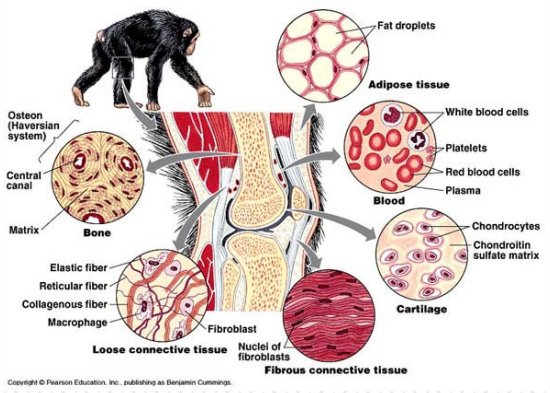
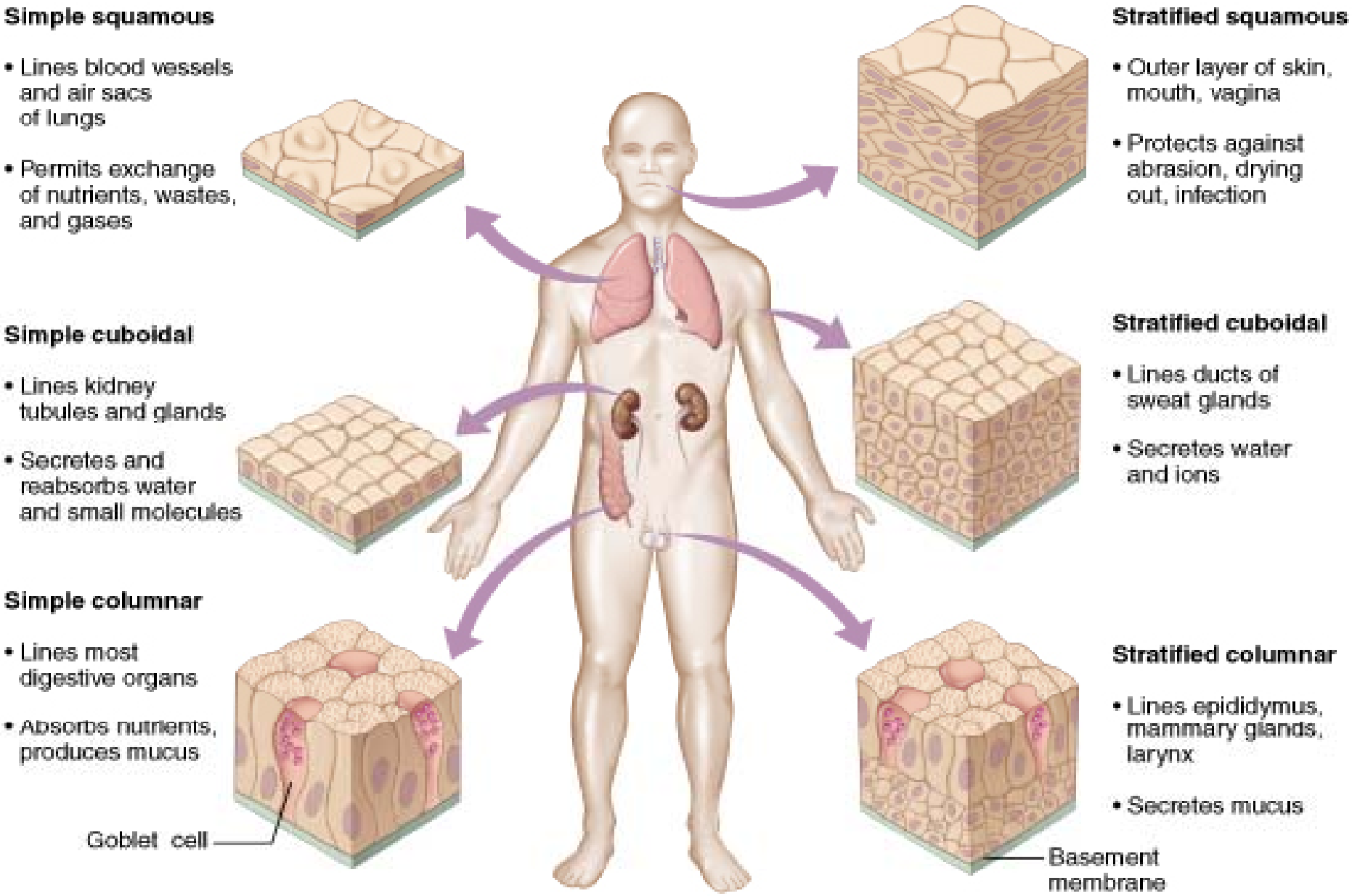
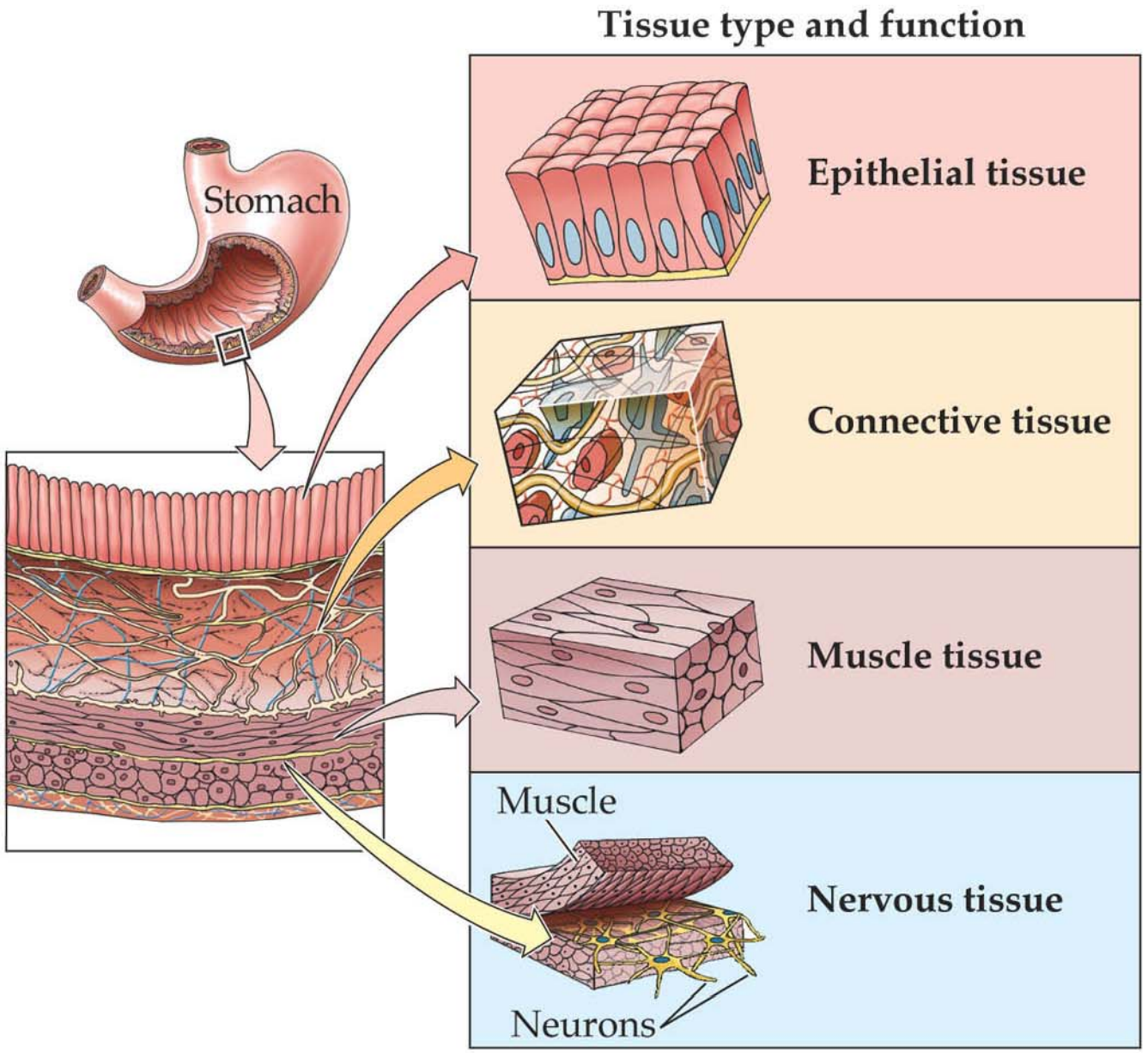
CONNECTIVE TISSUES

DANIL HAMMOUDI. MD

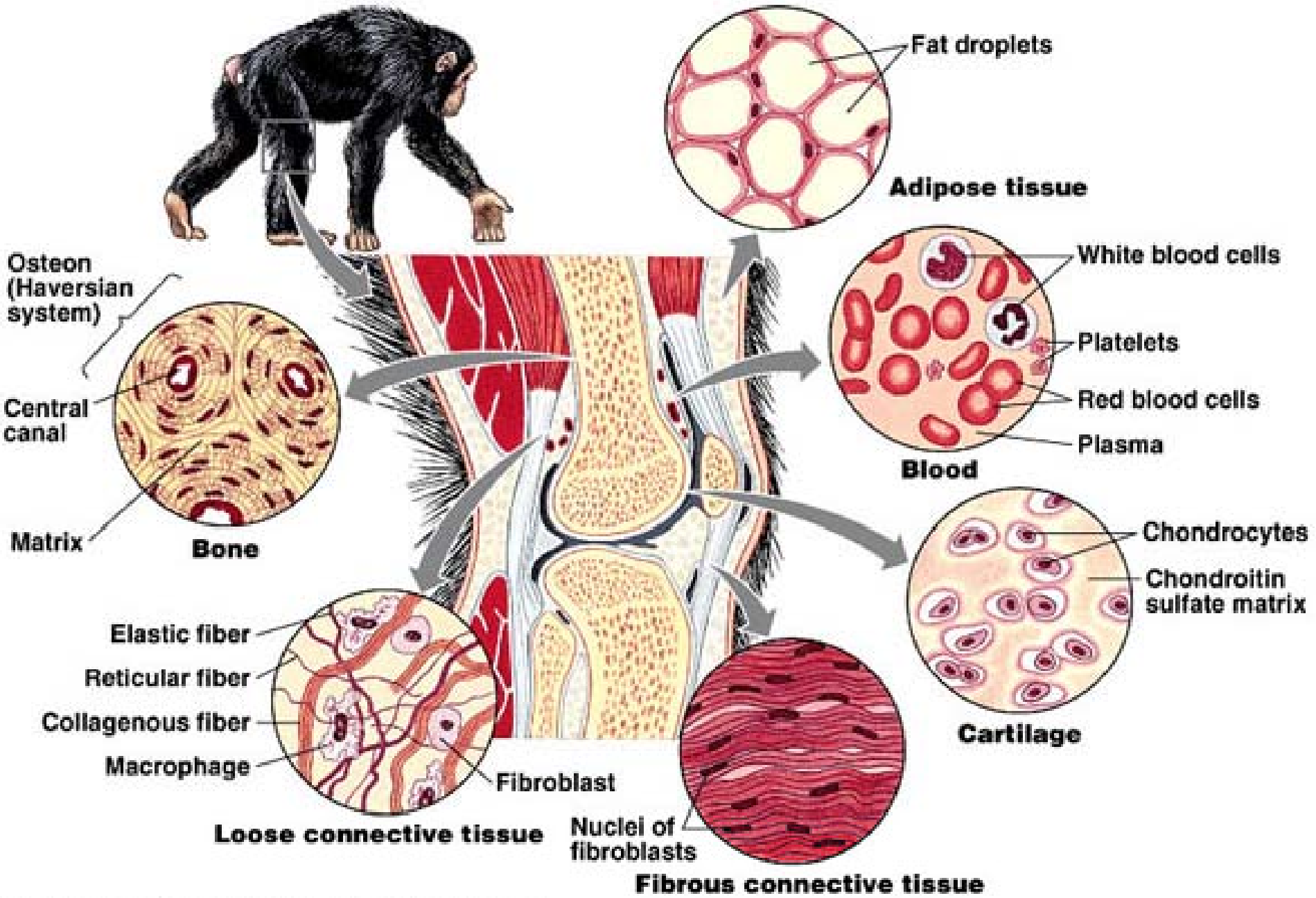




(a) Most epithelial tissues line or cover surfaces or body cavities



LIFE: THE SCIENCE OF BIOLOGY, Seventh Edition, **Figure 41.2 Four Types of Tissue**



Supporting Connective Tissues

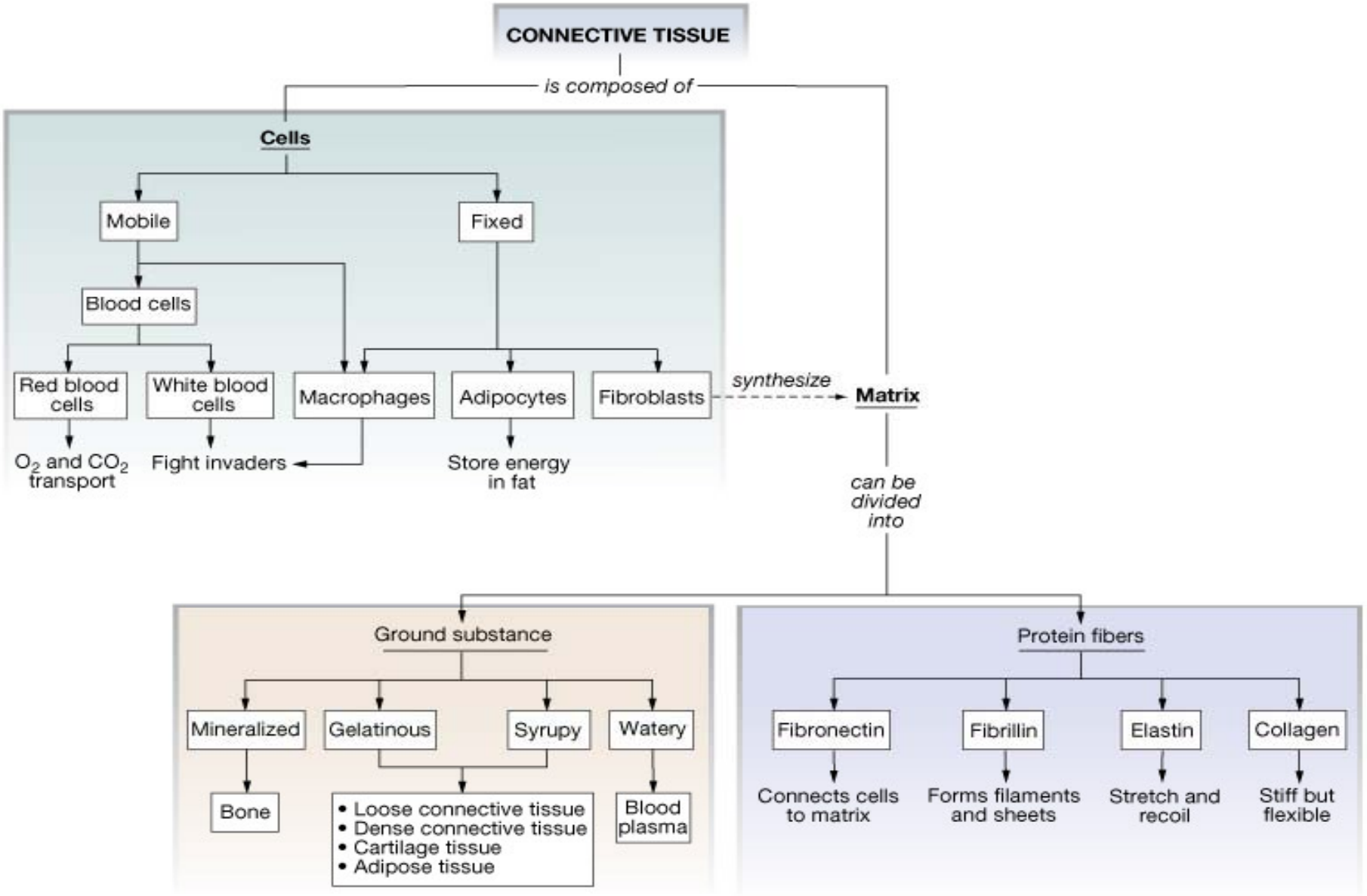


Table 4.8	Connective Tissue Proper		
Type	**Structure**	**Function**	**Location**
Loose Connective Tissue	Relatively fewer cells and fibers than in dense connective tissue; fibers are loosely arranged	Cushioning of organs; packing around organs	Surrounding vessels; in spleen and liver; in subcutaneous layer
Areolar (loose) connective tissue	Fibroblasts; lesser amounts of collagen and elastic fibers; viscous ground substance	Binds and packs around organs	Surrounding nerves, vessels; forming subcutaneous layer
Adipose tissue	Adipocytes	Protects; stores fat; insulates	Subcutaneous layer; surrounding kidney and selected other organs
Reticular connective tissue	Stroma of reticular fibers	Forms stroma of lymphatic organs	Stroma of spleen, liver, lymph nodes, bone marrow
Dense Connective Tissue	Higher proportion of fibers to ground substance; protein fibers densely packed together	Provides strength and support	Fibrous capsules; tendons, ligaments, dermis
Dense regular connective tissue	Densely packed collagen fibers are parallel to direction of stress	Provides strength and flexibility	Tendons and ligaments
Dense irregular connective tissue	Densely packed collagen fibers are interwoven; fibers are irregularly clumped together	Provides tensile strength in all directions	Dermis; capsules of organs
Elastic connective tissue	Elastic and collagen fibers are arranged irregularly	Provides framework and supports organs	Walls of large arteries

CONNECTIVE TISSUE

Connective tissues are broadly classified into three large groups:

Fluid connective tissue types, of which there are only two, are important in transport and body defense

Connective Tissue Category	*Tissue Types*
1. Fluid Connective Tissues	Blood and Lymph
2. Connective Tissue Proper	Loose and Dense Connective Tissues
3. Supportive Connective Tissues	Cartilage and Bone

CONNECTIVE TISSUE

•Connective tissue is responsible for providing structural support for the tissues and organs of the body.

• It is the most diverse tissue.

•Connective Tissue (CT) is found throughout the body.

• In fact the whole framework of the skeleton and the different specialized connective tissues from the crown of the head to the toes determine the form of the body and act as an entity.

•This mechanfunction is important in maintaining the form of the body, organs and tissues.

The tissue derives its name from its function in connecting or binding cells and tissues.

Connective tissue is composed of:

- **Cells**
- **fibers**
- **extracellular matrix**.

Structural Elements of Connective Tissue

- **Ground substance – unstructured material that fills the space between cells**
- **Fibers – collagen, elastic, or reticular**
- **Cells – fibroblasts, chondroblasts, osteoblasts, and hematopoietic stem cells**

Fibroblasts are the cells responsible for the production of connective tissue

Ground Substance

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

Functions of Connective Tissue

- **Binding and support .Connection of body tissues**
- **Protection**
- **Insulation, Storage of energy**
- **Transportation**
- **Providing structural framework for the body**

The **extracellular matrix** is composed of :

- **protein fibers** (collagen fibers, reticular fibers, elastic fibers)
- **amorphous ground substance**
- **tissue fluid** (not preserved in histological preparations).

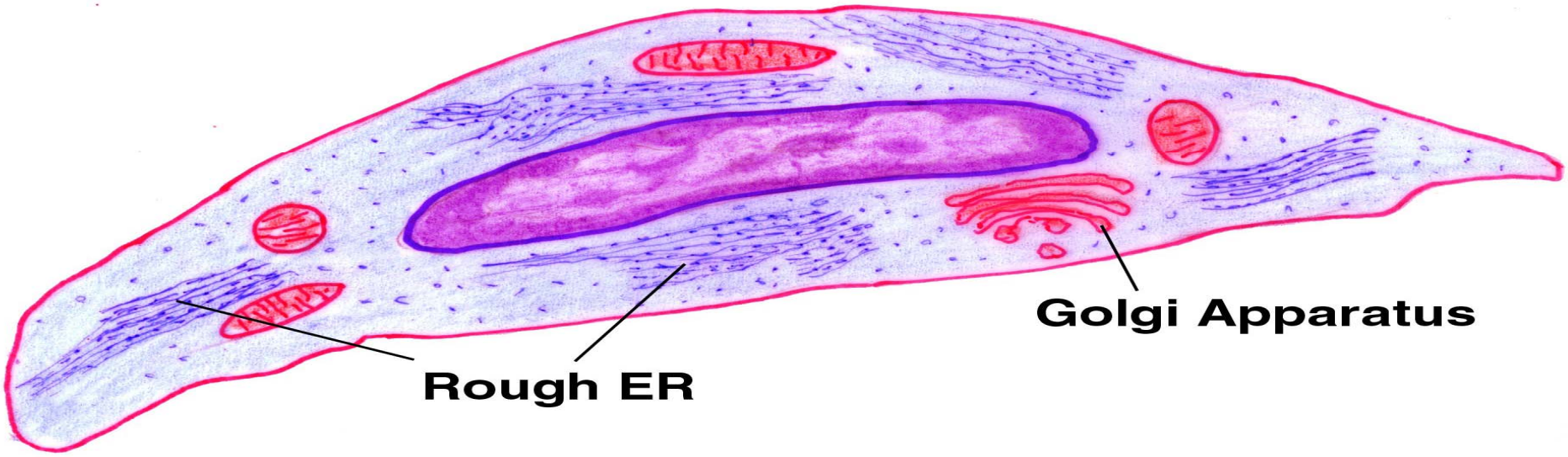
- The amount of tissue fluid is fairly constant and there is an equilibrium between the water entering and leaving the intercellular substance of the connective tissue.

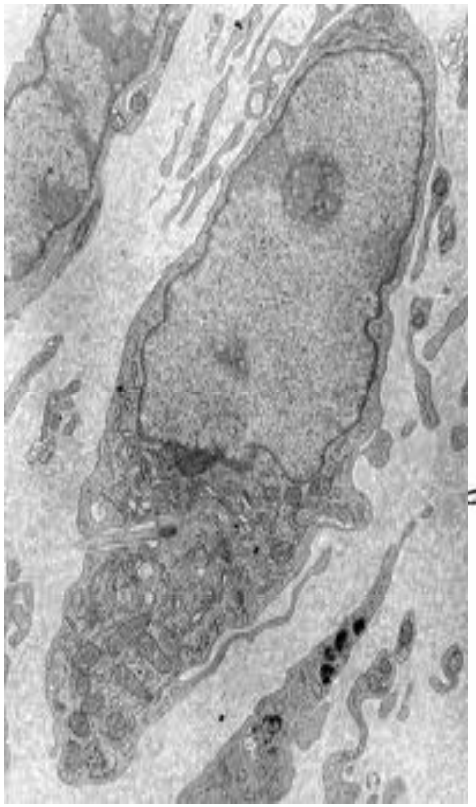
- In pathological conditions (traumatic injury, inflammation) fluid may accumulate in the connective tissue, a condition known as edema.

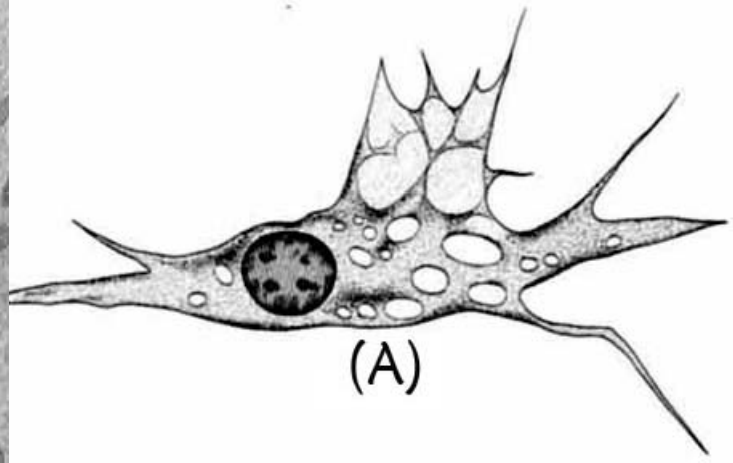
Cell type	Chief function
Mesenchyme	Embryonic source of all connective tissue cells
Fibroblasts **Chondroblasts** **Osteoblasts**	Structural support
Plasma cells **Lymphocytes** **Neutrophils** **Eosinophils** **Basophils** **Mast cells** **Macrophages**	Defense and immune
Adipocytes	Metabolic Energy storage Thermal insulation

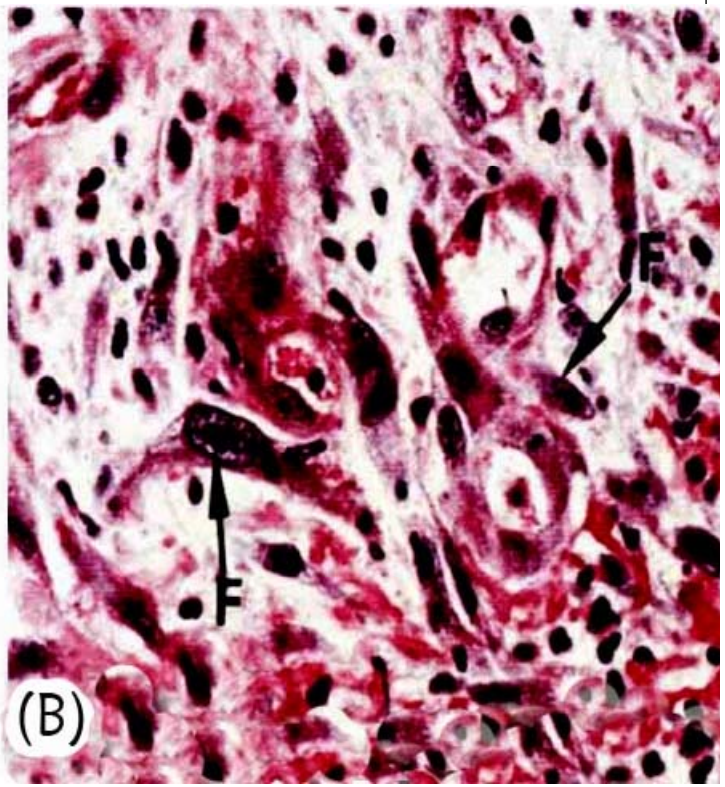
Common embryonic origin:	**Mesenchyme**			
Cellular descendants:	**Fibroblast**	**Chondroblast**	**Osteoblast**	**Hematopoietic stem cell**
	Fibrocyte 	**Chondrocyte** 	**Osteocyte** 	**Blood cells* (and macrophages)** 
Class of connective tissue resulting:	**Connective tissue proper**	**Cartilage**	**Osseous (bone)**	**Blood**
Subclasses:	**1.** Loose connective tissue Types: Areolar, Adipose, Reticular **2.** Dense connective tissue Types: Regular, Irregular, Elastic	**1.** Hyaline cartilage **2.** Fibrocartilage **3.** Elastic cartilage	**1.** Compact bone **2.** Spongy (cancellous) bone	** Blood cell formation and differentiation are quite complex. Details are provided in Chapter 17.*
Matrix components:	Gel-like ground substance; all three fiber types	Gel-like ground substance; collagen fibers, elastin fibers in some	Gel-like ground substance hardened with calcium salts; collagen fibers	Liquid plasma; no fibers
General function:	Acts as a binding tissue; resists mechanical stress, particularly tension	Resists compression; cushions and supports body structures	Rigidness that resists compression and tension; support	Fluid tissue; transports oxygen, carbon dioxide, nutrients, hormones, wastes


NIH/3T3 Mouse Embryo
Fibroblast


Golgi Apparatus
Rough ER



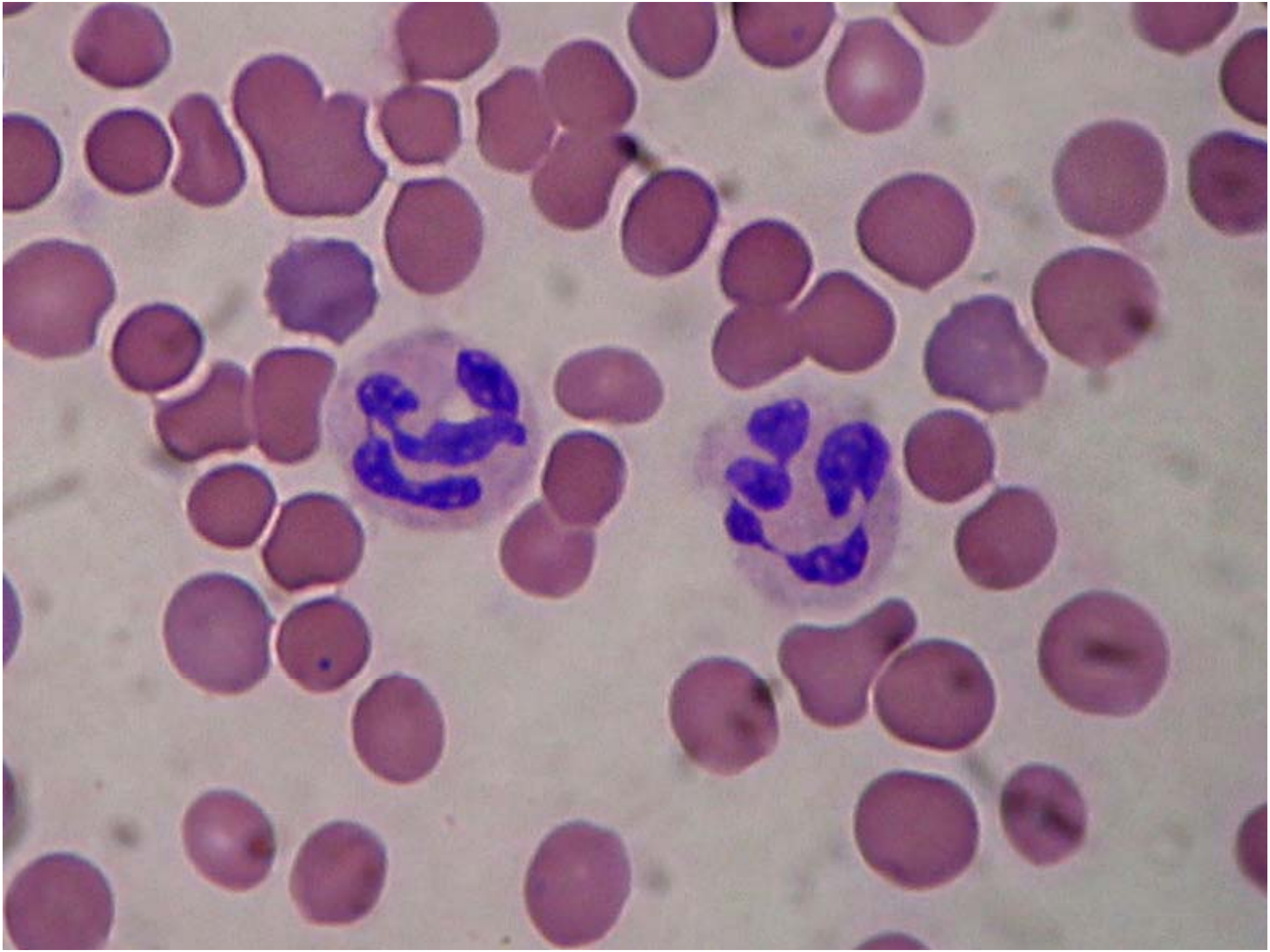

(A)

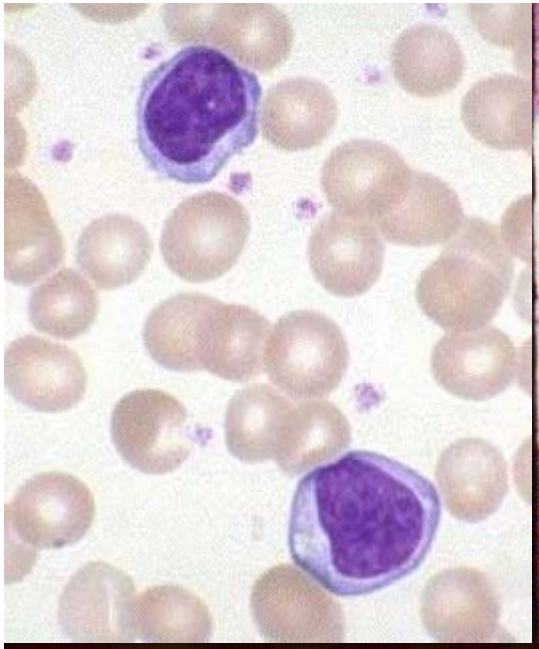

F
F
(B)

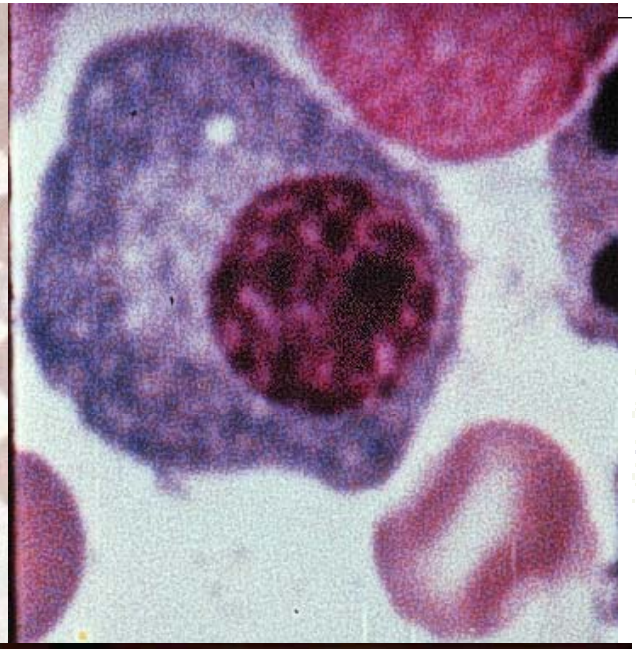
Leucocytes in situ

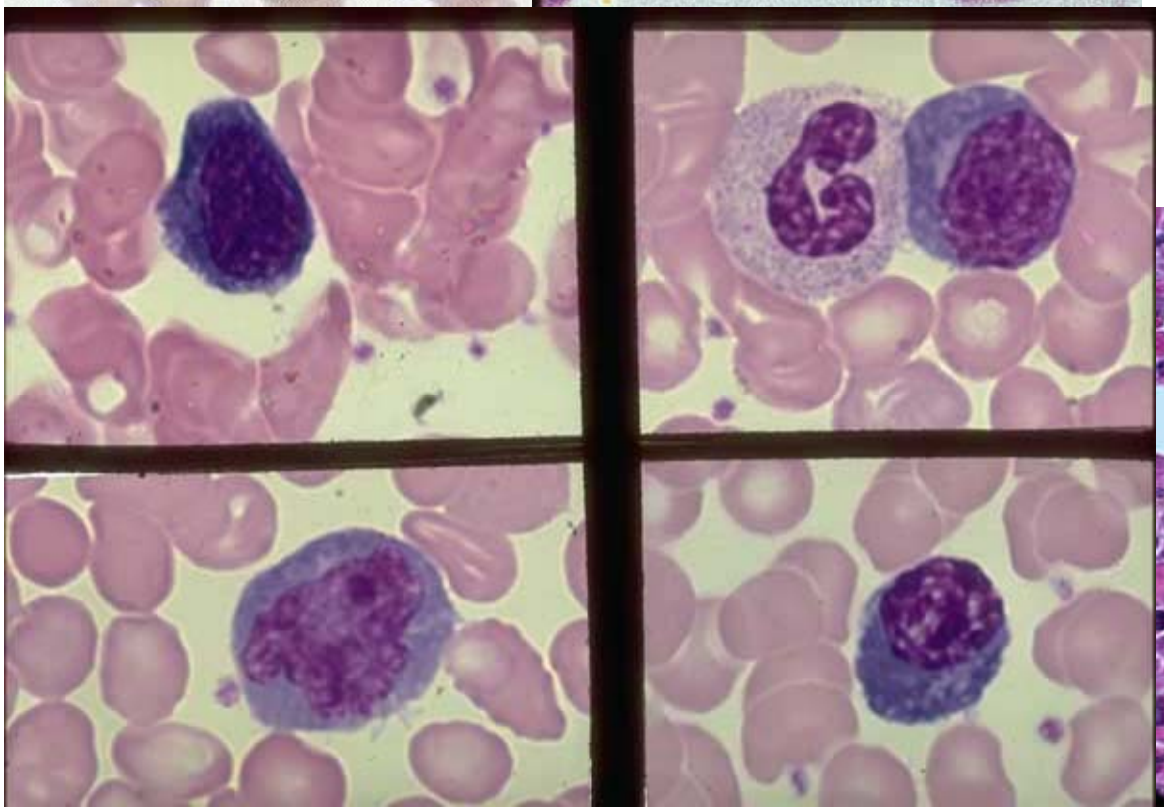
•Neutrophils : rare; multilobed nuclei poorly stained cytoplasm
•Eosinophils : abundant in loose ct; bilobed nuclei strongly eosinophilic cytoplasmic granules
•Basophils : resemble mast cells; poorly stained in H&E
•Monocytes = phagocytes = macrophages, fixed macrophages, histiocytes
- •nuclei irregular; heterochromatin clumped around envelope.
- residual bodies may be exocytized or sequestered
- antigen presenting cells (APC) also called dendritic cells
- combined or coated with antibodies and complement: opsonins;
- opsonization: enhancement of phagocytosis
- •lymphokines: act to increase metabolic and phagocytic activity.

