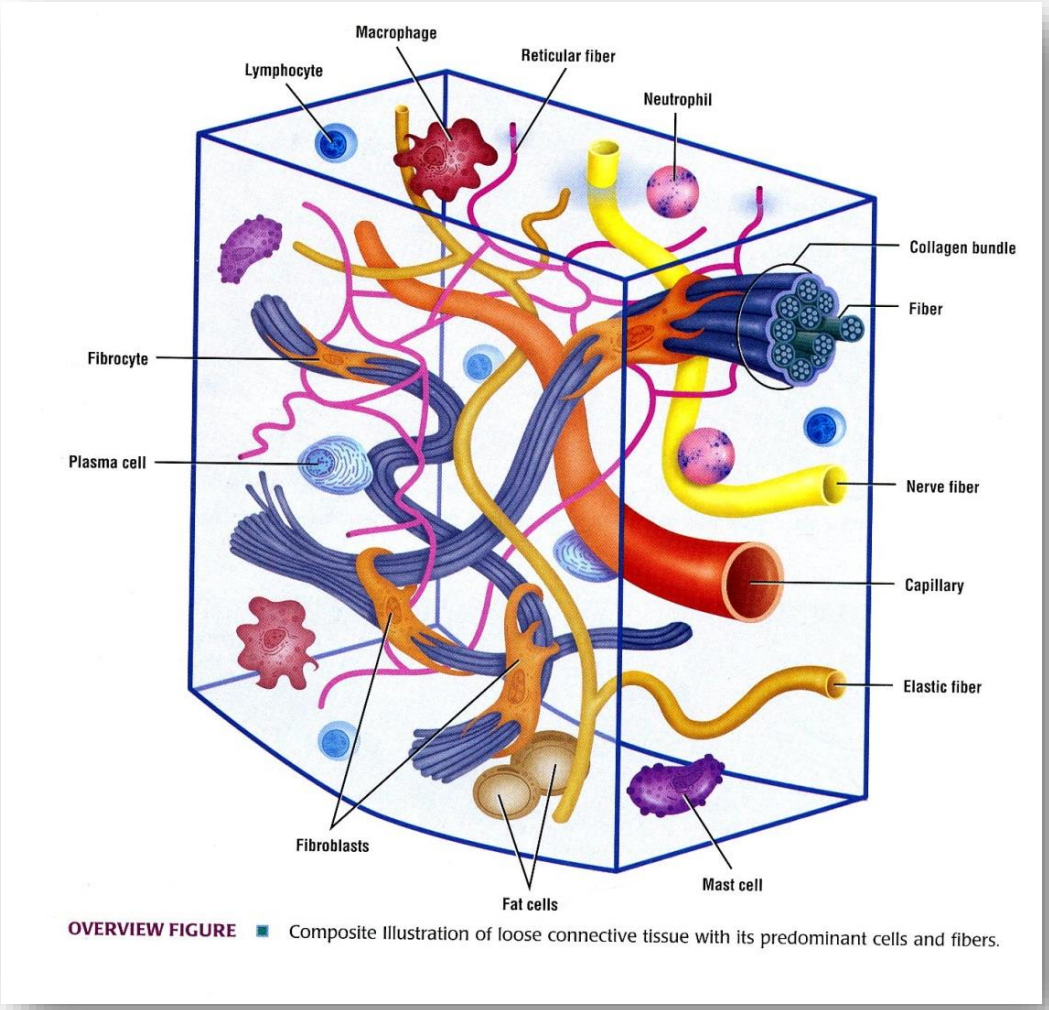
Connective tissue



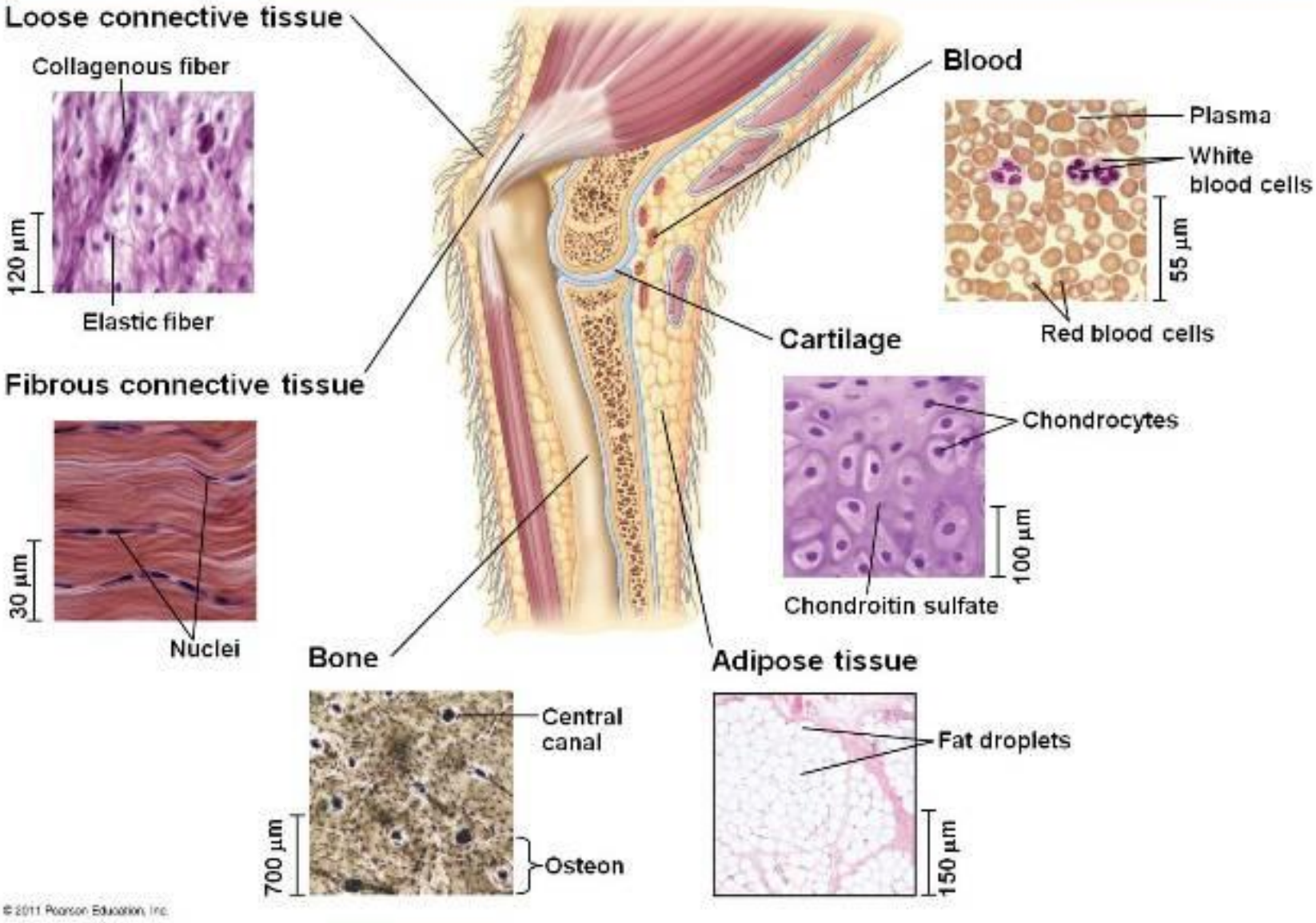
OVERVIEW FIGURE ■ Composite Illustration of loose connective tissue with its predominant cells and fibers.

General properties of connective tissue

1. **One of the four basic types of tissues**

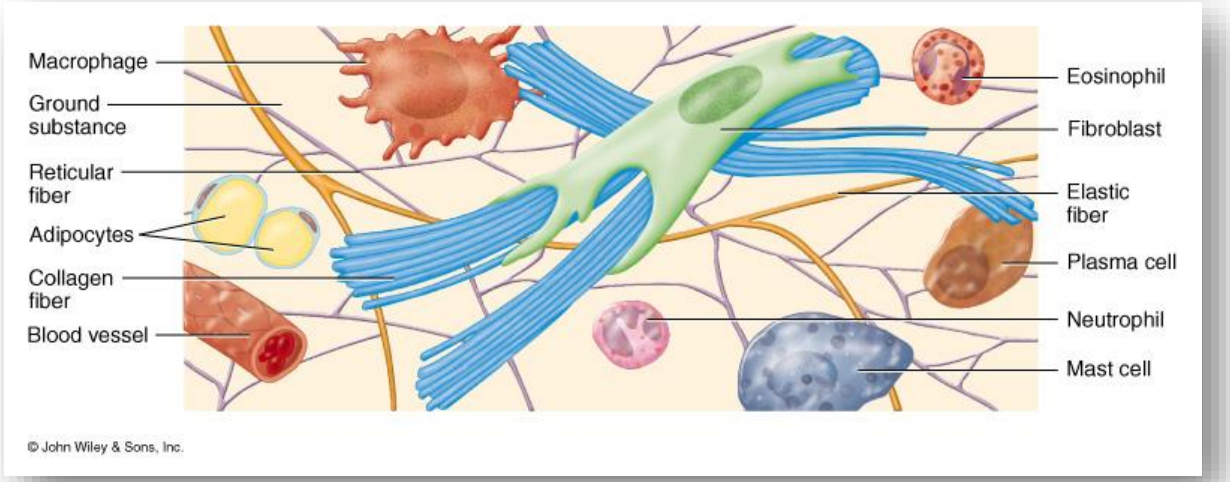
2. **Composition:**
   - cells (fibroblasts and others),
   - fibers
   - Ground substance (extracellular matrix)
3. **Functions:**
   - Architectural framework of the body
   - Bind together and provide mechanical support for other tissue (metabolic, defense, transport, storage)
   - Wound repair / inflammatory response

Connective Tissue



Connective tissue

Consists of three basic elements:



Cells

Fibers

Ground substance

Ground substance

Hyaluronic acid:

complex combination of polysaccharides and proteins found in “true” or proper connective tissue , skin , synovial fluid.

Chondroitin sulfate:

jellylike ground substance of cartilage, bone and skin.

Dermatin sulfate :

Skin , Cardiovascular system .

Keratin sulfate :

Fibrous cartilage

Heparine sulfate :

Lung , Liver , Basal lamina , skin.

