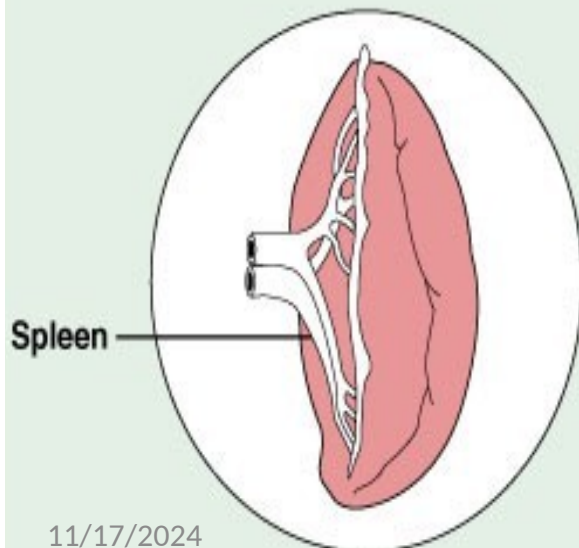
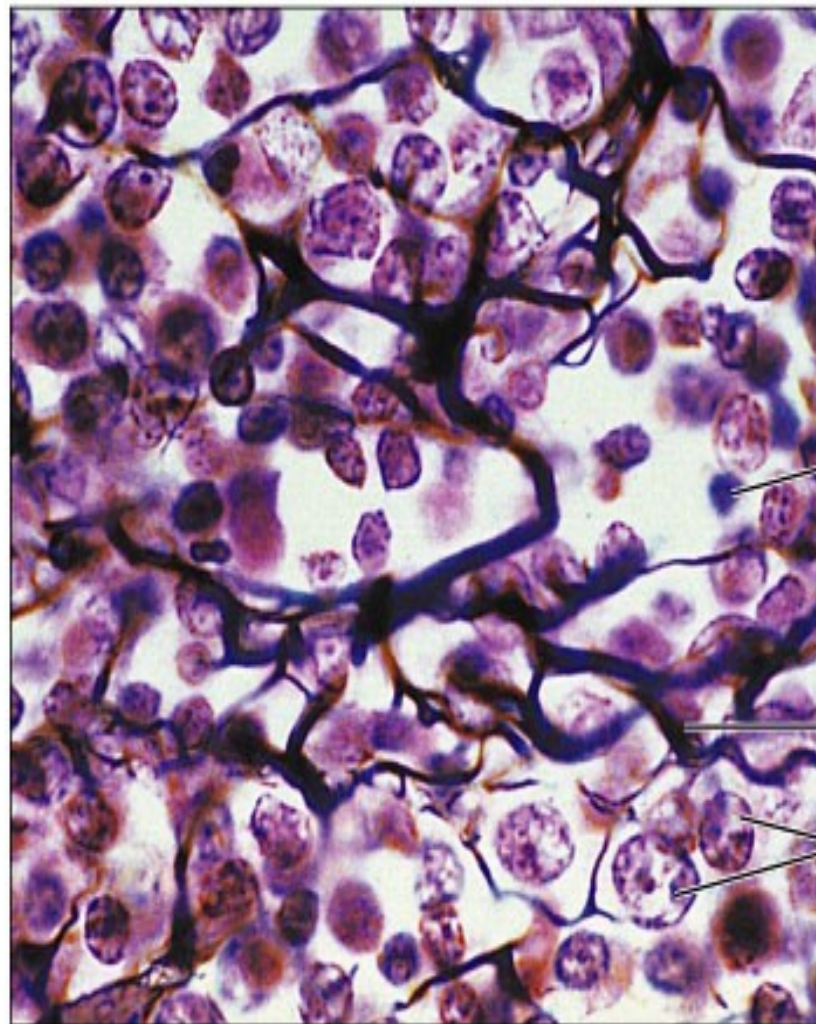
- Loose ground substance with reticular fibers
- Reticular cells lie in a fiber network
- Forms a soft internal skeleton, or stroma (framework), that supports other cell types
- Found in lymph nodes, liver, bone marrow, and the spleen

#### (d) Connective tissue proper: loose connective tissue, reticular

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

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

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



White blood (lymphocyte) cell

Reticular fibers

Mast cells

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

## Connective Tissue Proper: Dense Regular

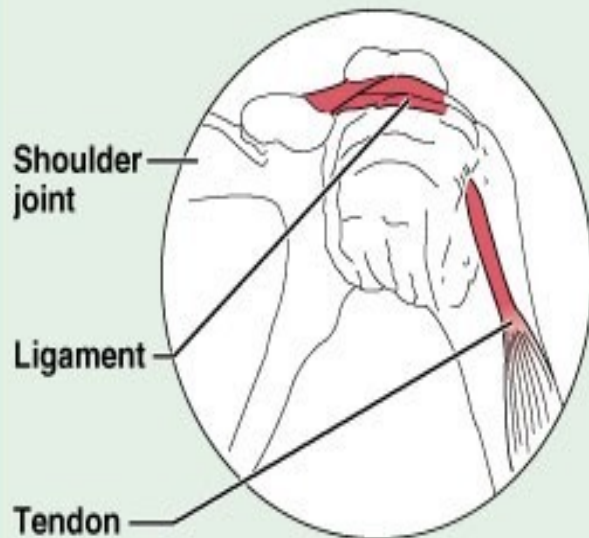
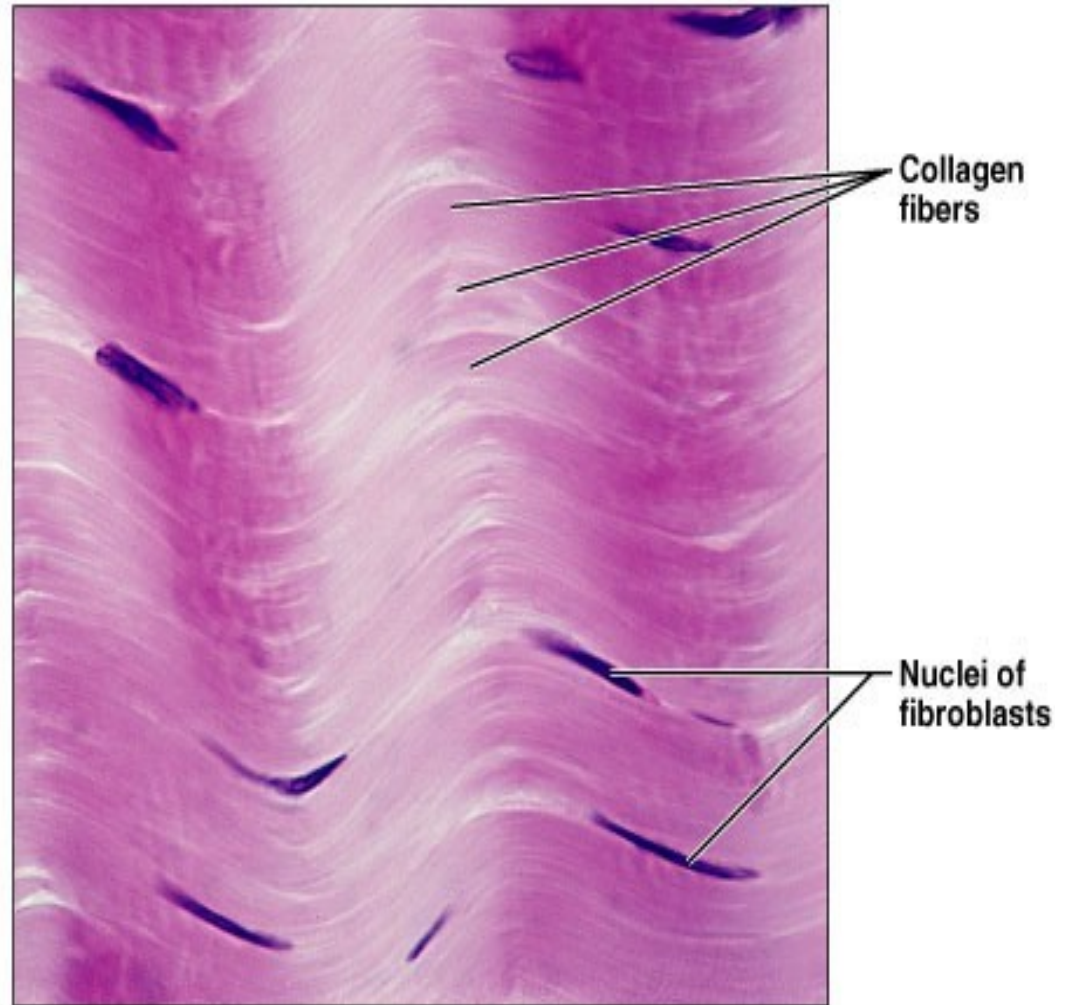
- contains collagen fibers oriented in **one direction** to provide strength in that direction
- Parallel collagen fibers with a few elastic fibers
- Major cell type is fibroblasts
- Found in tendons, ligaments, and aponeuroses
- Attaches muscles to bone or to other muscles, and bone to bone