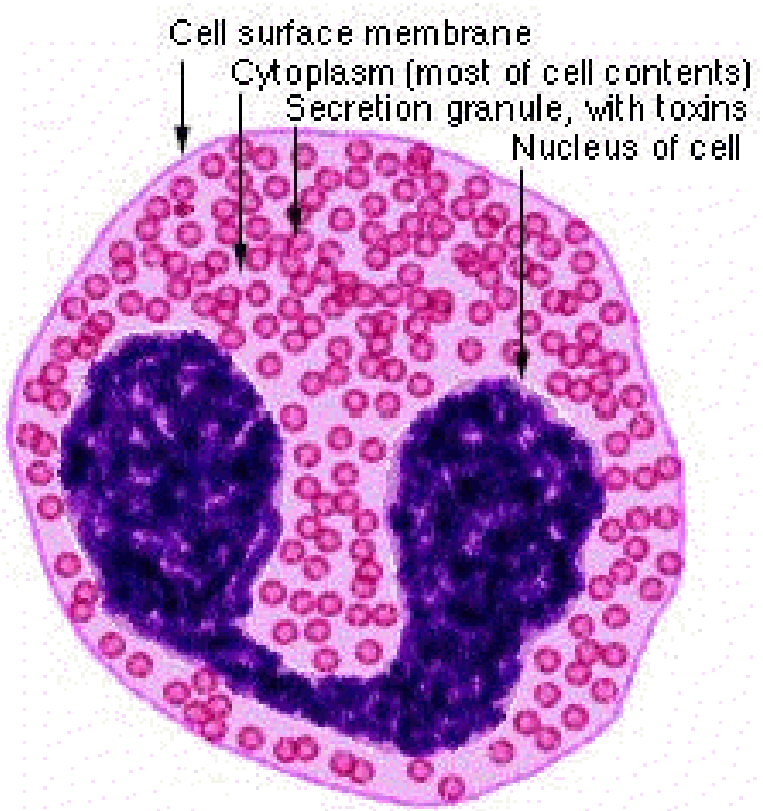
•Lymphocytes : small, densely-stained nuclei
•Plasma cells: synthesize antibodies; **clockface (cartwheel) nuclei; negatively stained golgi apparatus** (paranuclear); extensive basophilic cytoplasm
•Macrophages

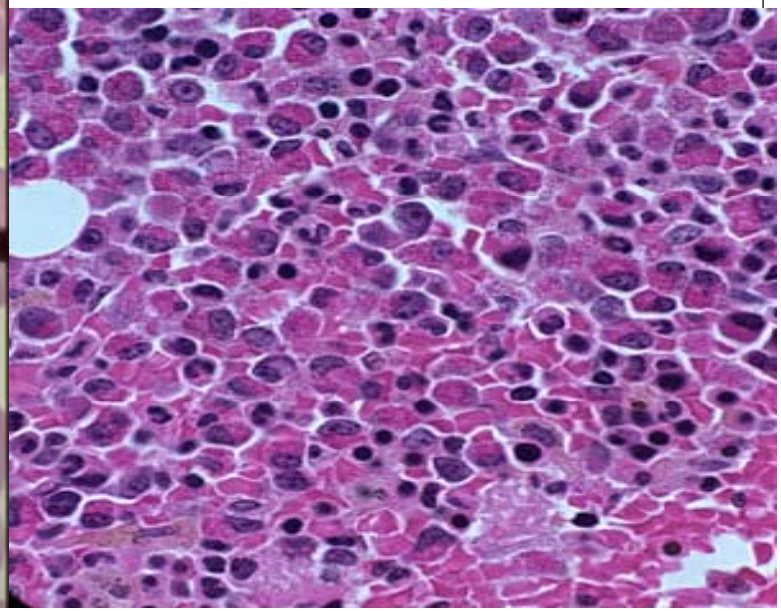









Cell surface membrane
Cytoplasm (most of cell contents)
Secretion granule, with toxins
Nucleus of cell

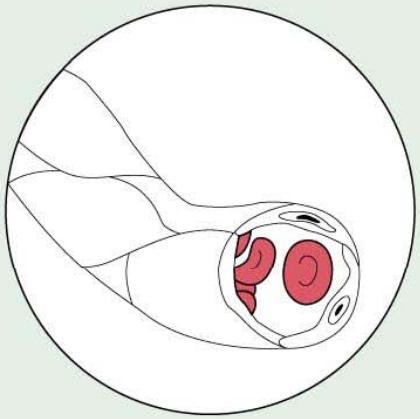


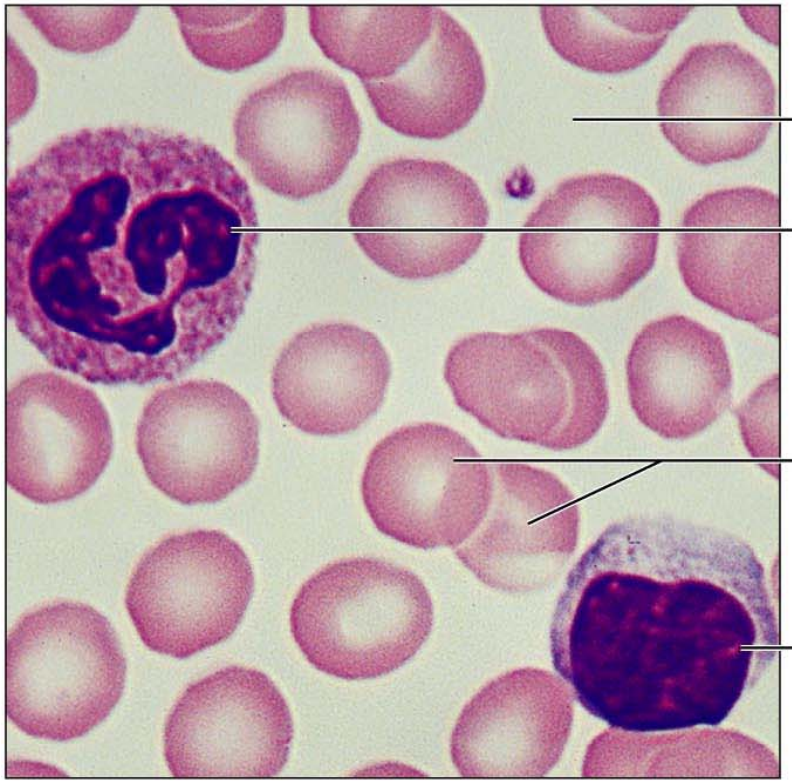
(j) Others: blood

Description: Red and white blood cells in a fluid matrix (plasma).

Function: Transport of respiratory gases, nutrients, wastes, and other substances.

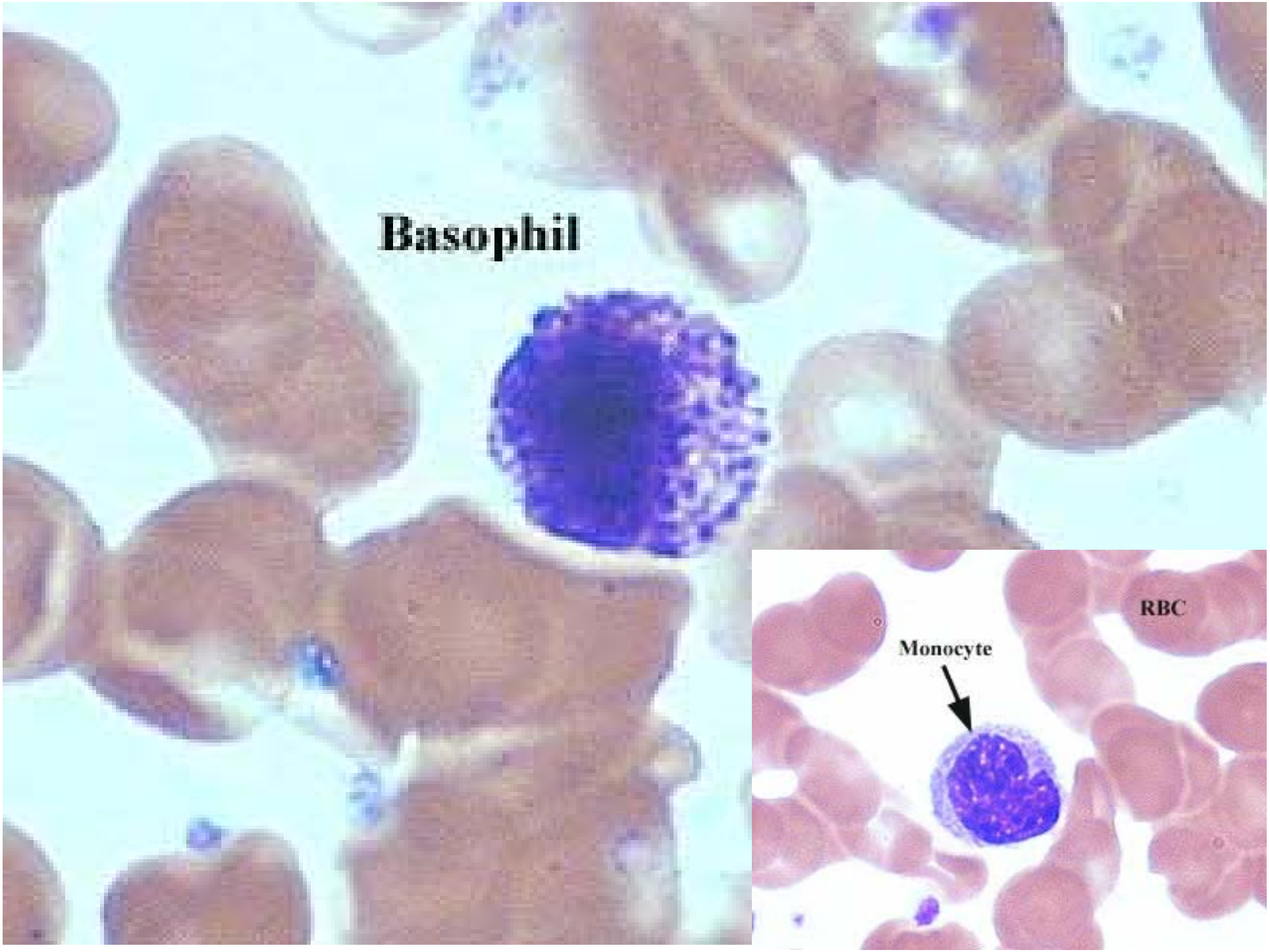
Location: Contained within blood vessels.





Photomicrograph: Smear of human blood (1500×); two white blood cells (neutrophil in upper left and lymphocyte in lower right) are seen surrounded by red blood cells.

Figure 4.9j


Basophil
RBC
Monocyte

Macrophages

•Macrophages show pronounced **phagocytotic activity**.

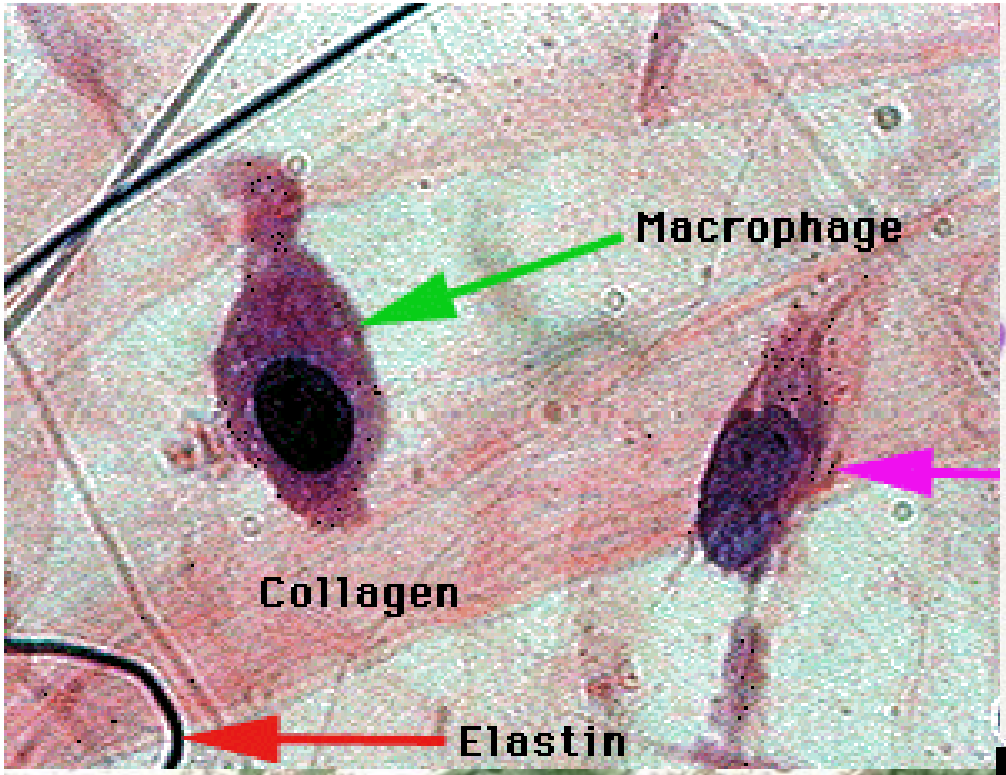
•Macrophages originate from monocytes (from precursor cells in bone marrow), which migrate to connective tissue and differentiate into tissue macrophages.

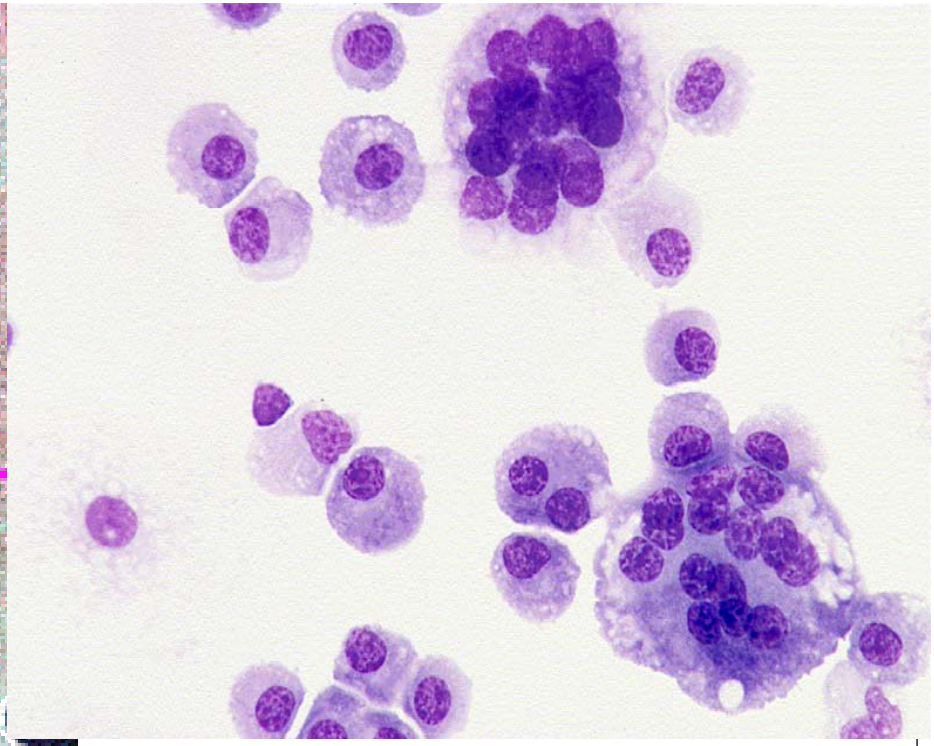
•Today the various macrophages of the body are grouped in a common system called the **Mononuclear Phagocyte System** (MPS).

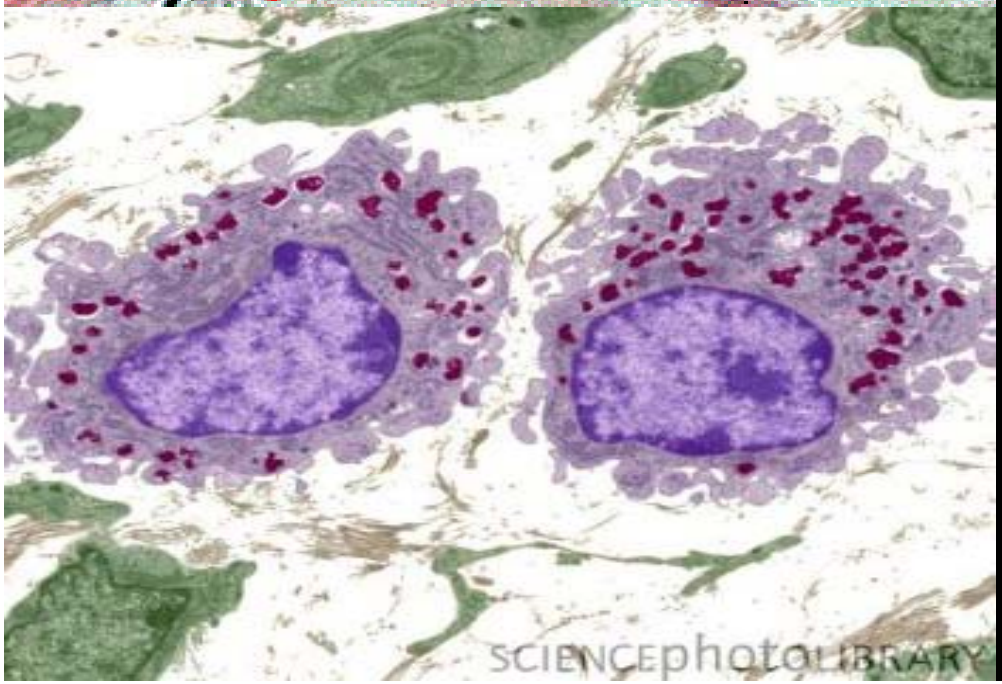
• Today a wide range of macrophages are included in the MPS and include : **Kupffer cells** of the liver, **alveolar macrophages** of the lung, **osteoclasts**, **microglia** etc.

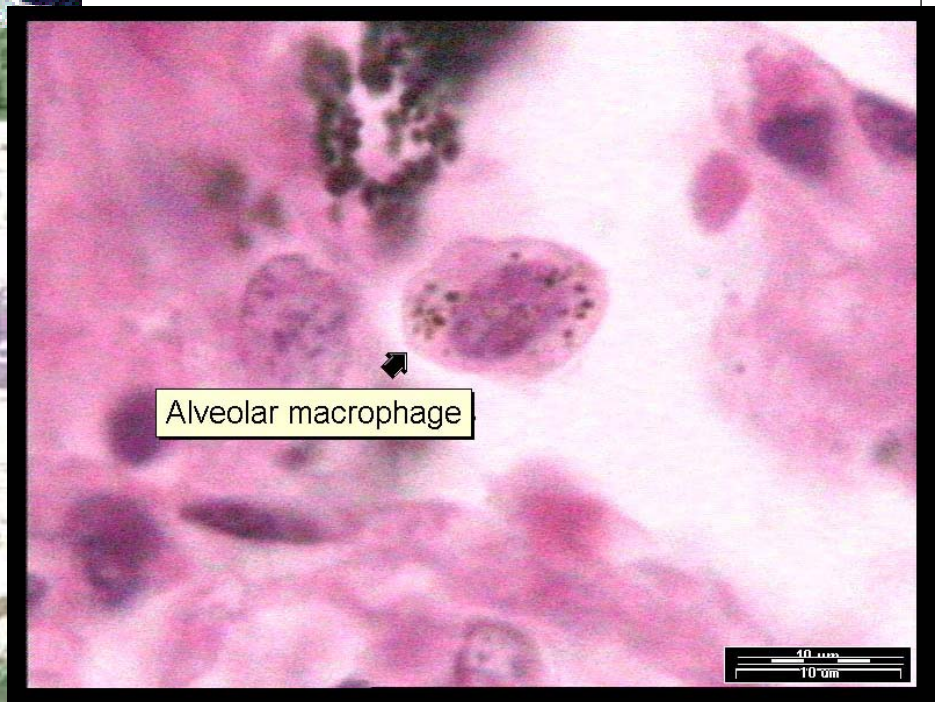
•The main functions of macrophages are ingestion by **phagocytosis** of microorganisms (bacteria, viruses, fungi), parasites, particulate matter such as dust, and they also participate in the breakdown of aged cells including erythrocytes. The **intracellular digestion** occurs as a result of fusion of **lysosomes** with the **phagosome** (ingested body).

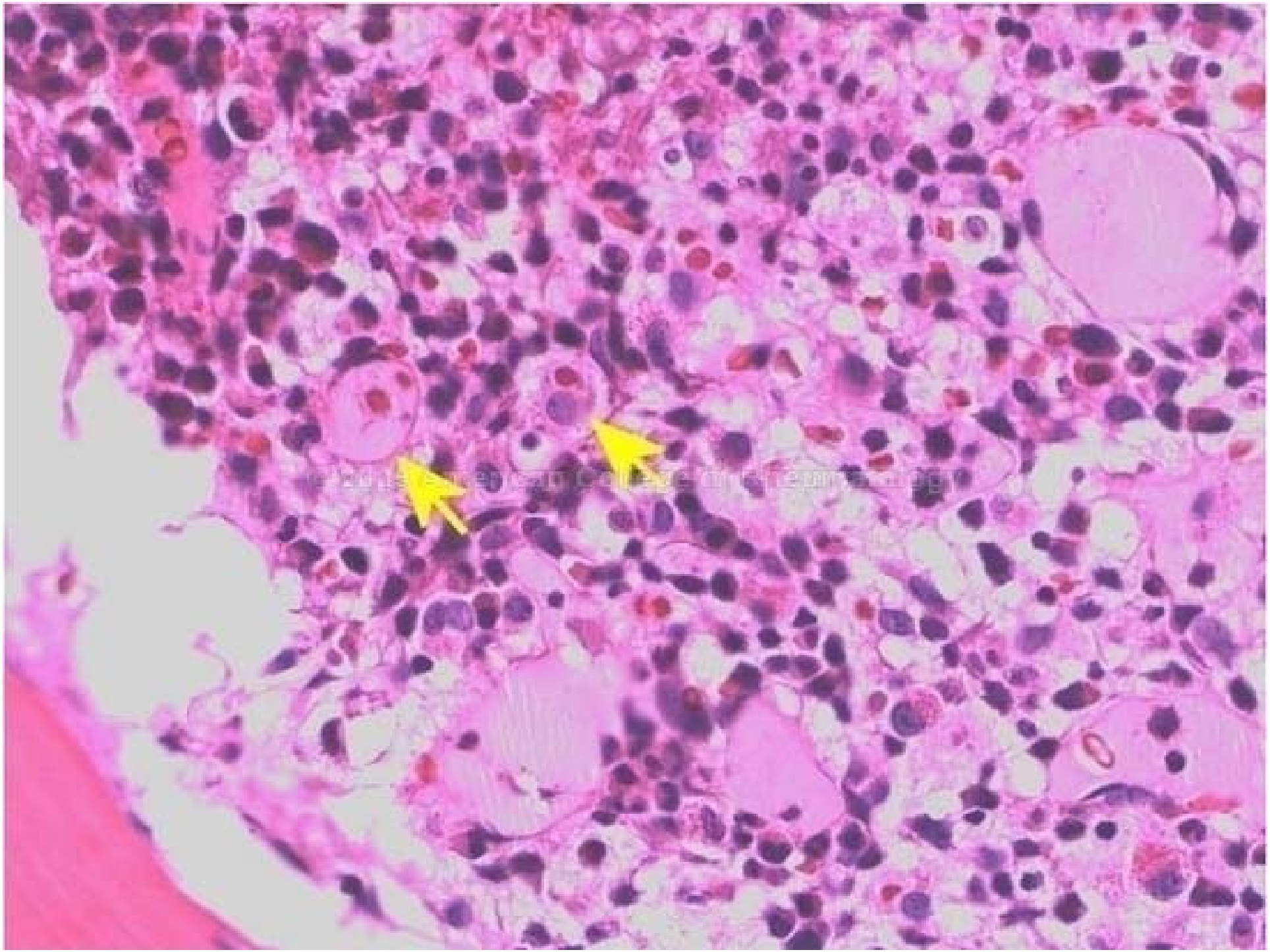
•Macrophages are normally long-lived and survive in the tissues for several months. In some cases where a foreign body (such as a small splinter) has penetrated the inner tissues of the body, several macrophages may fuse together to form multinuclear **foreign body giant cells**. These large cells accumulate at sites of invasion of the foreign body and sites of inflammation.

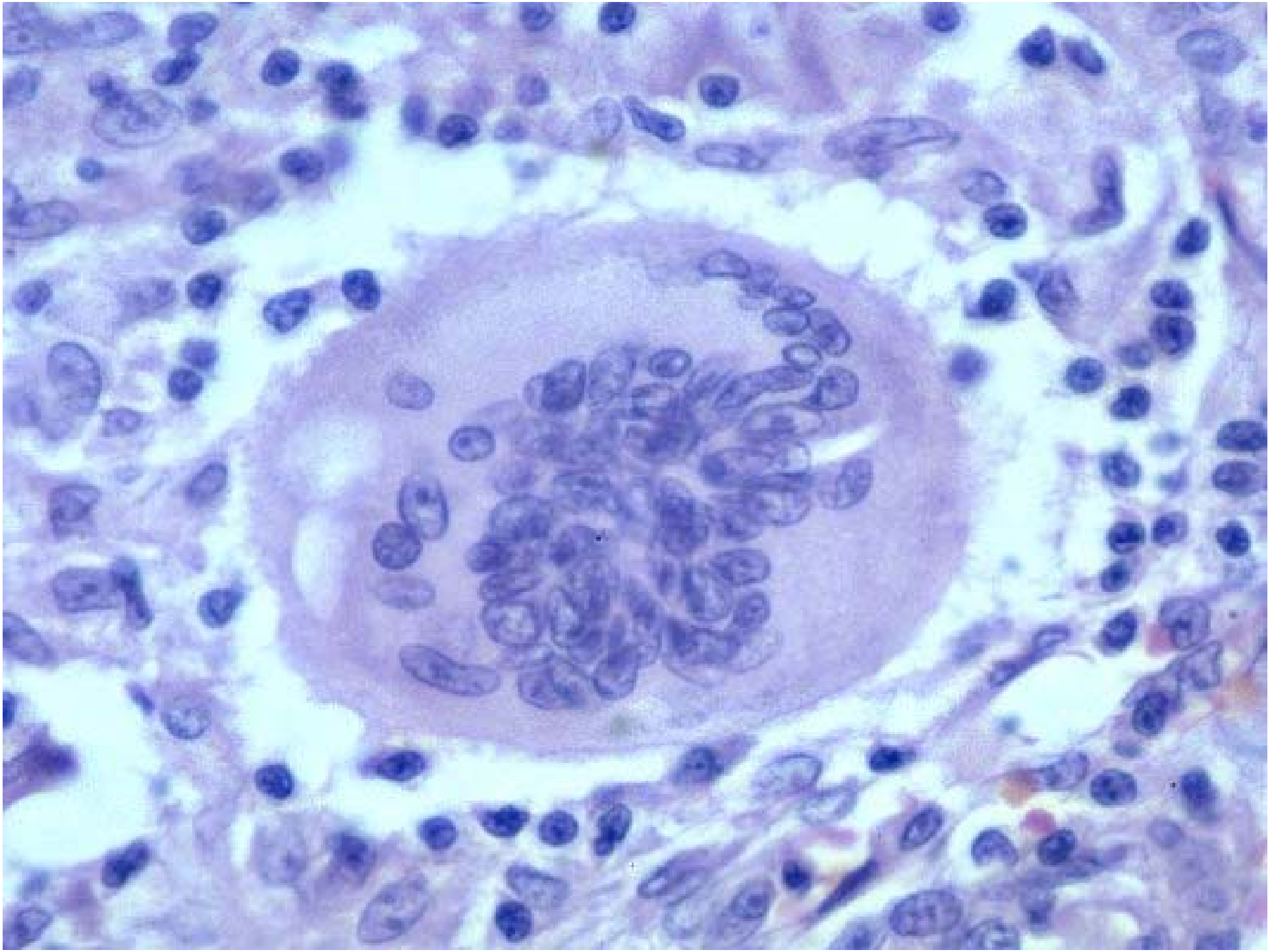

Macrophage
Collagen
Elastin




SCIENCEphotoLIBRARY


Alveolar macrophage





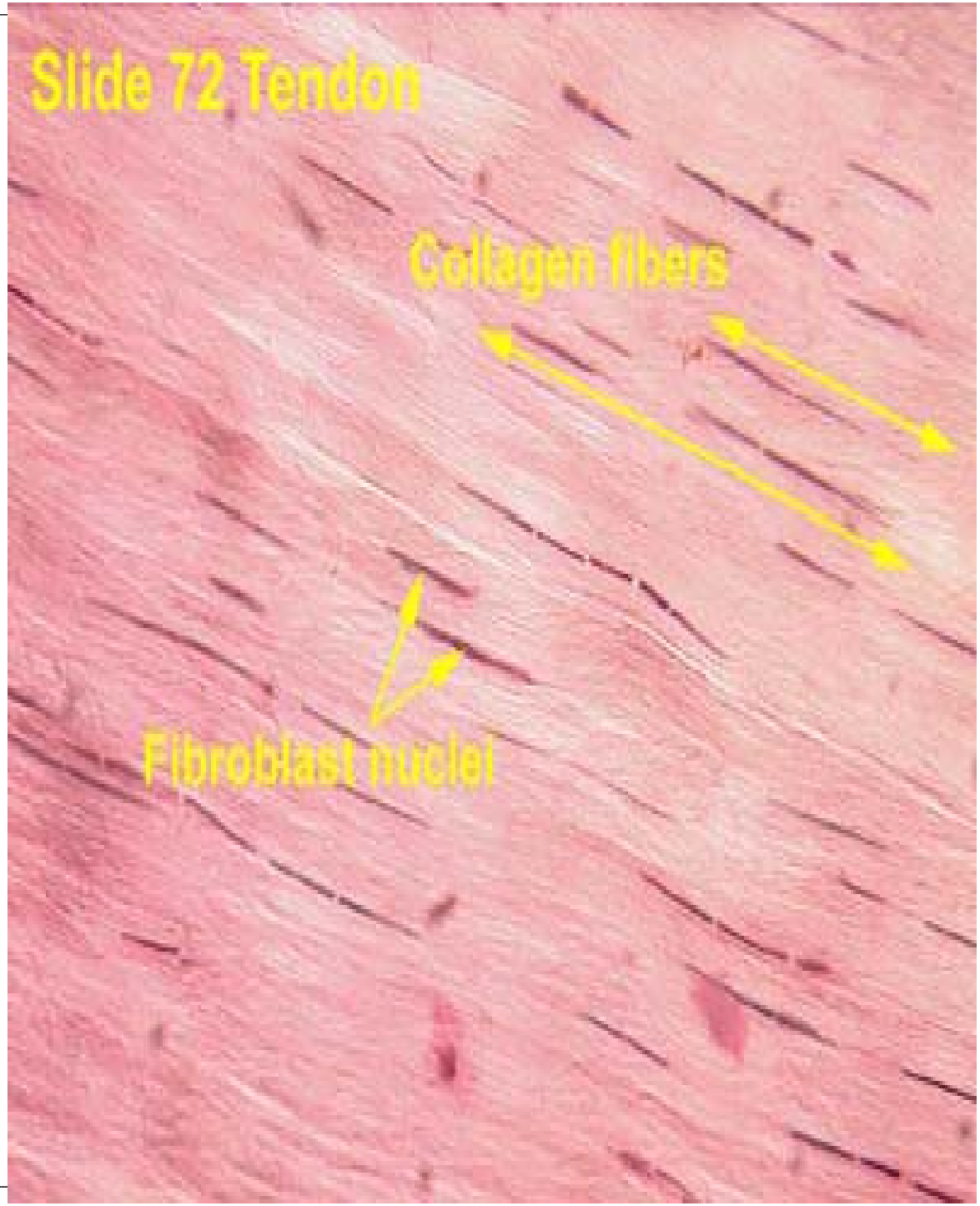
CONNECTIVE TISSUE FIBERS

- **Collagen** – tough; provides high tensile strength, **secreted as tropocollagen**
- **Elastic** – long, thin fibers that allow for stretch, secreted as tropoelastin;
- **Reticular** – branched collagenous fibers that form delicate networks

Types of fibers:

Tissue	Components	Location
Collagenous fibers	Alpha polypeptide chains	•tendon, •ligament, •skin, •cornea, •cartilage, •bone, •blood vessels, •gut, • intervertebral disc.
Elastic fibers	elastic microfibrill & elastin	•extracellular matrix
Reticular fibers	-	•liver, •bone marrow, • lymphatic organs

Collagen fibers



Collagen Types:

Collagen I:	•**Skin + Bone** •tendon, fascia, dentin,cornea, late wound
Collagen II: Cartilage	incld. Hyaline/Elastic C.,vitreus, nucleus pulposus
Collagen III: Aorta (Reticular Fibers)	fetal tissue, granulation tss. •These are also associated with **elastic fibers** •A silver stain will only stain reticular fibers.
Collagen IV:	•**Basement Membrane** or basal lamina of smooth muscle & blood vessle •Basement membranes retain the registration peptide. •As a result they don't form fibers but instead form sheets. •(cf. Collagen Type X : Epiphyseal plate)

So far, 28 types of collagen have been identified and described. The five most common types are:

•Collagen I: skin, tendon, vascular ligature, organs, bone (main component of the organic part of bone)

•Collagen II: cartilage (main component of cartilage)

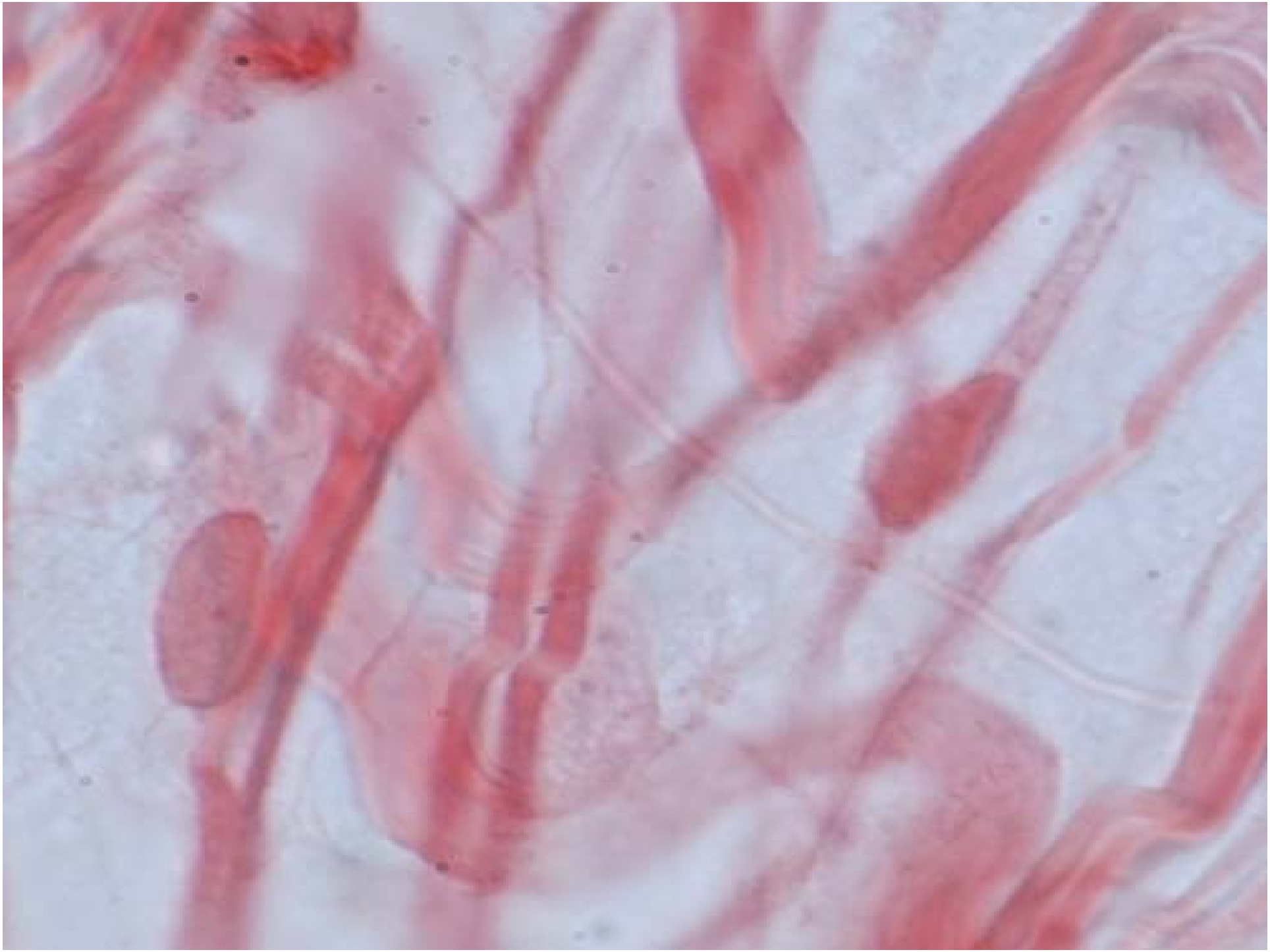
•Collagen III: reticulate (main component of reticular fibers), commonly found alongside type I.

