



КАЗАНСКИЙ (ПРИВОЛЖСКИЙ) ФЕДЕРАЛЬНЫЙ УНИВЕРСИТЕТ

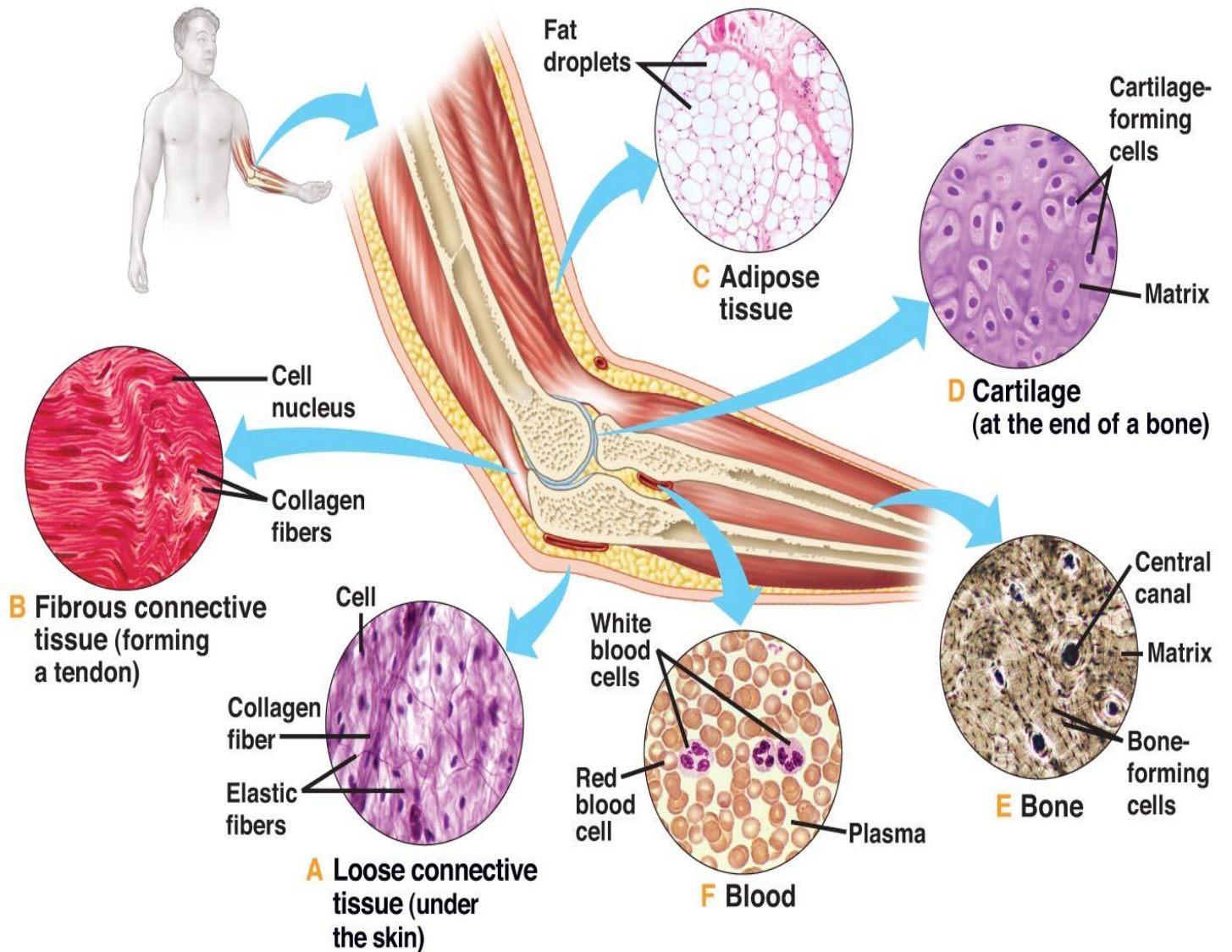
CONNECTIVE TISSUE Part I



Connective Tissue

✓ Found everywhere in the body (app. 50% of body weight)

✓ Includes the most abundant and widely distributed tissues



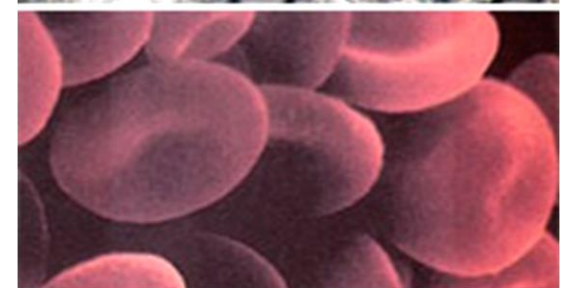
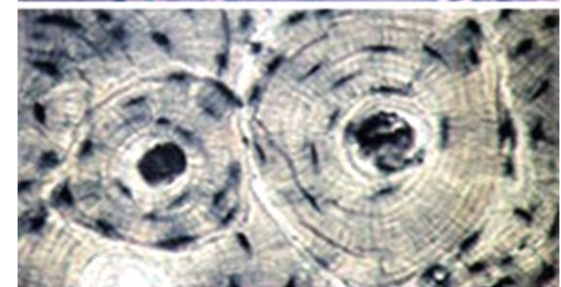
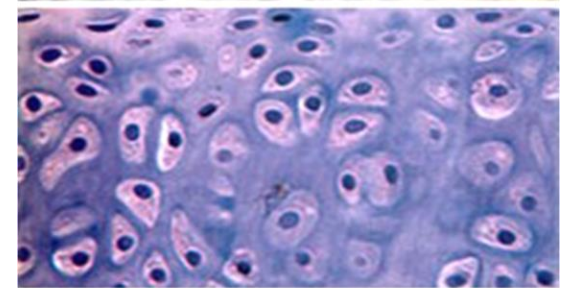
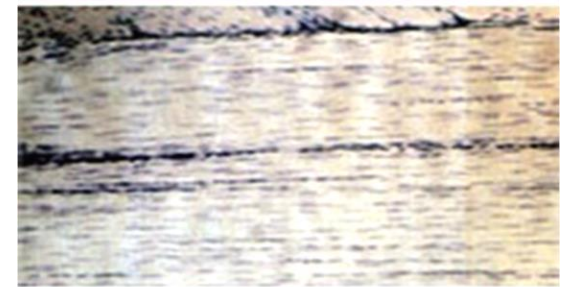
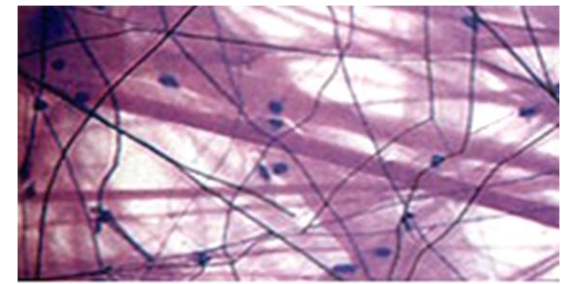
General features of CT

All CT arises from an embryonic tissue called *mesenchyme*

Consists of cells and extracellular matrix (predominant)

Cells are various in type, but little in number

Vascularized (except cartilage)

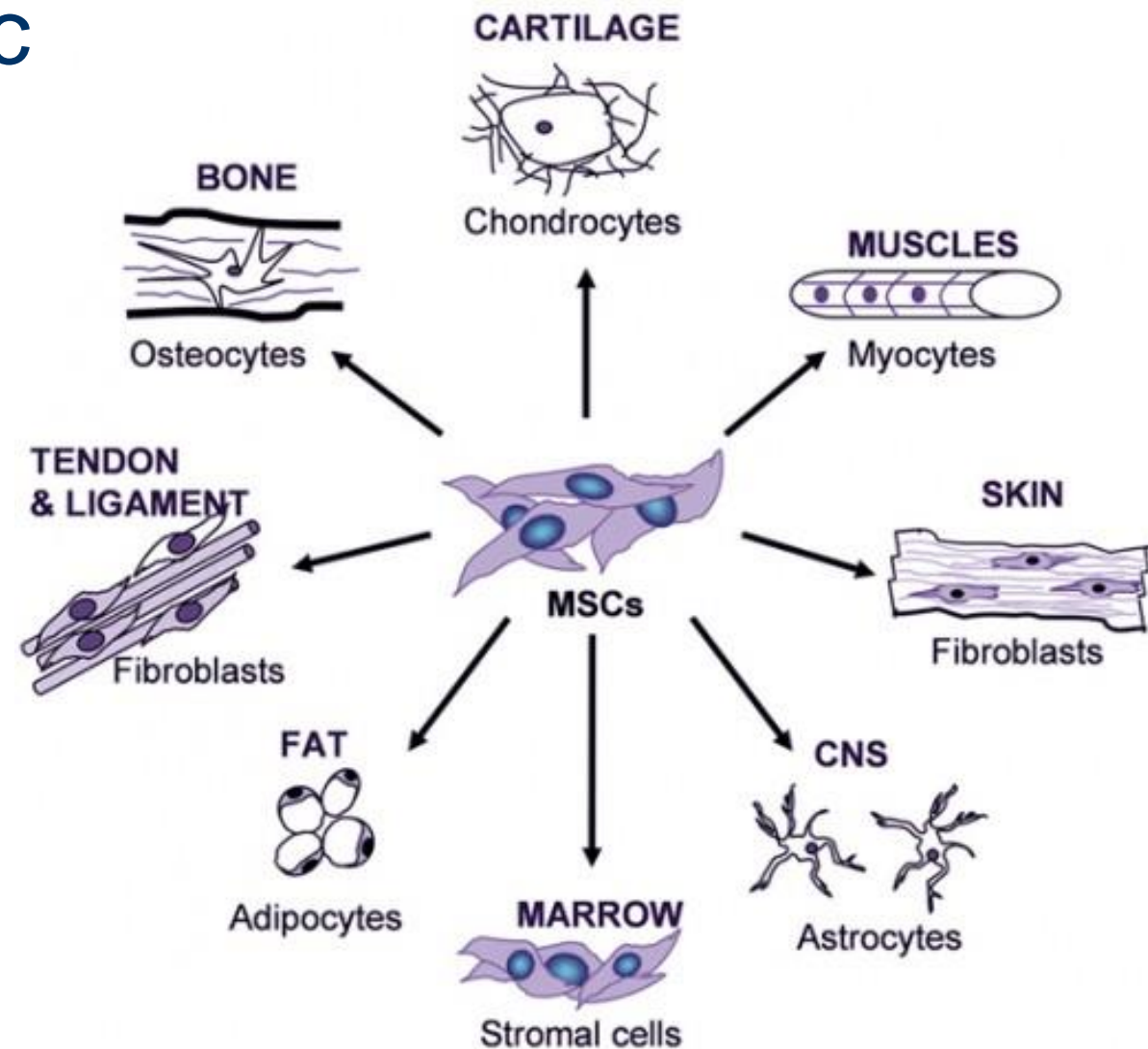


Functions of CT

- Provides substance and form to the body and organs
- Transportation of fluid and dissolved substances
- Protection
- Supports, surrounds and connects over tissues
- Storage of energy
- Defend the body from microorganisms
- Aids in injury repair

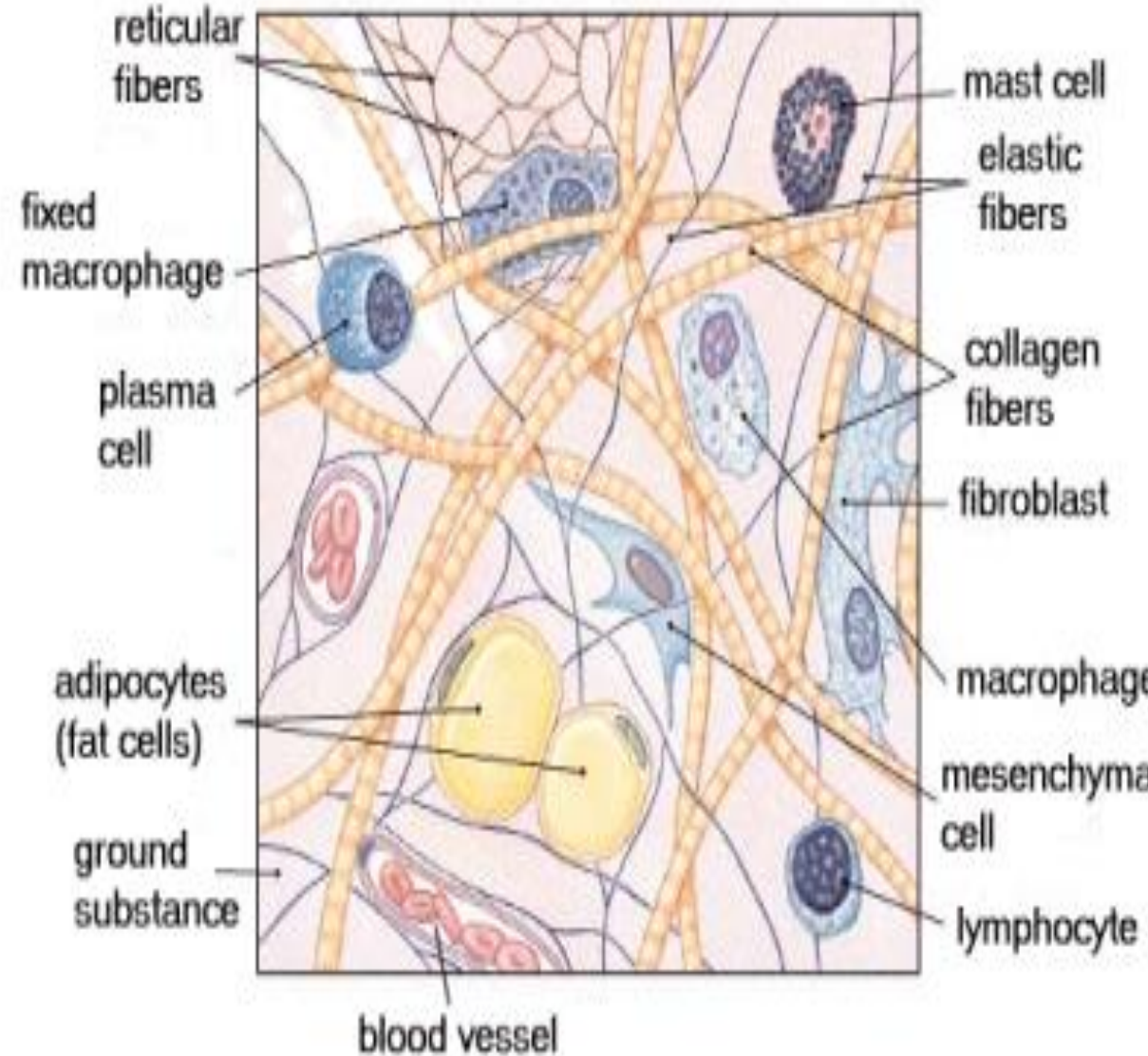
Mesenchyme

- Mesenchyme – embryonic CT
- Arises from mesoderm
- Mesenchyme cells– stem cells (MSC)- multipotent cells
- Reserved in the bone marrow



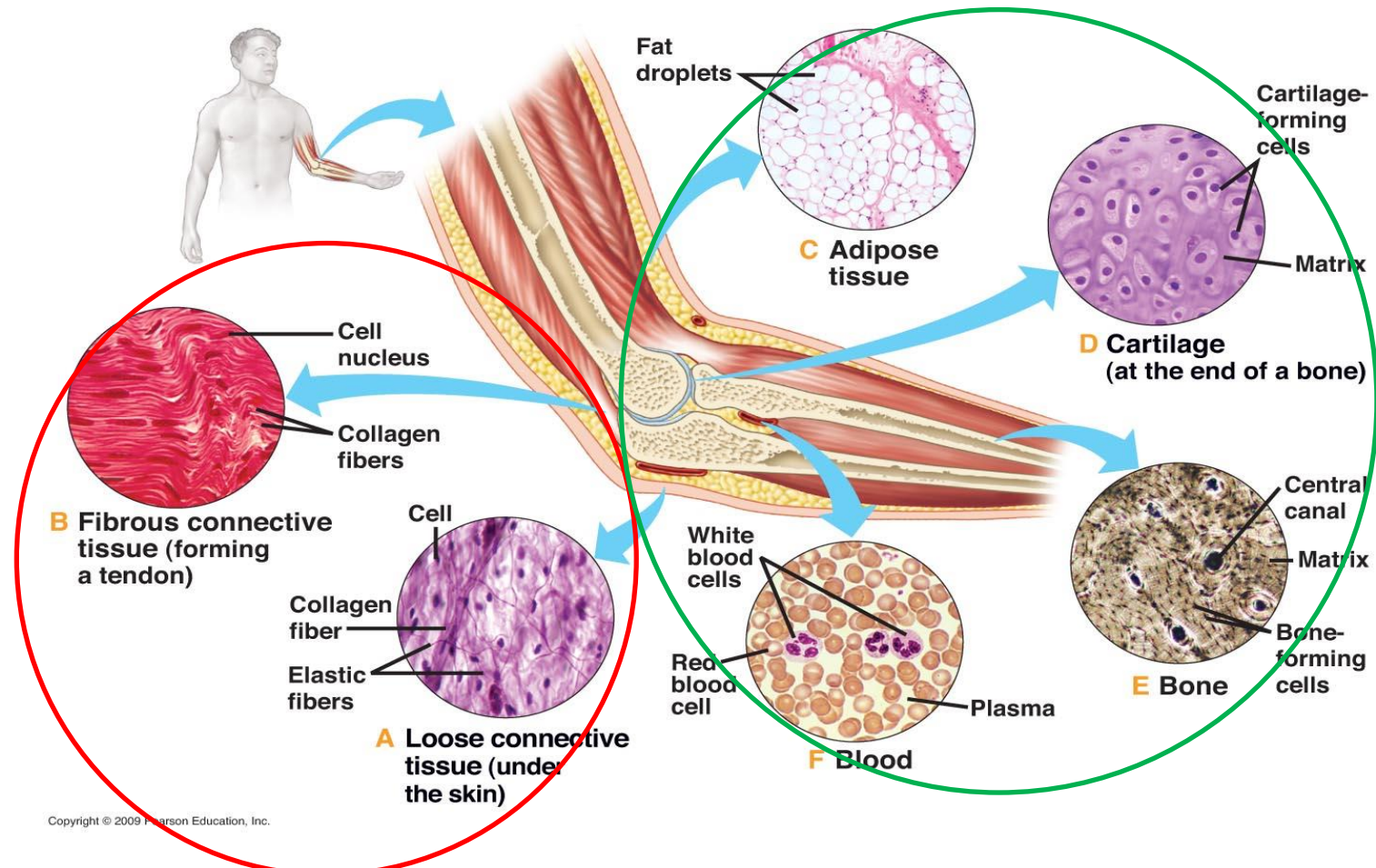
Connective Tissue consists of:

- Cells (various)
- Intercellular matrix:
 - Fibers
 - Collagen
 - Elastic
 - Reticular
 - Ground substance:
 - Glycosaminoglycans and its bonds dissolved in the tissue fluid



Types of Connective Tissue

1. Connective Tissue Proper
2. Specialized Connective Tissue



Connective Tissue Proper

- Loose connective tissue
- Dense connective tissue:
 - regular
 - irregular



Cells of Connective Tissue Proper:

Resident:

*native to the tissue
they are found*

1. **Fibroblasts**/fibrocyte
2. Reticular cells
3. Adipose cells

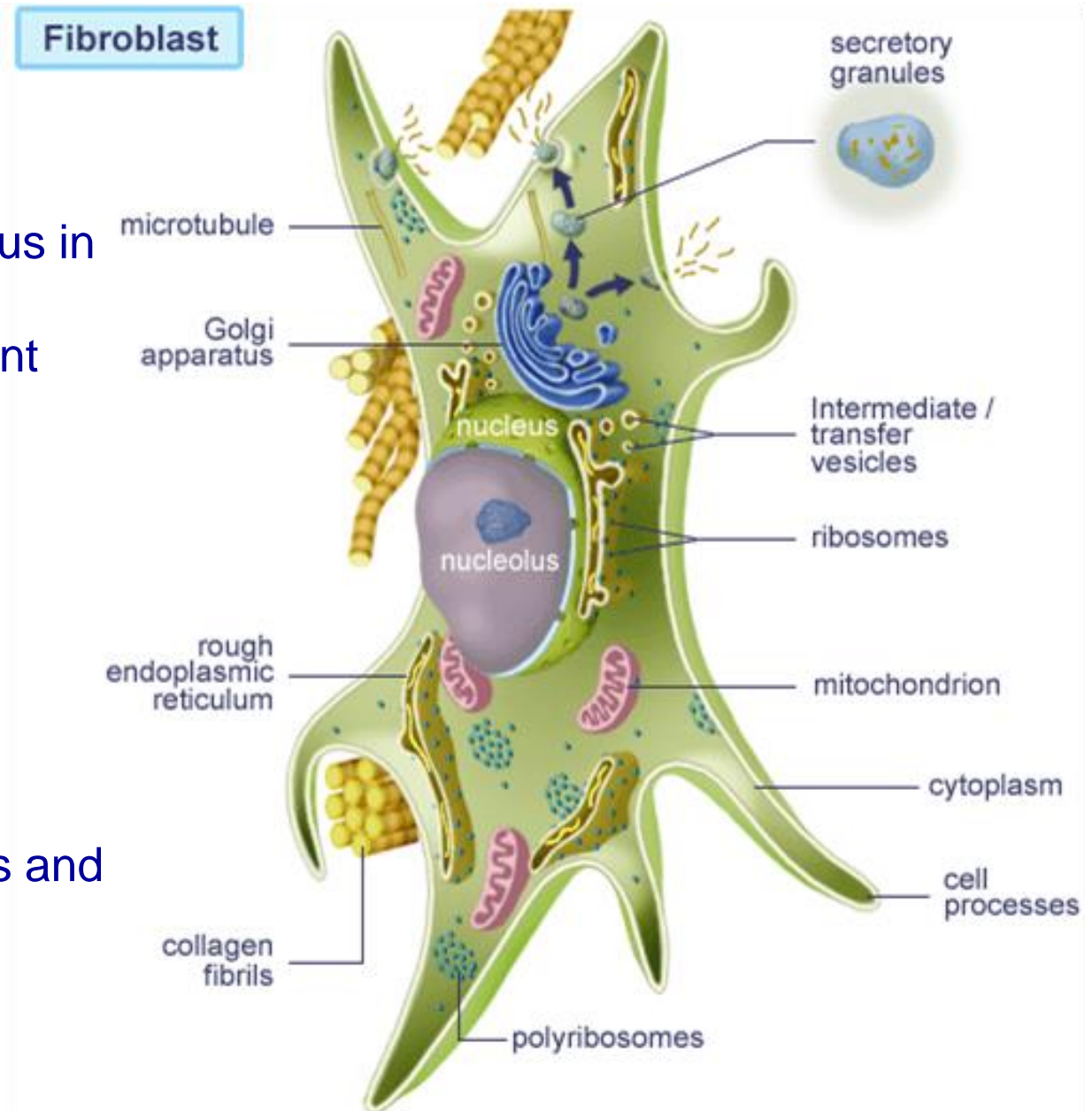
Wondering:

*immigrant cells usually
from blood or bone marrow*

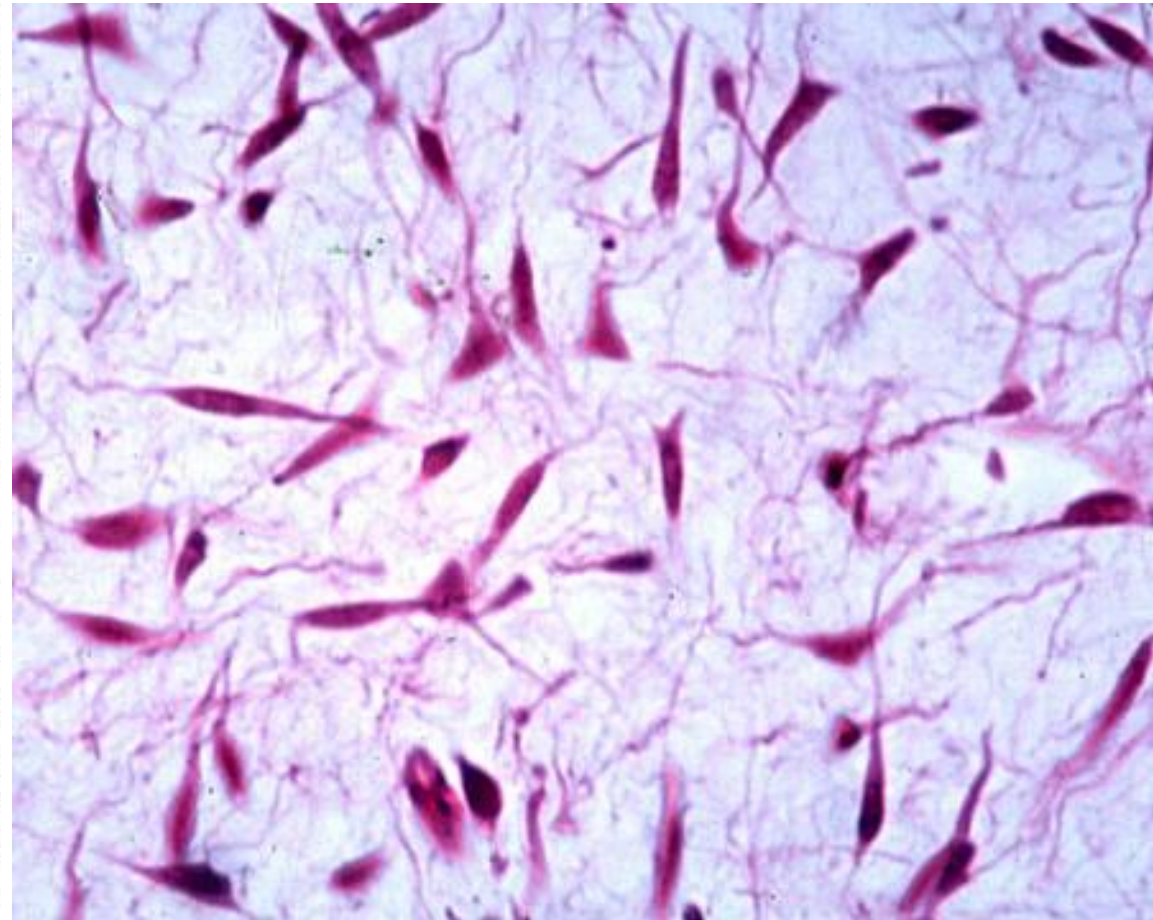
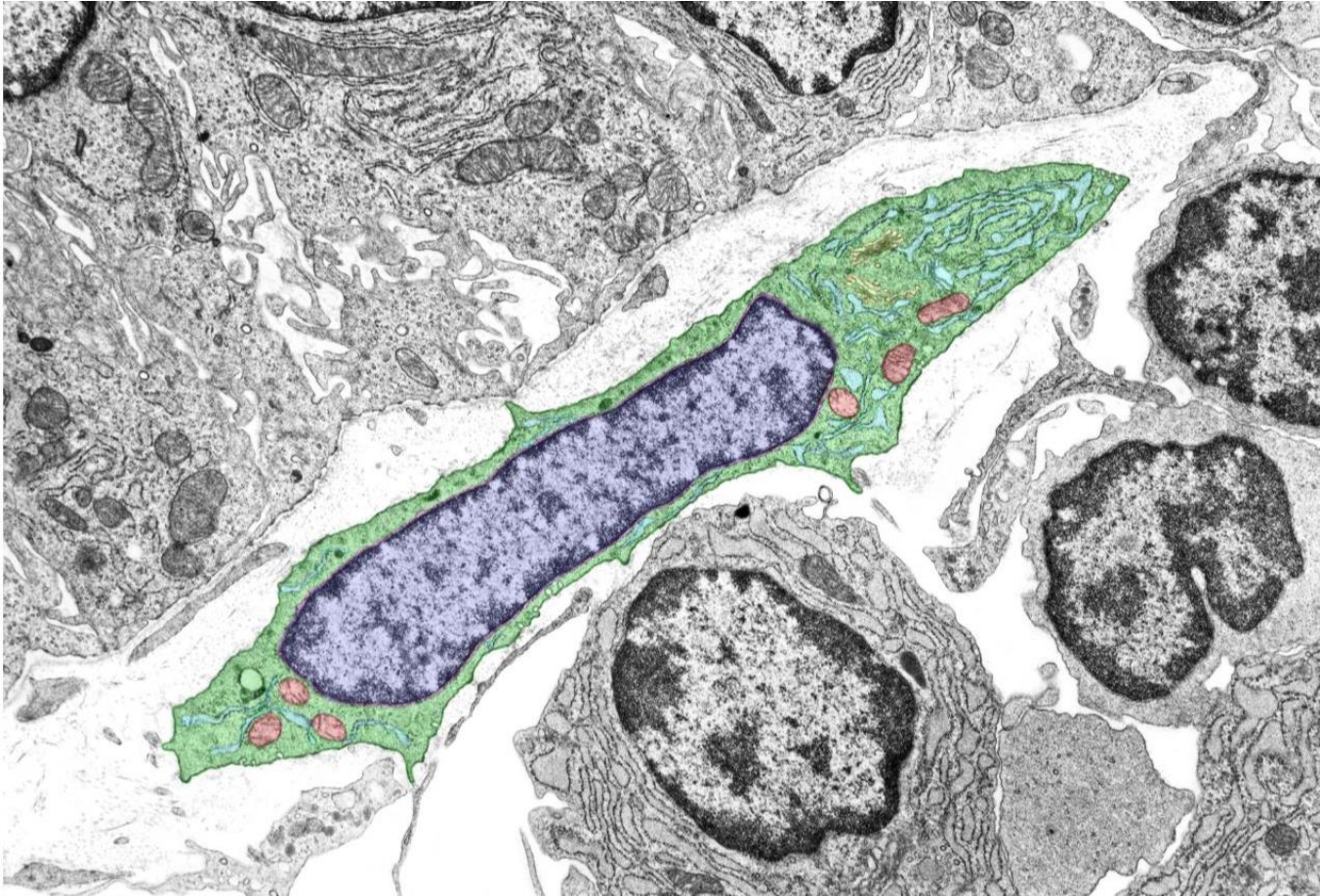
1. Mast cells
2. Macrophages
3. Plasma cells
4. Other blood derived cells

Fibroblast

- Main type of cells in CT
 - Spindle shaped, elongated, narrow, nucleus in the center
 - Cytoplasm is basophilic (contains abundant rough endoplasmic reticulum and Golgi complex)
 - High synthetic activity
-
- Functions:
 - synthesis of fibers and ground substance
 - synthesis of enzymes breaking down fibers and ground substance (collagenase, elastase)



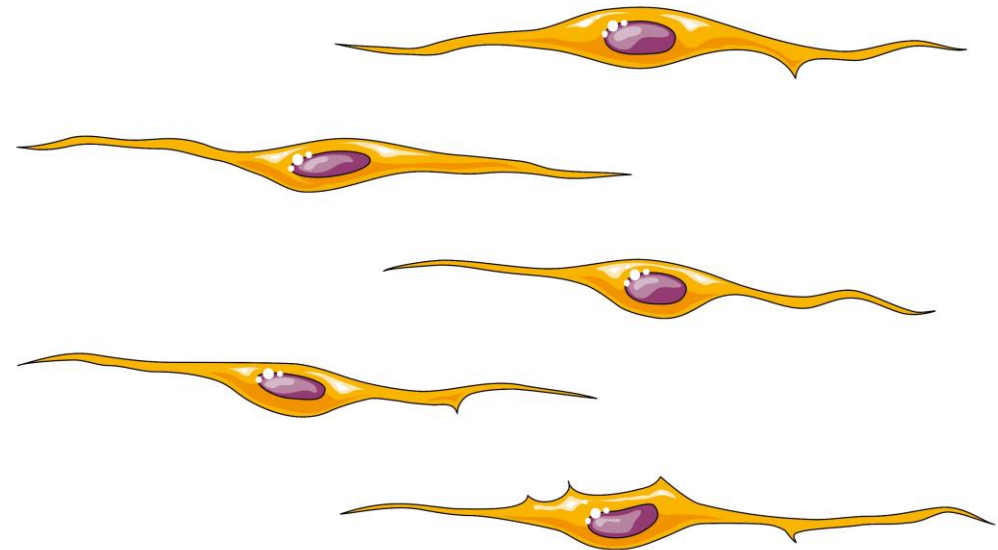
Fibroblasts



Fibrocytes

- Mature inactive cells
- Cytoplasm is asidophilic
- Under appropriate stimulation can retain the properties of fibroblasts

Fibrocytes

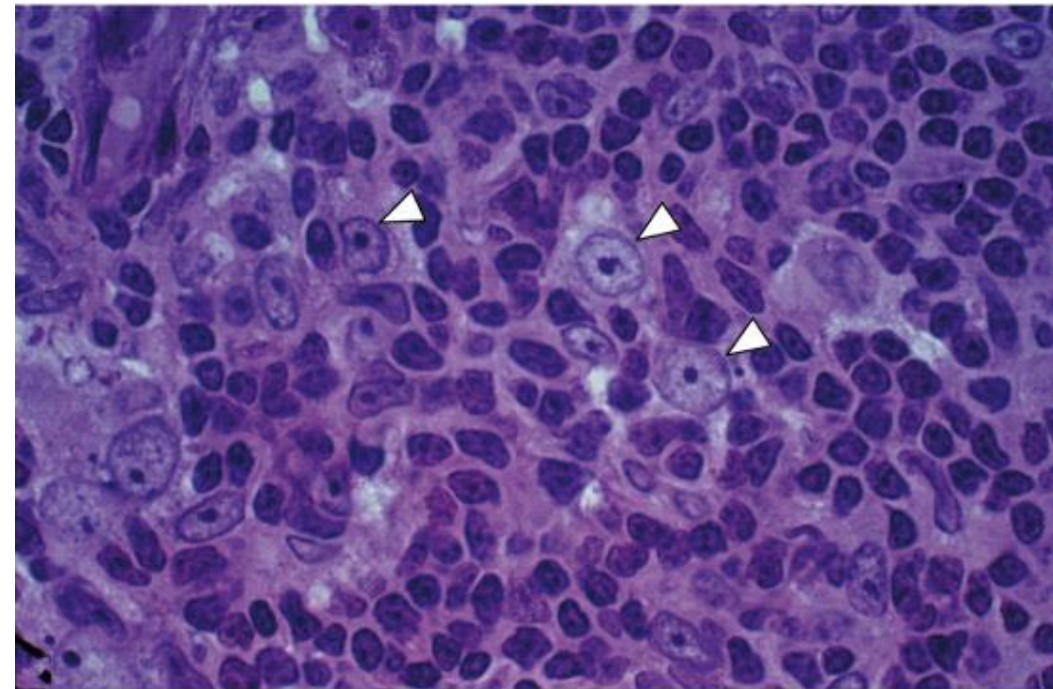


Myofibroblasts

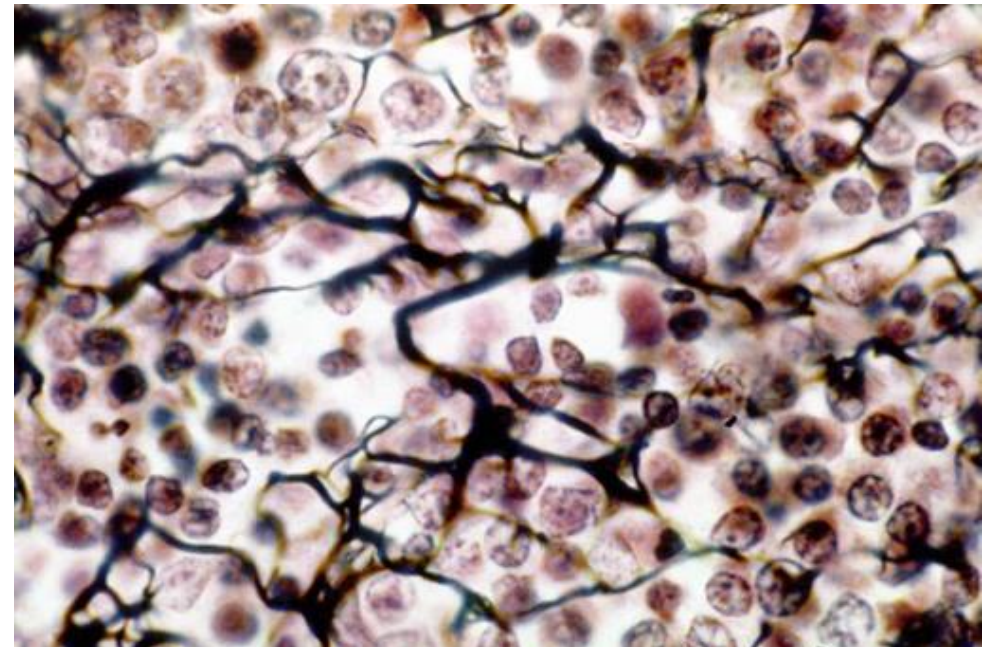
- Contractile web-like fusiform cells
- Wound healing (by contracting the edges of the wound)

Reticular Cells

- Have stellate shape
- Produce reticular fibers in hematopoietic and lymphoid tissue
- Can show phagocytic activity
- Can be antigen-presenting cells