## (e) Connective tissue proper: dense connective tissue, dense regular

**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.



**Photomicrograph:** Dense regular connective tissue from a tendon (1000x).

## Connective Tissue Proper: Dense Irregular

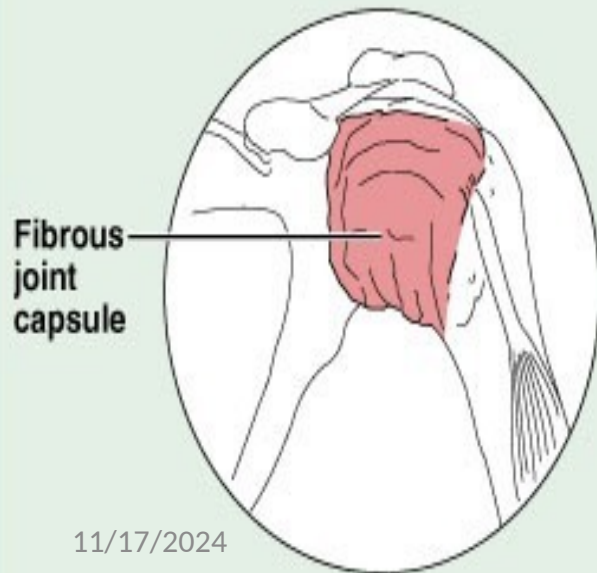
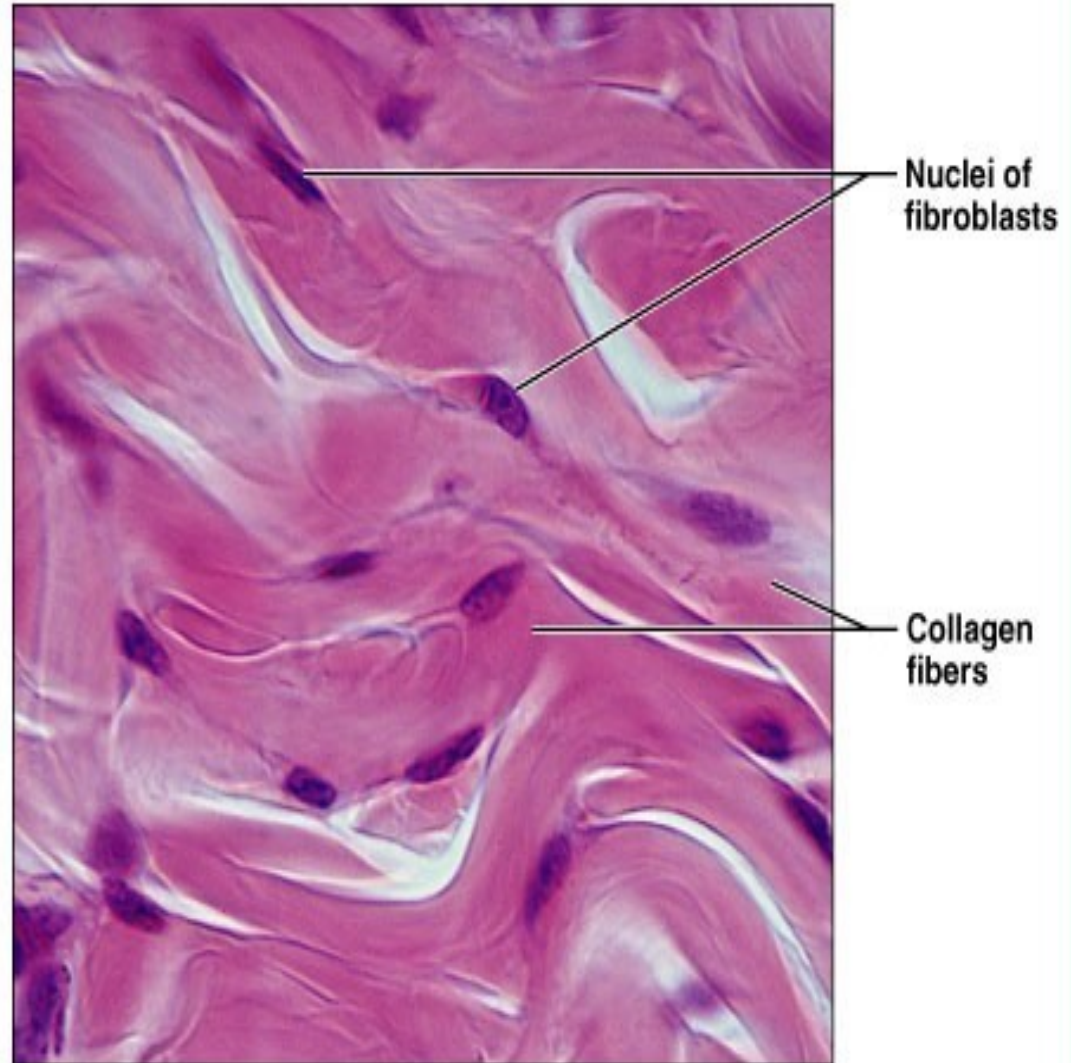
- **Irregularly arranged collagen fibers** with some elastic fibers
- Major cell type is fibroblasts
- **Withstands tension** in many directions providing structural strength
- Found in the dermis, submucosa of the digestive tract, and fibrous organ capsules

## (f) Connective tissue proper: dense connective tissue, dense irregular

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

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

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



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

# Connective Tissue: Cartilage

## ■ Hyaline cartilage

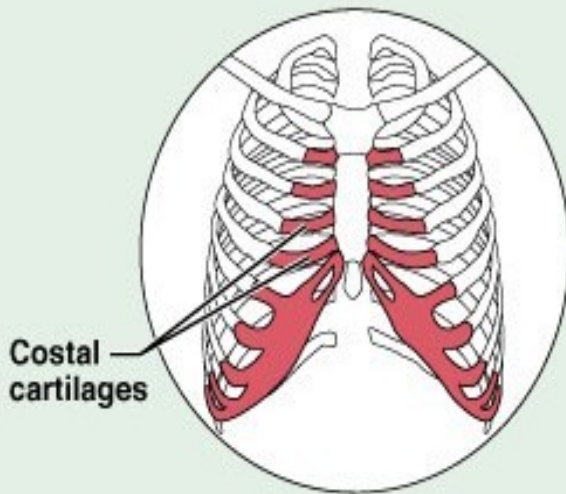
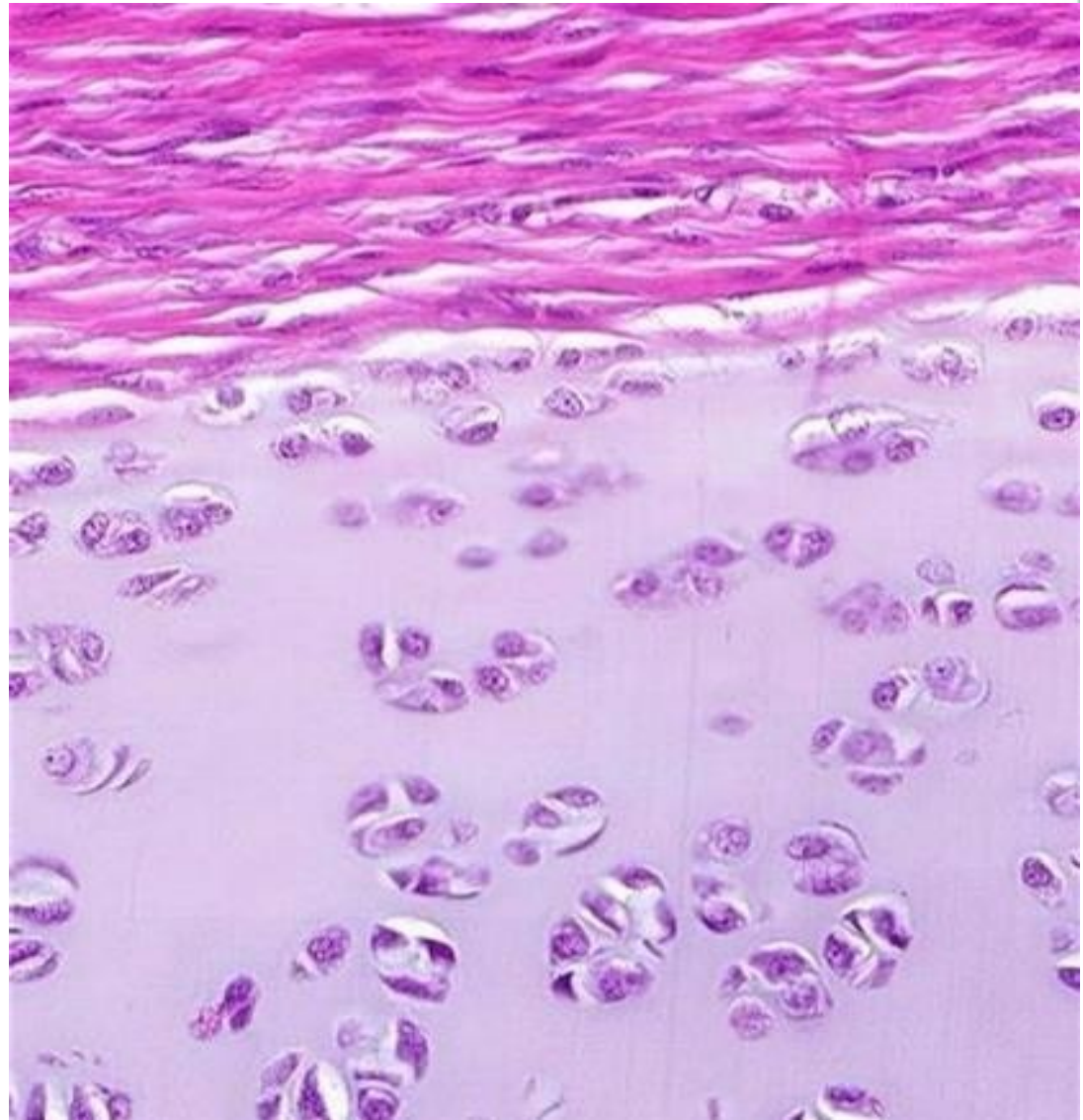
- Amorphous, firm matrix with imperceptible network of collagen fibers
- Chondrocytes lie in lacunae, arranged in group called isogenic group
- Has perichondrium- membrane cover outer part of cartilage
- Supports, reinforces, cushions, and resists compression
- Forms the costal cartilage
- Found in embryonic skeleton, the end of long bones, nose, trachea, and larynx

