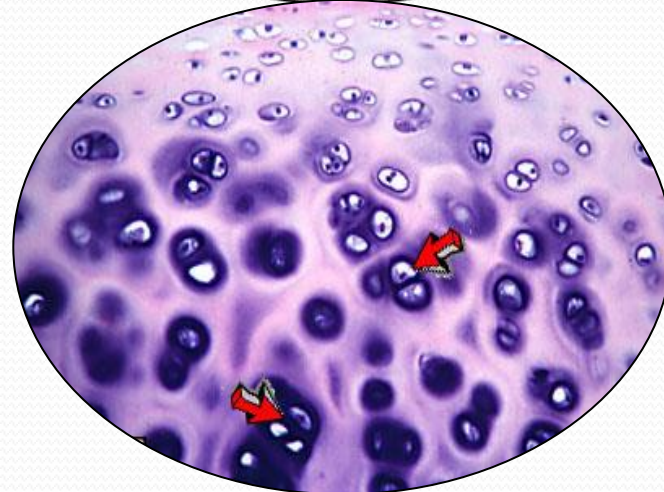
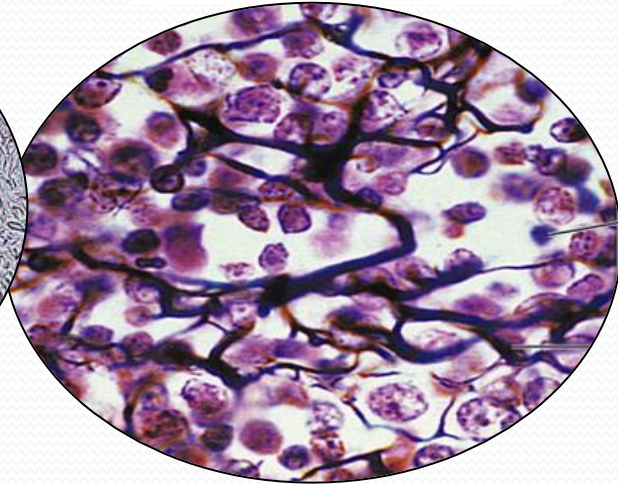
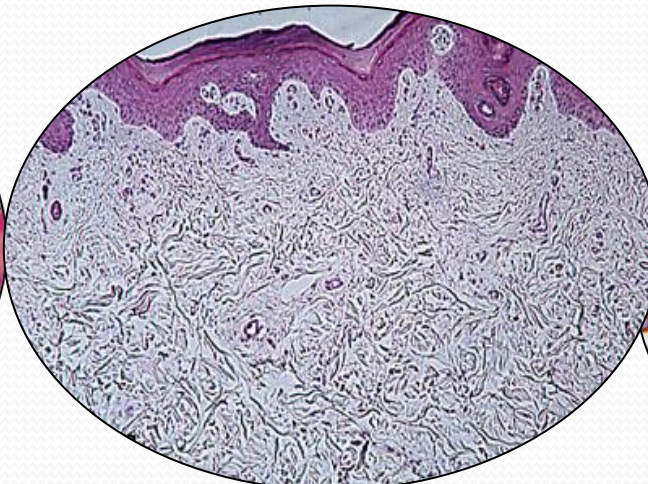
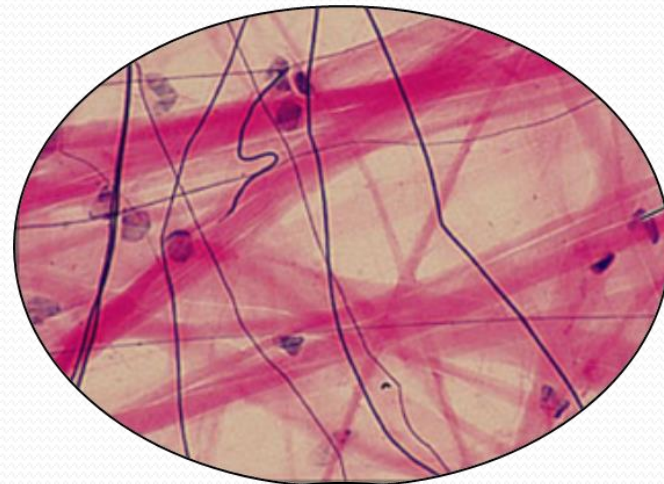




## **Connective Tissue**



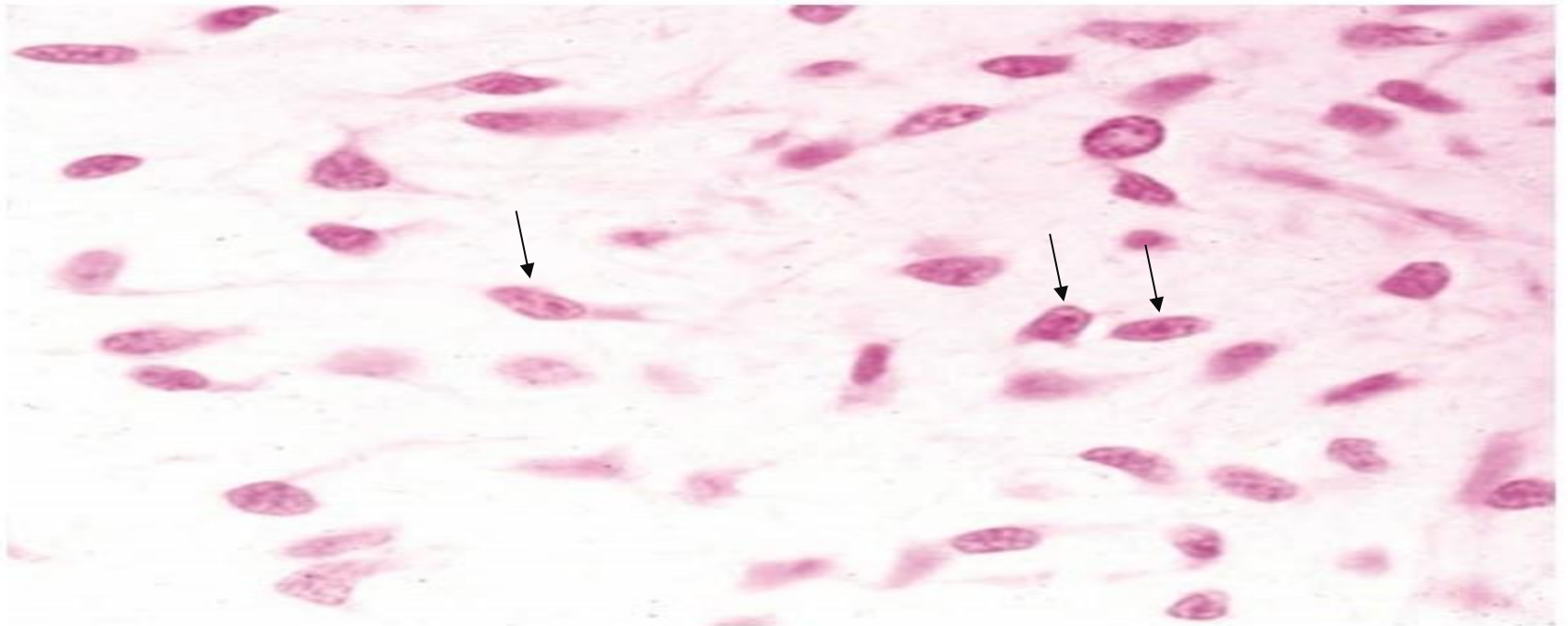
# **Learning objectives**

- 1. Origin of connective tissue**
- 2. Connective tissue components**
- 3. Function of connective tissue**
- 4. Classification of connective tissue**
- 5. Medical application**

## Origin of Connective tissues :

Originate from embryonic mesenchyme (**mesodermal layer of the embryo**) consists largely of **viscous ground substance** , **cells** with **collagen fibers**. Mesenchymal cells **are** undifferentiated and have **large nuclei**, and **prominent nucleolus** and **fine chromatin**.

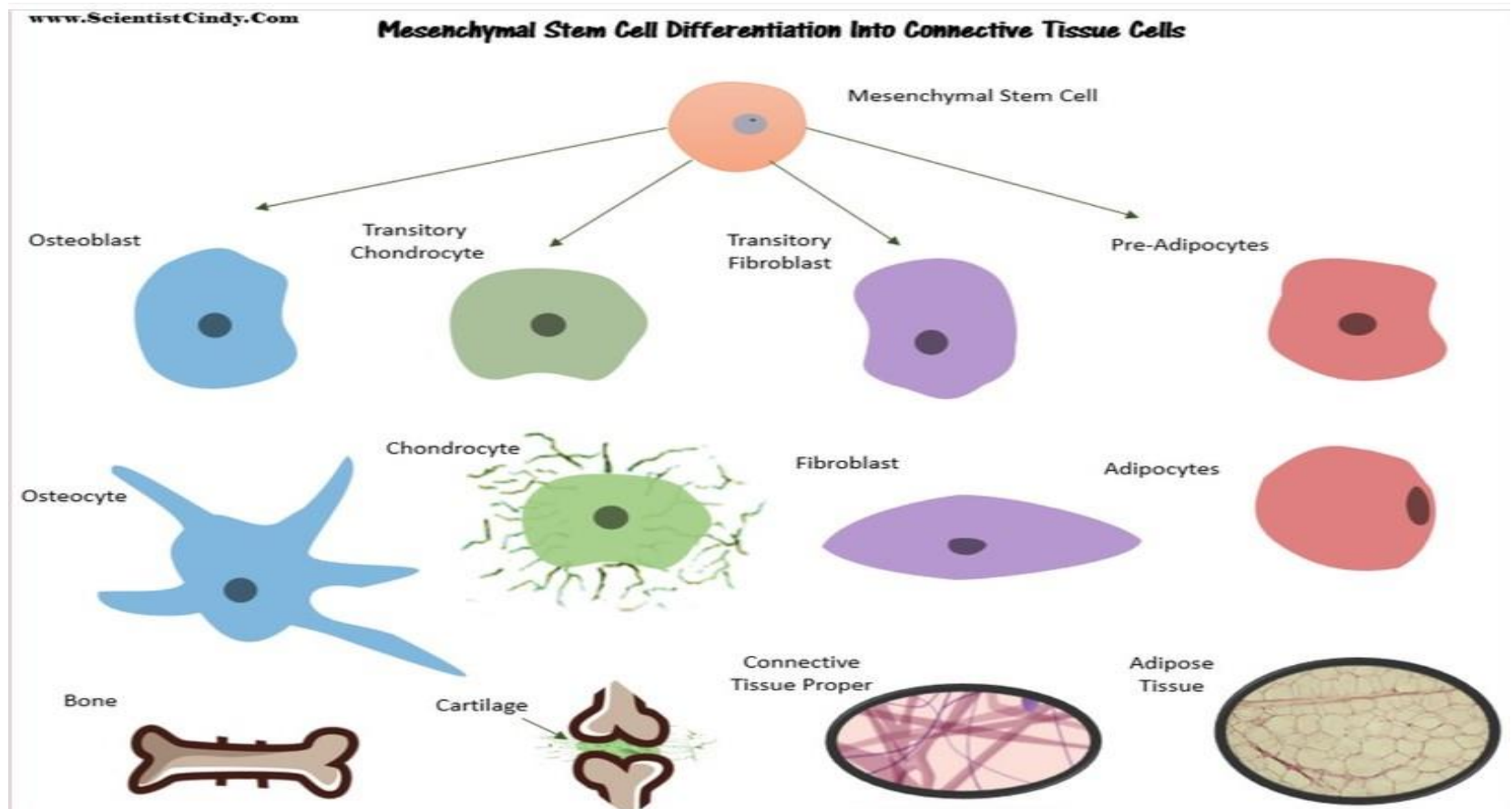
Mesenchymal cells





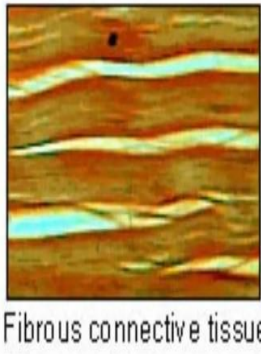
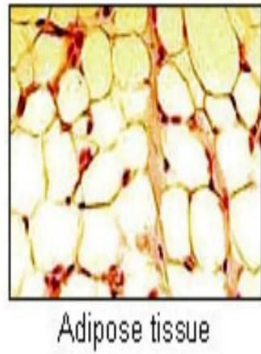
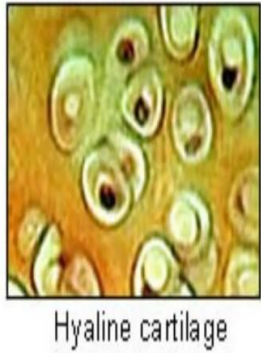
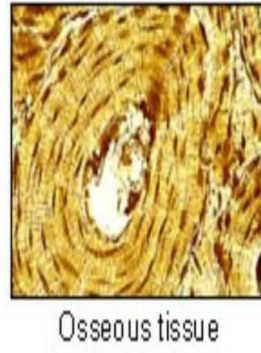
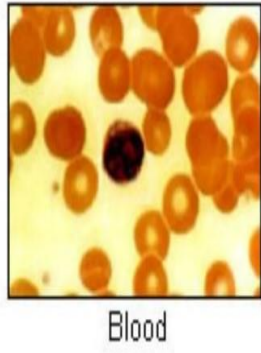
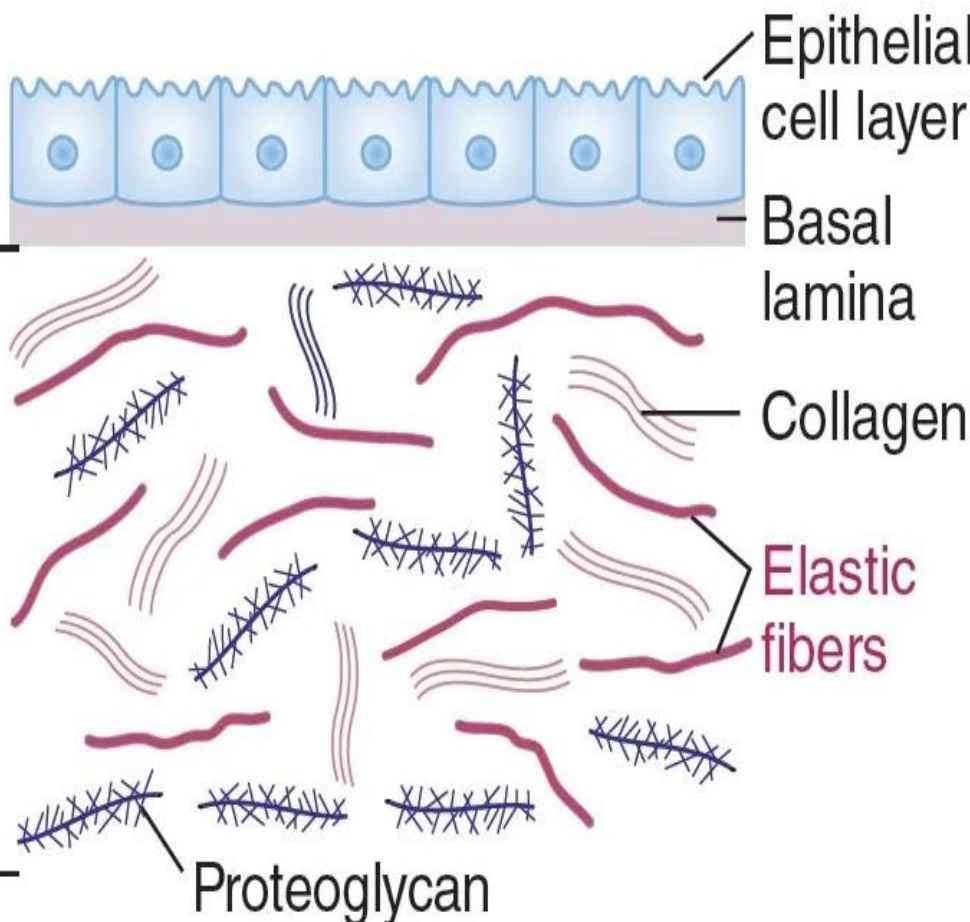
**Mesenchymal cells** migrate from their site of origin in the **embryo**, surrounding and penetrating developing organs to **producing all types of connective tissue** proper and the specialized (**bone and cartilage and blood**)

