# THE TISSUE LEVELS OF ORGANIZATION


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# TISSUES

- A **tissue** is a group of cells that usually have a common origin in an embryo and function together to carry out specialized activities.

- The structure and properties of a specific tissue are influenced by factors such as ***the nature of the extracellular material*** that surrounds the tissue cells and ***the connections between the cells*** that compose the tissue.

- **Tissues may be** hard, semisolid, or even liquid in their consistency, a range exemplified by bone, fat, and blood.

- Tissues vary tremendously with respect to the **kinds** of cells present, how the cells are **arranged**, and the **types of fibers** present, if any.

# TYPES OF TISSUES

*Body tissues can be classified into four basic types according to their structure and function:*

- ✓ Epithelial Tissue: **covers** body surfaces and lines hollow organs, body cavities, and ducts; it also **forms glands**. This tissue allows the body to interact with both its internal and external environments.
- ✓ Connective Tissue: **protects and supports** the body and its organs. Various types of connective tissues bind organs together, store energy reserves as fat, and help provide the body with immunity to disease-causing organisms.
- ✓ Muscle Tissue: is composed of cells specialized for **contraction** and generation of **force**. In the process, muscular tissue generates heat that warms the body.
- ✓ Nervous Tissue : **detects changes** in a variety of conditions inside and outside the body and **responds** by generating electrical signals called nerve action potentials (nerve impulses) that activate muscular contractions and glandular secretions.

# CELL JUNCTIONS- introduction

- **Cell junctions** are contact points between the plasma membranes of tissue cells.

→ ***examine how cells are held together to form tissues?***

→ Most epithelial cells and some muscle and nerve cells are tightly joined ***into functional units***

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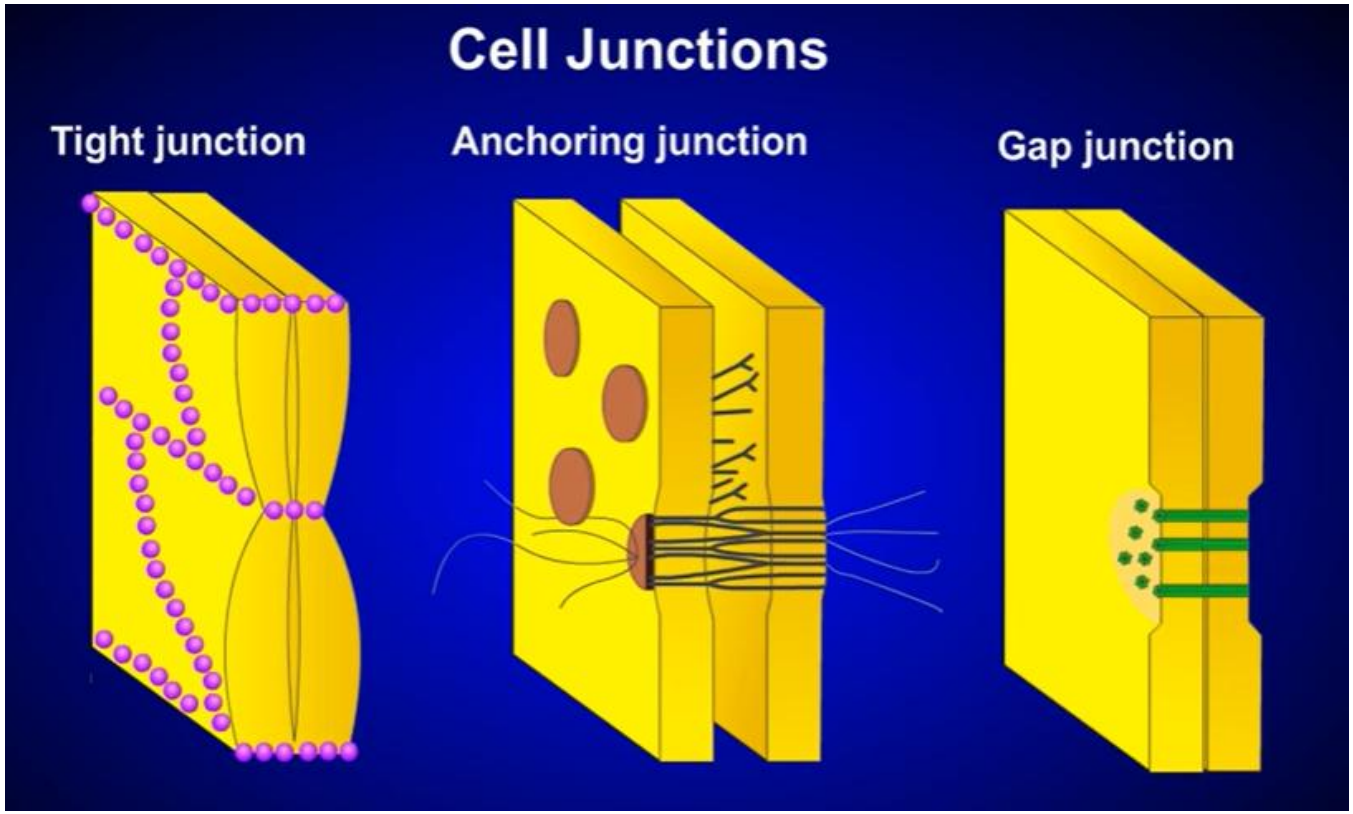



Reference: https://youtu.be/gJ9WTD0XEnc?si=3oVg7f0ahvPnXmDs

# The five most important types of cell junctions :

1- **Tight junctions:** = Occluding junction

Weblike strands of transmembrane proteins that **fuse together the outer surfaces of adjacent plasma membranes** to **seal off** passageways between adjacent cells. Cells of epithelial tissue that lines the stomach, intestines, and urinary bladder have many tight junctions. They inhibit the passage of substances between cells and prevent the contents of these organs from leaking into the blood or surrounding tissues.

2- **Adherens junctions:** = Anchoring junction

This type of junction help epithelial **surfaces resist separation during various contractile activities**, as when food moves through the intestines. In epithelial cells, adherens junctions often form extensive zones called **adhesion belts** because they encircle the cell similar to the way a belt encircles your waist.

# CELL JUNCTIONS (continued-1)

## 3- **Desmosomes:** = Anchoring junction

This structural arrangement contributes to the **stability** of the cells and tissue. These spot ***weld–like junctions*** are common among the cells that make up the epidermis (the outermost layer of the skin) and among cardiac muscle cells in the heart. Desmosomes **prevent epidermal cells from separating under tension** and cardiac muscle cells from pulling apart during contraction.

## 4- **Hemidesmosomes:** = Anchoring junction

Resemble desmosomes, but **hemidesmosomes anchor cells not to each other but to the basement membrane.** The name arises from the fact that they look like half of a desmosome.

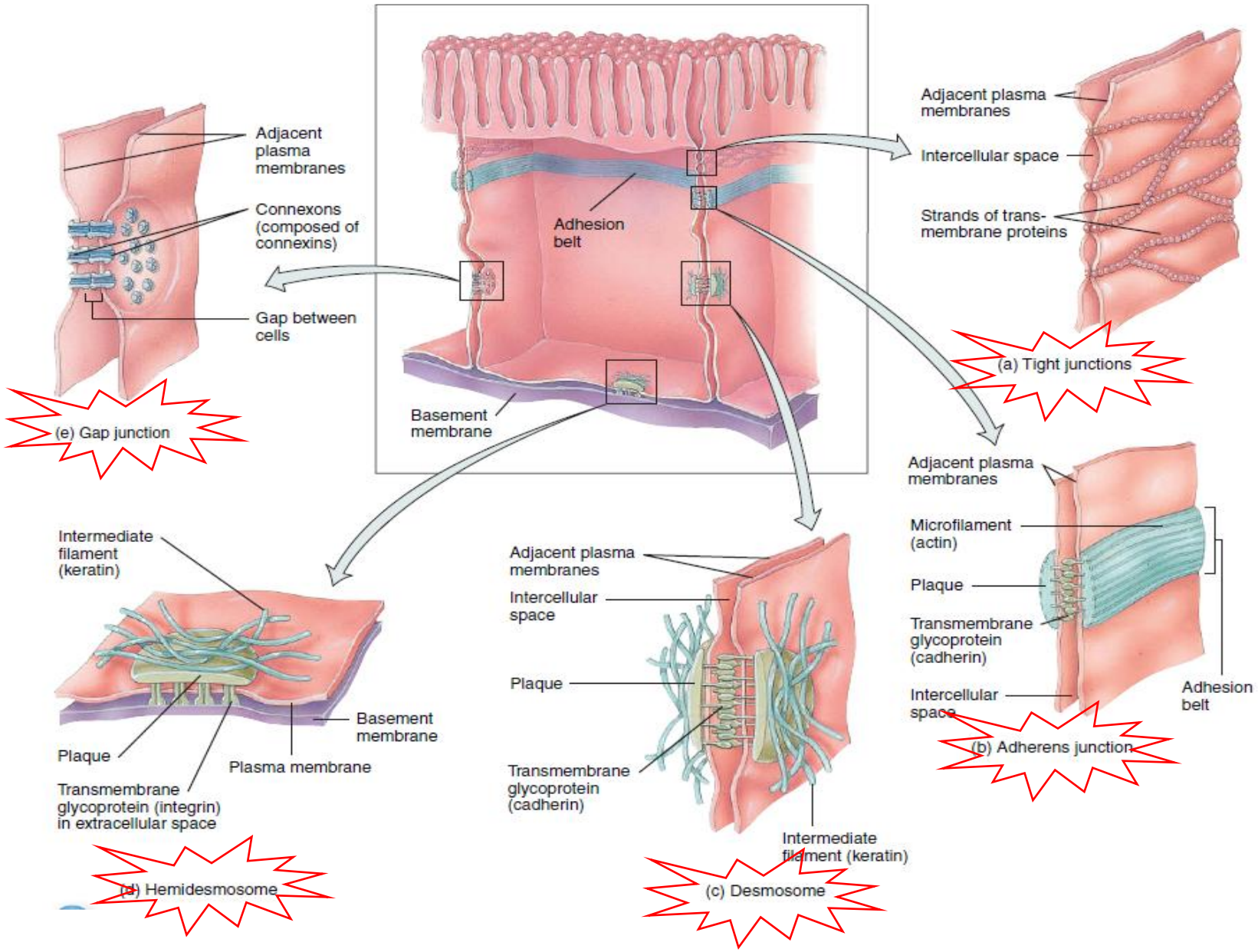
# CELL JUNCTIONS (continued-2)

## 5- **Gap junctions** = Communicating junctions

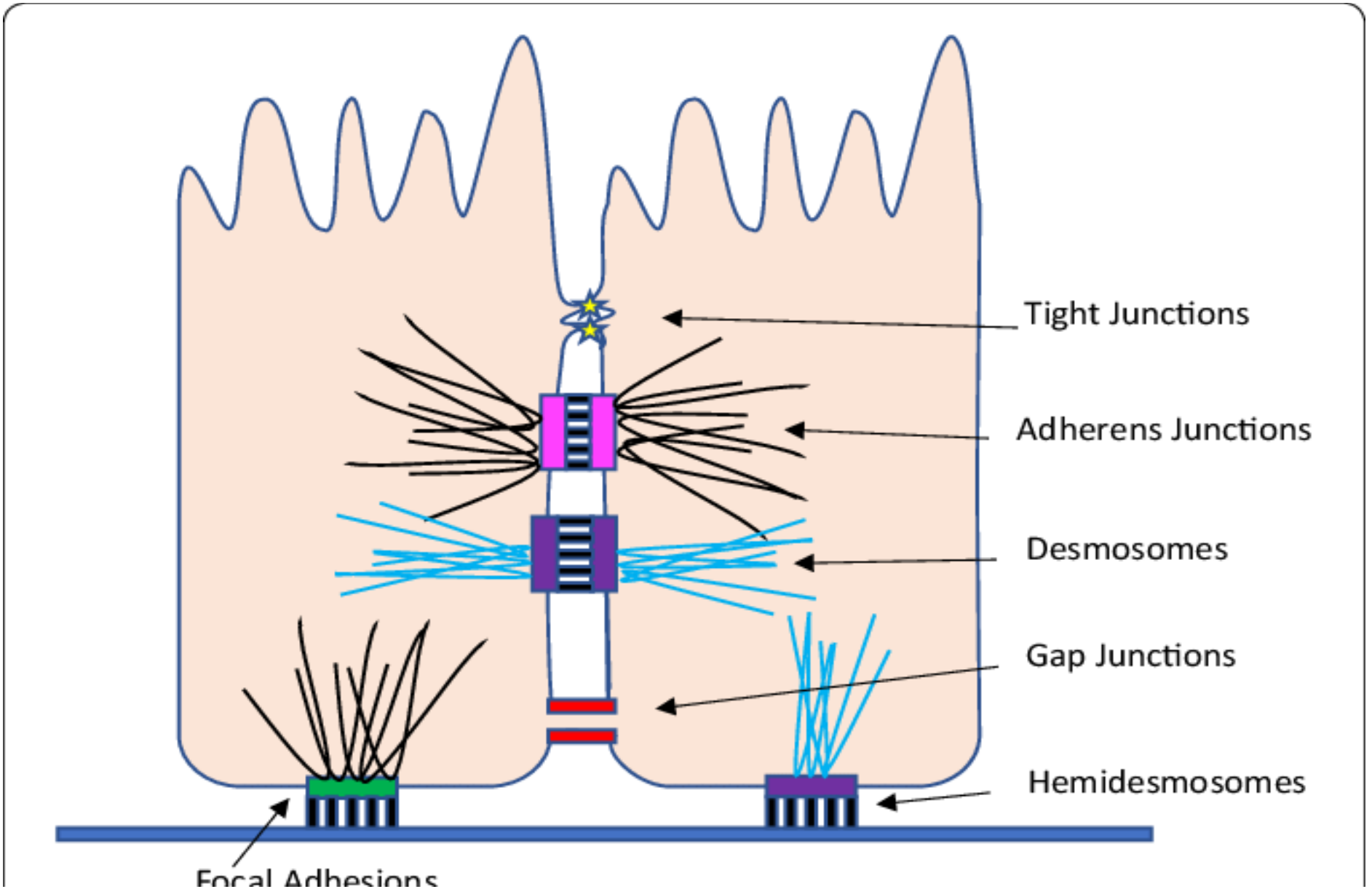
At **gap junctions,** membrane proteins called **connexins** form tiny fluid-filled tunnels called *connexons* that **connect neighboring cells**. The plasma membranes of gap junctions are not fused together as in tight junctions but are *separated by a very narrow intercellular gap (space)*. Through the connexons, ions and **small** molecules can diffuse from the cytosol of one cell to another, but the passage of large molecules such as vital intracellular proteins is prevented. The transfer of nutrients, and perhaps wastes, takes place through gap junctions in **avascular** tissues such as the lens and cornea of the eye. **Gap junctions allow the cells in a tissue to communicate with one another**.

Gap junctions enable nerve or muscle impulses to spread rapidly among cells, a process that is crucial for the normal operation of some parts of the nervous system and for the contraction of muscle in the heart, gastrointestinal tract, and uterus.

# Cell Junctions *Most epithelial cells and some muscle and nerve cells contain cell junctions.*



# Cell Junctions



# EPITHELIAL TISSUE

- An epithelial tissue (ep-i-THE¯-le¯-al) or epithelium (plural is epithelia) consists of cells arranged in continuous sheets, in either single or multiple layers.

- **Characteristics**:

✓ The cells are closely packed and are held tightly together by many cell junctions. Composed of one or more layers of closely packed cells that form a *barrier* between two compartments having different components.

✓ There is **little or no** intercellular space between adjacent plasma membranes.

✓ Epithelial tissue forms coverings and linings throughout the body. It is not covered by another tissue, so it always has a free surface. → both the external and internal lining of many organs.

✓ Constitutes the majority of glands.

✓ No blood vessels penetrate an epithelium→ *AVASCULAR*

✓ It is repeatedly subjected to physical stress and injury. A high rate of cell division allows epithelial tissue to constantly renew and repair itself.

# Characteristics of Epithelial Tissue:

## 1- Cellularity

- Composed almost entirely of cells bound closely together by different types of cell junctions.

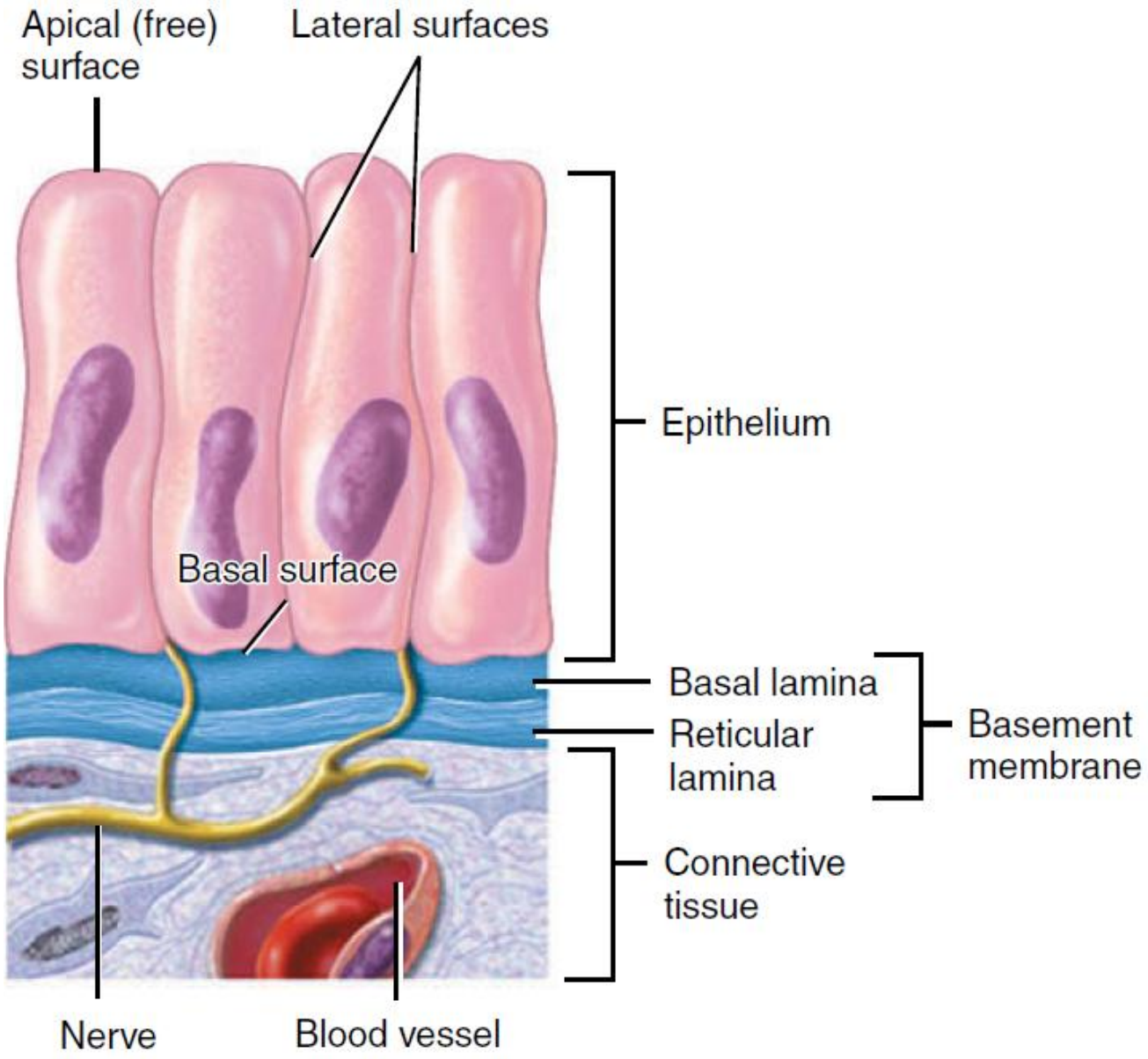
# Characteristics of Epithelial Tissue:
# 2- Polarity:

- The **apical** (*free*) **surface** of an epithelial cell faces the body surface,
- The **lateral surfaces** of an epithelial cell, which face the adjacent cells on either side, may contain tight junctions, adherens junctions, desmosomes, and/or gap junctions.
- The **basal surface** of an epithelial cell is opposite the apical surface. The basal surfaces of the deepest layer of epithelial cells adhere to extracellular materials such as the basement membrane→ fixed, or bottom surface

**NOTE**: Epithelia with ***multiple*** layers, the term *apical layer* refers to the most superficial layer of cells, and the *basal layer* is the deepest layer of cells

→ Surfaces of epithelial cells and the structure and location of the basement membrane.

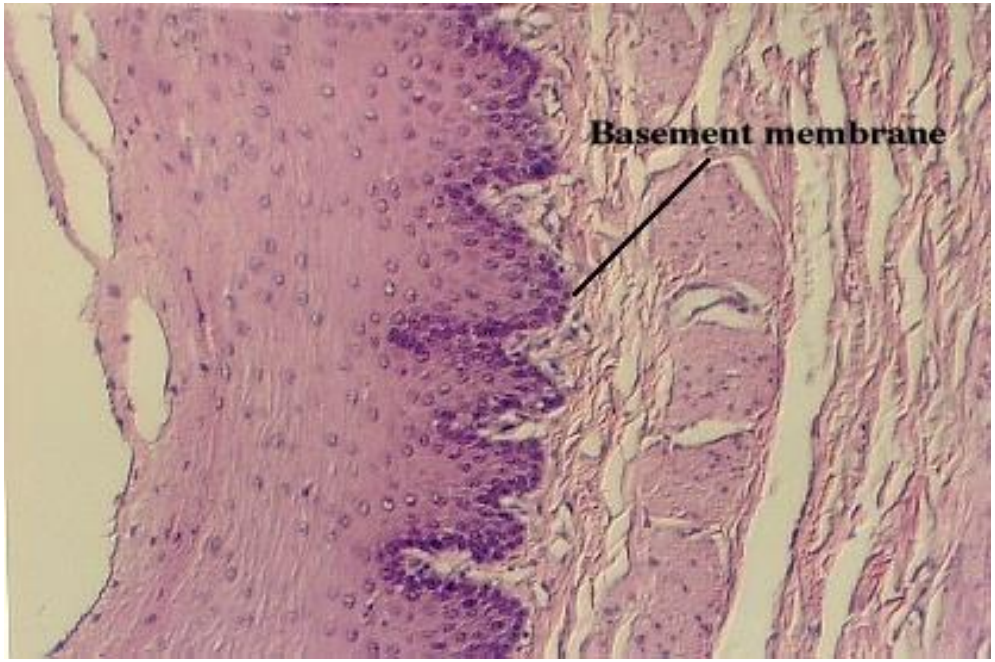
→ The basement membrane is found between an epithelial tissue and a connective tissue.



# Characteristics of Epithelial Tissue:

## 3- Attachment

- The basal surface of an epithelium is bound to a thin basement membrane.

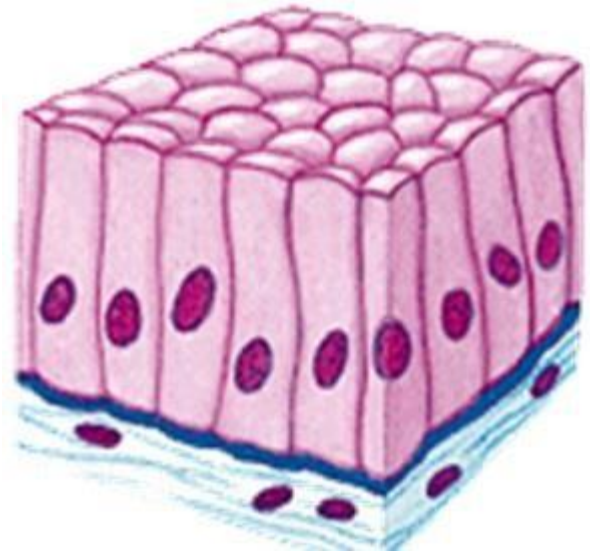


# Characteristics of Epithelial Tissue:

## 4- Avascularity

- Lack blood vessels.

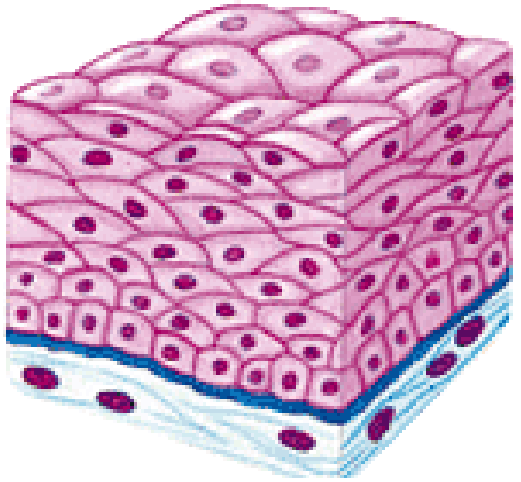
- Nutrients obtained either directly across the apical surface or by diffusion across the basal surface.