### (g) Cartilage: hyaline

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

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

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



## Elastic Cartilage

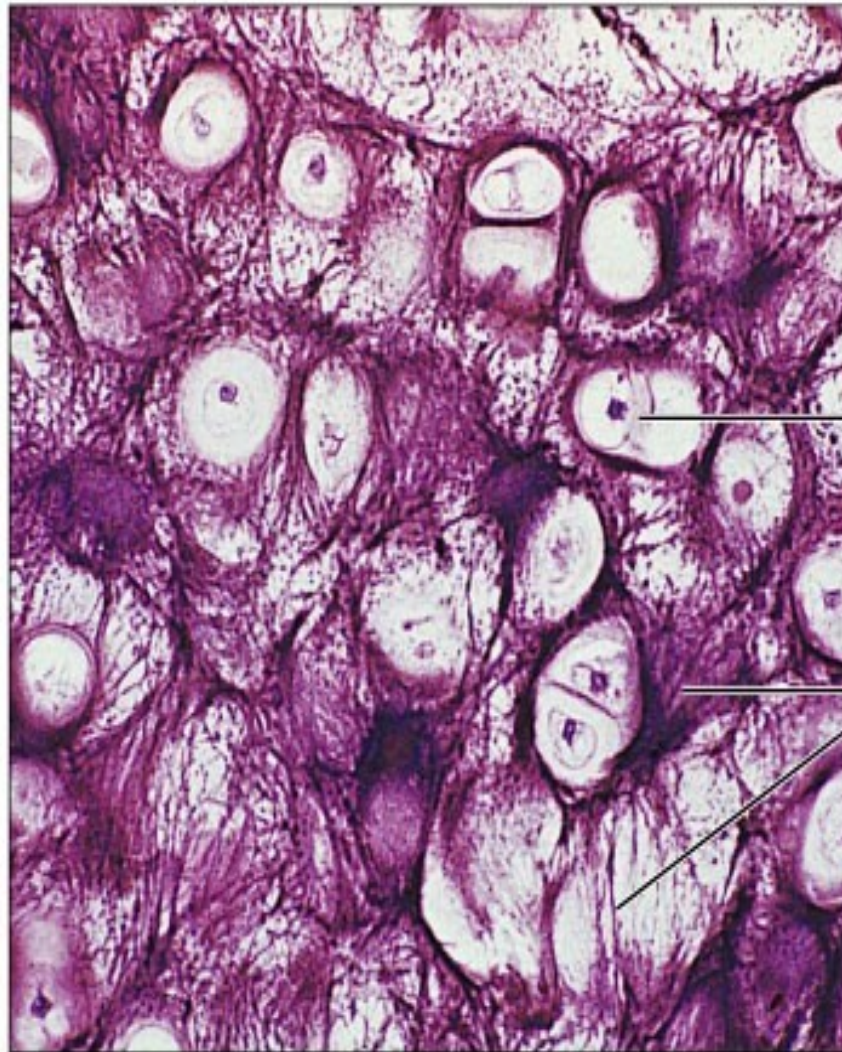
- Similar to hyaline cartilage but with more **elastic fibers**
- Maintains shape and structure while allowing flexibility
- Supports external ear (pinna) and the epiglottis