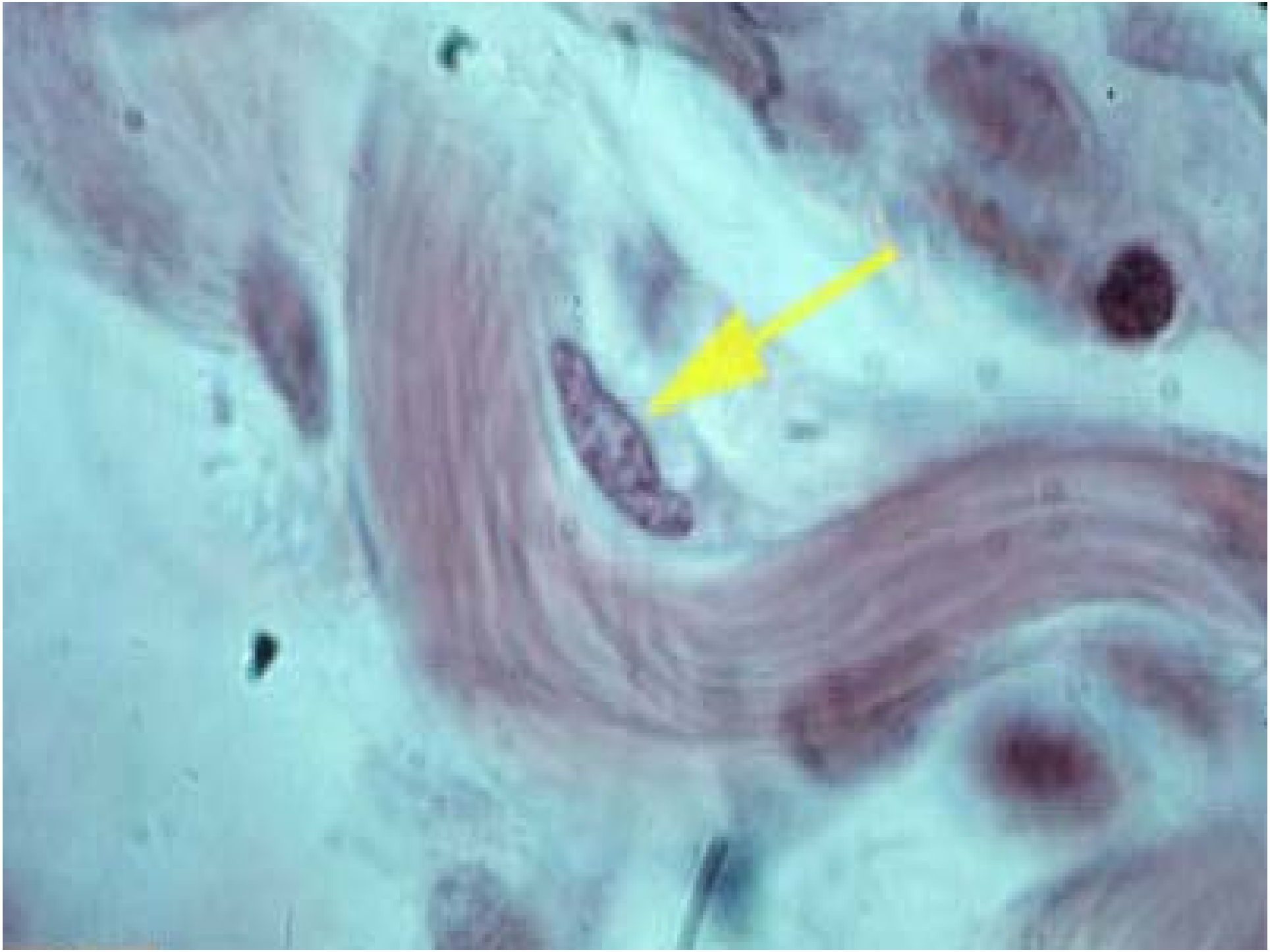
•Collagen IV: forms bases of cell basement membrane

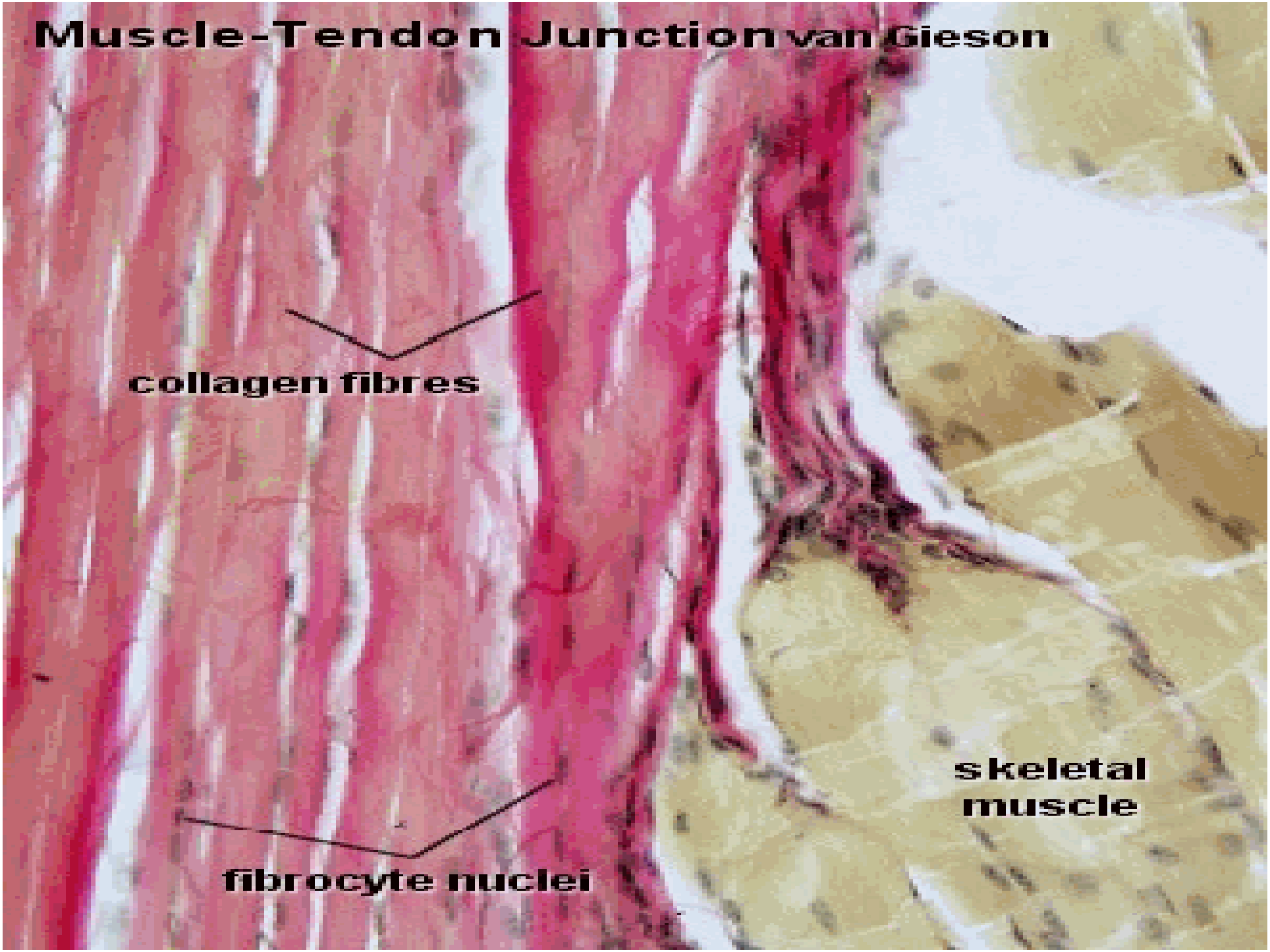
•Collagen V: cell surfaces, hair and placenta

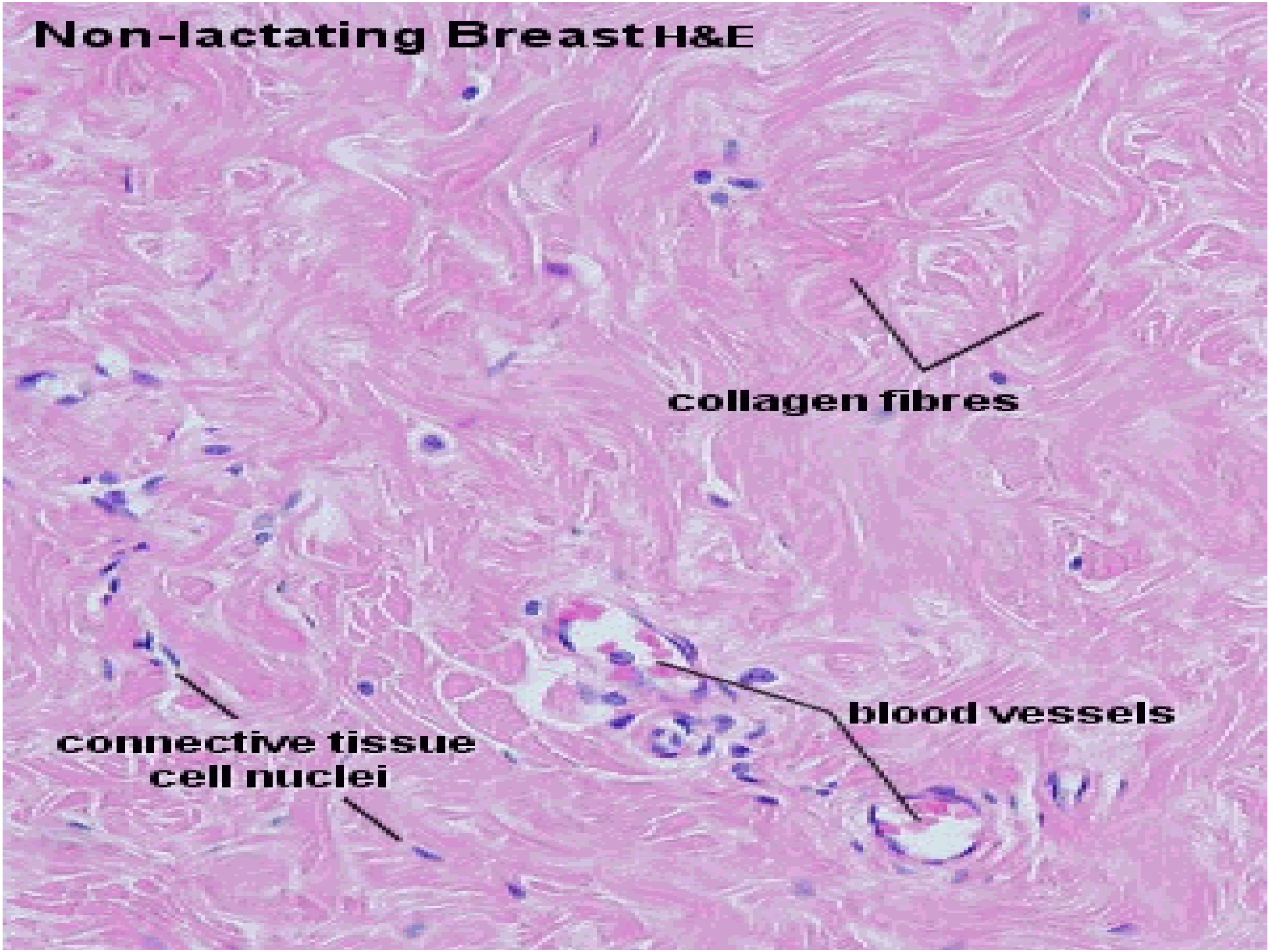
Extracellular matrix comprised of proteins

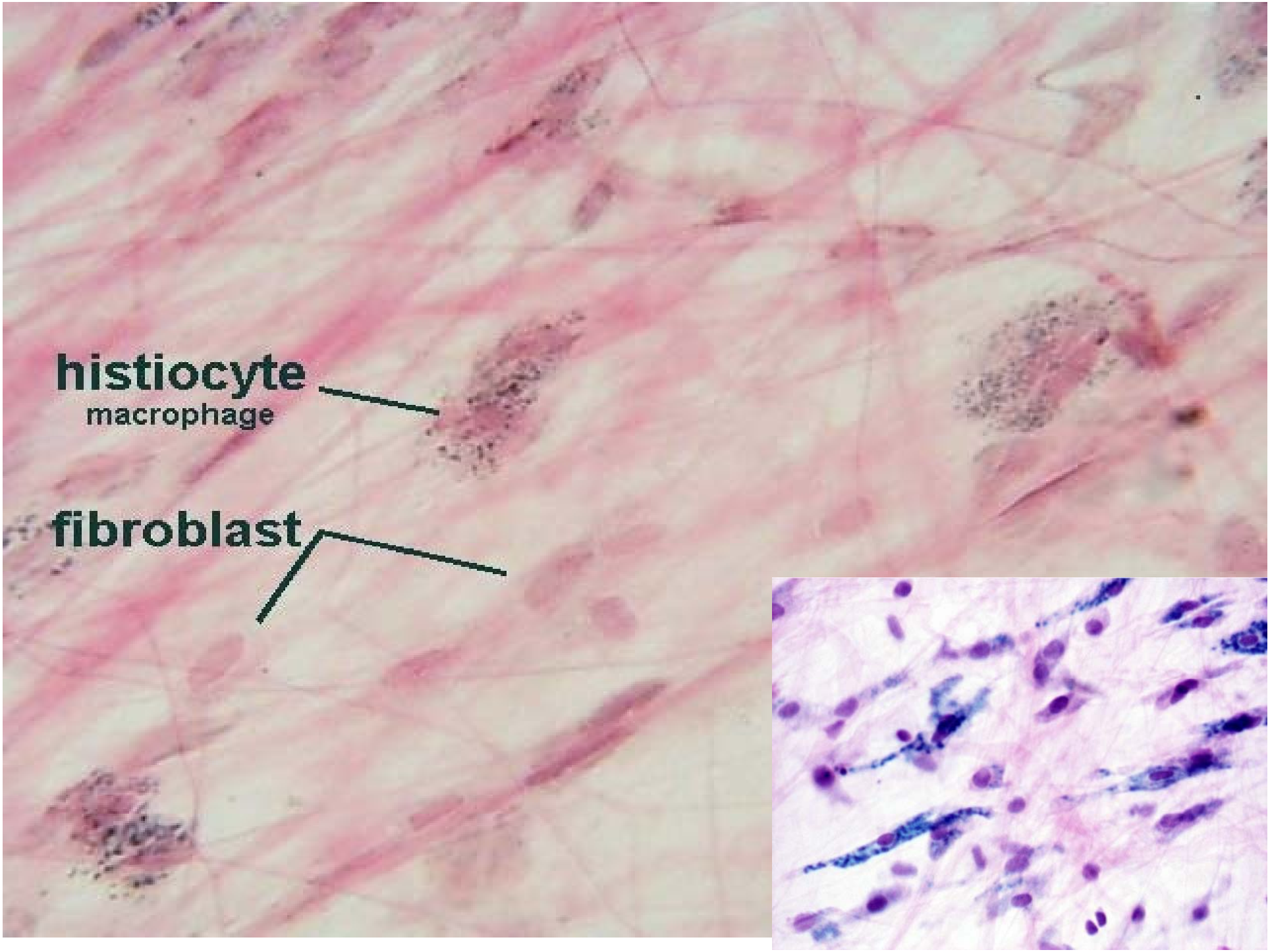
- **Collagen (25% total body protein)**
- **Elastin (wrinkles with aging)**






Muscle-Tendon Junction van Gieson
collagen fibres
fibrocyte nuclei
skeletal muscle


Non-lactating Breast H&E
collagen fibres
blood vessels
connective tissue
cell nuclei


histiocyte
macrophage
fibroblast

COLLAGEN RELATED DISORDERS

- **Ehlers-Danlos Syndromes**:

Hyperextensibility of

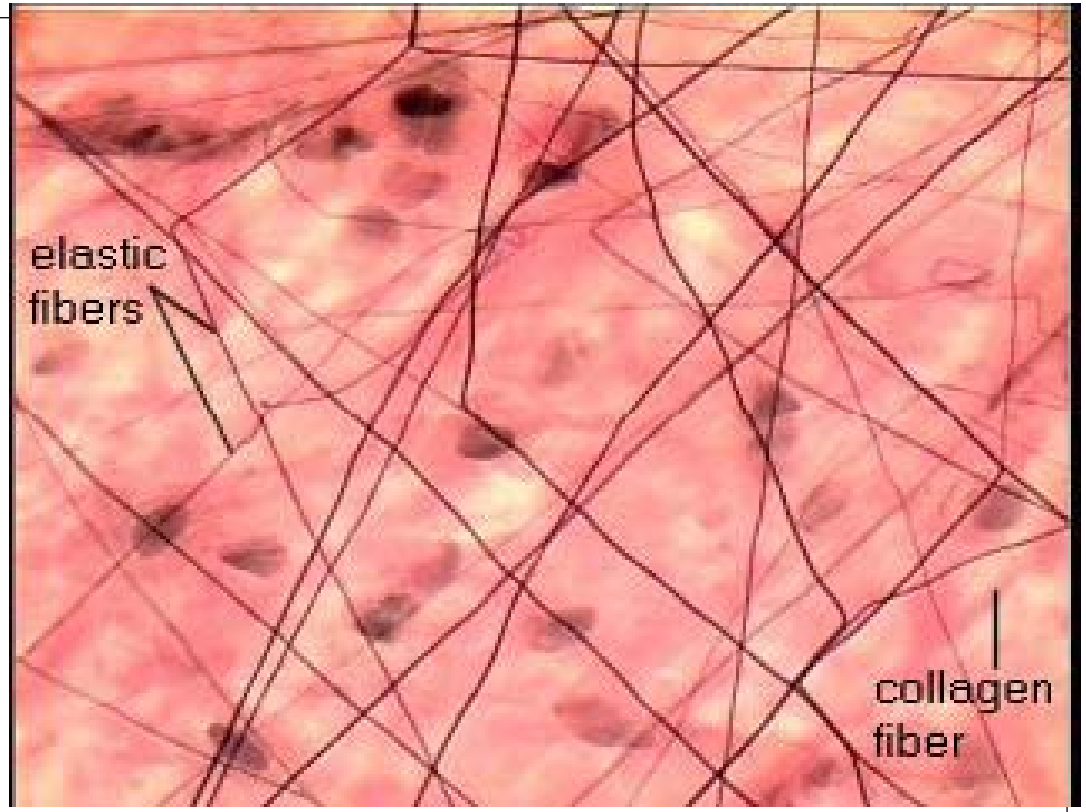
- skin and joints.

- **Osteogenesis Imperfecta**

- **Scurvy**: Vitamin-C deficiency leads to malfunctioning
- prolyl hydroxylase

Recessive Dystrophic Epidermolysis Bullosa:
Too much collagenase

Elastic fibers



Elastic fibers (or **yellow fibers**) are bundles of proteins (elastin) found in extracellular matrix

Produced by fibroblasts and smooth muscle cells in arteries

ELASTIC FIBERS:

Arrangements of elastic fibers: They can be arranged in 3 different ways

- **Fibers / Fiber Bundles** -- as in skin
- **Lamellae (sheets)** -- as in vasculature
- **Fine Networks** -- as in the lung

Protein Composition:

- **Microfibrillar Protein:**
- **Elastin:**.
  - Elastin is resistant to degradation, except by **elastase**.
- **Desmosine & Isodesmosine**:.
- **Elaunin and oxytalan**

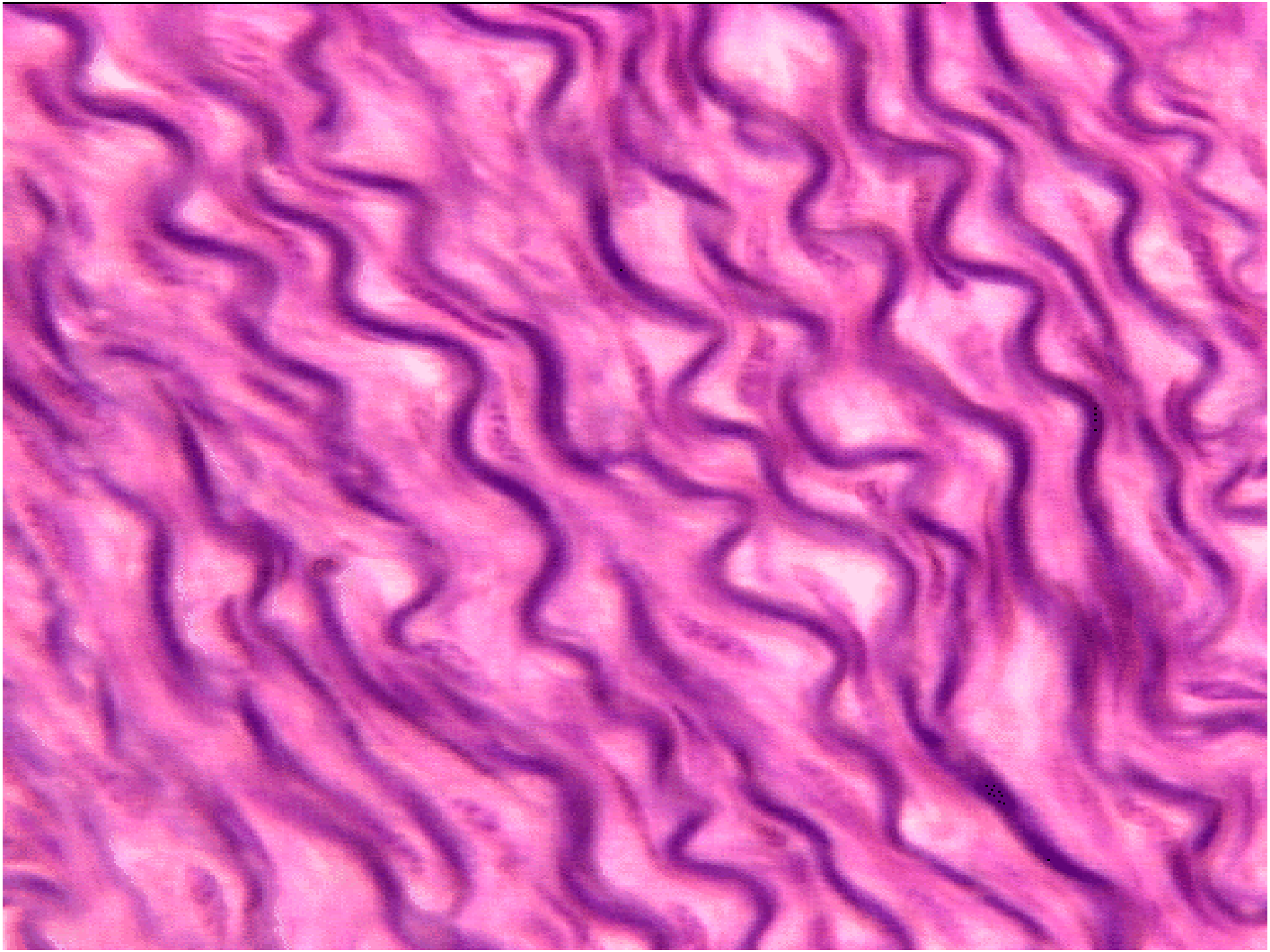
.

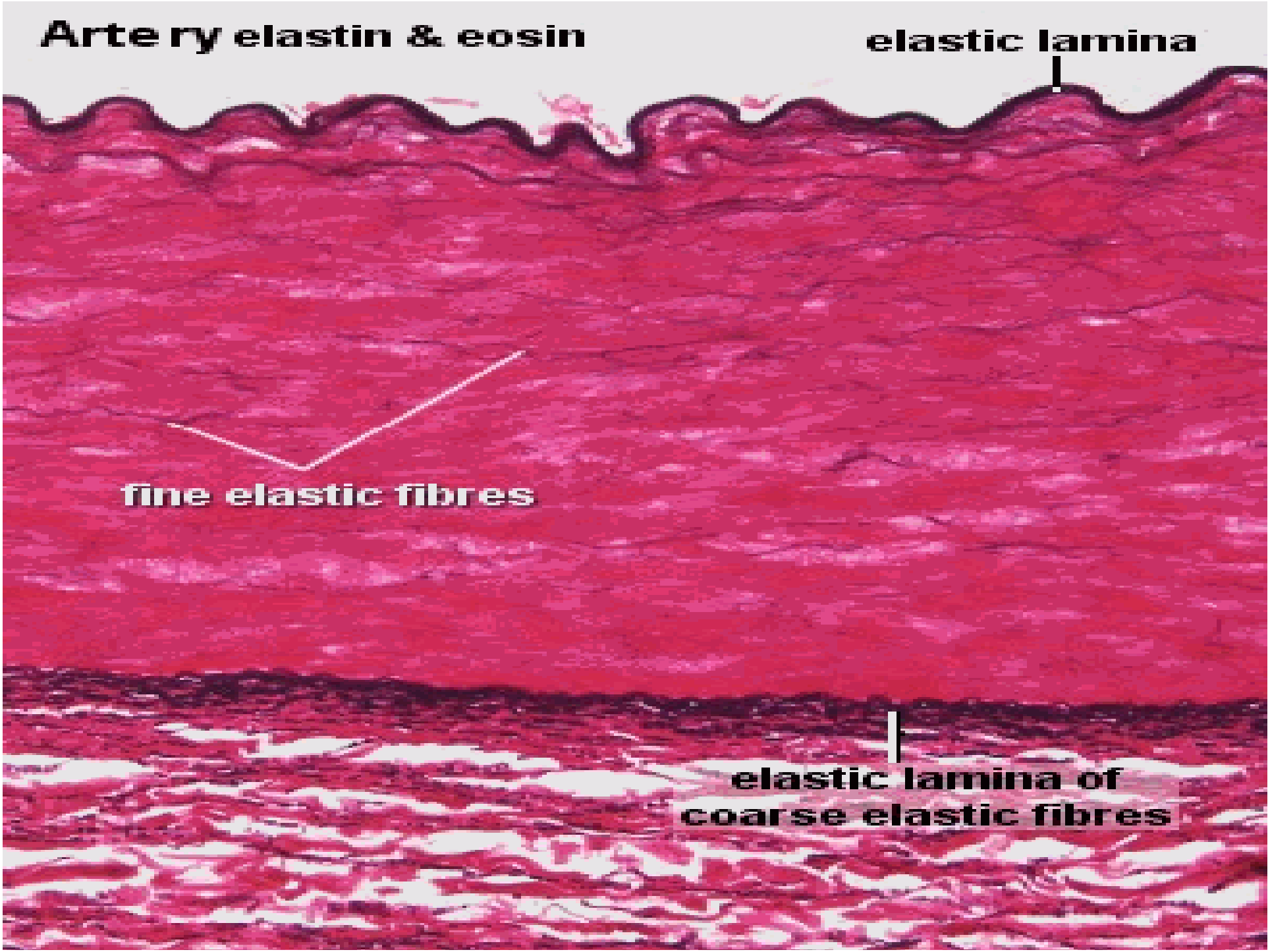
•AGING: Wrinkles occur as microfibrillar structure is lost

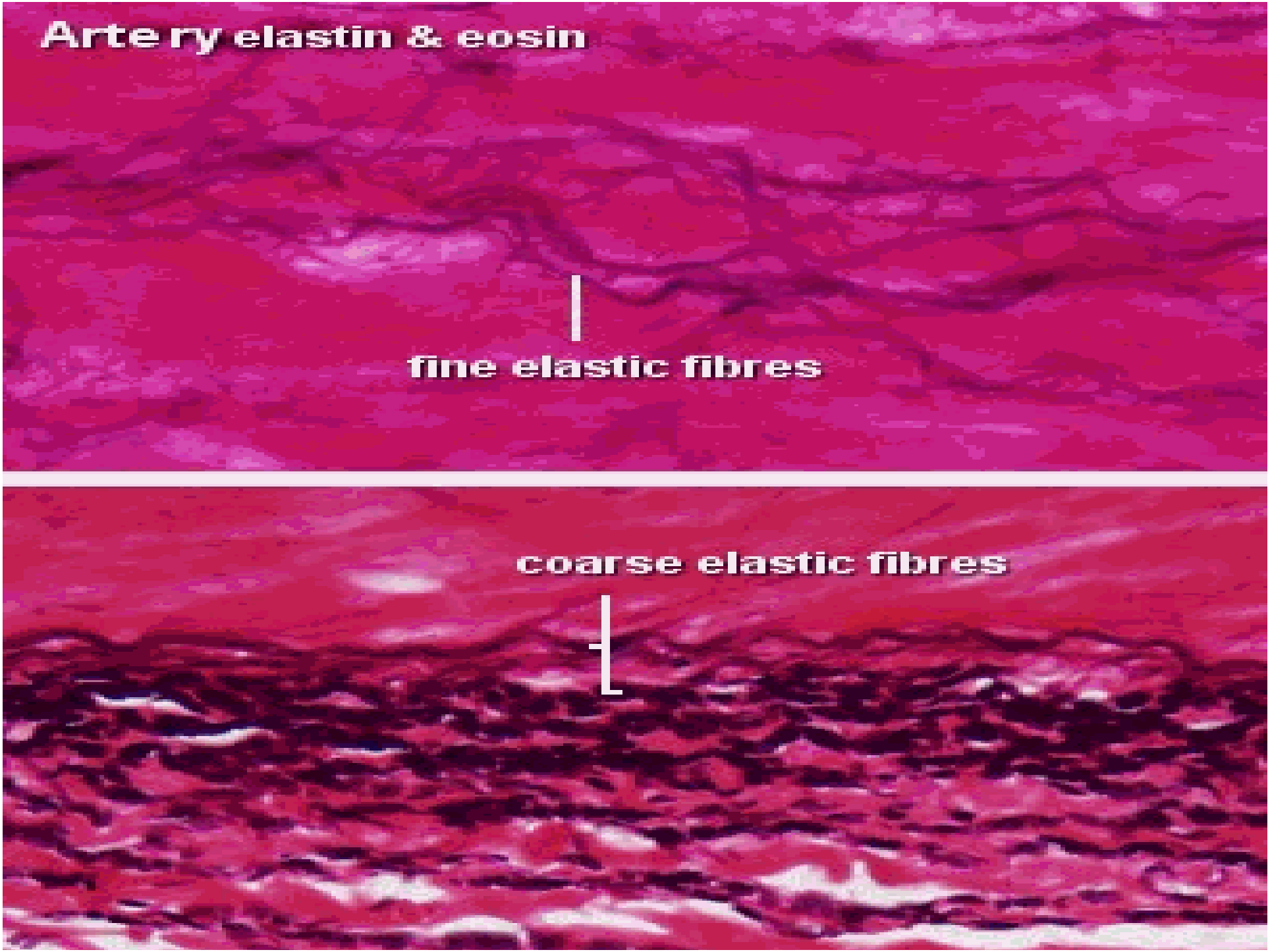
•Emphysema: Loss of elasticity in lung. Rare form = congenital malfunction of elastase in lung.