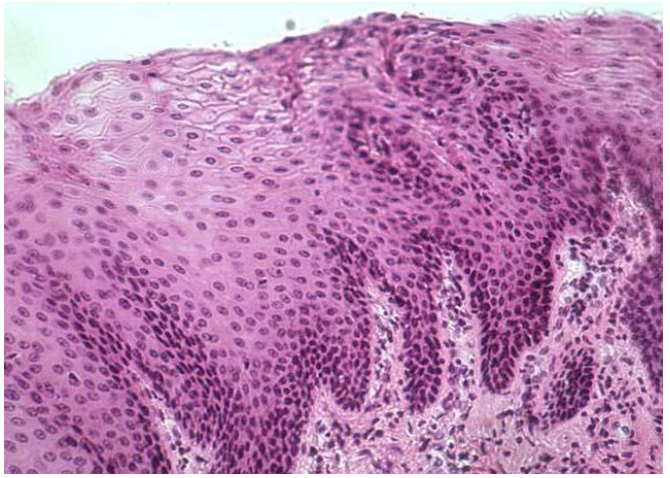


# Characteristics of Epithelial Tissue:

## 5- Innervation

- Some epithelia are richly innervated to detect changes in the environment at that body or organ surface.
- Most nervous tissue is in the underlying connective tissue.





# Characteristics of Epithelial Tissue:

## 6- Regeneration Capacity

- Frequently damaged or lost by abrasion and is replaced via **high regeneration capacity.**
- Continual replacement occurs through the divisions of the deepest epithelial cells (called stem cells) near its base.

# Functions of Epithelial Tissue

- Epithelial tissue has major functions:

(1) a selective barrier that limits or aids the transfer of substances into and out of the body→ regulation.

(2) a secretory surface that releases products produced by the cells onto its free surfaces.

(3) a protective surface that resists the abrasive influences of the environment.

(4) Nerve endings detect changes in the external environment at their surface. Continuously supply information to the nervous system concerning touch, pressure, temperature, and pain.

Epithelial tissues are classified according to:

1) Number of cell layers
2) Shape of superficial cells
3) Modifications at their free surface.

# Epithelial tissues are classified according to:

## 1- Number of cell layers:

→ Simple (monolayer of cells) epithelia

→ Stratified (at least 2 cell layers) epithelia

→ Pseudostratified epithelia: *cell nuclei lie at different levels and not all cells reach the apical surface; it is actually a simple epithelium because **all** its cells rest on the basement membrane.*

# Epithelial tissues are classified according to:

## 2- Shape of cells:

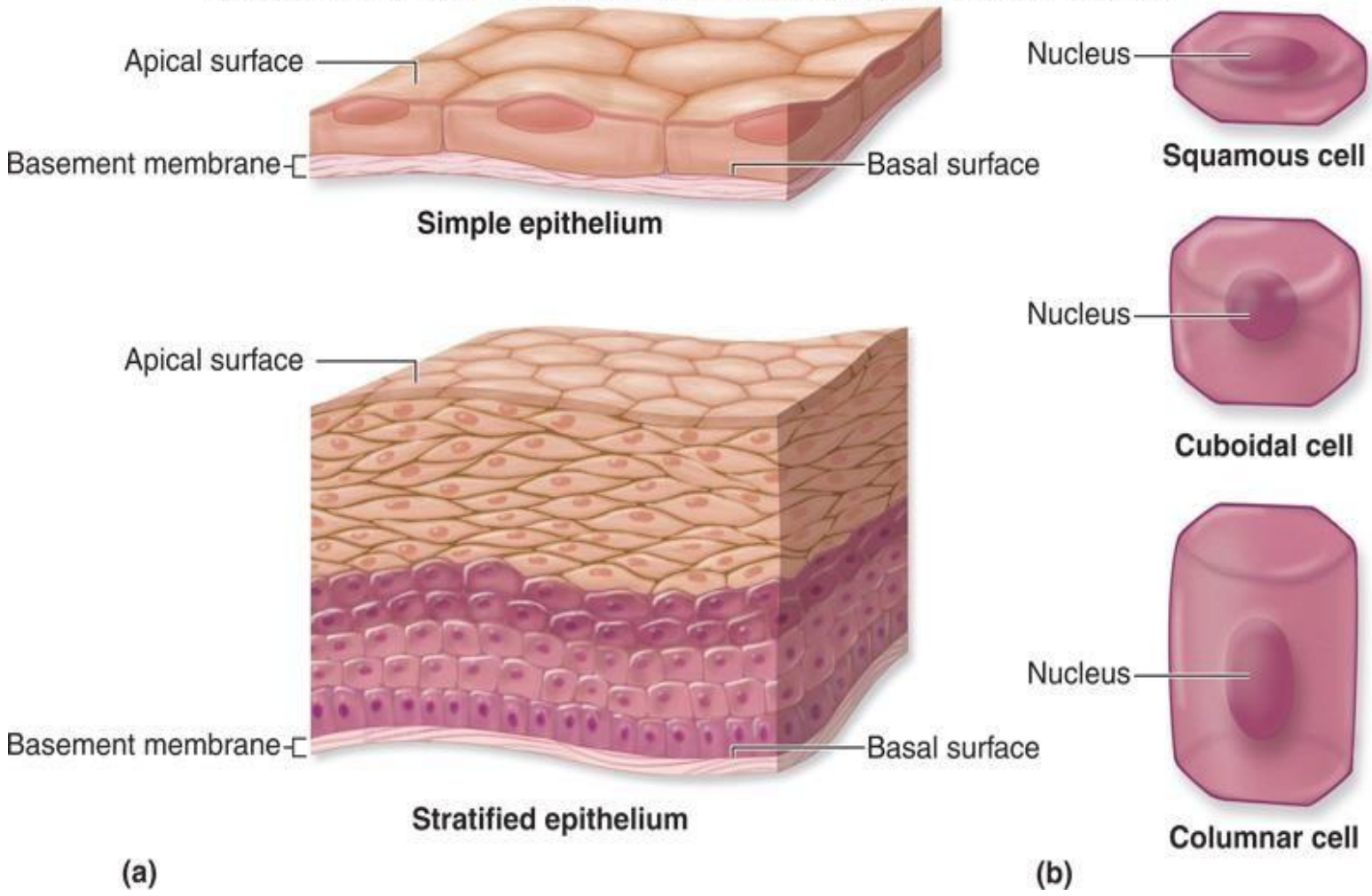
a. *Squamous* cells (SKWA¯-mus flat) are thin, which allows for the rapid passage of substances through them.

b. *Cuboidal* cells are as tall as they are wide and are shaped like cubes or hexagons. They may have microvilli at their apical surface and function in either secretion or absorption.

c. *Columnar* cells are much taller than they are wide, like columns, and protect underlying tissues. Their apical surfaces may have cilia or microvilli, and they often are specialized for secretion and absorption.

d. *Transitional* cells change shape, from squamous to cuboidal and back, as organs such as the urinary bladder stretch (distend) to a larger size and then collapse to a smaller size.

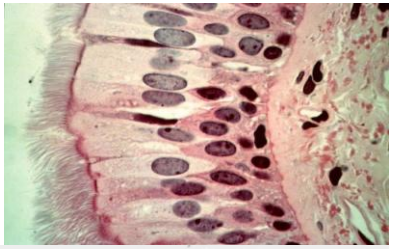
→ *In **relaxed** or unstretched state, looks like stratified **cuboidal** epithelium, except apical layer cells tend to be large and rounded. As tissue is **stretched**, cells become flatter, giving the appearance of stratified squamous epithelium. Multiple layers and elasticity make it ideal for lining hollow structures (urinary bladder) subject to expansion from within.*

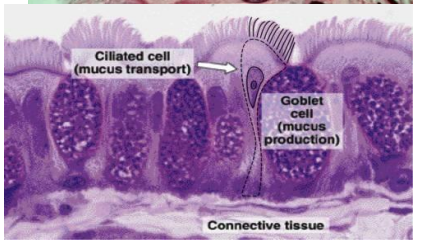


# Epithelial tissues are classified according to:

<u>3- Modifications at their free surface:</u>

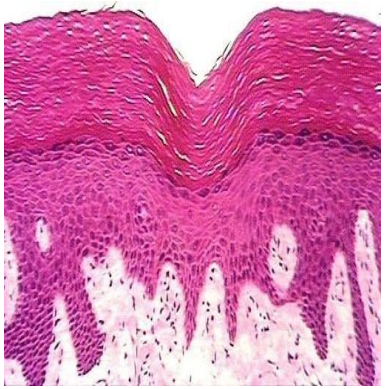
A- Cilia→ **Pseudostratified ciliated columnar epithelium .** Appears to be layered but it is not. eg: Lines the bronchi, trachea






B- Keratinized→ tough layer of keratin in apical layer of cells and several layers deep to it.

→ Relative amount of keratin increases in cells as they move away from nutritive blood supply and organelles die.



# Arrangements Of Epithelial Tissues:

When we combine the two characteristics (arrangements of layers and cell shapes), we come up with the following types of epithelial tissues:

I. Simple epithelium

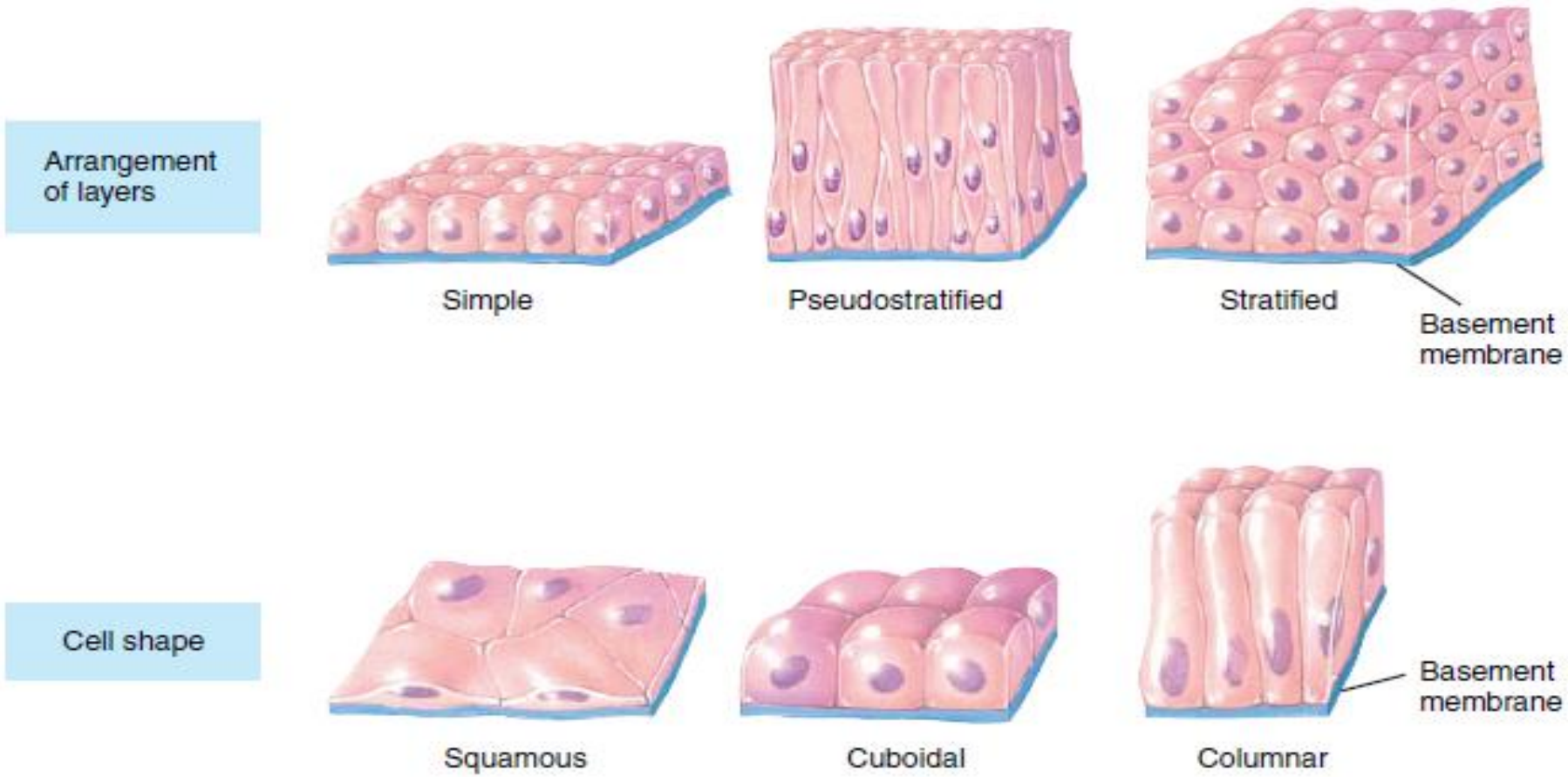
- A. Simple squamous epithelium
- B. Simple cuboidal epithelium
- C. Simple columnar epithelium (nonciliated and ciliated)
- D. Pseudostratified columnar epithelium (nonciliated and ciliated)

II. Stratified epithelium

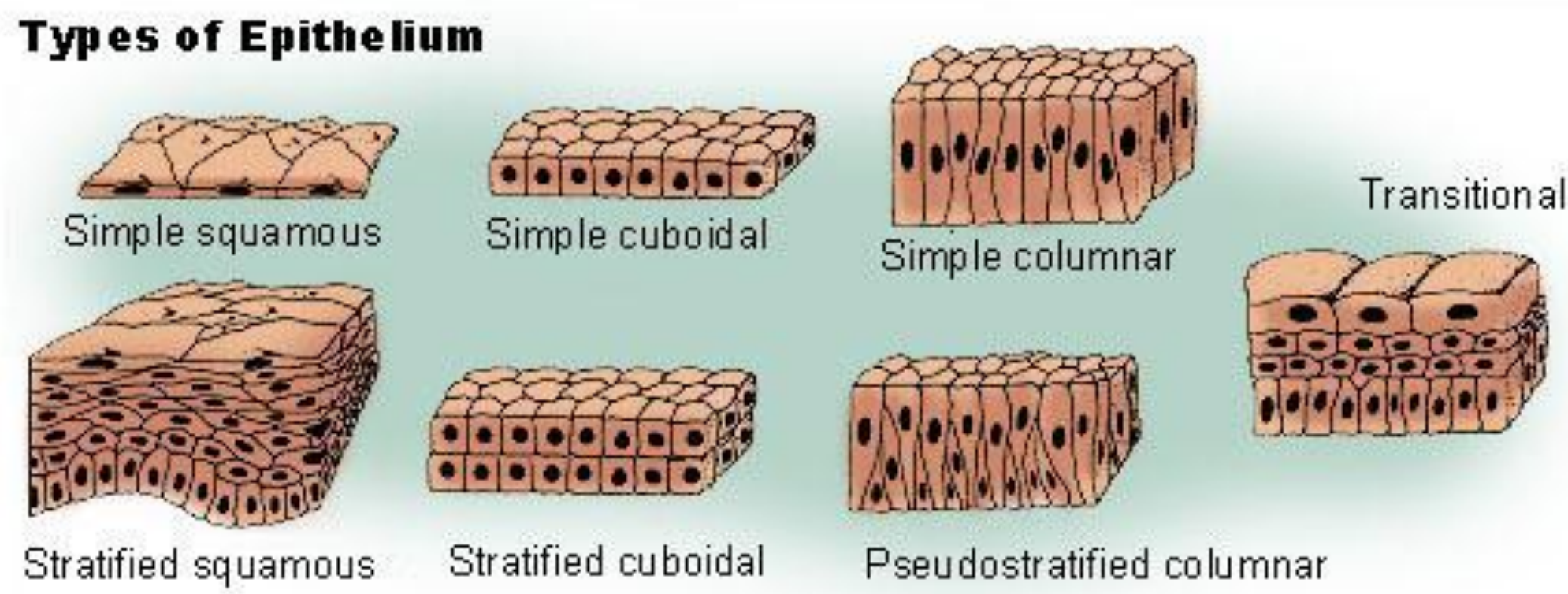
- A. Stratified squamous epithelium (keratinized, when surface cells are dead and become hardened, and nonkeratinized, when surface cells remain alive)*
- B. Stratified cuboidal epithelium*
- C. Stratified columnar epithelium*
- D. Transitional epithelium

**This classification is based on the shape of the cells in the apical layer.*

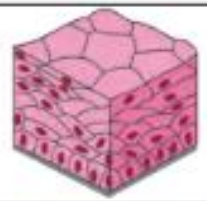
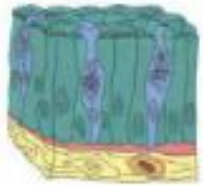
## Cell shapes and arrangement of layers for covering and lining epithelium



Reference: https://en.wikipedia.org/wiki/File:Illu_epithelium.jpg



## Types of epithelial tissues

| Name | Appearance (diagrammatic) | Location | Sturcture | Function |
|---|---|---|---|---|
| Squamous epithelium |  | Inner surface of mouth, oesophagus, blood-vessels, alveoli | Thin, small, flat cells form semipermeable membrane. | Selective transport of substances. |
| Stratified epithelium |  | Outer layer of skin | Many layers of cells | Prevention of wearing of organs, protection of organs. |
| Glandular epithelium |  | Inner layer of skin, etc. | Cells contain vesicles packed with secretory material | Secretion of sweat, oil (sebum), mucus, etc. |
| Columnar epithelium |  | Inner surface (mucosa) of intestine, alimentary canal | Column-like tall cells. Upper free surface bears folds made of these cells at places of absorption | Secretion of digestive juice, absorption of nutrients |
| Ciliated Epithelium |  | Inner surface of respiratory tract | Upper free surface of cells bears minute hair-like processes | Push mucus and air forward to keep the air passage free |
| Cuboidal epithelium |  | Tubules of kidney (nephron), salivary gland | Cells are cuboidal | Reabsorption of useful materials from urine, secretion of saliva |

Reference: https://pediaa.com/what-is-the-difference-between-myoepithelial-and-lamina-epithelial-cells/

# MYOEPITHELIAL CELLS VERSUS LAMINA EPITHELIAL CELLS

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| MYOEPITHELIAL CELLS | LAMINA EPITHELIAL CELLS |
| --- | --- |
| The monolayer of specialized pavement-like cells that often line the body's serous cavities and vital organs | A type of cells that line the outer surface of the organs and blood vessels and inner surface cavities of the many internal organs |
| Thin and spindle-shaped and ultrastructurally possess a number of Cytoplasmic processes that extend between and over the acinar and ductal-lining cells | Thin, continuous, protective layer of compactly packed cells with a little intercellular matrix |
| Occur in multiple glandular organs such as the lacrimal, salivary, harderian, sweat, prostate, and mammary glands | Line the internal organs and body cavities and form the outer layer of the skin |
| Regulate the flow of fluid and control the entry and exit of nutrients, electrolytes, and other growth factors | Diffusion, filtration, secretion, selective absorption, germination, and transcellular transport are the functions |

# Glandular Epithelium→ SPECIAL EPETHELIUM!!

- ✓ **The function of glandular epithelium** is secretion, which is accomplished by glandular cells that often lie in clusters deep to the covering and lining epithelium.

- ✓ A **gland** may consist of a single cell or a group of cells that secrete substances into ducts (tubes), onto a surface, or into the blood in the absence of ducts.

- ✓ All glands of the body are classified as either endocrine or exocrine.

## Glandular Epithelium (continued)

- ENDOCRINE GLANDS

➢ The secretions of **endocrine glands**, called hormones, enter the interstitial fluid and then diffuse directly into the bloodstream without flowing through a duct.

➢ Endocrine secretions have far-reaching effects because they are distributed throughout the body by the bloodstream.

- EXOCRINE GLANDS

➢ Secrete their products *into ducts* that empty onto the surface of a covering and lining epithelium such as the skin surface or the lumen of a hollow organ.

➢ The secretions of exocrine glands have limited effects and some of them would be harmful if they entered the bloodstream.

- **Some glands of the body, such as the pancreas, ovaries, and testes, are mixed glands that contain both endocrine and exocrine tissue.**

# Classification of Exocrine Glands

A. Form and structure (morphology)
B. Type of secretion
C. Method of secretion

# *A. Structural Classification of Exocrine Glands*

- **Exocrine glands are classified as unicellular or multicellular.**

✓ **Unicellular glands** are single-celled glands.

- → Examples include: goblet cells, important unicellular exocrine glands that secrete mucus directly onto the apical surface of a lining epithelium.

✓ **Multicellular glands (**Most exocrine glands**),** composed of many cells that form a distinctive microscopic structure or macroscopic organ.

- → Examples include sudoriferous (sweat), sebaceous (oil), and salivary glands.

# *A. Structural Classification of Exocrine Glands (continued)*

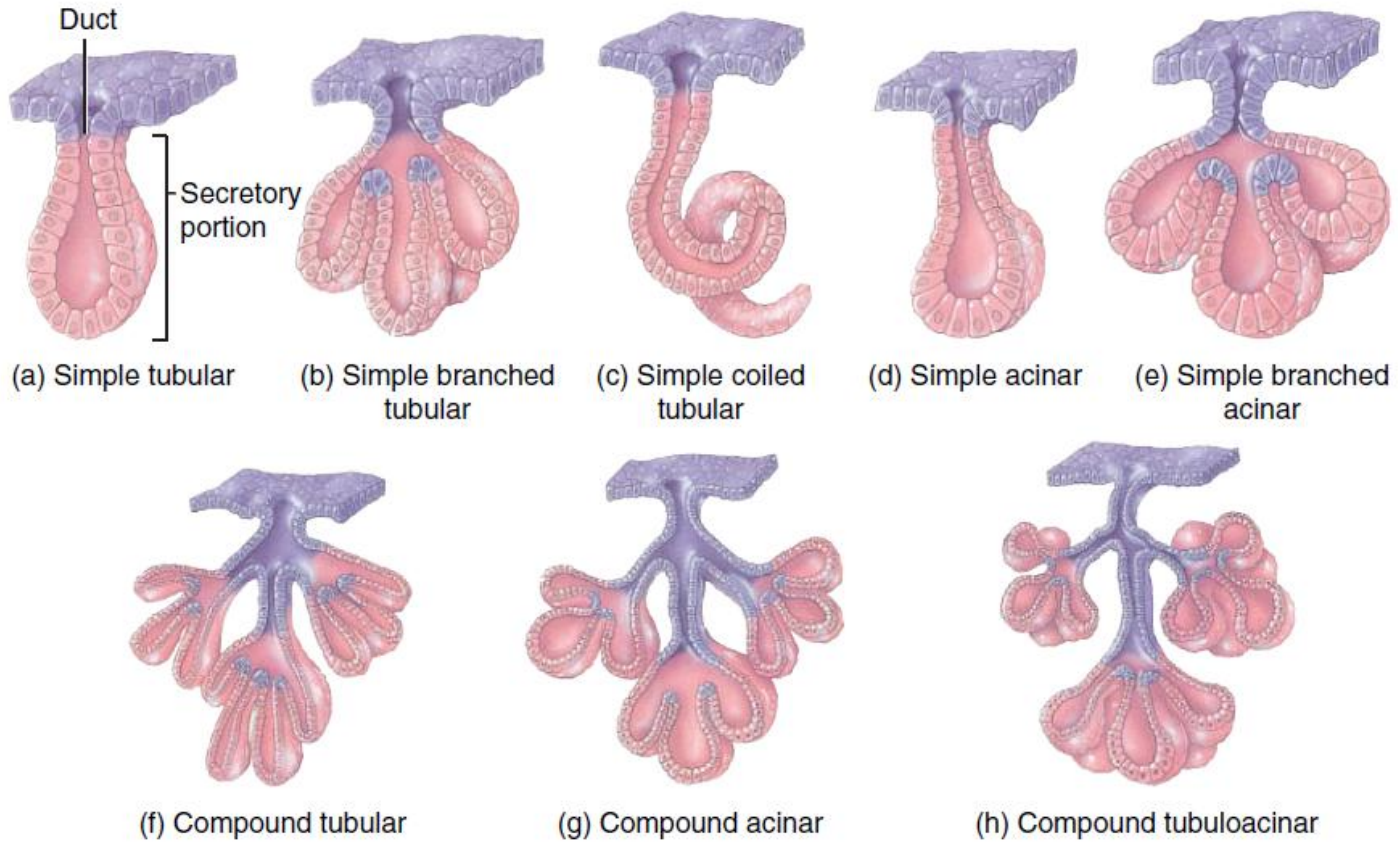
- Multicellular glands are categorized according to two criteria:

(1) whether their ducts are branched or unbranched

(2) The shape of the secretory portions of the gland

- **Simple gland :** If the duct of the gland does not branch
- **Compound gland:** If the duct branches
- **Tubular glands :** Glands with tubular secretory parts
- **Acinar glands** (AS-i-nar; *acin-* berry), also called *alveolar glands:* those with rounded secretory portions.
- **Tubuloacinar glands** have both tubular and more rounded secretory parts.