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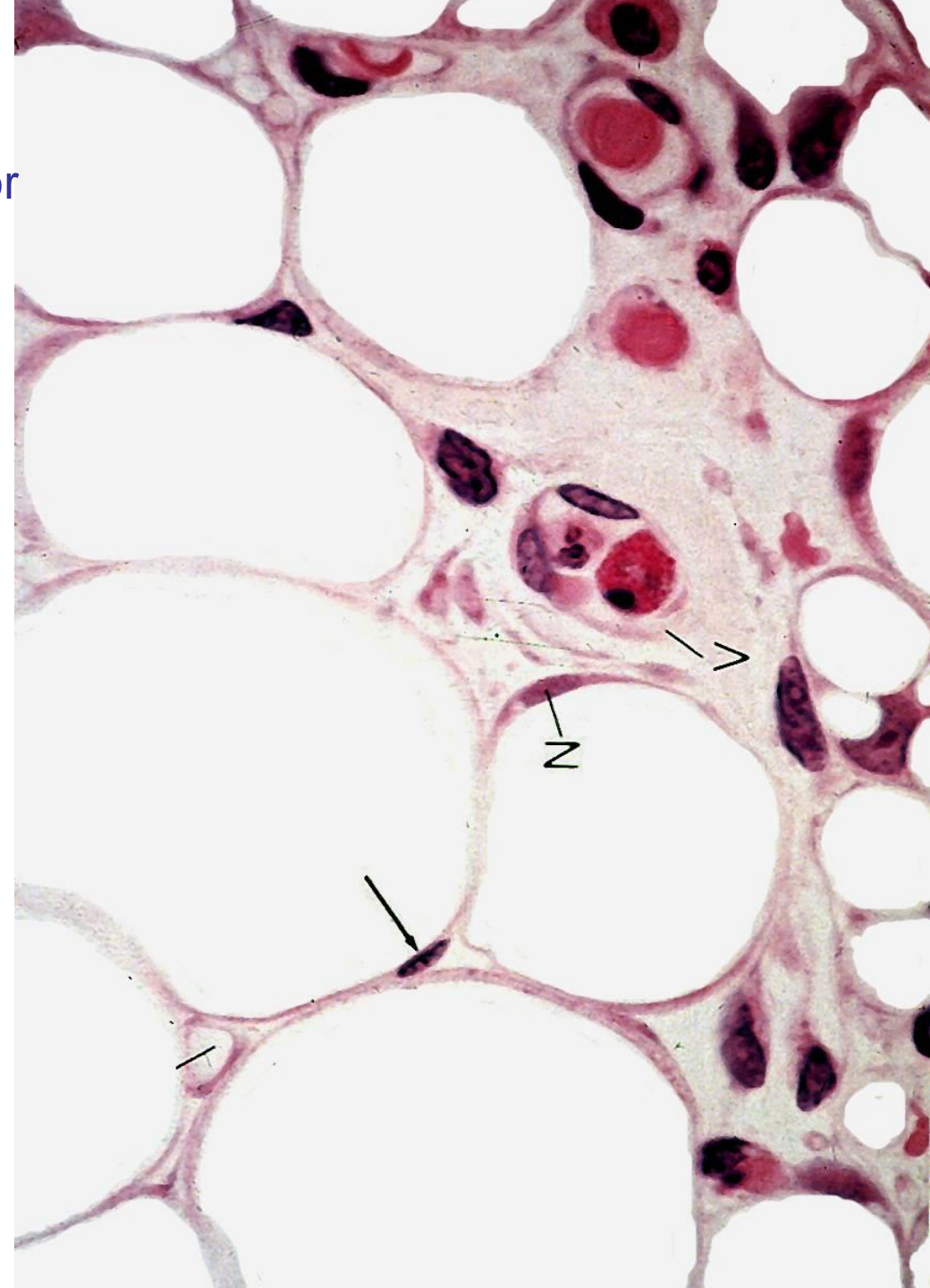
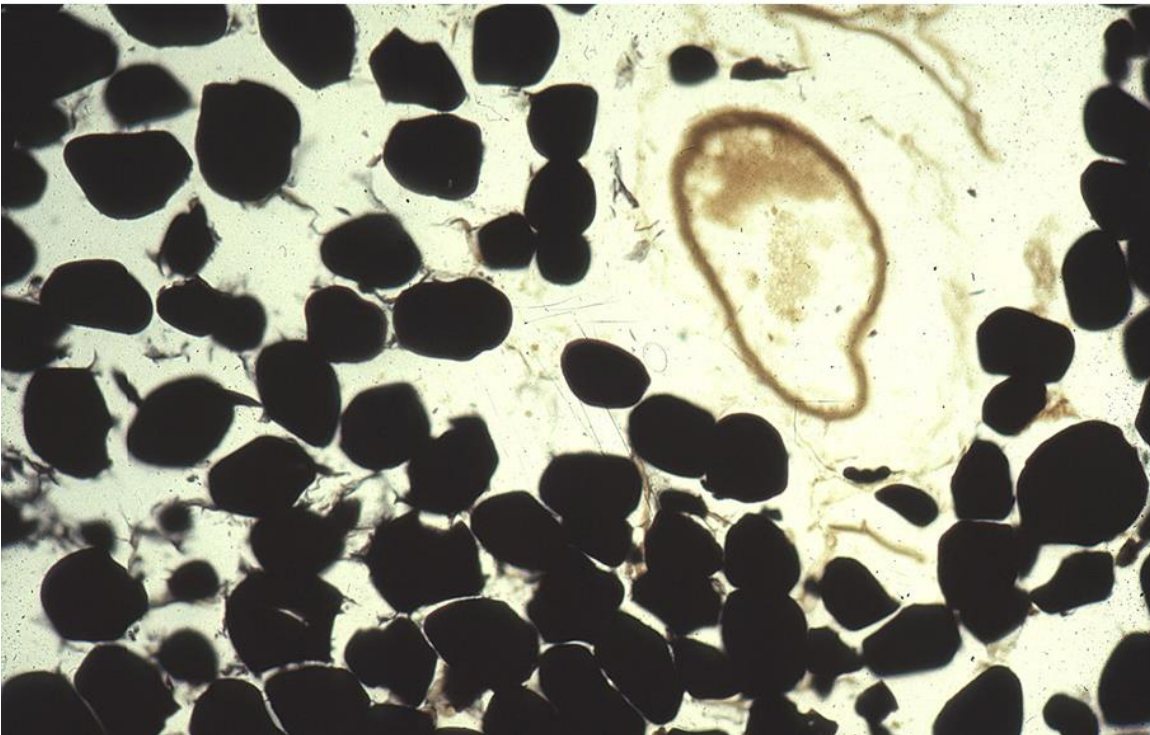


Adipocytes (fat cells)

The adipocyte is a connective tissue cell specialized for lipid storage

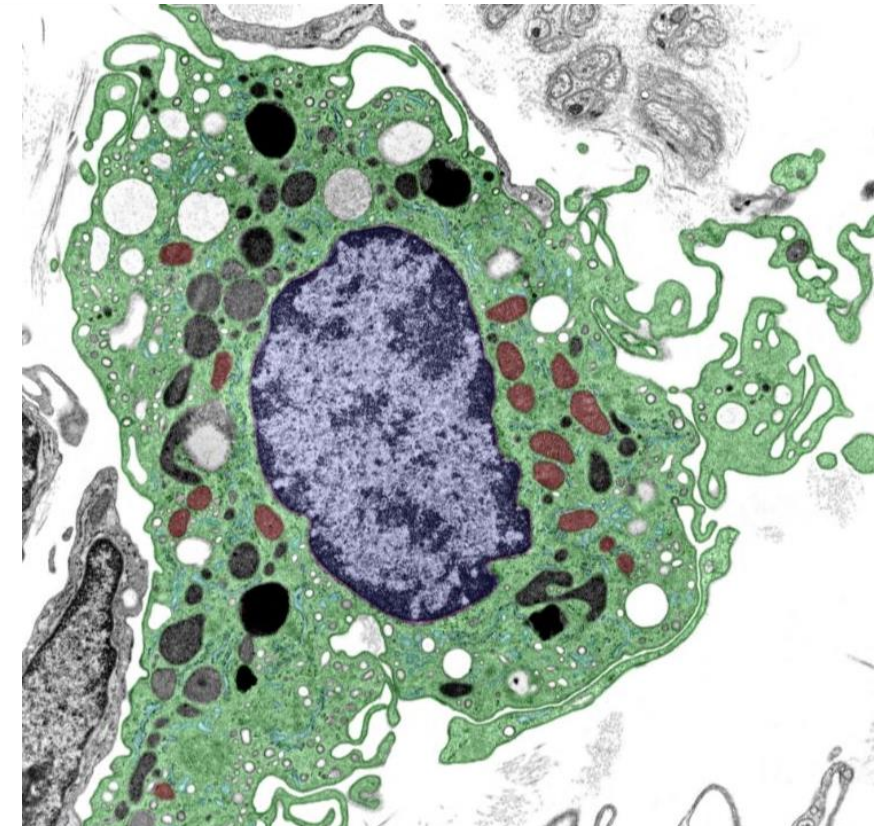
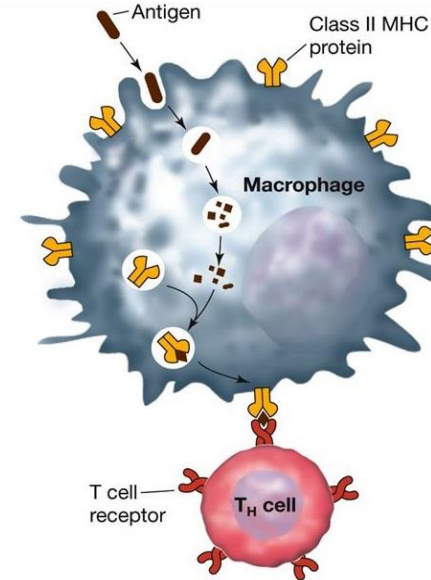
*When they accumulate in large numbers, they are called **adipose tissue**.*

Adipose Tissue fixed and stained w/ Osmium Tetroxide



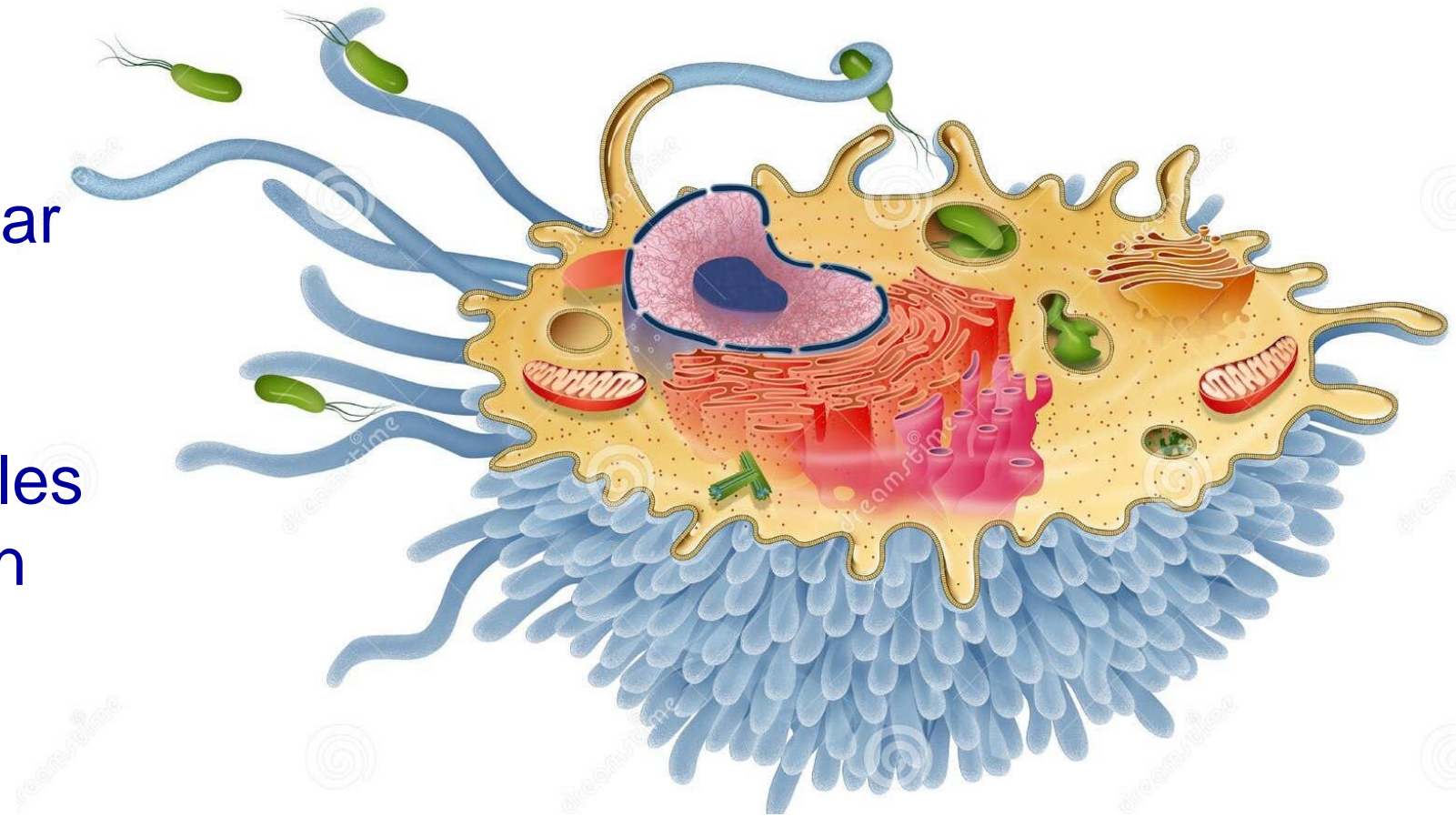
Macrophages

- Derived from blood monocytes that infiltrate CT and develop into phagocytes
- Remove (phagocytose) foreign particles and cell debris
- Participate in the immune response presenting phagocytosed antigens to lymphocytes
- Comprise the mononuclear phagocyte system of the body (Kupffer cells in the liver, alveolar macrophages in the lung, microglia the central nervous system, Langerhans cells in the skin, and osteoclasts in bone tissue)



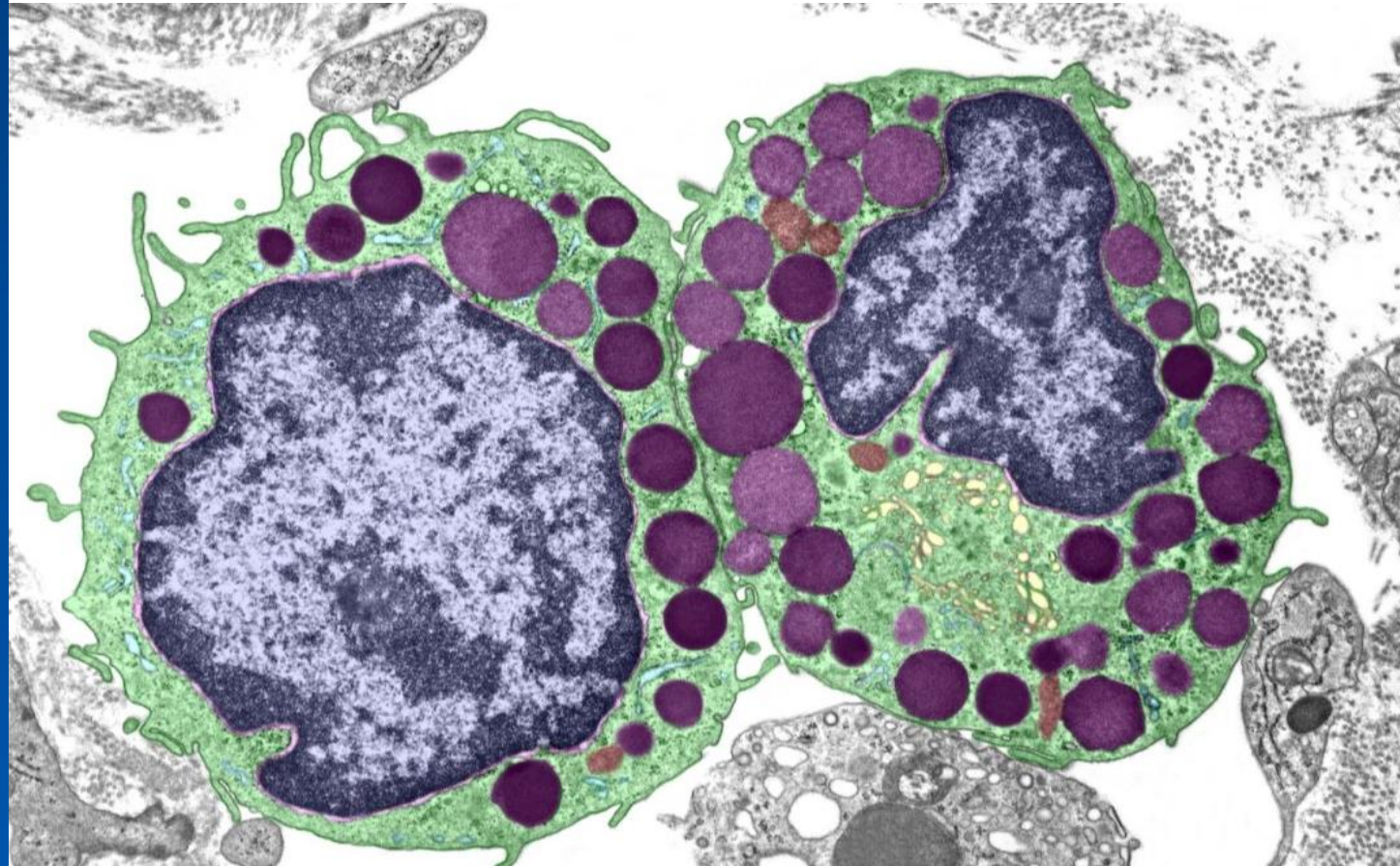
Macrophage

- Oval nucleus with an indentation in the nuclear envelope; prominent perinuclear heterochromatin
- Cytoplasm contains vacuoles and granules that are basophilic in nature



Mast cells

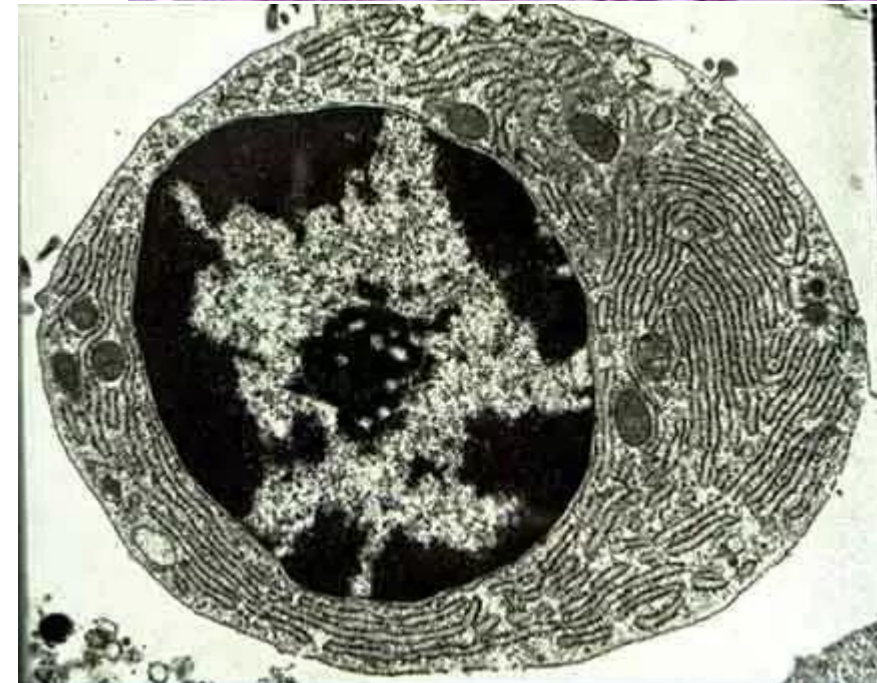
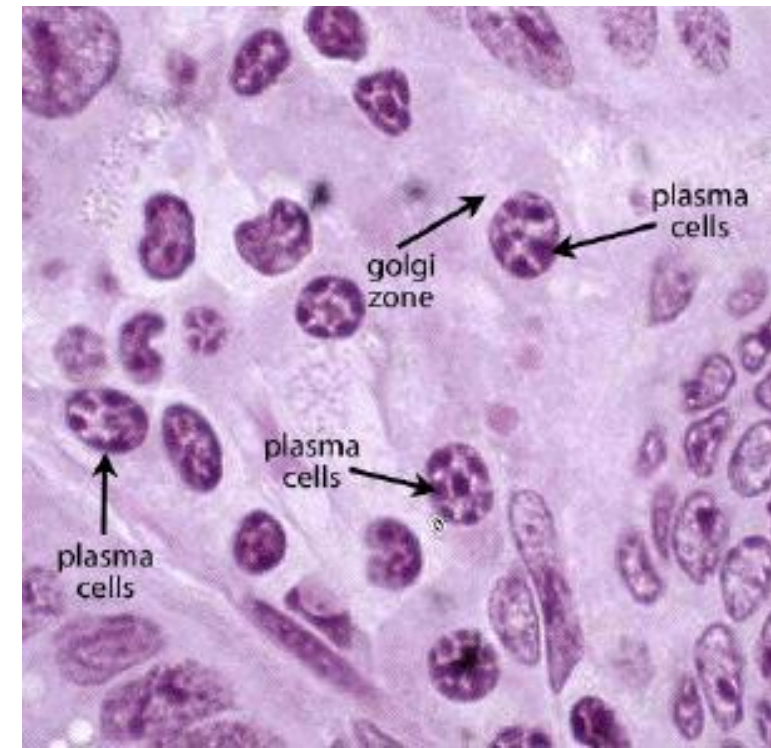
- Derive from bone marrow, then migrate into the CT
- Have abundant basophilic granules in the cytoplasm
- The granules contain **histamine** and **heparin**
- Have surface receptors for the IgE antibodies that trigger degranulation in case of allergic reactions