**The interstitial fluid of connective tissue** gives metabolic support to cells as the medium for diffusion of nutrients and waste products, The major constituent of connective tissue is the extracellular matrix (ECM)



Connective tissue is made up of **cells**, **extracellular matrix** and **fibers** . Variations in the composition of the extracellular matrix, **determines the properties of the connective tissue**. For example, if the matrix is calcified, it can form bone or teeth.

**Ground substance:** is a complex of **anionic**, **hydrophilic proteoglycans**, **glycosaminoglycan's** (GAGs), and multiadhesive **glycoproteins** (laminin, fibronectin, and others)



# CONNECTIVE TISSUE FUNCTIONS

## 1. Structural support

“Hard” connective tissues

“Soft” connective tissues

## 2. Energy storage

Adipose tissue

## 3. Medium for exchange

Tissue fluid

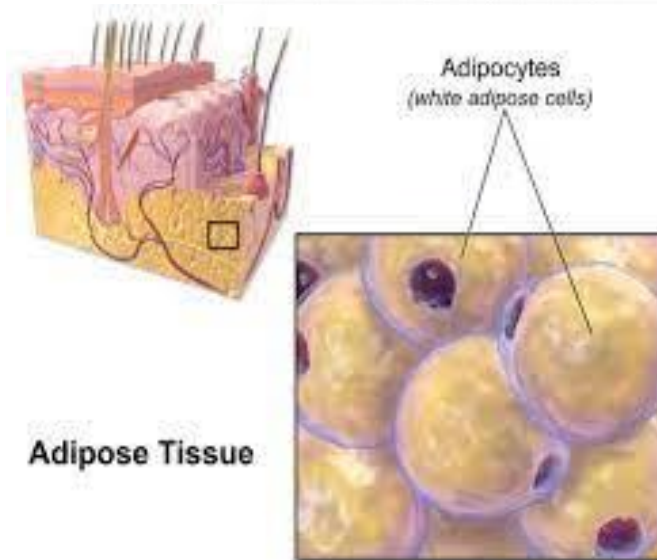
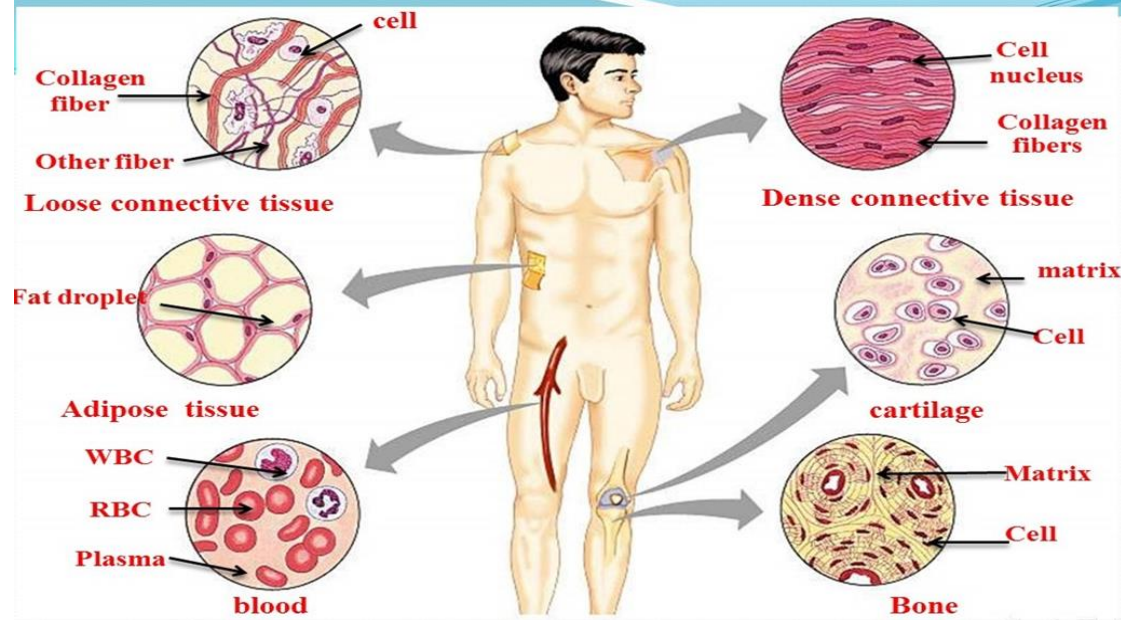
## 4. Defense and protection (blood cells)

Inflammatory response

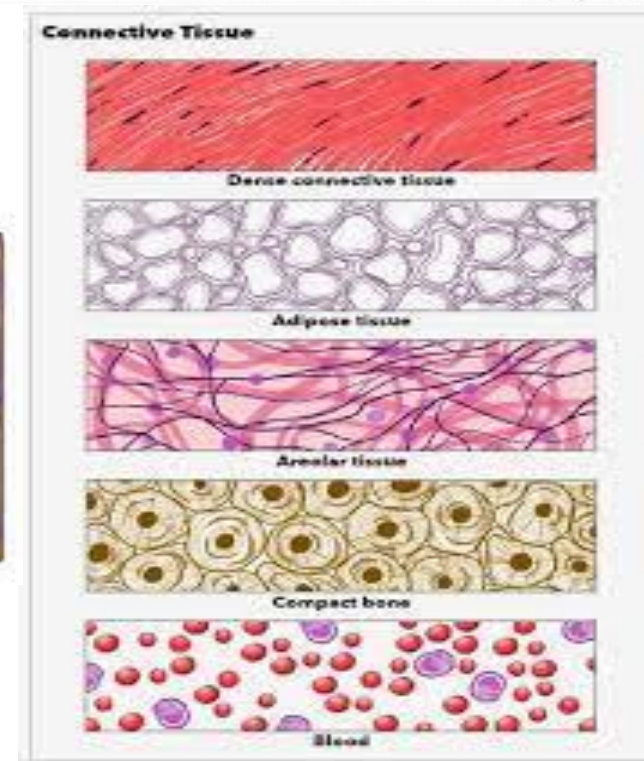
Immune response

Wound repair

## 5. Insulation



Adipose Tissue





## Cells of connective tissue:

There are **two most common** cell types in the connective tissue are **active fibroblasts** and the **inactive or resting fibrocytes**. These are called **resident(fixed cell)** cells involved **adipose cell**, while **wandering cells** that migrate into connective tissue all WBC.