**Figure 4.6** **Multicellular exocrine glands.** Pink represents the secretory portion; lavender represents the duct.
Structural classification of multicellular exocrine glands is based on the branching pattern of the duct and the shape of the secreting portion.



## *B. Secretion Types*

- **Serous glands** produce and secrete a nonviscous, watery fluid, such as sweat, milk, tears, or digestive juices.
- **Mucus glands** secrete mucin, which forms mucus when mixed with water.
- **Mixed glands**, such as the two pairs of salivary glands inferior to the oral cavity, contain both serous and mucus cells, and produce a mixture of the two types of secretions.

## *C. Functional Classification of Exocrine Glands*

- ✓ The functional classification of exocrine glands is based on **how their secretions are released.**

- ✓ Each of these secretory processes begins with the endoplasmic reticulum and Golgi complex working together to form intracellular secretory vesicles that contain the secretory product.

# *C. Functional Classification of Exocrine Glands (continued)*

**Merocrine glands (ECCRINE)**

- Package their secretions in secretory vesicles which travel to the apical surface of the glandular cell and release their secretion by exocytosis.
- The glandular cells remain intact and are not damaged in any way by producing the secretion.
- Some merocrine glands are also called eccrine glands, to denote a type of sweat gland in the skin that is not connected to a hair follicle
- Examples include the salivary glands and pancreas.

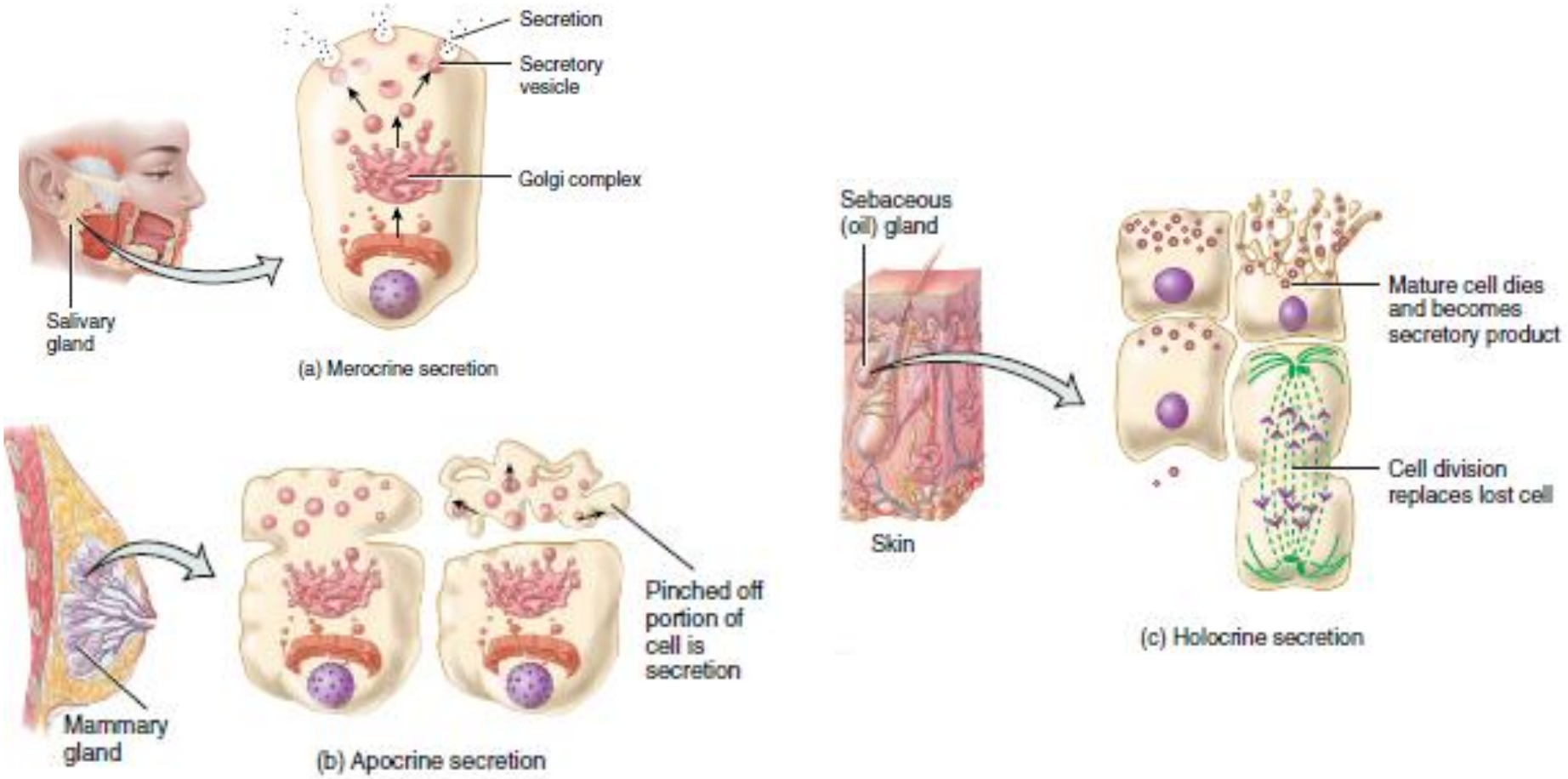
**Apocrine glands**

- Secretion occurs with the "decapitation" of the apical surface of the cell and release of secretory product.
- The cell repairs itself and repeats the process.
- Examples: The mammary glands, and some sweat glands in the axillary and pubic regions.

**Holocrine glands**

- Secretion is produced through the destruction of the secretory cell.
- The secretion contains large amounts of lipids from the plasma membrane and intracellular membranes.
- Lost cells are replaced by cell division at the base of the gland.
- One example of a holocrine gland is a sebaceous gland of the skin.

**Figure 4.7 Functional classification of multicellular exocrine glands.**
The functional classification of exocrine glands is based on whether a secretion is a product of a cell or consists of an entire or a partial glandular cell.



# CONNECTIVE TISSUE

- One of the most abundant and widely distributed tissues in the body.
- In its various forms, connective tissue has a variety of functions.
- Embryonic cells called mesenchymal cells give rise to the cells of connective tissue.

- **FUNCTIONS:**

- It binds together, supports, and strengthens other body tissues;
- Protects and insulates internal organs; compartmentalizes structures such as skeletal muscles;
- Serves as the major transport system within the body (blood, a fluid connective tissue);
- It is the primary location of stored energy reserves (adipose, or fat, tissue);
- It is the main source of immune responses.

## General Features of Connective Tissue

**Connective tissue consists of two basic elements:**

**A- Cells**

**B- Extracellular matrix** → located between its widely spaced cells

a- *Ground substance (gels)*

*b- Protein fibers*

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***NOTES:***

- The extracellular fibers are secreted by the connective tissue cells and account for many of the functional properties of the tissue
- In addition to controlling the surrounding watery environment via specific proteoglycan molecules, ***The structure of the extracellular matrix determines much of the tissue's qualities.***
- For instance, in cartilage, the extracellular matrix is firm but pliable. The extracellular matrix of bone, by contrast, is hard and inflexible.

# Connective Tissue VS. Epithelial Tissue

- ✓ Connective tissue does not usually occur on body surfaces (**unlike** epithelial tissue).

- ✓ Connective tissue usually is highly vascular (**unlike** epithelial tissue); that is, it has a rich blood supply. *Exceptions* include cartilage, which is avascular, and tendons, with a scanty blood supply.

- ✓ Connective tissue, ***like*** epithelial tissue, is supplied with nerves. Except for cartilage.

# A- Connective Tissue Cells

## 1- Immature cells with names ending in *-blast*

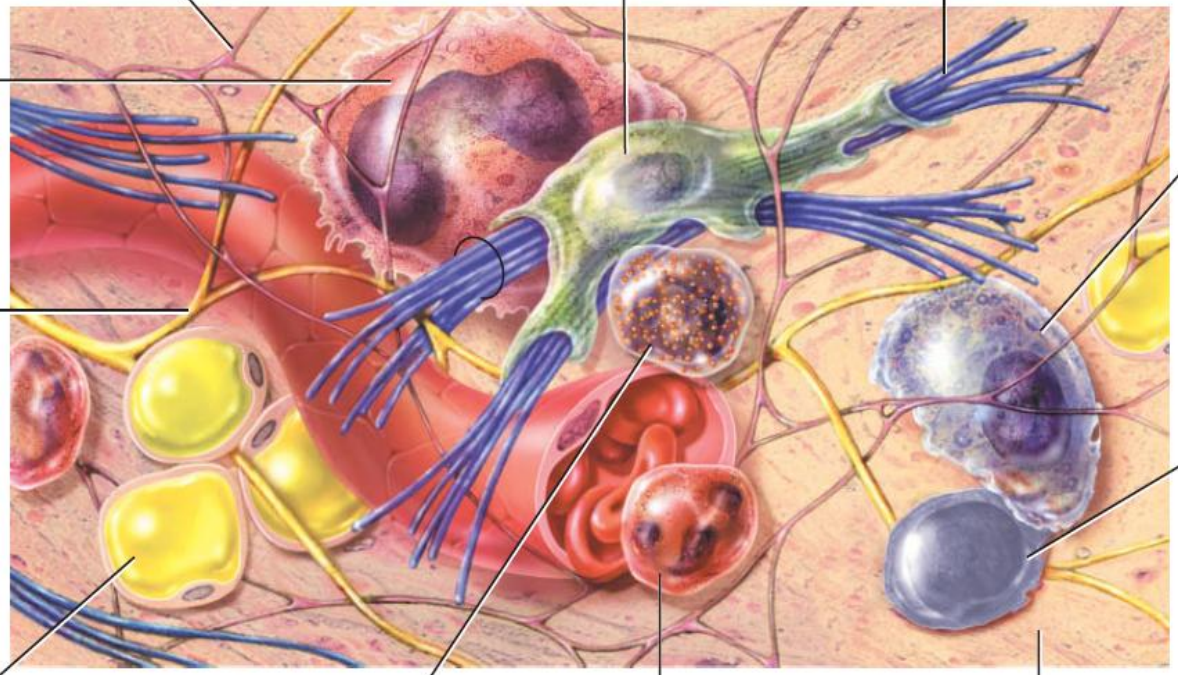
- ✓ Cells give rise to the cells of connective tissue → contains means "to bud or sprout."
- ✓ Examples: *chondroblasts* in cartilage, and *osteoblasts* in bone, *fibroblasts (connective tissue proper)*, *hemocytoblasts (blood cells)*.
- ✓ Blast cells retain the capacity for cell division and secrete the extracellular matrix that is characteristic of the tissue.

## *2-* Mature cells with names ending in *-cyte*

- ✓ Once the immature cells differentiate, the extracellular matrix is produced into mature cells.
- ✓ Examples: *FIXED*: *fibrocytes, chondrocytes, osteocytes, adipocytes*, *Macrophages (develops from monocytes → fixed and wandering)*, *WANDERING*: *Plasma cells (antibodies), Mast cells (histamine), Leukocytes.*
- ✓ Mature cells have reduced capacities for cell division and extracellular matrix formation and are mostly involved in monitoring and maintaining the extracellular matrix.

**Representative cells and fibers present in connective tissues**

→ Fibroblasts are usually the most numerous connective tissue cells



RETICULAR FIBERS
are made of collagen and glycoproteins. They provide support in blood vessel walls and form branching networks around various cells (fat, smooth muscle, nerve).

FIBROBLASTS
are large, flat cells that move through connective tissue and secrete fibers and ground substance.

COLLAGEN FIBERS
are strong, flexible bundles of the protein collagen, the most abundant protein in your body.

MACROPHAGES
develop from monocytes and destroy bacteria and cell debris by phagocytosis.

ELASTIC FIBERS
are stretchable but strong fibers made of proteins, elastin, and fibrillin. They are found in skin, blood vessels, and lung tissue.

MAST CELLS
are abundant along blood vessels. They produce histamine, which dilates small blood vessels during inflammation and kills bacteria.

PLASMA CELLS
develop from B lymphocytes. They secrete antibodies that attack and neutralize foreign substances.

ADIPOCYTES
or fat cells store fats. They are found below the skin and around organs (heart, kidney).

EOSINOPHILS
are white blood cells that migrate to sites of parasitic infection and allergic responses.

NEUTROPHILS
are white blood cells that migrate to sites of infection and destroy microbes by phagocytosis.

GROUND SUBSTANCE
is the material between cells and fibers. It is made of water and organic molecules (hyaluronic acid, chondroitin sulfate, glucosamine). It supports cells and fibers, binds them together, and provides a medium for exchanging substances between blood and cells.

# B- Connective Tissue Extracellular Matrix

## *1- Ground Substance (Gels)*

- The component of a connective tissue **between** the cells and fibers.
- The ground substance may be fluid, semifluid, gelatinous, or calcified.
- It supports cells, binds them together, stores water, and provides a medium for exchange of substances between the blood and cells.
- It plays an active role in how tissues develop, migrate, proliferate, and change shape, and in how they carry out their metabolic functions.
- **Ground substance contains water and an assortment of large organic molecules, many of which are complex combinations of polysaccharides and proteins.**

- They include:
  - **Glycosaminoglycans (GAGs)** → bristles of a brush, trap water, making the ground substance more jellylike): **Hyaluronic acid, Chondroitin sulfate, dermatan sulfate, keratan sulfate**
  - **Proteoglycans (**core protein**): glucosamine**
  - **Adhesion proteins : fibronectin**, main adhesion protein of connective tissues, binds to both collagen fibers and ground substance, linking them together. Fibronectin also attaches cells to the ground substance.

## B- Connective Tissue Extracellular Matrix (continued)

***2- Fibers*** → Embedded in the extracellular matrix between the cells

**TYPES:**

1- **Collagen fibers** → very strong and resist pulling forces (tension), but they are not stiff, which allows tissue flexibility, has different properties according to function (bone, cartilage, skin ..etc.)

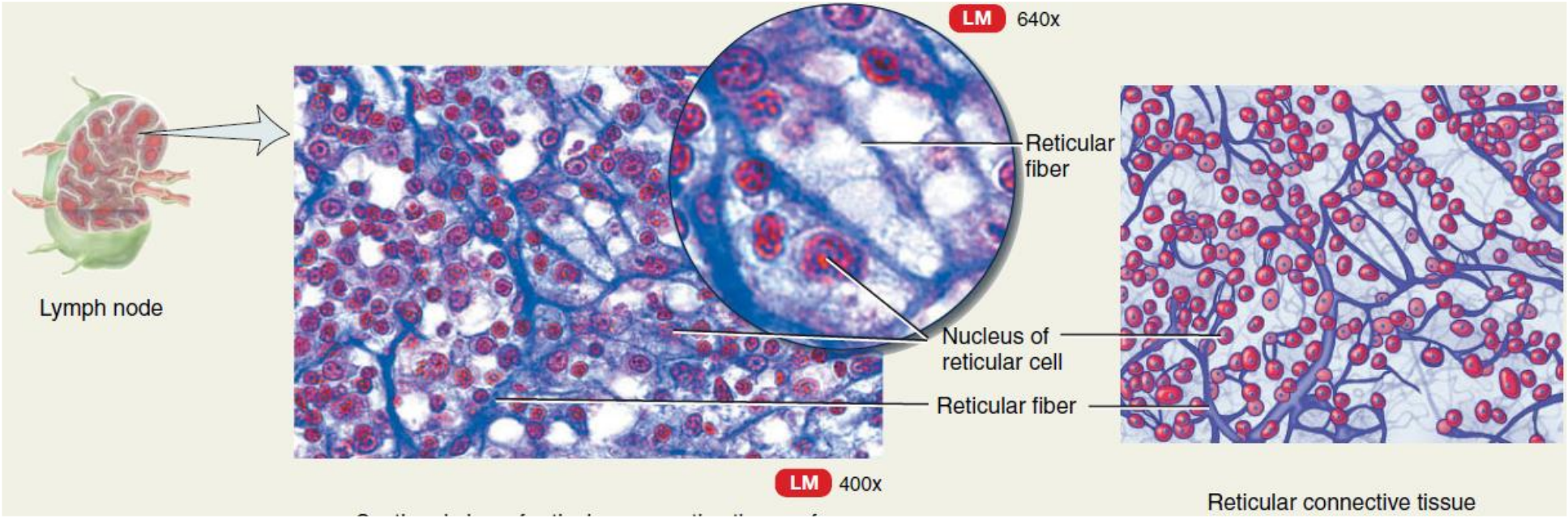
2- **Elastic fibers**

- ✓ Branch and join together to form a fibrous network within a connective tissue, adds strength and stability
- ✓ Can be stretched up to 150% of their relaxed length without breaking. Equally important, elastic fibers have the ability to return to their original shape after being stretched (Elasticity).

3- **Reticular fibers**

- ✓ Are much thinner than collagen fibers and form branching networks.
- ✓ Like collagen fibers, reticular fibers provide support and strength.
- ✓ Reticular fibers are plentiful in reticular connective tissue, which forms the **stroma** (supporting framework) of many soft organs, such as the spleen and lymph nodes. These fibers also help form the basement membrane.

# Reticular fibers



# Classification of Connective Tissue

***the classification of connective tissue is not always clear-cut and several classifications exist.***

## Mature connective tissue

### *A. Connective Tissue Proper*

→ Holds and binds

*A.1. Loose connective tissue*

1. Areolar connective tissue
2. Adipose tissue
3. Reticular connective tissue

*A.2. Dense connective tissue*

1. Dense regular connective tissue
2. Dense irregular connective tissue
3. Elastic connective tissue → *fibroblasts*

### *B. Supporting Connective Tissue*

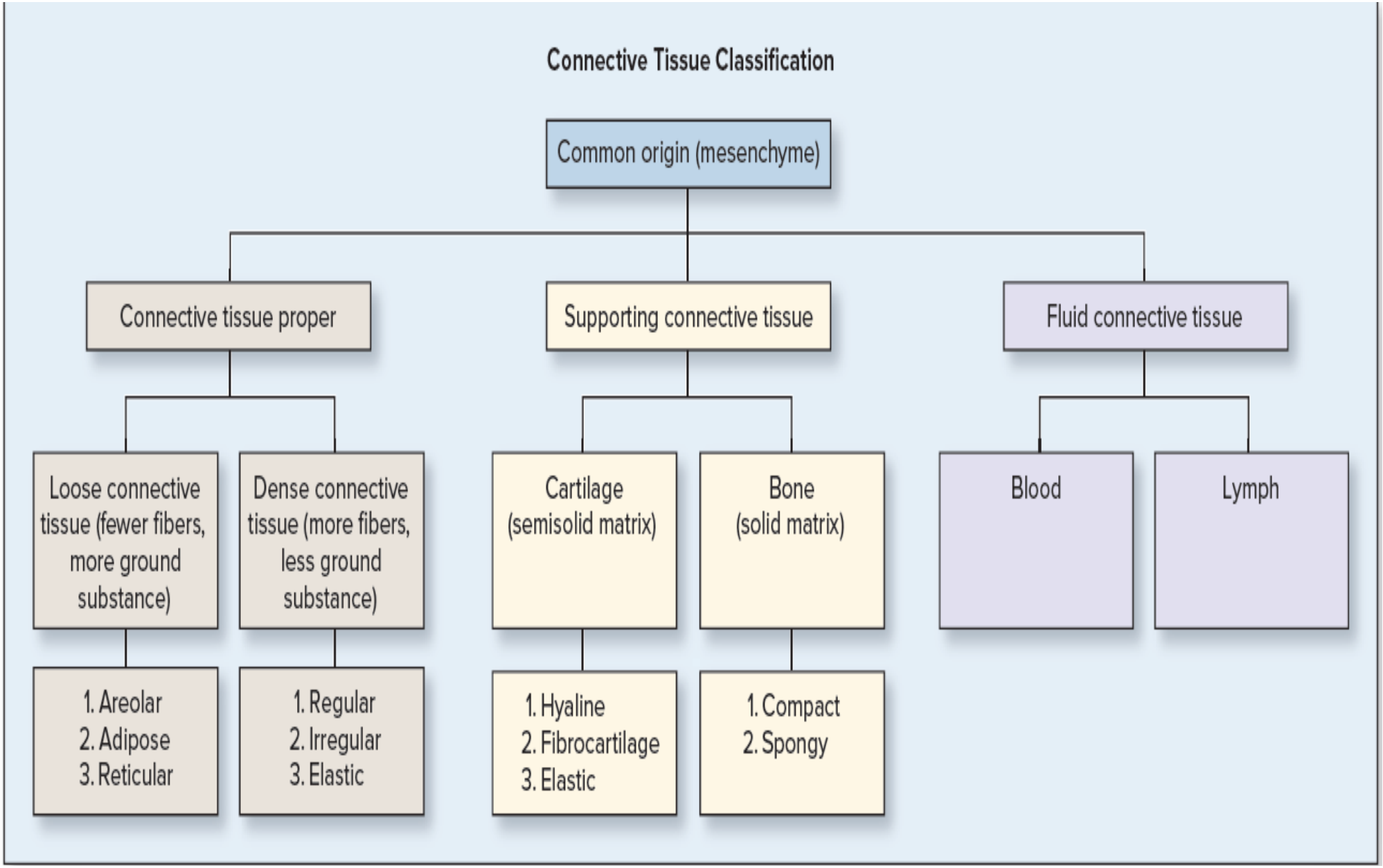
*B.1. Cartilage*

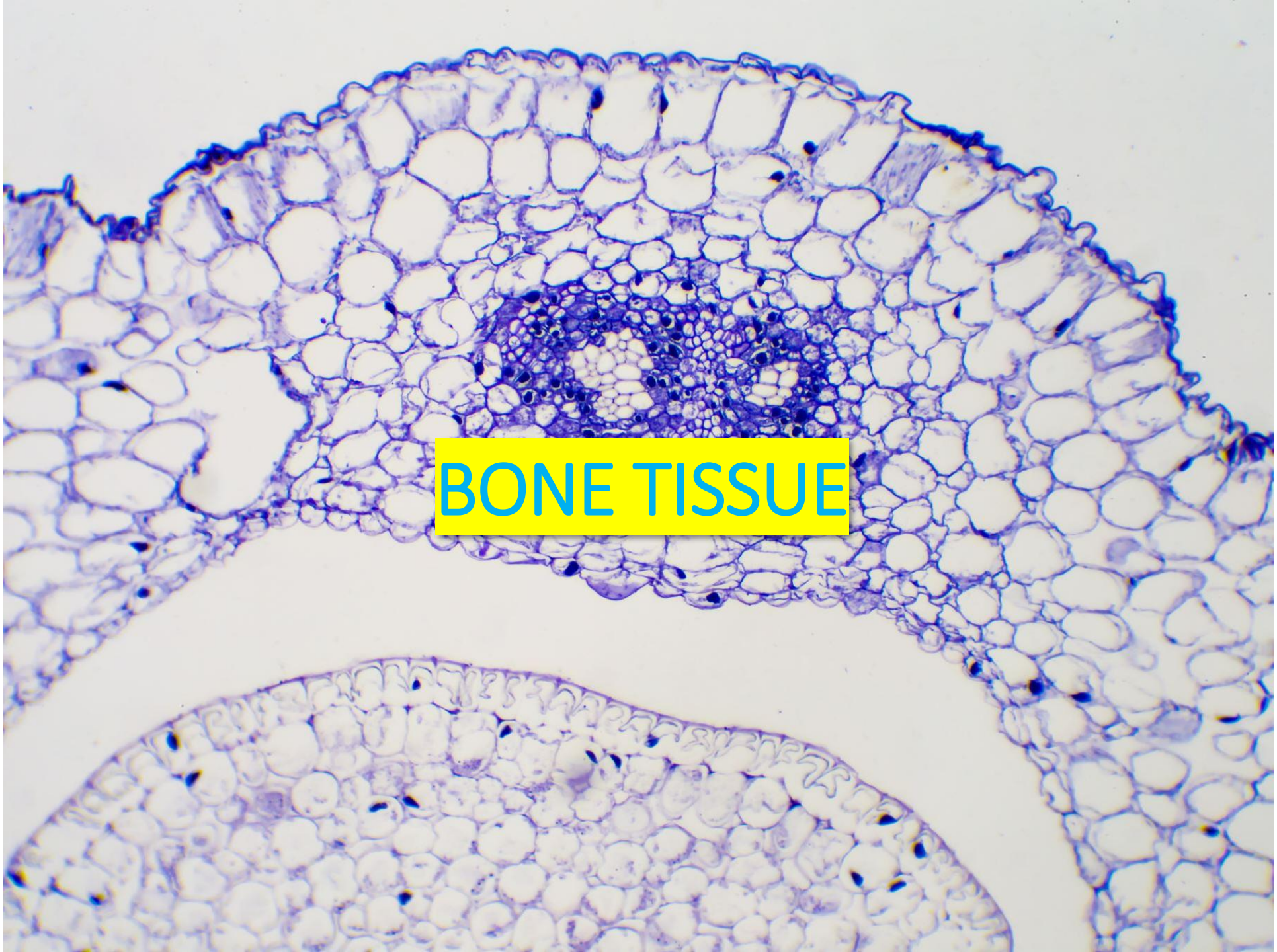
1. Hyaline cartilage (glassy)
2. Fibrocartilage
3. Elastic cartilage → *chondroblasts*

*B.2. Bone tissue*

### *C. Liquid Connective Tissue*

1. Blood tissue (Plasma, RBCs, Platelets)
2. Lymph


Connective Tissue Classification
Common origin (mesenchyme)
Connective tissue proper
Supporting connective tissue
Fluid connective tissue
Loose connective tissue (fewer fibers, more ground substance)
Dense connective tissue (more fibers, less ground substance)
Cartilage (semisolid matrix)
Bone (solid matrix)
Blood
Lymph
1. Areolar
2. Adipose
3. Reticular
1. Regular
2. Irregular
3. Elastic
1. Hyaline
2. Fibrocartilage
3. Elastic
1. Compact
2. Spongy


BONE TISSUE

# STRUCTURE OF BONE- MACROSCOPIC ANATOMY

✓Macroscopic bone structure may be analyzed by considering the parts of a long bone, such as the humerus (the arm bone).