Elastic fibers are found in

- **The skin,**
- **Lungs,**
- **Arteries,**
- **Veins,**
- **Connective tissue proper,**
- **Elastic cartilage,**
- **Periodontal ligament,**
- **Fetal tissue**




Artery elastin & eosin
elastic lamina
fine elastic fibres
elastic lamina of
coarse elastic fibres


Artery elastin & eosin
fine elastic fibres
coarse elastic fibres

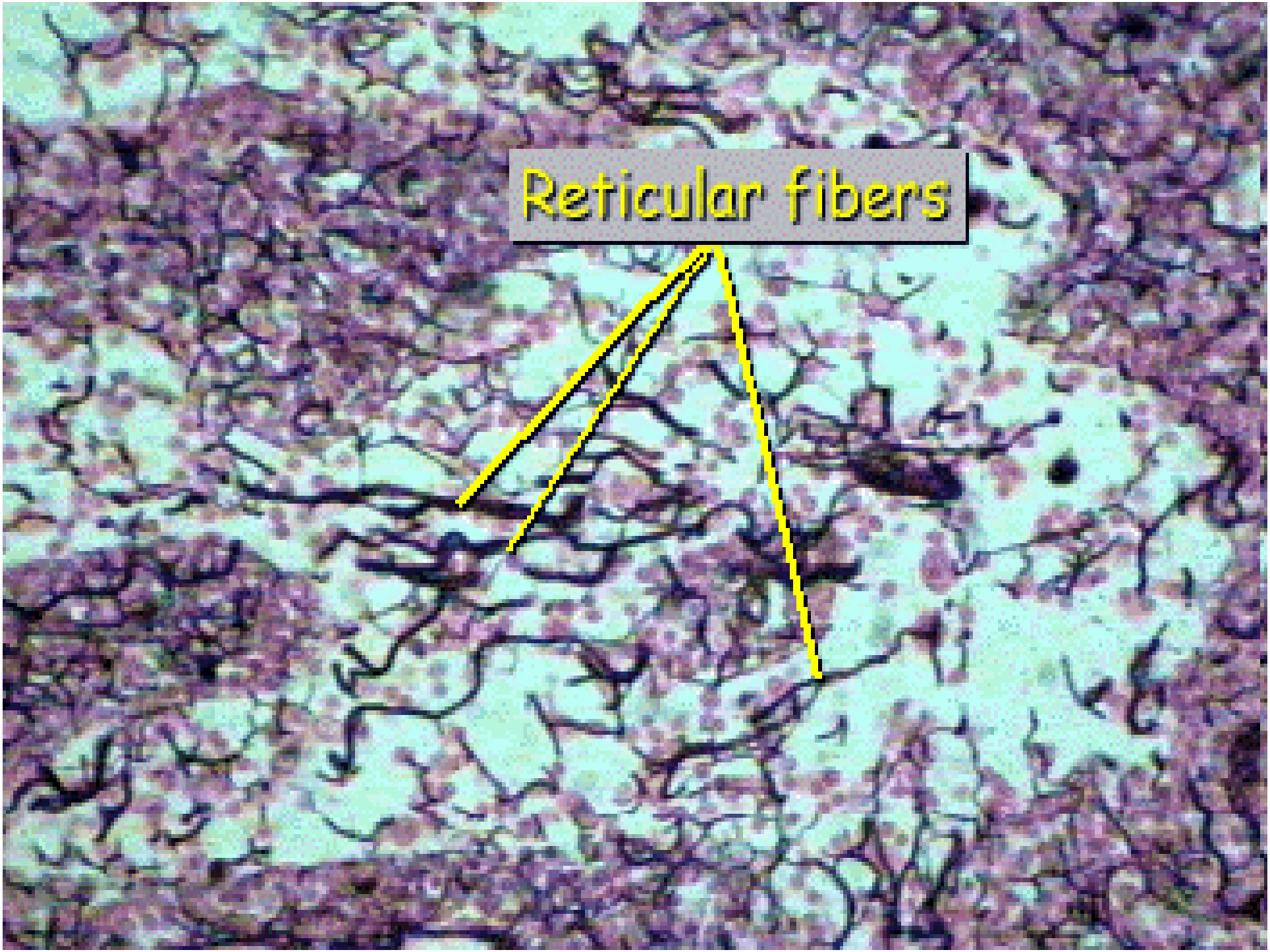
Reticular fibers = reticulin

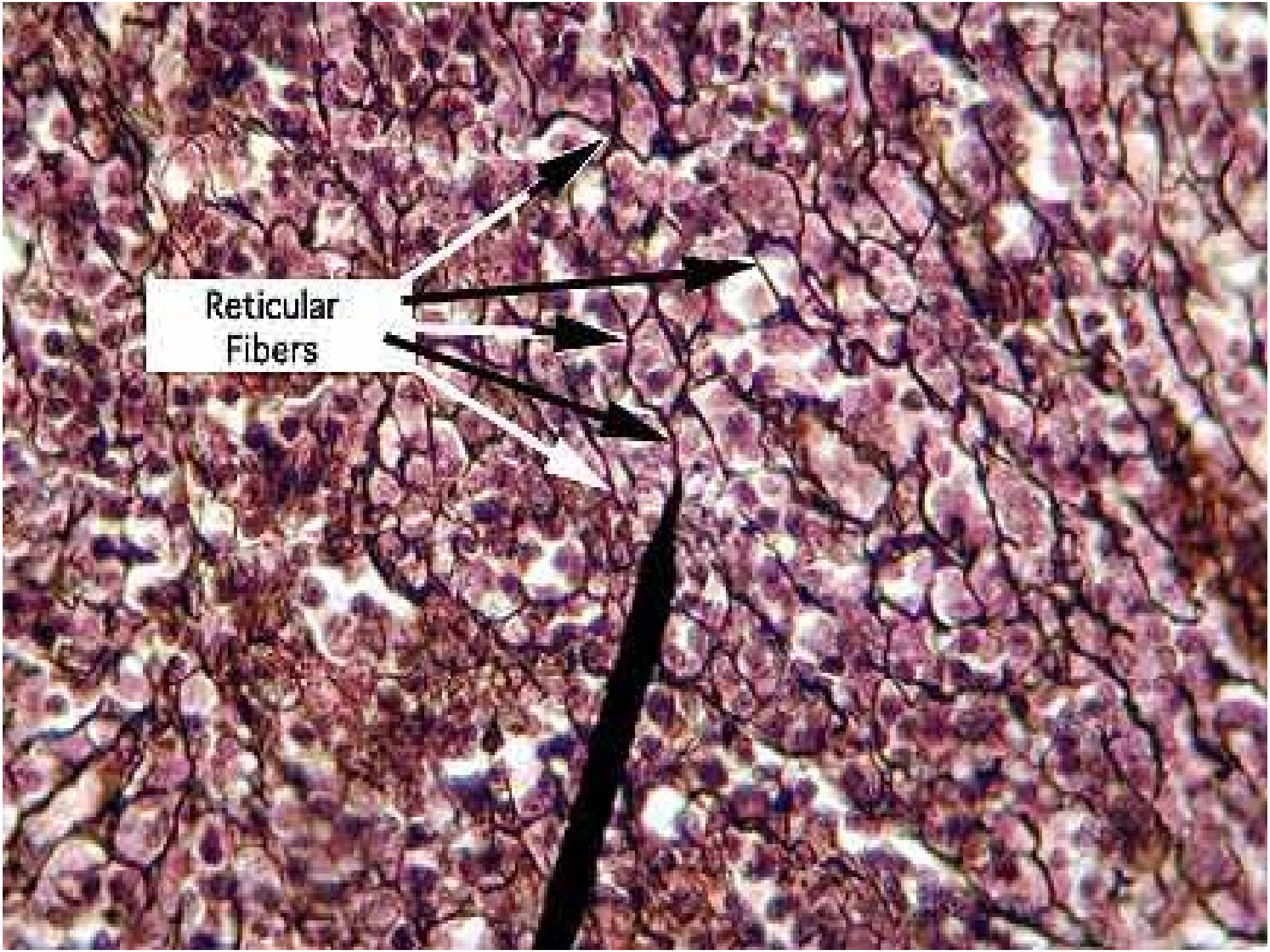
Composed of type III collagen.

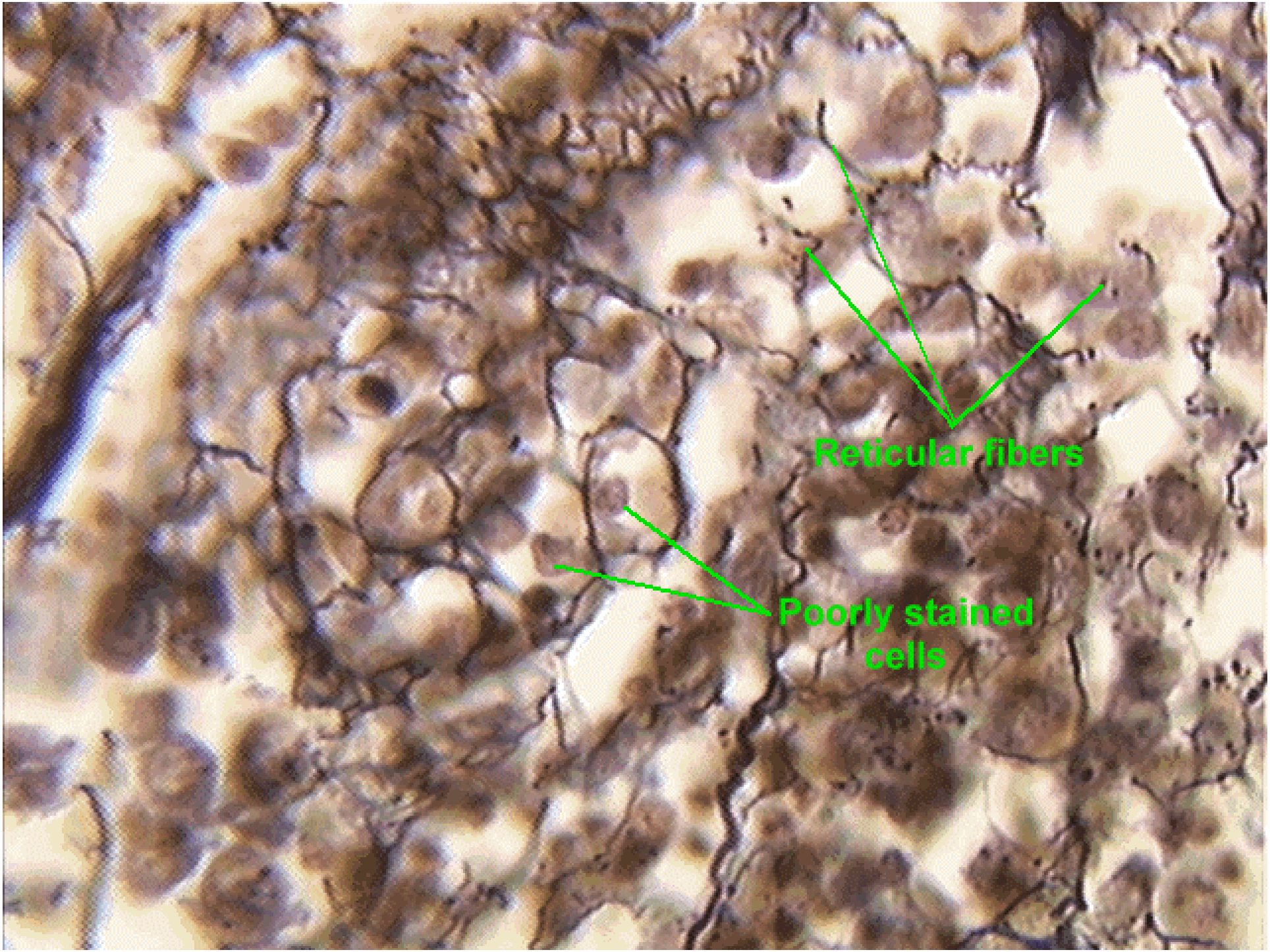
Reticular fibers crosslink to form a fine meshwork (reticulin).

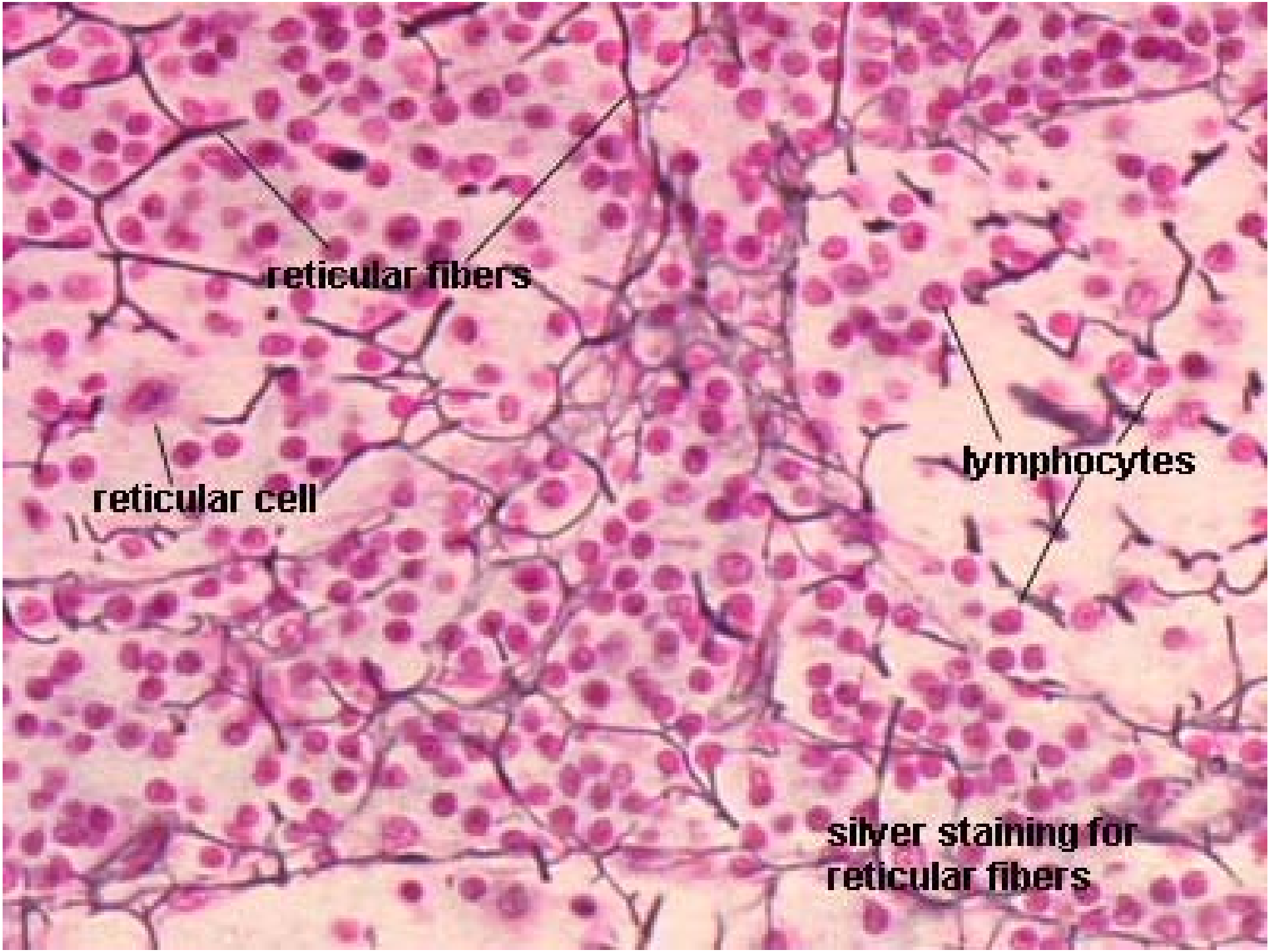
This network acts as a supporting mesh in soft tissues such as

- liver,
- bone marrow,
- and the tissues and organs of the lymphatic system [spleen, lymph nodes]


Reticular fibers


Reticular
Fibers


Reticular fibers
Poorly stained cells


reticular fibers
reticular cell
lymphocytes
silver staining for
reticular fibers

Types

- ***Loose CT***:
  - biological packing material;
  - supports epithelia lining gut,
  - respiratory & urinary tracts, etc.;
  - open = areolar.
- ***Dense CT***: physical support,

- ***regular***: ligaments, tendons and caps

  irregular: dermis

- ***Adipose tissue*** (adipocytes)

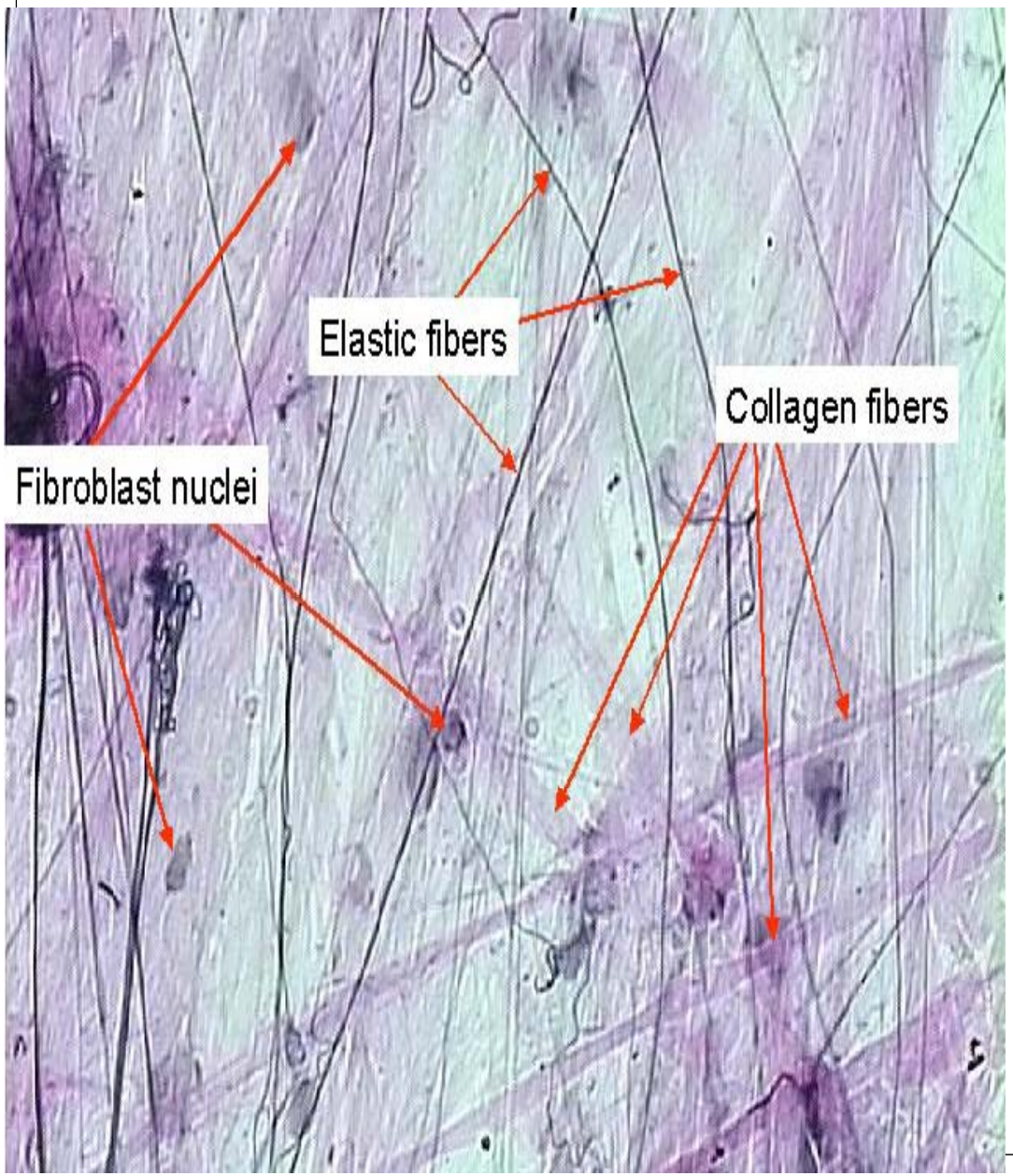
  Brown: multilocular
  White: unilocular
- ***Cartilage***
  - Hyaline
    Elastic
    Fibroelastic
- ***Bone***

CLASSIFICATION OF CONNECTIVE TISSUE

The two main categories of connective tissue are:

- **Loose Connective Tissue**
- **Dense Connective Tissue**

Connective Tissue Proper: Loose



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

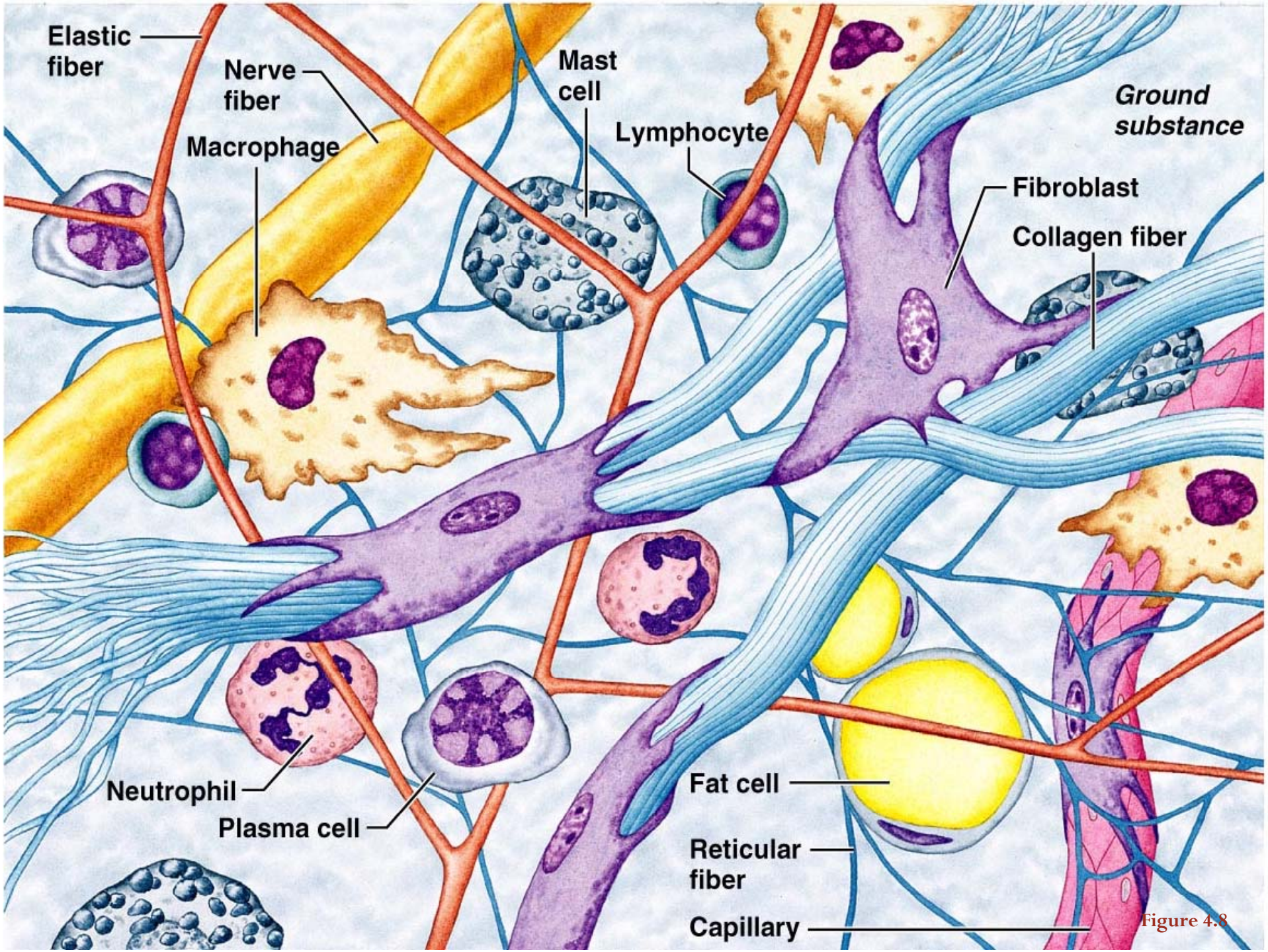
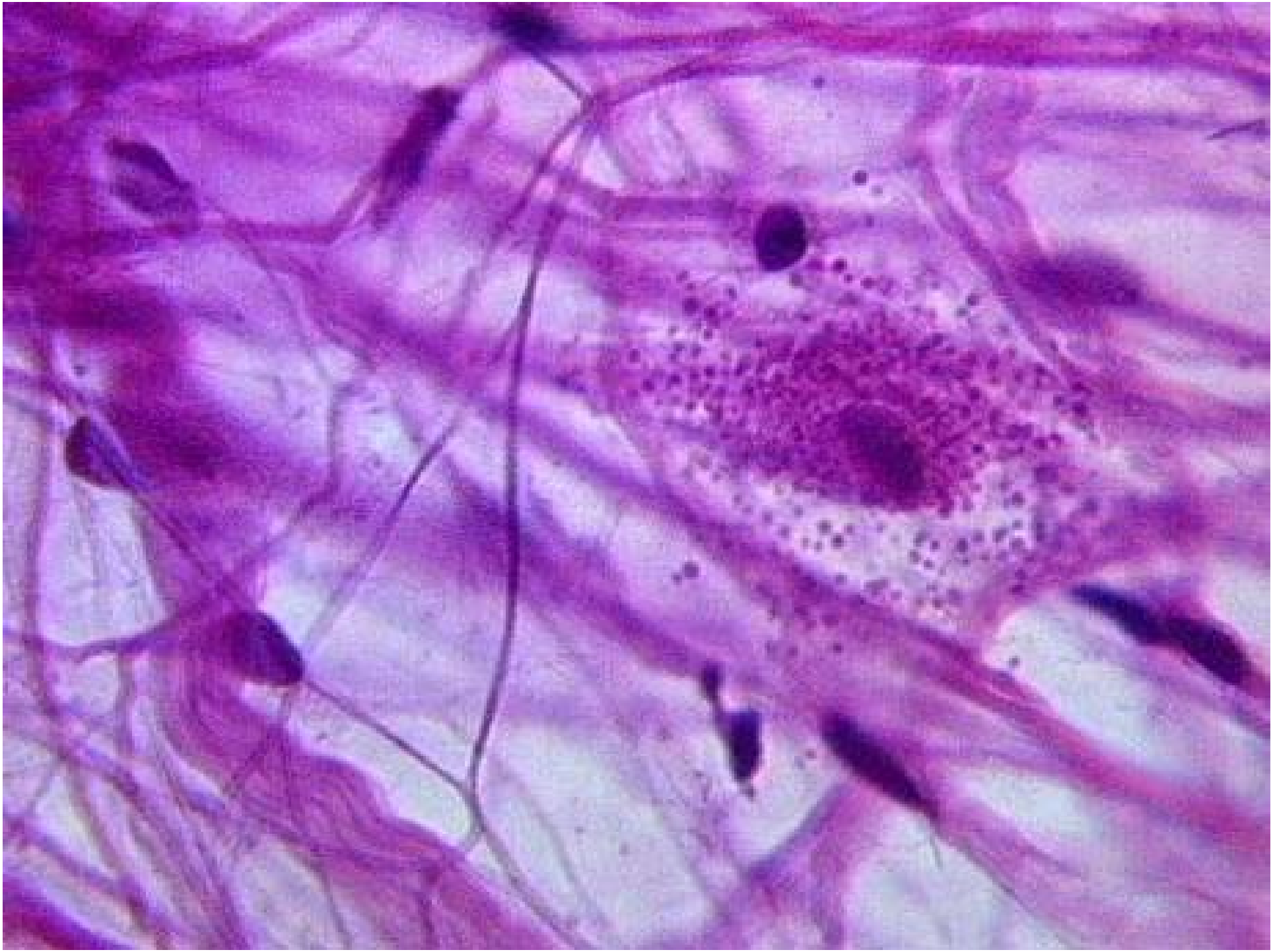

Elastic fiber
Nerve fiber
Macrophage
Mast cell
Lymphocyte
Ground substance
Fibroblast
Collagen fiber
Neutrophil
Plasma cell
Fat cell
Reticular fiber
Capillary

Figure 4.8



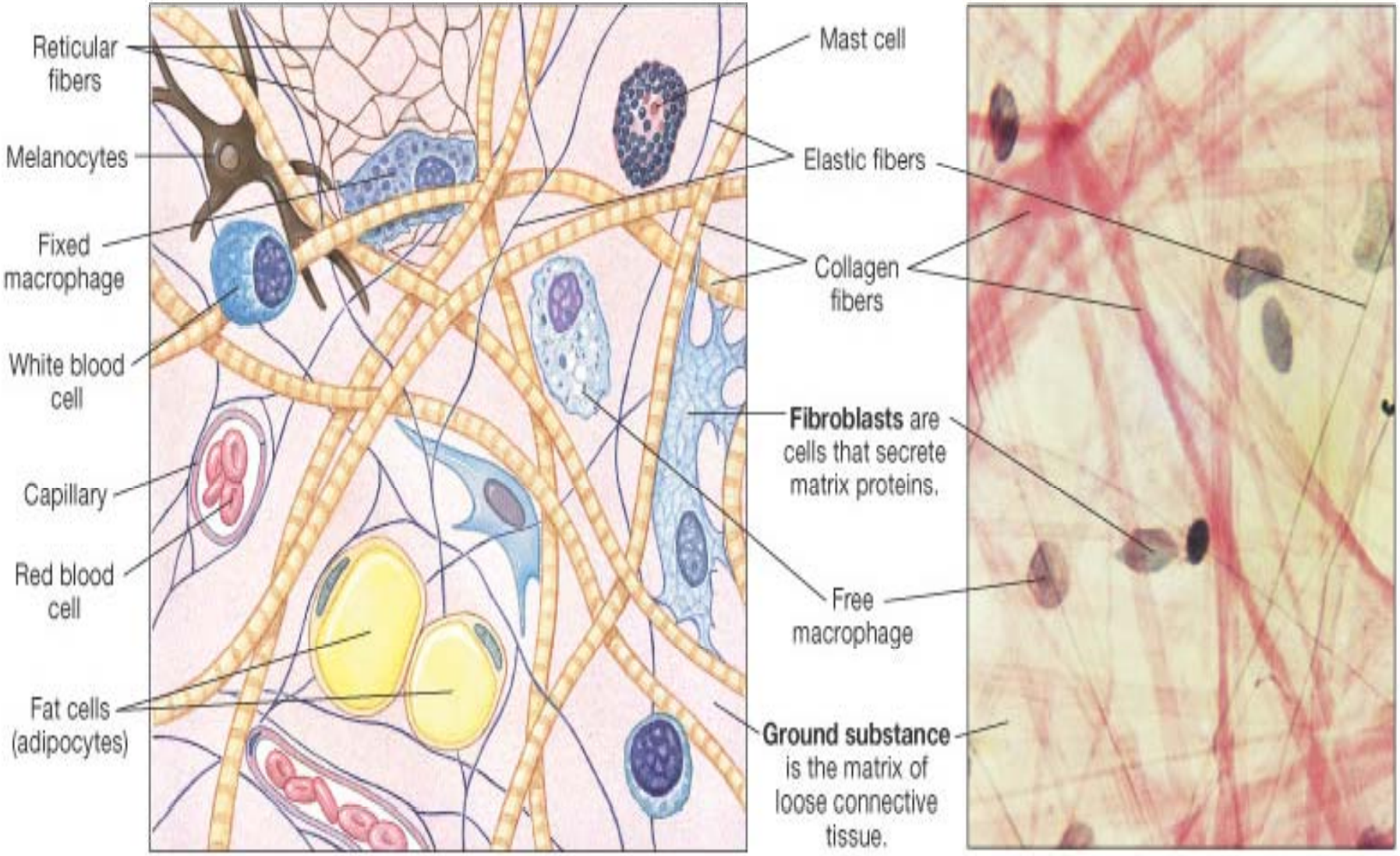
Loose Connective Tissue

Loose connective tissue (**areolar tissue**) is the more common type.