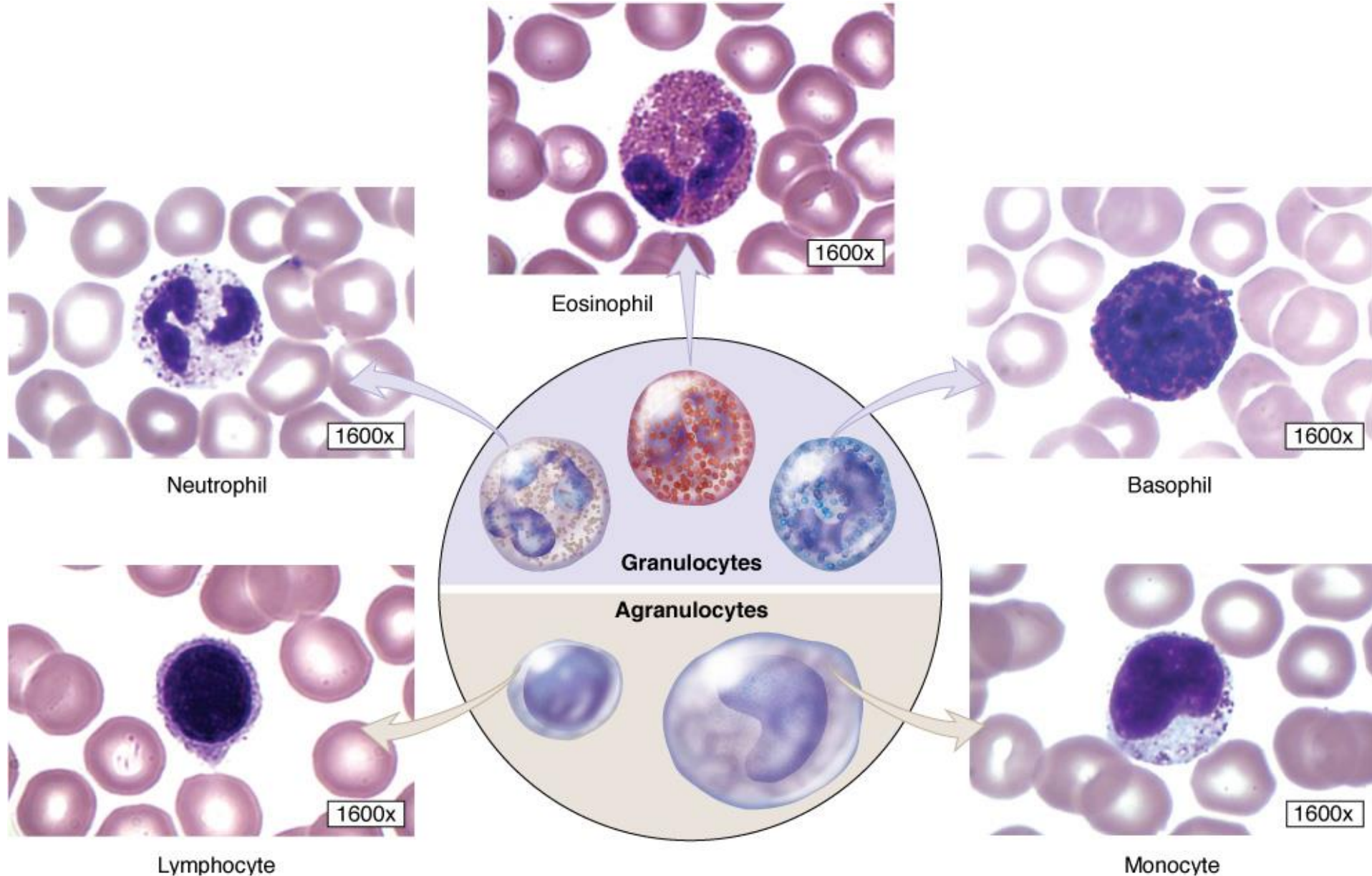
Histamine is a biogenic amine that increases the **permeability of blood vessels**, causing edema in the surrounding tissue and a skin reaction demonstrated by an itching sensation. In addition, it **increases mucus production** in the bronchial tree and prompts contraction of smooth muscle in the pulmonary airways.

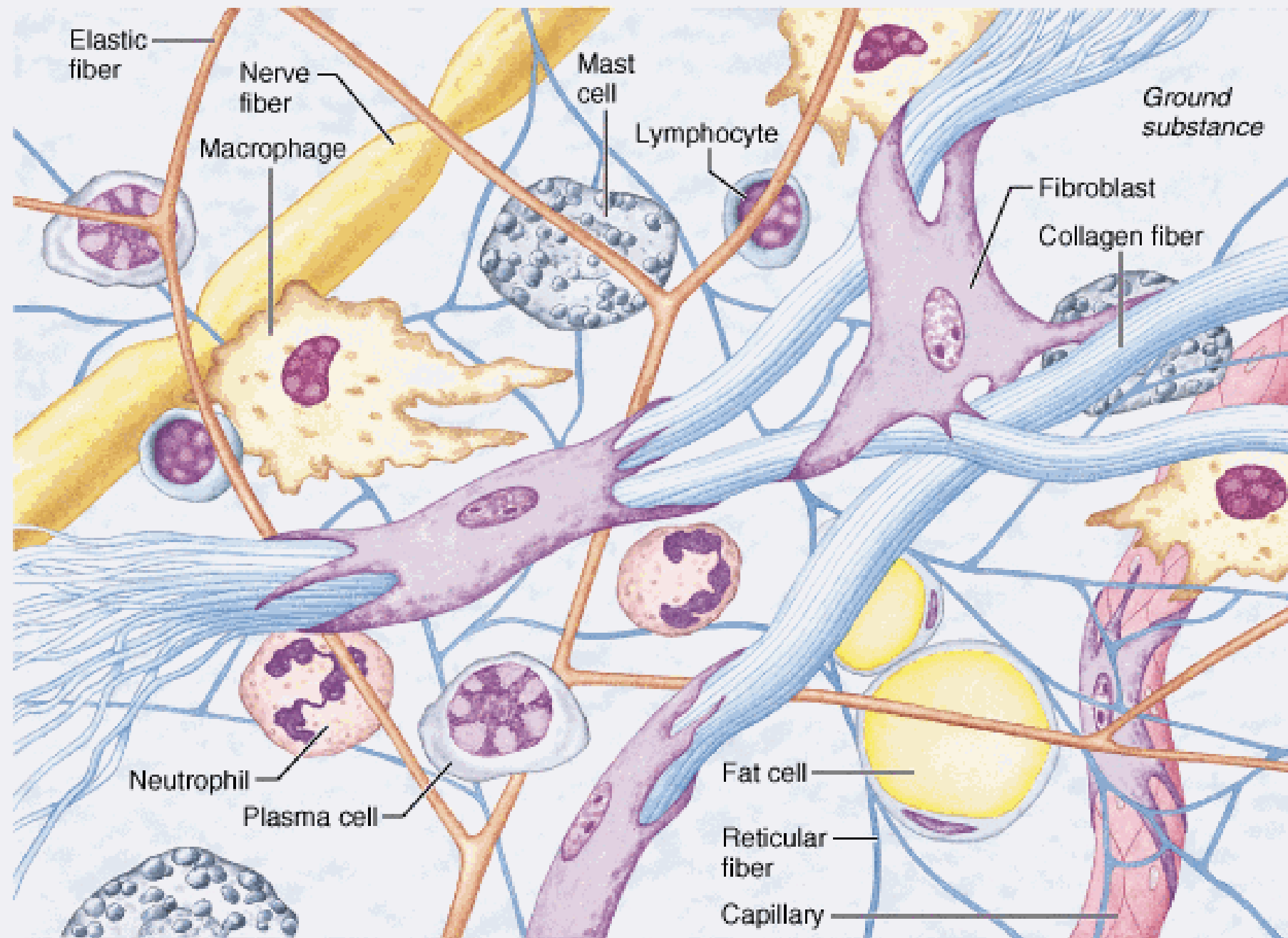
Plasma cells

- Primary effectors of humoral immune response
- Differentiate from antigen-stimulated B-lymphocytes
- Produce circulating antibodies
- Basophilic cytoplasm due to large amounts of rough endoplasmic reticulum
- Have a characteristic “clock-face” nucleus

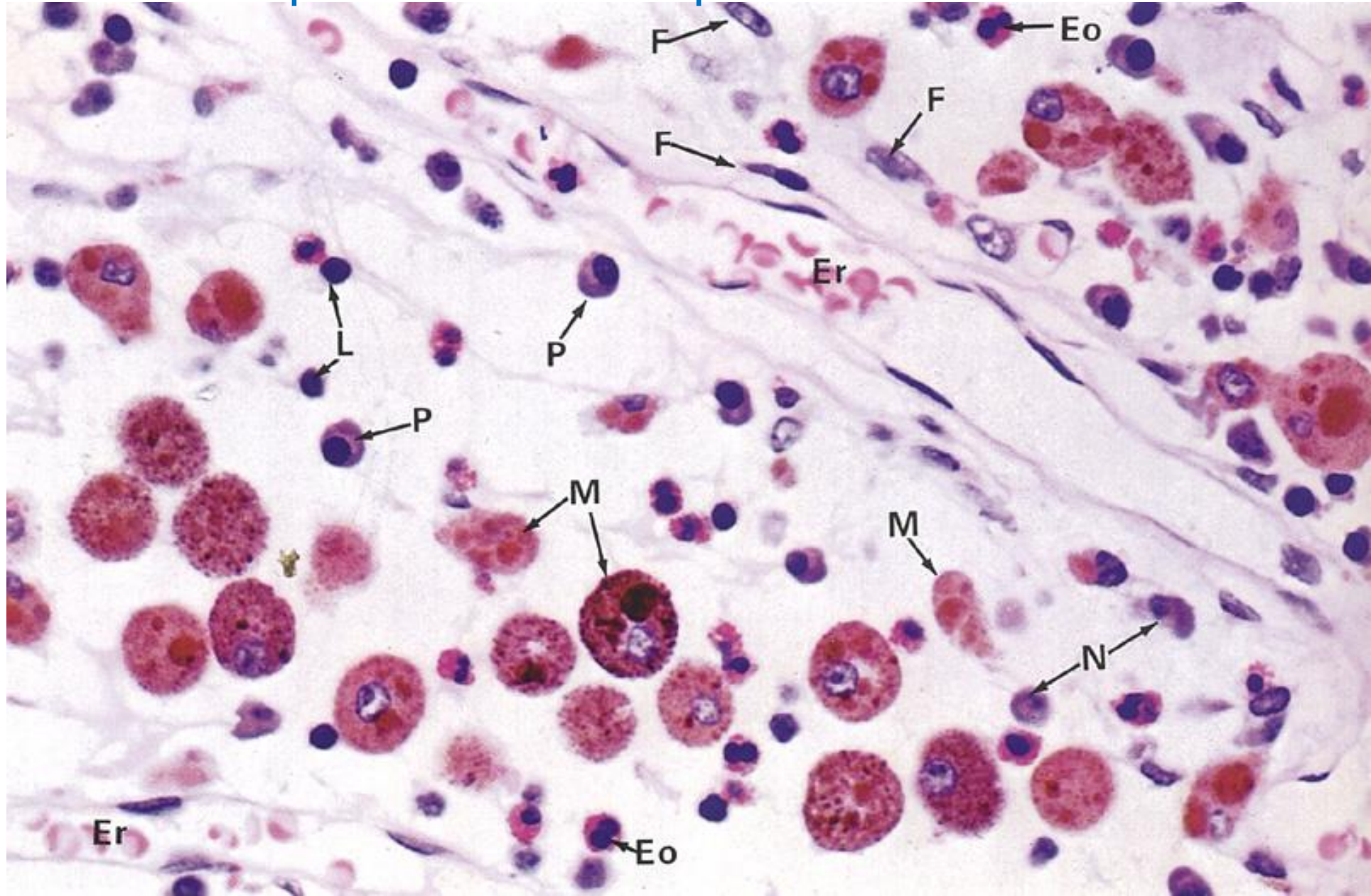


Other blood derived cells





M – mast cells P – plasma cells F - fibroblasts
Eo - eosinophils N - neutrophils

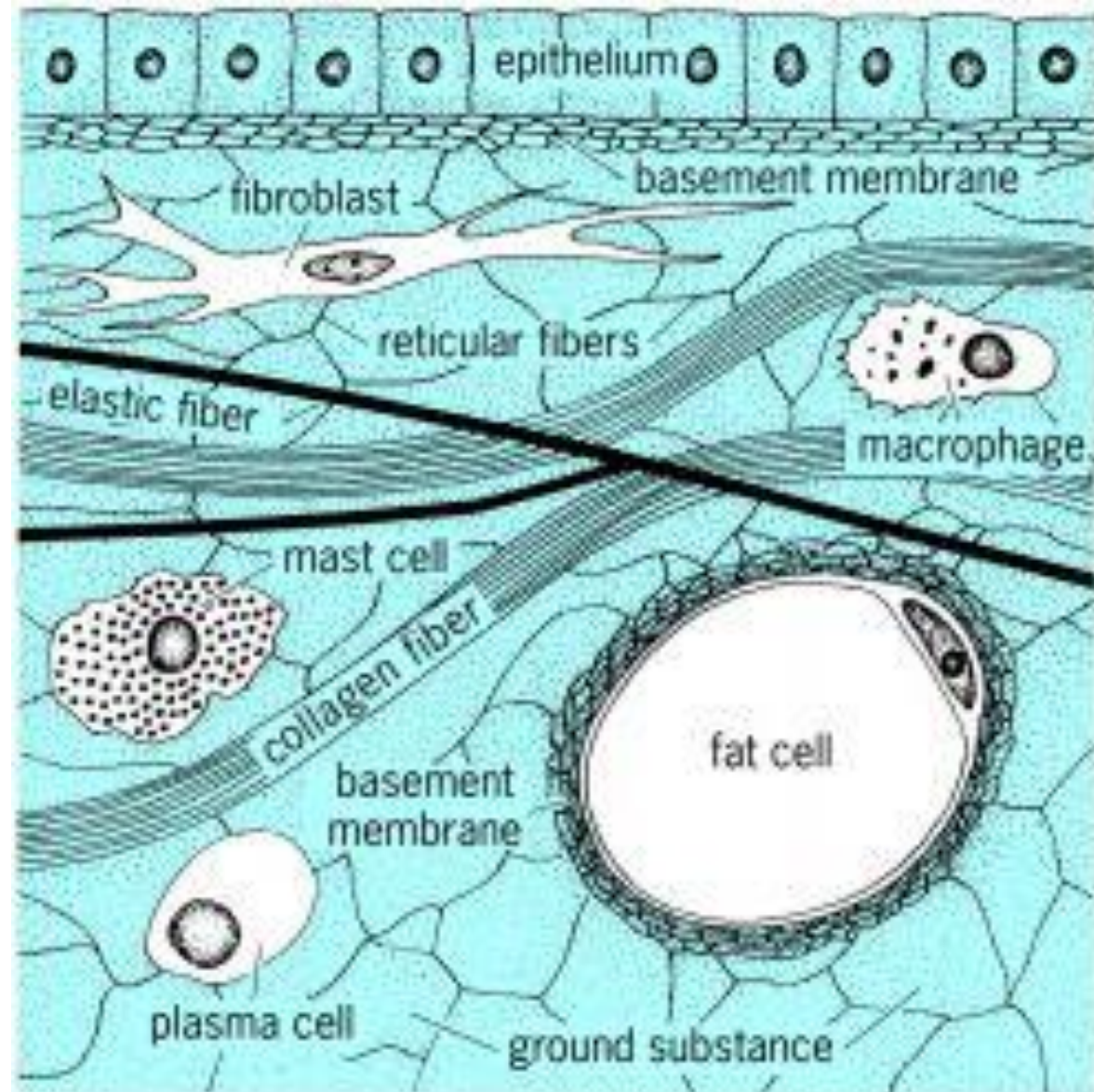


Fibers of Connective Tissue

Fiber type	Composition	Properties
Collagen	Collagen I, II	Inelastic, eosinophilic
Reticular	Collagen III	Inelastic, branched, argyrophilic
Elastic	Elastin	Elastic, eosinophilic

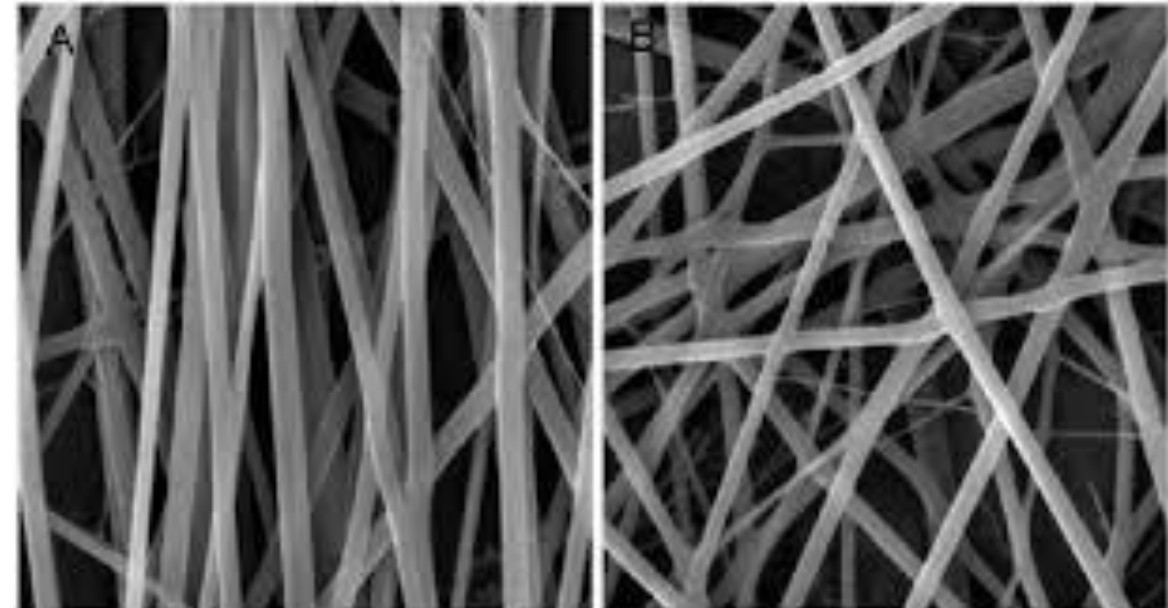
Fibers of Connective Tissue

- Collagen fibers
- Elastic fibers
- Reticular fibers



Collagen fibers

- Made by fibrillar protein - collagen – most abundant protein in the body
- Aminoacids- hydroxyproline, hydroxylysine
- Thick fibers with great tensile strength (it is hard to pull them apart)
- Occur in most CT (tendons, ligaments, dermis)



Types of collagen

- About 28 types of collagen known
- The difference is in the amino-acid sequence
- The most abundant and strong is Type I collagen

Fibril forming	Tissue	Function
Type 1 (90%)	Tendon, bone, ligaments and skin	Resistance to tension
Type 2	Hyaline and elastic cartilage	Resistance to pressure
Type 3	Skin, muscle, blood vessels	Structural framework for expanding tissues
Network forming	Tissue	Function
Type 4	Basement membrane	Filtration and support

Types of collagen

Types of collagen	Fibers formation	Location
Type I	Fibrils aggregate into fibers and fiber bundles	forms a component of the extracellular matrix (“interstitial collagen”), tendons, ligaments and capsules of organs.
Type II	Fibrils do not form fibers	present in cartilages
Type III	Fibrils aggregate into fibers	present surrounding smooth muscle cells and nerve fibers. Forms the stroma of lymphatic tissues and organs.
Type IV	Chemically unique form of collagen that does not form fibrils	major component of the basal lamina