## (h) Cartilage: elastic

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

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

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



Chondrocyte  
in lacuna

Elastic  
fibers

**Photomicrograph:** Elastic cartilage from the human ear pinna; forms the flexible skeleton of the ear (400 $\times$ ).

## Fibrocartilage Cartilage

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

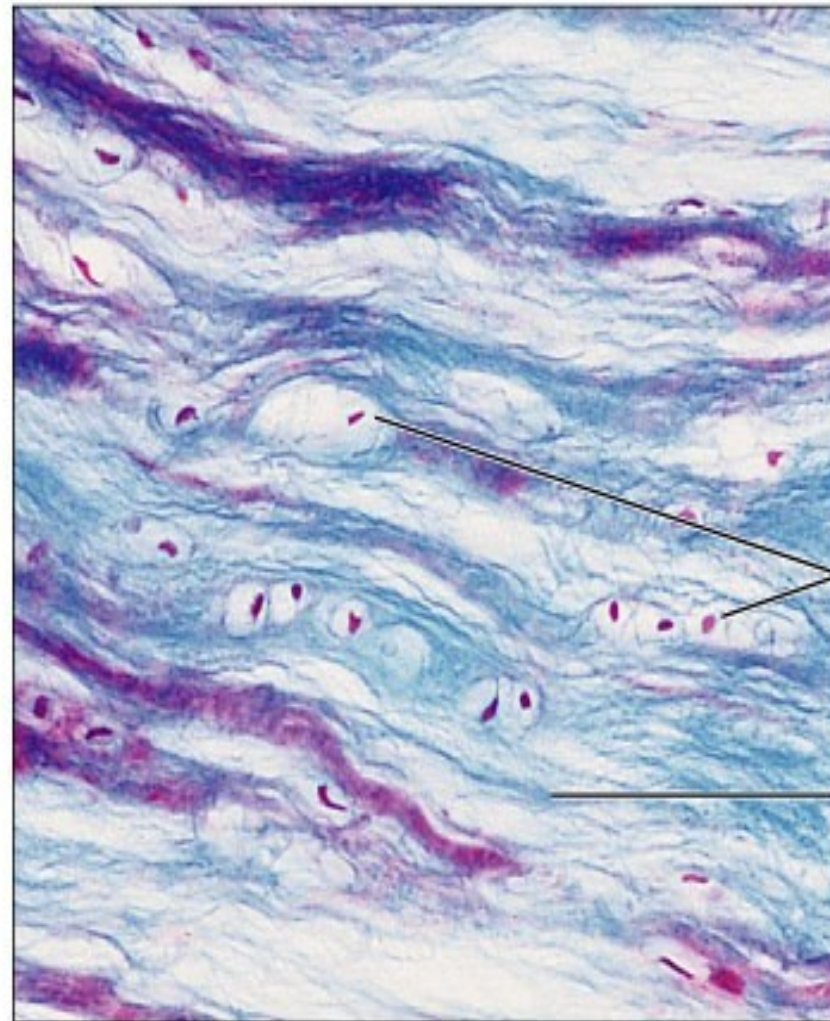
## (i) Cartilage: fibrocartilage

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

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

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

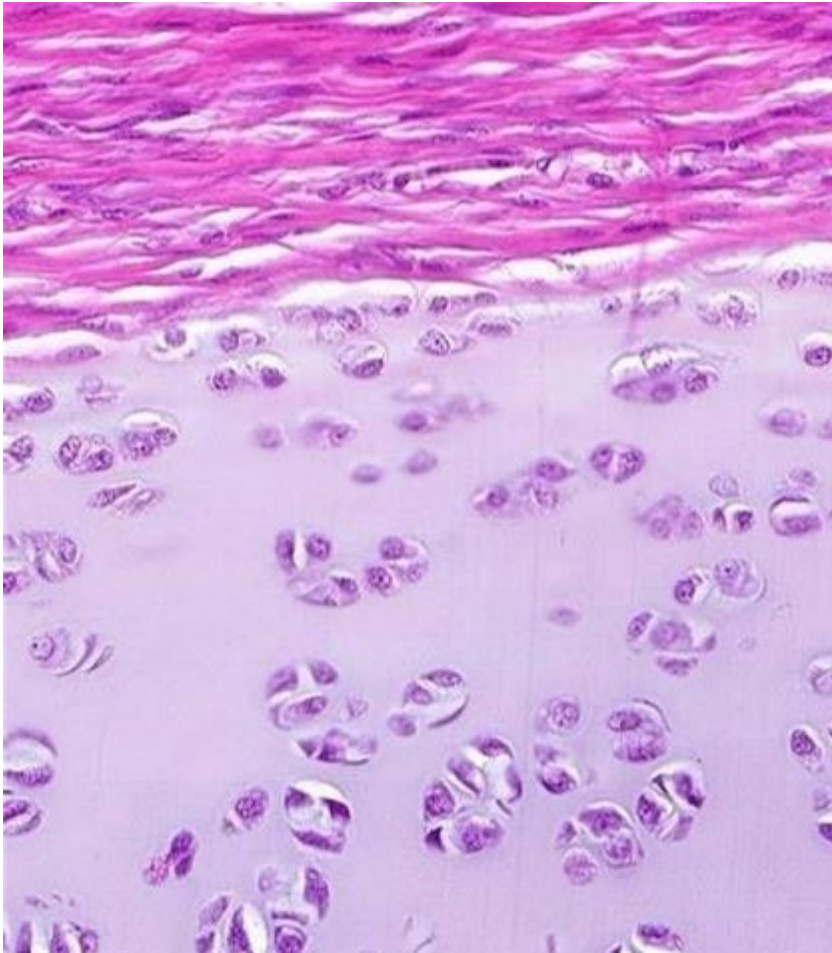
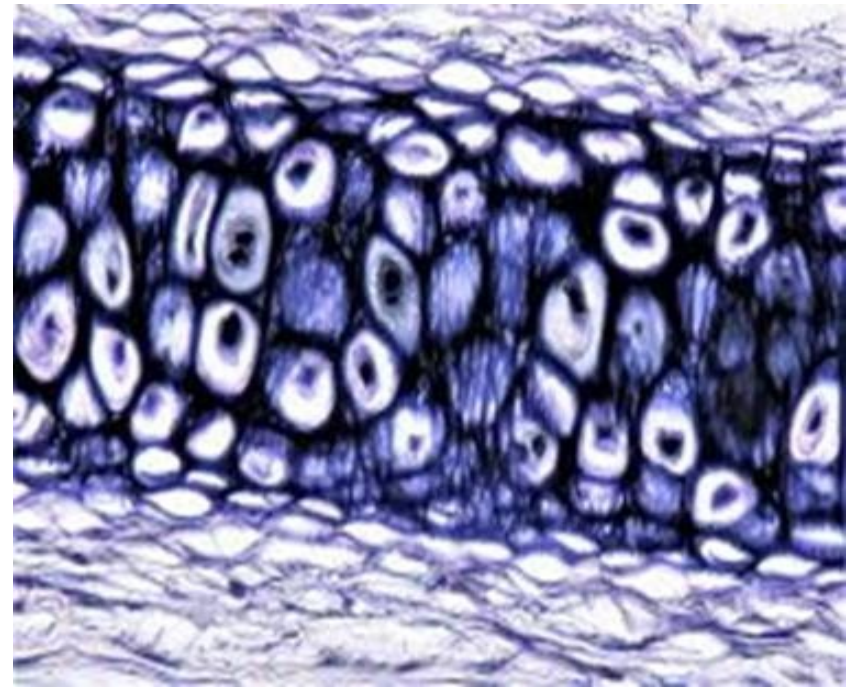
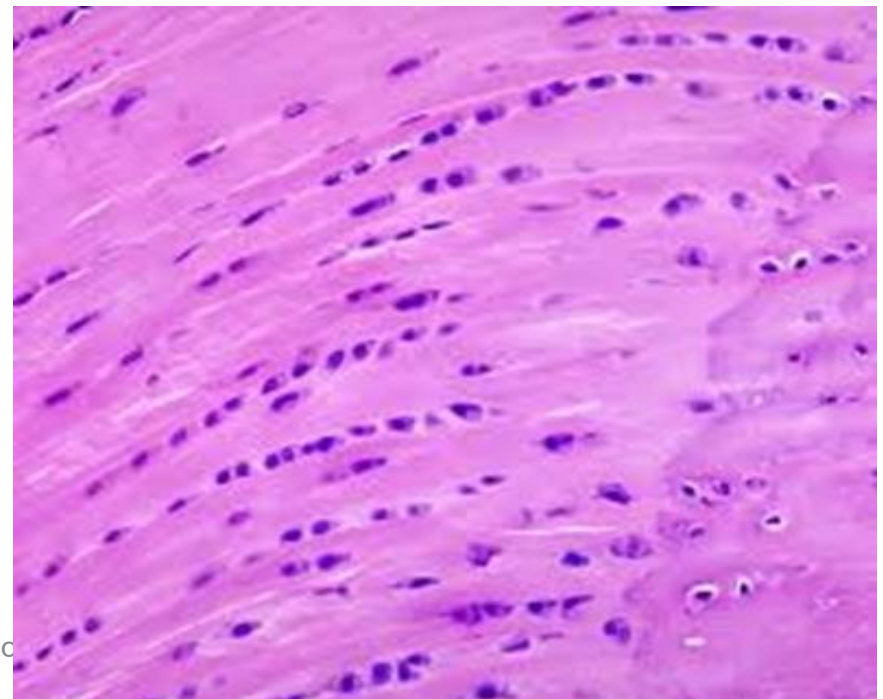
Intervertebral discs



**Photomicrograph:** Fibrocartilage of an intervertebral disc (200x).

| Type of Cartilage | Identifying Characteristics                                                                                                                                                                  | Perichondrium                                              | Location                                                                                                                     |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
| Hyaline           | Type II collagen, basophilic matrix, chondrocytes usually arranged in groups (isogenous groups)                                                                                              | Perichondrium usually present except on articular surfaces | Articular ends of long bones, nose, larynx, trachea, bronchi, ventral ends of ribs, template for endochondral bone formation |
| Elastic           | Type II collagen, elastic fibers                                                                                                                                                             | Perichondrium present                                      | Pinna of ear, auditory canal and tube, epiglottis, some laryngeal cartilages                                                 |
| Fibrocartilage    | Type I collagen, acidophilic matrix, chondrocytes arranged in parallel rows between bundles of collagen, always associated with dense collagenous connective tissue and/or hyaline cartilage | Perichondrium absent                                       | Intervertebral discs, articular discs, pubic symphysis, insertion of tendons, meniscus of knee                               |

Identify types of cartilage??



# CONNECTIVE TISSUE

## Histology of bone

- Hard calcified connective tissue

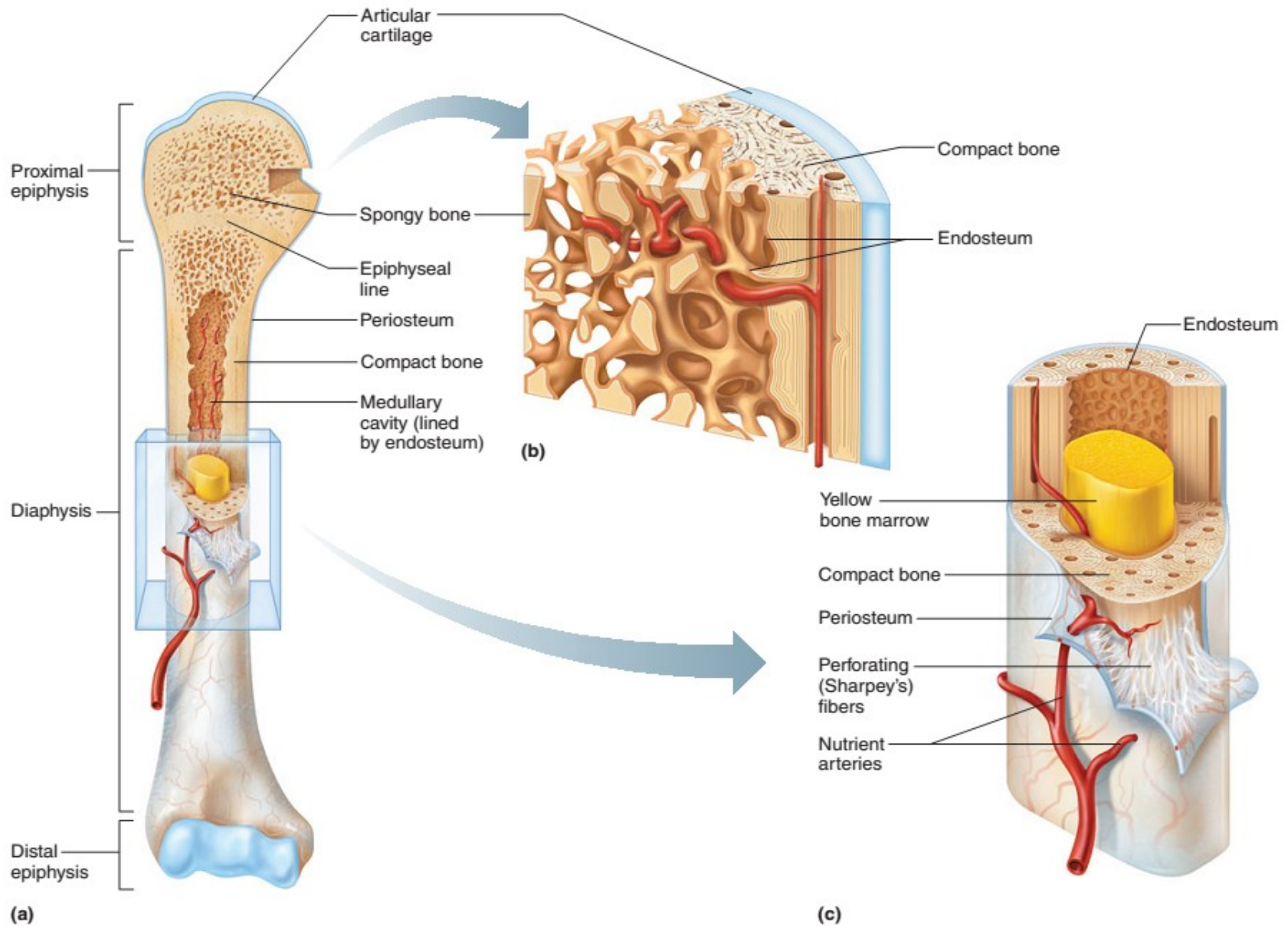
### Function:

- Support
- Protection
- Movement
- Reserve calcium , phosphate, magnesium
- Blood formation

❑ **Macroscopically**, cross-sectional anatomy of bone shows

- ✓ 1. Outer smooth surface called compact bone
- ✓ 2. Internal cortical region called spongy bone
- Has Medullary cavity inside the diaphysis of bone
- Has two membranes that cover bones :- outer membranes called **periosteum** and inner membrane called **endosteum**
- Longitudinally:- long bone is divided in to diaphysis(shaft) and epiphysis (ends of long bone)

# CONNECTIVE TISSUE



# Microscopic Anatomy of compact Bone

## ❑ Osteon (Haversian System)

- A unit of bone

## ❑ Central (Haversian) canal

- Opening in the center of an osteon
- Carries blood vessels and nerves

## ❑ Perforating (Volkman's) canal

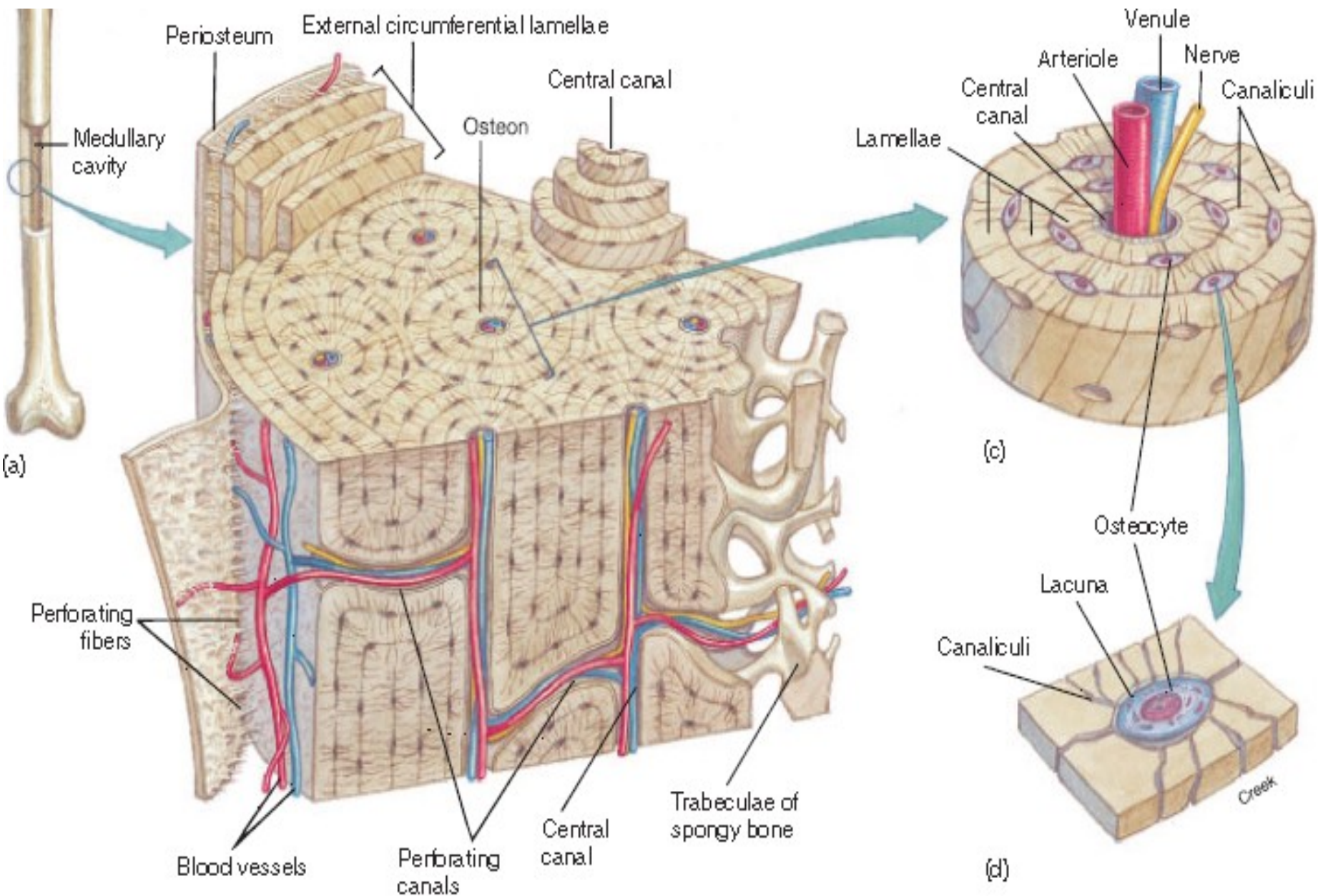
- Canal perpendicular to the central canal
- Carries blood vessels and nerves

## ❑ Lacunae

- Cavities containing bone cells (osteocytes)
- Arranged in concentric rings

## ❑ Lamellae

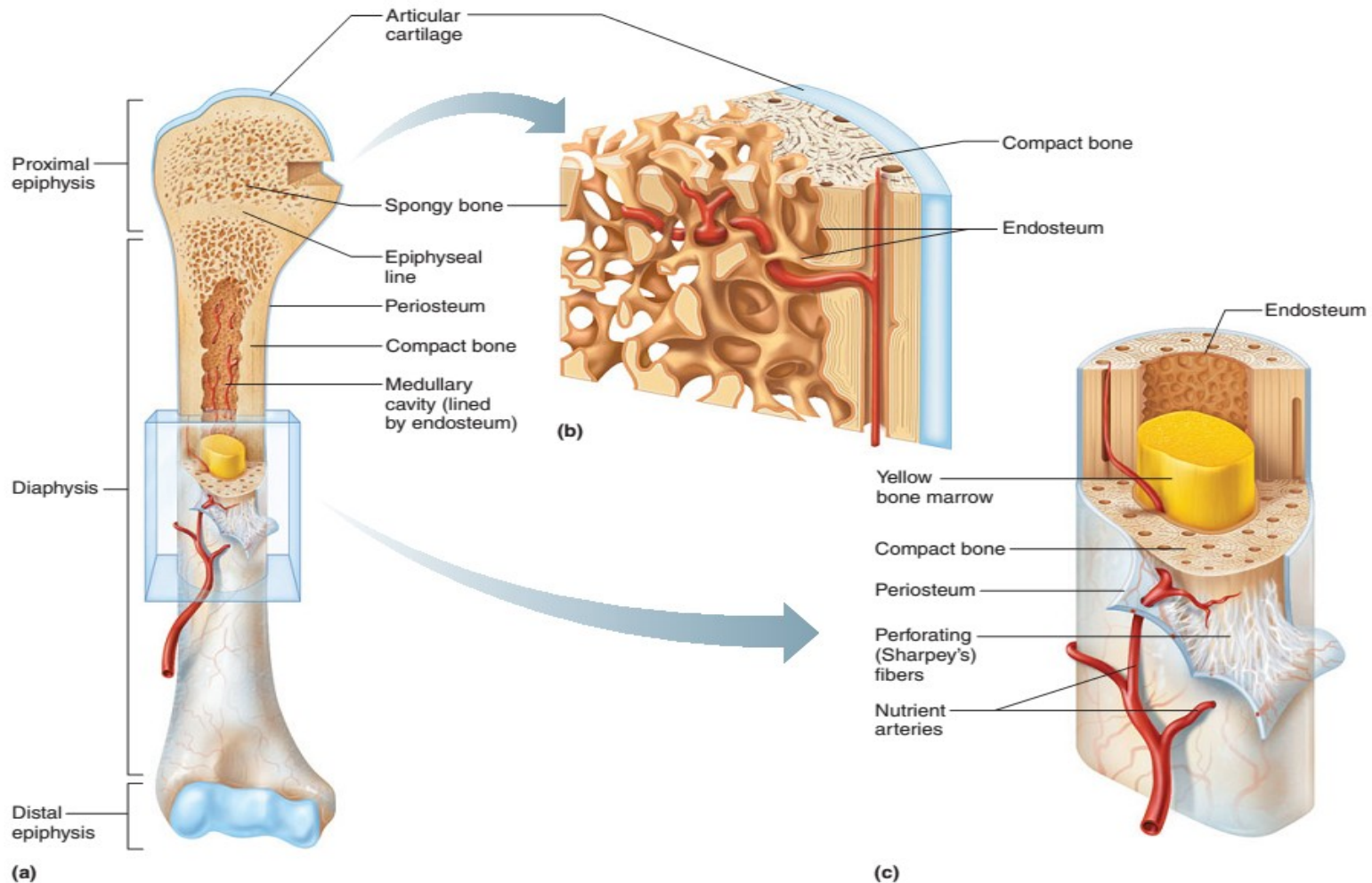
- Rings around the central canal
- Sites of lacunae



# CONNECTIVE TISSUE

## Spongy bone

- In mature bones, spongy bone is composed of interconnected irregular plates called trabeculae.
- Trabeculae surround cavities filled with bone marrow.