### Resident (or fixed) cells in CT

**Fibroblast (including reticular cells)**

**Adipocyte**

### Transient (or wandering) cells - migrate into CT

**Neutrophil**

**Eosinophil**

**Basophil**

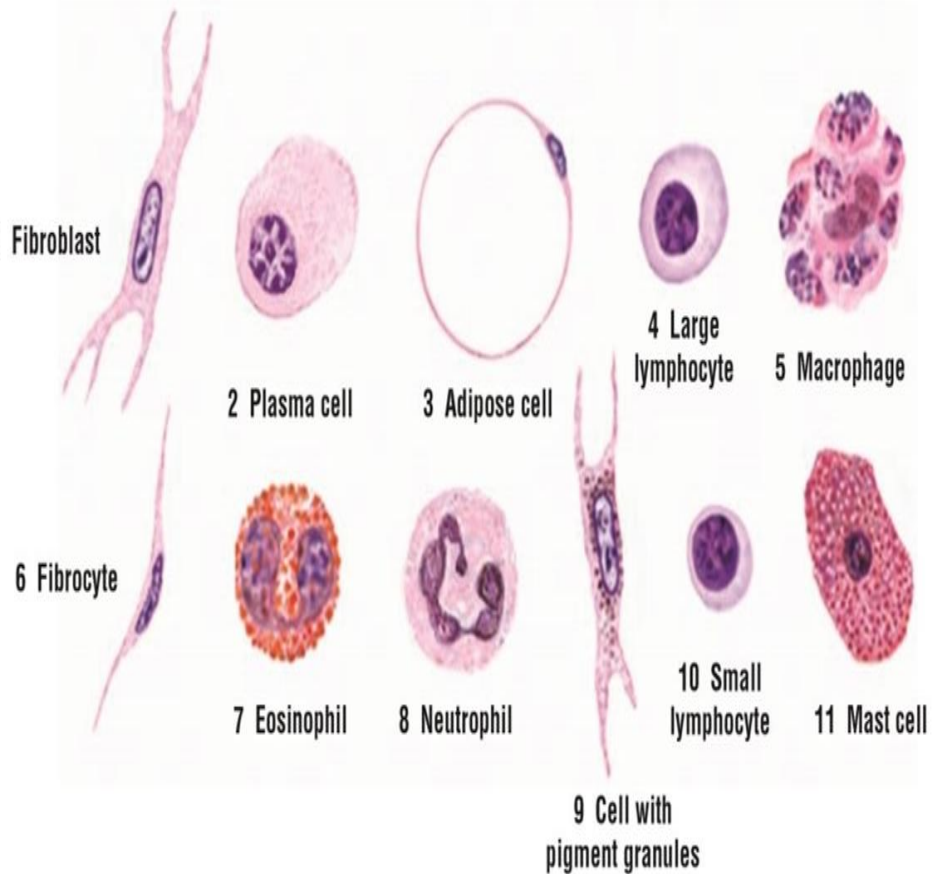
**Lymphocyte**

**Monocyte (Macrophage )**

**Plasma cell (differentiates from B lymphocyte)**

**Mast cell**

all blood cells

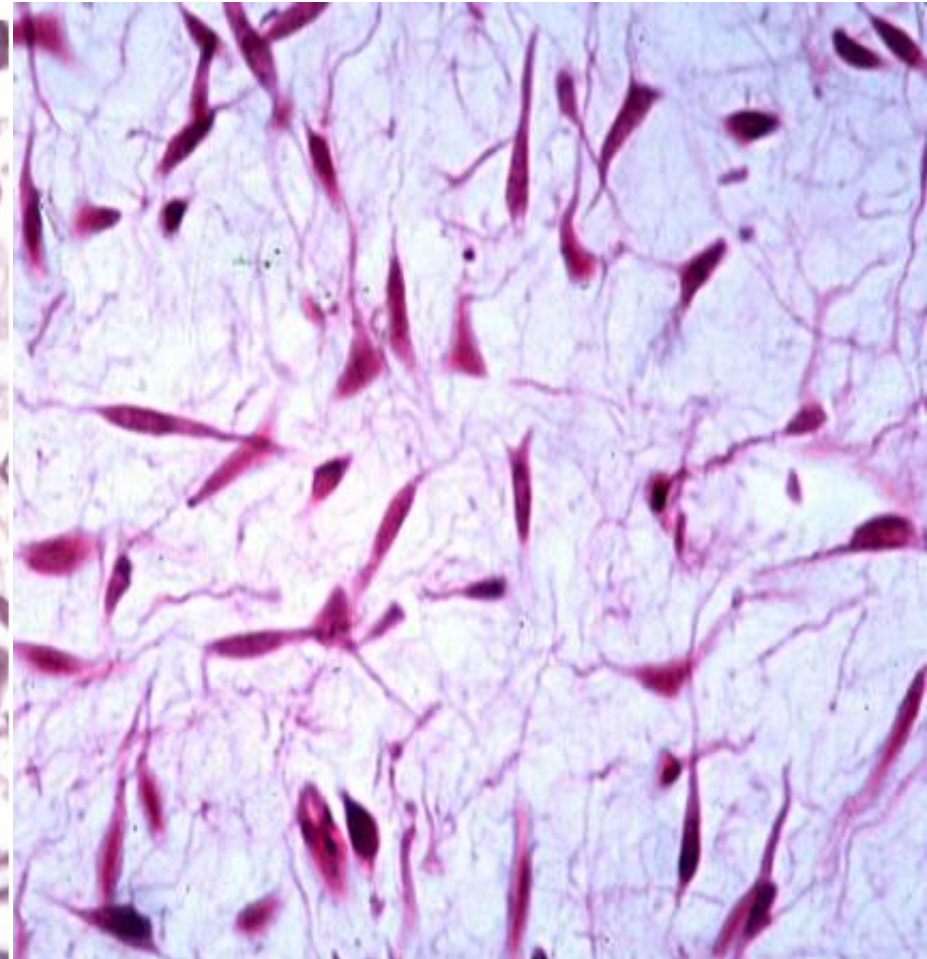
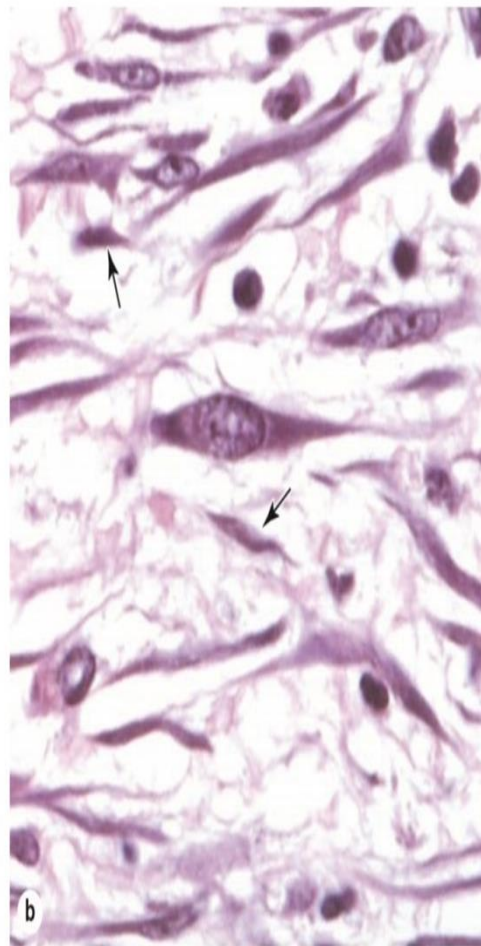
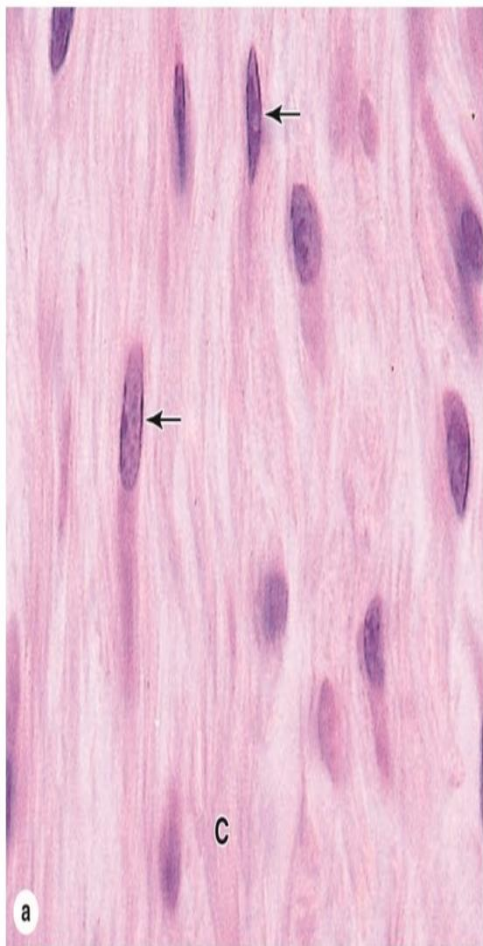


**FIGURE 3.2** ■ Cells of the connective tissue. Stain: hematoxylin and eosin. High magnification or oil immersion.

**Fibroblast:** Fusiform-shaped fibroblasts synthesize **all of the connective tissue fibers** and the **extracellular ground substance**.

**Functions of fibroblasts:**

- 1. remodeling and secretion of signaling factors for surrounding cells**
- 2. mechanical force generation**
- 3. regulation of tissue metabolism and secretion**





## Types of Fibroblasts

There are many types of fibroblasts involved in different body parts and systems.

1. **Pericytes:** This common type supports the structure of tiny blood vessels called **capillaries** by surrounding and holding them in place.
2. **Cardiac fibroblasts:** The walls of the heart have their own fibroblasts. These are **associated with heart muscle function**.
3. **Muscular fibroblasts:** These **contain three layers of fibroblasts** (the endomysium, perimysium, and epimysium) that support skeletal muscles.
4. **Dermal fibroblasts:** These play an **essential role in wound healing**. Several fibroblasts support the layers of skin.
5. **Fat:** Some fibroblasts **turn into adipocytes**, or fat cells, which make up the layer of cells that include body fat.
6. **Other types:** Certain **fibroblasts** are associated with the structure and function of the colon, bladder, lungs, and digestive organs.

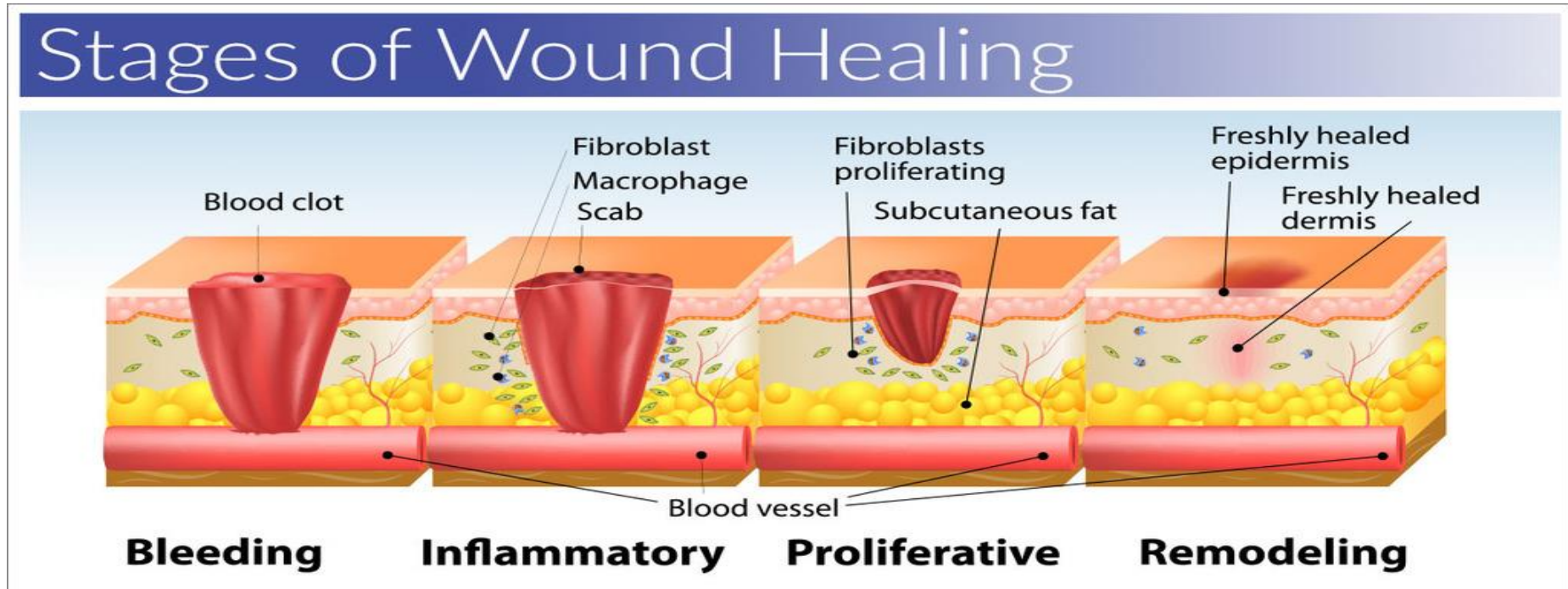


## MEDICAL APPLICATION:

The regenerative capacity of connective tissue is clearly observed in organs **damaged by ischemia, inflammation, or traumatic injury**. Especially in tissues whose **cells divide poorly or not at all** (eg. **cardiac muscle**) are **filled by connective tissue, forming dense irregular scar tissue**.

The healing of surgical incisions and other wounds **depends on the reparative capacity of connective tissue**, particularly on activity and growth of fibroblasts.

in some rapidly closing wounds, a cell called the **myofibroblast**, with features of both **fibroblasts and smooth muscle cells**. These cells have most of the morphologic characteristics of fibroblasts but contain **increased amounts of actin and myosin** and **behave much like smooth muscle cells**. Their activity is important for the phase **of tissue repair called wound contraction**.



## Transient (or wandering) cells - migrate into CT

Plasma cell (differentiates from B lymphocyte)

Mast cell

Neutrophil

Eosinophil

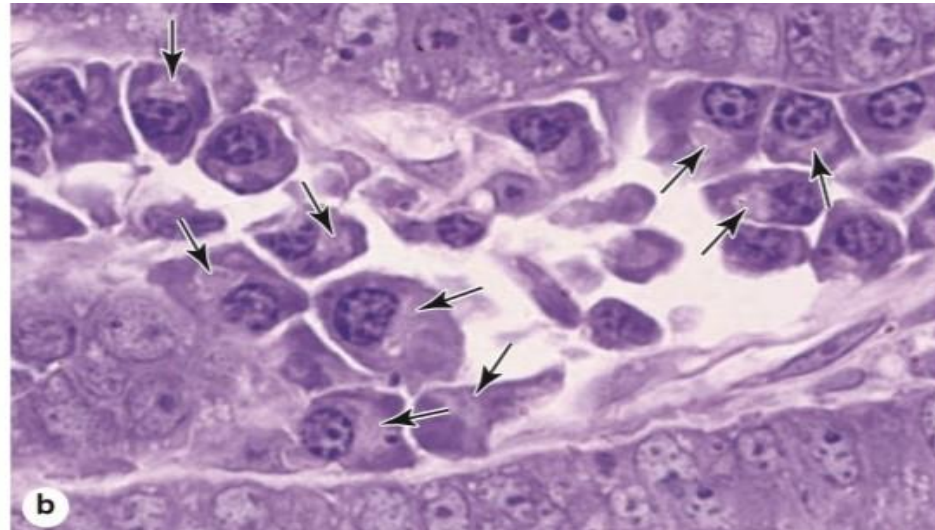
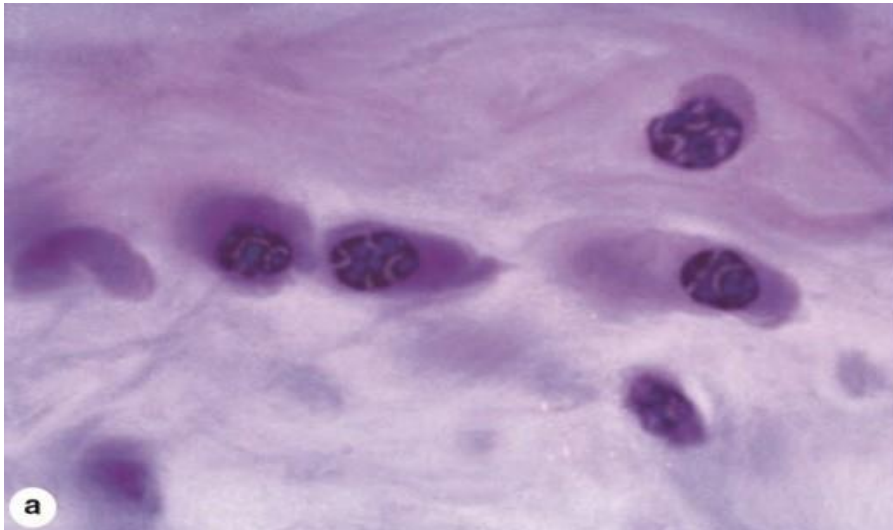
Basophil

Lymphocyte

Monocyte (Macrophage )

all blood cells

**Plasma cell:** vary in size from **14 to 20** micrometers. They are **round cells** containing **deep blue cytoplasm** with **a pale perinuclear area** corresponding to the Golgi apparatus. derived from B lymphocytes that migrate into the connective tissue. They synthesize and secrete of **antibodies**. one antigen that stimulated the clone of B cells reacts with **antibody**. The results of the antibody-antigen reaction are variable, but they usually neutralize harmful effects caused by antigens. These cells are **found in great abundance in loose connective tissue, lymphatic tissue, respiratory and digestive tracts.**