Collagen synthesis and assembly

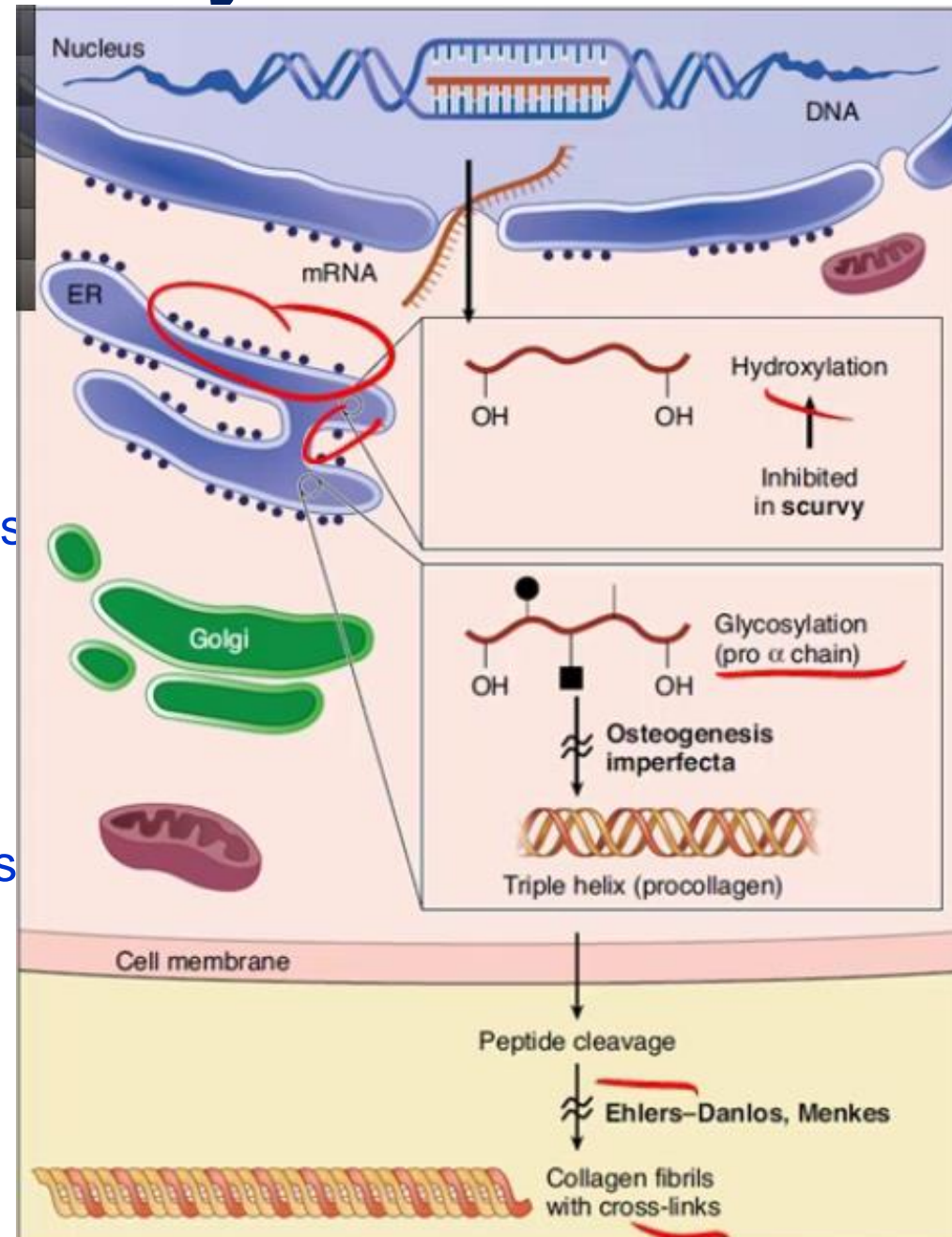
Intracellular steps:

1. **Preprocollagen** synthesis in ribosomes on RER
2. Alpha chain (**protocollagen**) synthesis (*glycin, proline, lysine*)
3. **Hydroxylation** of amino acids– *hydroxyproline, hydroxylysine (vitamin C*)*
4. Glycosylation of hydroxylysine
5. With help of *registration peptides* three alpha chains coil around one another to form triple chain of **procollagen**
6. Exocytosis

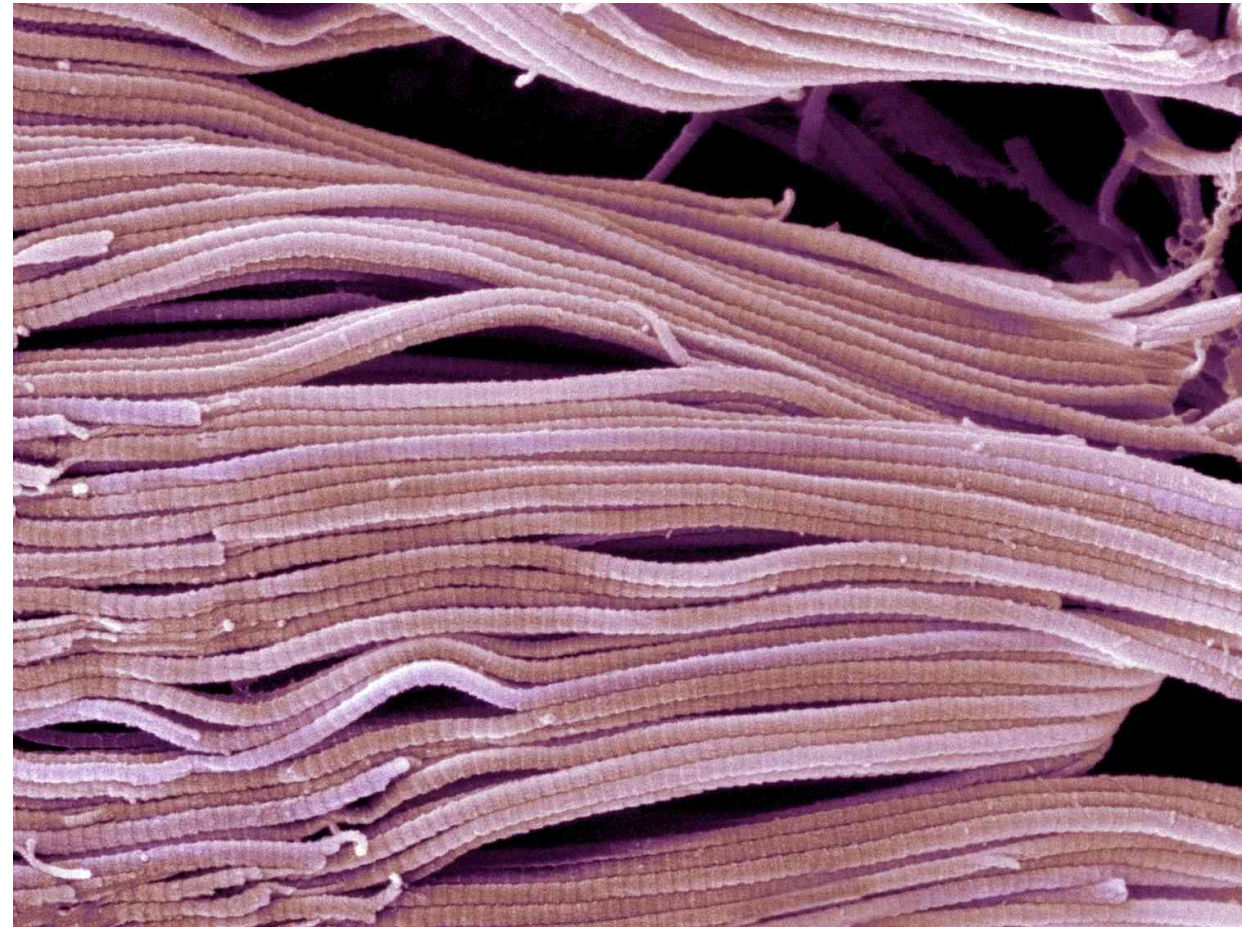
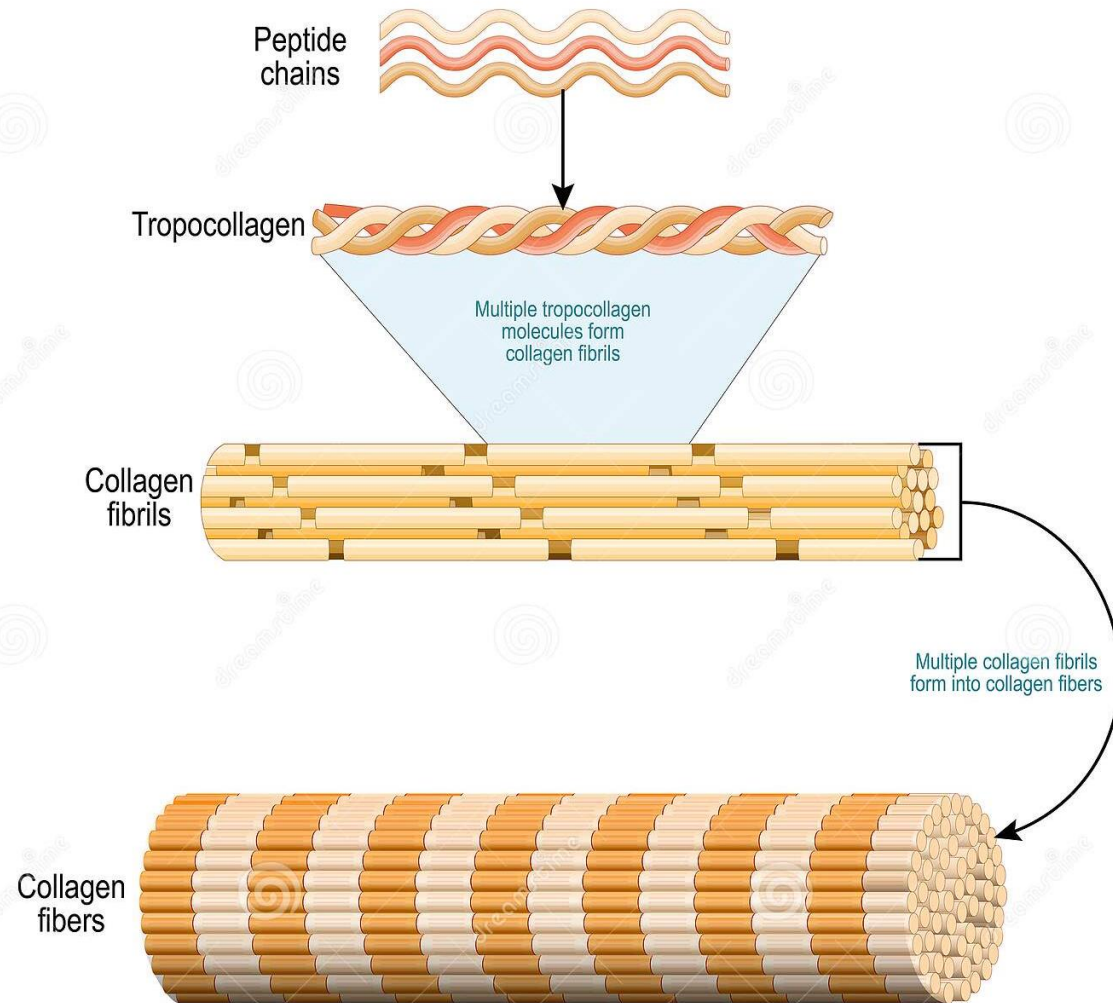
Extracellular steps:

1. *Procollagen peptidase* cleaves registration peptides from procollagen, converting it to **tropocollagen**
2. Tropocollagen forms **collagen fibrils**
3. Arrangement of fibrils into **fibers**

* *scurvy*

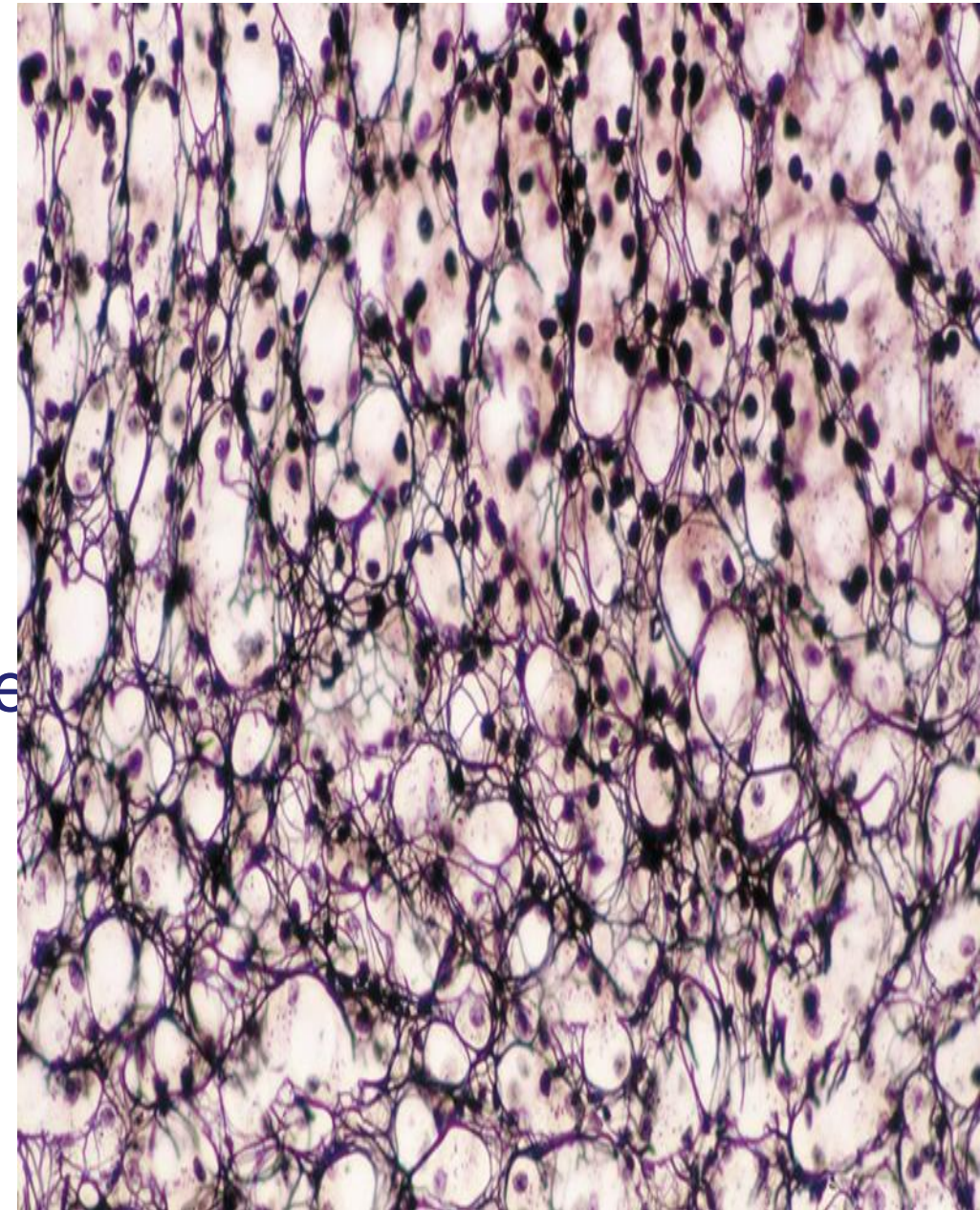


Collagen fibers are striated



Reticular fibers

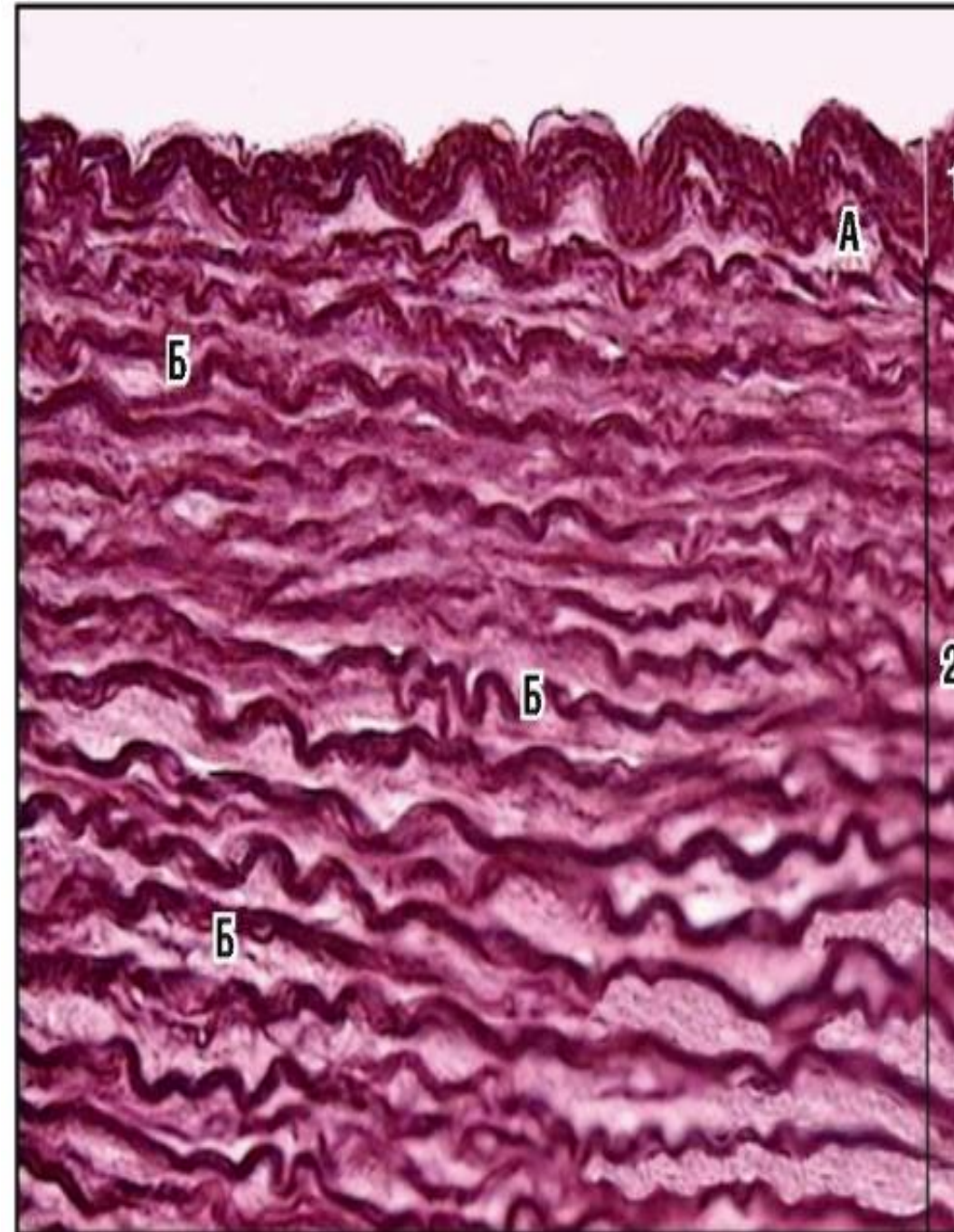
- Consist of Type III collagen
- Thin fibers forming a delicate network in the liver, lymph nodes, spleen, hematopoietic organs
- Support capillaries, nerves and muscle fibers
- Stained with silver (argyrophilic)



Elastic fibers

- Composed of globular protein elastin and micro fibrils
- Thinner than collagen fibers
- Aminoacids- desmosine and isodesmosine

- Less tensile than collagen fibers
- Can stretch and return to the original size without deformation
- Aorta, lungs, yellow ligament



GROUND (AMORPHOUS) SUBSTANCE

- ✓ Gel like structure in which cells and fibers are embedded

- ✓ Highly hydrophilic, transparent, viscous complex of anionic macromolecules:
 - glycosaminoglycans (GAG),
 - proteoglycans
 - multi-adhesive glycoproteins