✓ A *long bone* is one that has greater length than width.

---

**A typical long bone consists of the following parts:**

1. The **diaphysis** (growing between) is the bone's shaft or body—the long, cylindrical, main portion of the bone.
2. The **epiphyses** (growing over; singular is *epiphysis*) are the proximal and distal ends of the bone.
3. The **metaphyses** (*meta-* = between; singular is *metaphysis*) are the regions between the diaphysis and the epiphyses. In a growing bone, each metaphysis contains an *epiphyseal (growth) plate*, a layer of *hyaline cartilage* that allows the diaphysis of the bone to grow in length. When a bone ceases to grow in length at about ages 14–24, the cartilage in the epiphyseal plate is replaced by bone; the resulting bony structure is known as the *epiphyseal line.*

# STRUCTURE OF BONE- MACROSCOPIC ANATOMY (continued-1)

**4.** The **articular cartilage** is a thin layer of hyaline cartilage covering the part of the epiphysis where the bone forms an articulation (joint) with another bone. Articular cartilage **reduces friction and absorbs shock** at freely movable joints.

→Because articular cartilage lacks a perichondrium and lacks blood vessels, repair of damage is limited.

**5.** The **periosteum** (*peri-* = around) is a **tough** connective tissue sheath and its associated blood supply that surrounds the bone surface wherever it is not covered by articular cartilage.

→ It is composed of ***an outer fibrous layer*** of dense irregular connective tissue and **an *inner osteogenic layer*** that consists of cells.

→ Some of the cells enable bone to grow in thickness, but not in length.

→ The periosteum also protects the bone, assists in fracture repair, helps nourish bone tissue, and serves as an attachment point for ligaments and tendons.

→ The periosteum is attached to the underlying bone by **perforating fibers** or *Sharpey's fibers*, thick bundles of collagen that extend from the periosteum into the bone extracellular matrix.

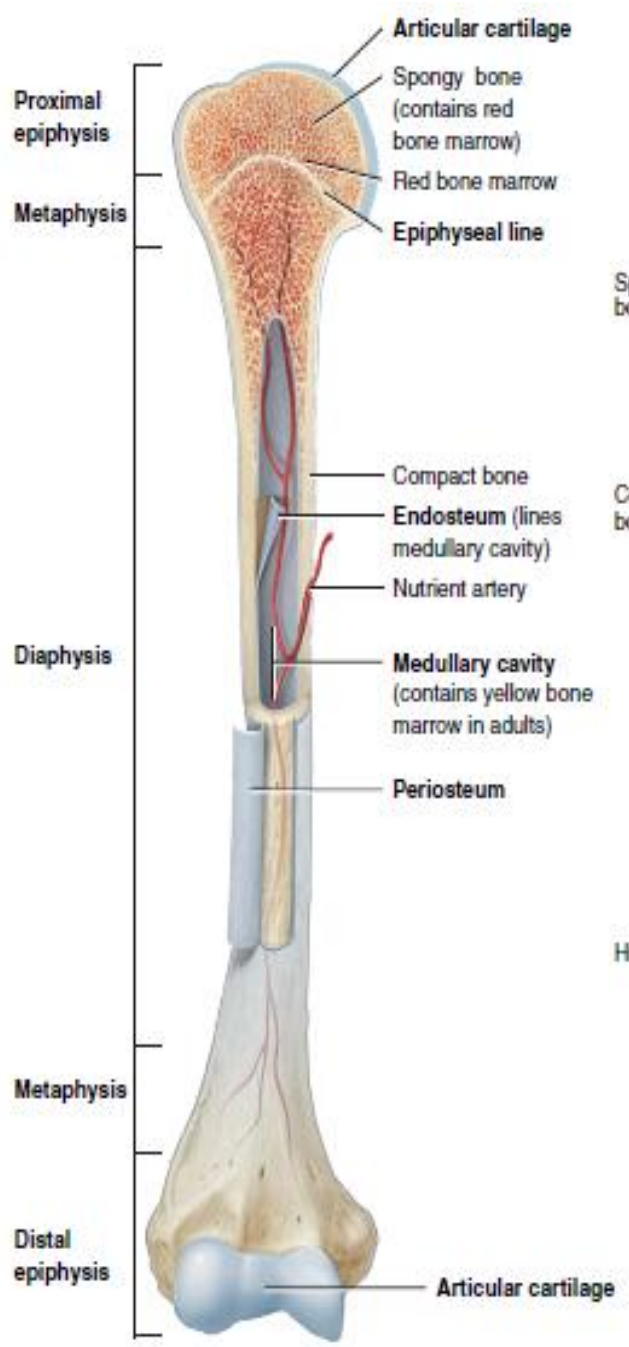
# STRUCTURE OF BONE- MACROSCOPIC ANATOMY (continued-2)

**6.** The **medullary cavity** (*medulla*- = marrow, pith), or *marrow cavity*, is a hollow, cylindrical space within the diaphysis that contains fatty yellow bone marrow and numerous blood vessels in adults. This cavity minimizes the weight of the bone by reducing the dense bony material where it is least needed. The long bones' tubular design provides maximum strength with minimum weight.

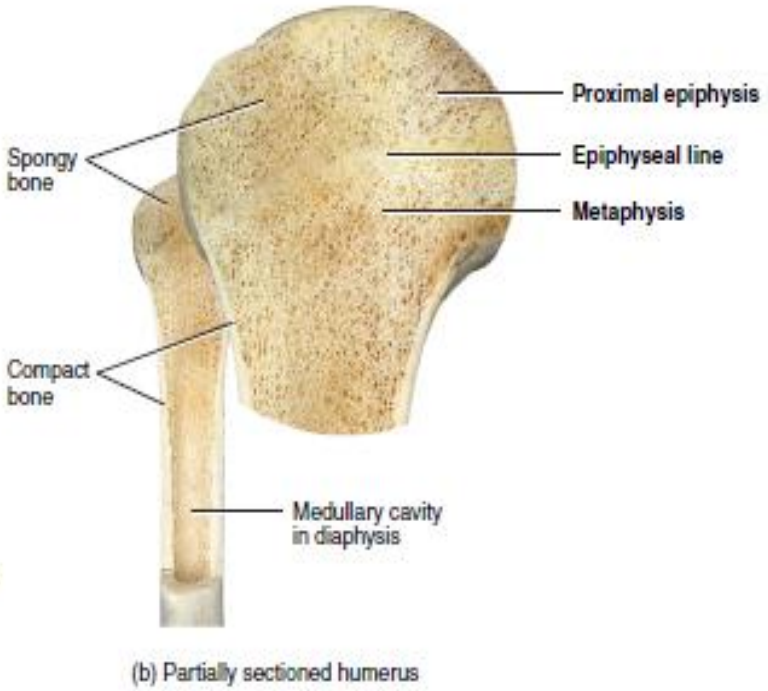
**7.** The **endosteum** (*endo*- = within) is a thin membrane that lines the medullary cavity. It contains a single layer of bone-forming cells and a small amount of connective tissue.

**Parts of a long bone.**

The spongy bone tissue of the epiphyses and metaphyses contains red bone marrow, and the medullary cavity of the diaphysis contains yellow bone marrow (in adults).




(a) Partially sectioned humerus (arm bone)




(b) Partially sectioned humerus

# Histology of Bone Tissue- Introduction

- Like other connective tissues, **bone**, or *osseous tissue* (OS-ē-us), contains an abundant extracellular matrix that surrounds widely separated cells.
- The extracellular matrix is about 15% water, 30% collagen fibers, and 55% crystallized mineral salts.
- The most abundant mineral salt is **calcium phosphate** [$Ca_3(PO4)_2$]. It combines with another mineral salt, **calcium hydroxide** [$Ca(OH)_2$], to form crystals of **hydroxyapatite**.
- As the crystals form, they combine with still other mineral salts, such as **calcium carbonate** ($CaCO_3$), and ions such as magnesium, fluoride, potassium, and sulfate. As these mineral salts are deposited in the framework formed by the collagen fibers of the extracellular matrix, they crystallize and the tissue hardens. This process, called **calcification**, is initiated by bone-building cells called **osteoblasts**.

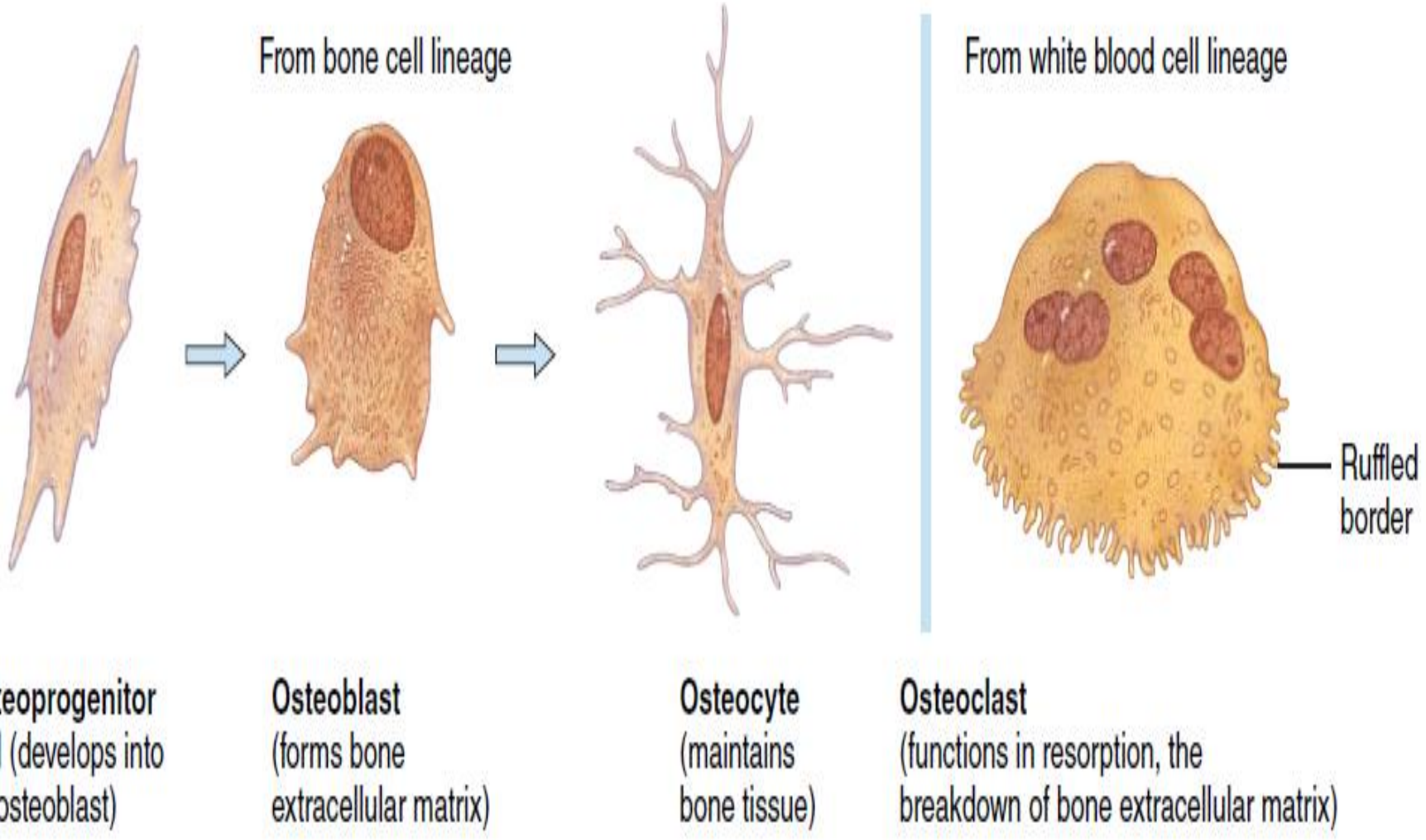
**CALCIFICATION**:

- Mineral salts first begin to crystallize in the microscopic spaces between collagen fibers. After the spaces are filled, mineral crystals accumulate around the collagen fibers. The combination of crystallized salts and collagen fibers is responsible for the characteristics of bone.
- Although a bone's *hardness* depends on the crystallized inorganic mineral salts, a bone's *flexibility* depends on its collagen fibers.
- The process by which bone forms is called **ossification** or ***osteogenesis***.

# Histology of Bone Tissue- MICROSCOPIC ANATOMY (4 Cell types)

- ✓**Osteoprogenitor cells** (*genic* = producing) are unspecialized bone stem cells derived from mesenchyme, the tissue from which almost all connective tissues are formed. **They are the ONLY bone cells to undergo cell division; the resulting cells develop into osteoblasts.**
- ✓**Osteoblasts** are bone-building cells. They synthesize and secrete collagen fibers and other organic components needed to build the extracellular matrix of bone tissue, and they initiate calcification. As osteoblasts surround themselves with extracellular matrix, they become trapped in their secretions and become osteocytes.
- ✓**Osteocytes**, mature bone cells, are the **main cells in bone tissue** and maintain its daily metabolism, such as the exchange of nutrients and wastes with the blood.
- ✓**Osteoclasts** (-*clast* = break) are huge cells derived from the fusion of as many as 50 monocytes (a type of white blood cell) and are concentrated in the **endosteum**. On the side of the cell that faces the bone surface, the osteoclast's plasma membrane is deeply folded into a *ruffled border*. Here the cell releases powerful lysosomal enzymes and acids that digest the protein and mineral components of the underlying extracellular bone matrix.

# Types of cells in bone tissue.



# Histology of Bone – Compact and Spongy bone

- Bone is **not** completely solid but has many small spaces between its cells and extracellular matrix components.
- Some **spaces** serve as channels for blood vessels that supply bone cells with nutrients.
- **Other spaces** act as storage areas for red bone marrow.
- **Depending on the size and distribution** of the spaces, the regions of a bone may be categorized as **compact or spongy.**
- ***Overall, about 80% of the skeleton is compact bone and 20% is spongy bone.***

---

→ **Compact bone tissue** contains few spaces and is the strongest form of bone tissue. It is found beneath the periosteum of all bones and makes up the bulk of the diaphyses of long bones.

- FUNCTION: provides protection and support and resists the stresses produced by weight and movement
- COMPOSED OF repeating structural units called **osteons**, or *haversian systems* (ha-VER-shan). Each osteon consists of concentric lamellae (circular plates of mineralized extracellular matrix of increasing diameter,) arranged around an **osteonic** (haversian or central) **canal**.

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→ **Spongy bone tissue**, does not contain osteons, and it is always located in the *interior* of a bone, protected by a covering of compact bone.

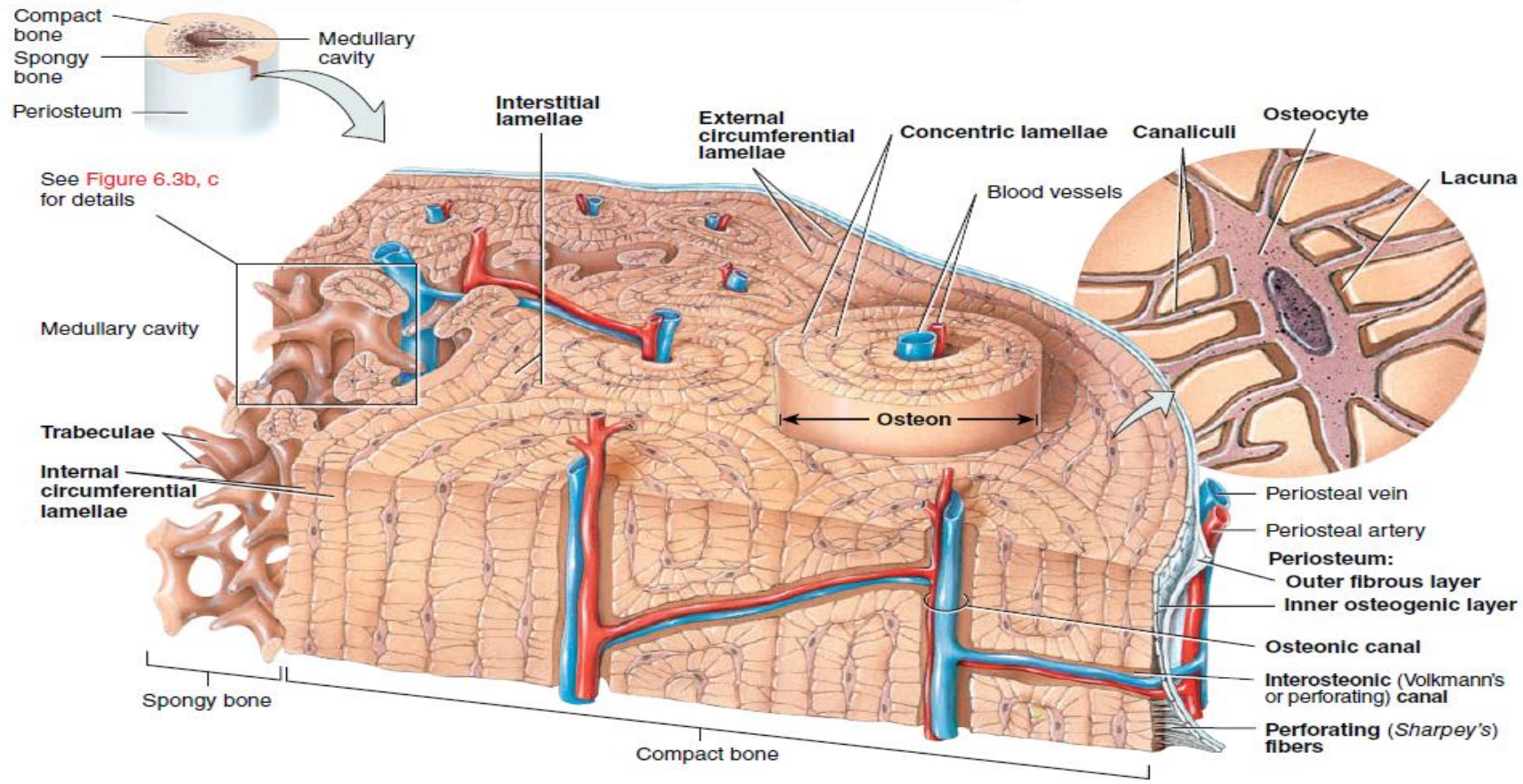
- It consists of lamellae that are arranged in an irregular pattern of thin columns called **trabeculae.**

# Histology of Bone
## Compact Bone Tissue VS Spongy Bone Tissue

**Spongy bone tissue is different from compact bone tissue in two respects:**

- ✓**First**, spongy bone tissue is light, which reduces the overall weight of a bone. This reduction in weight allows the bone to move more readily when pulled by a skeletal muscle.
- ✓**Second**, the trabeculae of spongy bone tissue support and protect the red bone marrow.
- Spongy bone in the hip bones, ribs, sternum (breastbone), vertebrae, and the proximal ends of the humerus and femur is the only site where red bone marrow is stored and, thus, the site where **hemopoiesis** (blood cell production) occurs in adults.

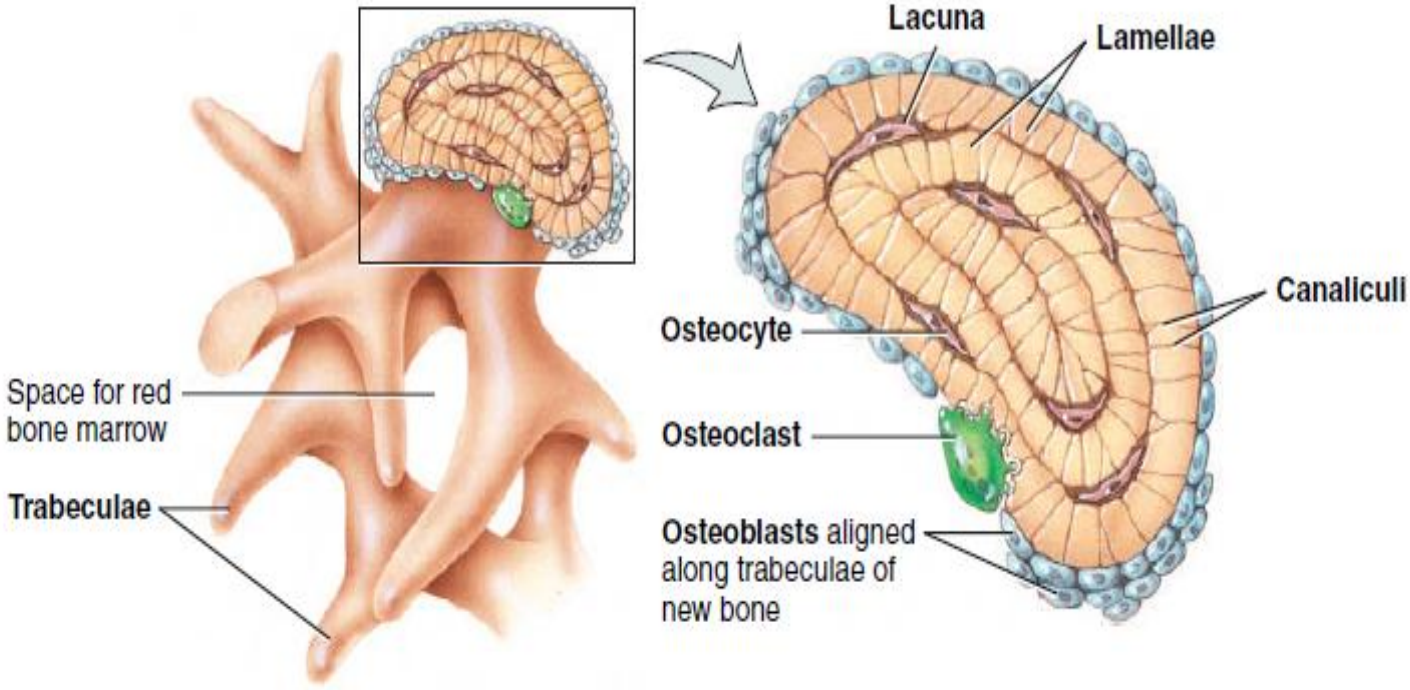
**Histology of compact and spongy bone.** (a) Sections through the diaphysis of a long bone, from the surrounding periosteum on the right, to compact bone in the middle, to spongy bone and the medullary cavity on the left . The inset at the upper right shows an osteocyte in a lacuna.




(a) Osteons (haversian systems) in compact bone and trabeculae in spongy bone

***Blood* and Nerve Supply of Bone?????**

**Histology of compact and spongy bone.** (b, c) Details of spongy bone.




(b) Enlarged aspect of spongy bone trabeculae

(c) Details of a section of a trabecula

# Bone Growth during Infancy, Childhood, and Adolescence

## Growth in Length

- During infancy, childhood, and adolescence, bones throughout the body grow in **thickness** **by appositional growth**, and long bones **lengthen** by the addition of bone material on the diaphyseal side of the epiphyseal plate **by interstitial growth**.