Ground substance

Proteins in Matrix :

1.Collagen

2.Fibrilin

3.Elastin

4.Fibronectin

Fibers in connective tissue

Collagen

- most abundant protein in human body (up to 30% dry weight)
- multiple types: fibril-forming or fibril-associated (in skin, tendon, cartilage, bone, dentin, blood vessels); cross-linked networks (in all basement membranes)

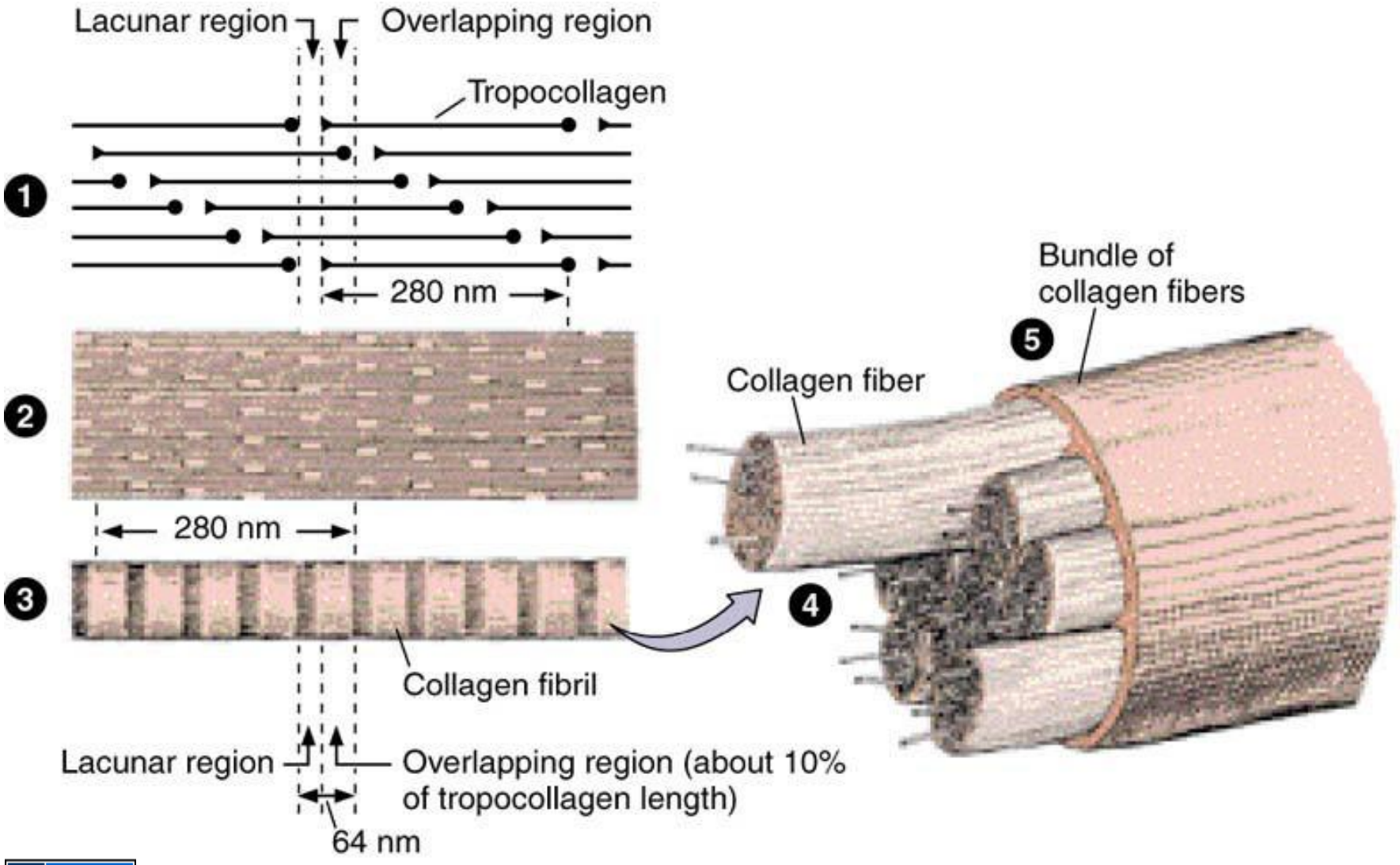
Reticular Fibers

specialized type of collagen (Type III; reticulin) associated with smooth muscle in organs subjected to changes in volume, forms the stroma in lymphatic and hematopoietic organs.

Elastic Fibers

thin fibers or fenestrated sheets composed of various glycoproteins, including the protein elastin, providing elastic properties to tissues that experience repeated deformation (in skin, blood vessels, lung, bladder)

Assembly of collagen fiber bundles

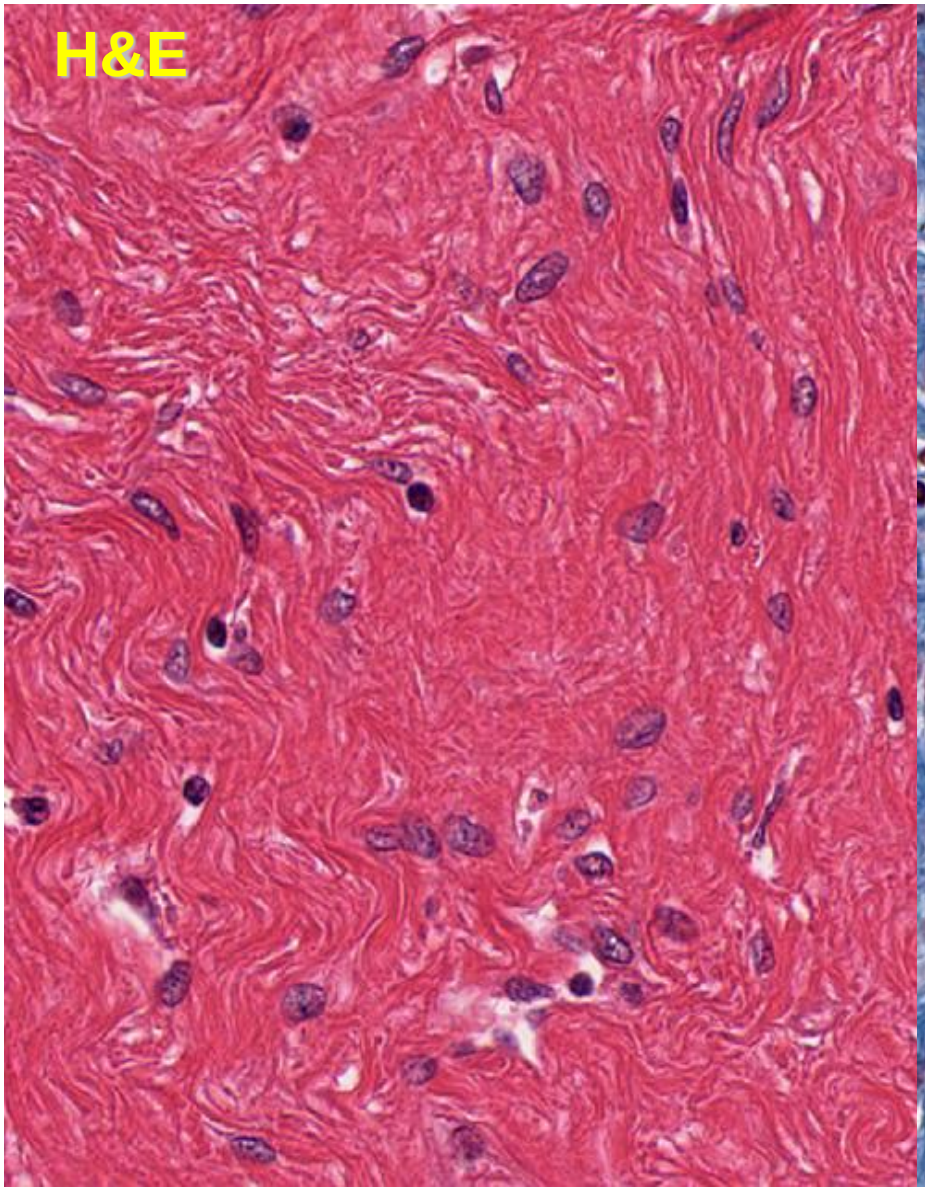


Junquiera and Carneiro. *Basic Histology*. Tenth Edition. 2003. Figure 5-19.

Major collagen fiber types (out of at least 20)

Collagen Type	Tissues	Function
Fibril-forming collagens (these are visible)		
I (most abundant)	Skin, tendon, bone, dentin	Resistance to tension
II	Cartilage, vitreous of eye	Resistance to pressure
III (reticulin)	Skin, muscle, blood vessels, liver, etc.	Structural framework and stability
Network-forming collagens		
IV	All basement membranes	Support and filtration
Fibril-associated collagens with interrupted triple helices (FACIT)		
VI, IX	Assoc. w/ type I and II fibrils	Fibril-fibril / fibril-ECM binding
Anchoring filament collagens		
VII	Epithelia	Epidermis to basal lamina