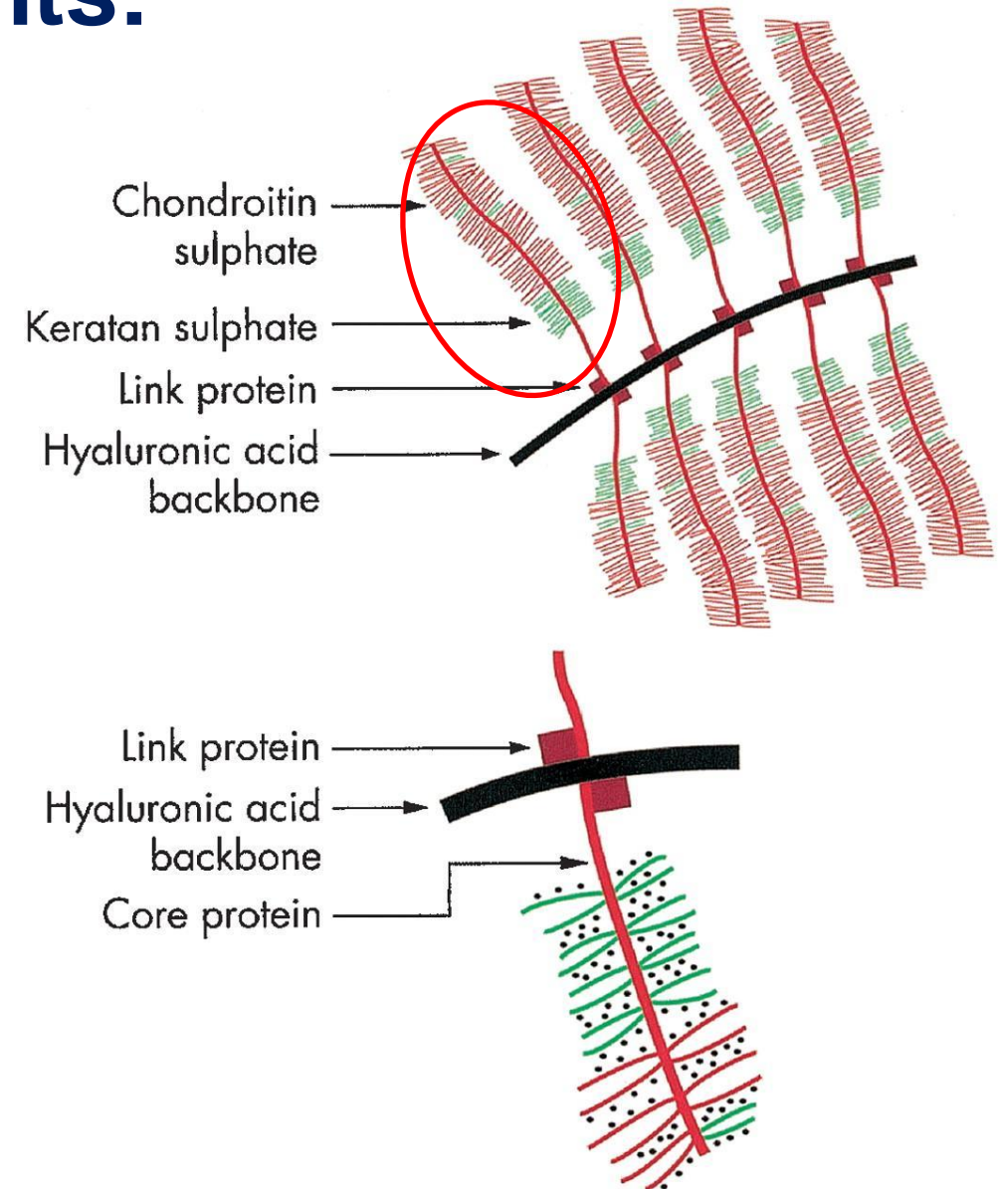
- ✓ **Functions:**
 - Provides a medium for passage of molecules and cells migrating through the tissue.
 - Contains adhesive proteins that regulate cell movements and provide anchorage.
 - Retards passage of bacteria

GROUND (AMORPHOUS) SUBSTANCE

Components:

Glycosaminoglycans (GAGs):

- Long, unbranched polysaccharides composed of repeating disaccharide units, which are usually sulfated.
- GAGs are generally attached to proteins to form **proteoglycans**.
- Many proteoglycans are attached to hyaluronic acid, which is itself a **glycosaminoglycan**.



GROUND (AMORPHOUS) SUBSTANCE

Components:

Proteoglycans (GAGs+ core Proteins):

Glycosaminoglycans (GAGs)

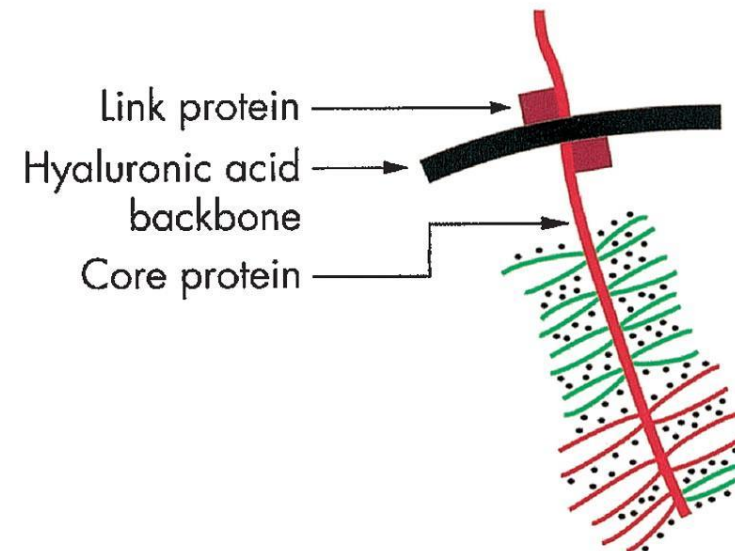
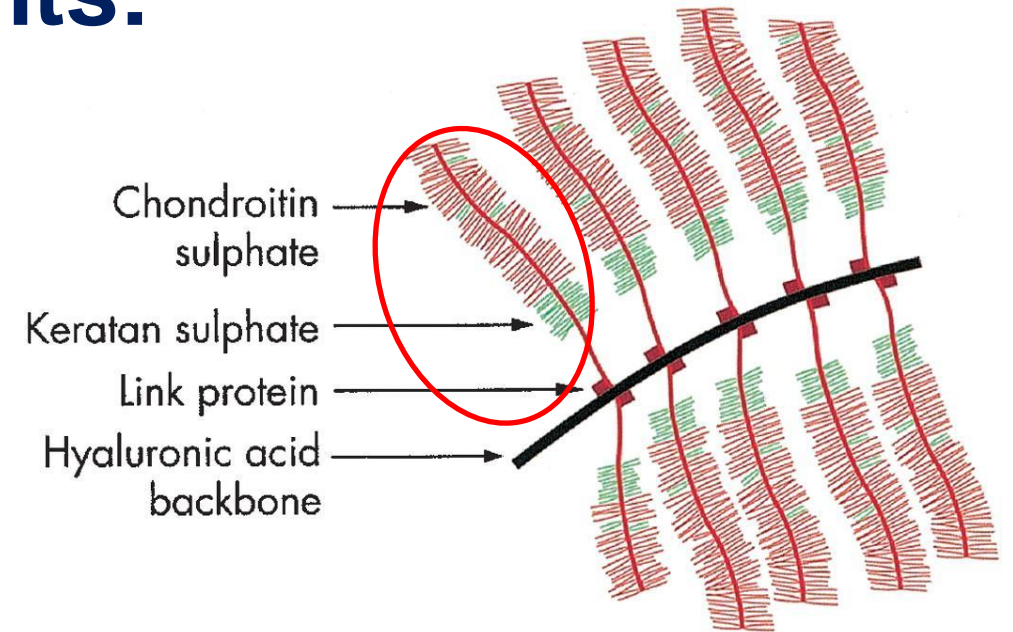
– **Sulfated GAGs:**

- Heparan-sulfate
- Chondroitin-sulfate
- Keratan sulfate
- Dermatan-sulfate

• **Hyaluronic acid**

• **Glycoproteins**

– fibronectin, laminin





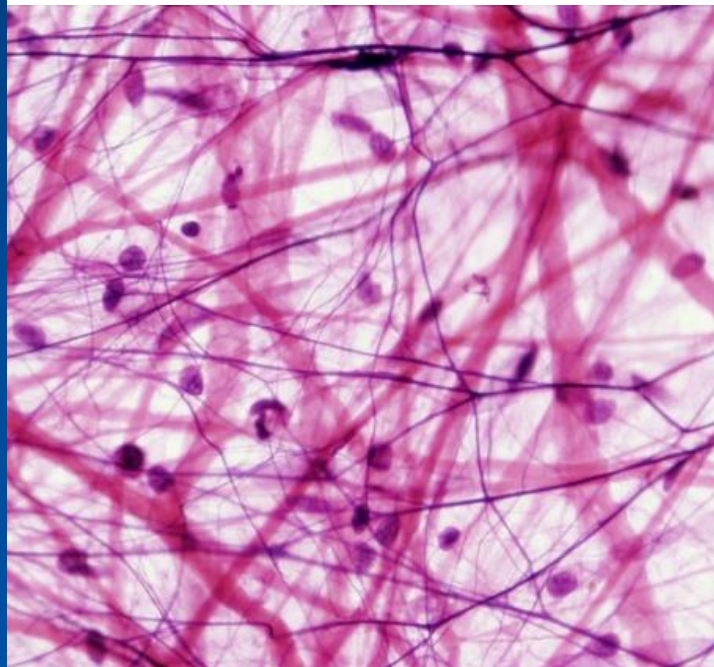
Connective tissue proper

Functions

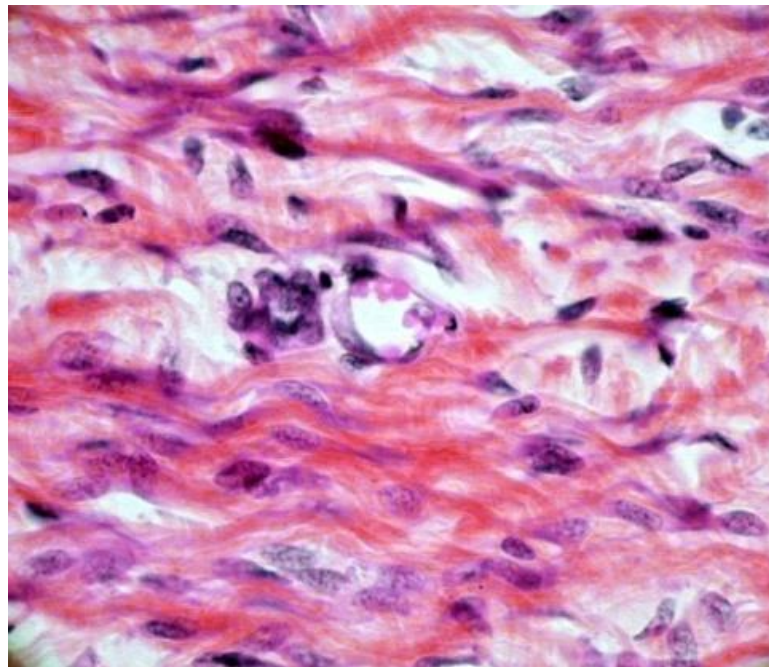
- ✓ Structural functions of connective tissue proper
 - Forms a portion of the wall of hollow organs and vessels and the stroma of solid organs
 - Forms the stroma of organs and subdivides organs into functional compartments
- ✓ Provides padding between and around organs and other tissues
- ✓ Provides anchorage and attachment (e.g., muscle insertions)
- ✓ Provides a medium for nutrient and waste exchange
- ✓ Stores lipid in adipocytes
- ✓ Defends the body and provides immune surveillance via lymphoid and phagocytic cells

Connective tissue proper

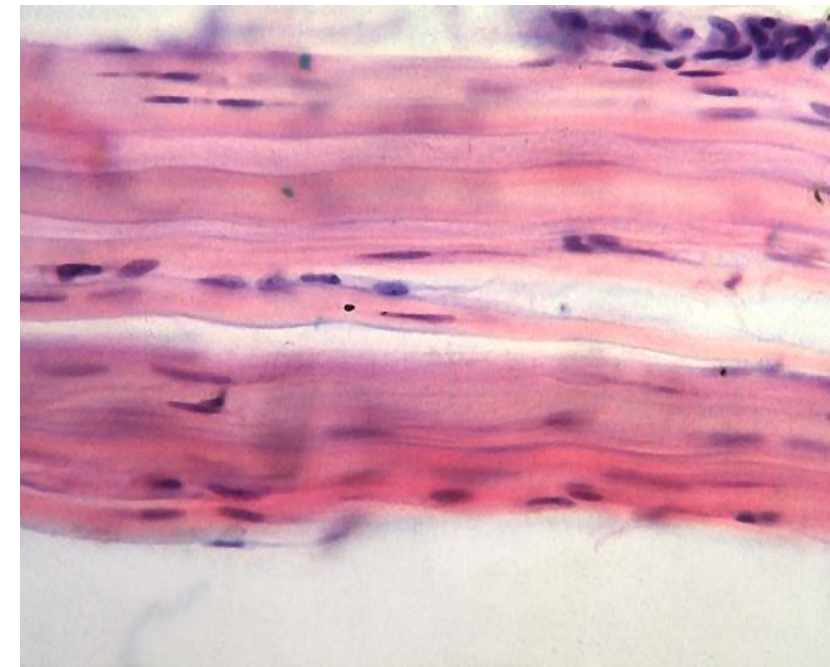
Loose CT



Dense
irregular CT

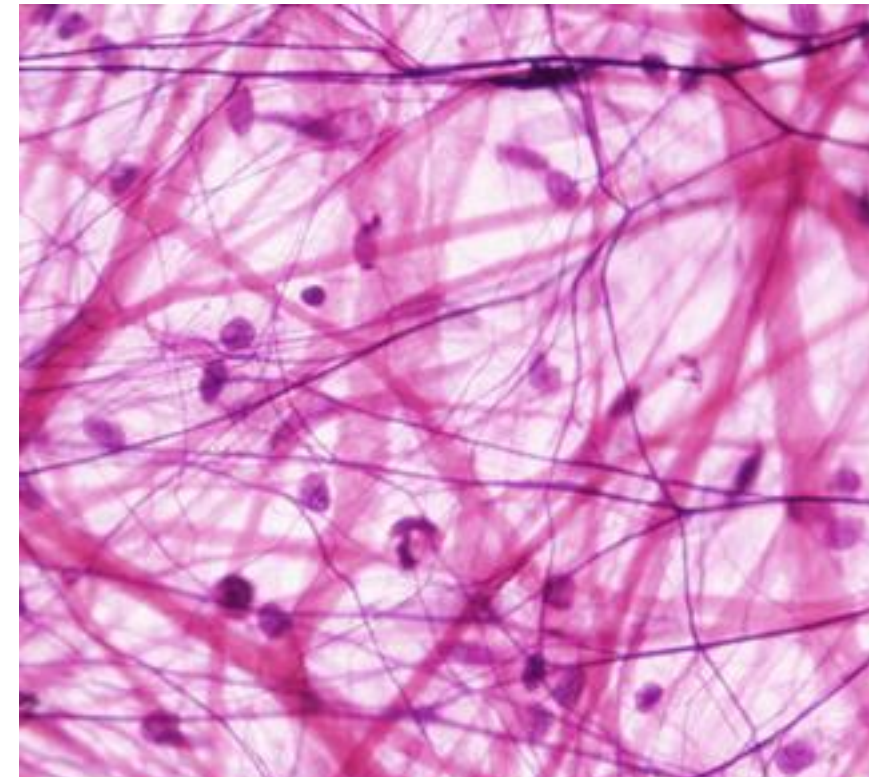
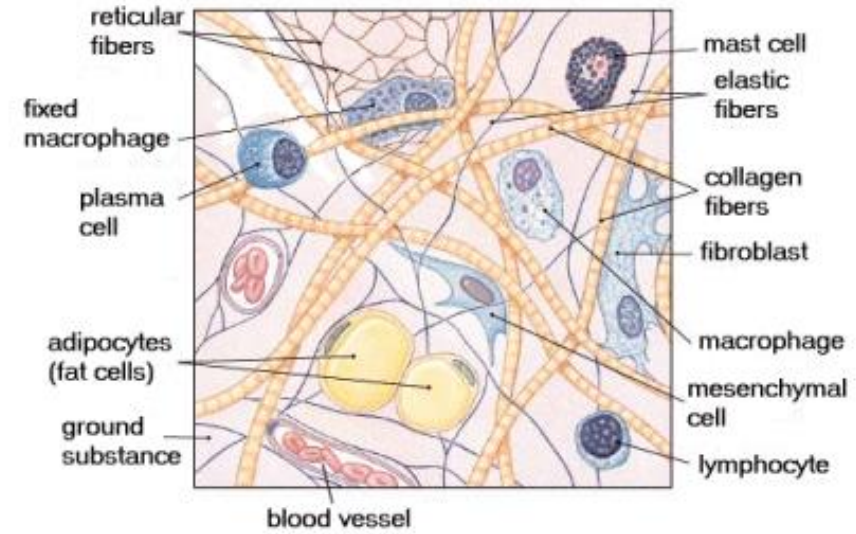


Dense
regular CT



Loose Connective Tissue

- **Highly cellular**, numerous cell types present
- **Fewer and smaller caliber collagen fibers** compared with dense
- **Abundant ground substance**, allows for diffusion of nutrients and wastes
- Highly vascularized
- Provides padding between and around organs and tissues
- Forms stroma of many organs
- Underlines the epithelial cells



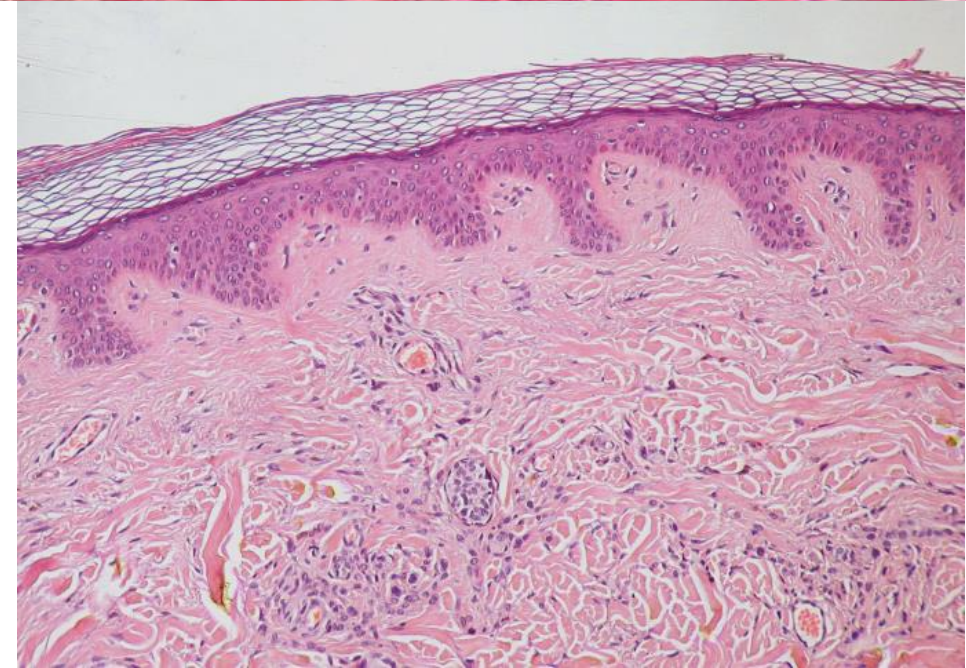
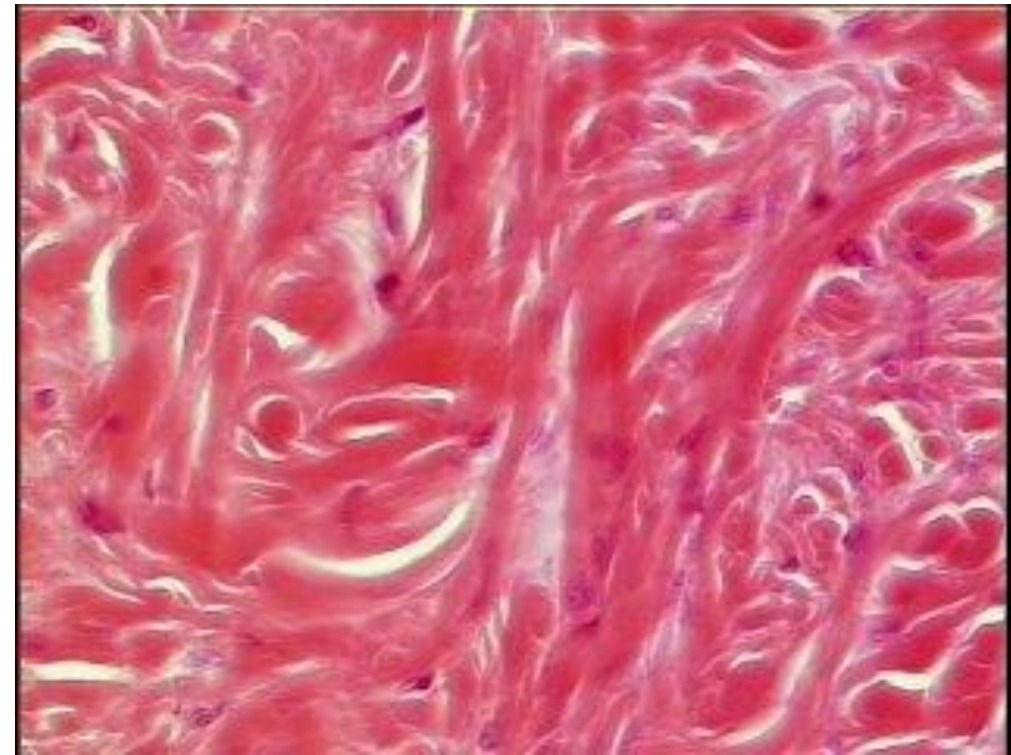