**Growth in Length**

The growth in length of long bones involves the following two major events:

(1) Interstitial growth of cartilage on the epiphyseal side of the epiphyseal plate

(2) Replacement of cartilage on the diaphyseal side of the epiphyseal plate with bone by endochondral ossification.

# Bone Growth during Infancy, Childhood, and Adolescence

## Growth in Length

To understand how a bone grows in length, you need to know some of the details of the structure of the epiphyseal plate. The epiphyseal (*growth*) plate (ep-i-FIZ-ē-al) is a layer of hyaline cartilage in the metaphysis of a growing bone that consists of four zones

Zones of Growth at Epiphyseal Plate

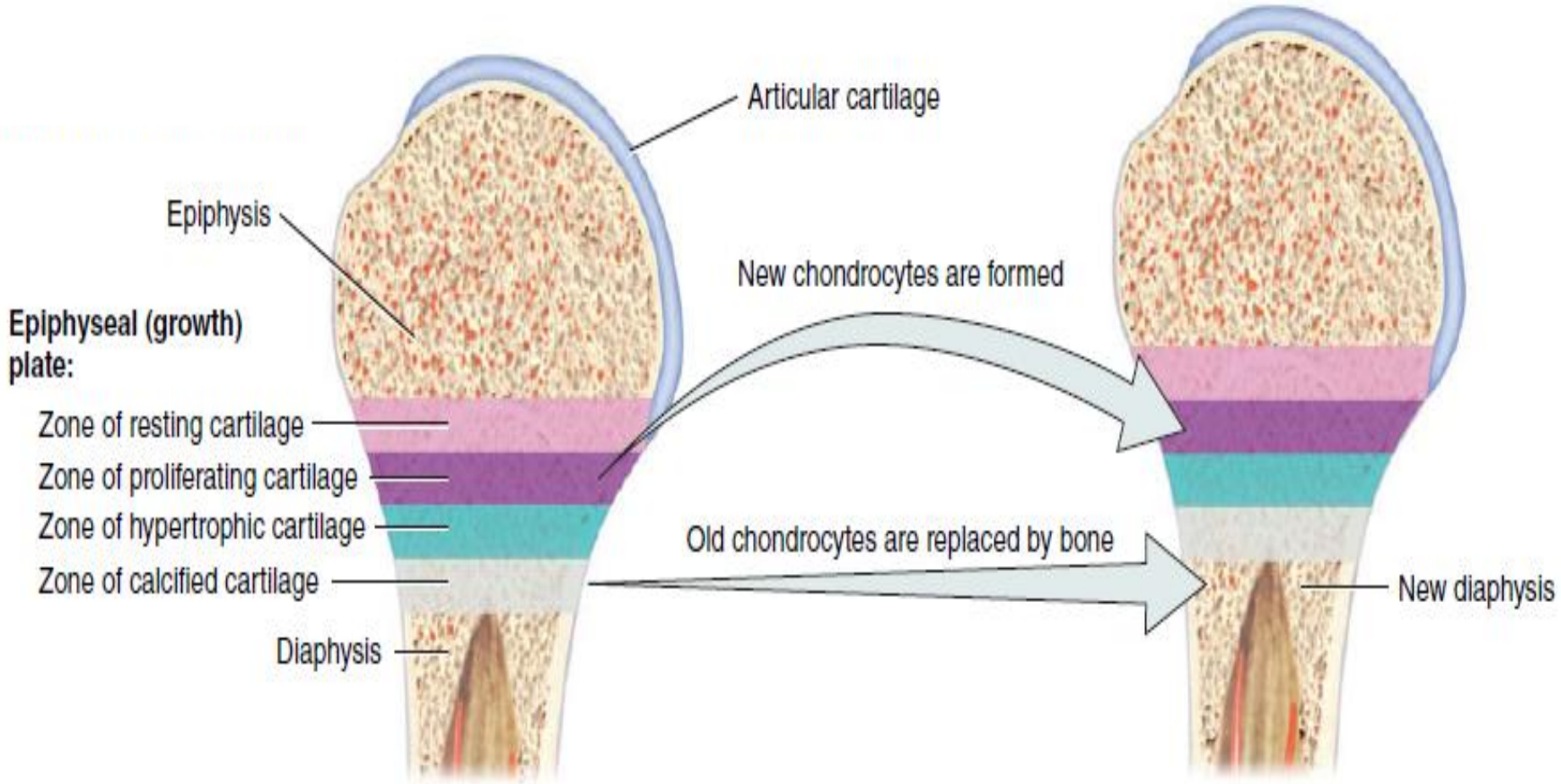
1. **Zone of resting cartilage** → cells do not function in bone growth, they anchors growth plate to bone
2. **Zone of proliferating cartilage** → rapid cell division (stacked coins), The chondrocytes in this zone divide to replace those that die at the diaphyseal side of the epiphyseal plate.
3. **Zone of hypertrophic cartilage** → This layer consists of large, maturing chondrocytes arranged in columns.
4. **Zone of calcified cartilage**

   → Thin zone, mostly dead **chondrocytes** since matrix is calcified

   →**Osteoclasts** dissolve the calcified cartilage

   → **Osteoblasts** and capillaries from the diaphysis invade the area

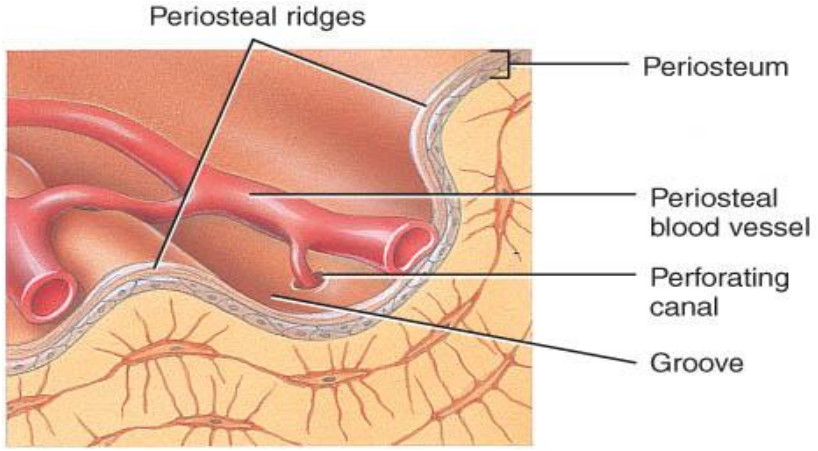
**Epiphyseal (growth) plate.**
Lengthwise growth of bone at epiphyseal plate

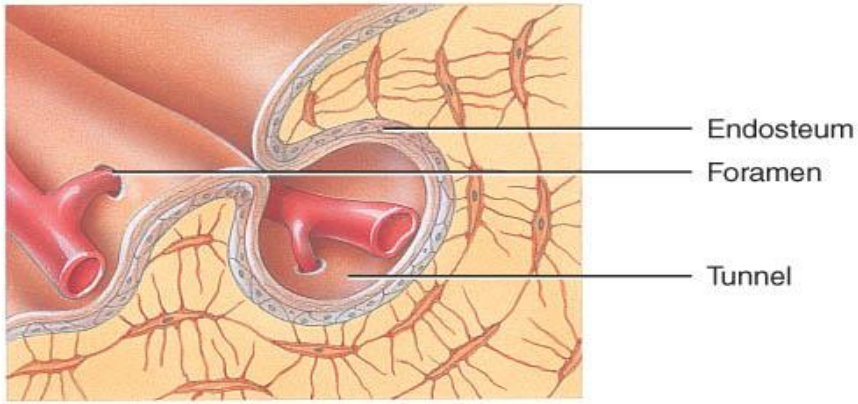


# Bone Growth during Infancy, Childhood, and Adolescence
## Growth in Thickness

**Like cartilage, bone can grow in thickness (diameter) only by appositional growth**

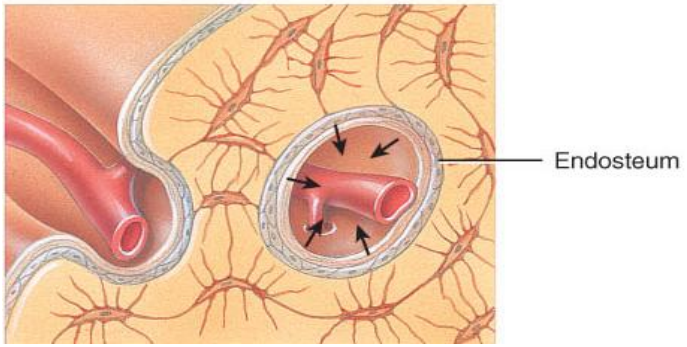
1. **At the bone surface**, periosteal cells differentiate into osteoblasts, which secrete the collagen fibers and other organic molecules that form bone extracellular matrix. The osteoblasts become surrounded by extracellular matrix and develop into osteocytes. This process forms bone ridges on either side of a periosteal blood vessel. The ridges slowly enlarge and create a groove for the periosteal blood vessel.
2. Eventually, the ridges fold together and fuse, and the groove becomes a tunnel that encloses the blood vessel. The former periosteum now becomes the endosteum that lines the tunnel.

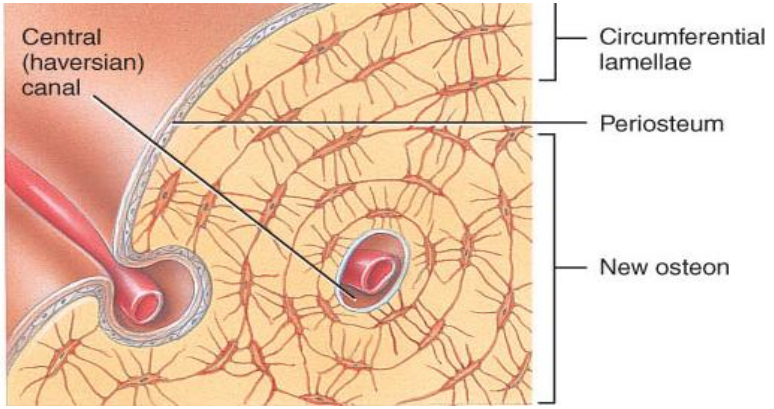


# Bone Growth during Infancy, Childhood, and Adolescence
## Growth in Thickness -continued

3. Osteoblasts in the endosteum deposit bone extracellular matrix, forming new concentric lamellae. The formation of additional concentric lamellae proceeds inward toward the periosteal blood vessel. In this way, the tunnel fills in, and a new osteon is created.
4. As an osteon is forming, osteoblasts under the periosteum deposit new circumferential lamellae, further increasing the thickness of the bone. As additional periosteal blood vessels become enclosed as in step 1, the growth process continues.



# JOINT TISSUE

# CARTILAGE

- A **joint**, also called an **articulation** or **arthrosis** , is a point of contact between two bones, between bone and cartilage, or between bone and teeth.
- The scientific study of joints is termed **arthrology**.
- The study of motion of the human body is called **kinesiology**
- Cartilage is found throughout the human body.
- Cartilage is a semirigid connective tissue that is weaker than bone, but more flexible and resilient.
- Cartilage contains a population of cells scattered throughout a matrix of protein fibers embedded within a gel-like ground substance.

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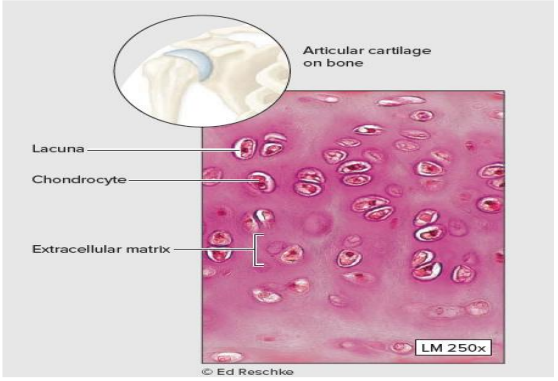
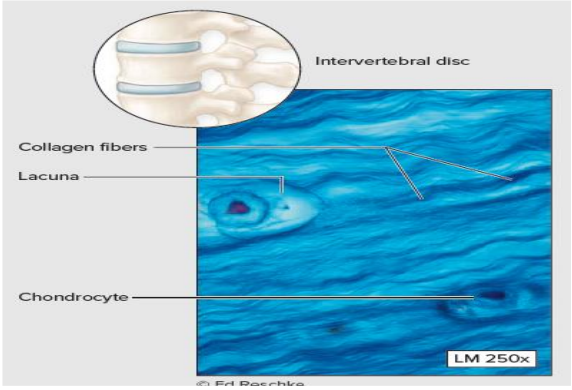
- **Chondroblasts** are the cells that produce the matrix of cartilage. Once they become encased within the matrix they have produced and secreted, the cells are called **chondrocytes** and occupy small spaces named **lacunae.**
- **Chondrocytes are** mature cartilage cells that maintain the matrix and ensure that it remains healthy and viable.
- Mature cartilage is **avascular** (not penetrated by blood vessels) so nutrients must **diffuse** through the matrix.
- The three different types of cartilage—hyaline, elastic, and fibrocartilage.

# The three different types of cartilage—hyaline, elastic, and fibrocartilage.

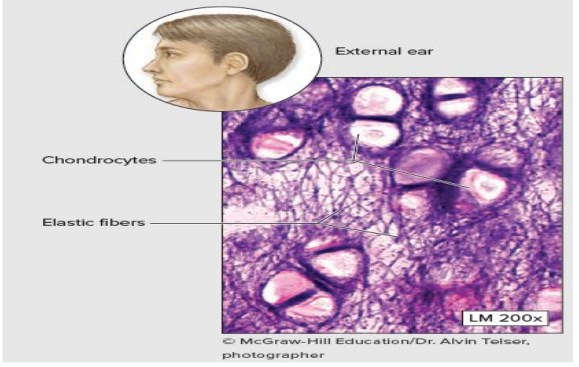
| (a) Hyaline Cartilage | |
|---|---|
| ***Structure*** | Glassy-appearing matrix; lacunae house chondrocytes; usually covered by perichondrium |
| ***Function*** | Smooth surfaces for movement at joints; model for bone growth; supports soft tissue |
| ***Location*** | Covers articular ends of long bones; most of fetal skeleton; costal cartilage; most of the larynx, trachea, nose |



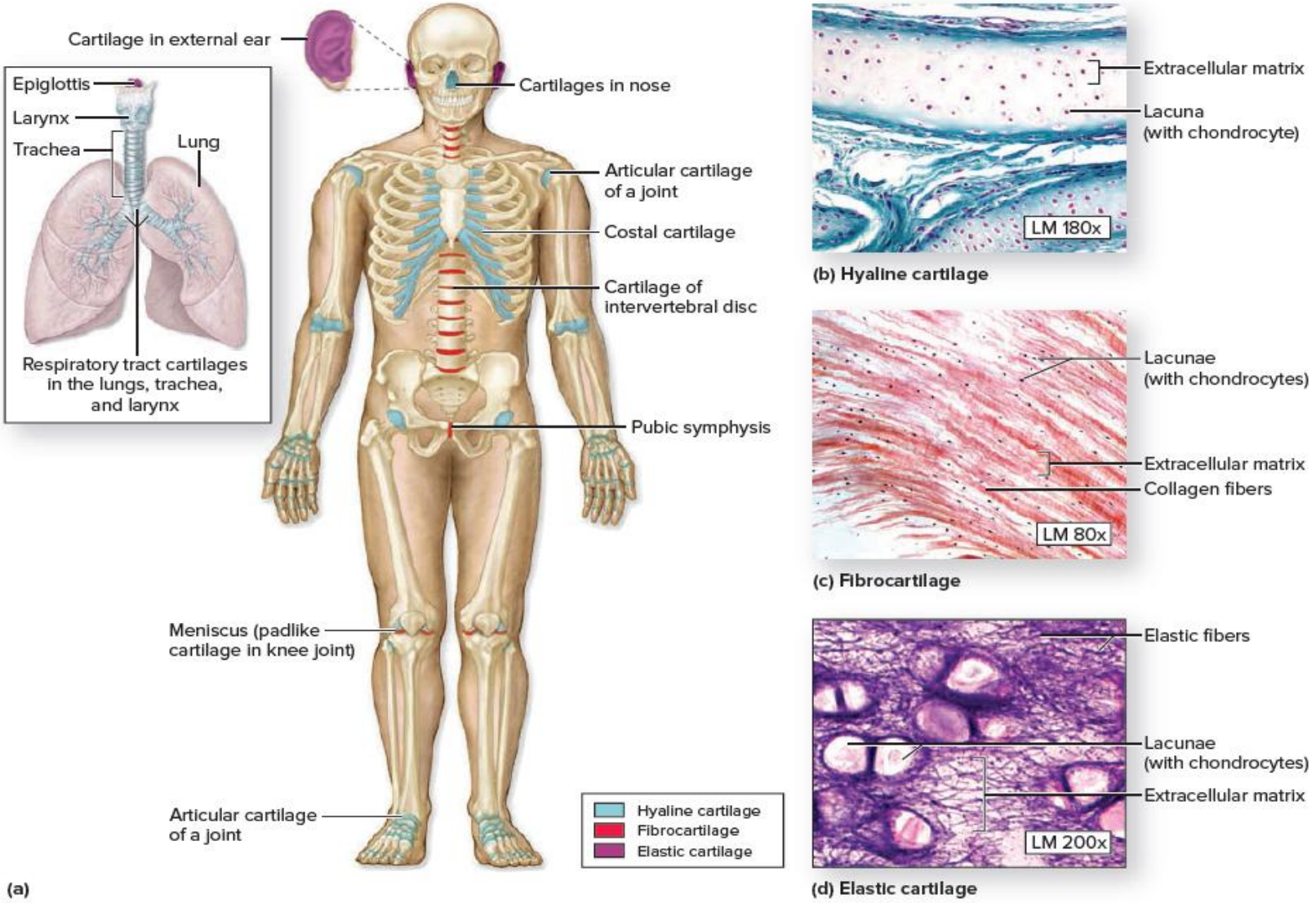

| (b) Fibrocartilage | |
|---|---|
| ***Structure*** | Readily visible, parallel collagen fibers in matrix; lacunae house chondrocytes; no perichondrium |
| ***Function*** | Resists compression; absorbs shock in some joints |
| ***Location*** | Intervertebral discs; pubic symphysis; menisci of knee joints |




| (c) Elastic Cartilage | |
|---|---|
| ***Structure*** | Contains abundant elastic fibers; elastic fibers form weblike mesh around lacunae; perichondrium present |
| ***Function*** | Maintains structure and shape while permitting extensive flexibility |
| ***Location*** | External ear; epiglottis of the larynx |



**Distribution of Cartilage in an Adult.** (*a*) Three types of cartilage occur within an adult. Photomicrographs show (*b*) hyaline cartilage, (*c*) fibrocartilage, and (*d* ) elastic cartilage.



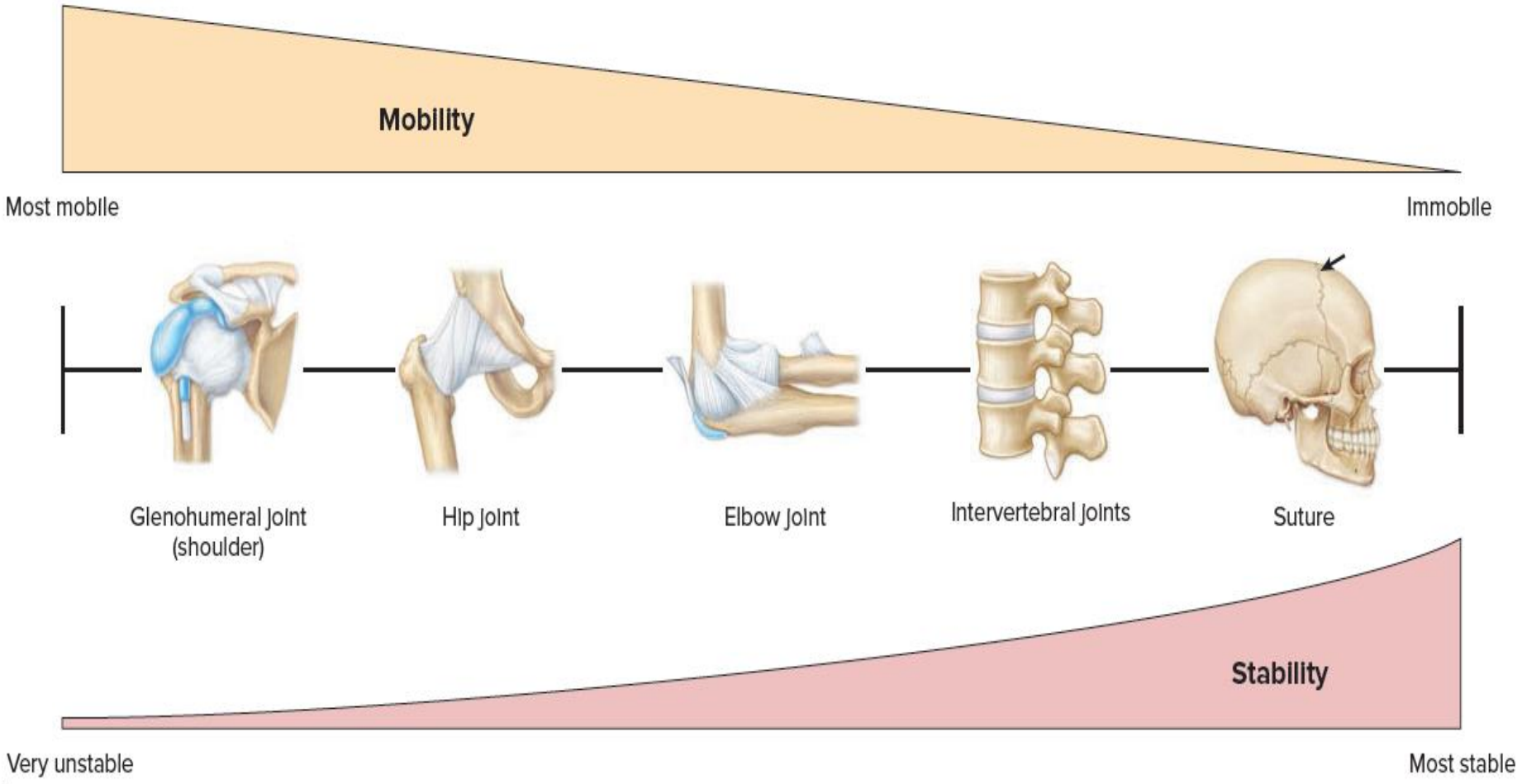
# Mobility of Joints

- The motion permitted at a joint ranges from no movement (e.g., where some skull bones interlock at a suture) to extensive movement (e.g., at the shoulder, where the arm connects to the scapula).
- The structure of each joint determines its mobility and its stability.
- There is an inverse relationship between mobility and stability in articulations.