## ❑ **Bone Development(ossification): Two Types**

### **1. Intramembranous ossification**

The development of bone from a **fibrous membrane**

Eg. skull, mandible and maxilla

### **2. Endochondral ossification**

The replacement of **hyaline cartilage** with bone . E.g bone of limbs

## **Two types of bone growth**

### **1-Appositional growth:**

By continuous deposition of new compact bone under the periosteum and resorption of bone from the endosteum. Result in increase **thickness**

### **2-Interstitial growth:-**

By continuous replacement of cartilage by bone at the epiphyseal plates. This allows bone to **lengthen** until the age of 22-23 years

## ❑ **ECM and cells of bone tissue**

- **ECM** -**Organic(1/3)**- consists of **type I collagen** (95%).
  - **Inorganic(2/3)**- consists of **hydroxyapatite crystals**, w/c composition  $\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$ .
- **Bone Cells**: osteoprogenitor cells, osteoblasts, osteocytes and osteoclasts.

1. Osteogenic cells - Undergo cell division; the resulting cells develop into osteoblasts

2. Osteoblasts - Bone-building cells

- Synthesize extracellular matrix of bone tissue

3. Osteocytes - Mature bone cells

- Exchange nutrients and wastes with the blood

4. Osteoclasts

Release enzymes that digest the mineral components of bone matrix (resorption) and remove old bone cell



- ❑ This bone: Has been demineralized (decalcified in acids)
  - its inorganic components are removed. **Bone's flexibility depends on collagen fibers.**



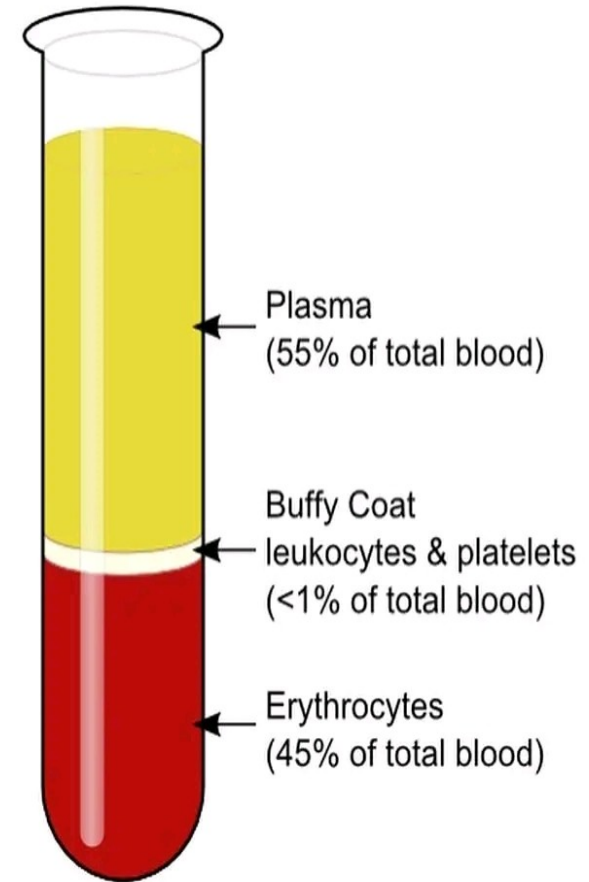
# Blood = formed elements + plasma.

Formed elements = 3 types of blood cells

## BLOOD TISSUE & HEMATOPOIESIS

**Blood** is a specialized connective tissue in which cells, such as **Blood cells/formed elements** are suspended in fluid, ECM called **Plasma**.

- ❑ human adult has about **5 liters of blood**.
- ❑ typical sample of blood is **45% formed elements** and **55% plasma** by volume.
- The **formed elements** include **erythrocytes (red blood cells)**, **leukocytes (white blood cells)** and **platelets**



| Plasma                        |                                 |                                      |
|-------------------------------|---------------------------------|--------------------------------------|
| <b>Water</b><br>92% by weight | <b>Proteins</b><br>7% by weight | <b>Other solutes</b><br>1% by weight |
|                               | Albumins 58%                    | Electrolytes                         |
|                               | Globulins 37%                   | Nutrients                            |
|                               | Fibrinogen 4%                   | Respiratory gases                    |
|                               | Regulatory proteins 1%          | Waste products                       |

| Erythrocytes                                                                        |
|-------------------------------------------------------------------------------------|
| <b>Erythrocytes</b><br>4.2–6.2 million per cubic mm                                 |
|  |



| Buffy Coat                                                                          |                                                                                      |
|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| <b>Platelets</b><br>120–300 thousand per cubic mm                                   | <b>Leukocytes</b><br>5–10 thousand per cubic mm                                      |
|  |   |
|                                                                                     | Lymphocytes<br>20–25%                                                                |
|                                                                                     |   |
|                                                                                     | Neutrophils<br>60–70%                                                                |
|                                                                                     |   |
|                                                                                     | Monocytes 3–8%                                                                       |
|                                                                                     |  |
|                                                                                     | Eosinophils<br>2–4%                                                                  |
|                                                                                     |  |
|                                                                                     | Basophils<br>0.5–1%                                                                  |

- ❑ **White blood cells/leukocytes-** main function defence against microbial invasions.

➤ According to the type of **cytoplasmic granules and the shape of their nuclei, leukocytes** are classified into two:-

**1-Granular leukocytes:-** (which contain specific granules and lobulated nuclei):

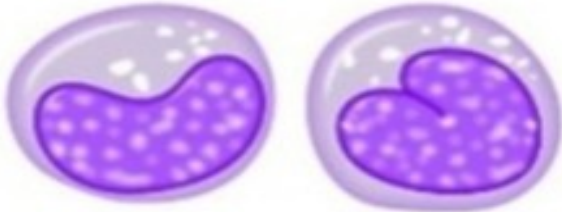
- 1-Neutrophils - 55-70%
- 2-Eosinophils - 2-4%
- 3-Basophils - 0- 1%

**2-Agranular leukocytes:-** (which do not contain specific granules with non-lobulated nuclei):

- 1-Lymphocytes - 20-40%
- 2-Monocytes - 3-8%

- ❑ RBC- carry oxygen to the body tissue by its haemoglobin, no nucleus

- ❑ Platelets' – blood clotting function

| Subtype                                                                                        | Nucleus                  | Function                                                                                                                                                             | Example                                                                               |
|------------------------------------------------------------------------------------------------|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| Neutrophil                                                                                     | Multi-Lobed              | Bacterial or fungal infection. These are the most common first responders to microbial infection.                                                                    |    |
| Eosinophil                                                                                     | Bi-Lobed                 | Parasitic infections and allergic reactions (inflammatory).                                                                                                          |    |
| Basophil                                                                                       | Bi/Tri-Lobed             | Allergic and antigen response (releases histamine causing vasodilation).                                                                                             |    |
| Lymphocyte                                                                                     | Deep Staining, Eccentric | Include B cells, CD4+ helper T cells, and CD8+ cytotoxic T cells. Operate primarily in the lymphatic system.                                                         |   |
| Monocyte<br> | Kidney Shaped            | Phagocytosis of pathogens. Presentation of antigens to T cells. Eventually, they become tissue macrophages, which remove dead cell debris and attack microorganisms. |  |

## Sites of hematopoiesis

Fetus: 0-2 months -Yolk sac

2-7 months -Liver, spleen

5-9 months -Bone marrow

Infants -Bone marrow, practically all bones

Adults -Vertebrae, ribs, sternum, sacrum and Ilium, proximal ends of long bones

### Functions of the blood:

- ❑ **Transport** of gases (oxygen & carbon dioxide), nutrients
  - transport metabolic waste products, cells
  - transport hormones through out the body
- ❑ It carries drugs, elements and cells that protects the body from infections and foreign bodies.

## Bone marrow(BM)- site where all blood cells are form

➤ is soft, fatty tissue found in the **bones** that has many blood vessels.