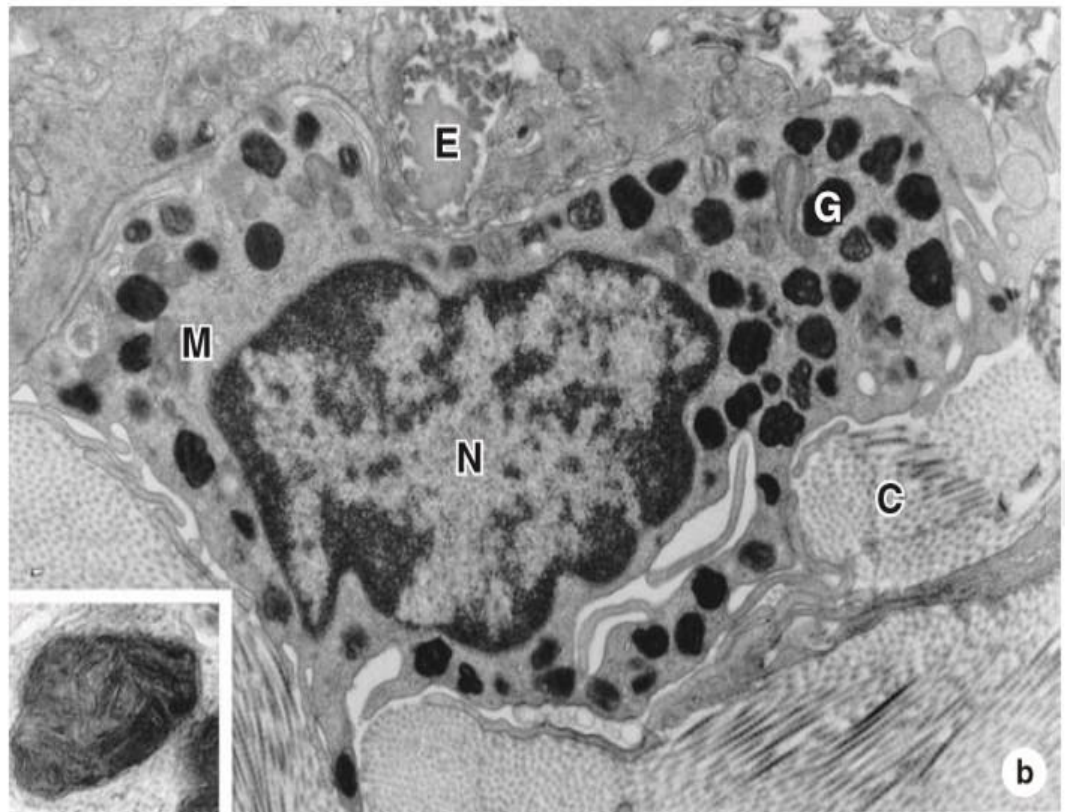
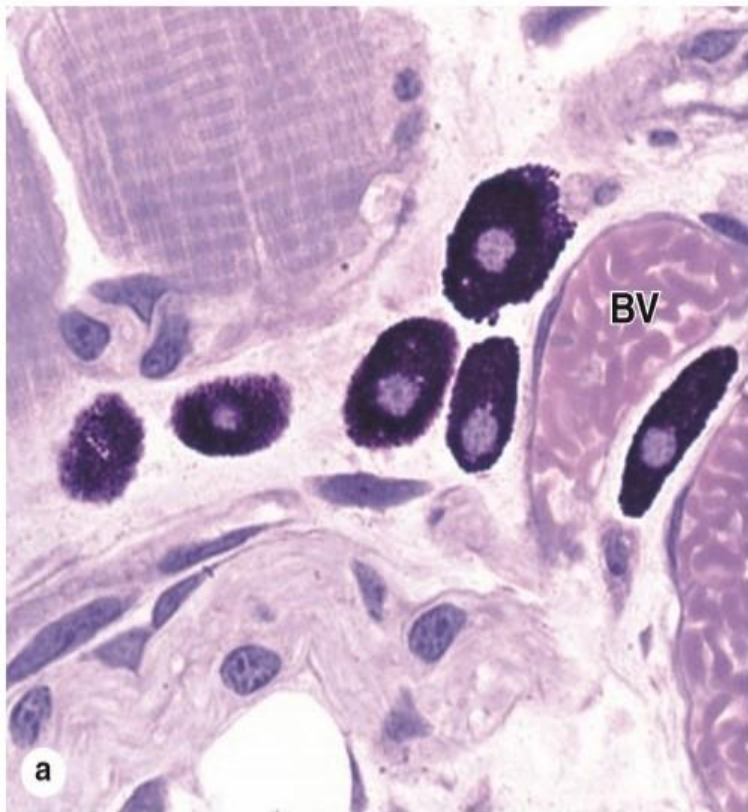


**Mast cell:** are **spherical** cells filled with **fine, regular dark-staining** and **basophilic granules** of cytoplasm, with a **small, centrally nucleus**. widely distributed in the connective tissue of the skin and in the digestive and respiratory organs. **Mast cell release of following**

**Heparin:** anticoagulant chemical that prevents blood clotting when free in the bloodstream

**Histamine:** substance that makes capillaries leaky

**Proteases:** protein-degrading enzymes **immediate hypersensitivity reactions** .



## MEDICAL APPLICATION

increased vascular permeability is caused by the action of **vasoactive substances** such as **histamine** released from mast cells during **inflammation** and **hypersensitivity**. Increase vascular permeability produce local **swelling (edema)**, **redness**, and **heat**.



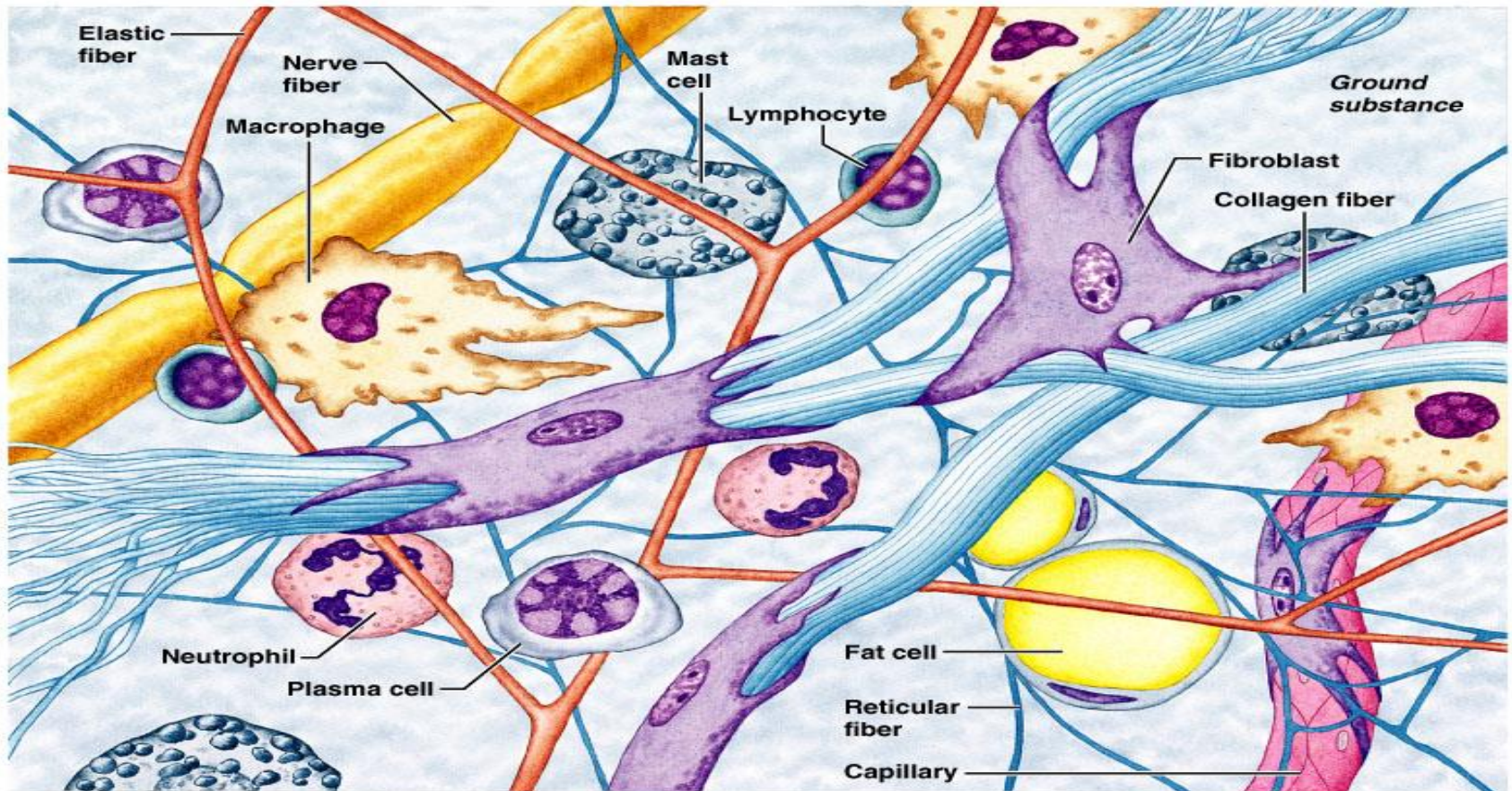
# CELLS

Cell Type	Representative Product or Activity	Representative Function
Fibroblast, chondroblast, osteoblast	Production of fibers and ground substance	Structural
Plasma cell	Production of antibodies	Immunological (defense)
Lymphocyte (several types)	Production of immunocompetent cells	Immunological (defense)
Eosinophilic leukocyte	Participation in allergic and vasoactive reactions, modulation of mast cell activities and the inflammatory process	Immunological (defense)
Neutrophilic leukocyte	Phagocytosis of foreign substances, bacteria	Defense
Macrophage	Secretion of cytokines and other molecules, phagocytosis of foreign substances and bacteria, antigen processing and presentation to other cells	Defense
Mast cell and basophilic leukocyte	Liberation of pharmacologically active molecules (eg, histamine)	Defense (participate in allergic reactions)
Adipose (fat) cell	Storage of neutral fats	Energy reservoir, heat production



❖ **EXTRA CELLULAR MATRIX (ECM):**Ground substance -glycosaminoglycan, adhesive proteoglycans and glycoprotein

- ❖ **Fibers types** - **Collagen Fibers**
- **Elastic Fibers** (lung, recoiling organs)
  - **Reticular Fibers** (lymph node, Liver )





**Collagen fibers** are **white** in colour and are made up of **collagen protein**, it is the most abundant protein in mammals, making up **from 25% to 35%** of the whole-body protein content. The fibers are unbranched and usually **occur in bundles**.

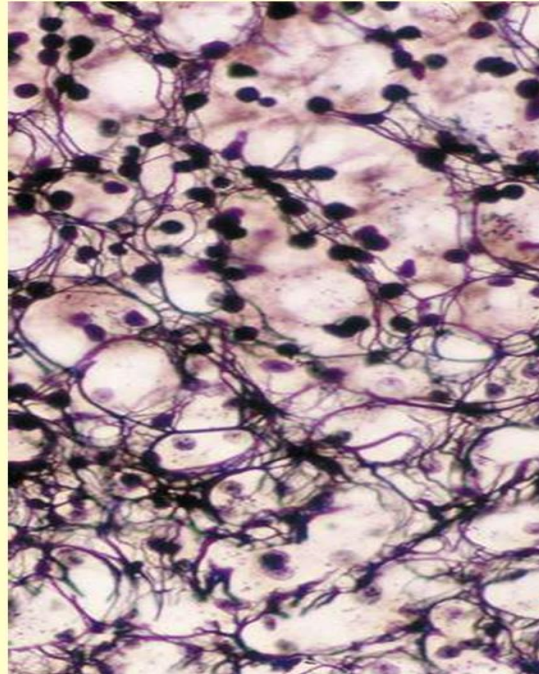
**Reticular fibers** or reticulin is a type of fiber in connective tissue composed of type III collagen secreted by reticular cells

**Elastic fibers (or yellow fibers)** These fibres occur singly and are **branched** composed of **bundles of proteins (elastin)** which are produced by a number of different cell types including **fibroblasts, endothelial, smooth muscle, and airway epithelial cells**.

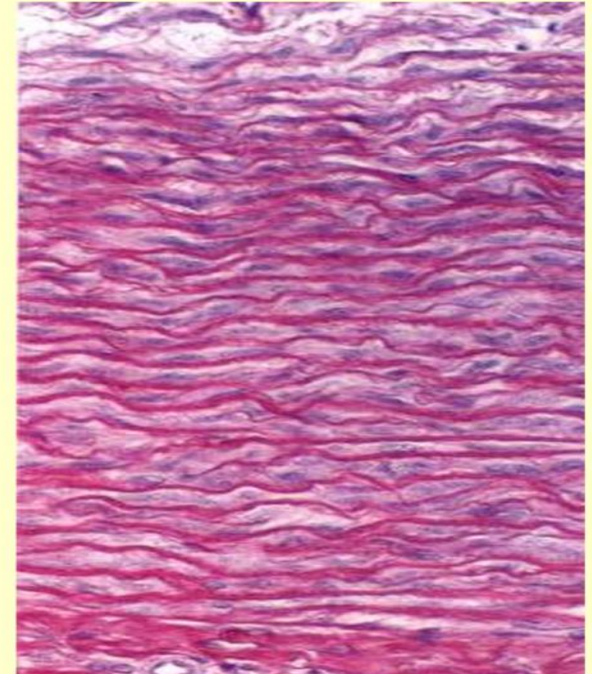
## ***CONNECTIVE TISSUE FIBERS***



**Collagen fibers  
(tendon)**



**Reticular fibers  
(adrenal cortex)**



**Elastic lamellae  
(aortic wall)**

# The five most common types of collagen :

Type I. This type makes up 90% of your body's collagen, bone and skin.

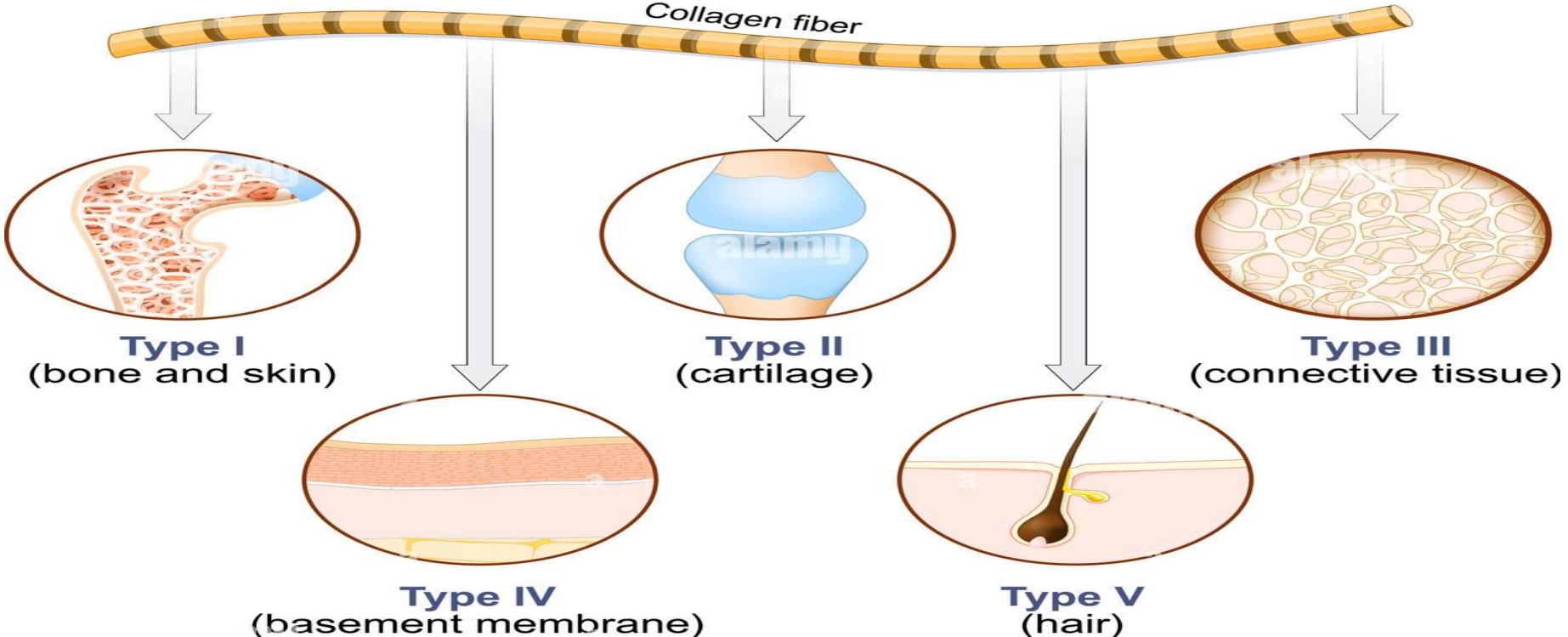
Type II. This type is found in elastic and hyaline cartilage, which provides joint support.