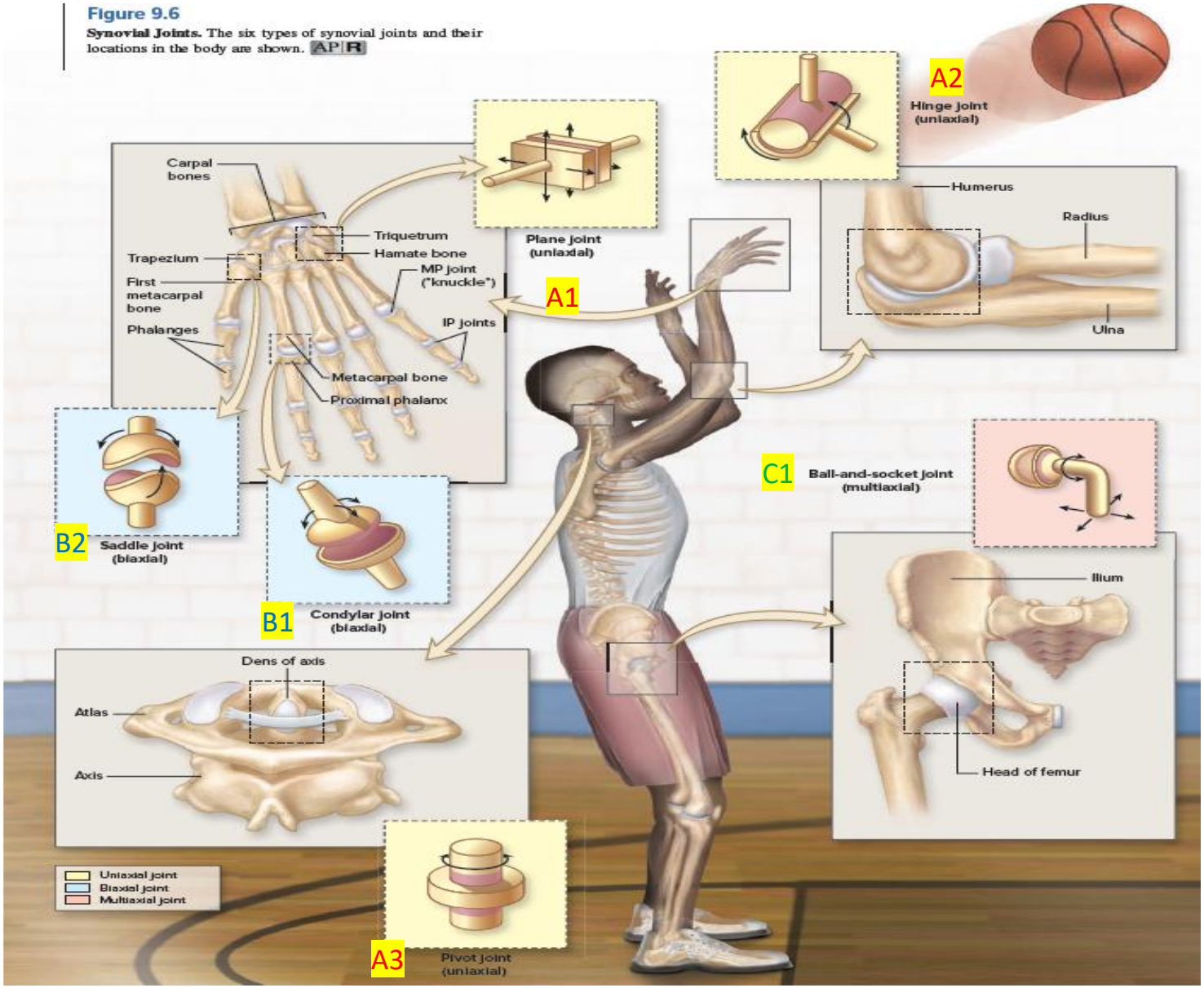
  → The more mobile a joint is, the less stable it is; and the more stable a joint is, the less mobile it is.
- **Figure 9.1** illustrates the "tradeoff" between mobility and stability for various joints.

**Relationship Between Mobility and Stability in Joints.** In every joint, there is a "tradeoff" between the relative amounts of mobility and stability.

The **more mobile** the joint, the **less stable** it is. Conversely, the **more stable** the joint, the **less mobile** it is.
→ Note how the glenohumeral (shoulder) joint is very mobile but not very stable, whereas a suture is immobile and yet very stable.



https://www.youtube.com/watch?v=0cYal_hitz4



# General Synovial Joint Structure

## Basic, distinguishing features:

**Joint (Articular) capsule:**

Two layer capsule, outer layer is dense irregular connective tissue is called the fibrous layer, whereas the inner layer is a synovial membrane (or synovium) composed of areolar connective tissue.

**Articular cartilage:**

Thin layer of hyaline cartilage lining the ends of the epiphyses, that lacks a perichondrium. Mature cartilage is avascular

**Synovial (Joint/ Articular) cavity:**

Closed sac surrounded by the synovial membrane.

**Synovial fluid:**

Clear, viscous fluid that moistens and lubricates articular surfaces. composed of secretions from synovial membrane cells and a filtrate from blood plasma.

**Ligaments:**

Composed of dense regular connective tissue. Ligaments connect one bone to another bone and strengthen and reinforce most synovial joints.

- ✓ **Extrinsic ligaments** are outside of and physically separate from the articular capsule,
- ✓ I**ntrinsic ligaments** represent thickenings of the articular capsule itself. (*extracapsular ligaments* and *intracapsular ligaments.*

**Sensory nerves and blood vessels**

Innervate and supply the articular capsule and associated ligaments. The sensory nerves detect painful stimuli in the joint and report on the amount of movement and stretch in the joint.

# General Synovial Joint Structure

## Accessory structures:

**Bursae:**

Synovial fluid-filled sacs between the skin and underlying bony prominences.

→ ***Tendon sheath:***

An elongated bursa wraps around tendons where there may be excessive friction. Tendon sheaths are especially common in the confined spaces of the wrist and ankle

**Fat pads**

Distributed along the margins of a synovial joint. Provide some protection for the joint. Often fat pads fill the spaces that form when bones move and the joint cavity changes shape.

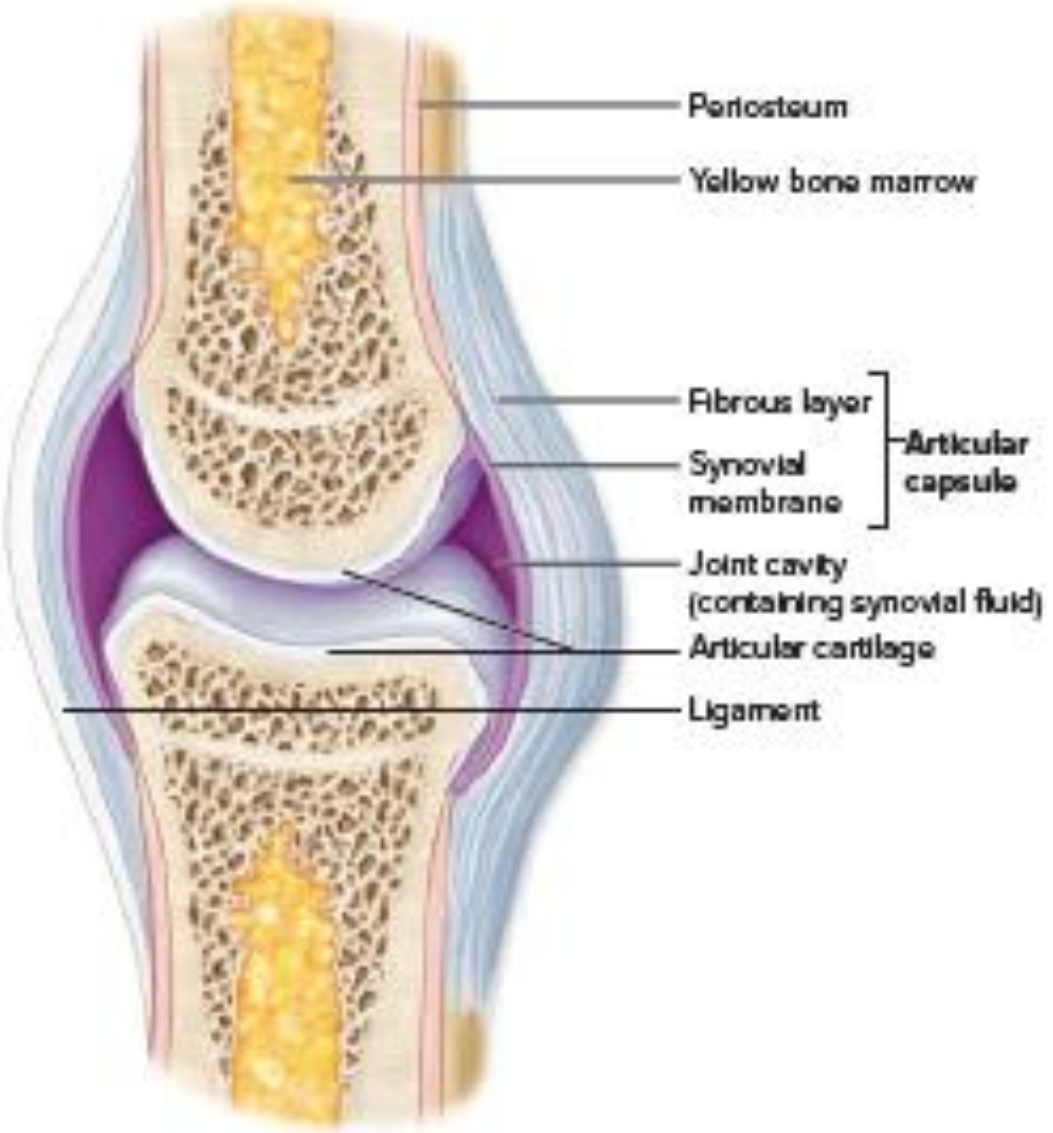
**Tendons**

Not a part of the synovial joint itself. It composed of dense regular connective tissue. A tendon attaches a muscle to a bone

**Menisci:**

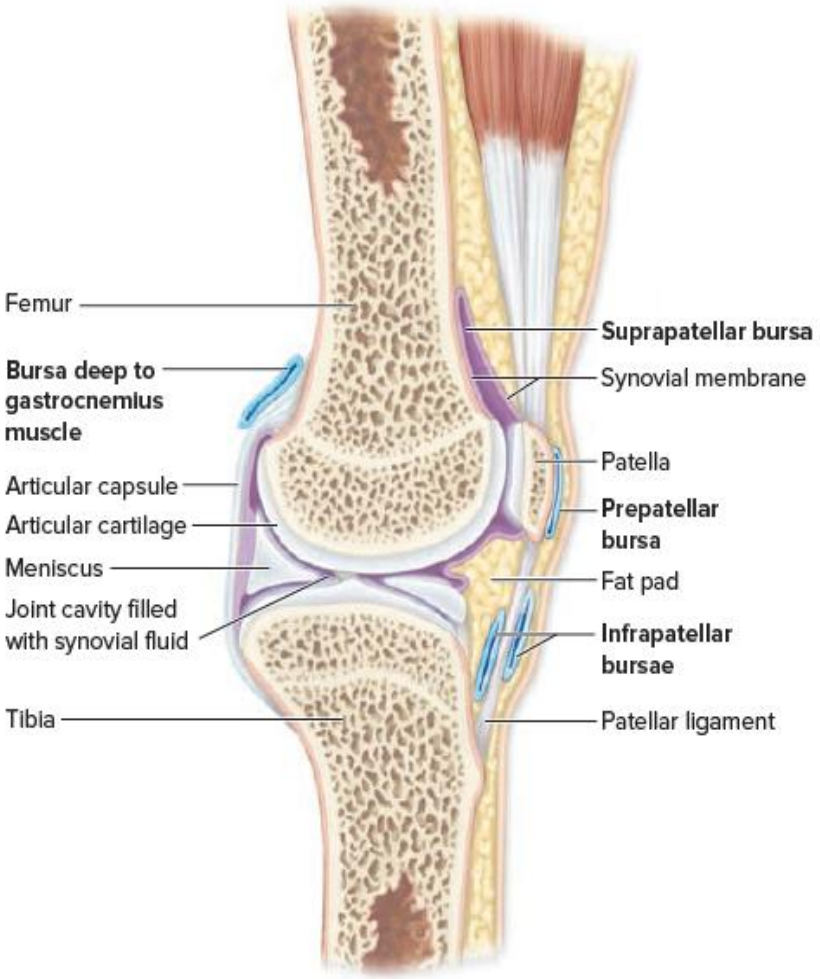
A c-shaped pad of fibrocartilage located between articular surfaces.

**Synovial Joints.**
All synovial joints are diarthroses, and they permit a wide range of motion.

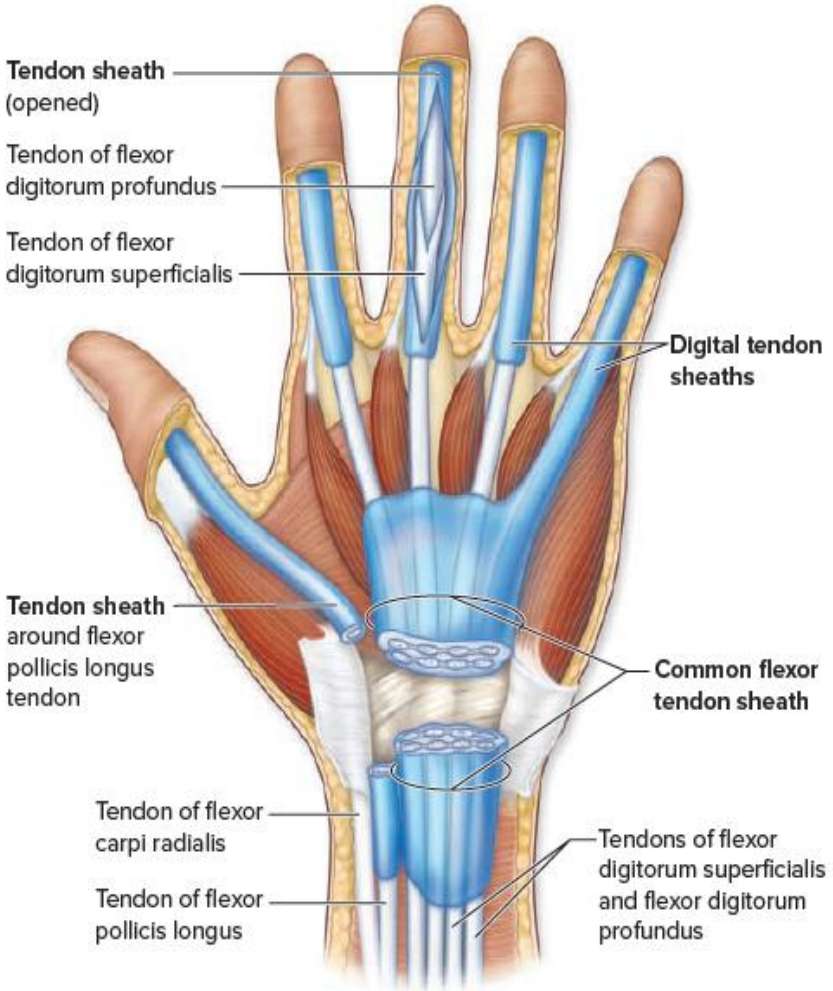


Typical synovial joint

**Bursae and Tendon Sheaths.** Synovial-fluid-filled structures called bursae and tendon sheaths reduce friction where ligaments, muscles, tendons, and bones rub together.
(*a*) The knee joint contains a number of bursae.
(*b*) The wrist and hand contain numerous tendon sheaths (blue).




(a) Bursae of the knee joint, sagittal section




(b) Tendon sheaths of wrist and hand, anterior view

# MEMBRANES

- **Membranes** are flat sheets of pliable tissue that cover or line a part of the body. The majority of membranes consist of an epithelial layer and an underlying connective tissue layer and are called **epithelial membranes**.

**The principal epithelial membranes of the body are:**

1- Mucous membranes

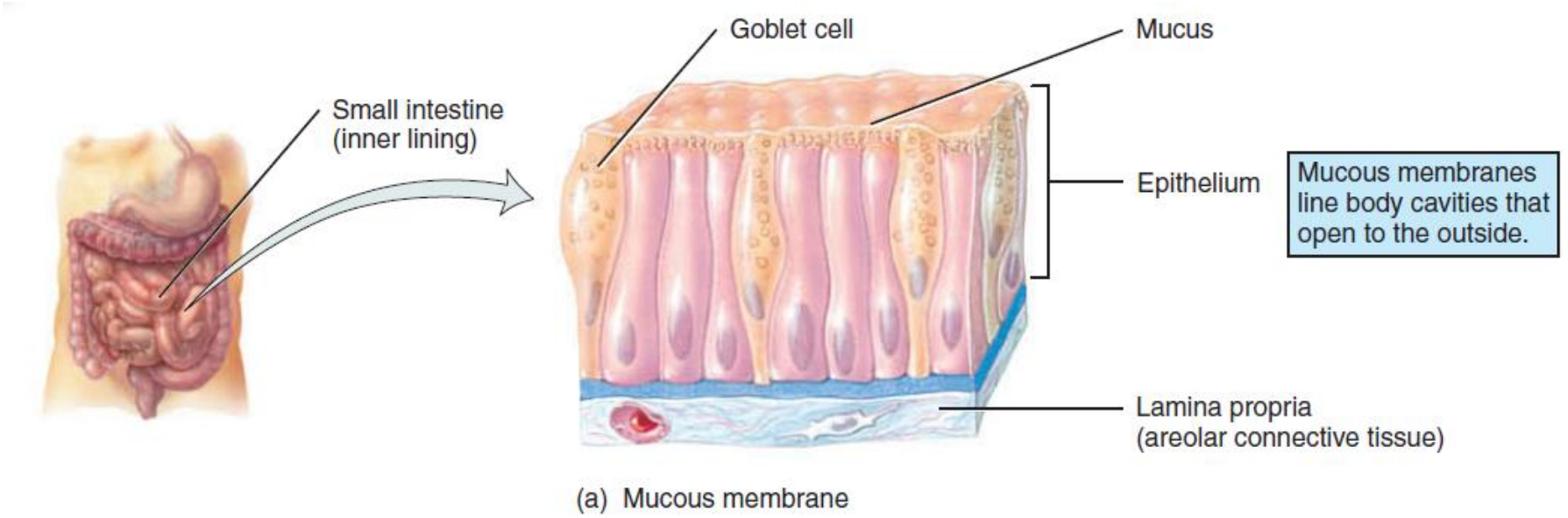
2- Serous membranes

3- Cutaneous membrane, or skin.

4- Synovial membrane, lines joints and contains connective tissue but no epithelium.

1- Mucous membranes:

- ✓ Lines a body cavity that opens directly to the exterior (membrane secrete mucus, and this slippery fluid prevents the cavities from drying out)
- ✓ Defense mechanisms because it is a barrier
- ✓ Trap particles, lubricate and secretes some of the enzymes needed for digestion and is the site of food and fluid absorption



(a) Mucous membrane

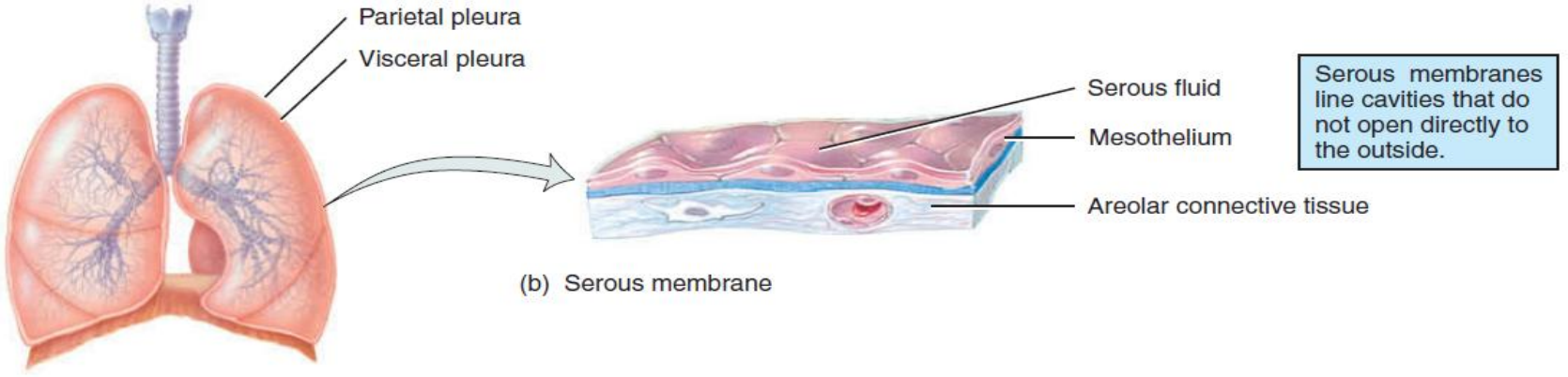
## 2- Serous membranes:

- ✓ *Serosa* lines a body cavity that does not open directly to the exterior (thoracic or abdominal cavities), and it covers the organs that are within the cavity.
- ✓ Serous membranes consist of areolar connective tissue covered by mesothelium (simple squamous epithelium)
- ✓ The mesothelium of a serous membrane secretes **serous fluid**, a watery lubricant that allows organs to glide easily over one another or to slide against the walls of cavities.

**Serous membranes have TWO layers:**

1- The layer attached to and lining the cavity wall is called the **parietal layer** (the wall)

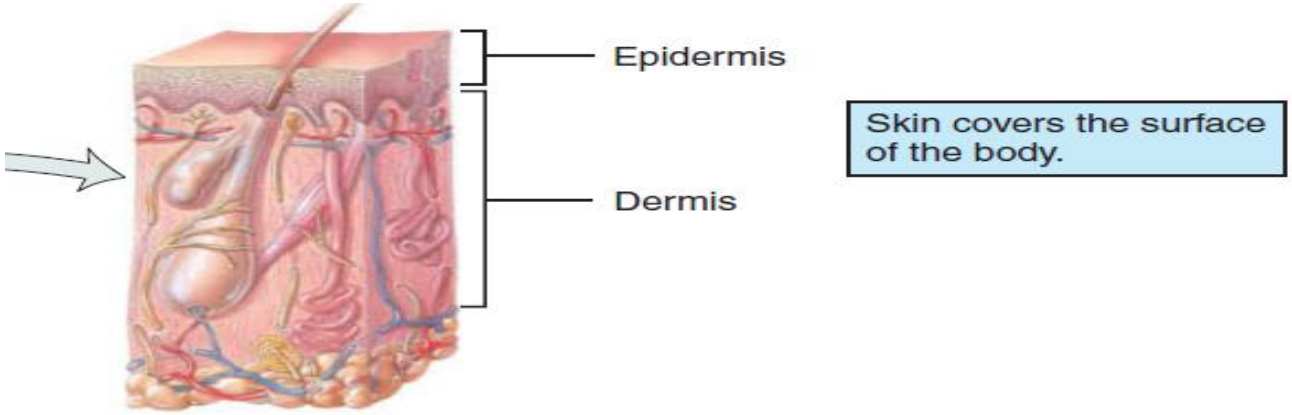
2- The layer that covers and adheres to the organs within the cavity is the **visceral layer** (body organ).



# 3- Cutaneous Membrane:

The **cutaneous membrane** or *Skin* covers the entire surface of the body and consists of a superficial portion called the *epidermis* and a deeper portion called the *dermis.*

- ✓ The epidermis consists of keratinized stratified squamous epithelium, which protects underlying tissues.
- ✓ The dermis consists of dense irregular connective tissue and areolar connective tissue.




(c) Skin (cutaneous membrane)

# 4- Synovial Membranes:

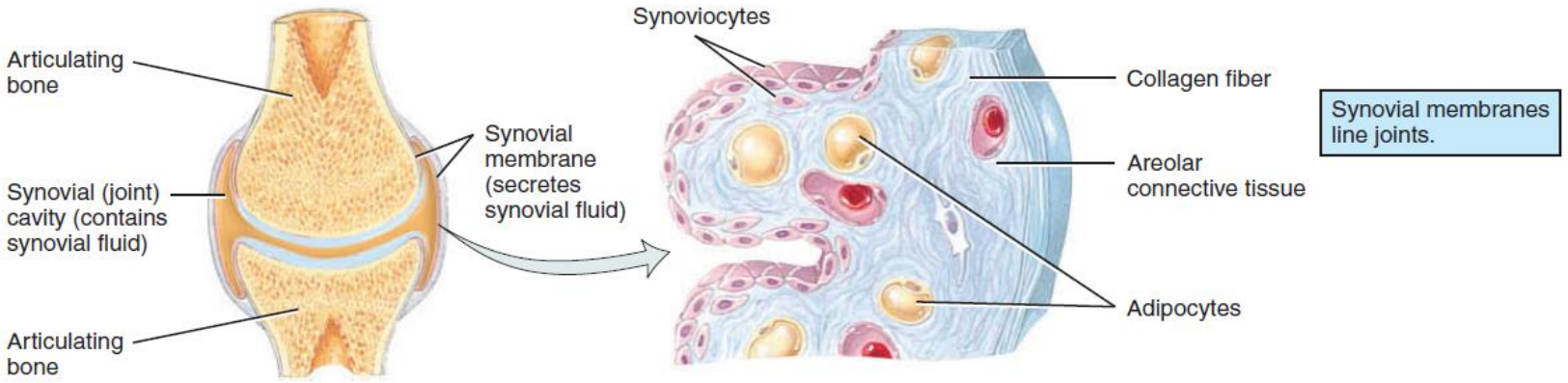
- ✓ **Synovial membranes** line the cavities of freely movable joints (joint cavities).
- ✓ Line structures that do not open to the exterior. (like serous membranes)
- ✓ They lack an epithelium and are therefore not epithelial membranes (Unlike mucous, serous, and cutaneous membranes)

**Synovial membranes are composed of**

1- A discontinuous layer of cells called **synoviocytes,** which are closer to the synovial cavity (space between the bones),

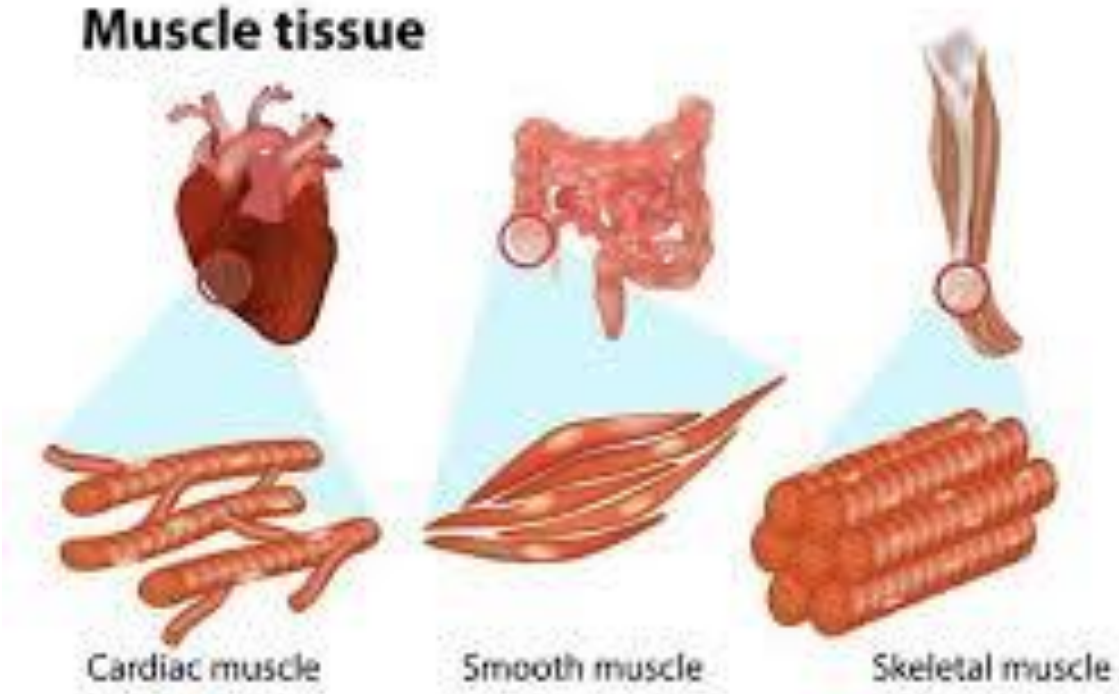
→ Synoviocytes secrete some of the components of synovial fluid. **Synovial fluid** lubricates and nourishes the cartilage covering the bones at movable joints and contains macrophages that remove microbes and debris from the joint cavity.