Collagen fibers viewed by light microscopy



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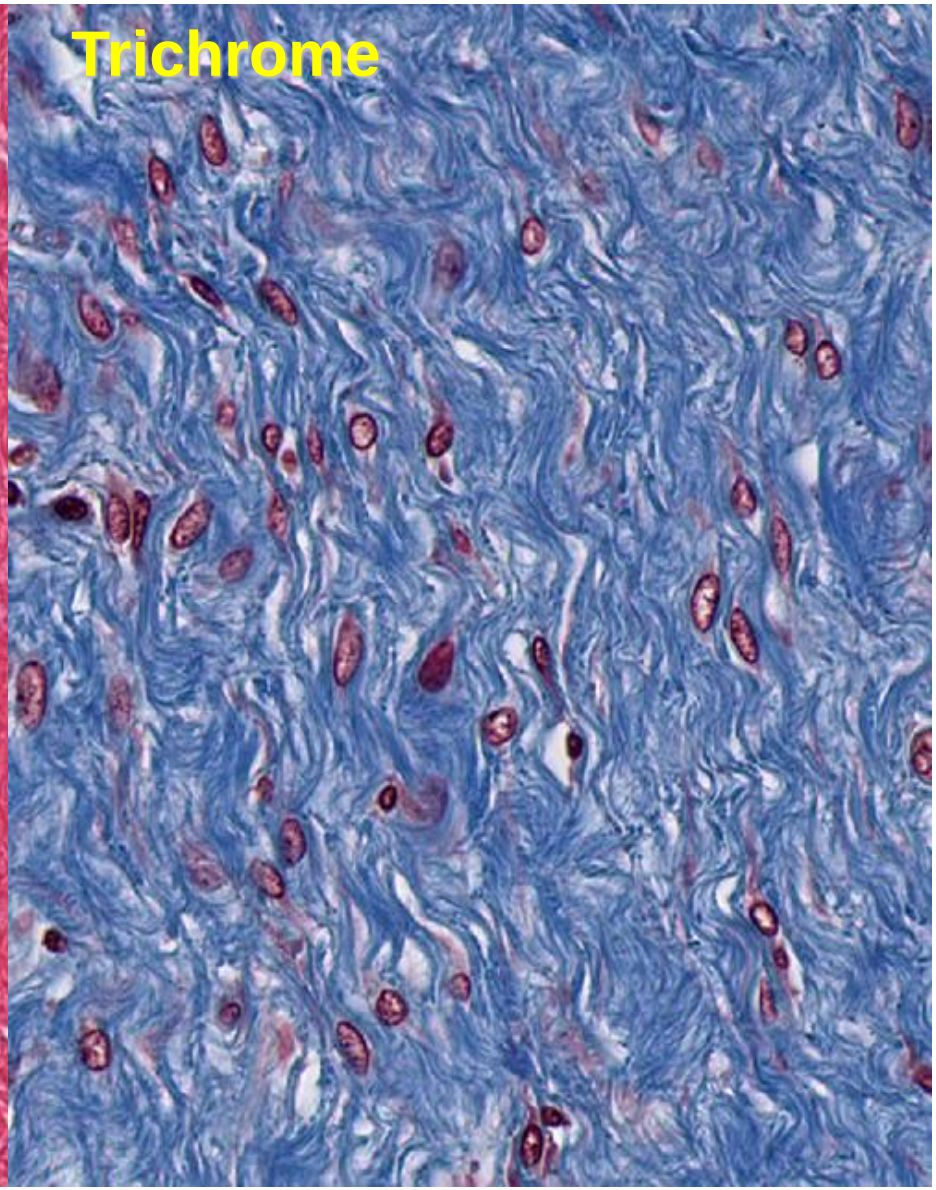

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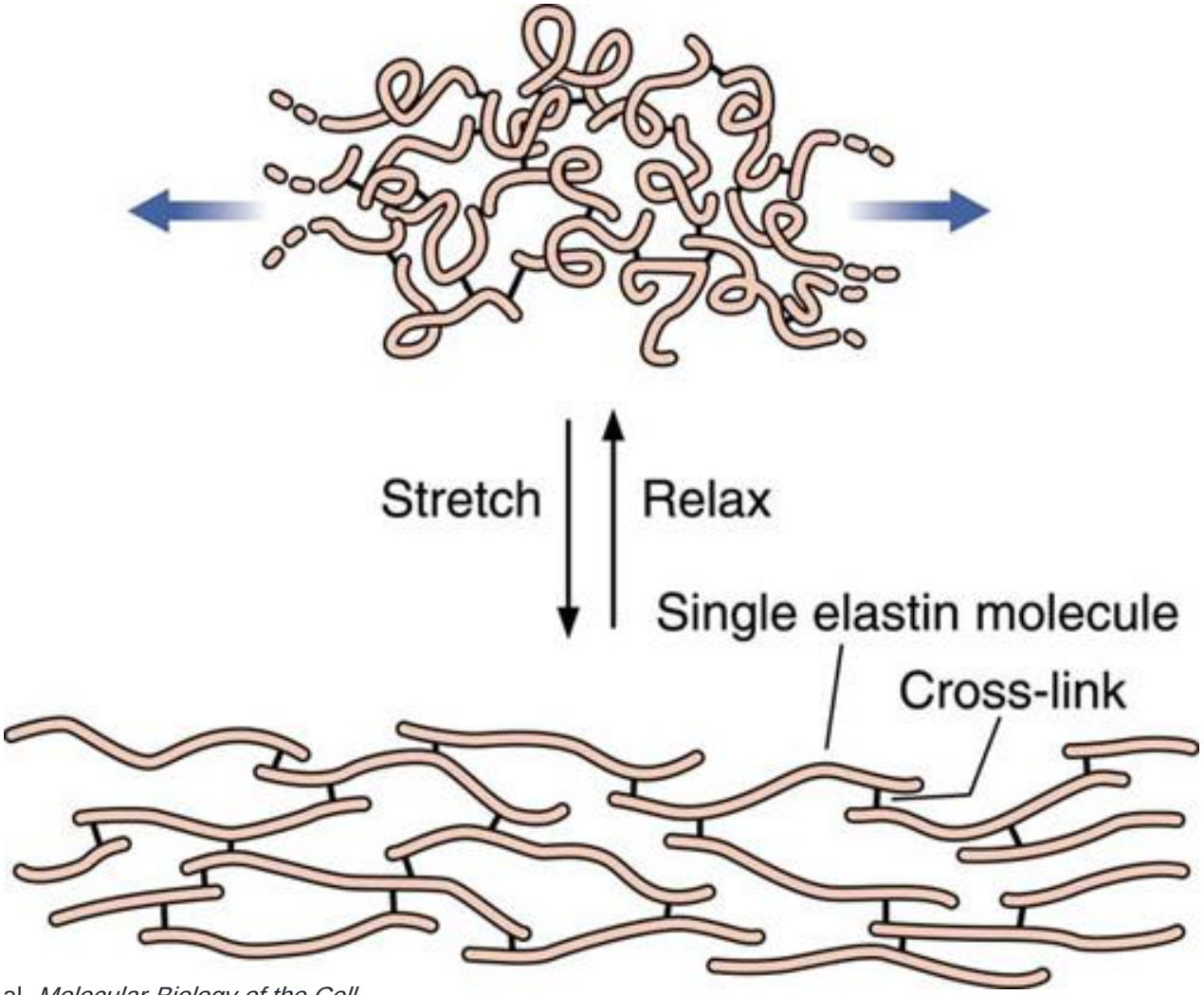
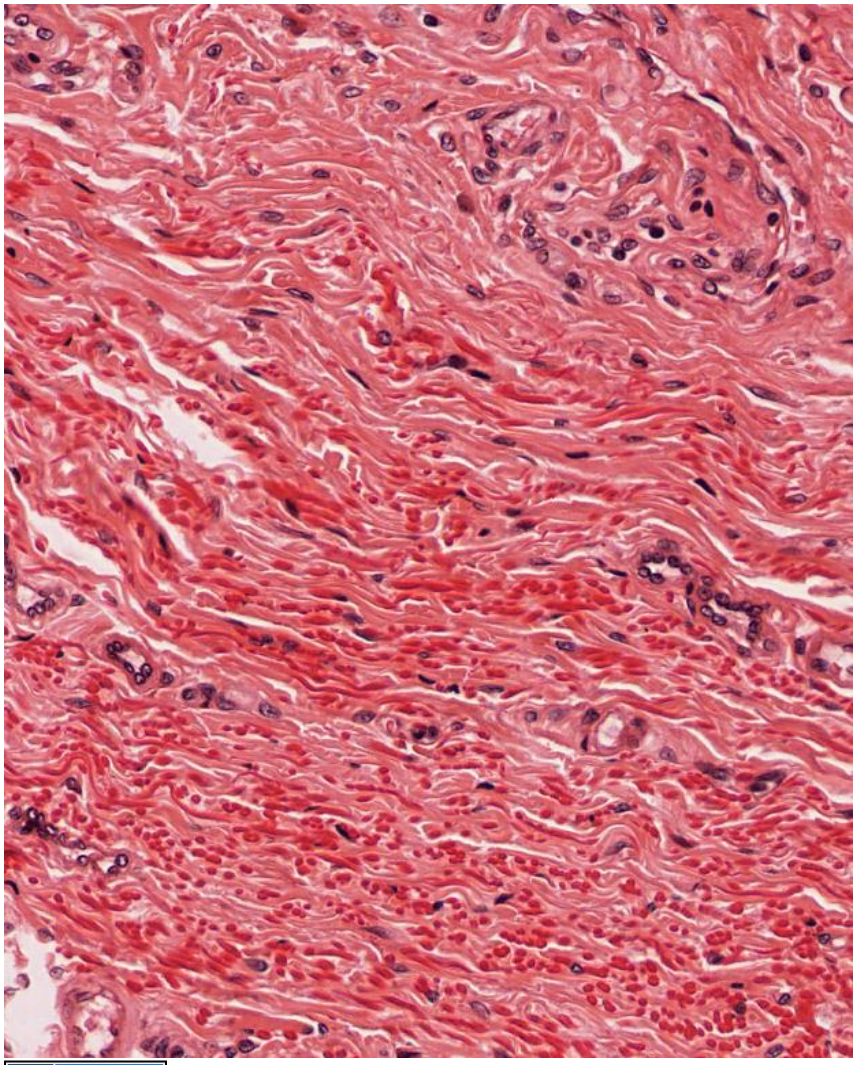
Network of elastin molecules can stretch and recoil like a rubber band



 Alberts et. al. *Molecular Biology of the Cell*.