It fills the spaces between

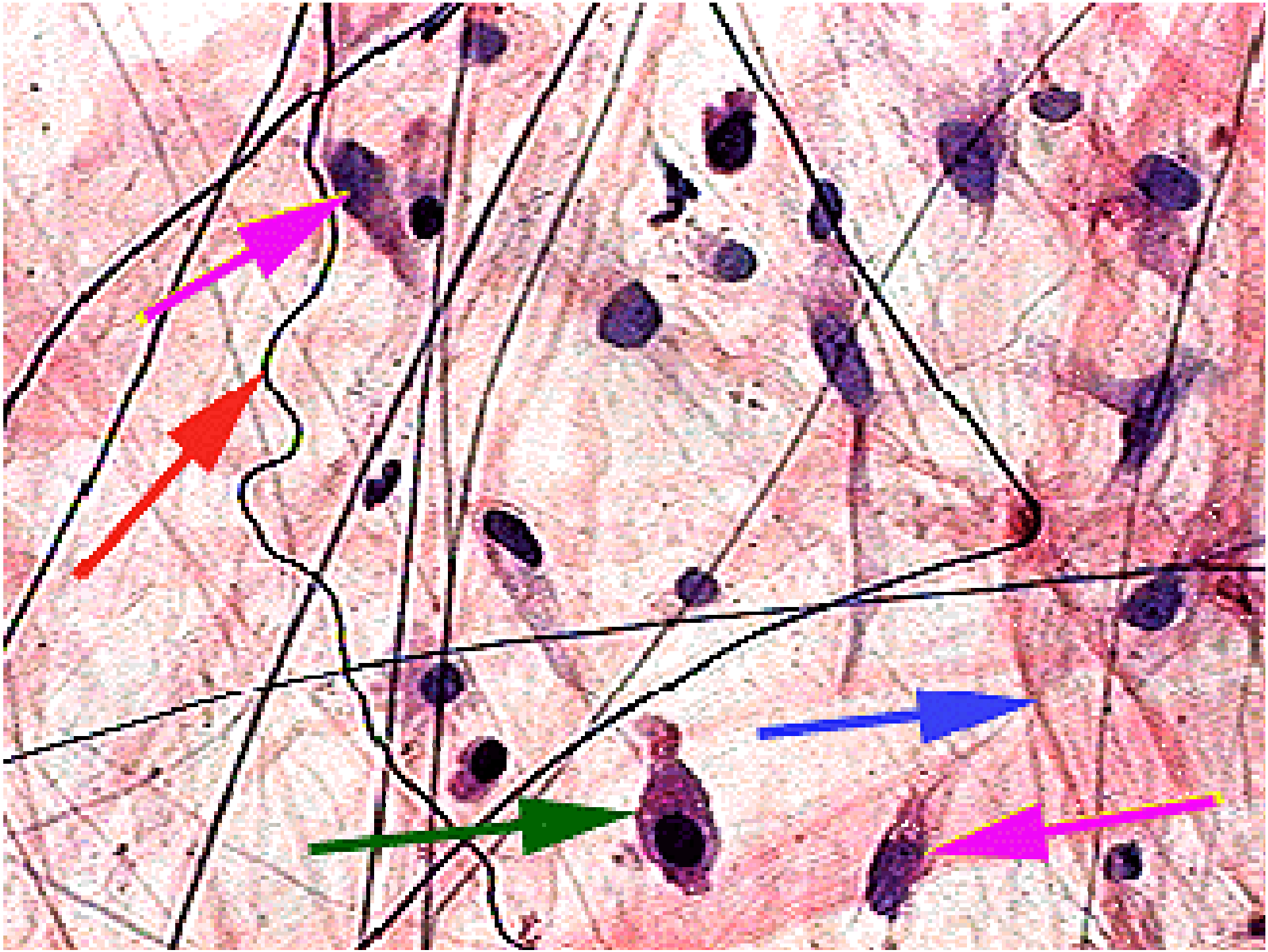
- **muscle fibers,**
- **surrounds blood and lymph vessels,**
- **is present in the serosal lining membranes (of the peritoneal, pleural and cardiac cavities),**
- **in the papillary layer of the dermis and in the lamina propria of the intestinal and respiratory tracts etc.**

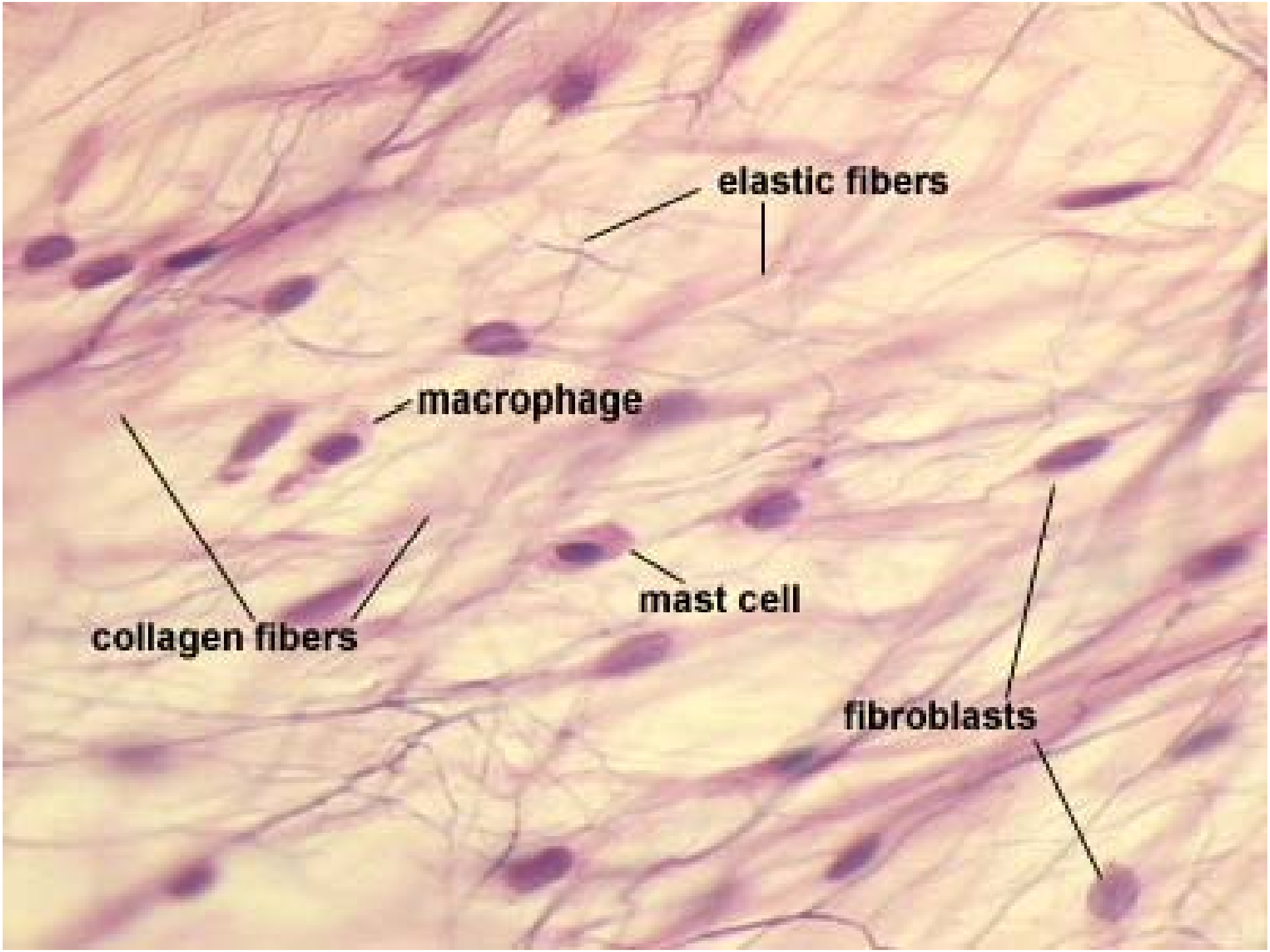
Connective Tissues (CT)



Loose connective tissue

Light micrograph of loose connective tissue




elastic fibers
macrophage
collagen fibers
mast cell
fibroblasts

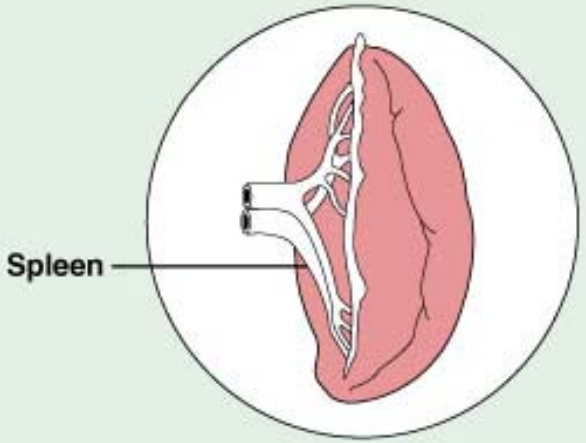
Connective Tissue Proper: Loose

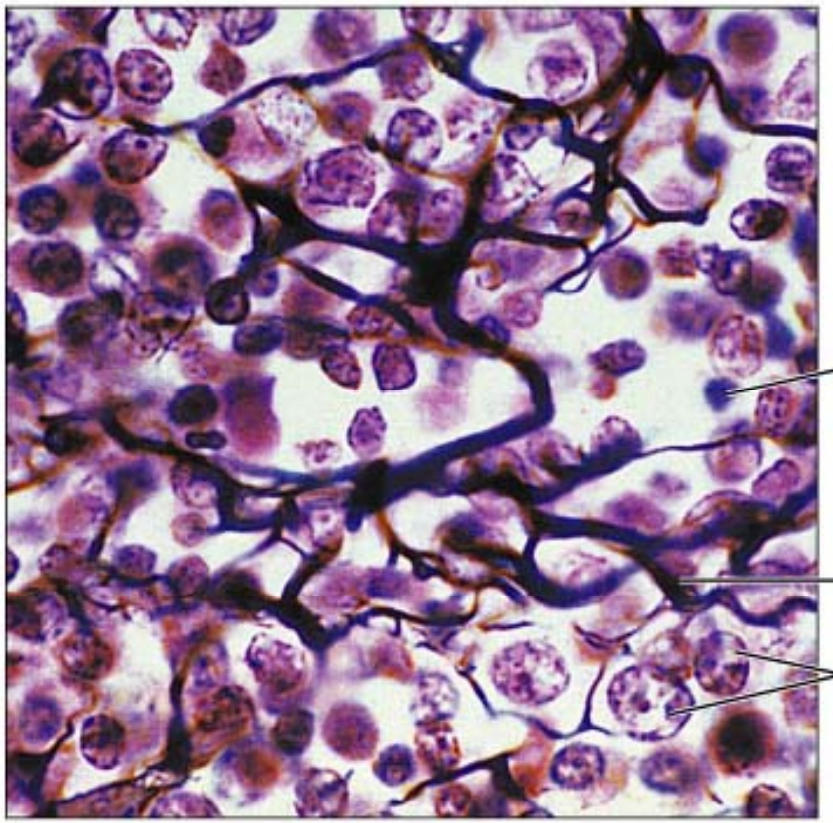
(d) Connective tissue proper: loose connective tissue, reticular

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

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

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





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

Dense Connective Tissue

Dense connective tissue is divided into two sub-categories:

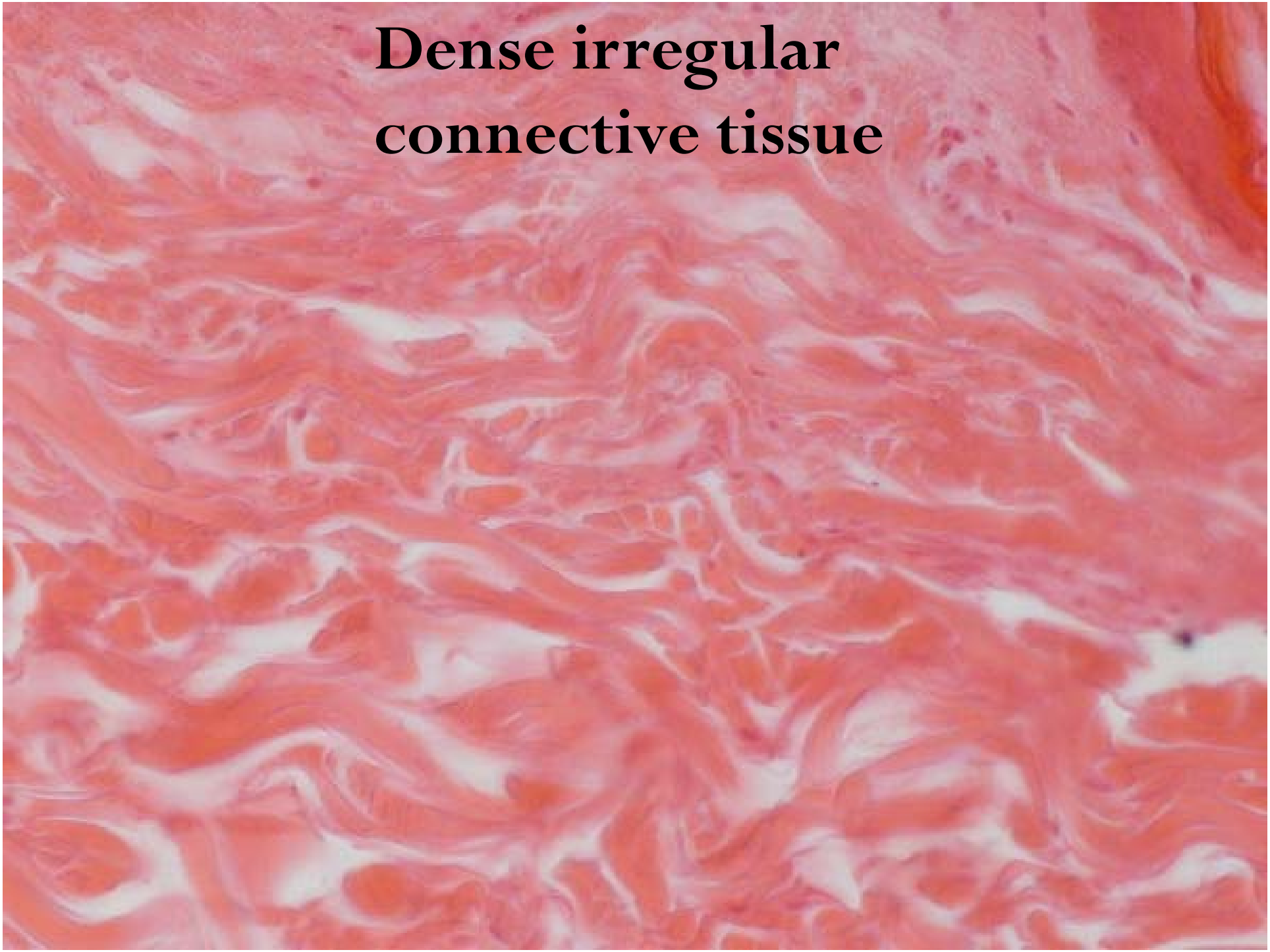
- **dense irregular connective tissue**
- **dense regular connective tissue**

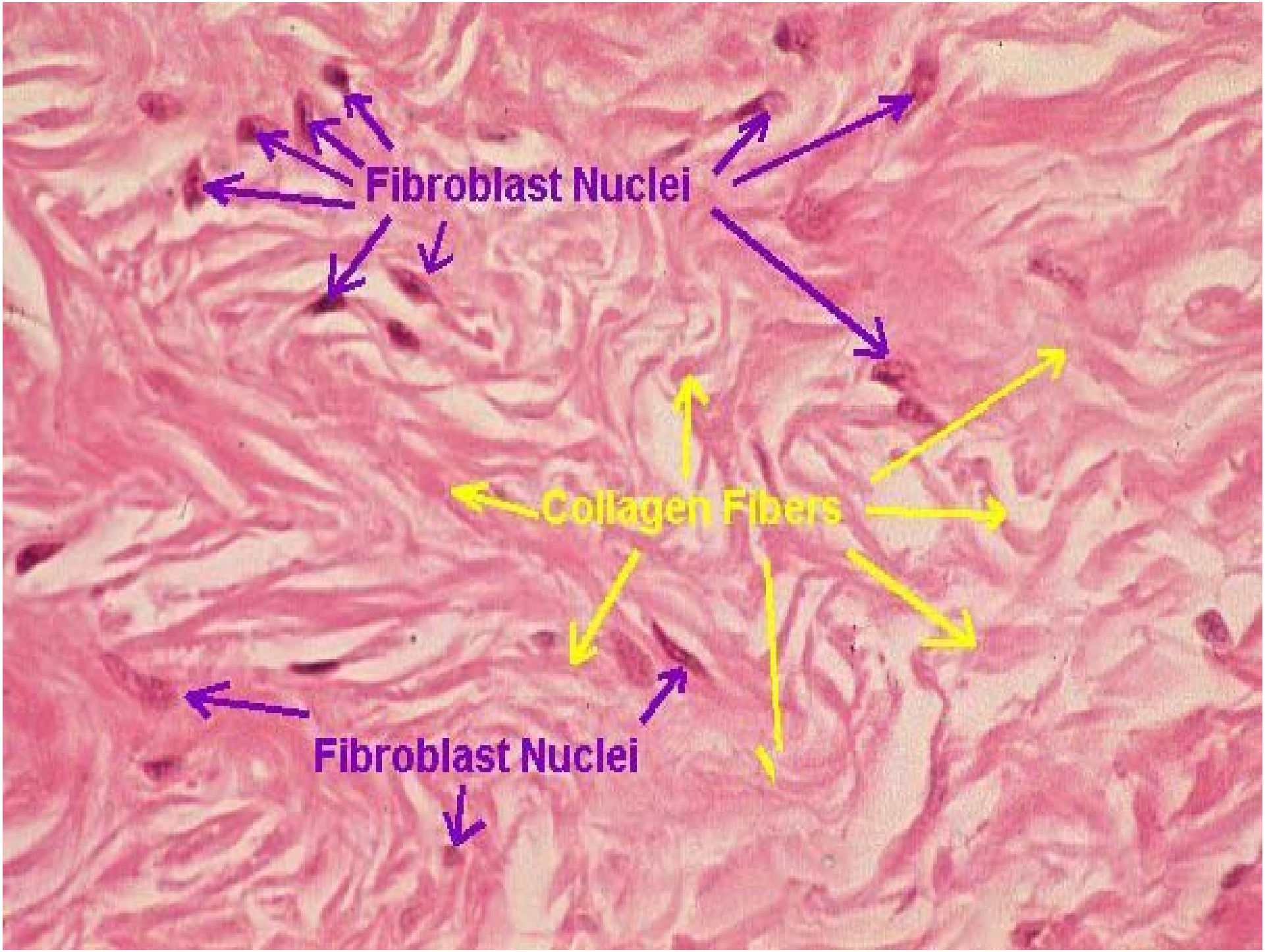
Dense connective tissue contains relatively few cells with much greater numbers of collagen fibers.

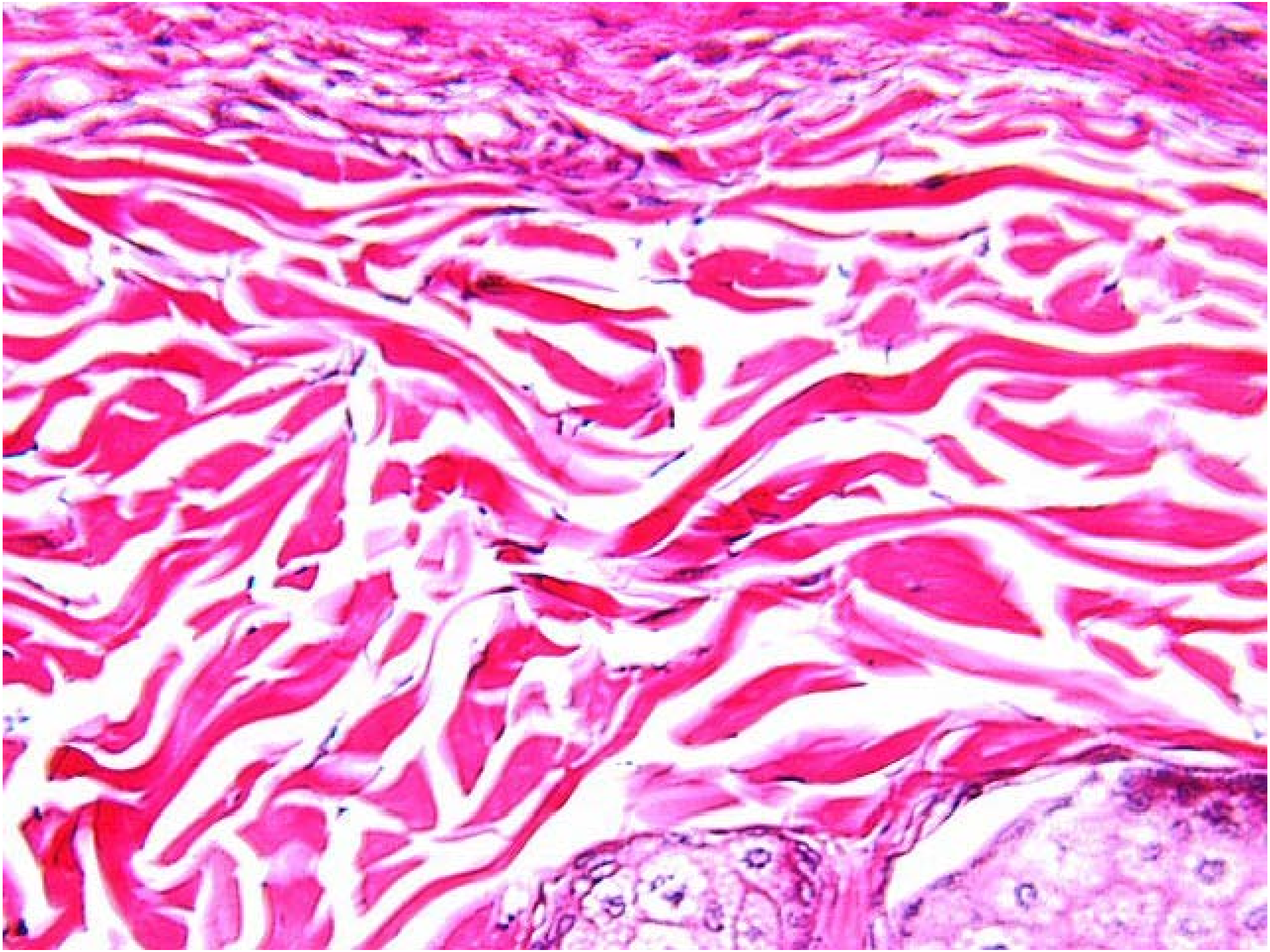
Dense irregular connective tissue has bundles of collagen fibers that appear to be fairly randomly orientated (as in the dermis).

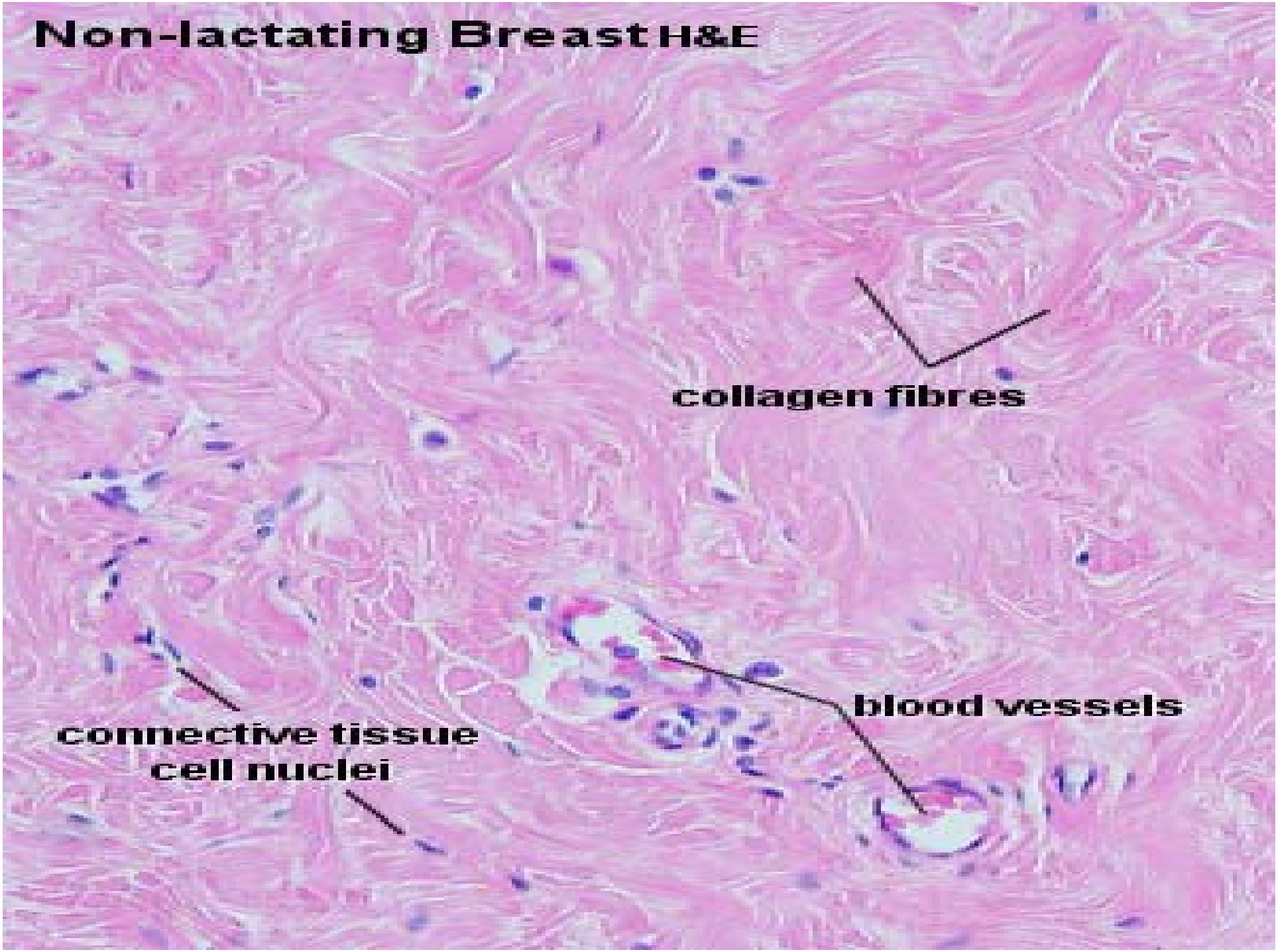
Dense regular connective tissue has closely-packed densely-arranged fiber bundles with clear orientation (such as in tendons) and relatively few cells.

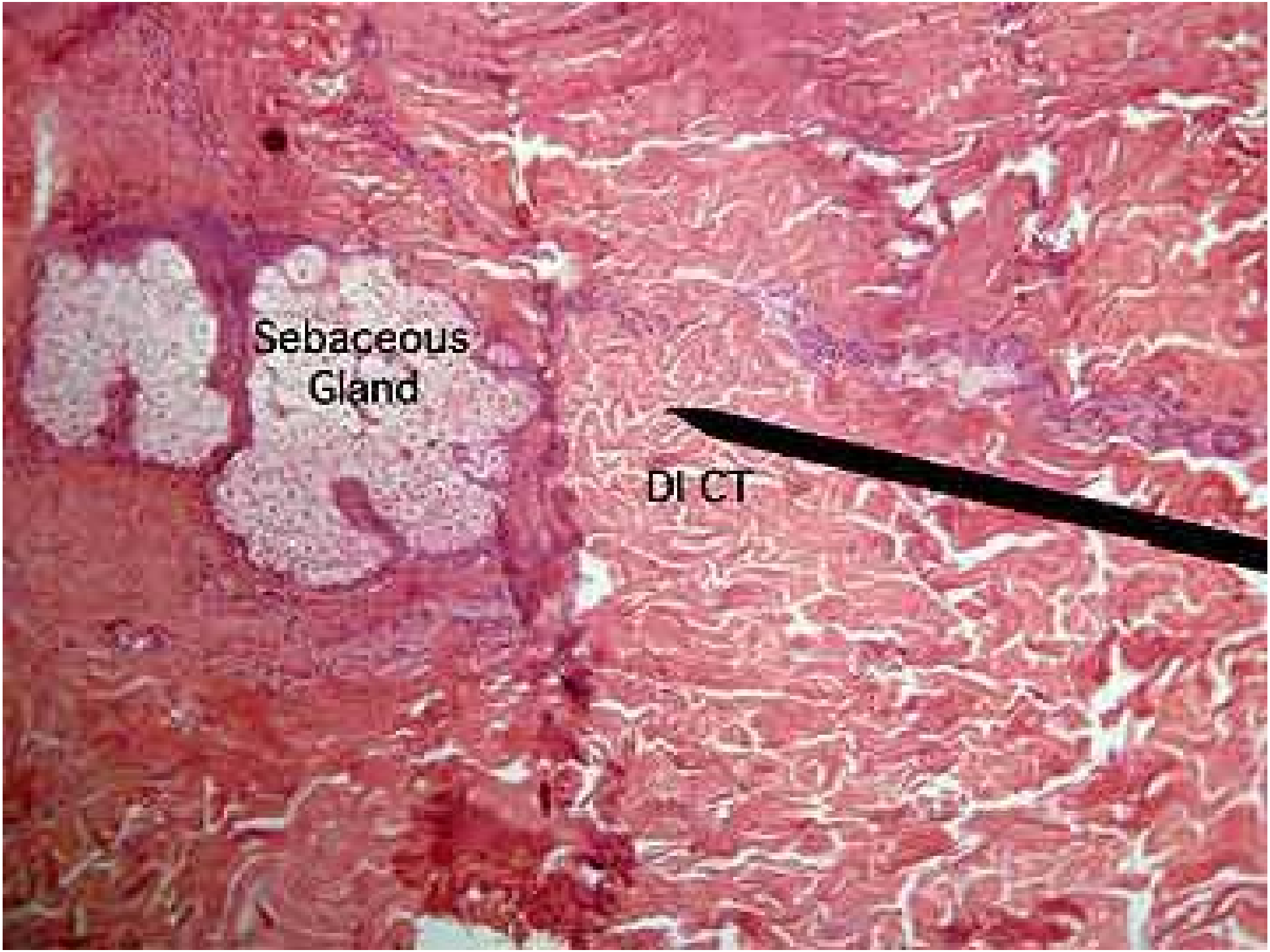
Dense irregular connective tissue




Fibroblast Nuclei
Collagen Fibers
Fibroblast Nuclei

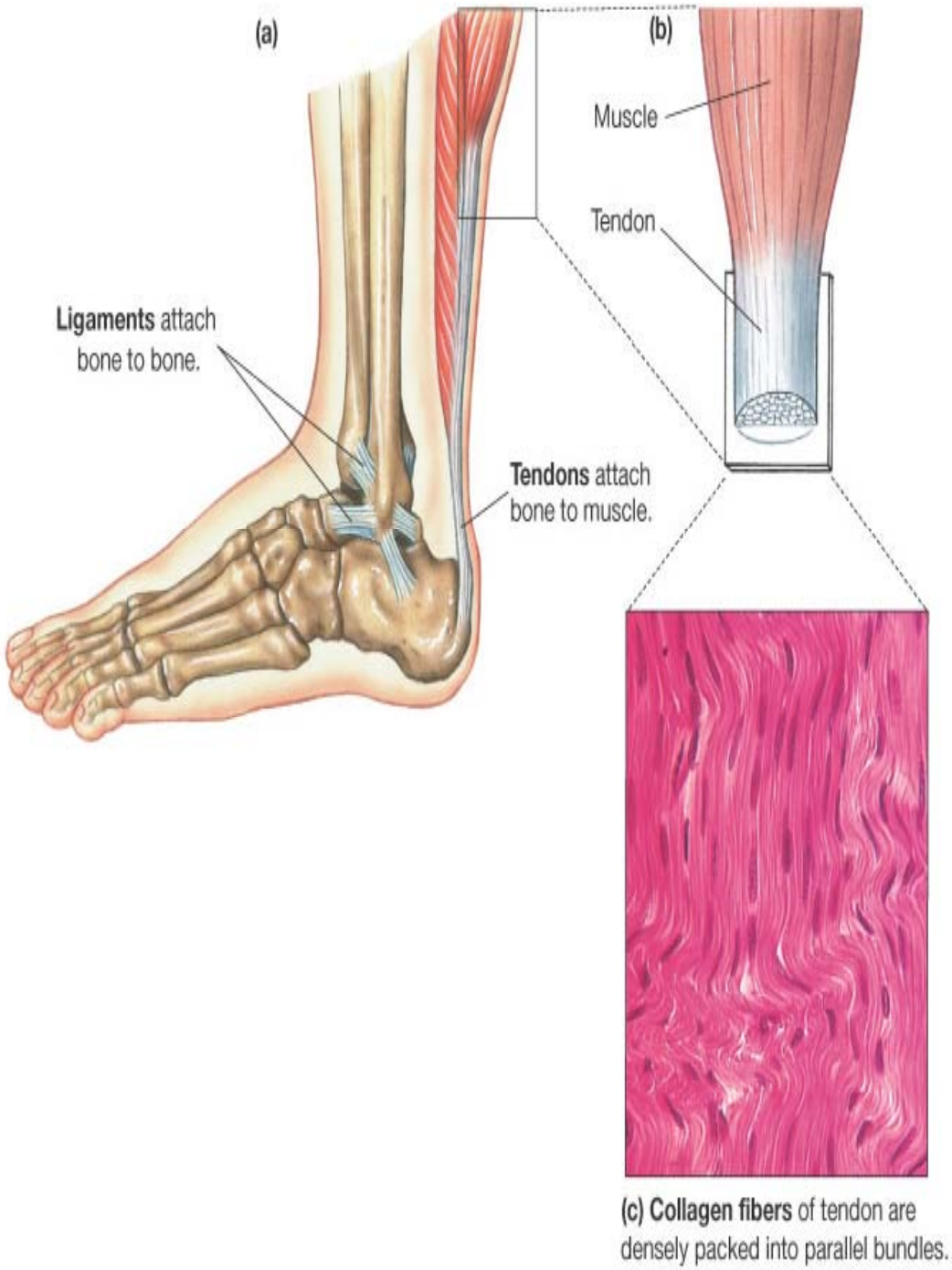


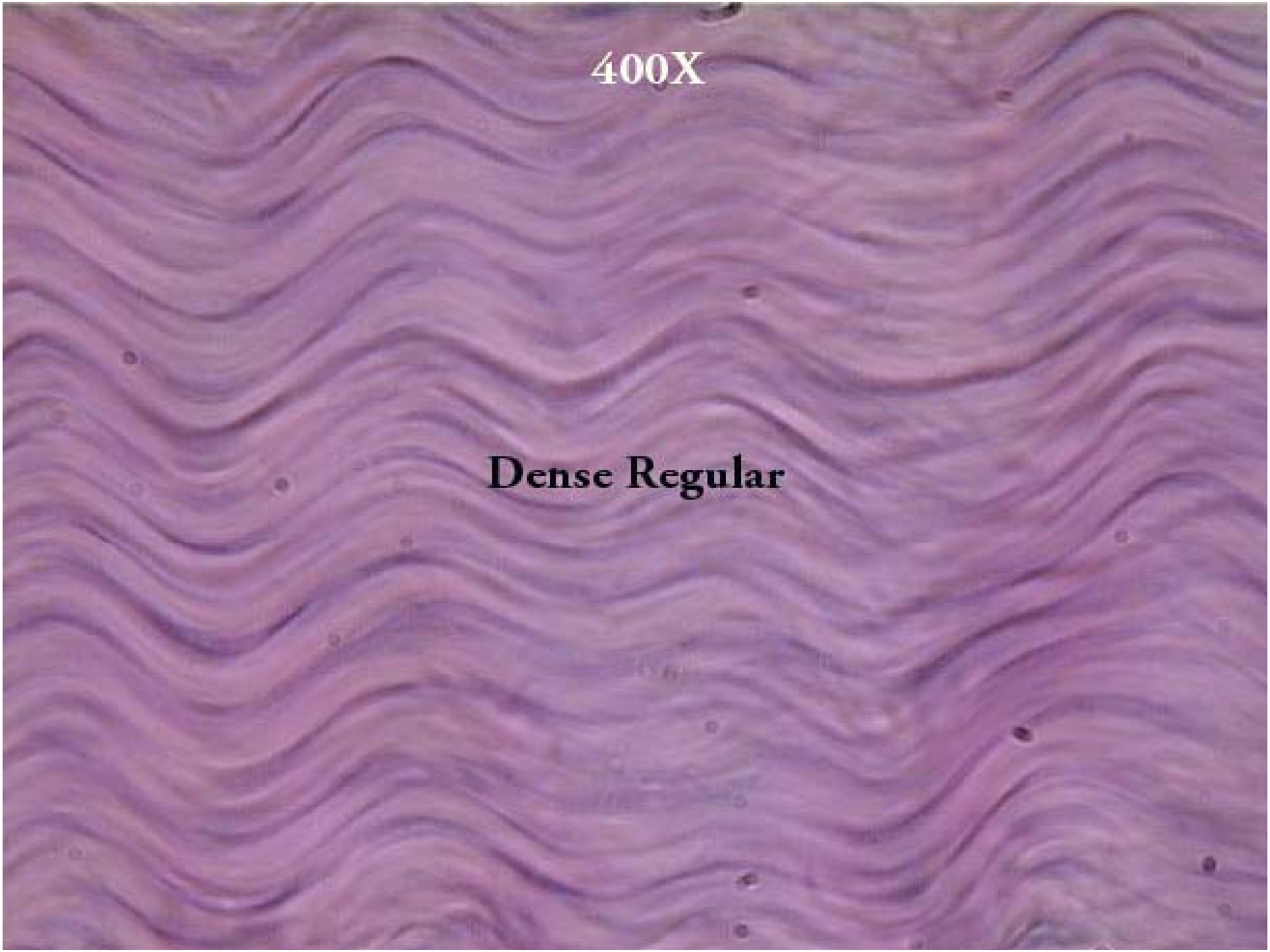

Non-lactating Breast H&E
collagen fibres
blood vessels
connective tissue
cell nuclei