2- A layer of connective tissue (areolar and adipose) deep to the synoviocytes.




(d) Synovial membrane

# MUSCLE TISSUE



# Three Types of Muscular Tissue

| | Location | Function | Appearance | Control |
|---|---|---|---|---|
| Skeletal | skeleton | move bones | multi-nucleated & striated | voluntary |
| Cardiac | heart | pump blood | one nucleus, striated, & intercalated discs | involuntary |
| Visceral (smooth muscle) | various organs, example: GI tract | various functions, example: peristalsis | one nucleus & no striations | involuntary |

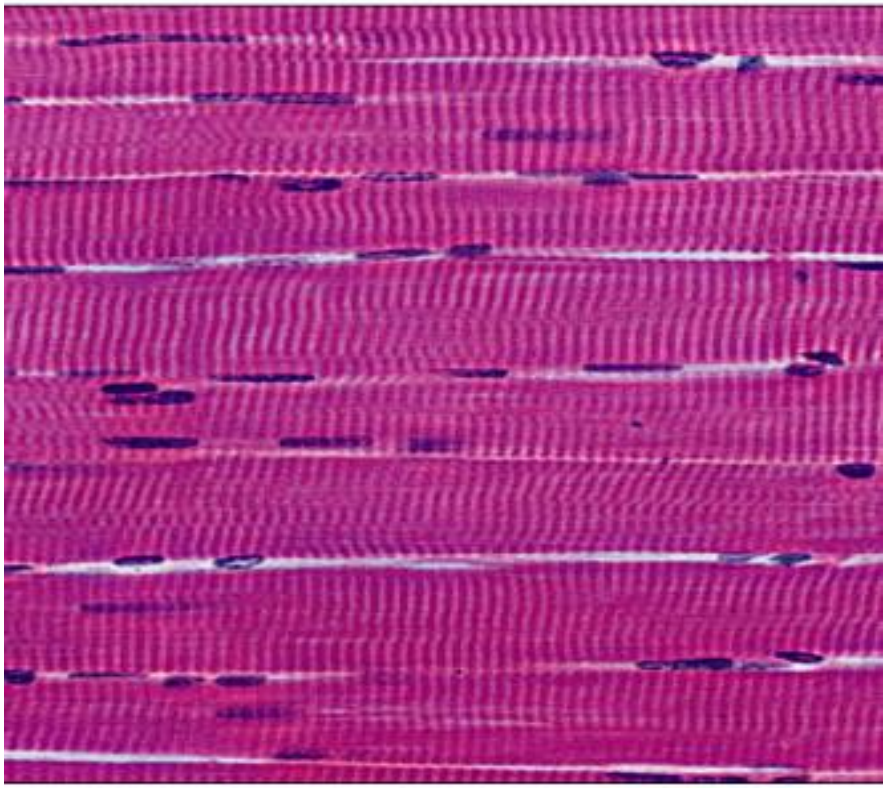
# Skeletal muscles

Skeletal Muscle

- Increase in size (hypertrophy)
- Increase in number (regeneration/proliferation)
  - Satellite cells are proposed source of regenerative cells

**Skeletal muscles**

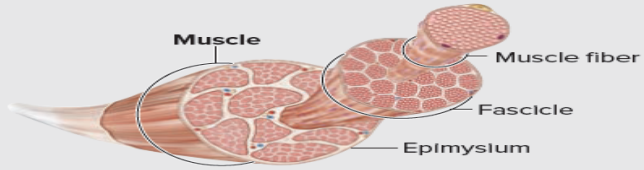
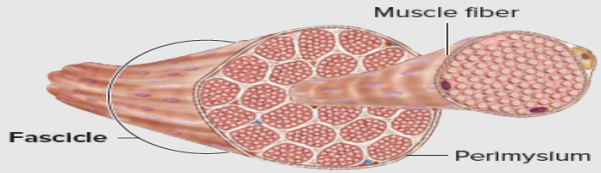
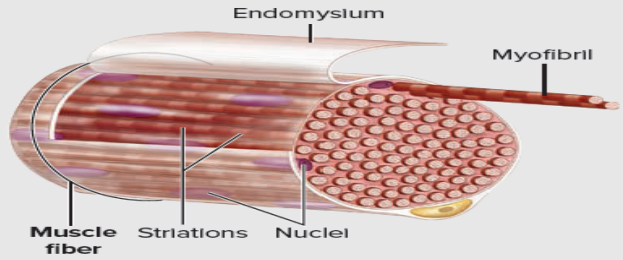
- Attach to and move skeleton
- 40% of body weight
- Fibers = multinucleate cells (As a results of embryonic cells fuse)
- Cells with obvious striations
- Contractions are voluntary



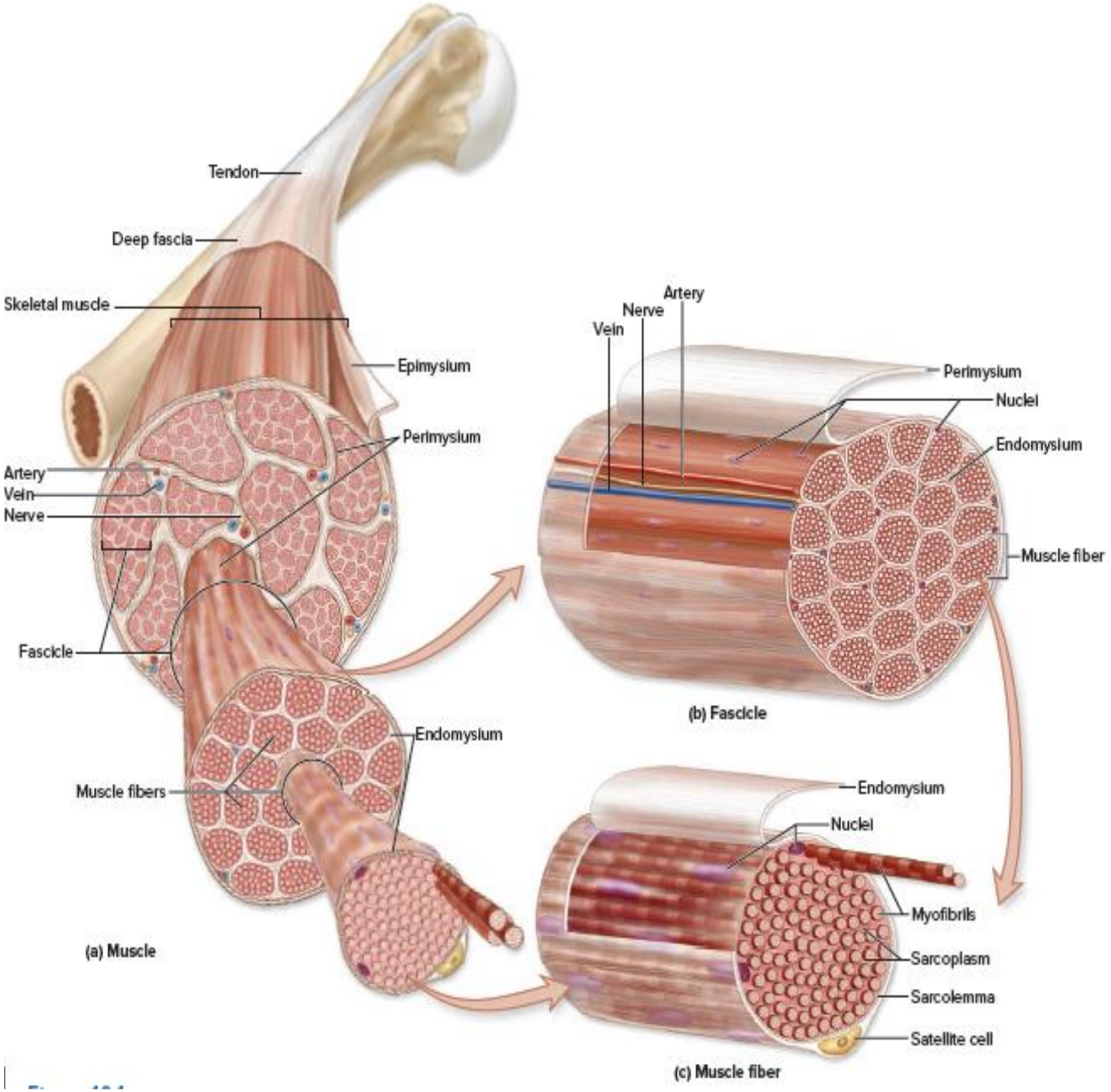
# Composition of Skeletal Muscle

- ✓Each skeletal muscle is composed of fascicles.
- ✓Fascicles are bundles of cylindrical muscle cells (muscle fibers).
- ✓Muscle fibers slender and often long cells , contain myofibrils (also known as a muscle fibril), have striations
- ✓Myofibrils are organelles, composed of repeating sections of sarcomeres, which appear under the microscope as dark and light bands. These are made up of filaments (actin and myosin)
- ✓Sarcomere
  - Basic unit of contraction
  - Boundaries: ***Z discs*** (or lines)

# Organizational Levels of Skeletal Muscle

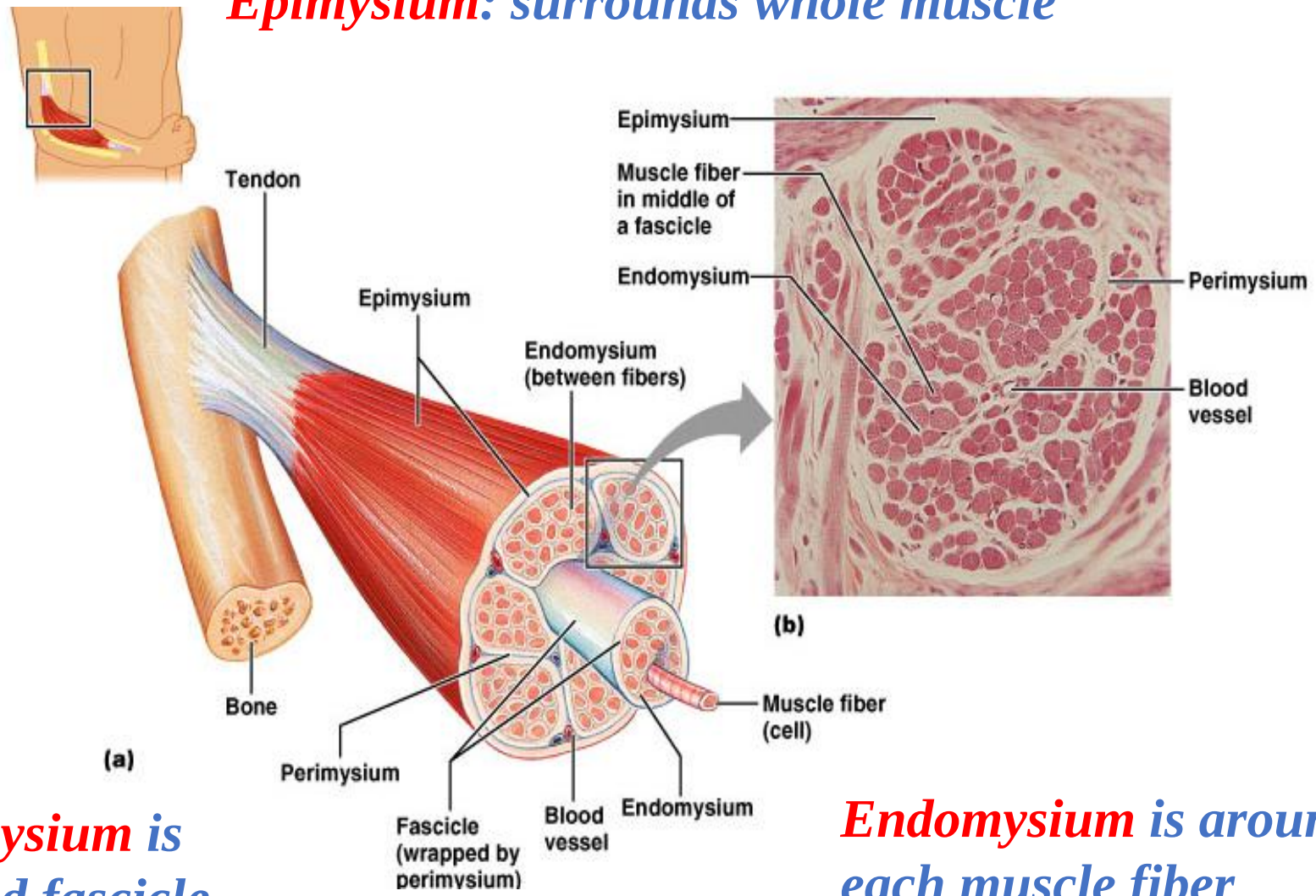
| Level | Appearance | Description | Connective Tissue Covering |
|---|---|---|---|
| ***Muscle*** |  | Multiple fascicles housing many muscle fibers, connective tissue coverings, blood vessels, nerve fibers | Epimysium |
| ***Fascicle*** |  | A bundle of muscle fibers separated from other bundles of fibers by a dense irregular connective tissue covering | Perimysium |
| ***Muscle Fiber (muscle cell)*** |  | Elongated, multinucleated, cylindrical fiber (cell); contains myofibrils, separated from other fibers by layer of areolar connective tissue; exhibits striations | Endomysium |
| ***Myofibril*** |  | Long, cylindrical contractile element within muscle fiber; as long as the muscle fiber itself; composed of myofilaments; exhibits striations | None |
| ***Myofilaments*** |  | Short contractile proteins of two types: thick (composed of myosin) and thin (composed of actin, tropomyosin, and troponin) | None |

**Structural Organization of Skeletal Muscle.**
(*a*) A skeletal muscle is ensheathed within a connective tissue layer called the epimysium.
(*b*) Each fascicle (bundle of muscle fibers) is wrapped within a connective tissue layer called the perimysium.
(*c*) Each muscle fiber is surrounded by a delicate connective tissue layer termed the endomysium



# SKELETAL MUSCLE

***Epimysium**: surrounds whole muscle*

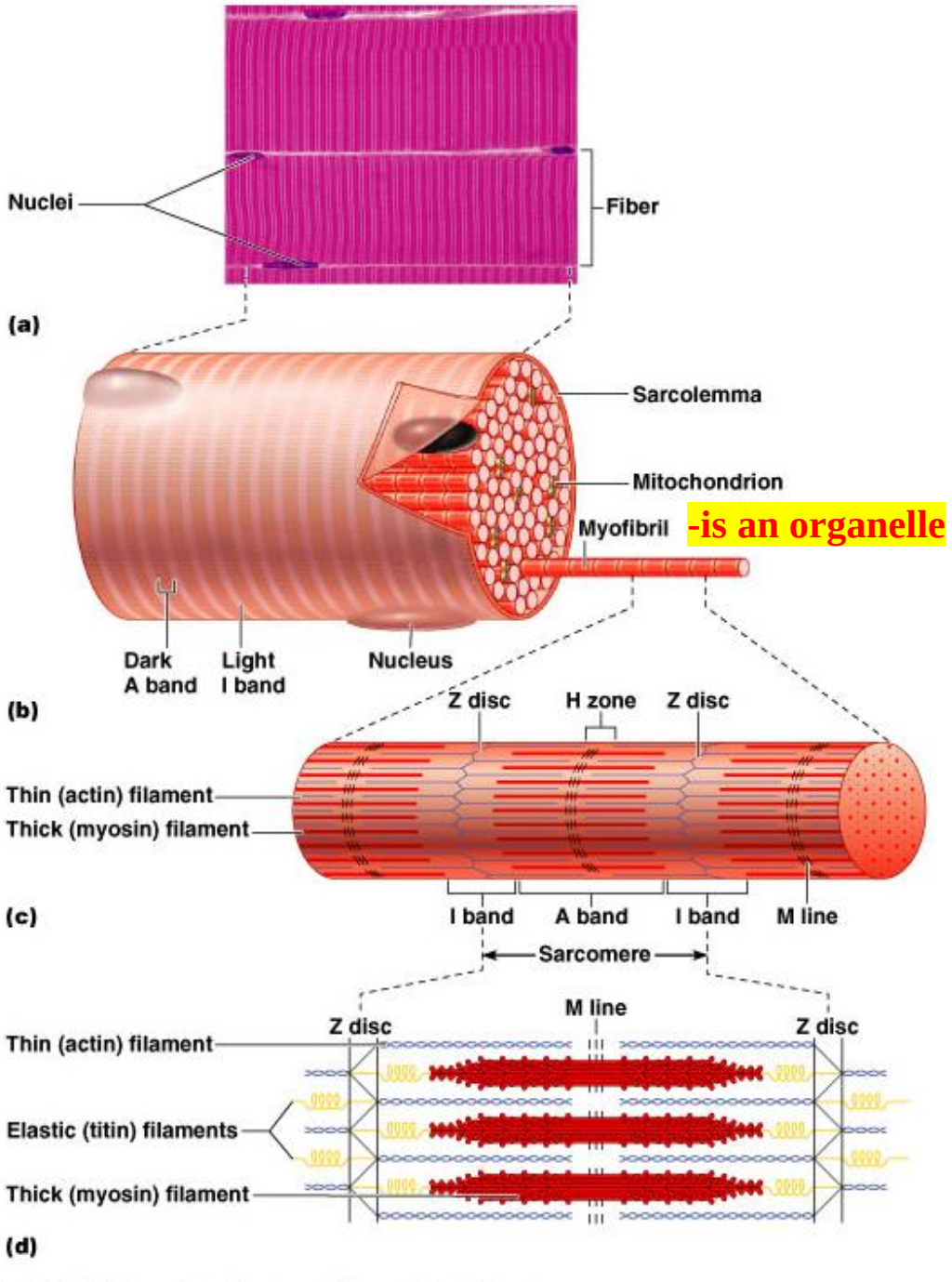



***Perimysium** is around fascicle*

***Endomysium** is around each muscle fiber*

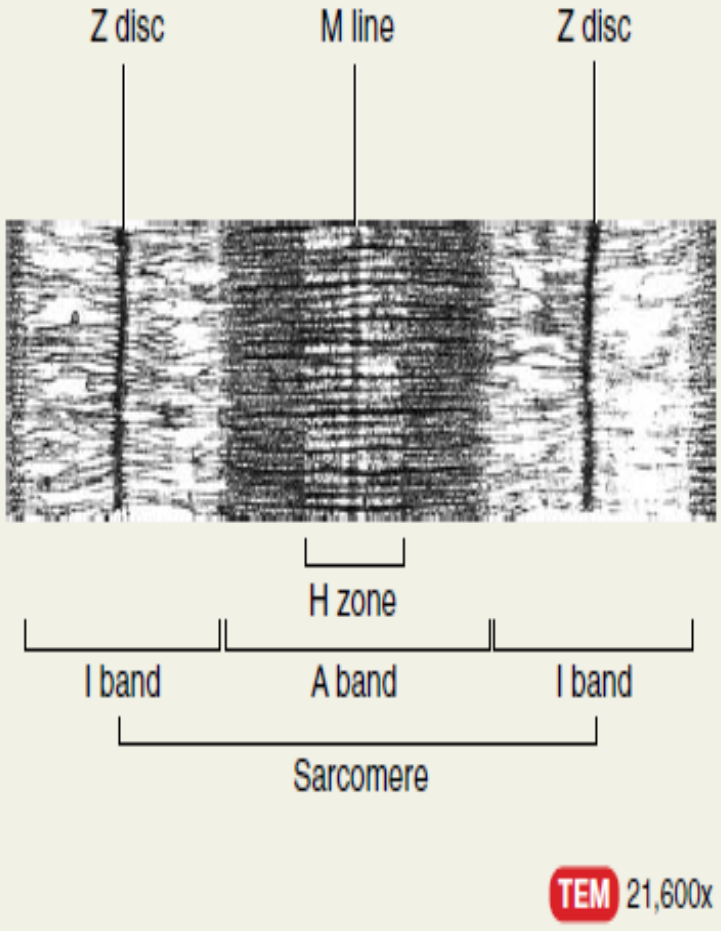
# Composition of Skeletal Muscle

This big cylinder is a fiber: 1 cell



## Components of a Sarcomere

| COMPONENT | DESCRIPTION |
|---|---|
| Z discs | Narrow, plate-shaped regions of dense material that separate one sarcomere from the next. |
| A band | Dark, middle part of sarcomere that extends entire length of thick filaments and includes those parts of thin filaments that overlap thick filaments. |
| I band | Lighter, less dense area of sarcomere that contains remainder of thin filaments but no thick filaments. A Z disc passes through center of each I band. |
| H zone | Narrow region in center of each A band that contains thick filaments but no thin filaments. |
| M line | Region in center of H zone that contains proteins that hold thick filaments together at center of sarcomere. |



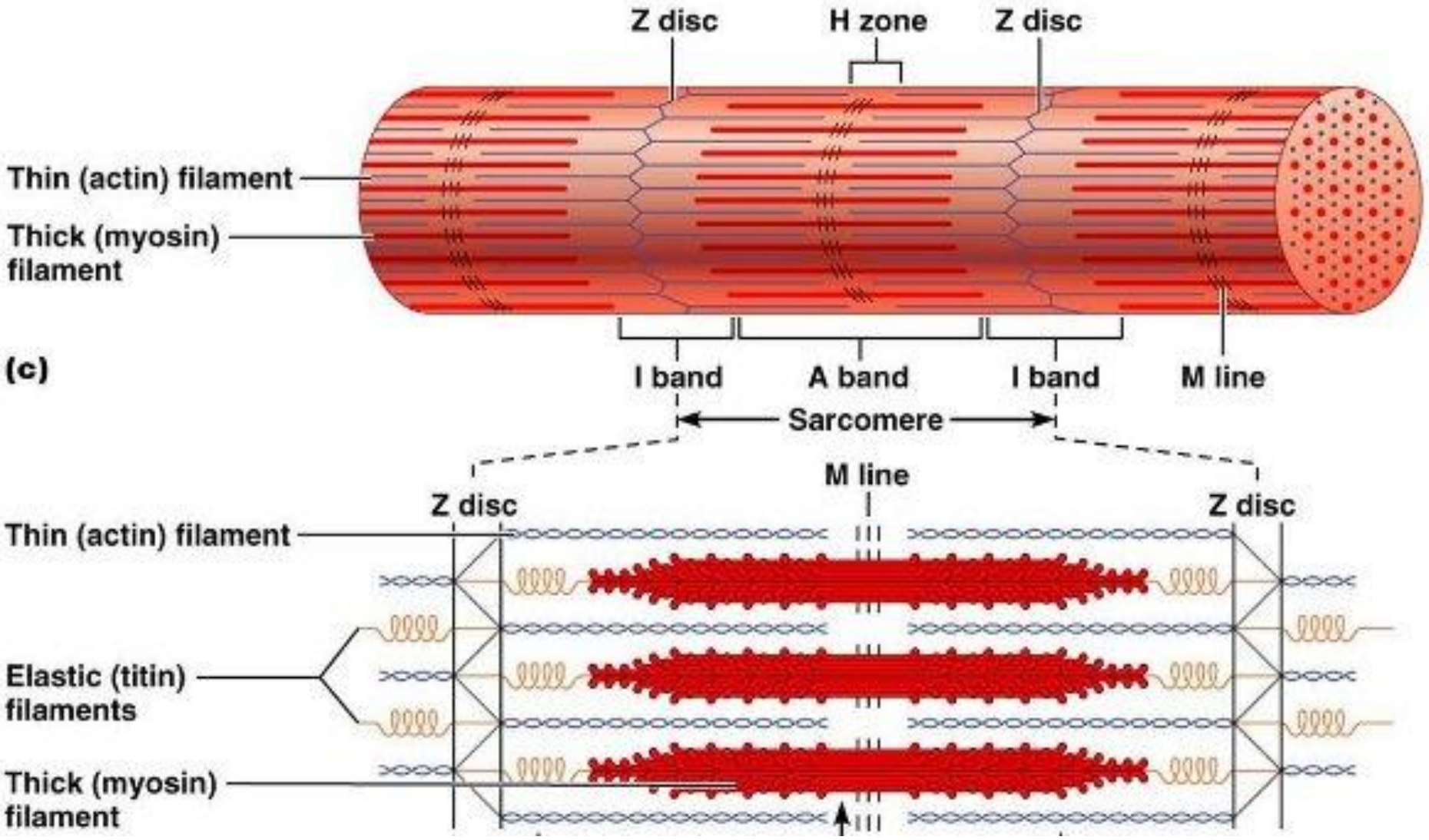
# Sarcomere: Contractile unit of striated muscle