Elastic and collagen fibers



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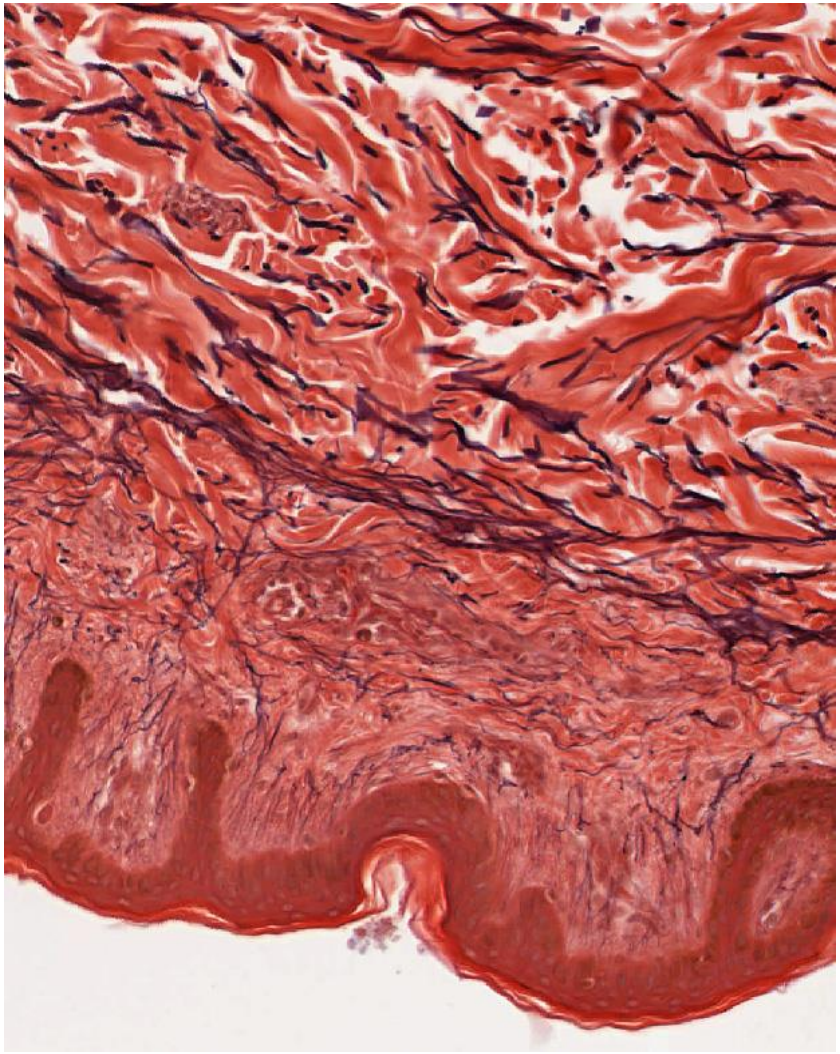
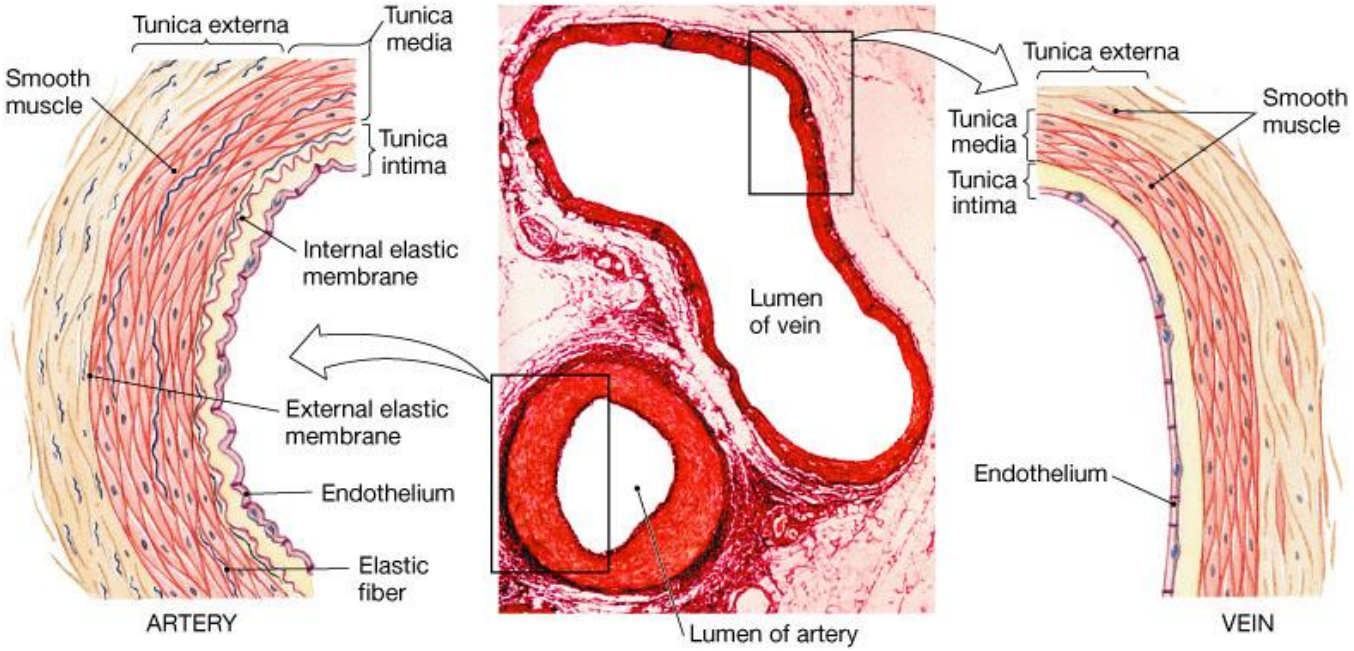


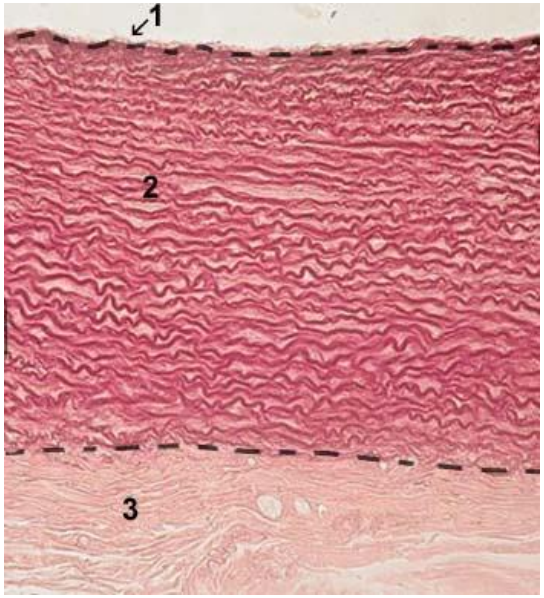
PD-INEL University of Michigan Histology Collection

H&E stain: collagen stains *orange/pink*; elastic fibers stain *glassy red* (generally only visible if in HIGH abundance)

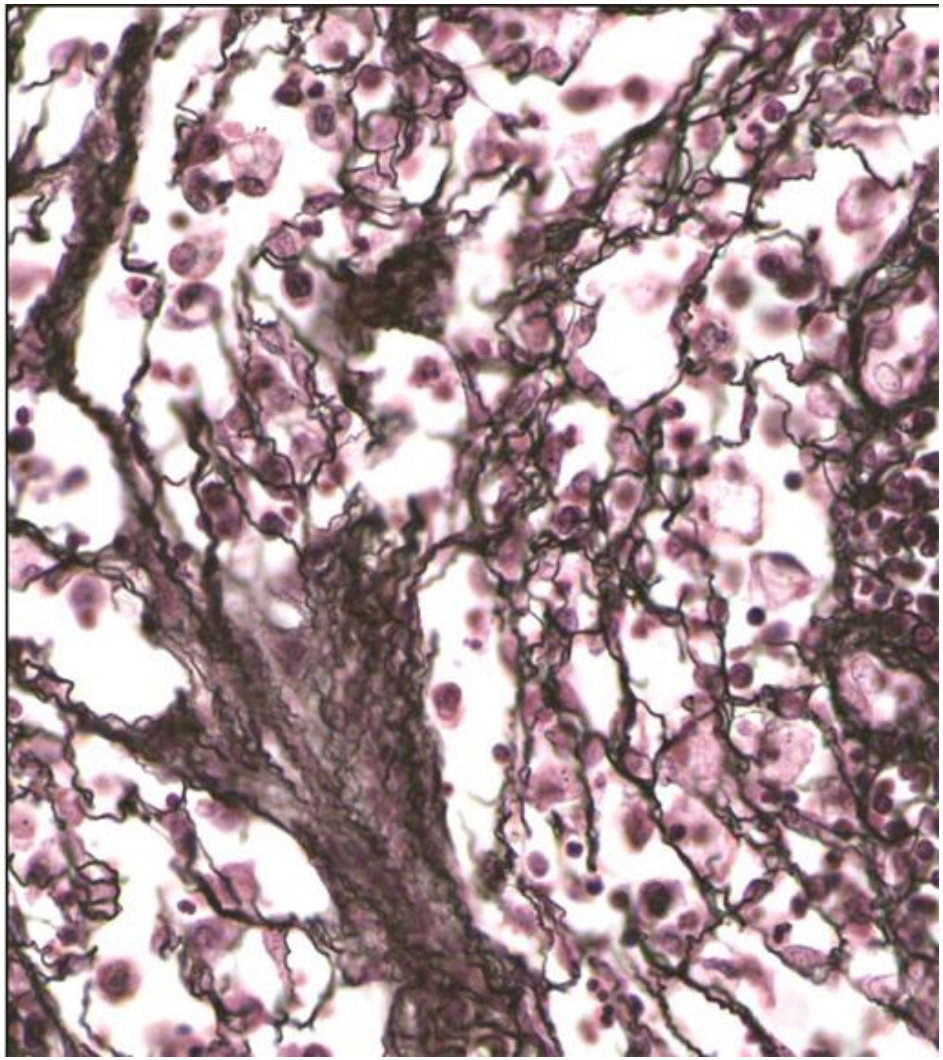
elastin stain ("Weigert's", "aldehyde fuchsin", "Verhoeff"): elastic fibers are *purple/black*

collagen fibers stain *orange/pink* or blue/green depending o other stains used (von Gieson's or trichrome, respectively)