Type III. This type is found in muscles, arteries, and connective tissue.

Type IV. This type is found in the layers of basement membrane

Type V. This type is found in cornea, blood vessels and hair

## Collagen The five most common types





# MAJOR TYPES OF CONNECTIVE TISSUE OR CLASSIFICATION

1. Embryonic connective tissues
2. Connective tissues proper( adult)
3. specialized connective tissues (**bone, cartilage, adipose tissue and hematopoietic tissue**).

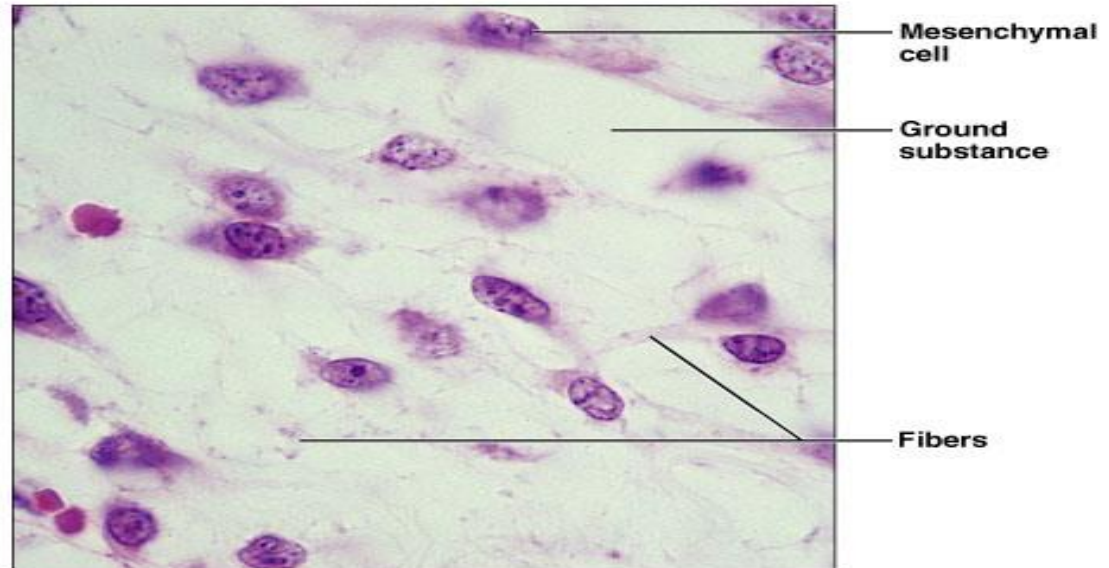
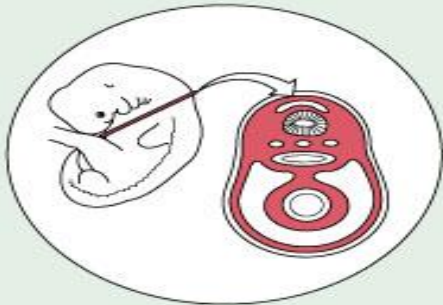
1. **Embryonic connective tissues** : is found in the **early embryos and umbilical cord**. Chief cells are **mesenchymal cells**. It is divided into **mesenchyme (in embryo)** and **mucoid connective tissue (umbilical cord)**, With abundant ground substance composed chiefly of **hyaluronic acid**, mucoid tissue is **jelly-like** with sparse collagen fibers and scattered fibroblasts. Mucoid tissue is the principal component of the umbilical cord, where it is referred to as **Wharton's jelly** .

## (a) Embryonic connective tissue: mesenchyme

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

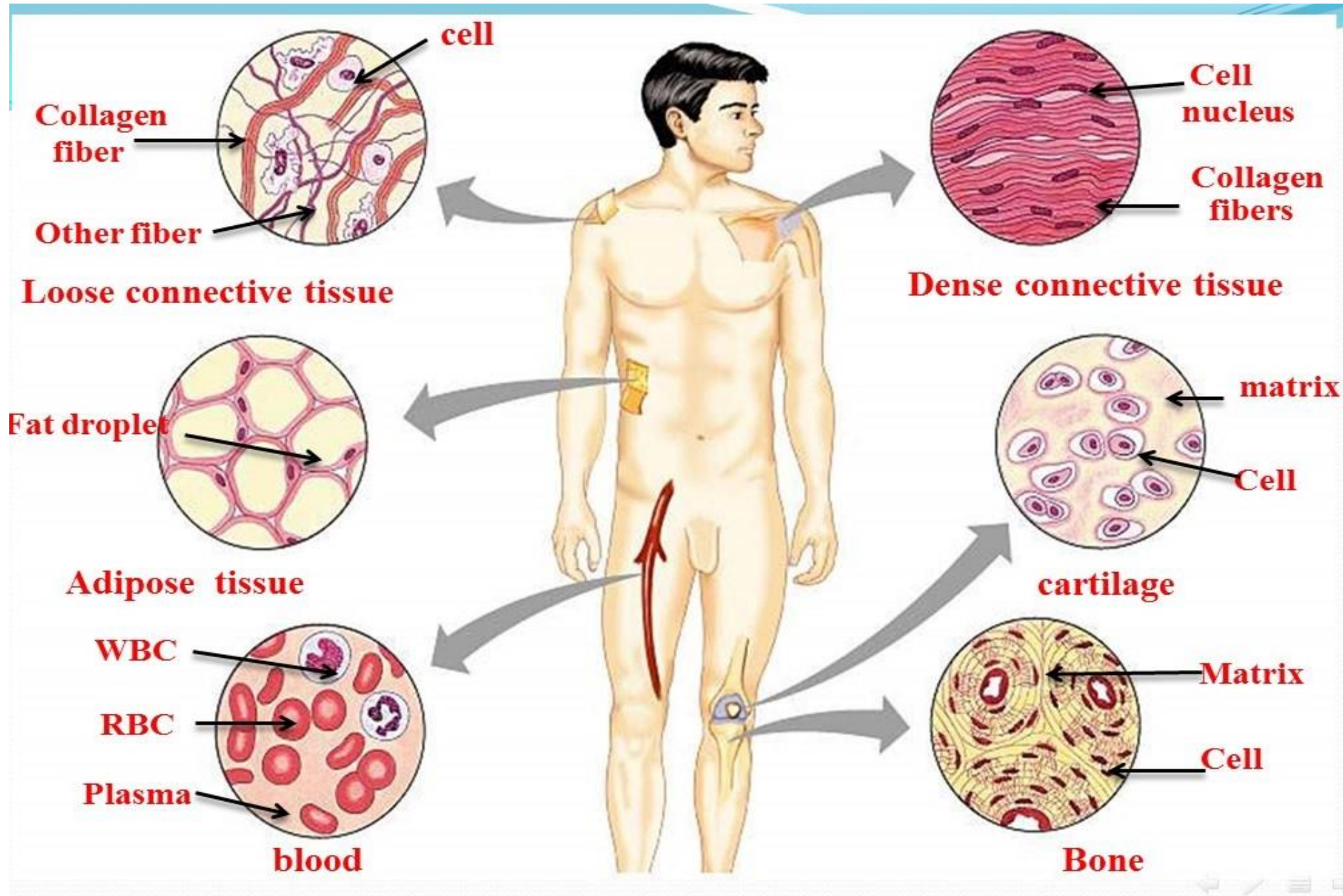
**Function:** Gives rise to all other connective tissue types.

**Location:** Primarily in embryo.



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

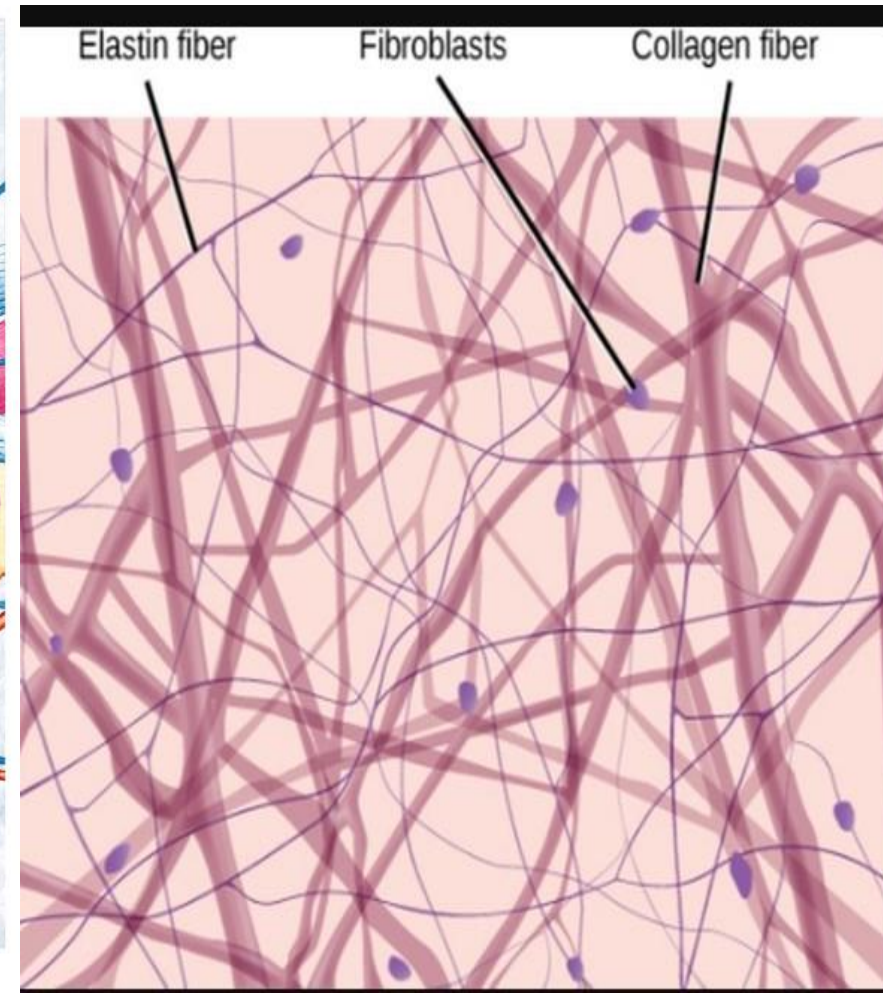
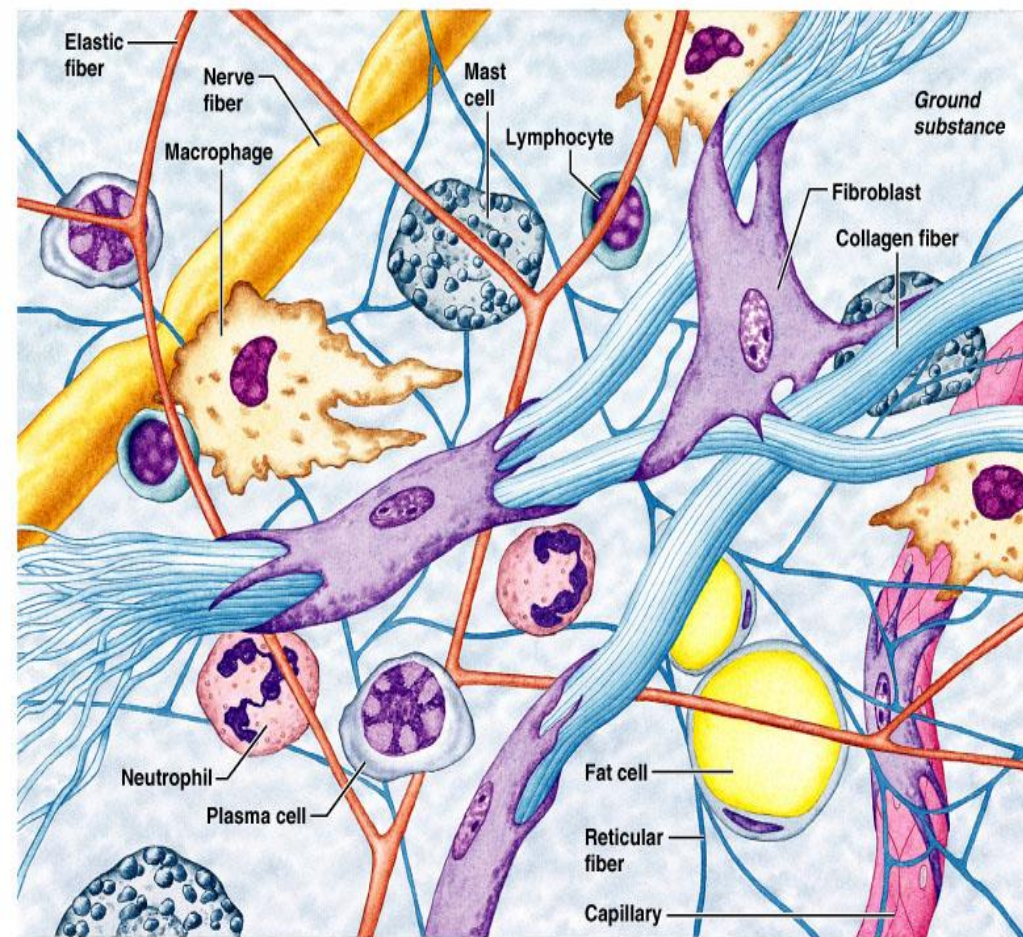
2. **Connective tissue proper ( adult)** includes: loose connective tissue (also called areolar) and dense connective tissue (**regular and irregular**).