- Structure that extend between two Z lines
  - A band
  - 2 halves of I bands
  - H zone
  - M line (*mittelscheibe,* Ger.“middle of the disc”)

  ---

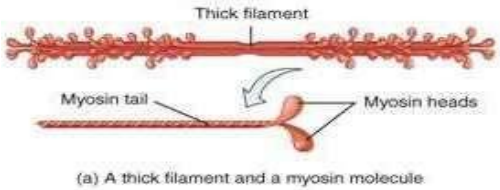
  - **Myofilaments**
    - Actin→ thin
    - Myosin→ thick

# Sarcomere

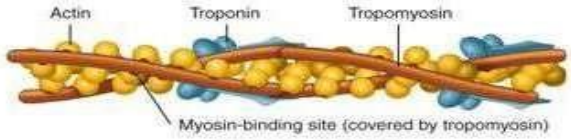

Z disc
H zone
Z disc
Thin (actin) filament
Thick (myosin) filament
(c)
I band
A band
I band
M line
Sarcomere
M line
Z disc
Z disc
Thin (actin) filament
Elastic (titin) filaments
Thick (myosin) filament

# Muscle Proteins

| Contractile | Regulatory | Structural |
|---|---|---|
| Myosin | Troponin | Titin |
| Actin | Tropomyosin | Nebulin |
| | | Alpha-actin |
| | | Myomesin |
| | | Dystrophin |



(a) A thick filament and a myosin molecule



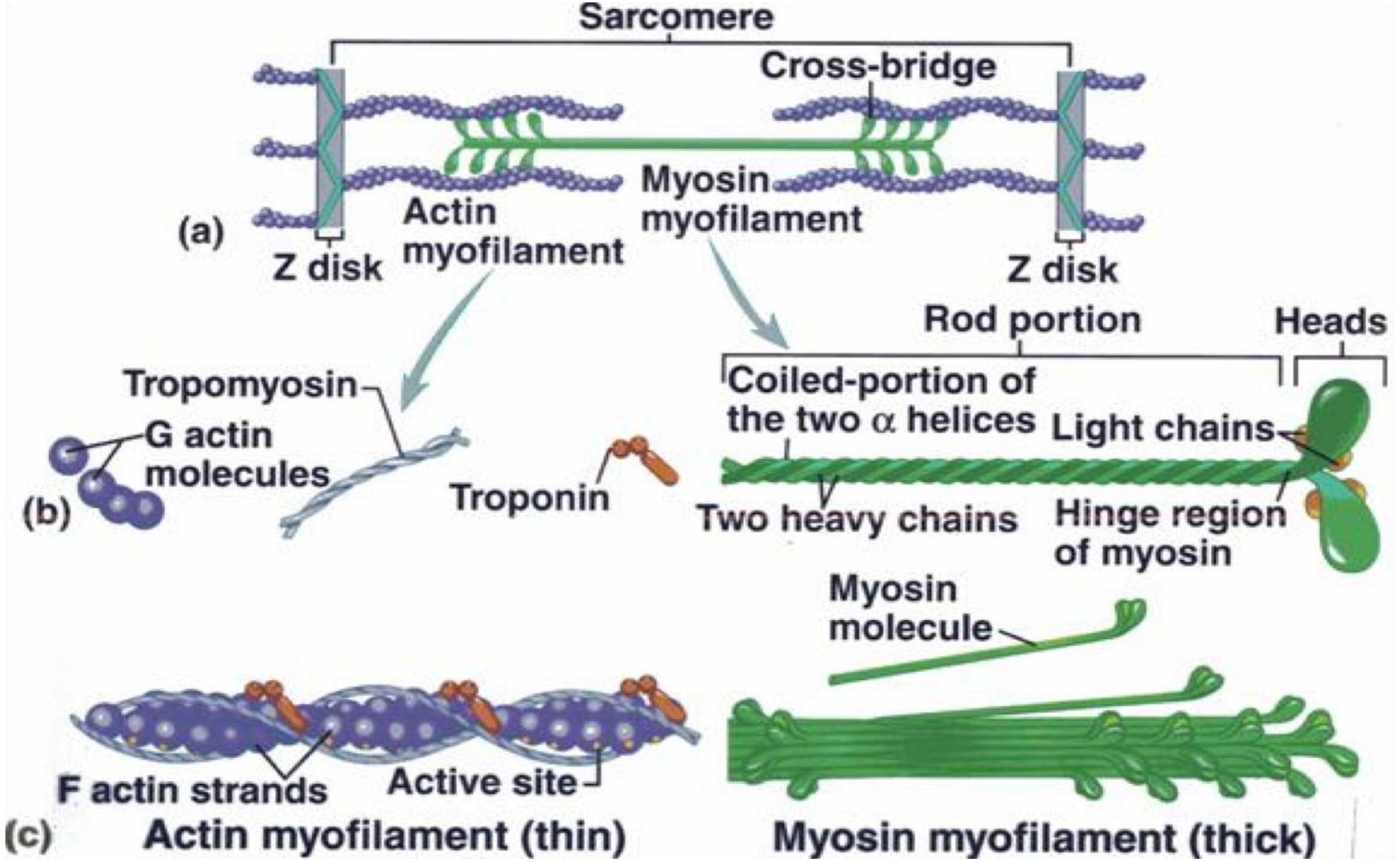
(b) Portion of a thin filament

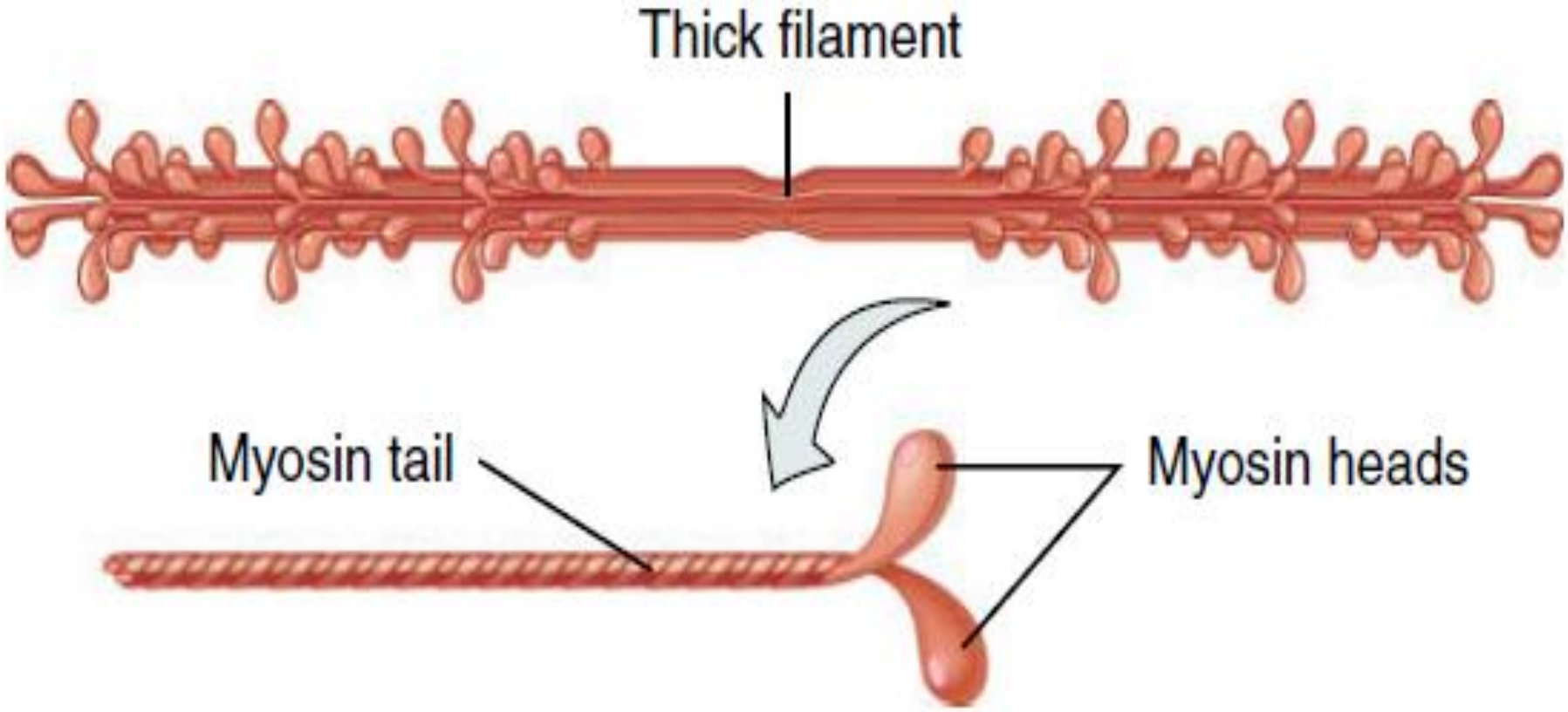


**Structure of thick and thin filaments.** (a) A thick filament contains about 300 myosin molecules, one of which is shown enlarged. The myosin tails form the shaft of the thick filament, and the myosin heads project outward toward the surrounding thin filaments. (b) Thin filaments contain actin, troponin, and tropomyosin.

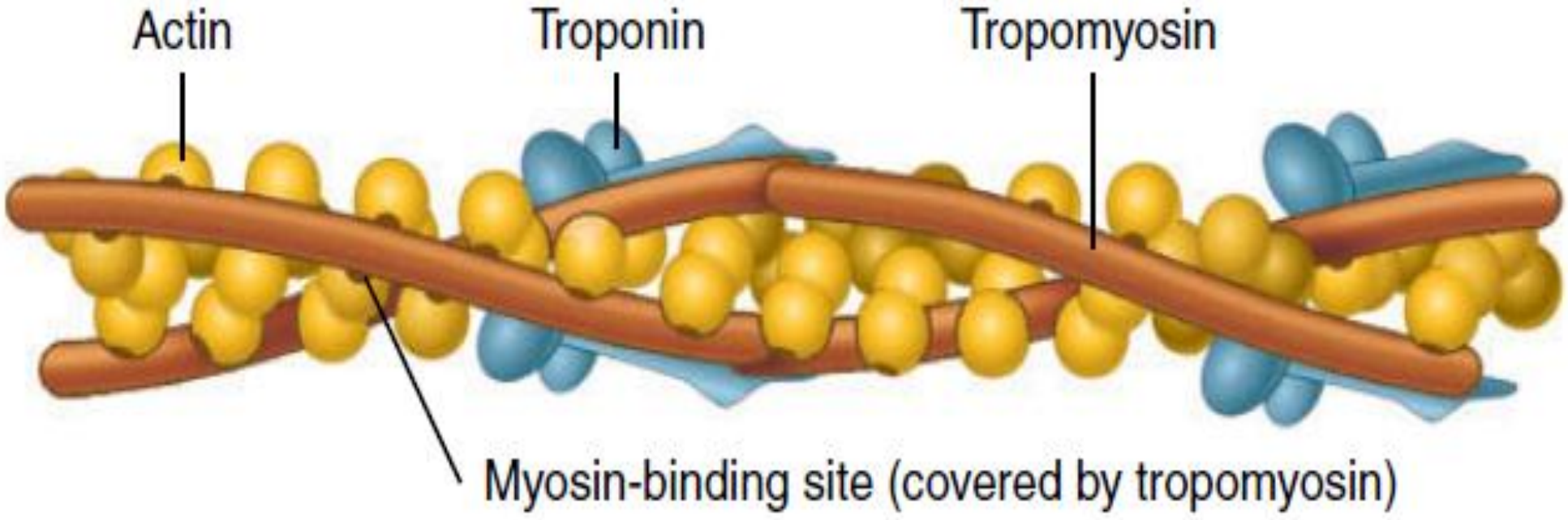
Contractile proteins (myosin and actin) generate force during contraction; regulatory proteins (troponin and tropomyosin) help switch contraction on and off.

# Sarcomere subunits



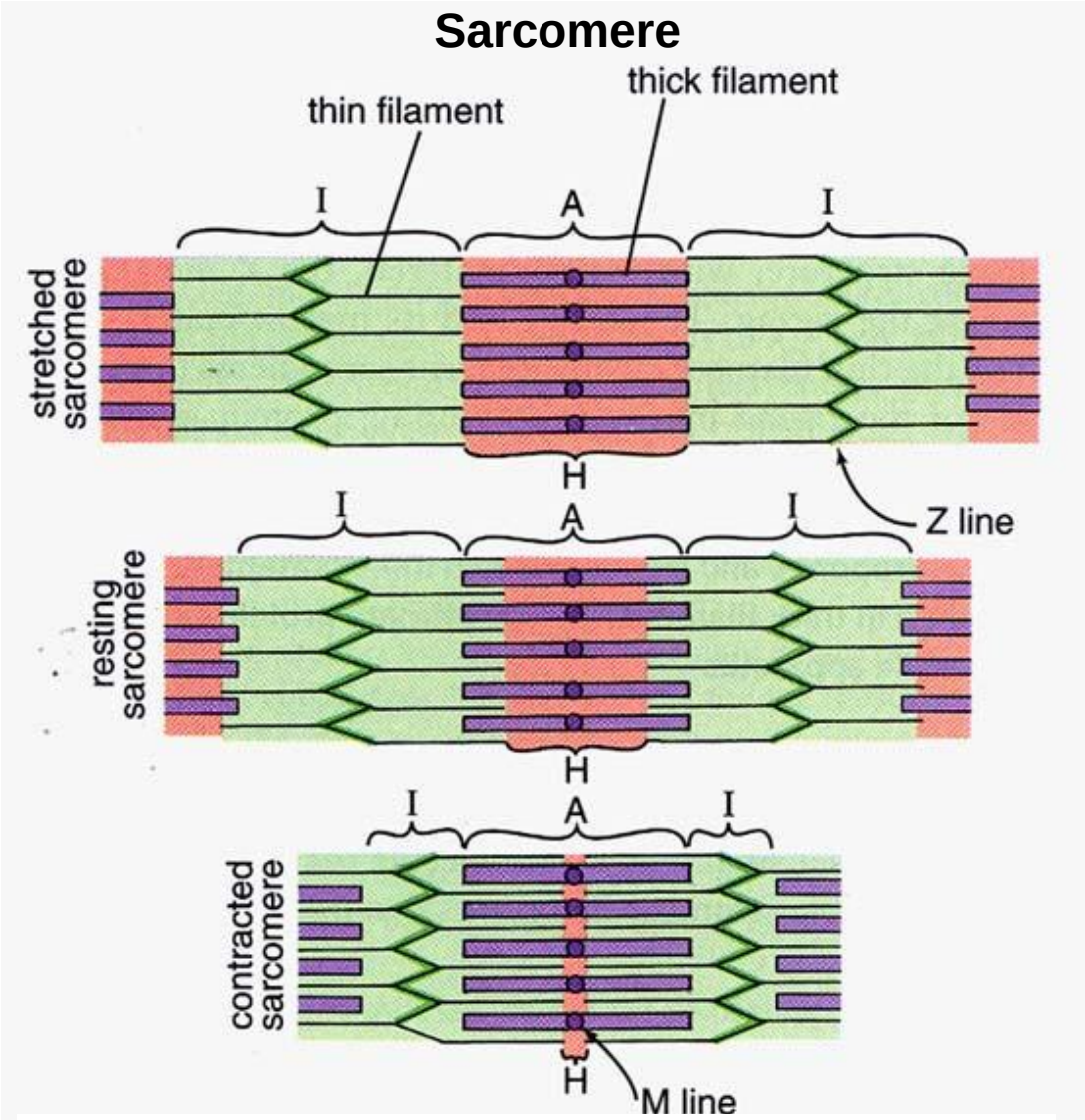



(a) A thick filament and a myosin molecule

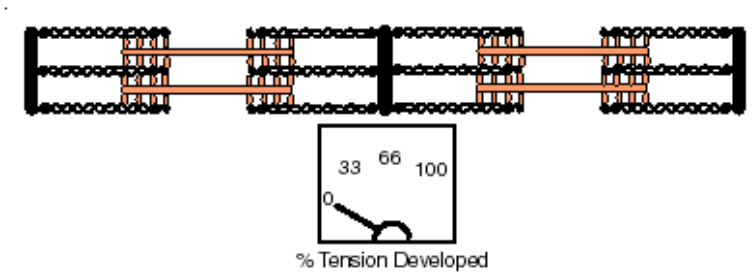



(b) Portion of a thin filament

# Sliding Filament Theory




**Note: Z lines** move closer together; I **band** and **H band** become smaller during contraction




**Muscle fibers are composed of many contractile units (sarcomeres)**

Changes in the amount of overlap between thick and thin filaments allows contraction and relaxation of muscle fibers

Many fibers contracting together result in gross movement

# NERVOUS TISSUE

- **Nervous tissue** consists of only two principal types of cells: neurons and neuroglia.
- **Neurons**, or nerve cells, are sensitive to various stimuli.

→ They convert stimuli into electrical signals called **nerve action potentials (nerve impulses)** and conduct these action potentials to other neurons, to muscle tissue, or to glands.

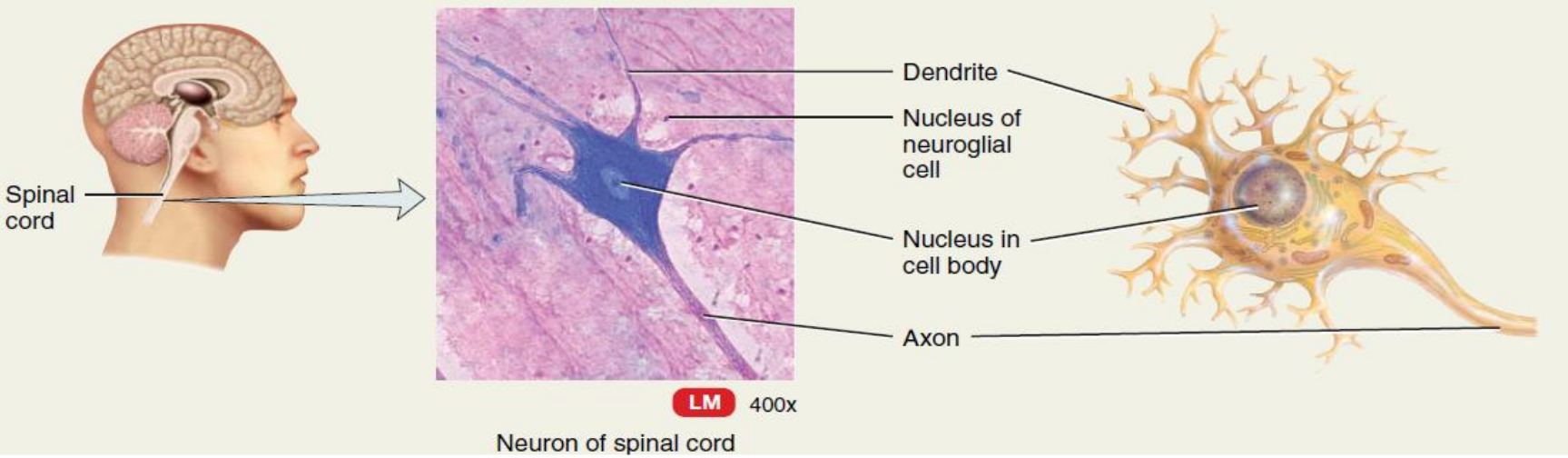
- **Neuroglia** (glue) do not generate or conduct nerve impulses, these cells do have many important supportive functions.

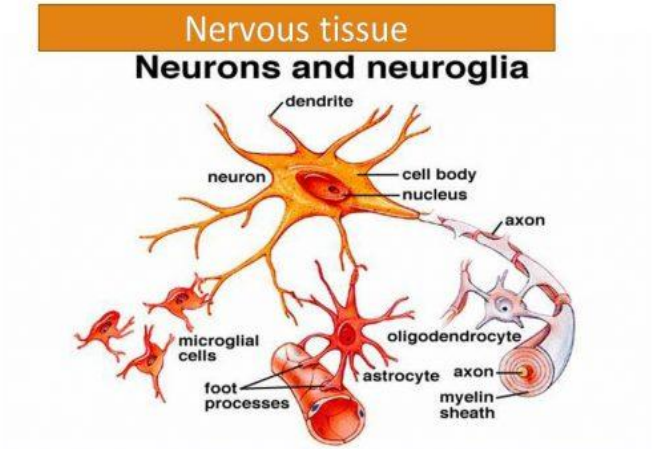
- **Most neurons consist of three basic parts:**

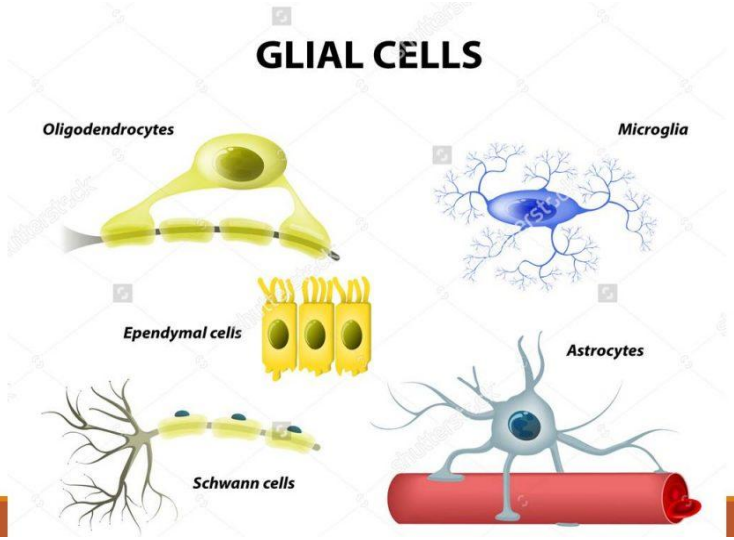
1. The **cell body** contains the nucleus and other organelles.
2. **Dendrites** (tree) are tapering, highly branched, and usually short cell processes (extensions). They are the major receiving or input portion of a neuron.
3. A**xon** (*axo-* axis) of a neuron is a single, thin, cylindrical process that may be very long. It is the output portion of a neuron, conducting nerve impulses toward another neuron or to some other tissue.

***** Dendrites and Axons are two kinds of cell processes***

# NERVOUS TISSUE (continued)



# EXCITABLE CELLS

- Neurons and muscle fibers are considered **excitable cells** because they exhibit **electrical excitability**, the ability to respond to certain stimuli by producing electrical signals such as *action potentials*.

- **Action potentials** can propagate (travel) along the plasma membrane of a neuron or muscle fiber due to the presence of specific voltage-gated ion channels.

- ***When an action potential forms in a neuron***, the neuron releases chemicals called *neurotransmitters*, which allow neurons to communicate with other neurons, muscle fibers, or glands.

- ***When an action potential occurs in a muscle fiber***, the muscle fiber contracts, resulting in activities such as movement of the limbs, propulsion of food through the small intestine, and movement of blood out of the heart and into the blood vessels of the body.