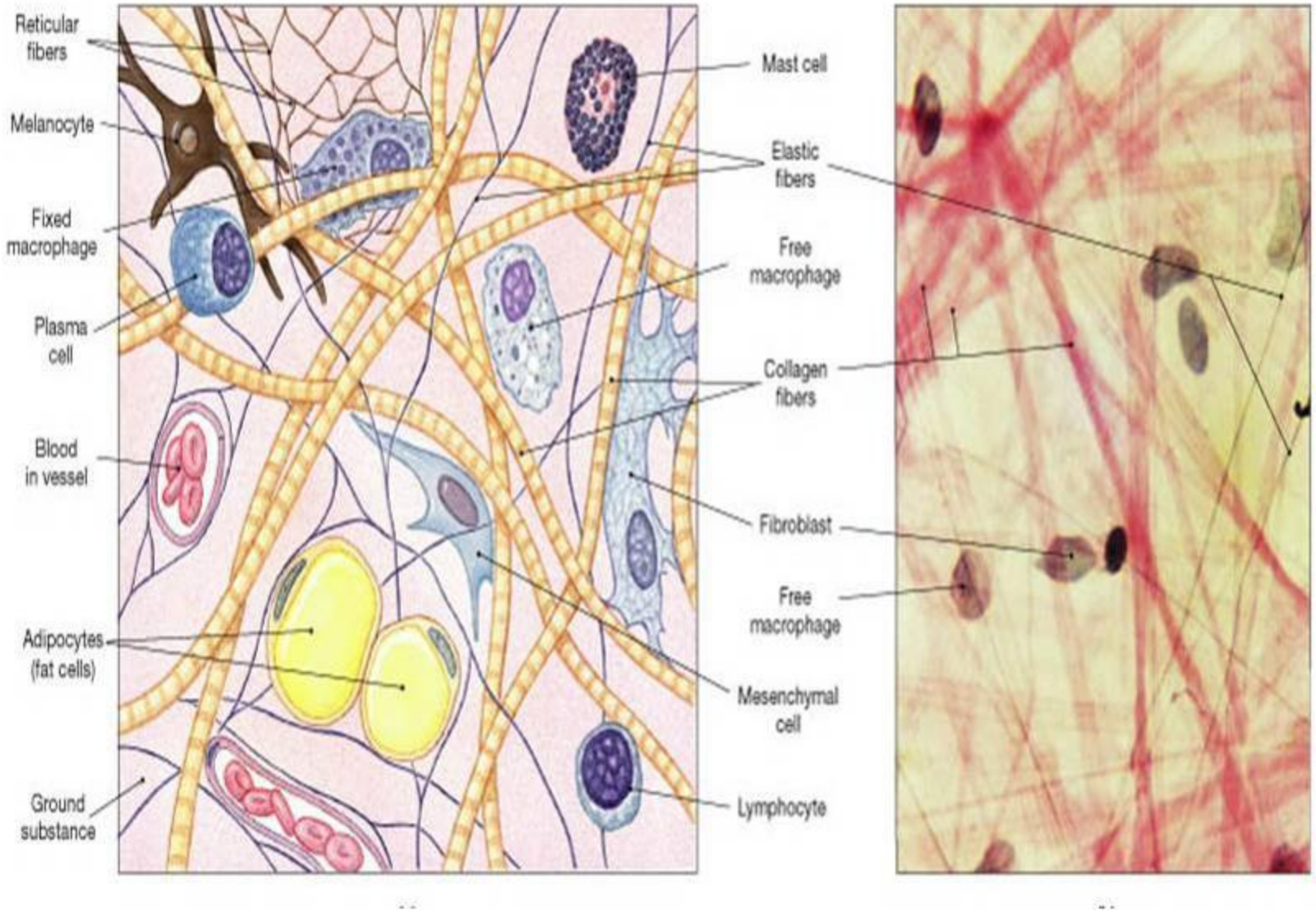




Reticular (reticulin) fibers



- Form a delicate supporting framework for highly cellular tissues (endocrine glands, lymph nodes, liver, bone marrow, spleen, smooth muscle).
- Composed mainly of Type III collagen, with a carbohydrate moiety that reduces Ag+ to metallic sliver = argyrophilic.
- Special stain: silver impregnation to visualize.
- Thinner than type I collagen
  (Type III fibrils are 30-40 nm diameter; type I fibrils are ~200 nm diameter)


Reticular fibers
Melanocyte
Fixed macrophage
Plasma cell
Blood in vessel
Adipocytes (fat cells)
Ground substance
Mast cell
Elastic fibers
Free macrophage
Collagen fibers
Fibroblast
Free macrophage
Mesenchymal cell
Lymphocyte

True connective tissue cells

Mesenchymal

Fibroblasts: Secrete both fibers and ground substance of the matrix (wandering)

Fibrocyte

Reticular

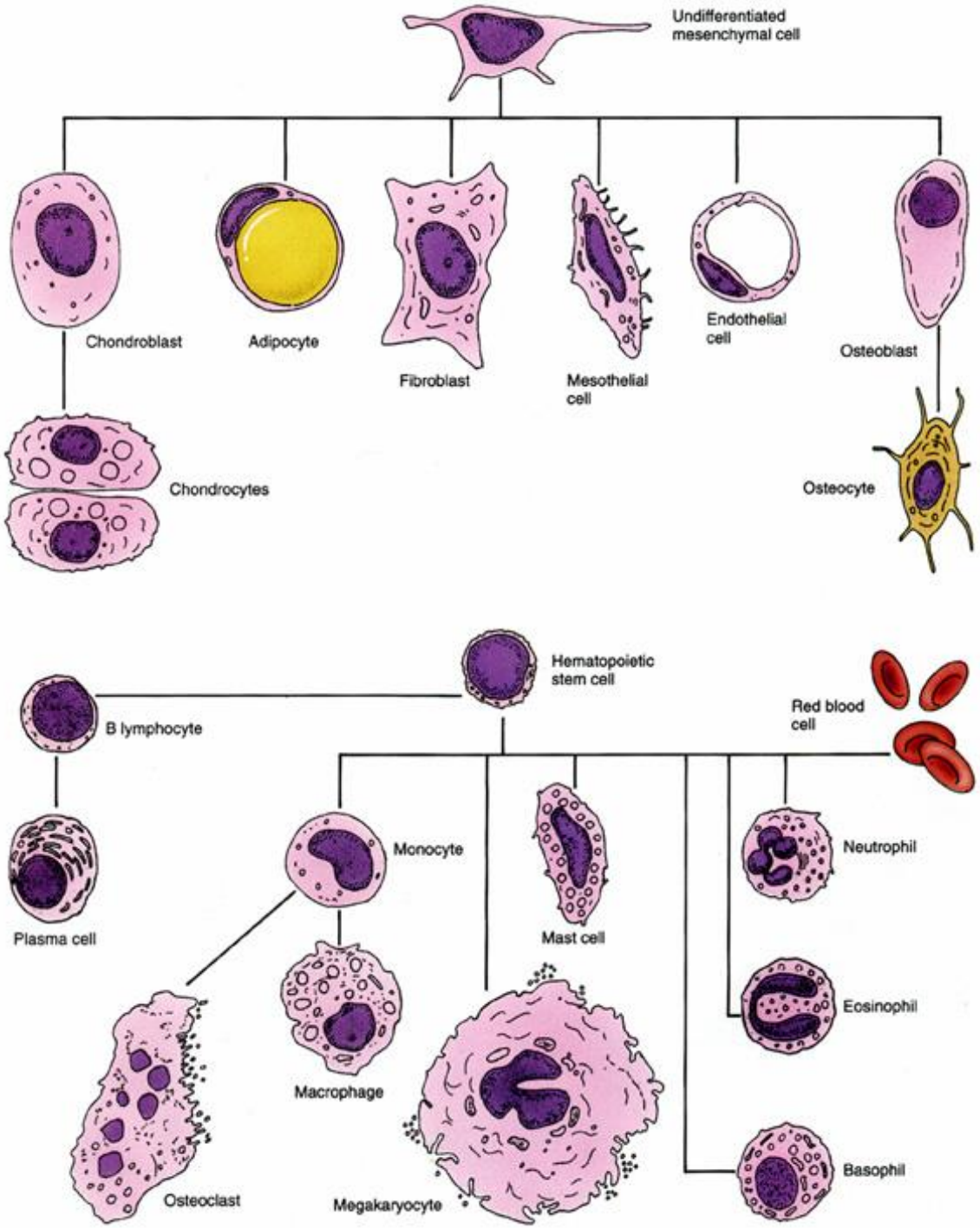
Macrophages: Phagocytes that develop from monocytes (wandering or fixed)

True connective tissue cells

Plasma Cells: Antibody secreting cells that develop from B Lymphocytes (wandering)

Mast Cells: Produce histamine that help dilate small blood vessels in reaction to injury (wandering)

Adipocytes: Fat cells that store triglycerides, support, protect and insulate (fixed)


Undifferentiated mesenchymal cell
Chondroblast
Adipocyte
Fibroblast
Mesothelial cell
Endothelial cell
Osteoblast
Chondrocytes
Osteocyte
Hematopoietic stem cell
B lymphocyte
Red blood cell
Plasma cell
Monocyte
Mast cell
Neutrophil
Eosinophil
Macrophage
Osteoclast
Megakaryocyte
Basophil