Dense Connective Tissue

- Fewer cells, mostly fibroblasts
- Highly fibrous with larger caliber collagen fibers, provides strength
- Minimal ground substance
- Poorly vascularized
- 2 types (dense regular and dense irregular)

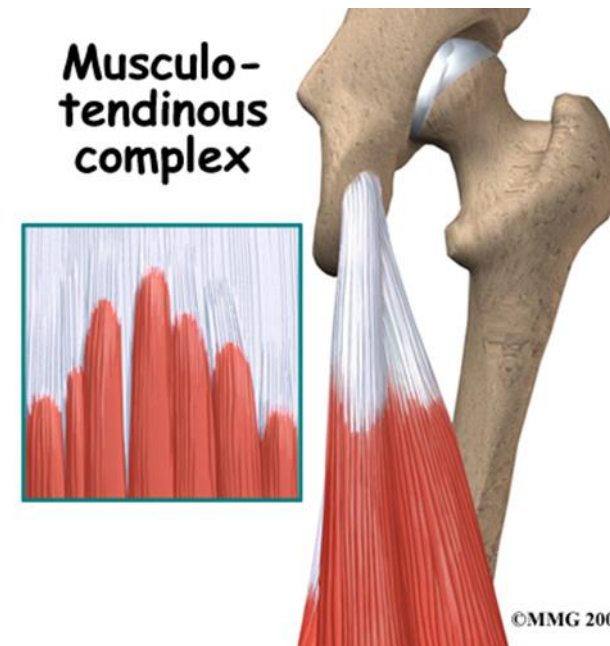
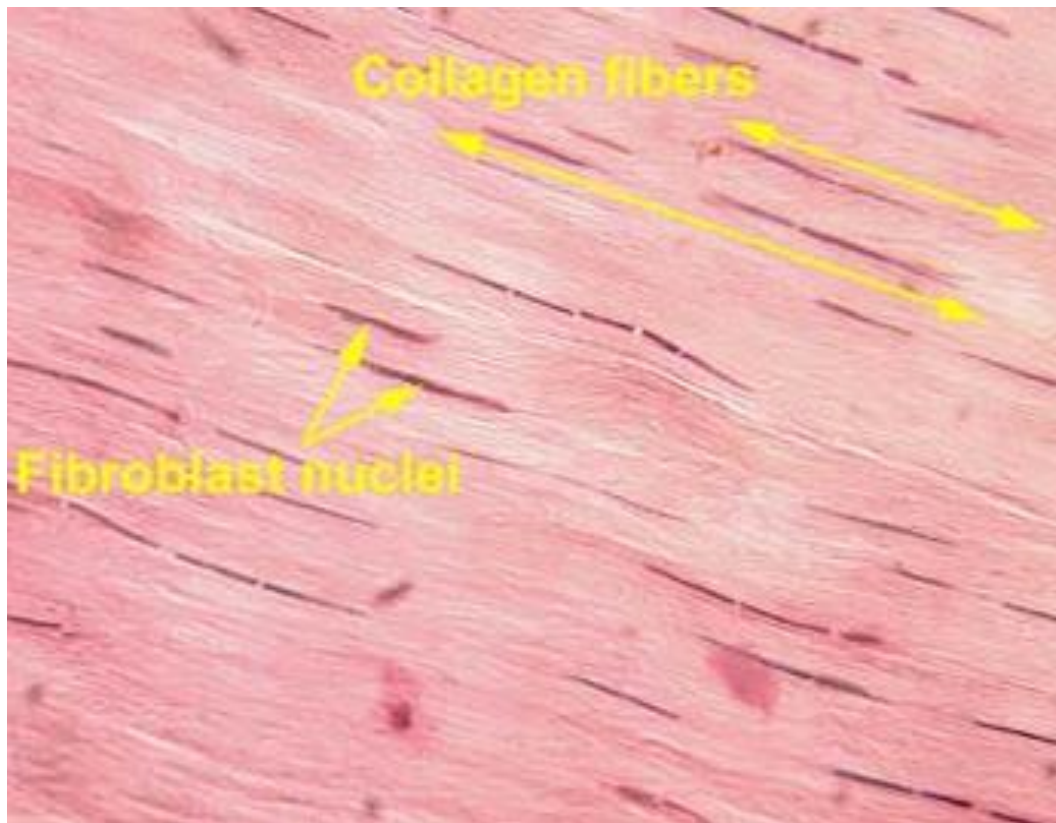
Dense Irregular Connective Tissue

- Fiber **bundles** arranged in an interlacing pattern
- Localization: reticular layer of dermis, capsule of organs, periosteum, perichondrium



Dense Regular Connective Tissue

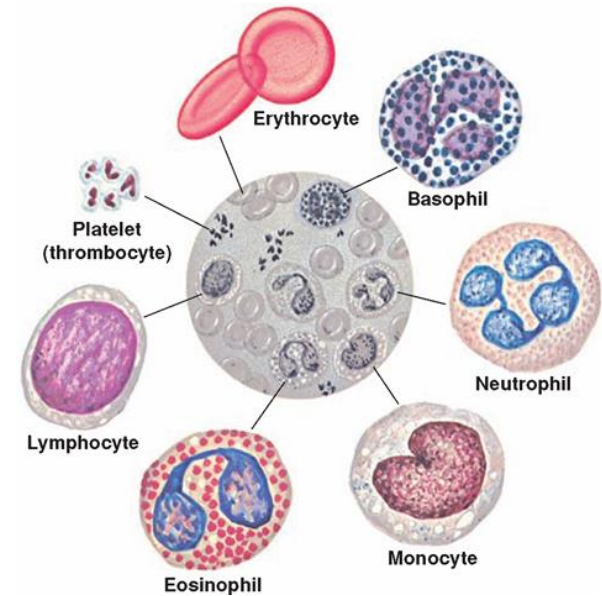
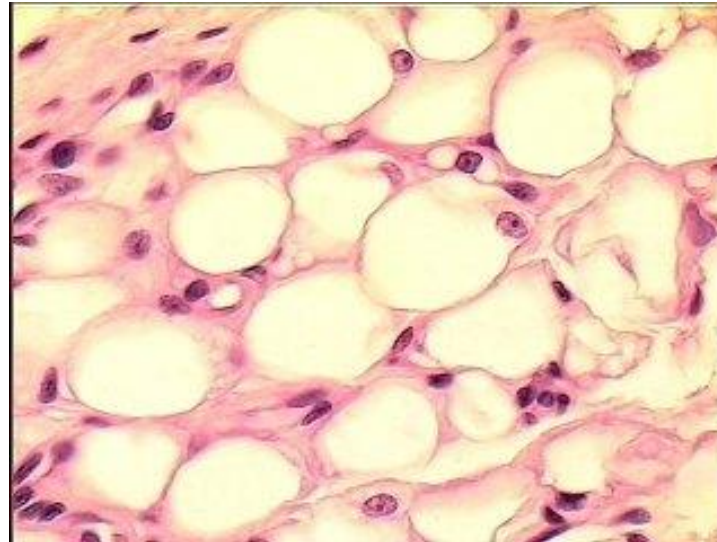
- Fiber **bundles** are parallel to each other
- Localization: tendons, ligaments, fascia



Specialized Connective Tissue

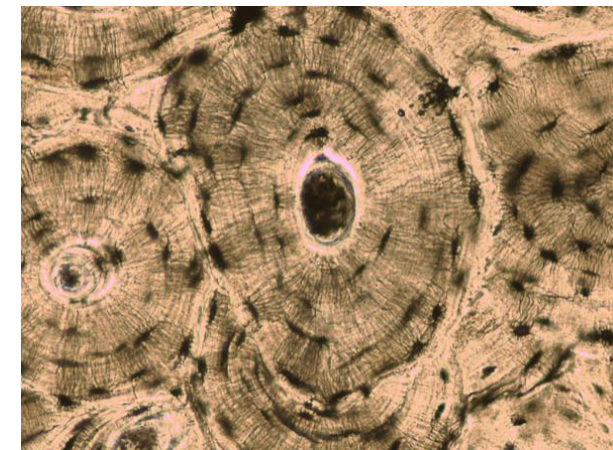
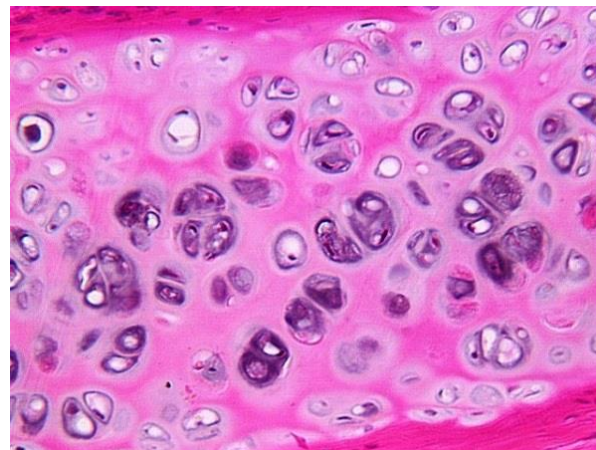
1. Tissue with special function:

- Adipose Tissue
- Blood
- Reticular connective tissue
- Mucus connective tissue



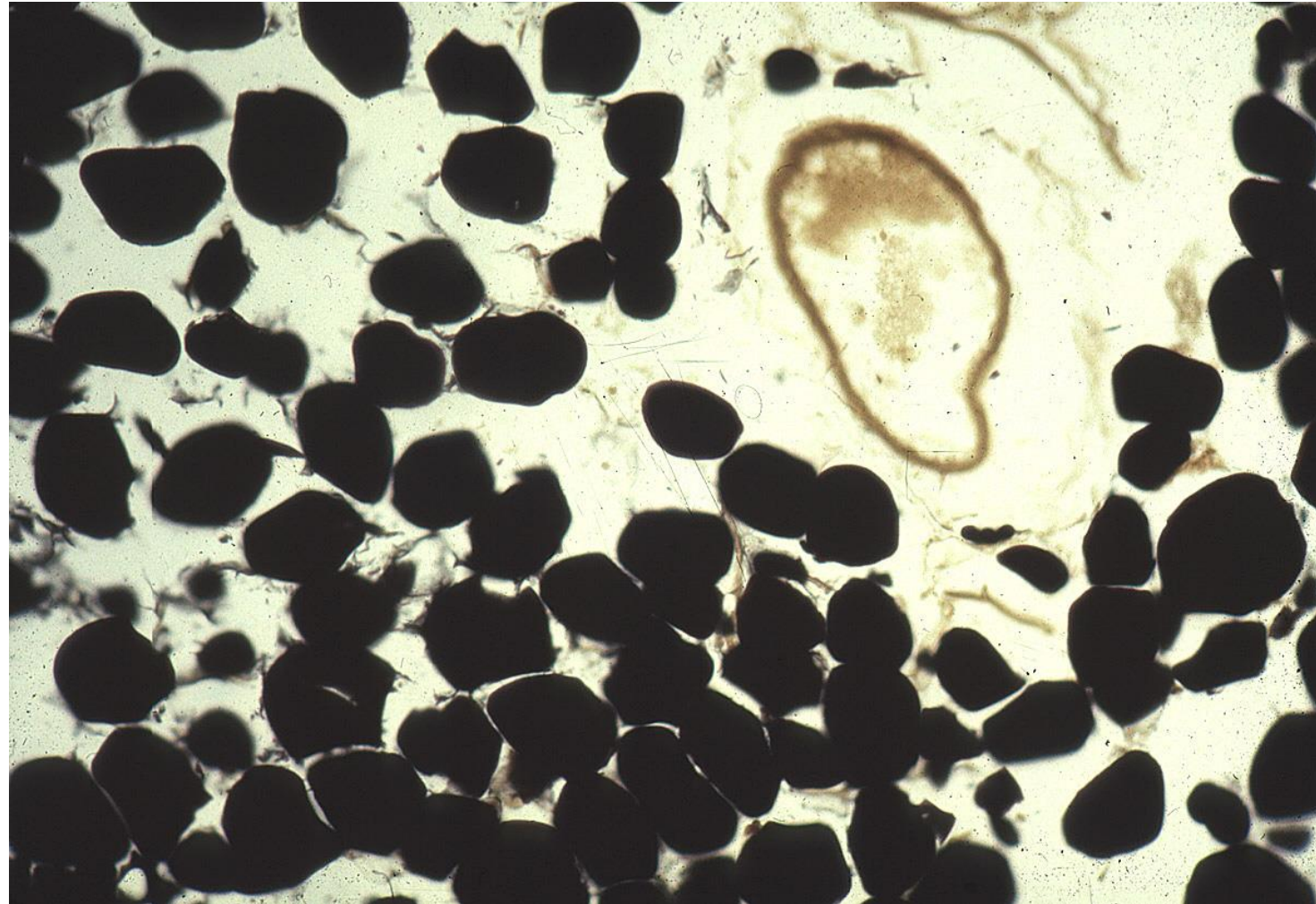
2. Skeletal Tissue:

- Cartilage
- Bone



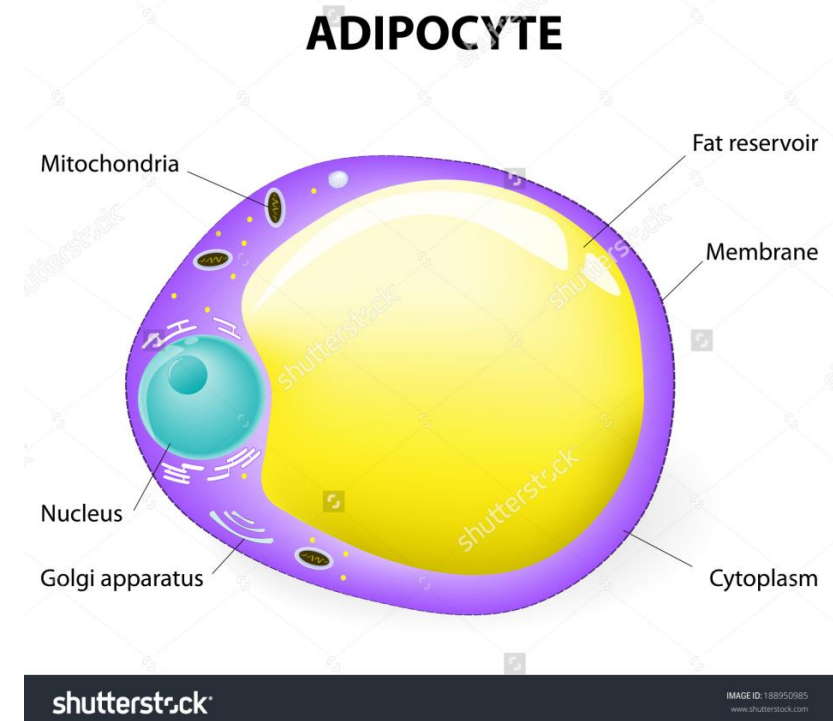
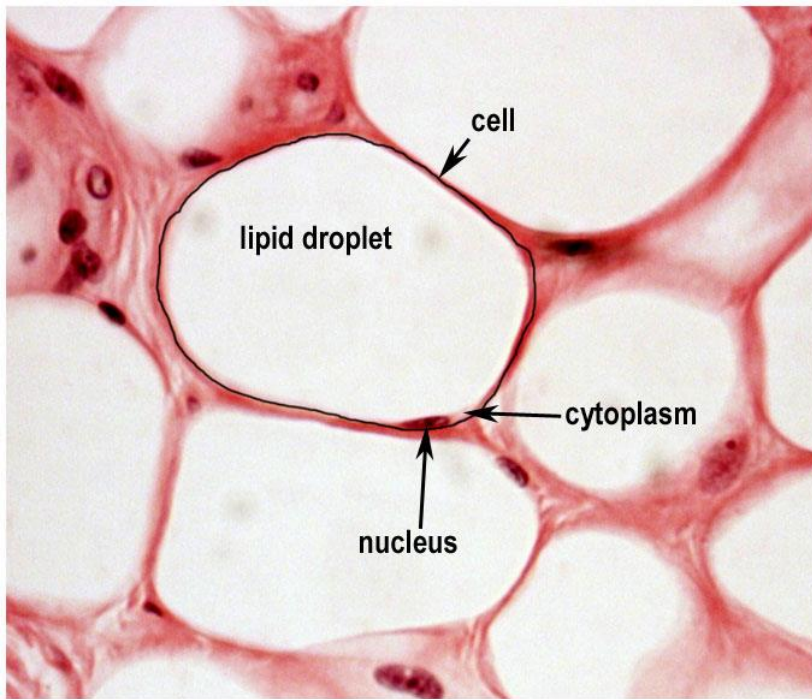
Adipose Tissue

Consists of accumulations of adipocytes that are partitioned into lobules by septa of connective tissue proper



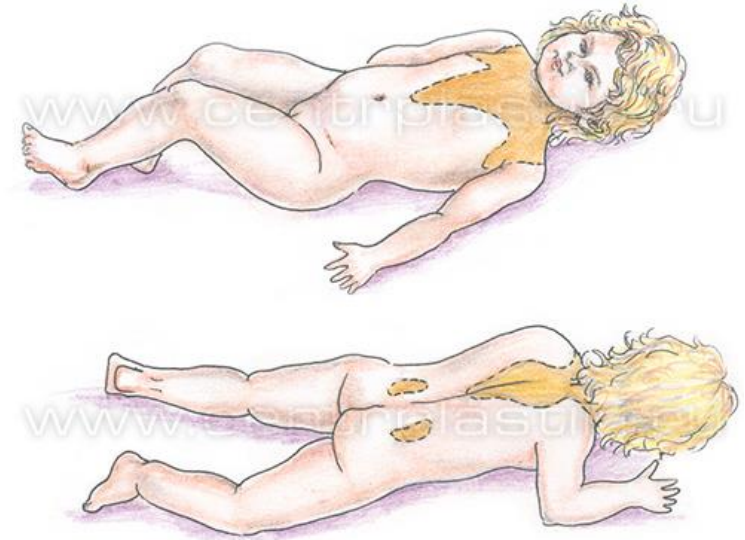
White adipose tissue

- Present throughout the body
- Consists of **white adipose cells (Unilocular)**
- One big central lipid drop, cytoplasm and nucleus are on the periphery of the cell
- Storage of energy
- Hormones production (leptin, adiponectin)