**\*LOOSE CONNECTIVE TISSUE OR AREOLAR CONNECTIVE TISSUE:** is more **prevalent** in the body than **dense connective** tissue. It is characterized by irregular arrangement of connective tissue fibers and abundant ground substance.

Numerous connective tissue cells and fibers are found in the matrix. **Collagen fibers, fibroblasts, adipose cells, mast cells, and macrophages predominate** in loose connective tissue, with fibroblasts being the most common cell types





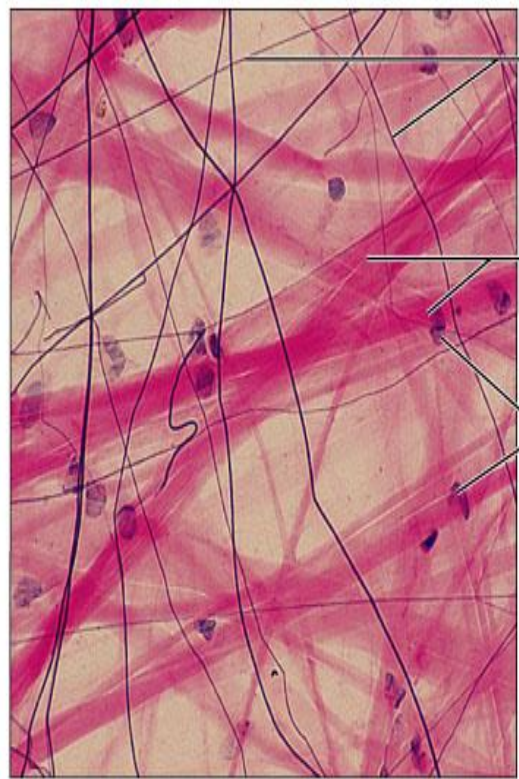
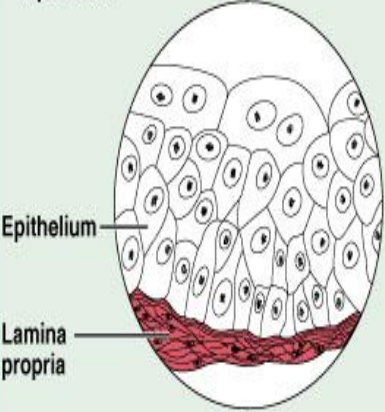
**Loose connective tissue:** wraps small blood vessels and nerves, surrounds glands, and forms the subcutaneous tissue. it consists of a thin extracellular matrix of hyaluronic and proteoglycans supported by a few collagen fibrils and elastic fibrils

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

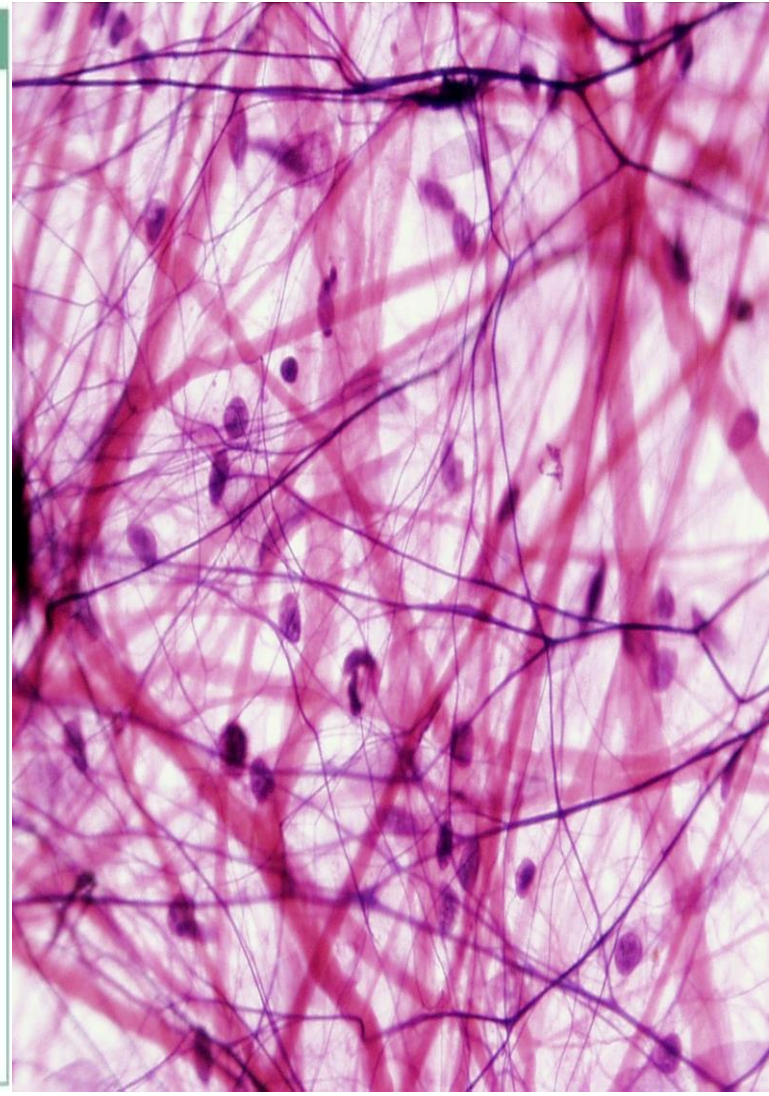
**Description:** Gel-like matrix with all three fiber types; cells: fibroblasts, macrophages, mast cells, and some white blood cells.

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

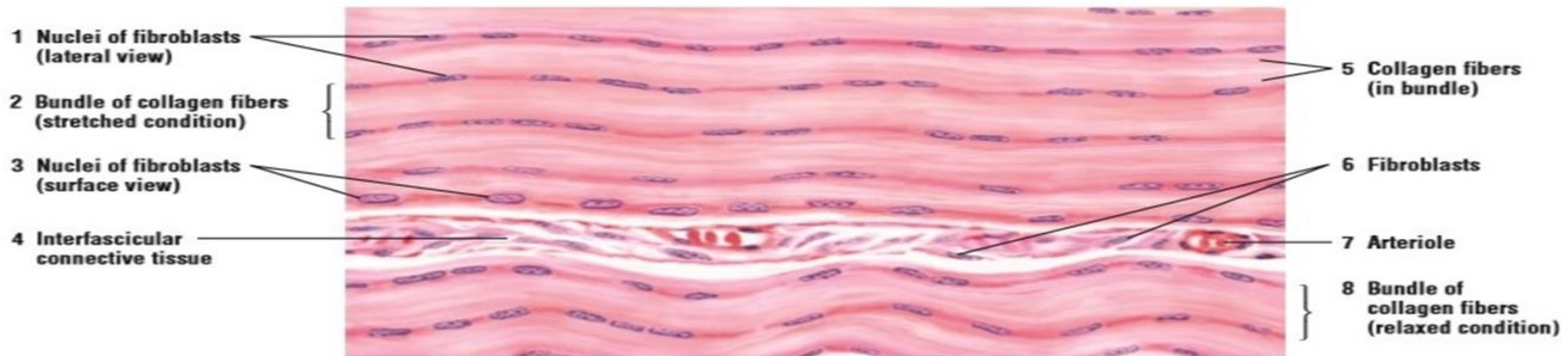
**Location:** Widely distributed under epithelia of body, e.g. forms lamina propria of mucous membranes; packages organs; surrounds capillaries.



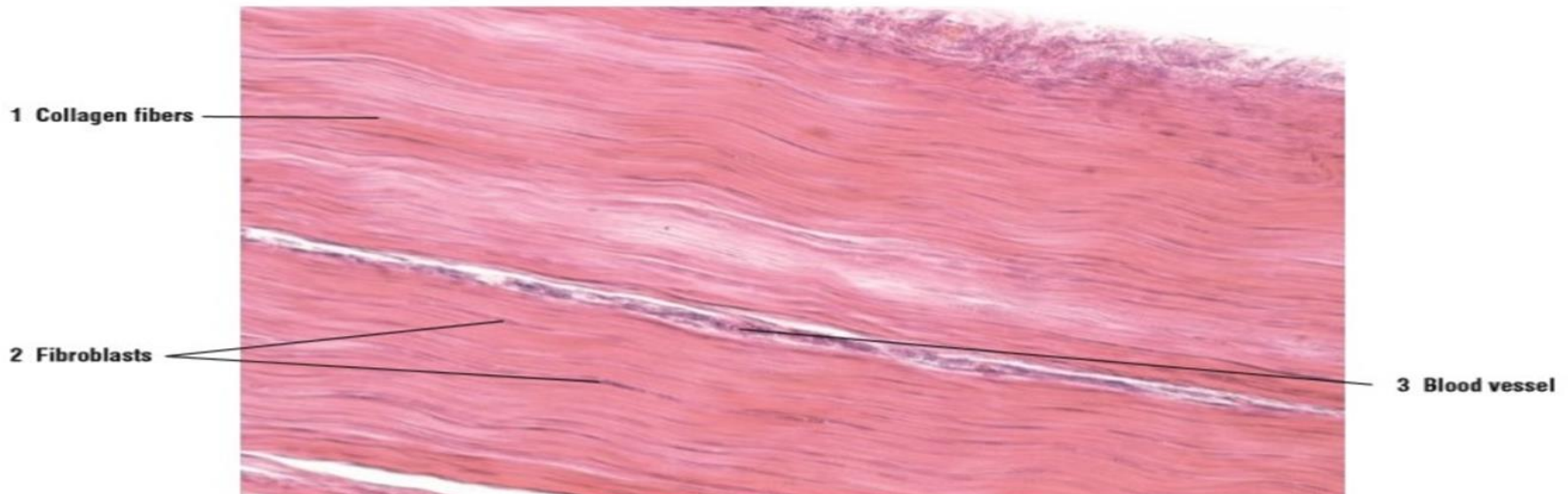
**Photomicrograph:** Areolar connective tissue, a soft packaging tissue of the body (400x).



**Dense (regular) Connective Tissue:** also called dense fibrous tissue. The fiber extend in one direction and mainly composed of **type I collagen** and crowded between the collagen fibers are **rows of fibroblasts**. This type of tissue is found **in the tendons and ligaments**.



**FIGURE 3.8** ■ Dense regular connective tissue: tendon (longitudinal section). Stain: hematoxylin and eosin. Medium magnification.



**FIGURE 3.9** ■ Dense regular connective tissue: tendon (longitudinal section). Stain: hematoxylin and eosin.  $\times 64$ .



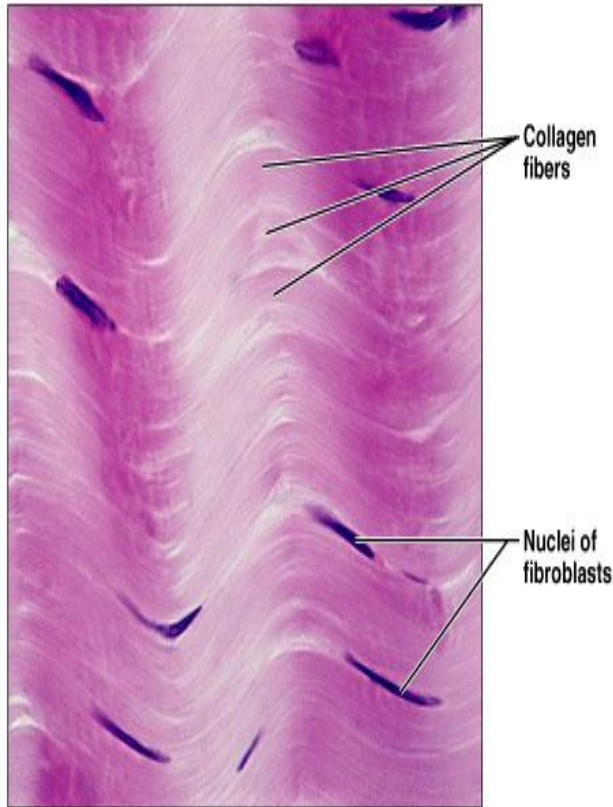
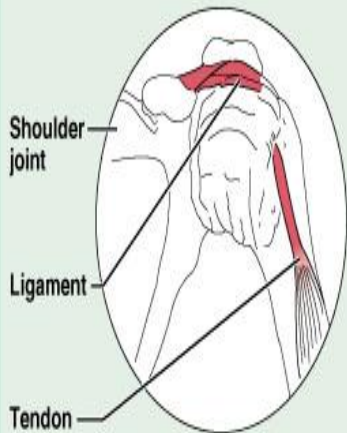
# connective tissue contains **densely packed collagen fibers** that show a regular and parallel arrangement

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

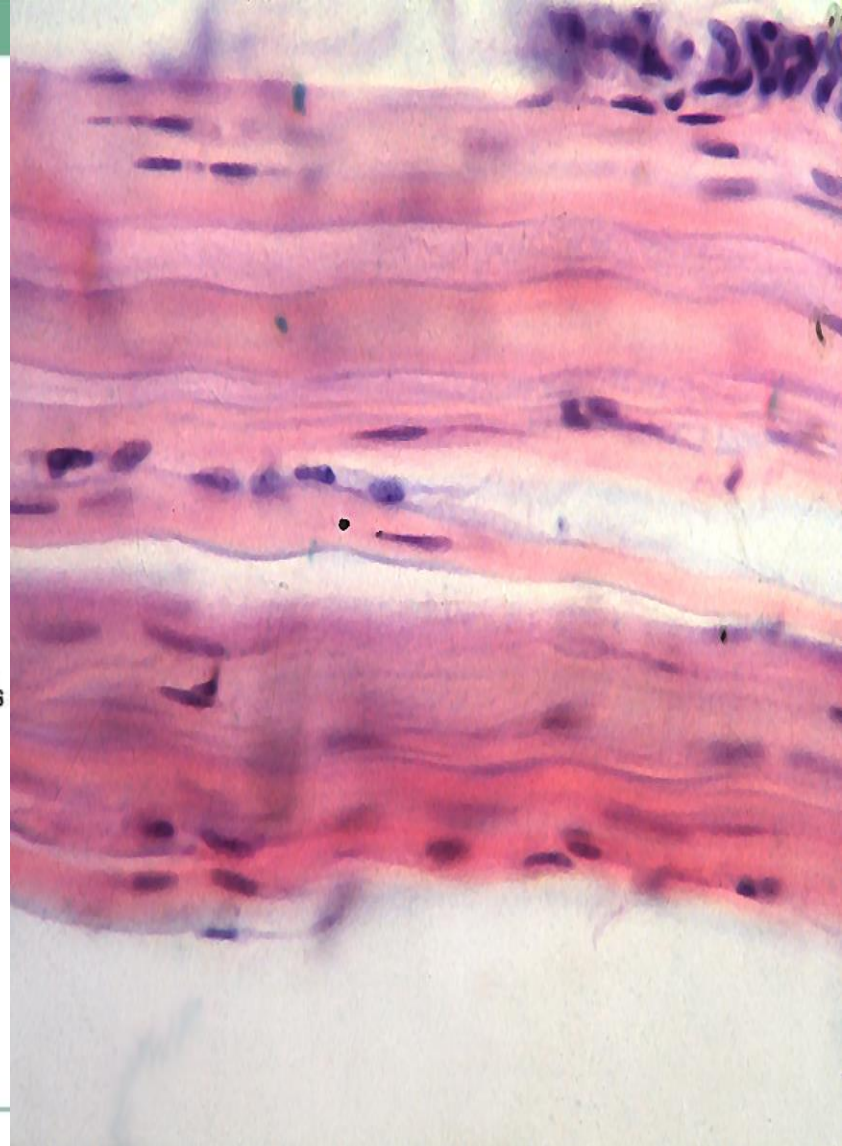
**Description:** Primarily parallel collagen fibers; a few elastin fibers; major cell type is the fibroblast.