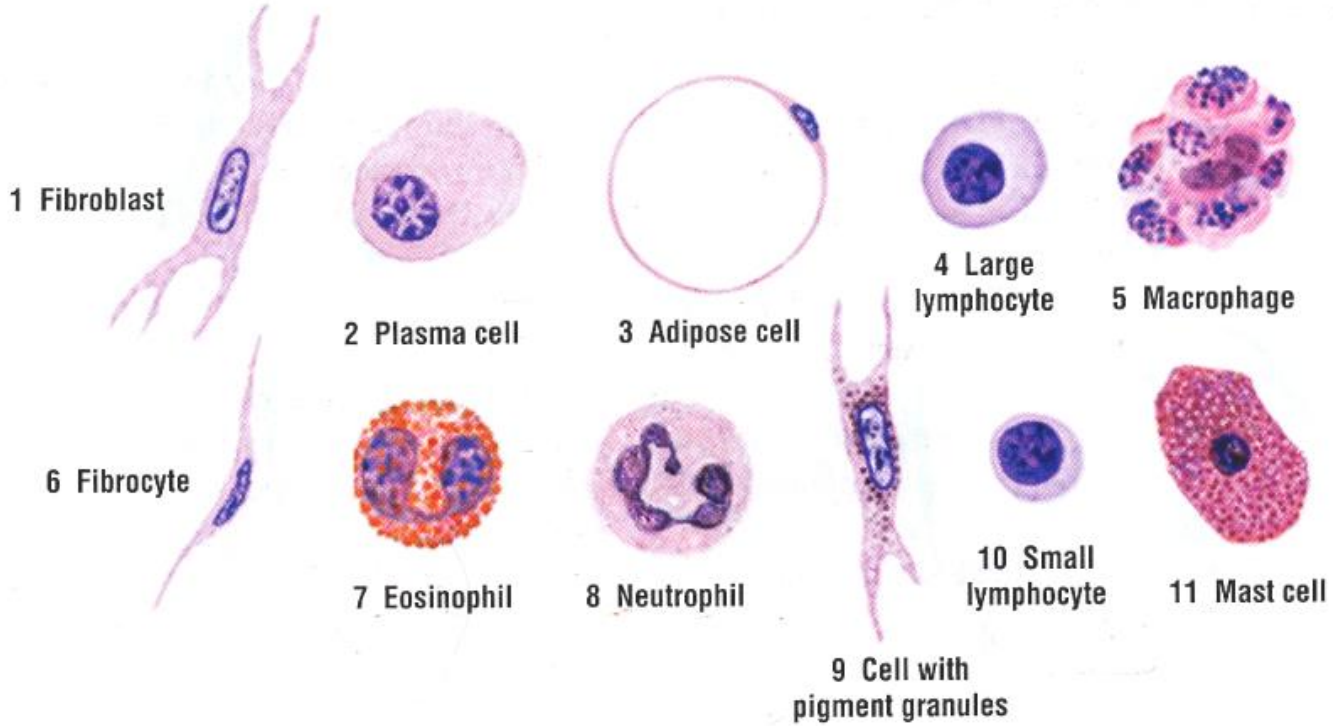
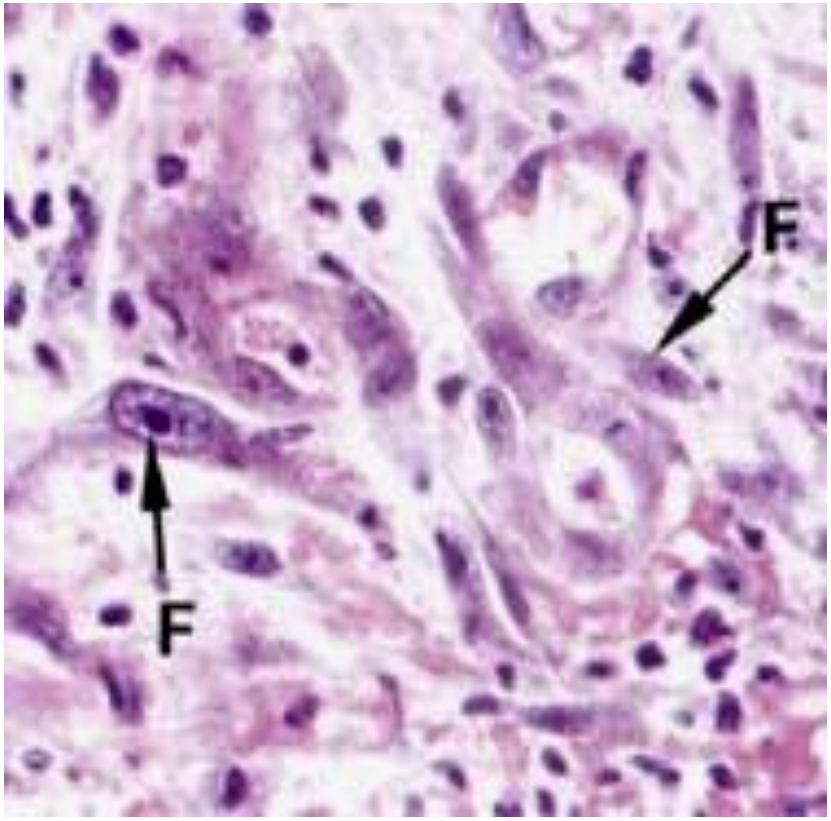
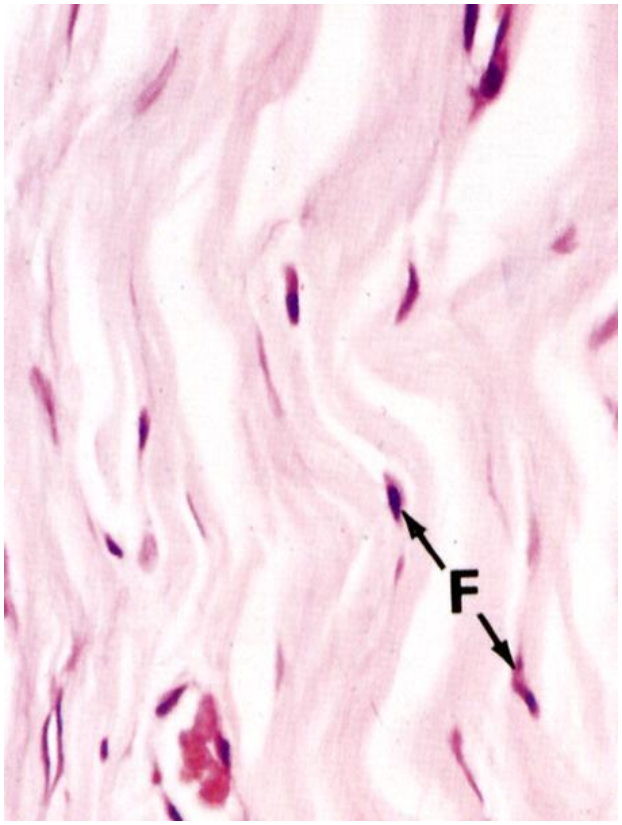


FIGURE 3.2 ■ Cells of the connective tissue. Stain: hematoxylin and eosin. High magnification and/or oil immersion.