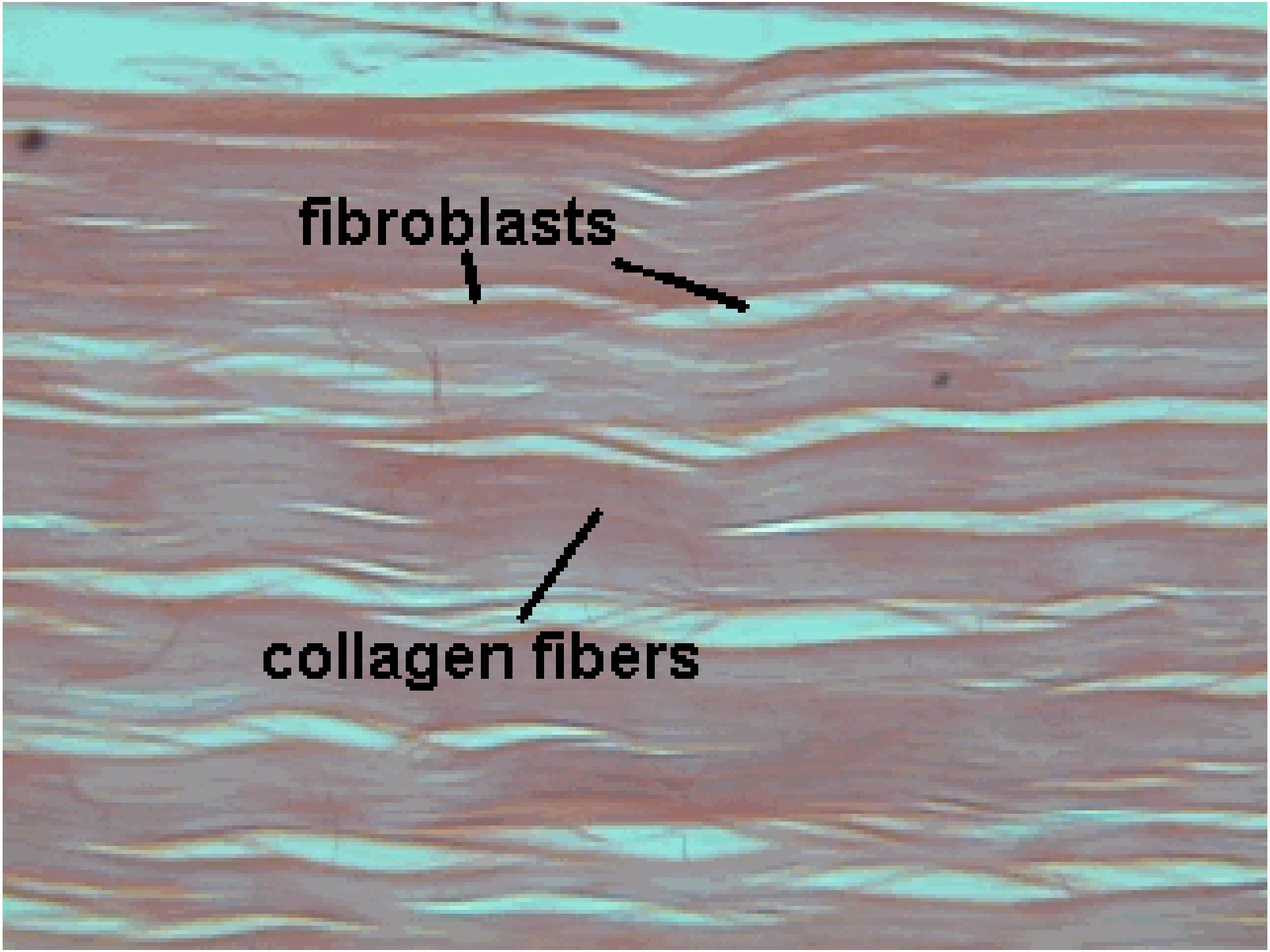

Sebaceous
Gland
DI CT

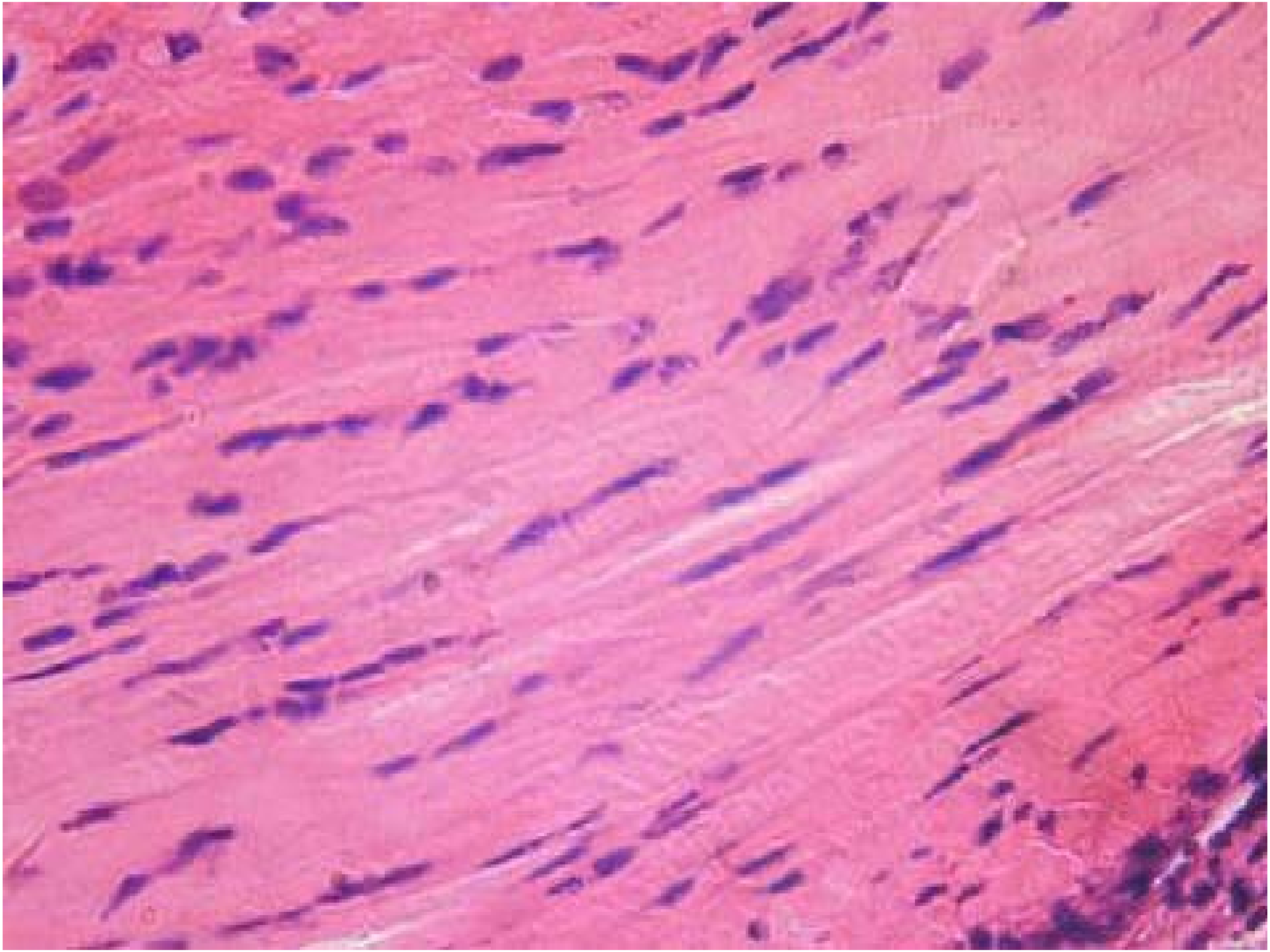
More Connective Tissues

- **Dense connective tissue**
  - Tendons & ligaments
  - Collagen dominates




400X
Dense Regular


fibroblasts
collagen fibers

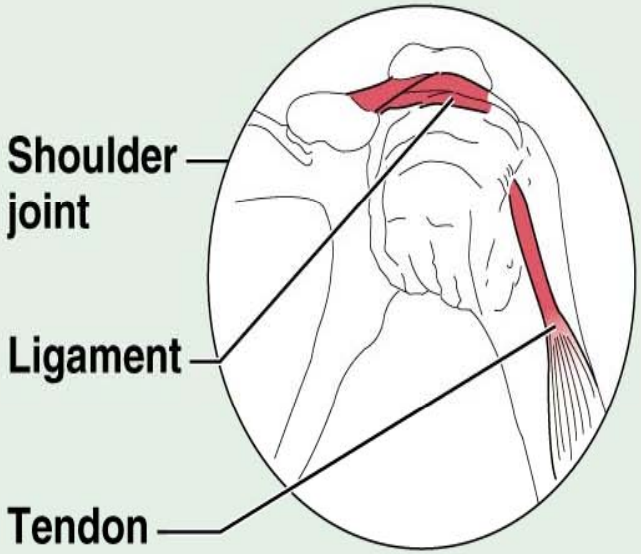


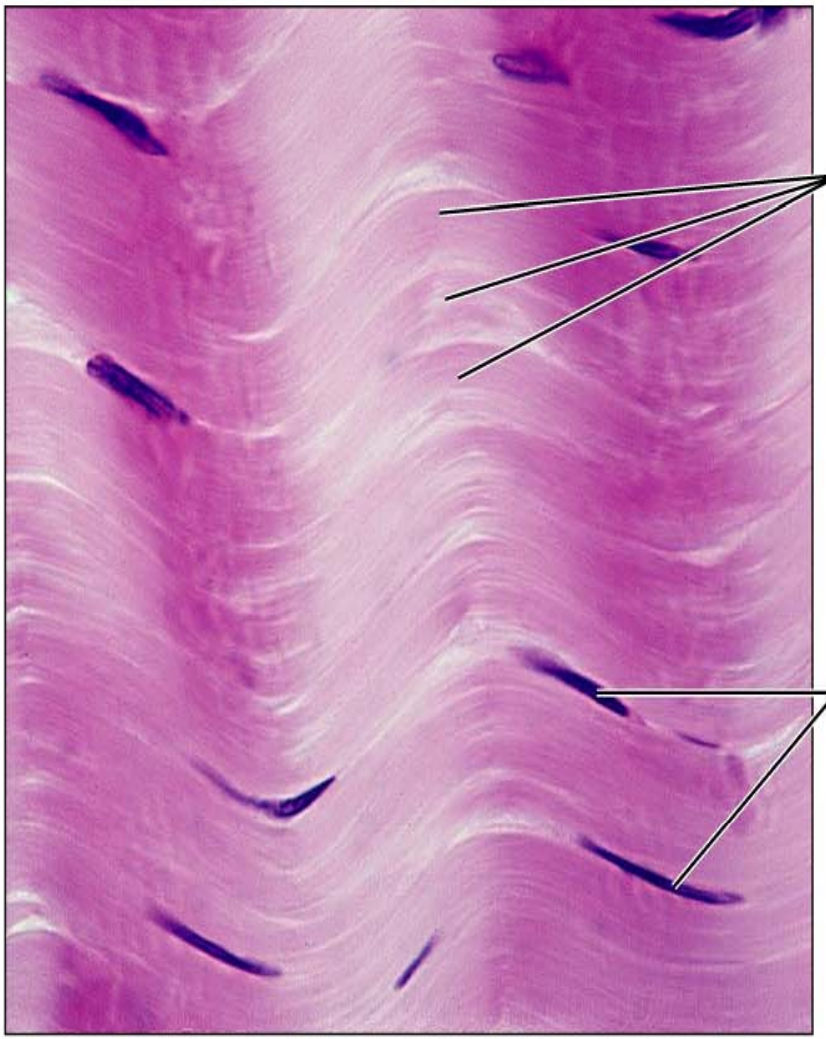
(d) Connective tissue proper: dense connective tissue, dense regular

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.

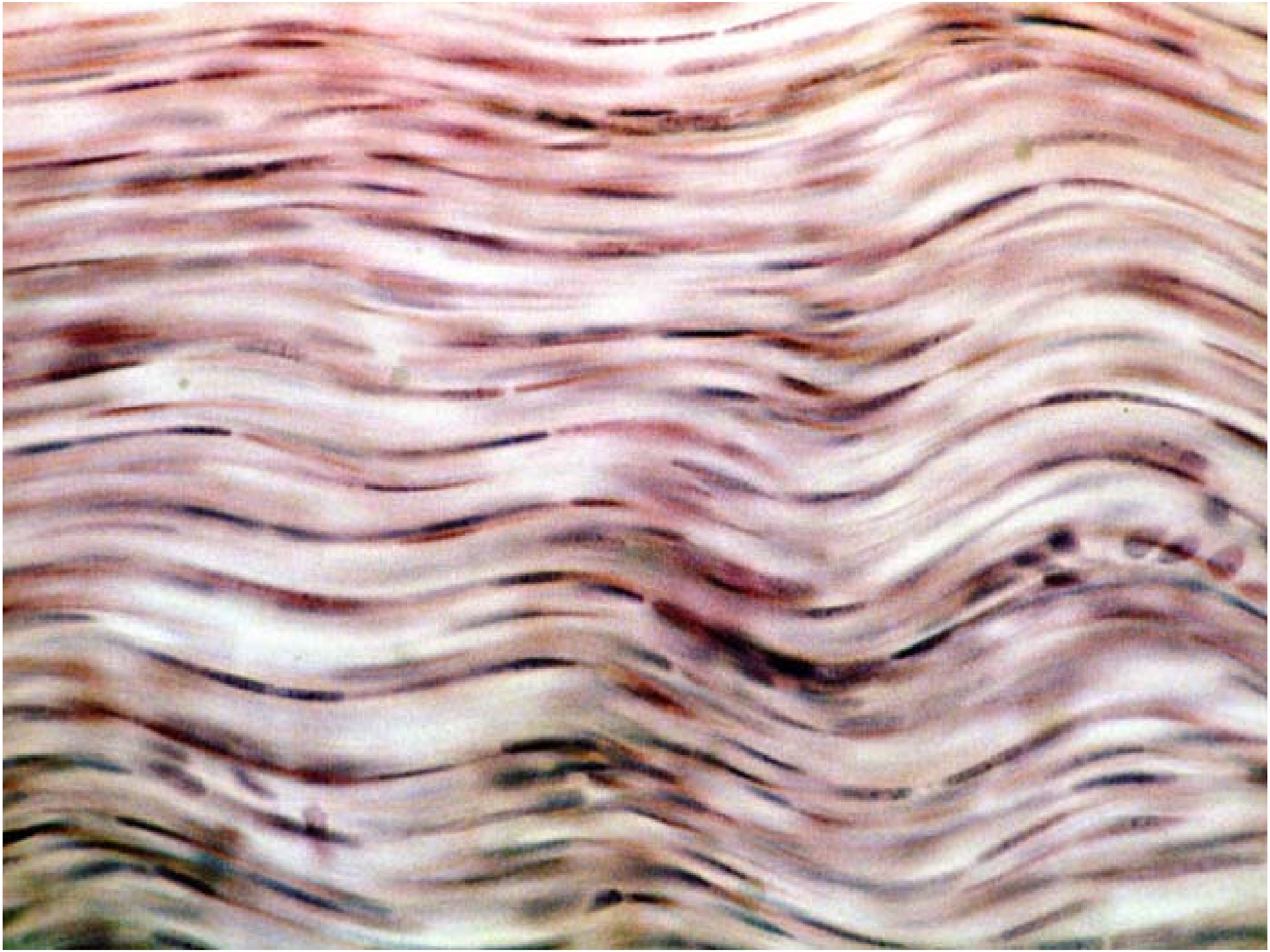
Location: Tendons, most ligaments, aponeuroses.





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

Figure 4.9d

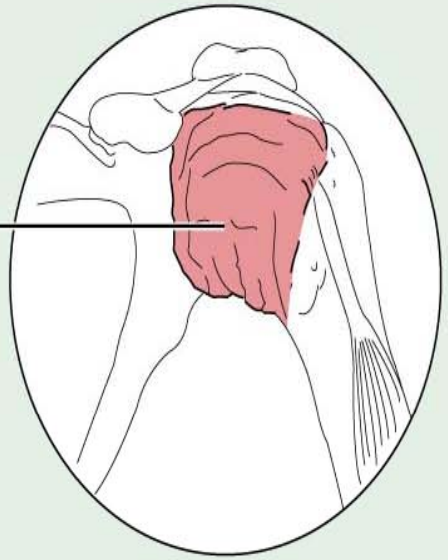


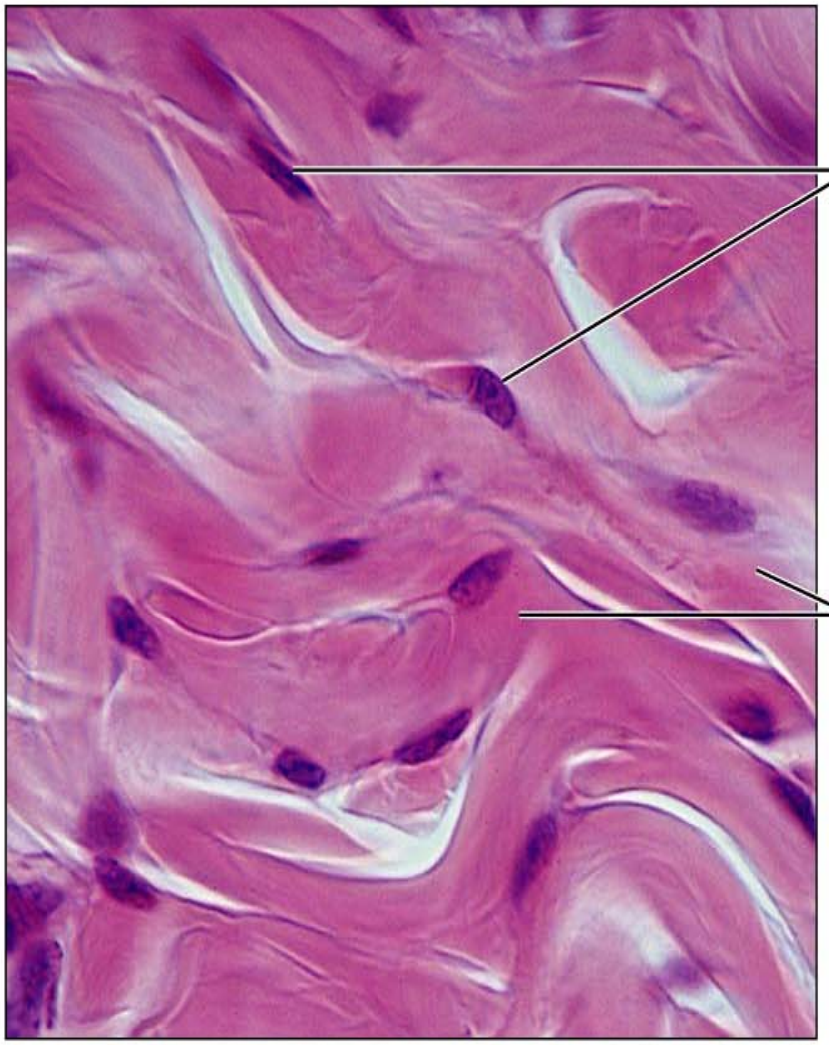
(e) Connective tissue proper: dense connective tissue, dense irregular

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.

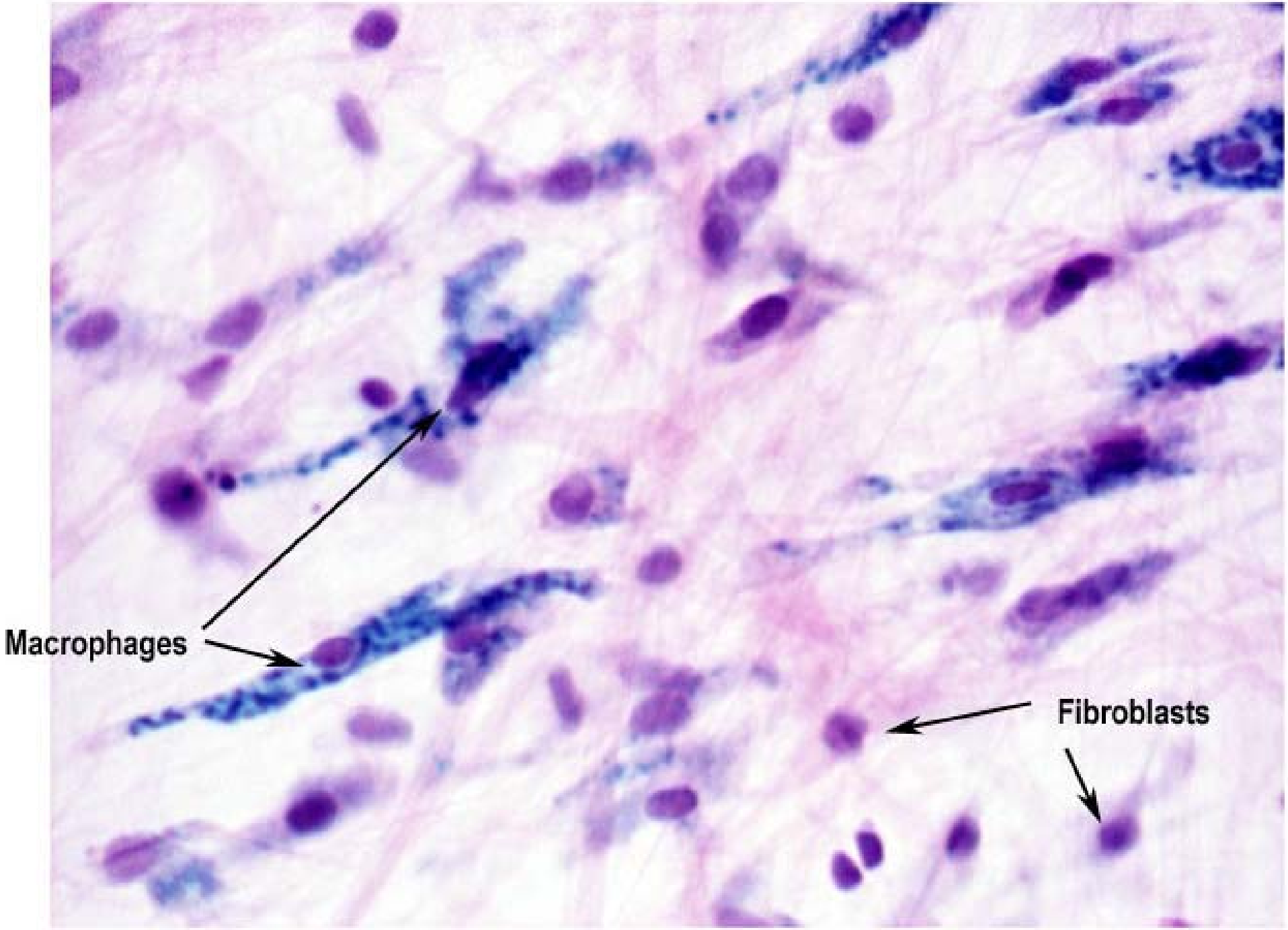
Location: Dermis of the skin; submucosa of digestive tract; fibrous capsules of organs and of joints.

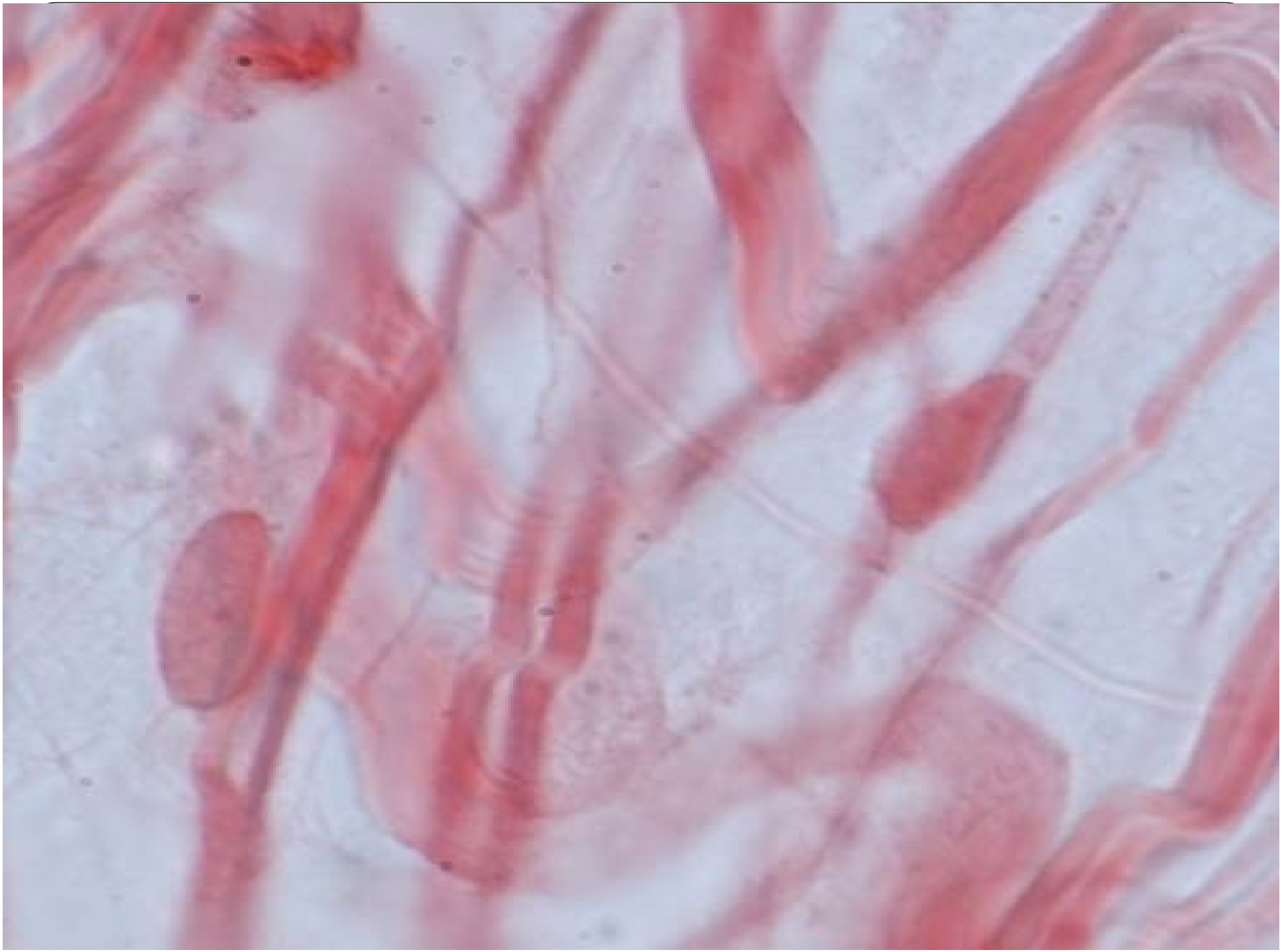


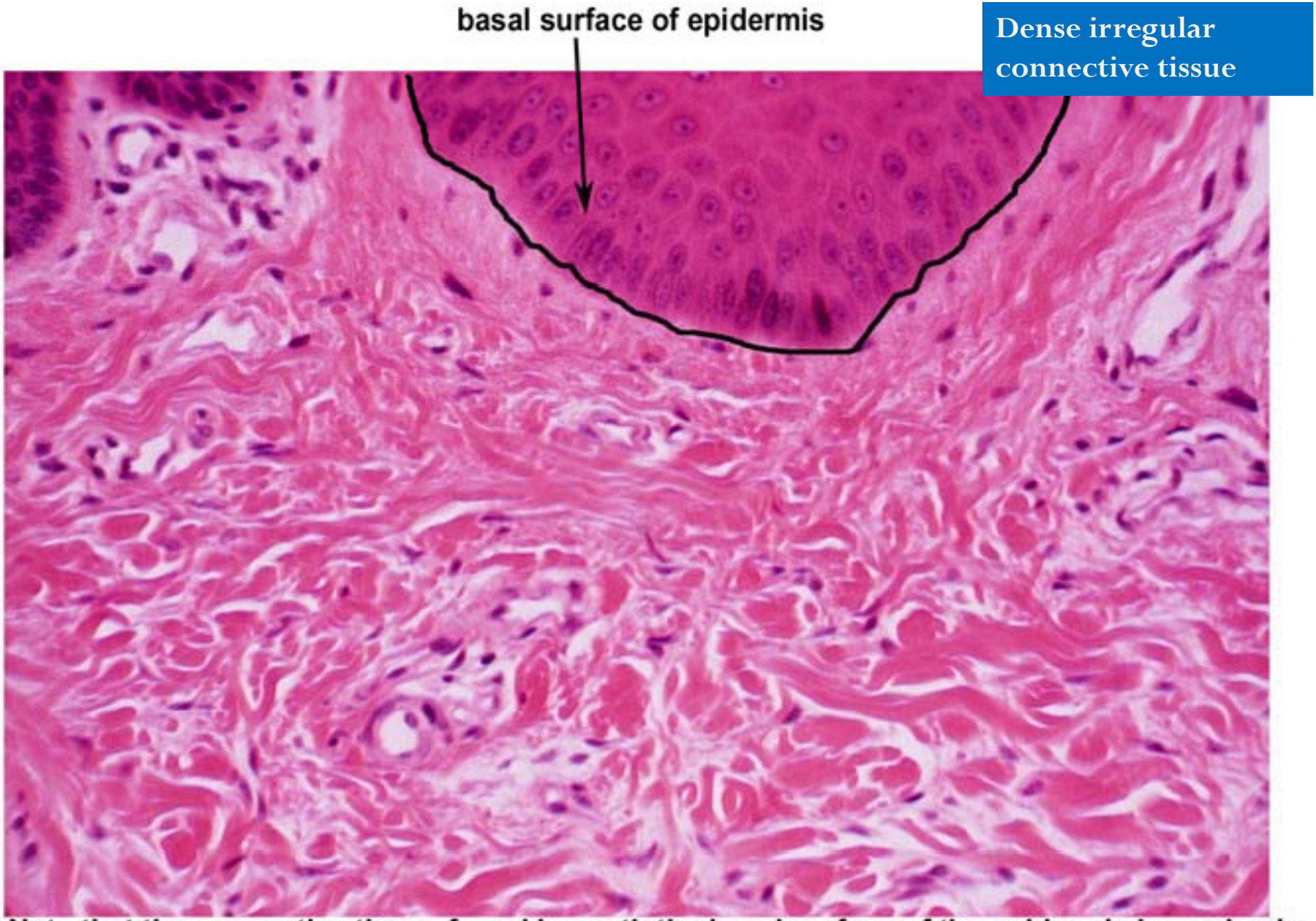


Photomicrograph: Dense irregular connective tissue from the dermis of the skin (400×).