**Function:** Attaches muscles to bones or to muscles; attaches bones to bones; withstands great tensile stress when pulling force is applied in one direction.

**Location:** Tendons, most ligaments, aponeuroses.



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





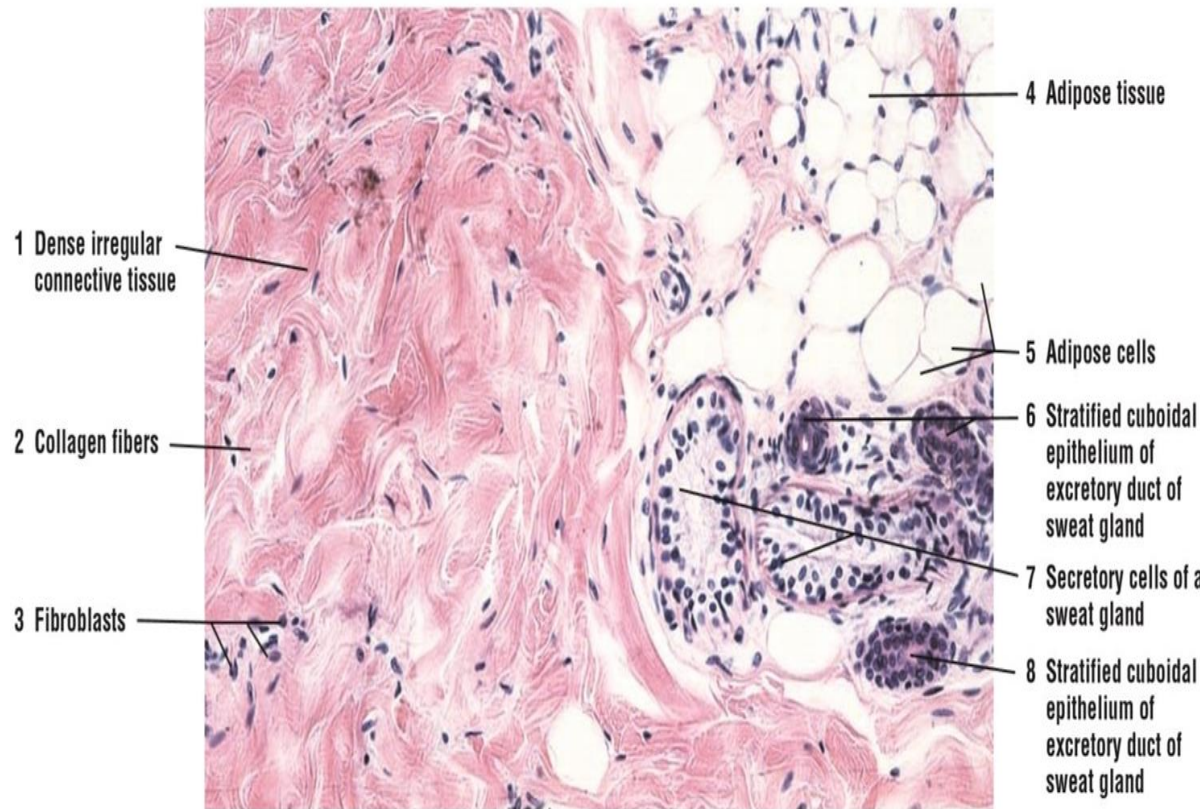
## Tendonitis

characterized by inflammation of the tendons and their attachments to muscle. Common locations are the **elbow**, the **achilles** tendon of the **heel**, and the **shoulder rotator cuff**. The swelling and pain produced by the localized inflammation



# Dense irregular connective tissue

consists of mostly **collagen fibers**. It has **less ground substance** than loose connective tissue. **Fibroblasts** are the **predominant cell**, scattered **irregularly across** the tissue contains thicker and densely **packed collagen fibers**, with fewer cell types. The collagen fibers in dense irregular connective tissue **show random orientation and provide strong tissue support found in (dermis), capsules of different organs, and in areas that need strong support.**



**FIGURE 3.7** ■ Dense irregular connective tissue and adipose tissue. Stain: hematoxylin and eosin.  $\times 64$ .



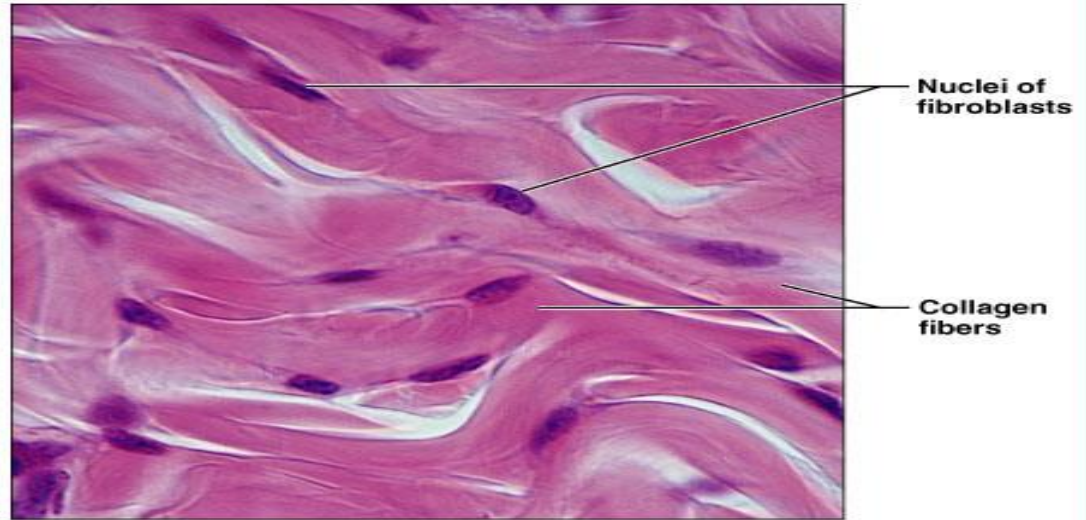
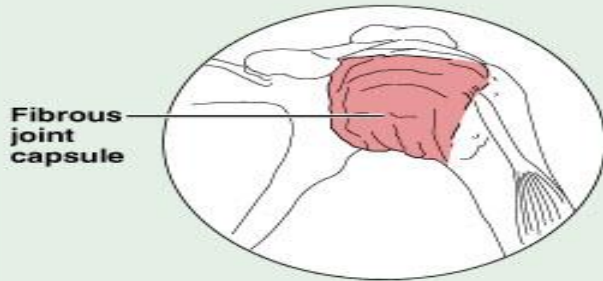


**(f) Connective tissue proper: dense connective tissue, dense irregular**

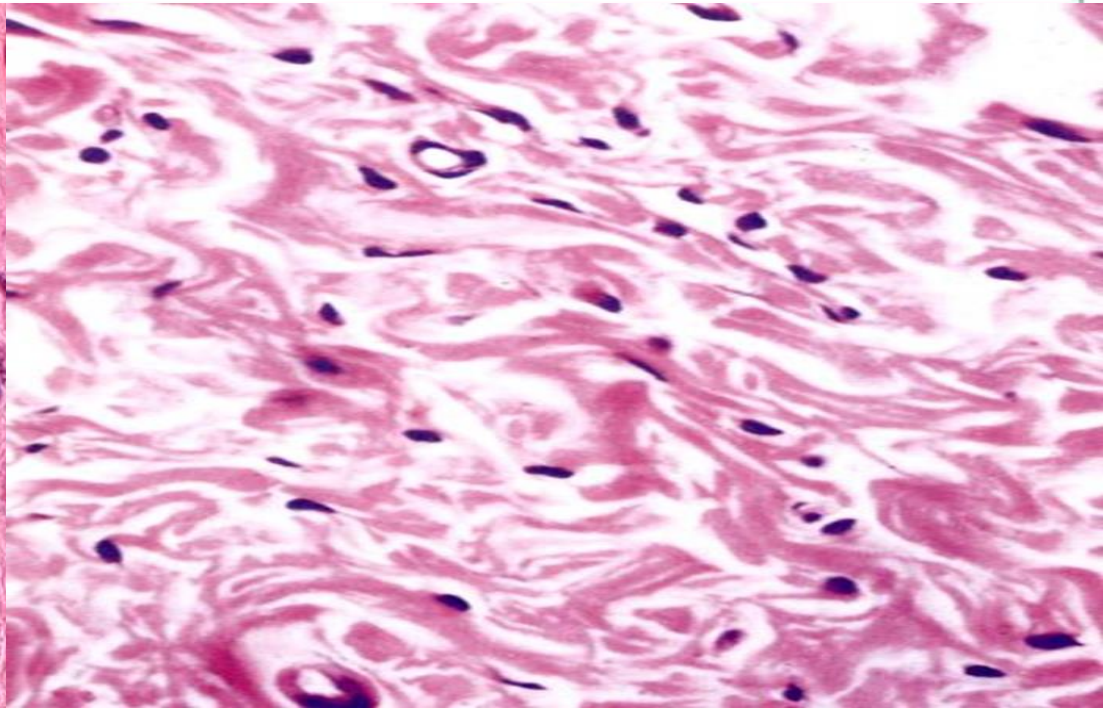
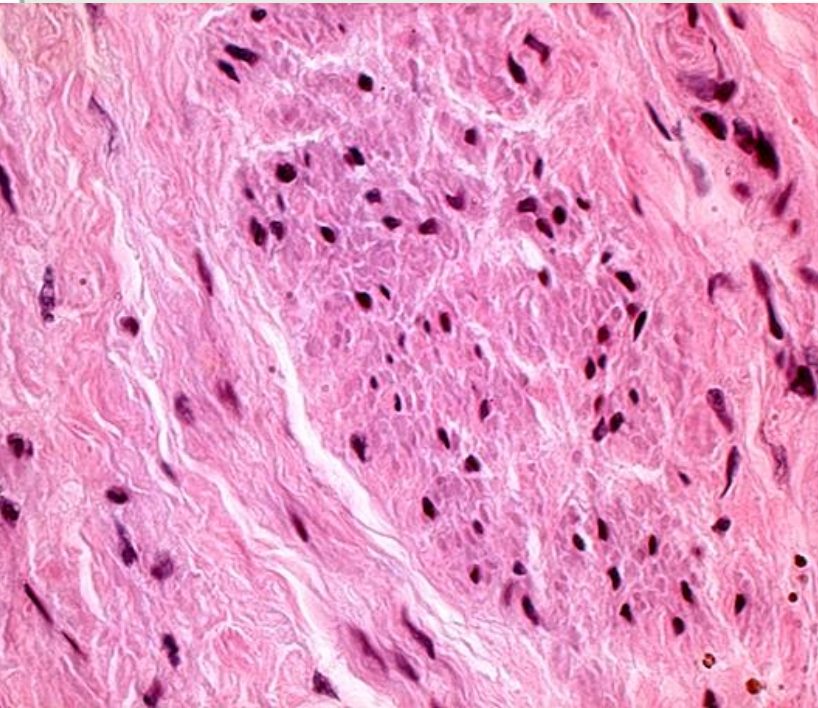
**Description:** Primarily irregularly arranged collagen fibers; some elastic fibers; major cell type is the fibroblast.

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

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



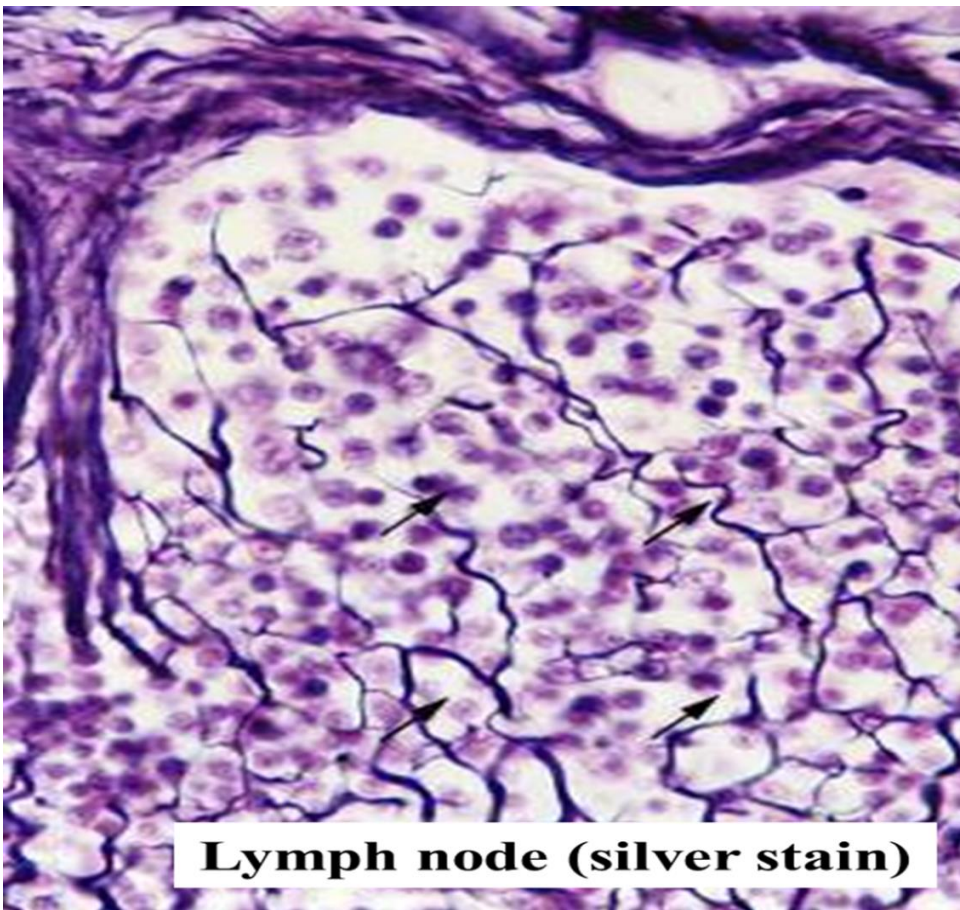
**Photomicrograph:** Dense irregular connective tissue from the dermis of the skin (400 $\times$ ).