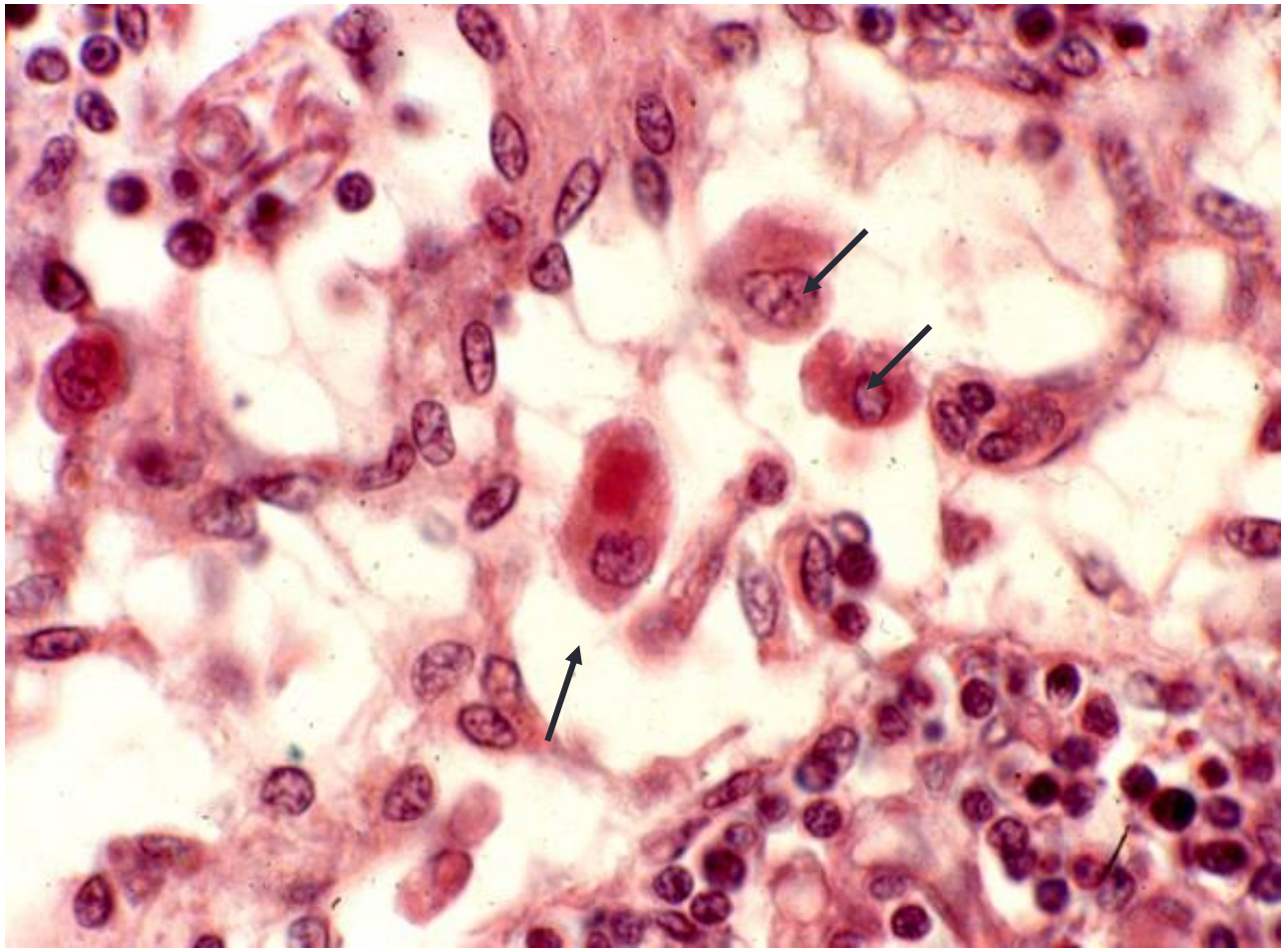
Fibroblasts and Fibrocyte



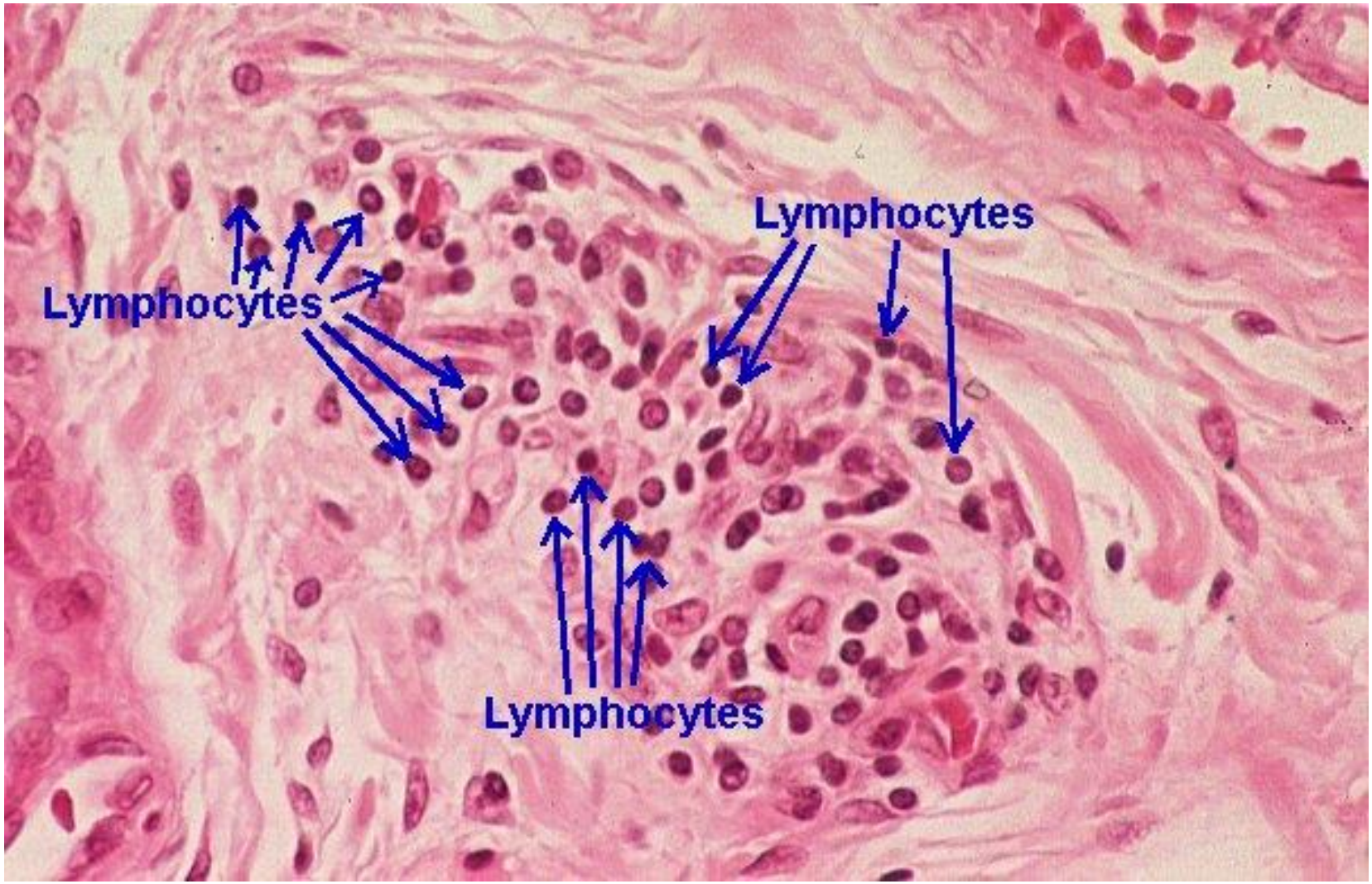


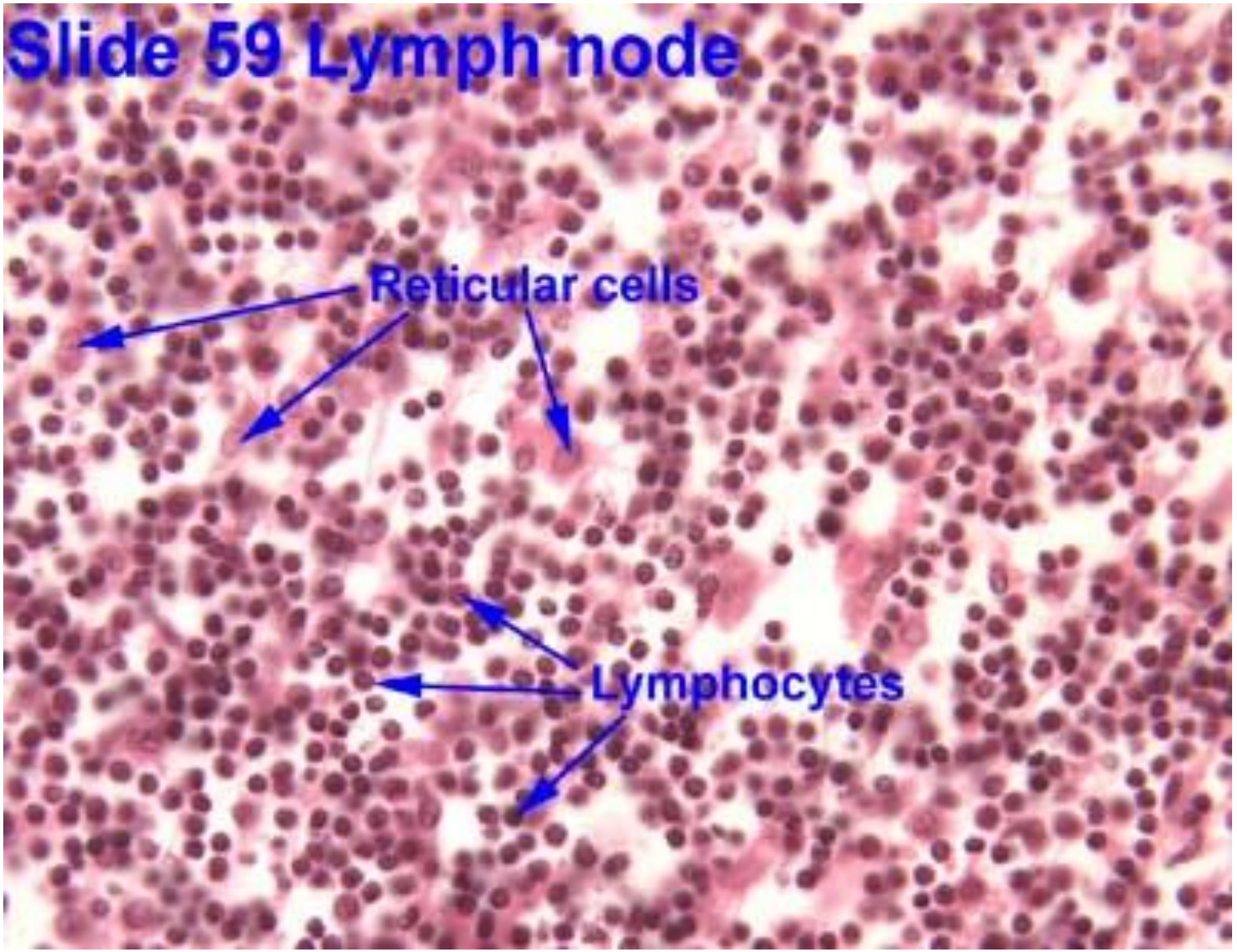
(Both images) Ross, M. Pawlina, W. *Wheater's Functional Histology: A Text and Atlas*. Fifth Edition. 2006.

Monocytes escape from blood vessels into connective tissue where they differentiate into macrophages