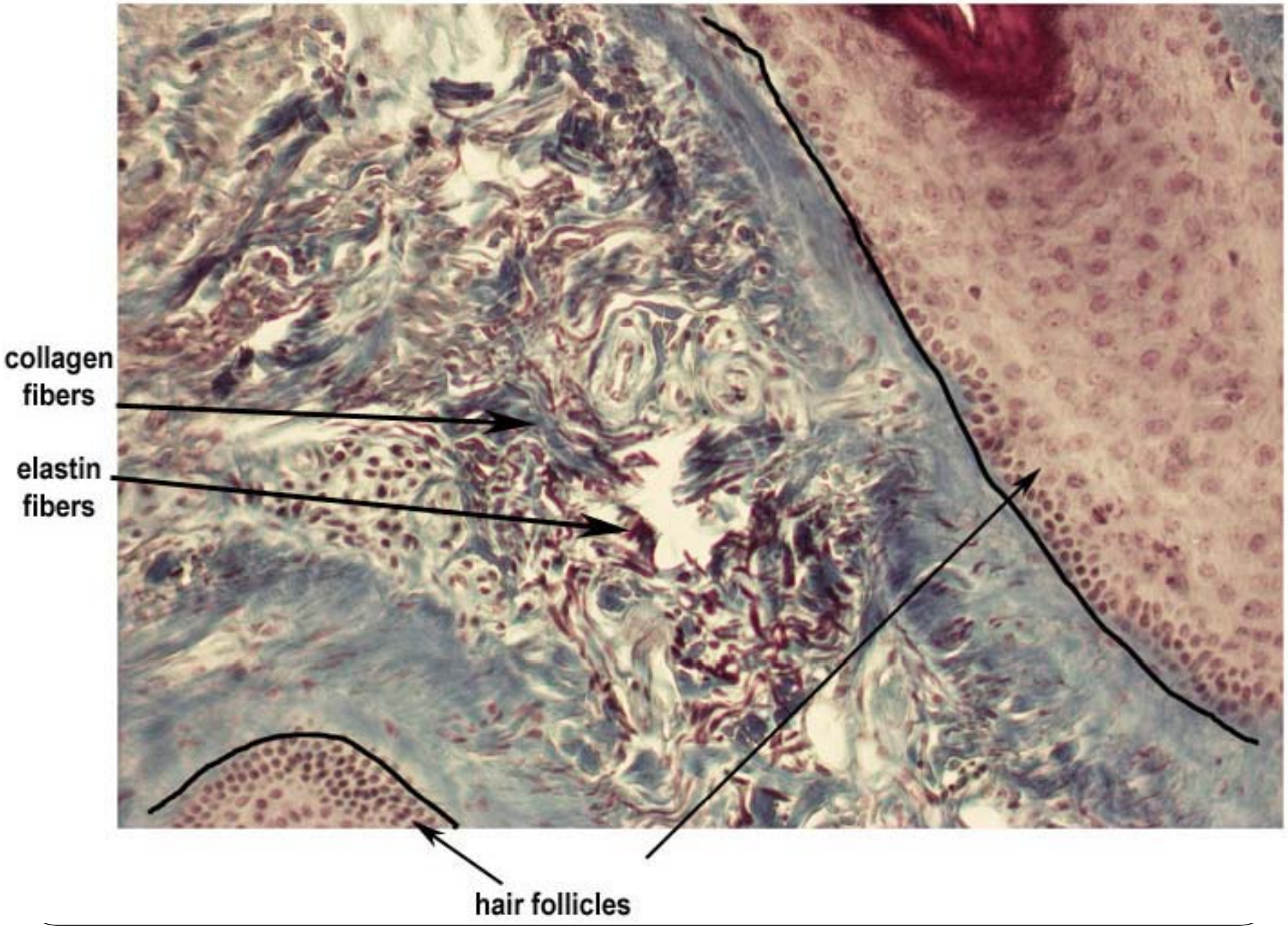
Figure 4.9e

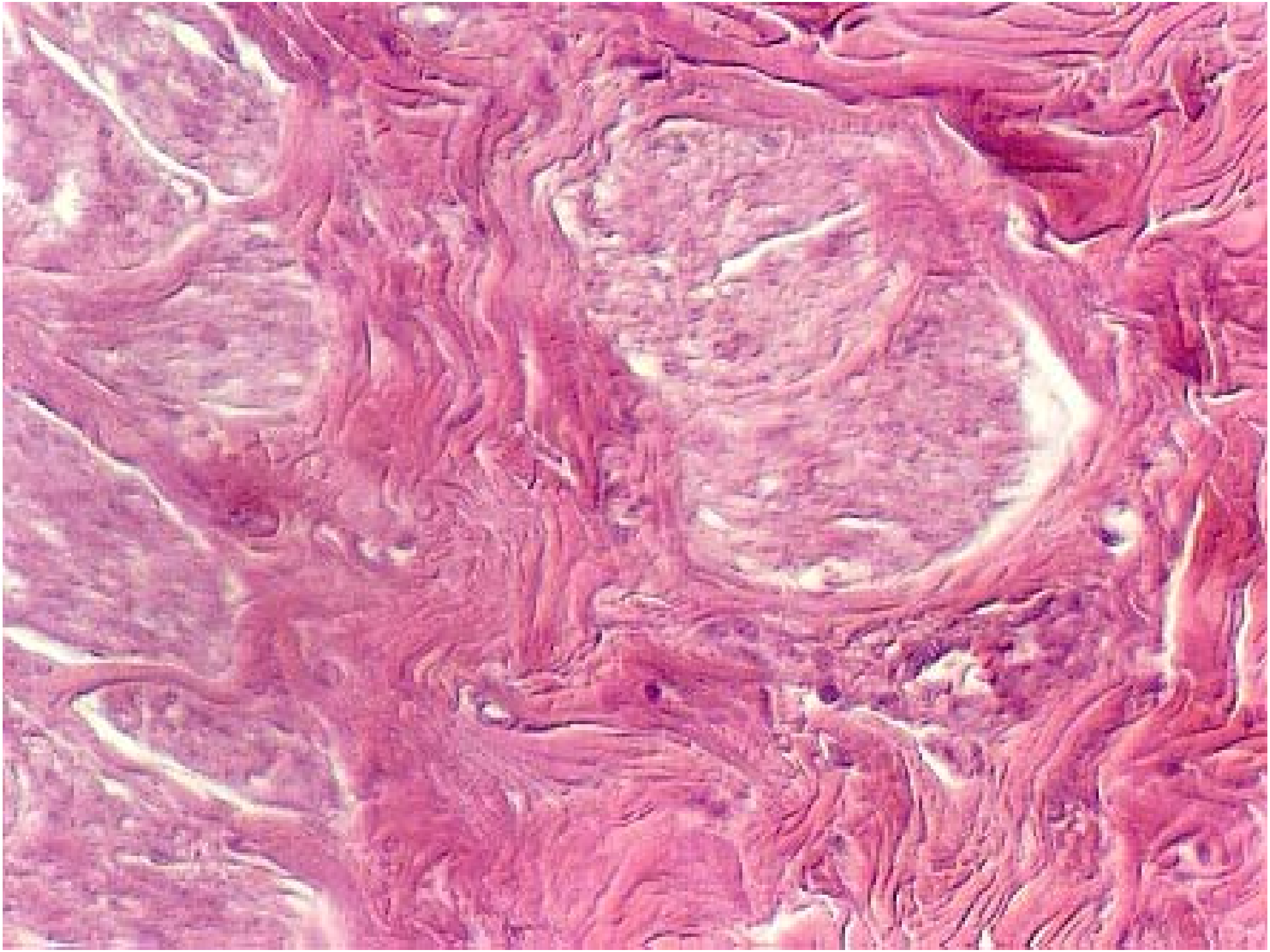

Macrophages
Fibroblasts

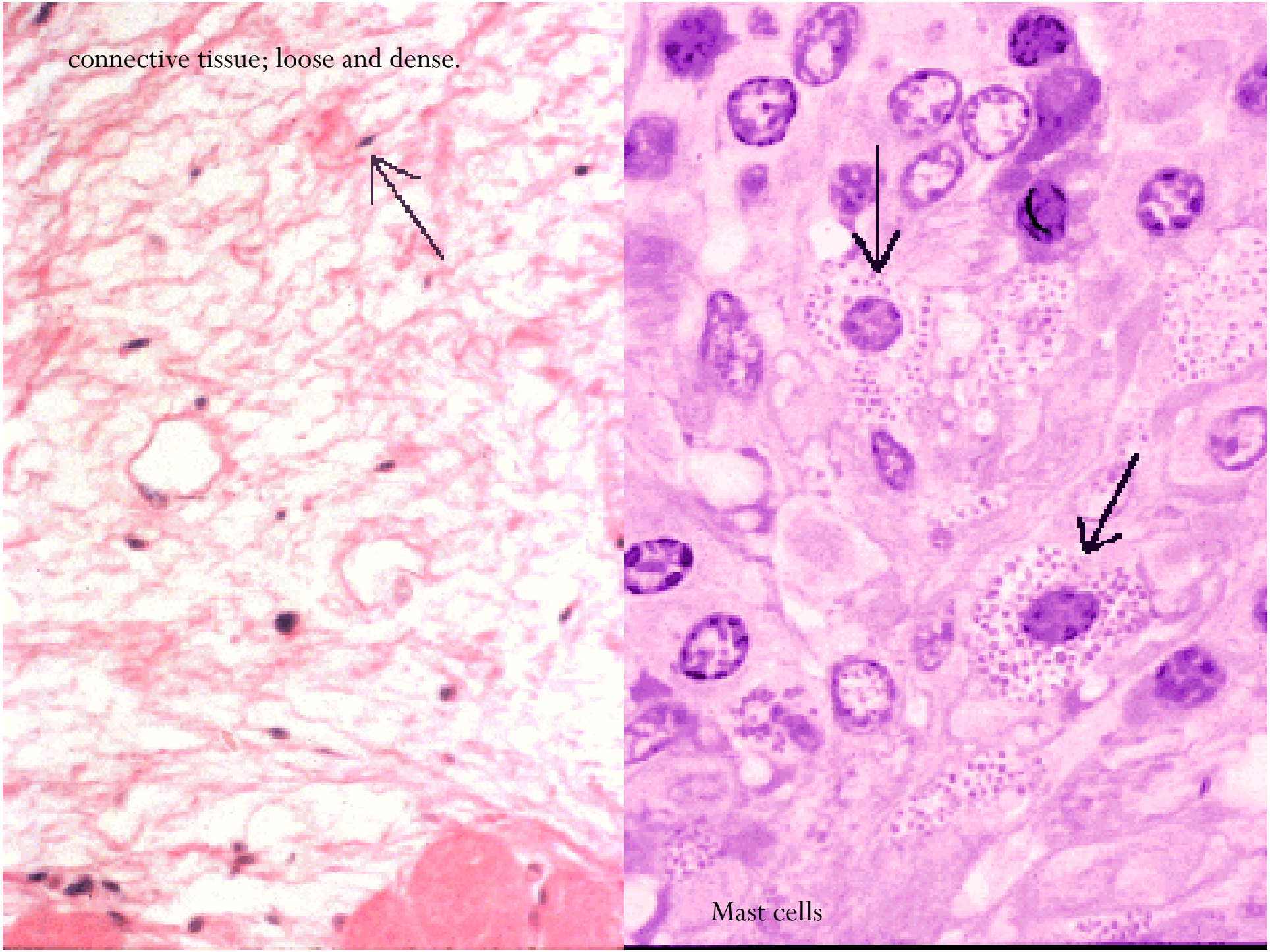


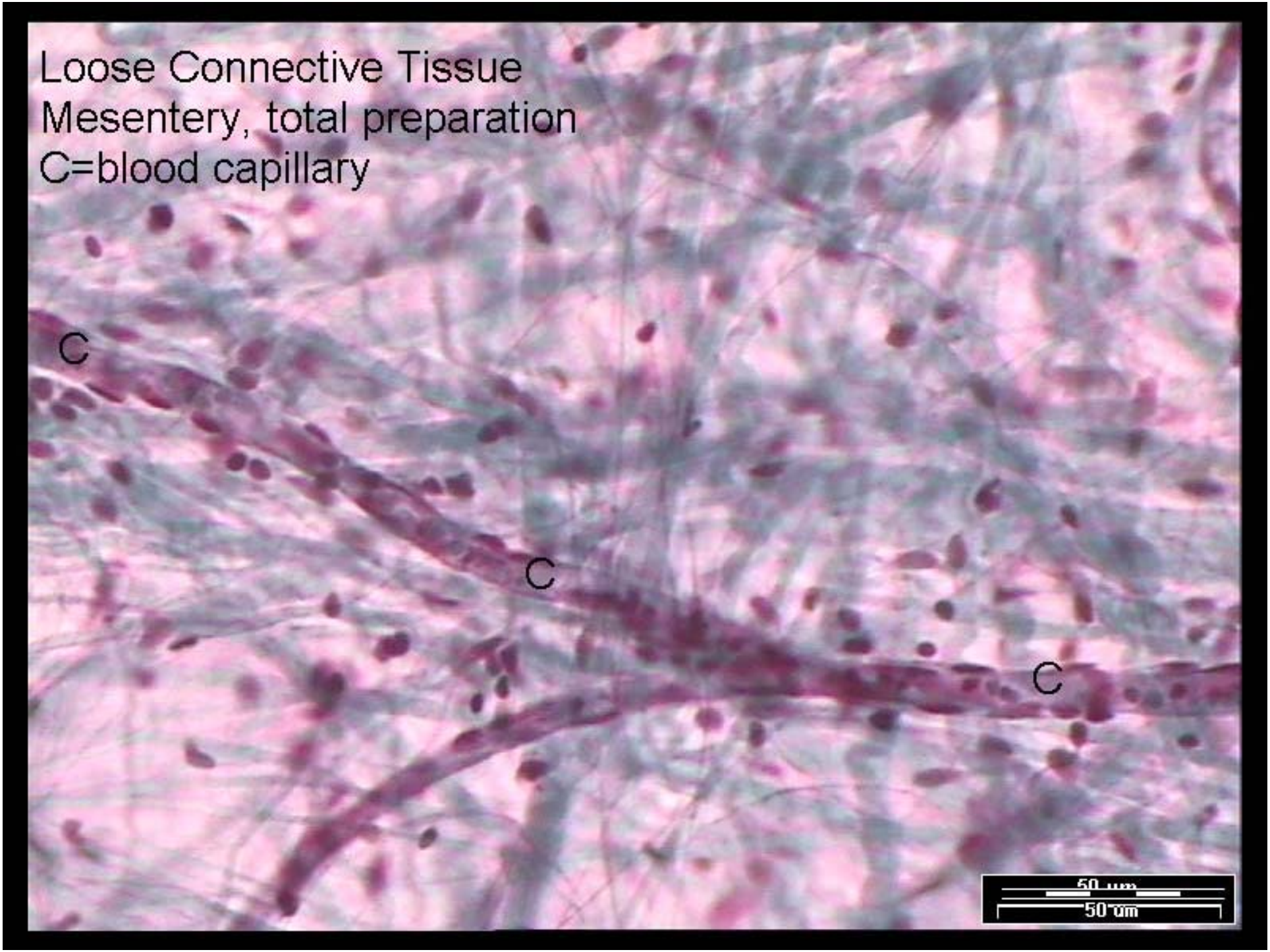


Note that the connective tissue found beneath the basal surface of the epidermis is randomly oriented.


collagen fibers
elastin fibers
hair follicles




connective tissue; loose and dense.
Mast cells

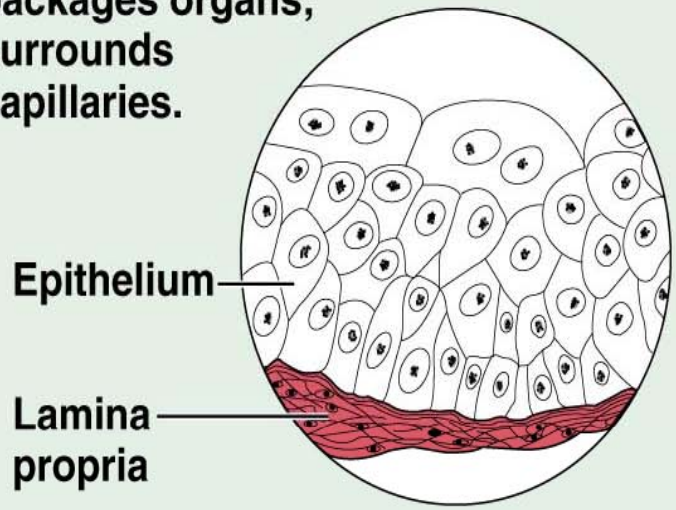

Loose Connective Tissue
Mesentery, total preparation
C=blood capillary
C
C
C
50 µm
50 µm

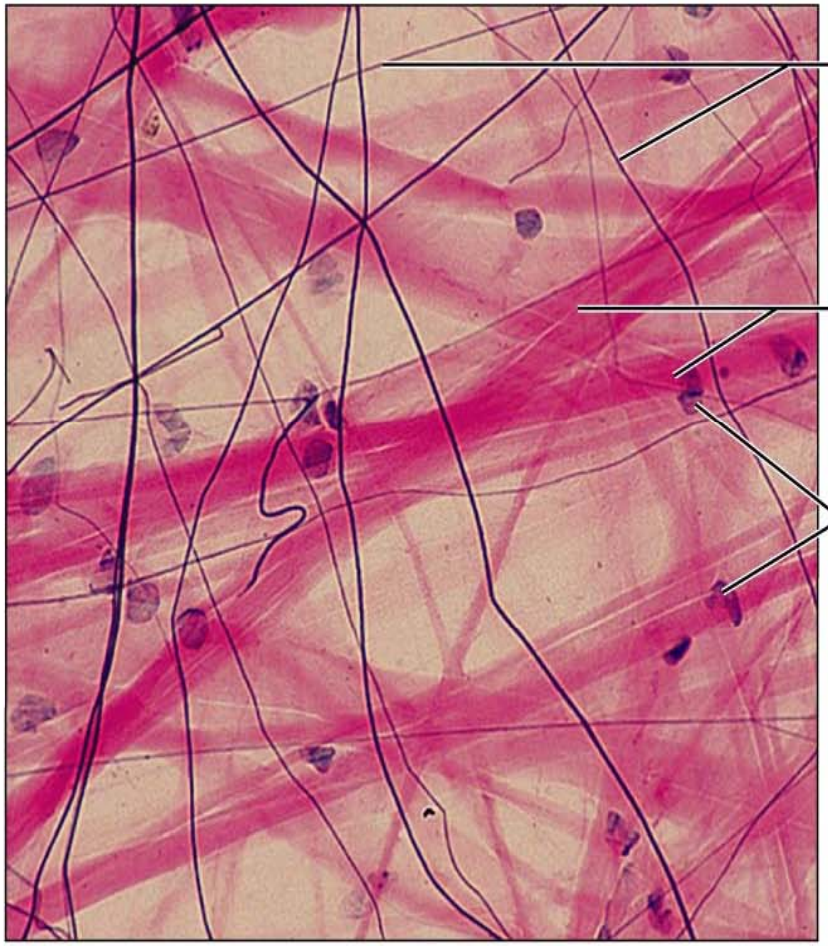
(a) Connective tissue proper: loose connective tissue, areolar

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

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

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





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

Figure 4.9a

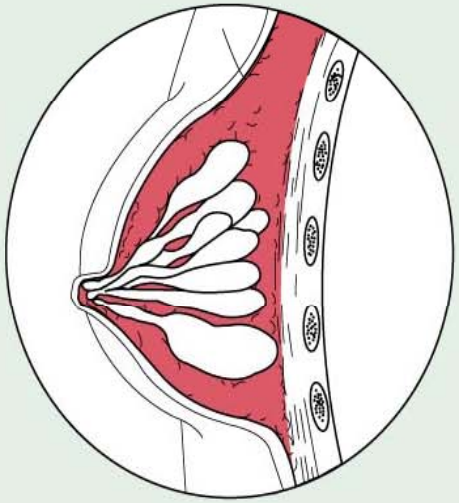
Adipose tissue

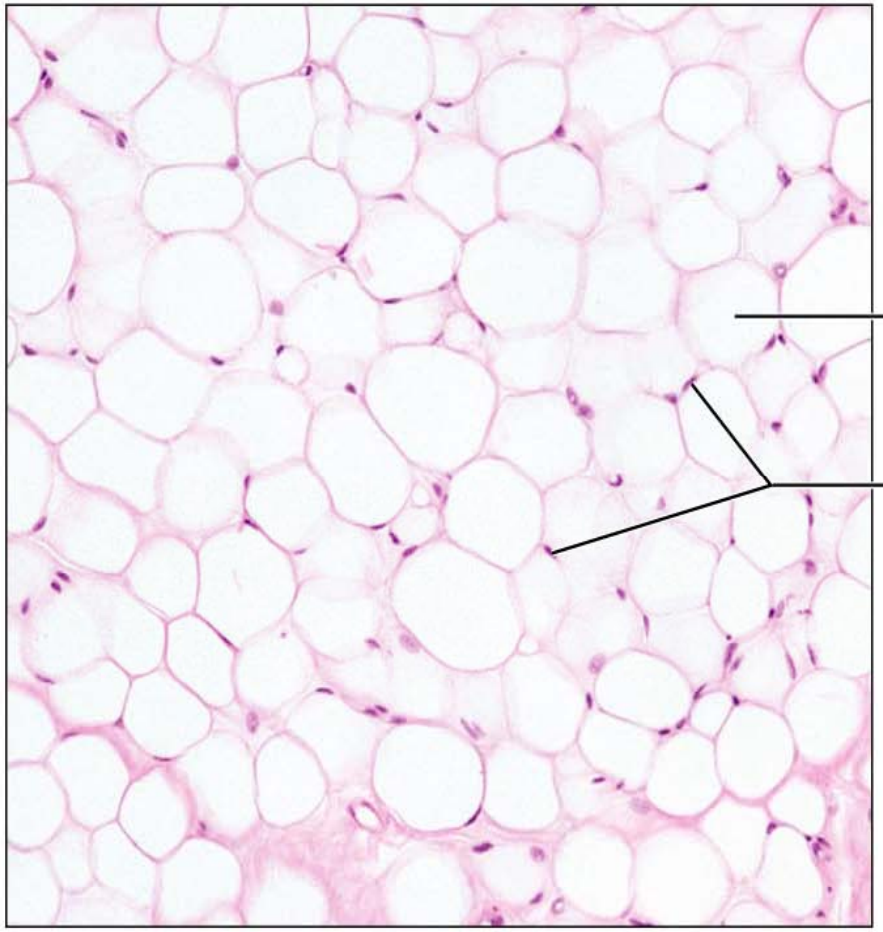
(b) Connective tissue proper: loose connective tissue, adipose

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

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

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





Photomicrograph: Adipose tissue from the subcutaneous layer under the skin (450×).

Figure 4.9b

Adipose tissue

•Loose connective tissue composed of adipocytes.

• It is technically composed of roughly **only 80% fat**;
•fat in its solitary state exists in the liver and muscles.

•Adipose tissue is derived from lipoblasts.
•Its main role is to store energy in the form oflipids, although it also cushions and insulates the body.

•Major endocrineorgan, as it produces hormones such as :
•leptin,
•estrogen,
• resistin,
• the cytokine TNFα.

•Moreover, adipose tissue can affect other organ systems of the body and may lead to disease.

• The two types of adipose tissue are white adipose tissue (WAT) and brown adipose tissue (BAT).

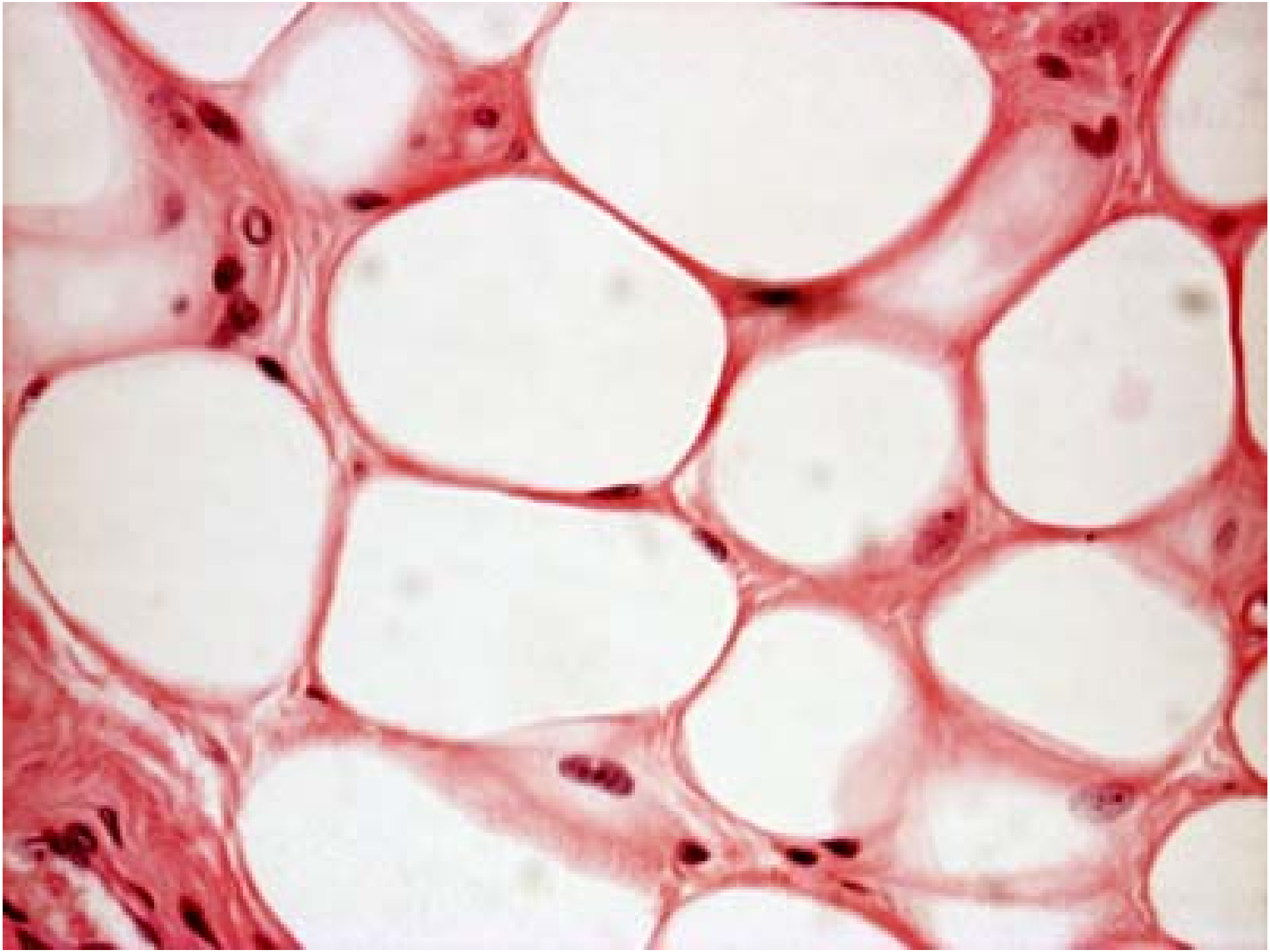

Adipose Tissue, White
50 um
50 um

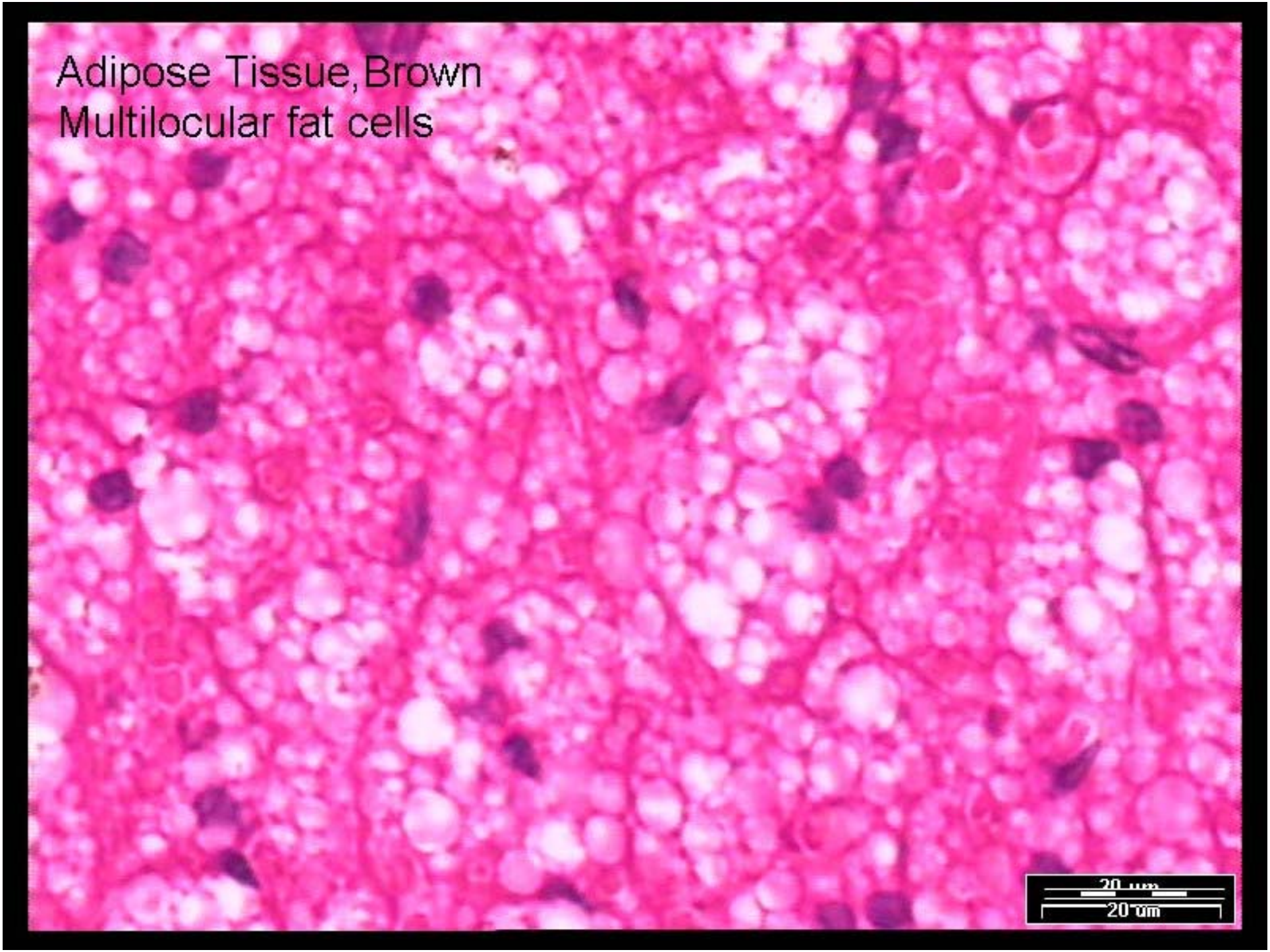
White adipose tissue

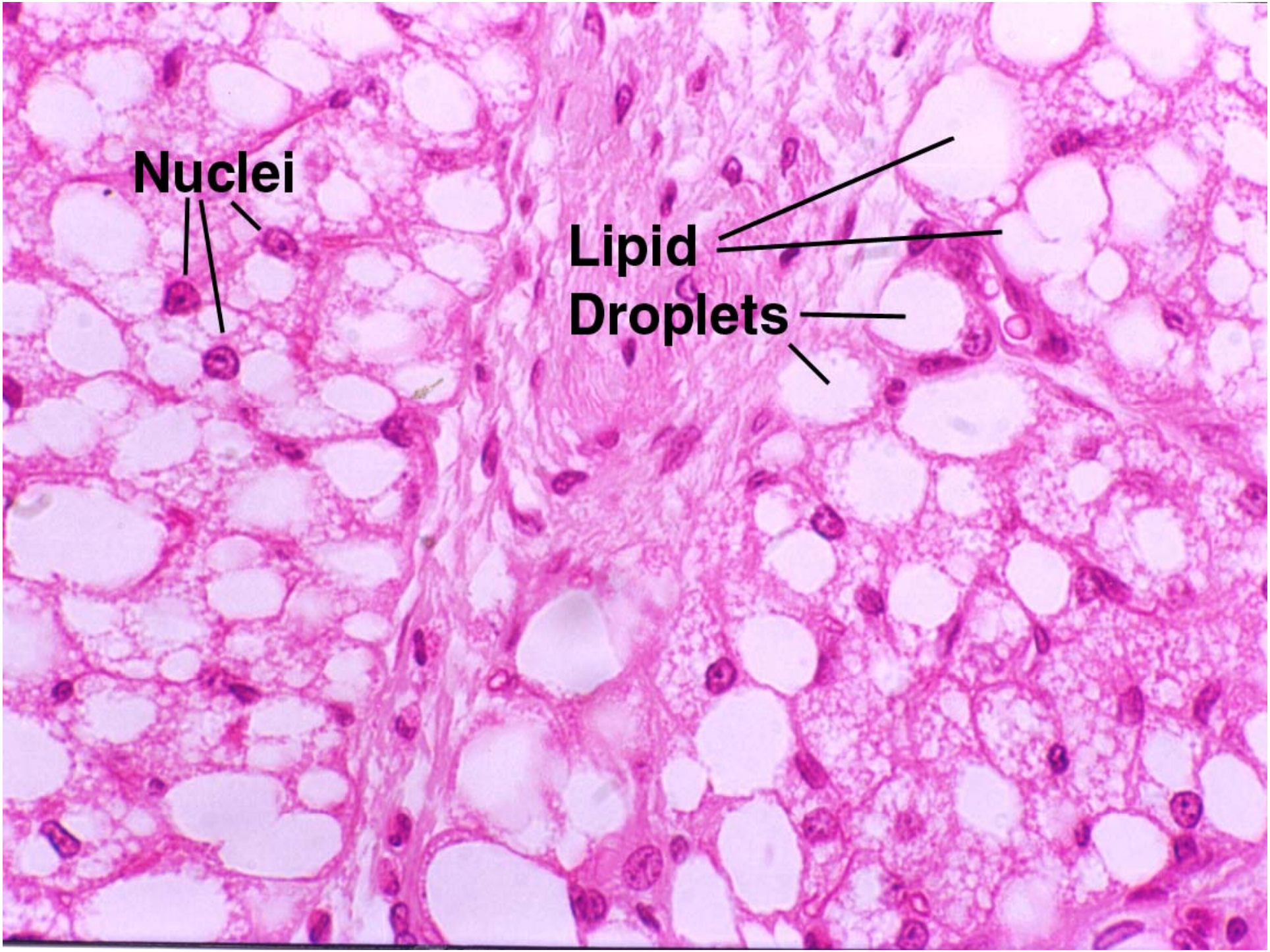
•Normal body fat
•Very large spherical cells which may become polyhedral due to deformation
•Contain single fat droplet with cytoplasm reduced to thin rim net to plasma membrane
•Nucleus displayed to one side of cell and flattened by accumulated fat
•Routine histological techniques extract the fat, leaving a large unstained space
•Adipose tissue may be portioned by connective tissue septa visible to the naked eye

Brown adipose tissue

•Prominent in newborn of all mammals
•In adults most conspicuous in species which hibernate
•Present in man throughout life
•Cells are smaller than those of white adipose tissue
•Cytoplasm relative abundant and contains lipid droplets of varying size
•Cytoplasm contains extraordinary large number of mitochondria
•Brown fat has a lobular organization
•Highly vascular with blood vessel distribution similar to that of a gland
•Numerous small unmyelinated nerves with axons ending on cell surface




Adipose Tissue, Brown
Multilocular fat cells
20 um
20 um


Nuclei
Lipid
Droplets

Adipose tissue

Adipose tissue is located :

- **beneath the skin (subcutaneous fat),**
- **around internal organs (visceral fat),**
- **in bone marrow (yellow bone marrow)**
- **in breast tissue.**

Adipose tissue

Adipose tissue contains several cell types, with the highest percentage of cells being :

- **Adipocytes, which contain fat droplets.**
- **Fibroblasts,**
- **Macrophages,**
- **Endothelial cells**
- **Stem cells**

excess adipose tissue hanging downward from the abdomen is referred to as a panniculus (or pannus). A panniculus complicates surgery of the morbidly obese.

Adipose tissue is the greatest peripheral source of aromatase in both males and females, contributing to the production of estradiol.

Adipose derived hormones include:

- **Adiponectin**
- **Resistin**
- **Plasminogen activator inhibitor-1 (PAI-1)**
- **TNFα**
- **IL-6**
- **Leptin**
- **Estradiol (E2)**

Adipose tissues also secrete a type of cytokines (cell-to-cell signalling proteins) called adipokines (adipocytokines), which play a role in obesity-associated complications.