**RETICULAR CONNECTIVE TISSUE:** Consist **mainly of type III collagen**, are thin and a **delicate framework in the liver, lymph nodes, spleen, hemopoietic organs**, and other locations where blood and lymph are filtered. **Reticular fibers** are not unique to reticular connective tissue. These fibers become visible only **when the tissue or organ is stained with silver stain** (special stain).

**ELASTIC CONNECTIVE TISSUE:** consists of **fibroblasts** and densely **compacted parallel bundles mainly of elastic fibers**, with a minor component of **collagen fibers**. It is found wherever a **strong, elastic tissue is needed**, such as in **the walls of large, elastic arteries**.



**Lymph node (silver stain)**

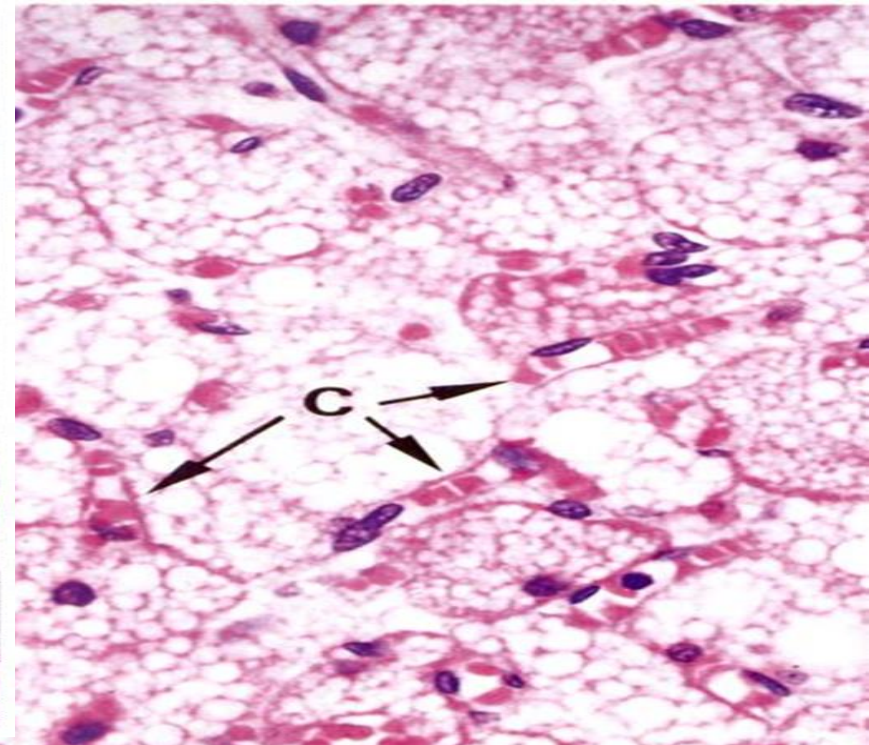
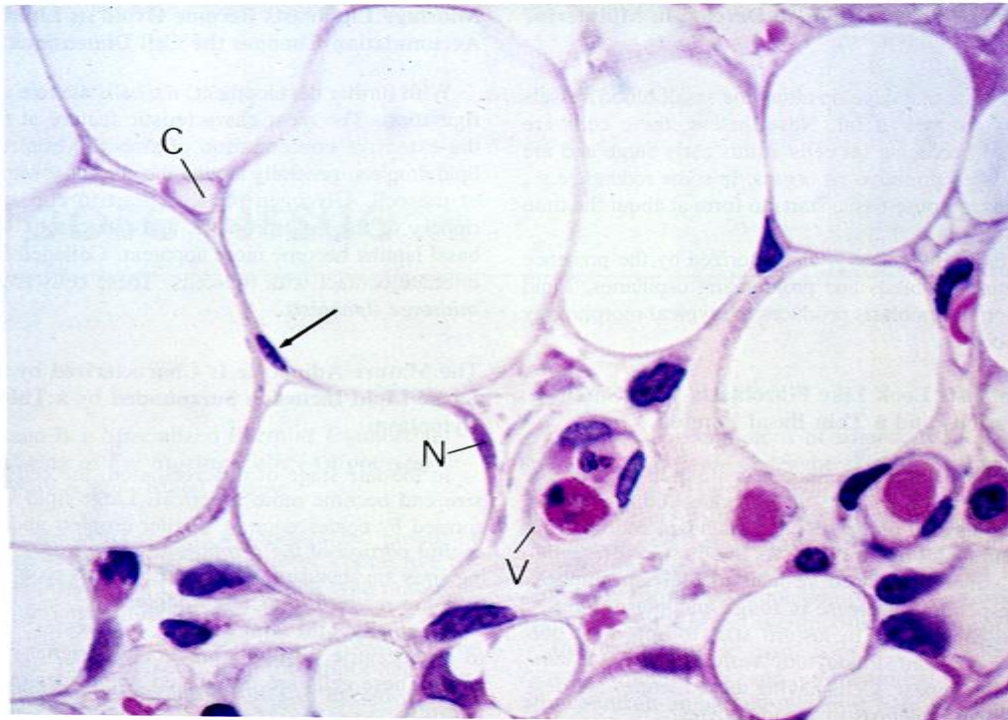




**Adipose tissue** is commonly known as **body fat**. It is found all over the body. It can be found under the skin (subcutaneous fat), **packed around internal organs** (visceral fat), between muscles, within bone marrow, and in breast tissue. **Adipose tissue can be classified** into two types, **white adipose tissue (WAT)** and **Brown adipose tissue (BAT)**, which are visibly distinguishable based on tissue color.

**The main function of white adipocytes** is to store excess energy in the form of fatty molecules, mainly triglycerides. Also provides insulation under the skin and forms cushioning **fat pads** around different organs.

**Brown Adipose tissue** Cells smaller than white adipose cells; store lipid as multiple droplets  
**In newborns, generates body heat** , Norepinephrine from sympathetic nervous system promotes hydrolysis of lipids



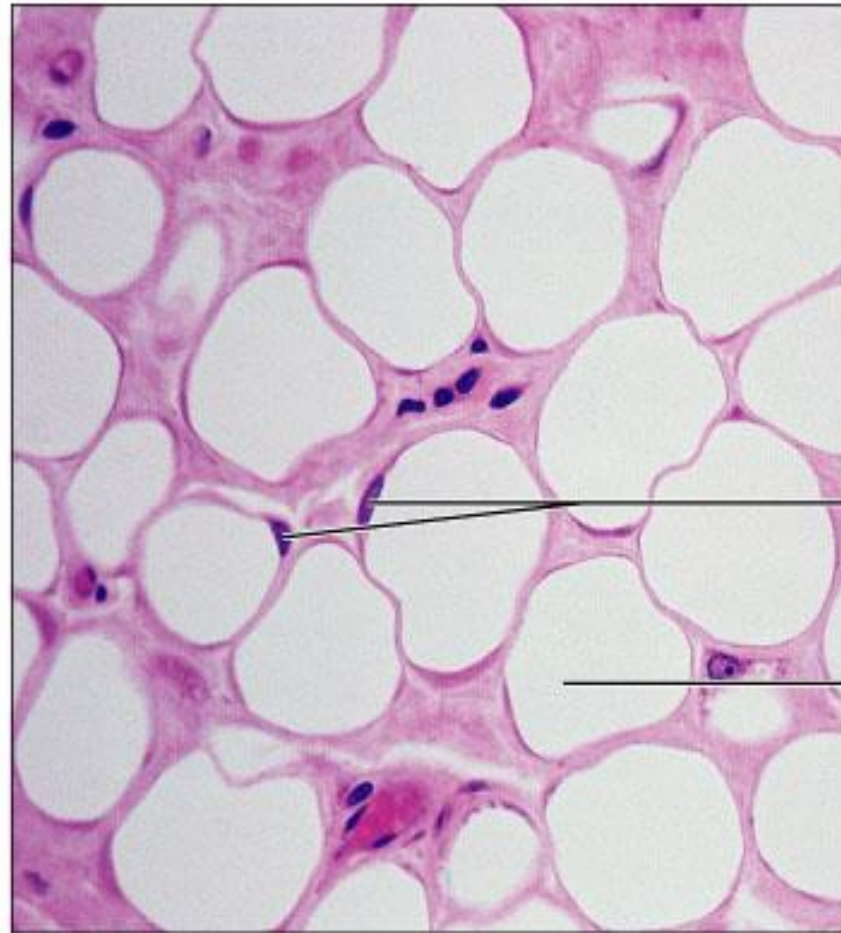
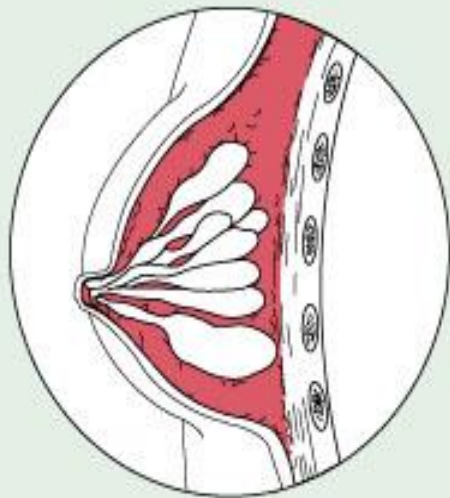


**(c) Connective tissue proper: loose connective tissue, adipose**

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

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

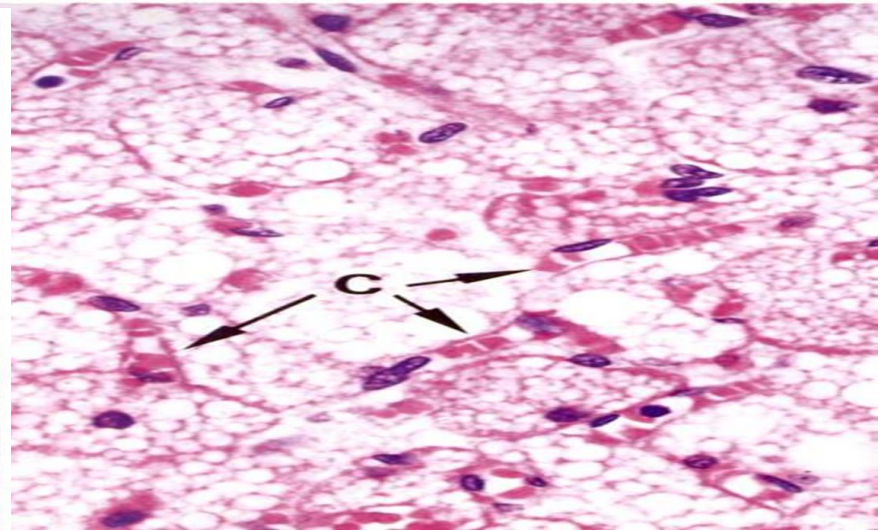
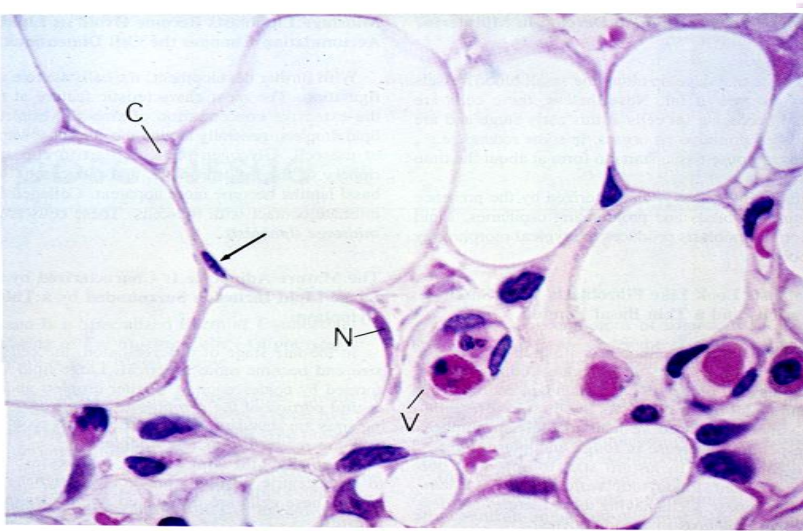
**Location:** Under skin; around kidneys and eyeballs; within abdomen; in breasts.



Nuclei of fat cells

Vacuole containing fat droplet

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



### UNILOCULAR ADIPOSE TISSUE

Unilocular adipose tissue is the adipose tissue where a majority of the cell cytoplasm is occupied by a very large lipid droplet

Common type of adipose tissue

Yellow adipose tissue

Contain one large central droplet of yellow fat in the cytoplasm

Store energy and release hormones and proteins

### MULTILOCULAR ADIPOSE TISSUE

Multilocular adipose tissue is the adipose tissue composed of cells that contain numerous lipid droplets and abundant brown mitochondria

Less common

Brown adipose tissue

Contain numerous lipid droplets and abundant mitochondria in the cytoplasm

Produce heat by non-shivering thermogenesis



Thank you for listening