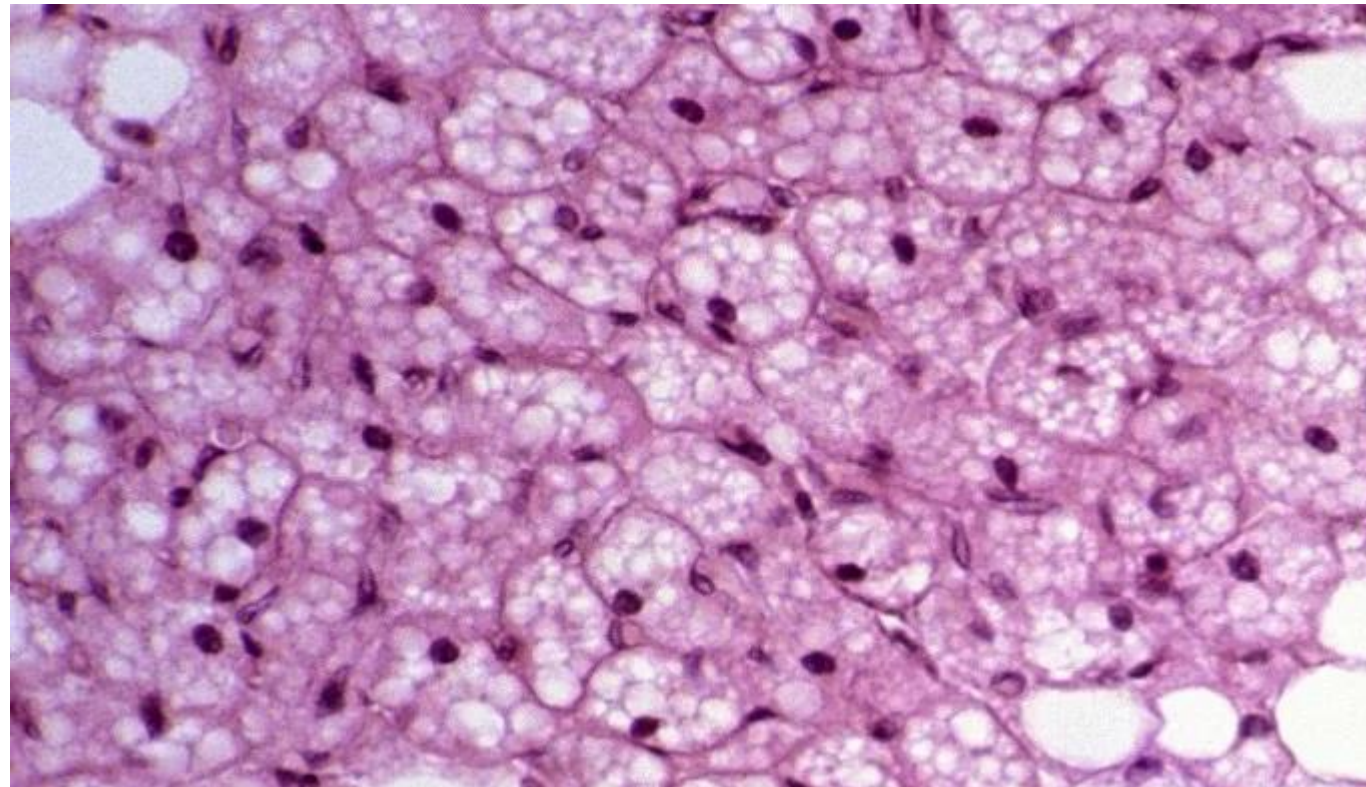
Brown Adipose Tissue

- Present in fetuses and newborns, after birth the amount of it decreases
- Localization:
 - Between scapula
 - Around kidneys
 - Around thyroid gland

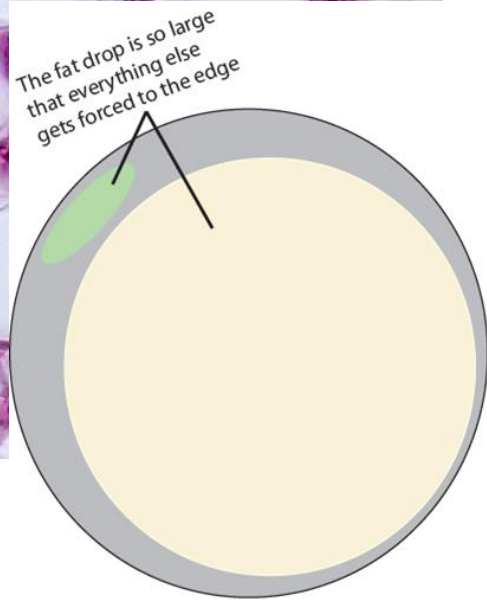
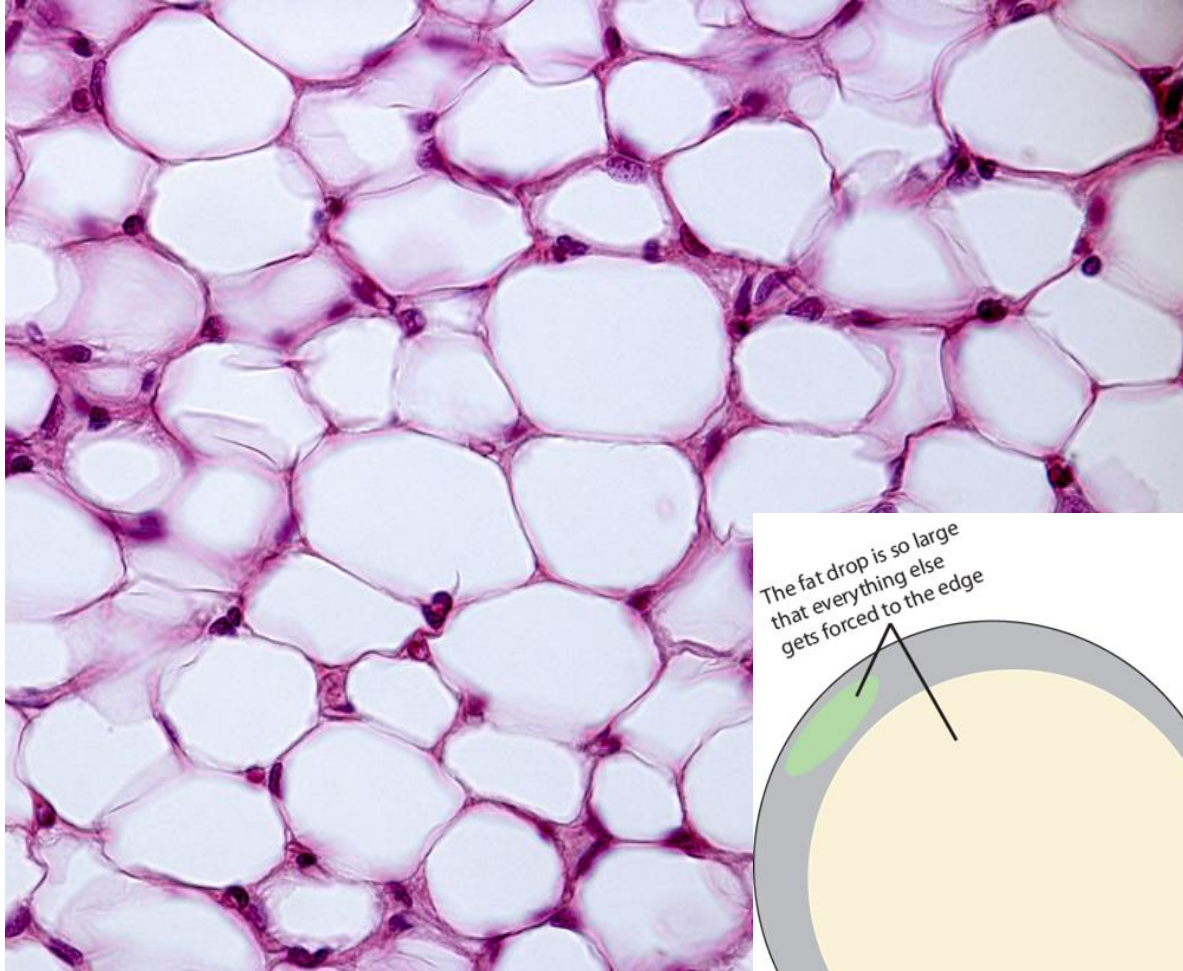


Brown fat cells (brown adipocytes):

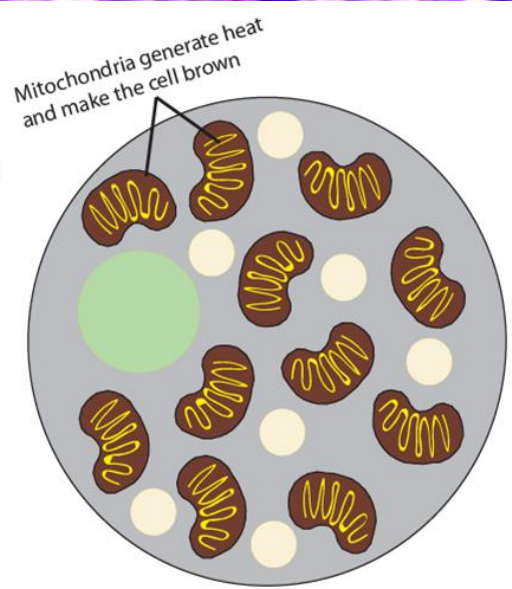
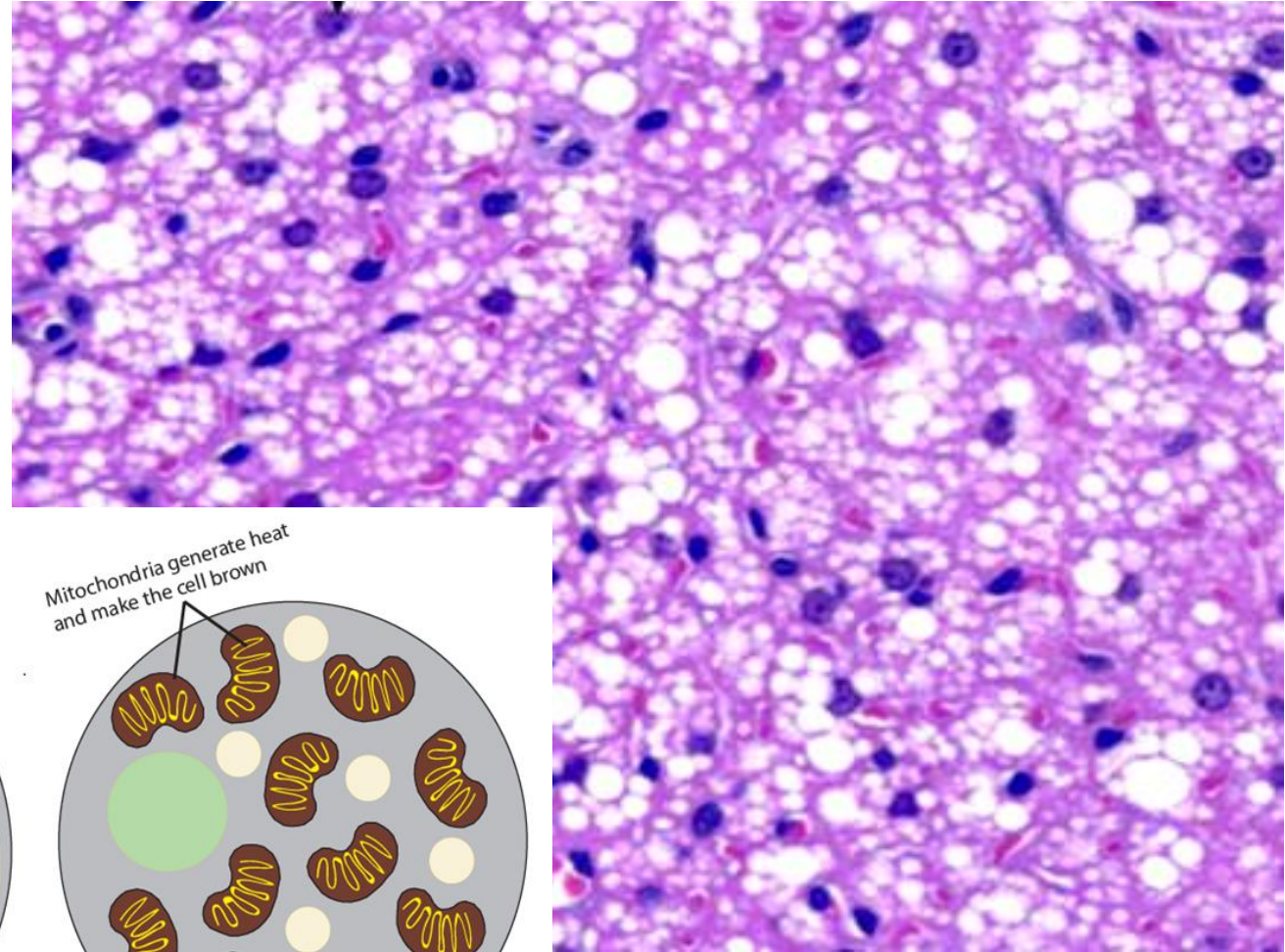
- Several small lipid droplets and mitochondria in the cytoplasm (multilocular cells)
- The brown color is due to the large amounts of iron-containing pigments - cytochromes in the mitochondria of brown adipocytes
- Function - heat production and regulation of thermogenesis



White

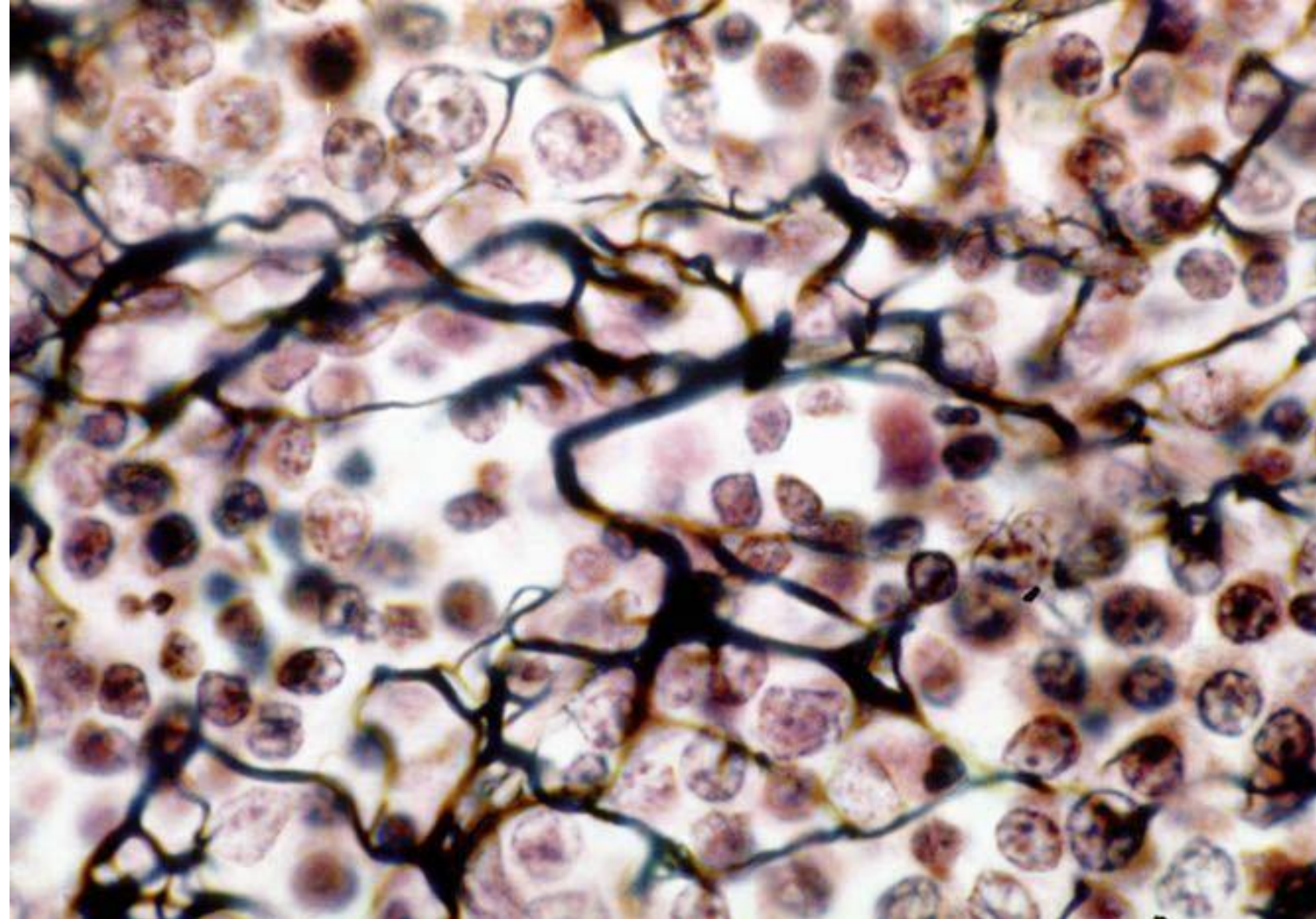


Brown



Reticular connective tissue

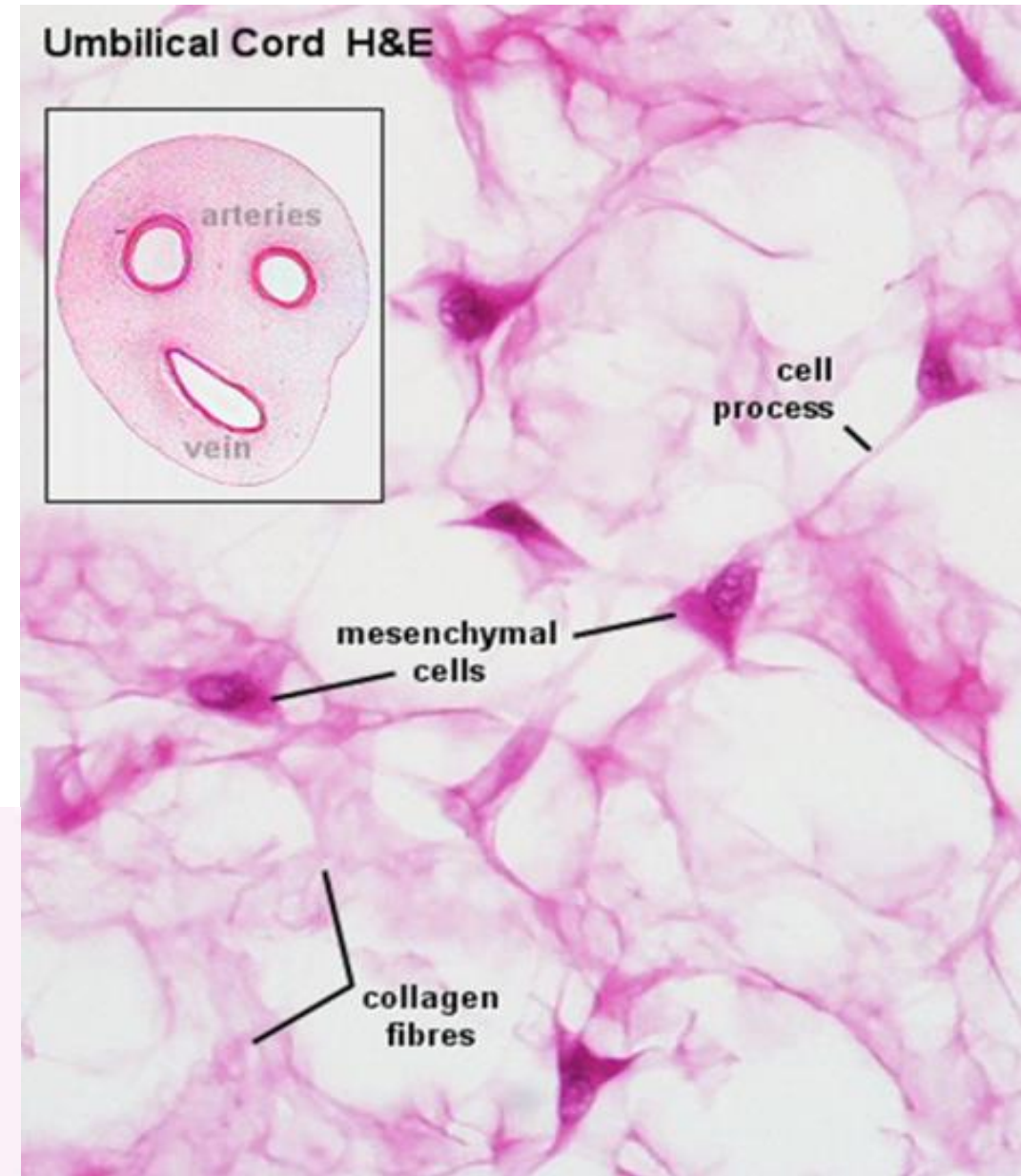
- Reticular cells
- Network of reticular fibers (type III collagen)
- Forms the stroma of hematopoietic and lymphoid organs



Mucous connective tissue

(Wharton jelly)

- Embryonic connective tissue
- Few cells and fibers
- Primary hyaluronic acid in the ground substance – jelly-like matrix
- Protects underlying structures from excess pressure
- Umbilical cord



Enjoy your classes!