There are **two** types

**1. Red bone marrow-** composed of **haematopoietic stem cells** that produce **two** other types of stem cells:

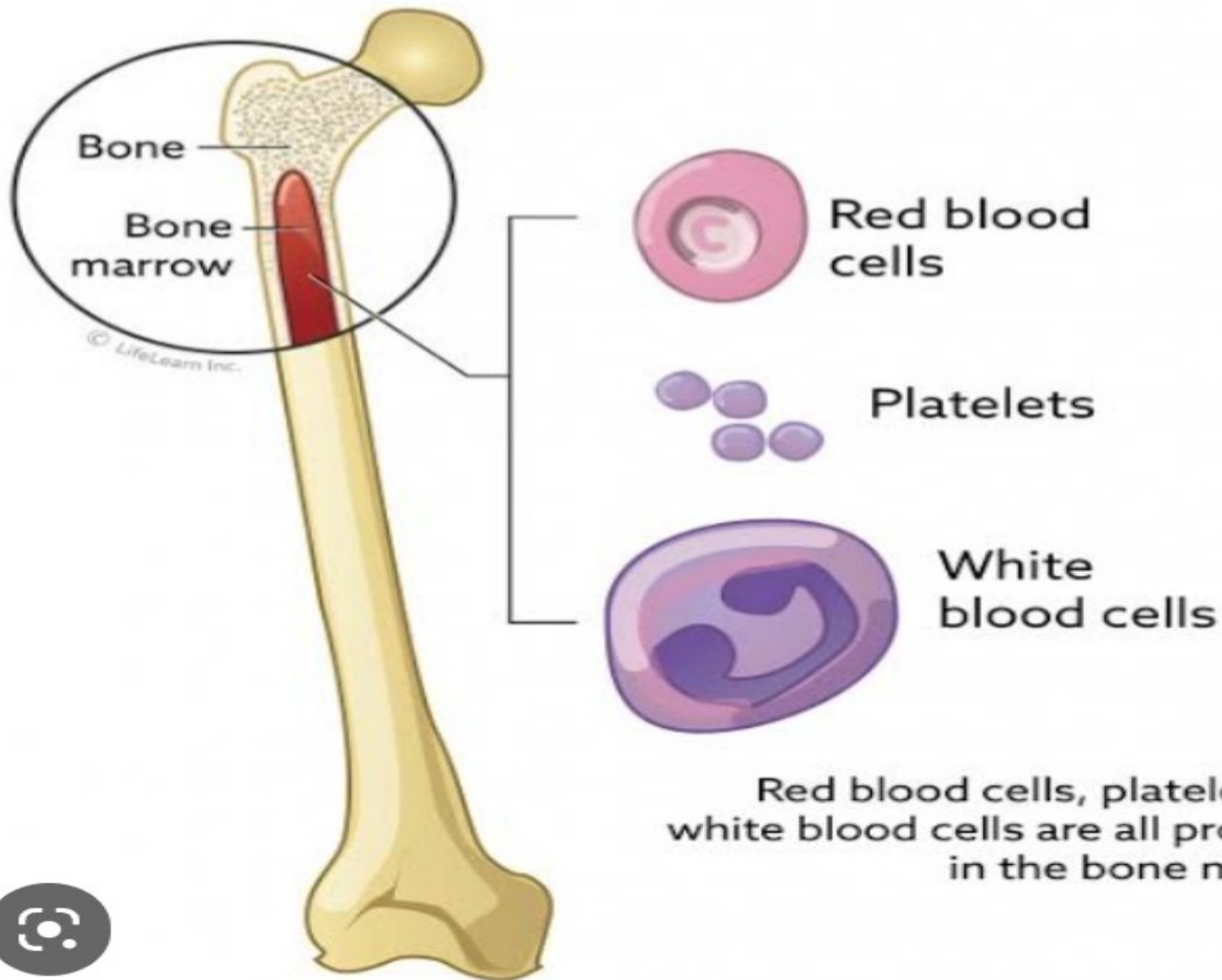
**1. Myeloid stem cells(mature in BM env't)-** include granulocytes, monocytes, erythrocytes, and platelets are develop and mature within BM.

**2. Lymphoid stem cells(mature outside of BM)-**migrate from the bone marrow to the thymus or lymphoid organs, where they mature. E.g. lymphocytes

-Both stem cells develop together into **RBC, WBC, and platelets.**

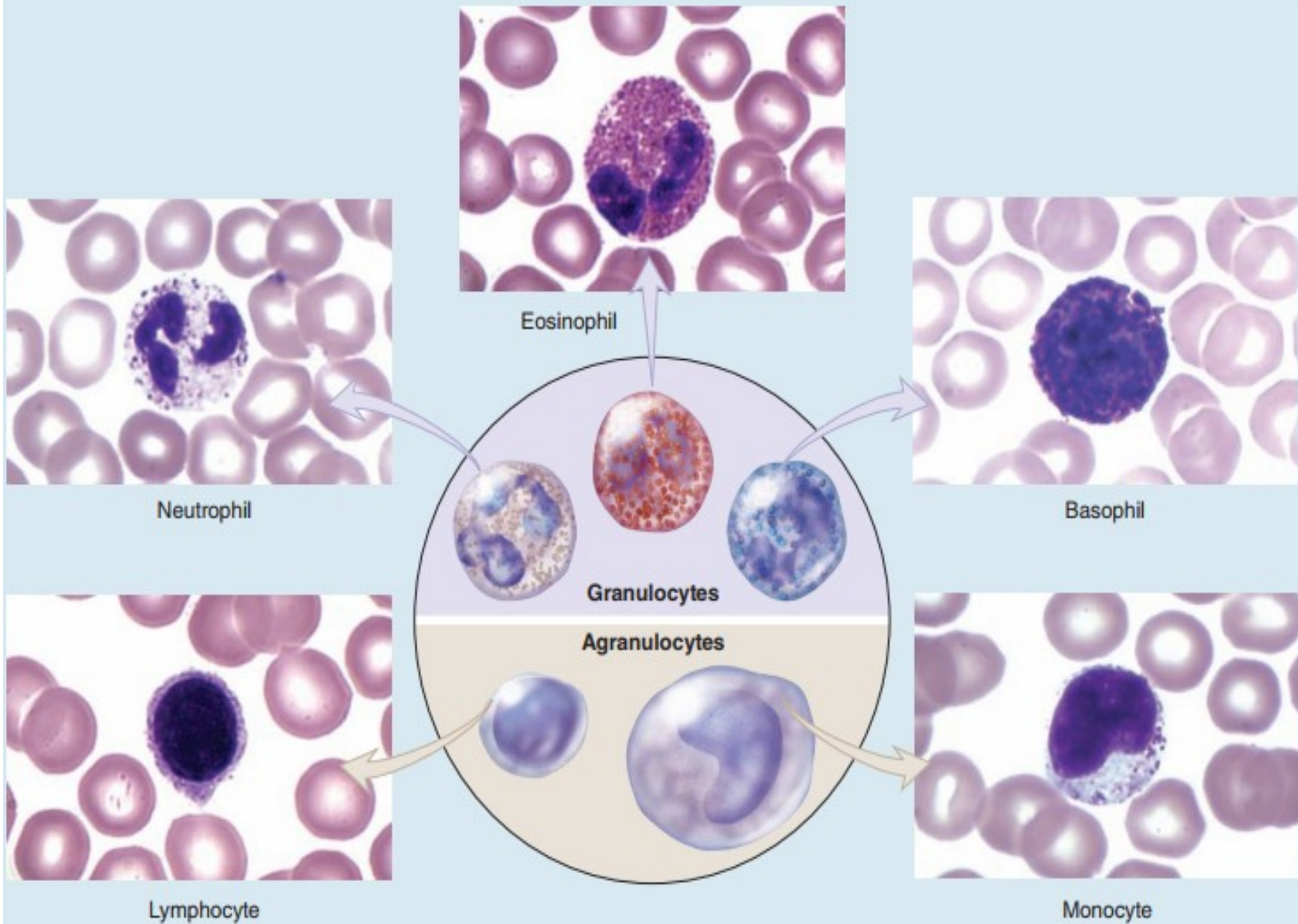
**2. Yellow bone marrow-** mostly made of **fat cells.**