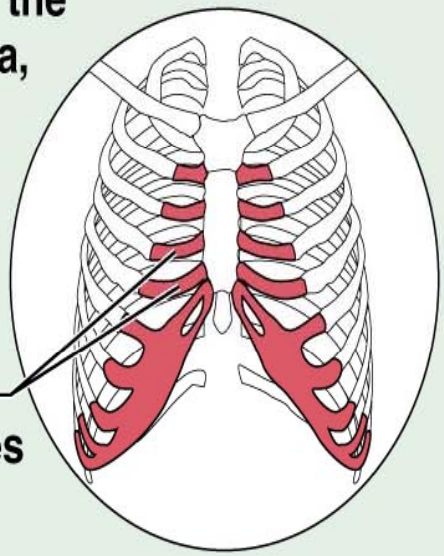
Other that will be studied in the mutual section

(f) Cartilage: hyaline

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

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

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



Photomicrograph: Hyaline cartilage from the trachea (300×).

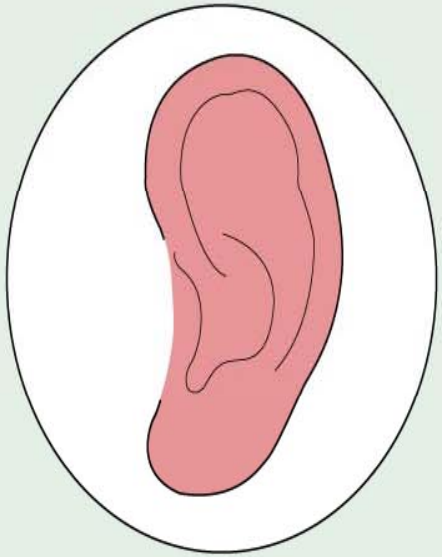
Figure 4.9f

(g) Cartilage: elastic

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

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

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



Photomicrograph: Elastic cartilage from the human ear pinna; forms the flexible skeleton of the ear (640×).

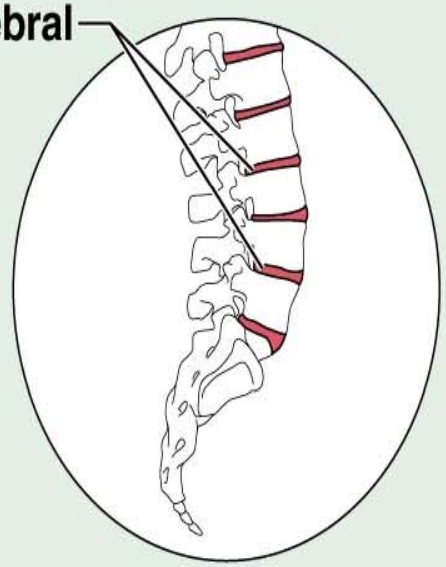
Figure 4.9g

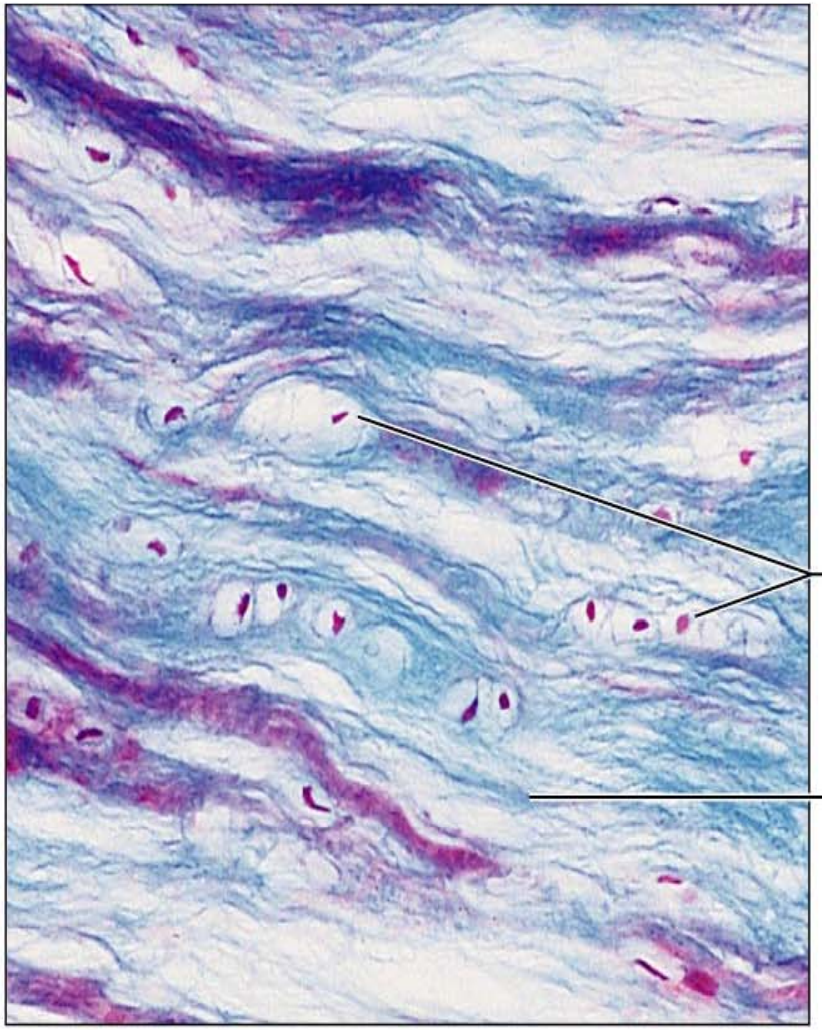
(h) Cartilage: fibrocartilage

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

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

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





Photomicrograph: Fibrocartilage of an intervertebral disc (200×). Special staining produced the blue color seen.

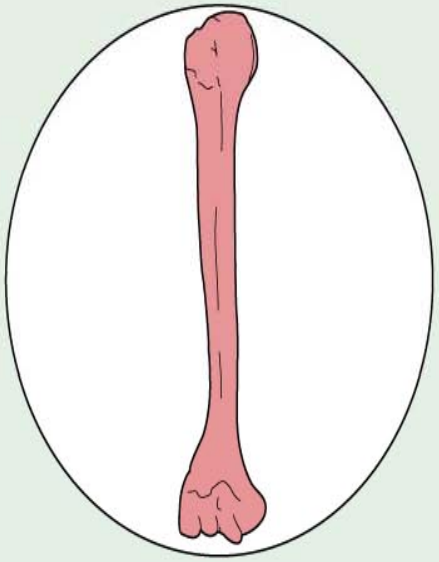
Figure 4.9h

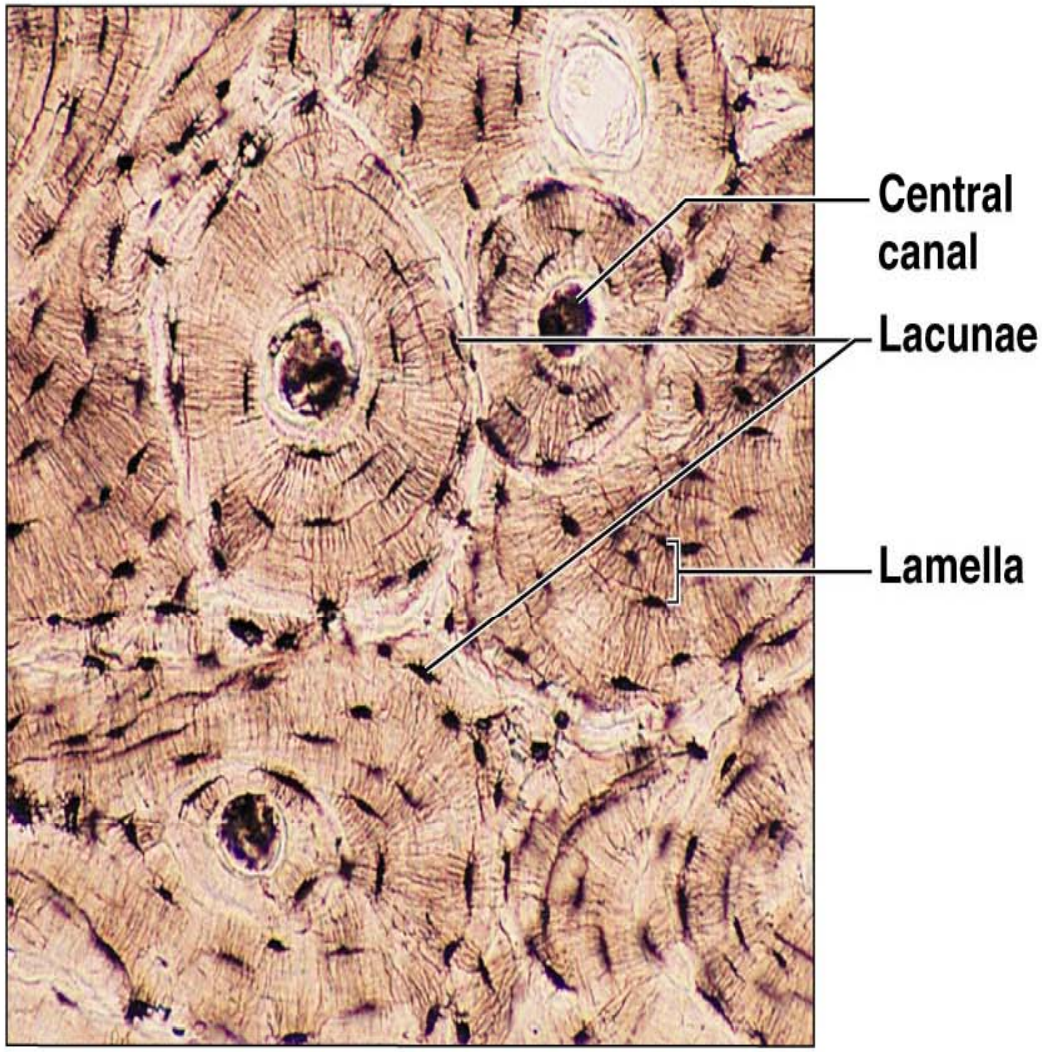
(i) Others: bone (osseous tissue)

Description: Hard, calcified matrix containing many collagen fibers; osteocytes lie in lacunae. Very well vascularized.

Function: Bone supports and protects (by enclosing); provides levers for the muscles to act on; stores calcium and other minerals and fat; marrow inside bones is the site for blood cell formation (hematopoiesis).

Location: Bones



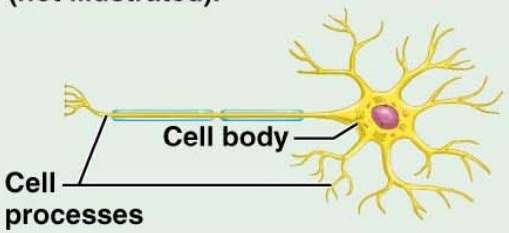


Photomicrograph: Cross-sectional view of bone (70×).

Figure 4.9i

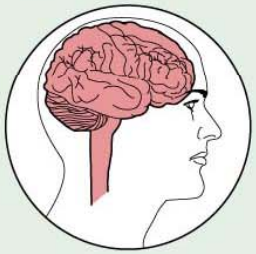
Nervous tissue

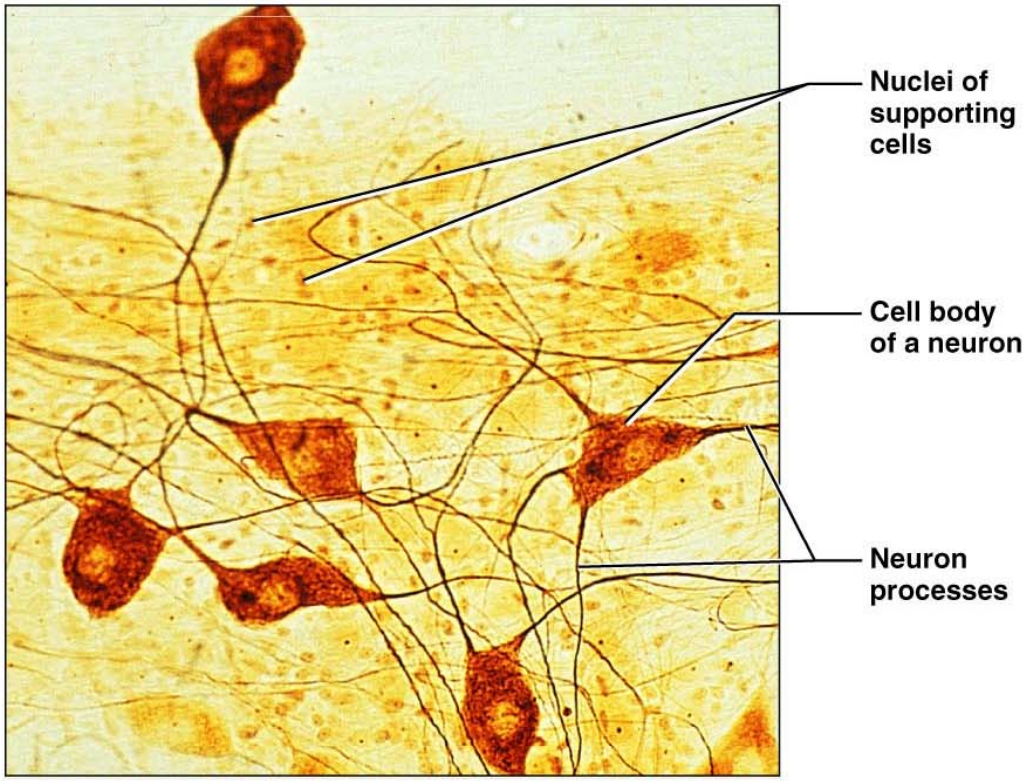
Description: Neurons are branching cells; cell processes that may be quite long extend from the nucleus-containing cell body; also contributing to nervous tissue are nonirritable supporting cells (not illustrated).



Function: Transmit electrical signals from sensory receptors and to effectors (muscles and glands) which control their activity.

Location: Brain, spinal cord, and nerves.





Photomicrograph: Neurons (100×)

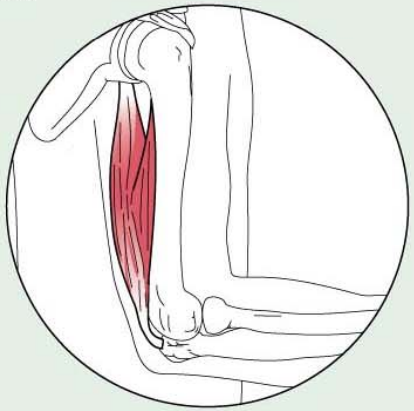
Figure 4.10

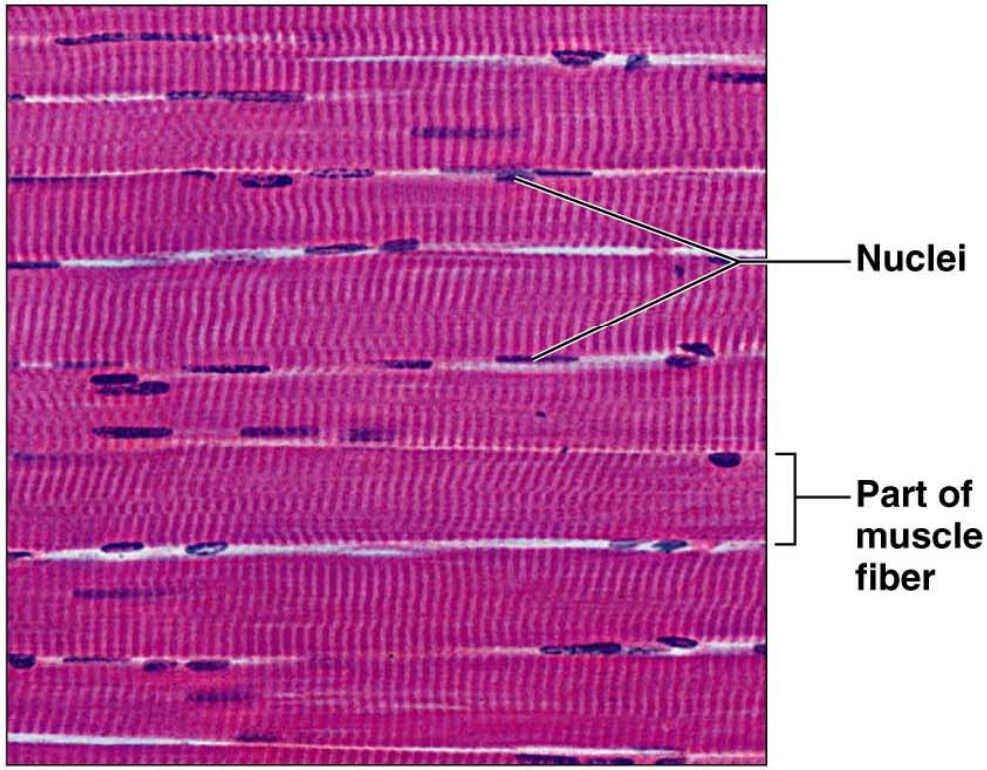
(a) Skeletal muscle

Description: Long, cylindrical, multinucleate cells; obvious striations.

Function: Voluntary movement; locomotion; manipulation of the environment; facial expression; voluntary control.

Location: In skeletal muscles attached to bones or occasionally to skin.



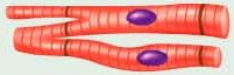


Photomicrograph: Skeletal muscle (approx. 300×). Notice the obvious banding pattern and the fact that these large cells are multinucleate.

Figure 4.11a

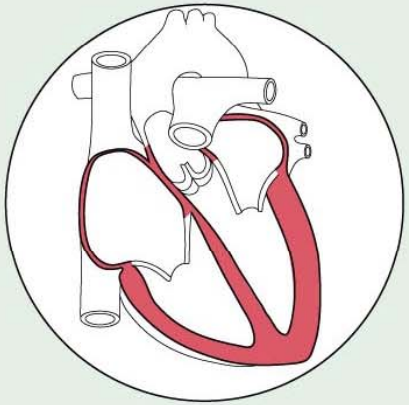
(b) Cardiac muscle

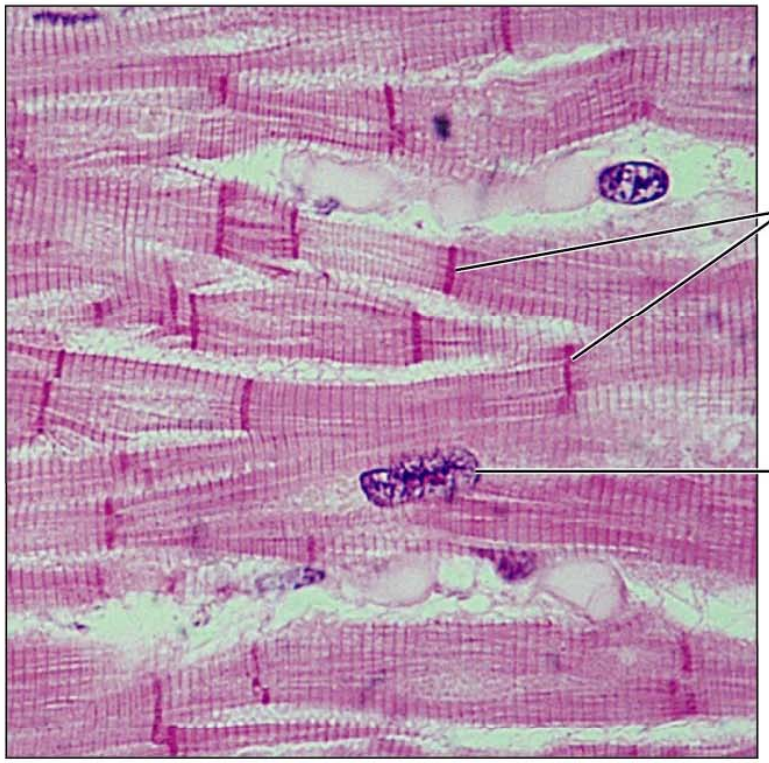
Description: Branching, striated, generally uninucleate cells that interdigitate at specialized junctions (intercalated discs).



Function: As it contracts, it propels blood into the circulation; involuntary control.

Location: The walls of the heart.





Photomicrograph: Cardiac muscle (800×); notice the striations, branching of cells, and the intercalated discs.

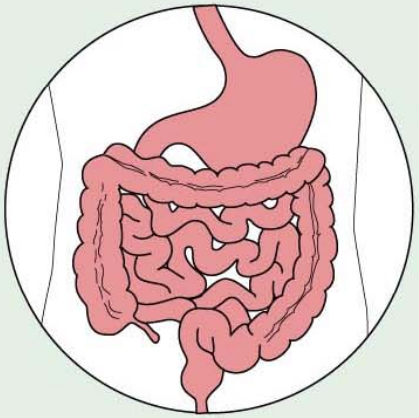
Figure 4.11b

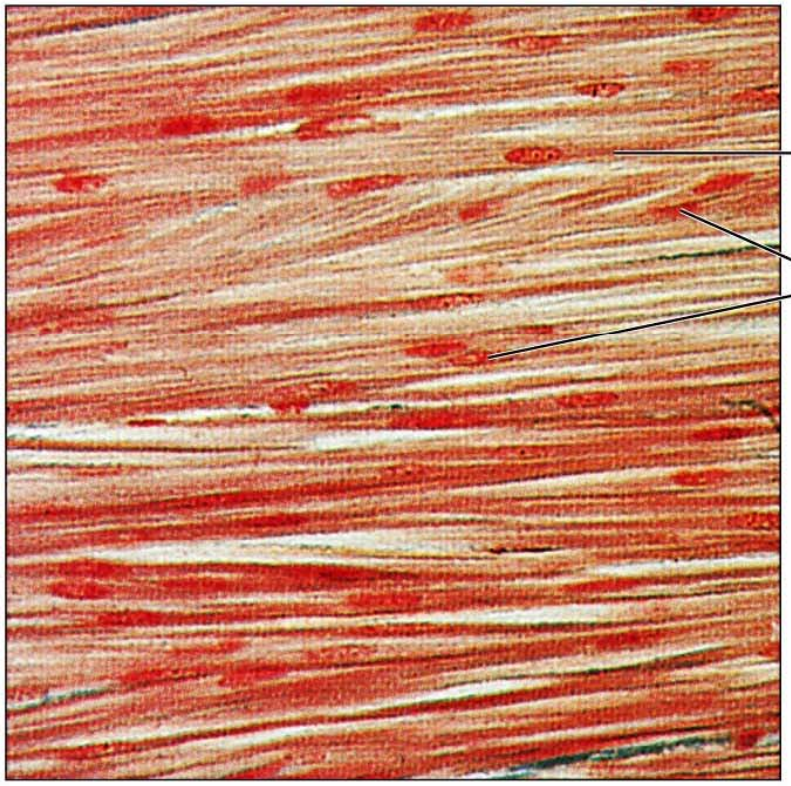
(c) Smooth muscle

Description: Spindle-shaped cells with central nuclei; no striations; cells arranged closely to form sheets.

Function: Propels substances or objects (foodstuffs, urine, a baby) along internal passageways; involuntary control.

Location: Mostly in the walls of hollow organs.





Photomicrograph: Sheet of smooth muscle (approx. 600×).

Figure 4.11c

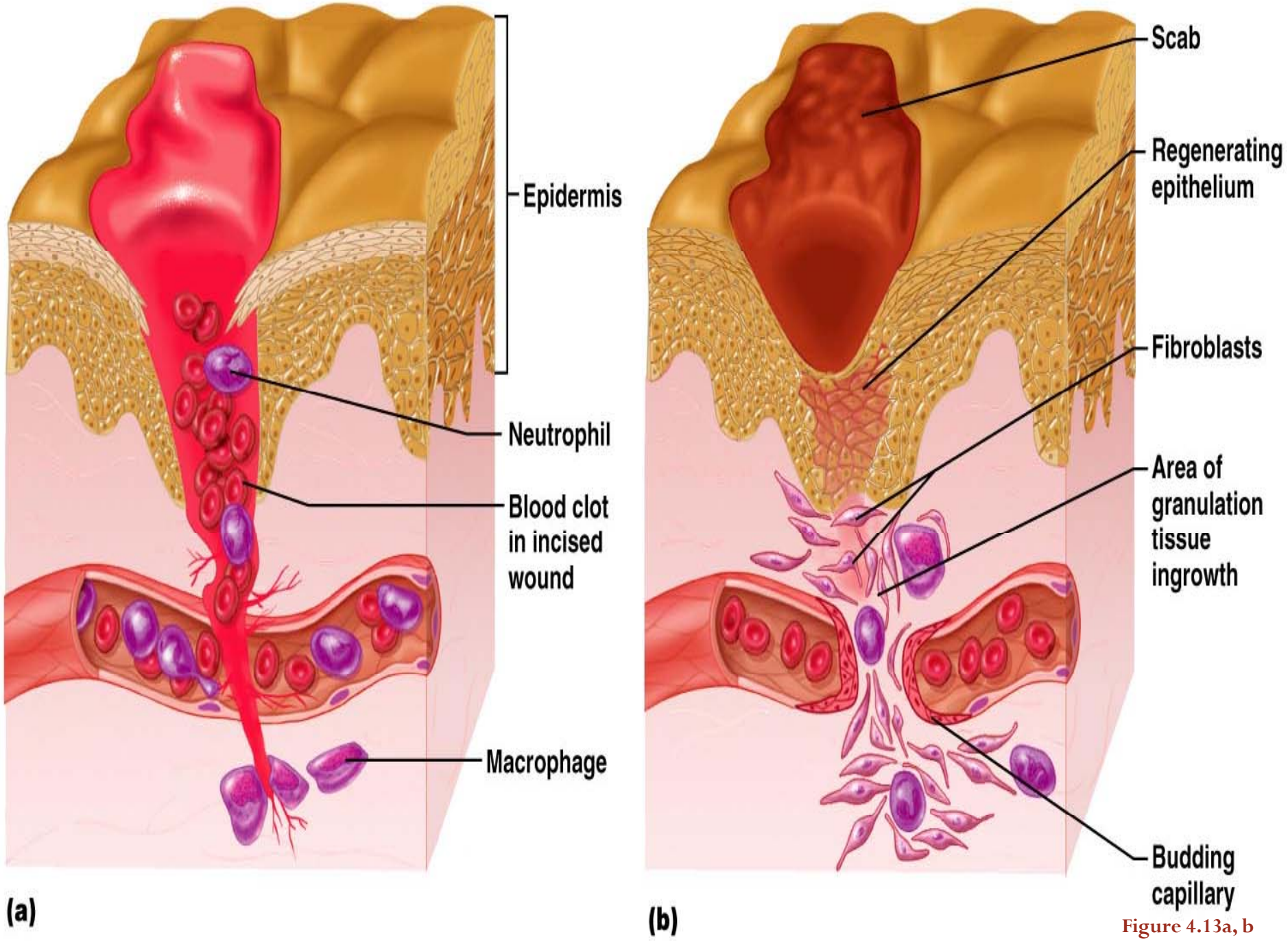


Figure 4.13a, b

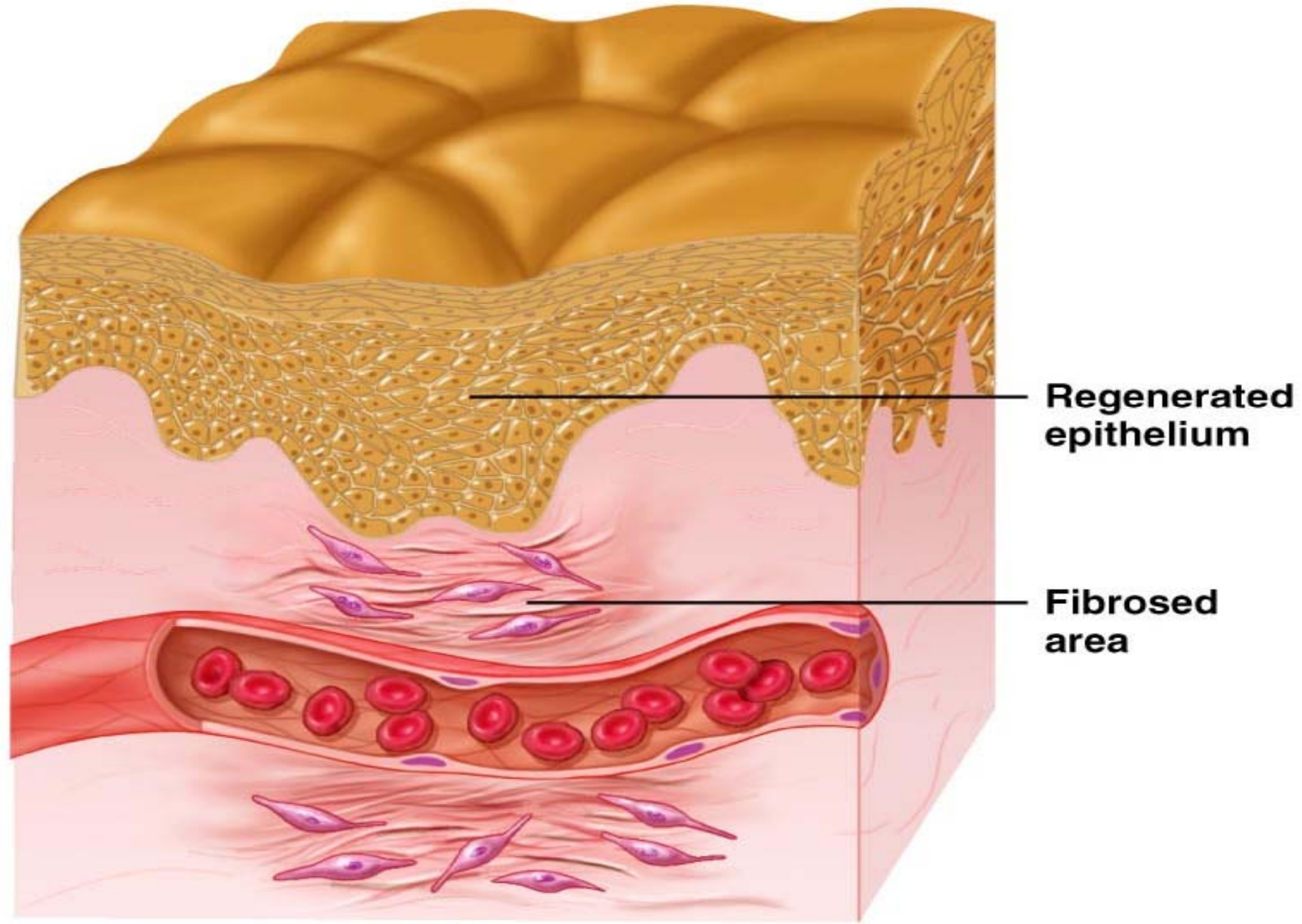


Figure 4.13c

Connective Tissue Diseases

Disease	Autoantibody
Systemic Lupus Erythematosus	Anti-dsDNA, Anti-SM
Rheumatoid Arthritis	RF, Anti-RA33
Sjogrens Syndrome	Anti-Ro(SS-A),Anti-La(SS-B)
Systemic Sclerosis	Anti-Scl-70, Anti-centromere
Polymyositis/Dermatomyositis	Anti-Jo-1
Mixed Connective Tissue Disease	Anti-U1-RNP
Wegener's Granulomatosus	c-ANCA

Systemic Lupus Erythematosus

- Discoid Lupus: Cutaneous manifestations
- Scar upon healing

Rheumatoid Arthritis

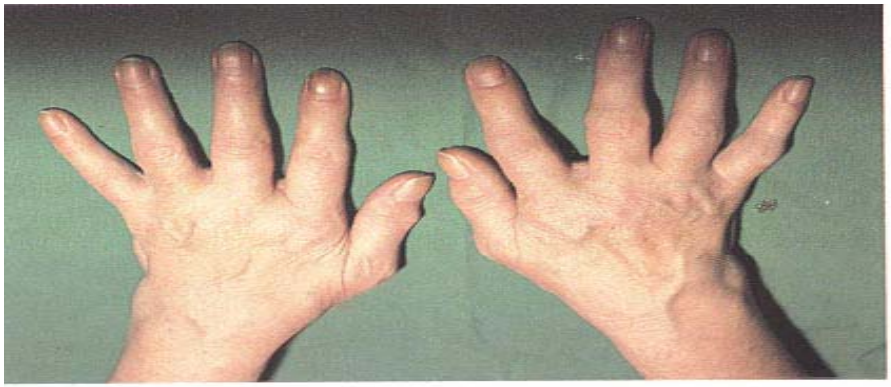


Fig. 3 Early RA. Synovial thickening of PIP joints and wrists. Deformity minimal.

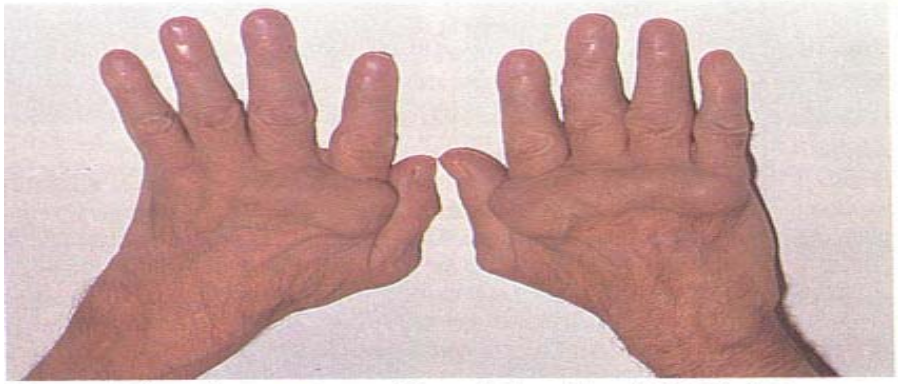
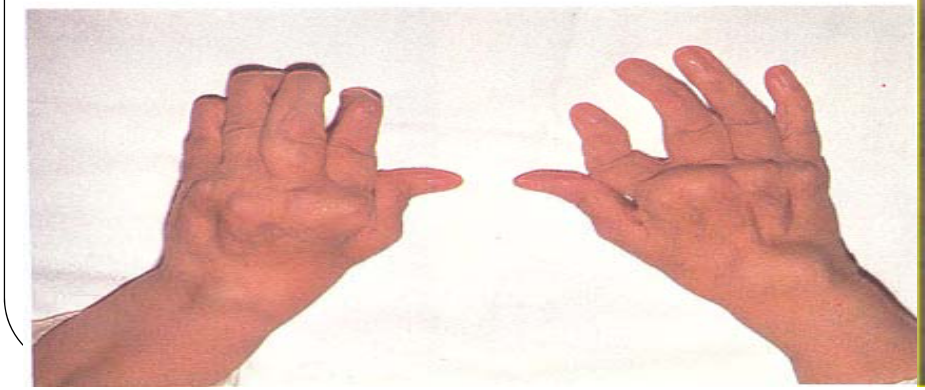


Fig. 4 RA at later stage. Considerable MCP joint thickening, subluxation and ulnar deviation.



Sjogren Syndrome

Scleroderma

Keloid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