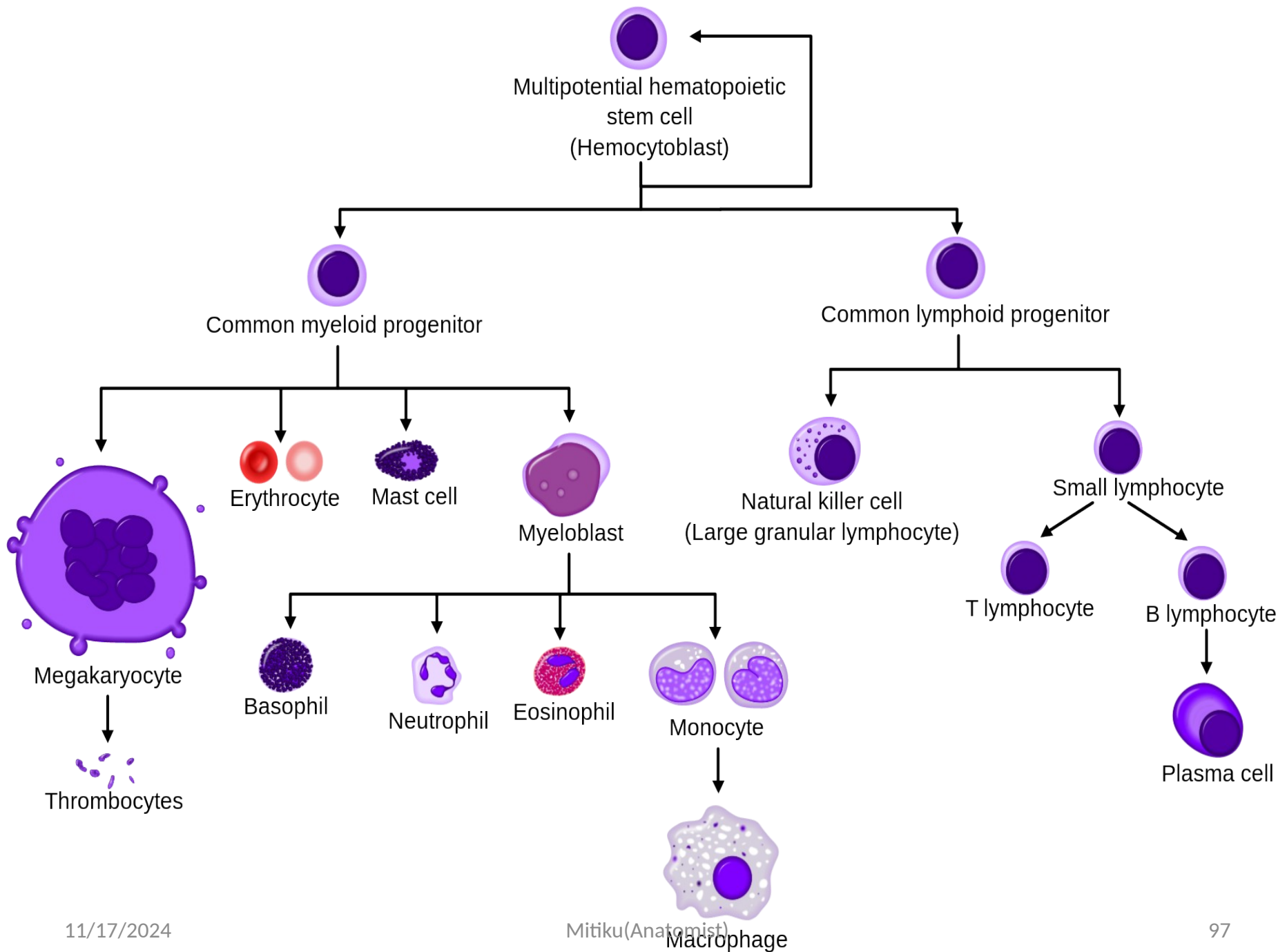
□ it don't form blood but it store fat. It located in spongy bone and in the shaft of long bone.



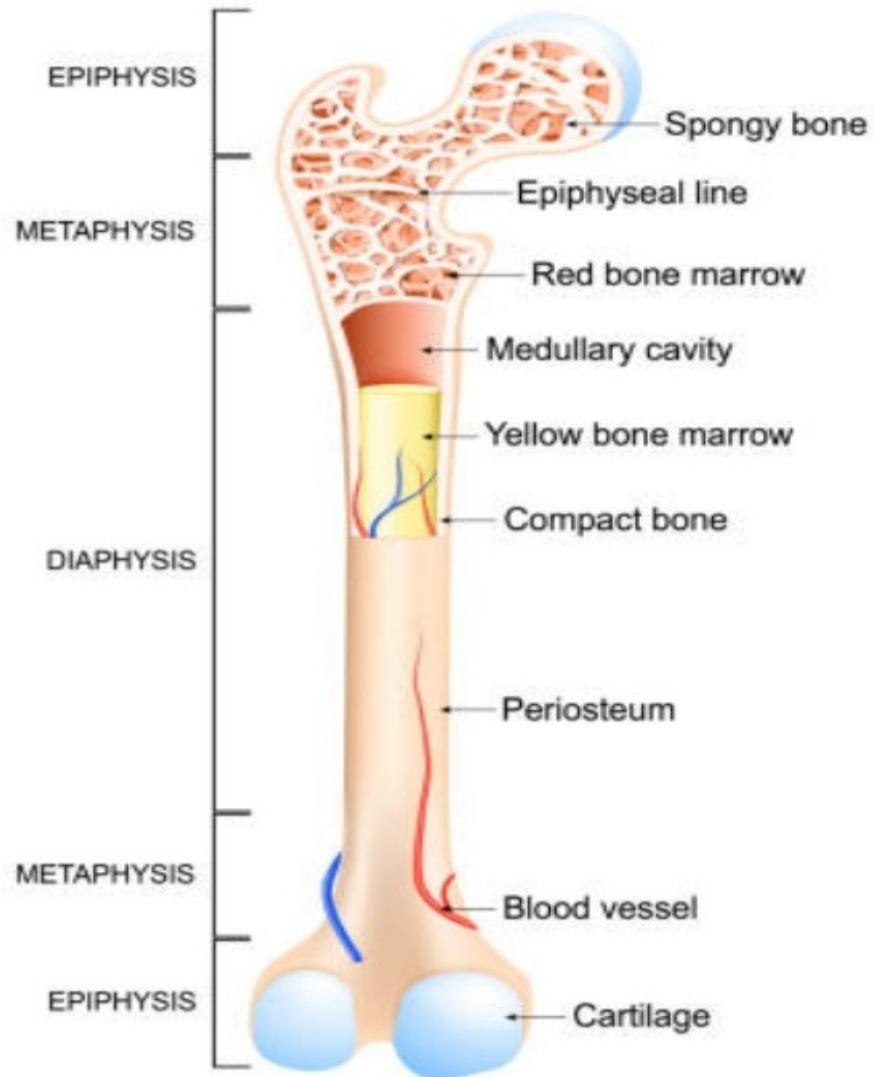
Red blood cells, platelets and white blood cells are all produced in the bone marrow.







# Bone anatomy

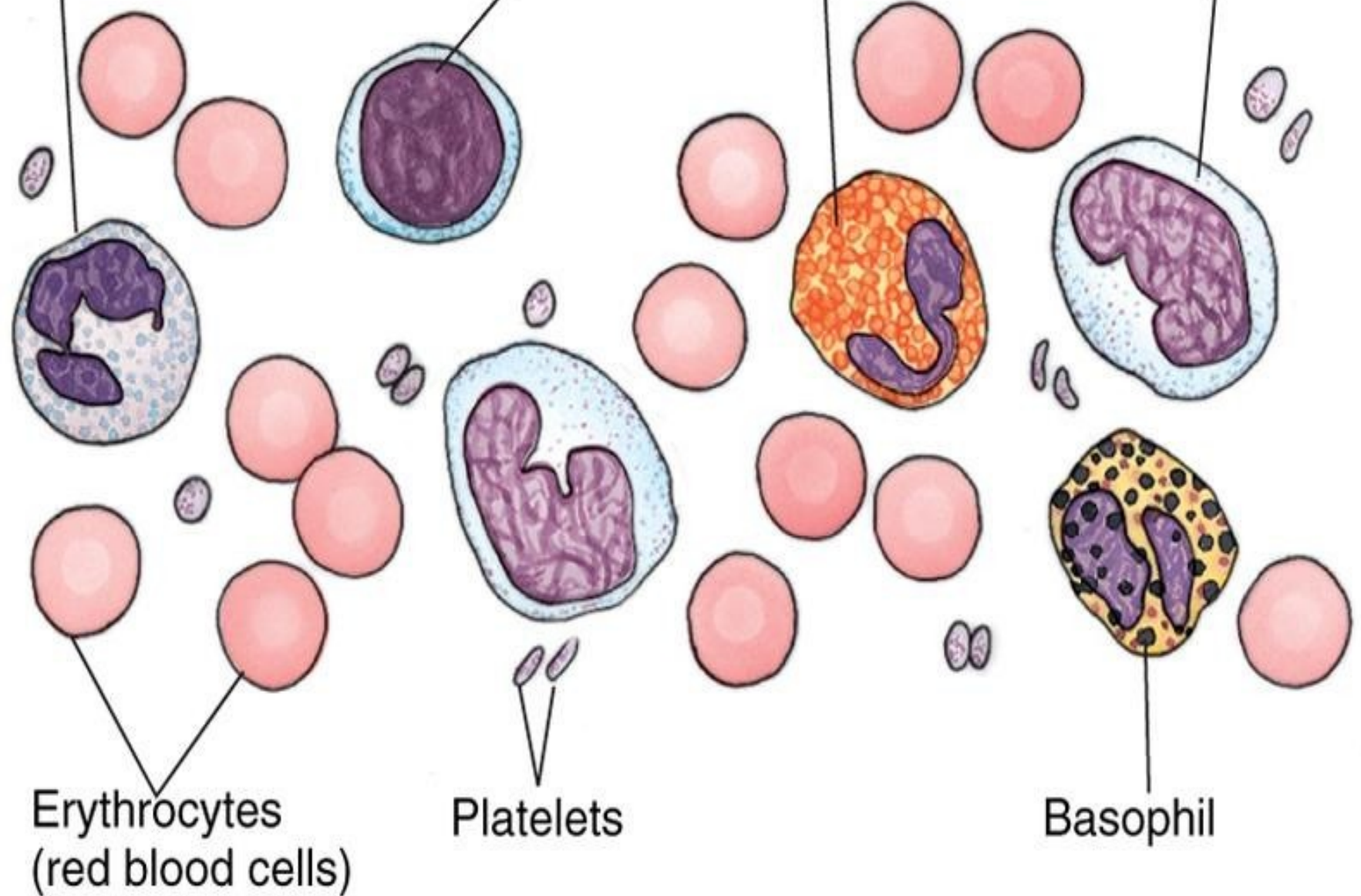


Neutrophil

Lymphocyte

Eosinophil

Monocyte



# THANK YOU