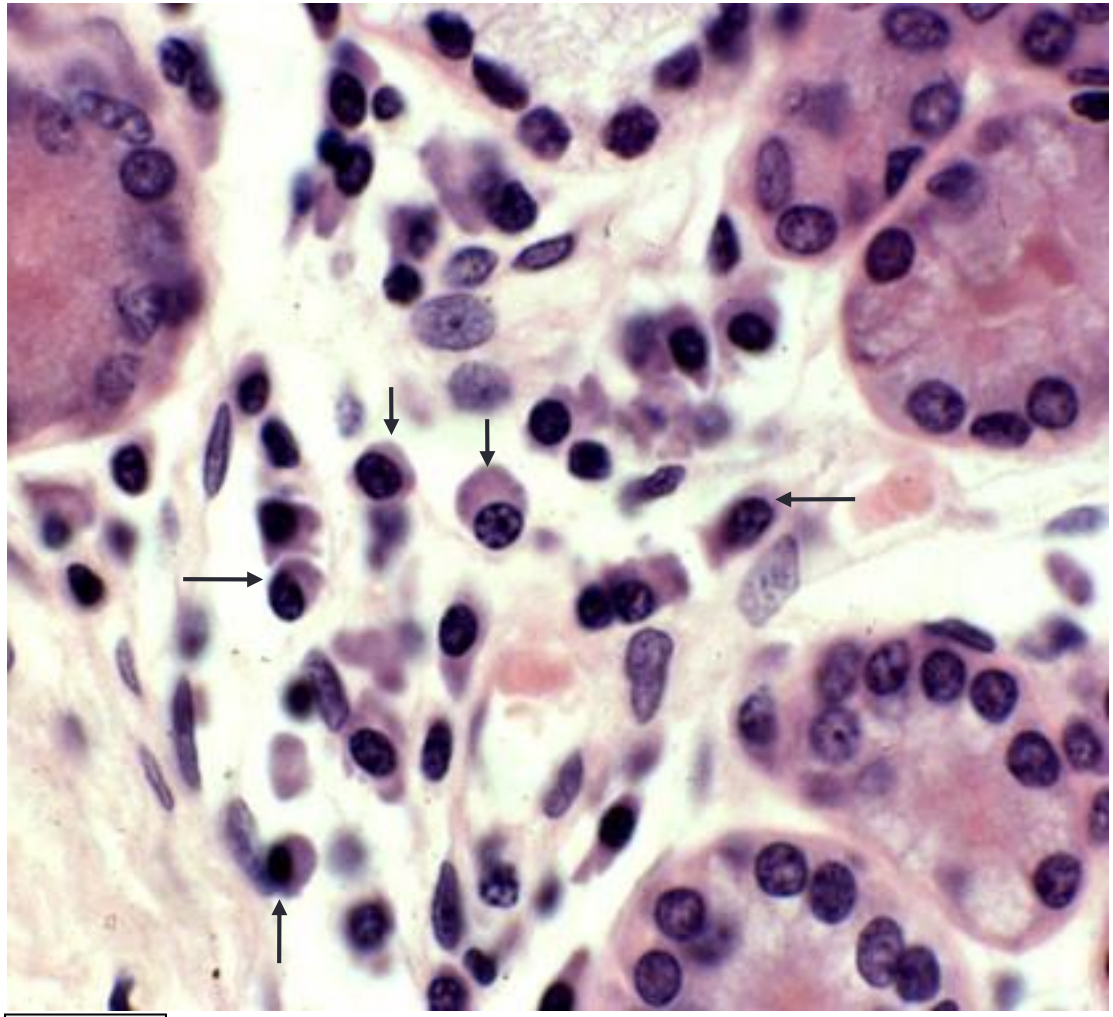


Primary function: phagocytosis and antigen presentation


Lymphocytes
Lymphocytes
Lymphocytes

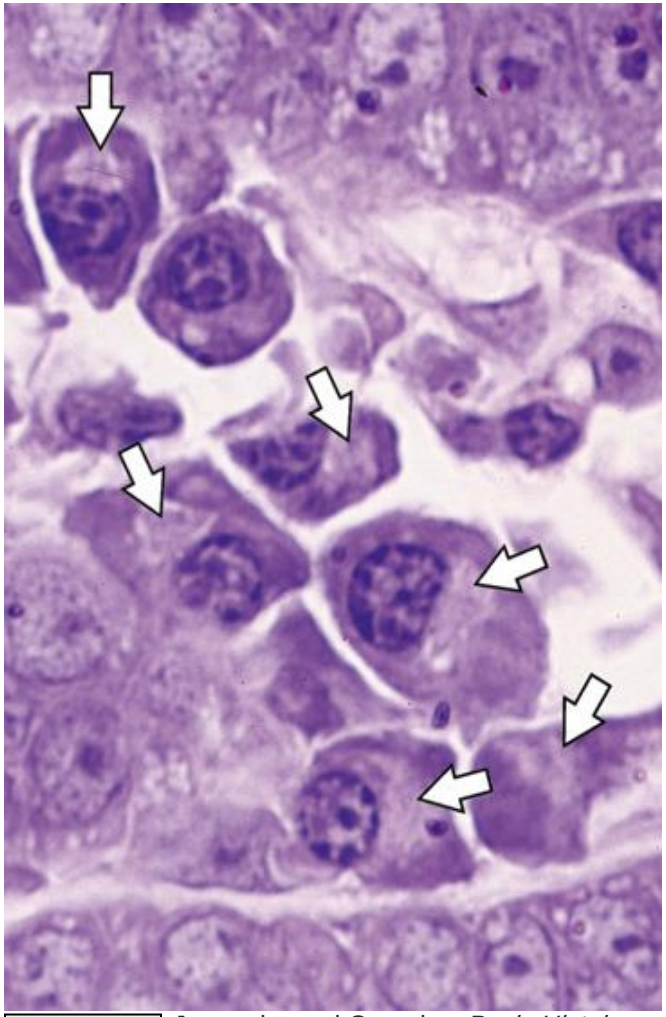

Slide 59 Lymph node
Reticular cells
Lymphocytes

Plasma cells are mature B lymphocytes that constitutively secrete antibodies



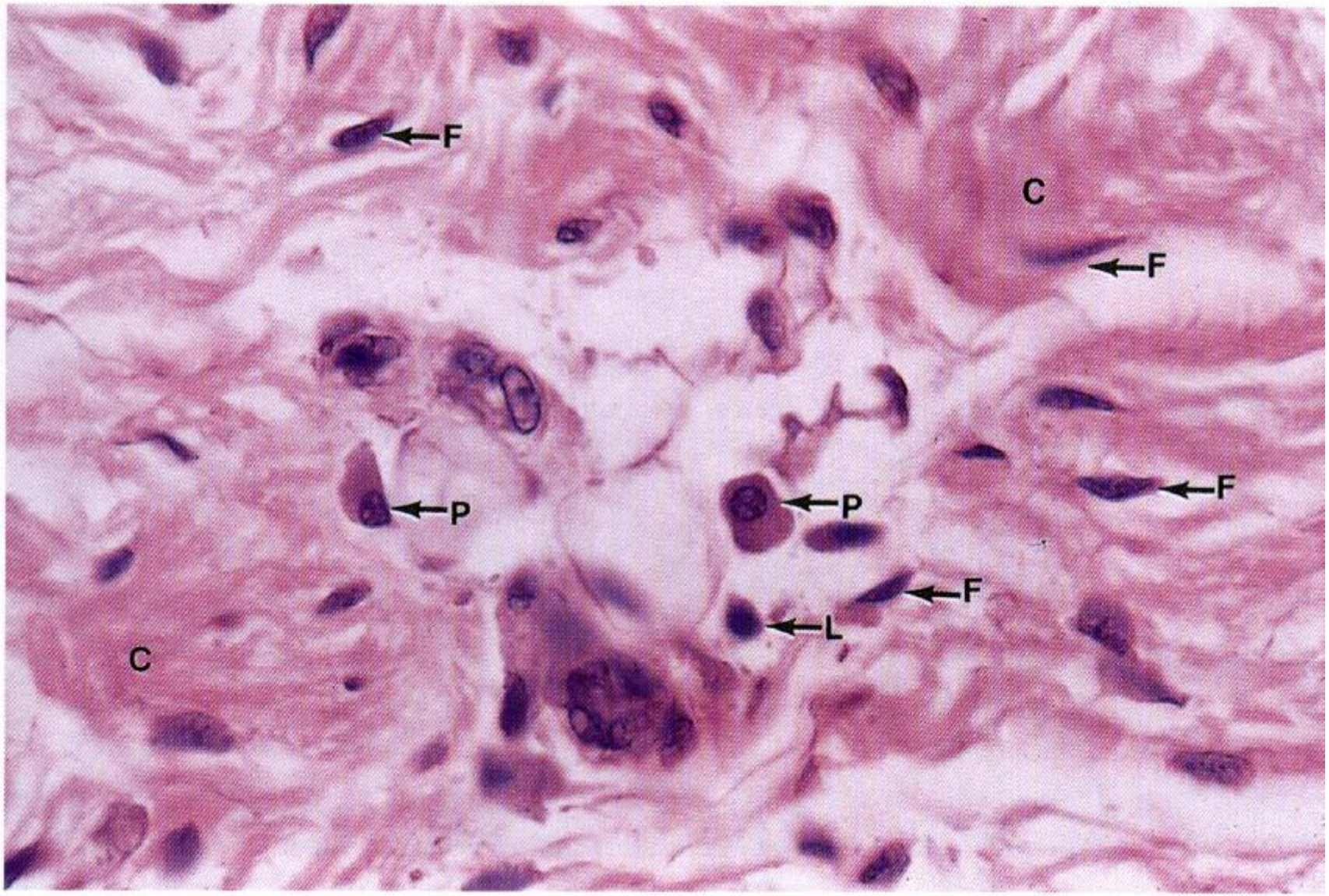
PD-INEL University of Michigan Histology Collection

Black arrows indicate several plasma cells



PD-INEL Junqueira and Carneiro. *Basic Histology.* Tenth Edition. 2003. Figure 6.5.

White arrows = Golgi regions


F
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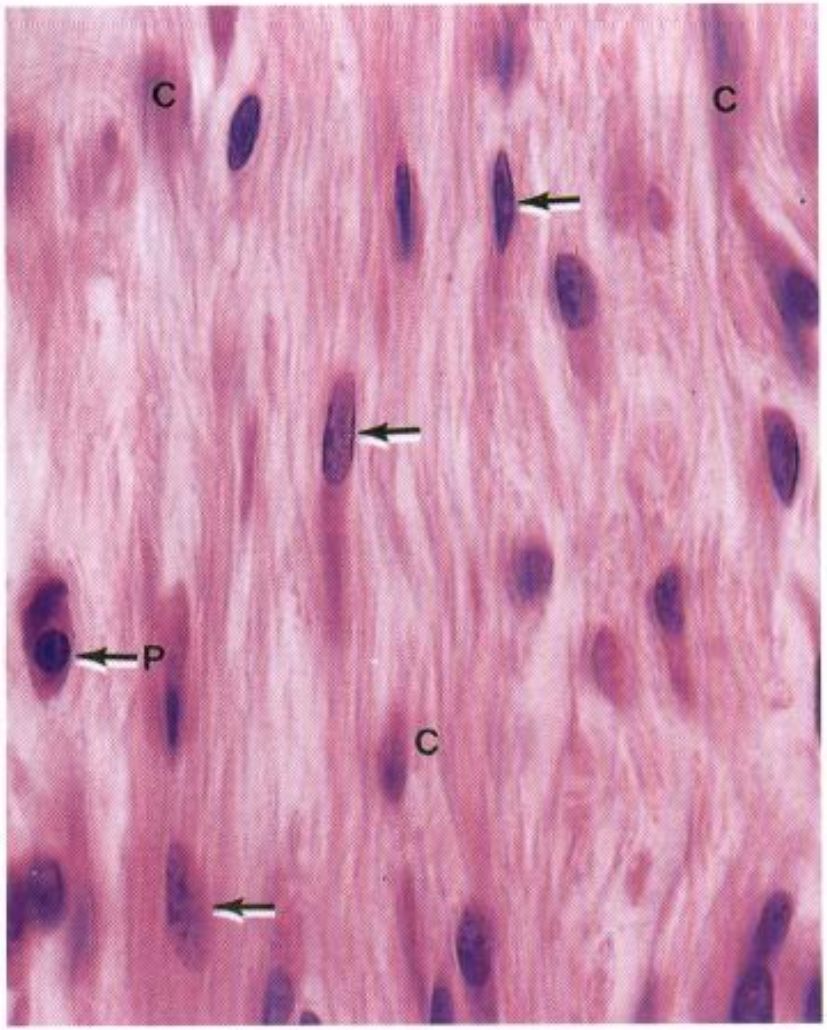


figure 2-6

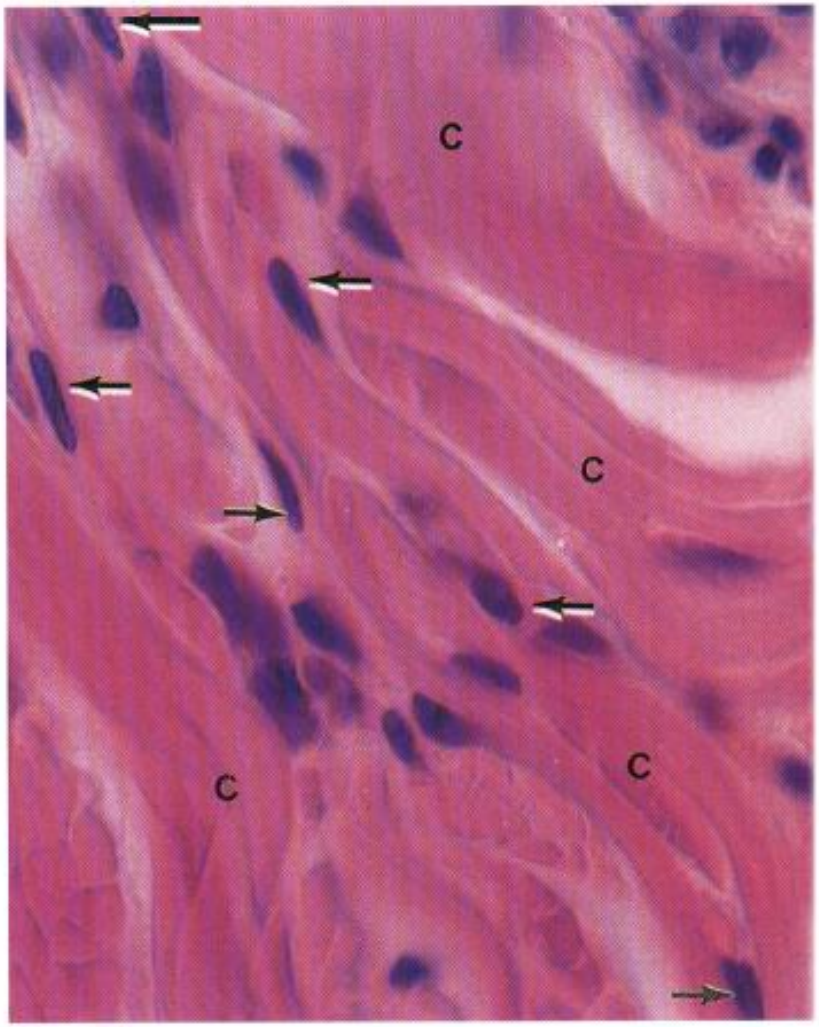
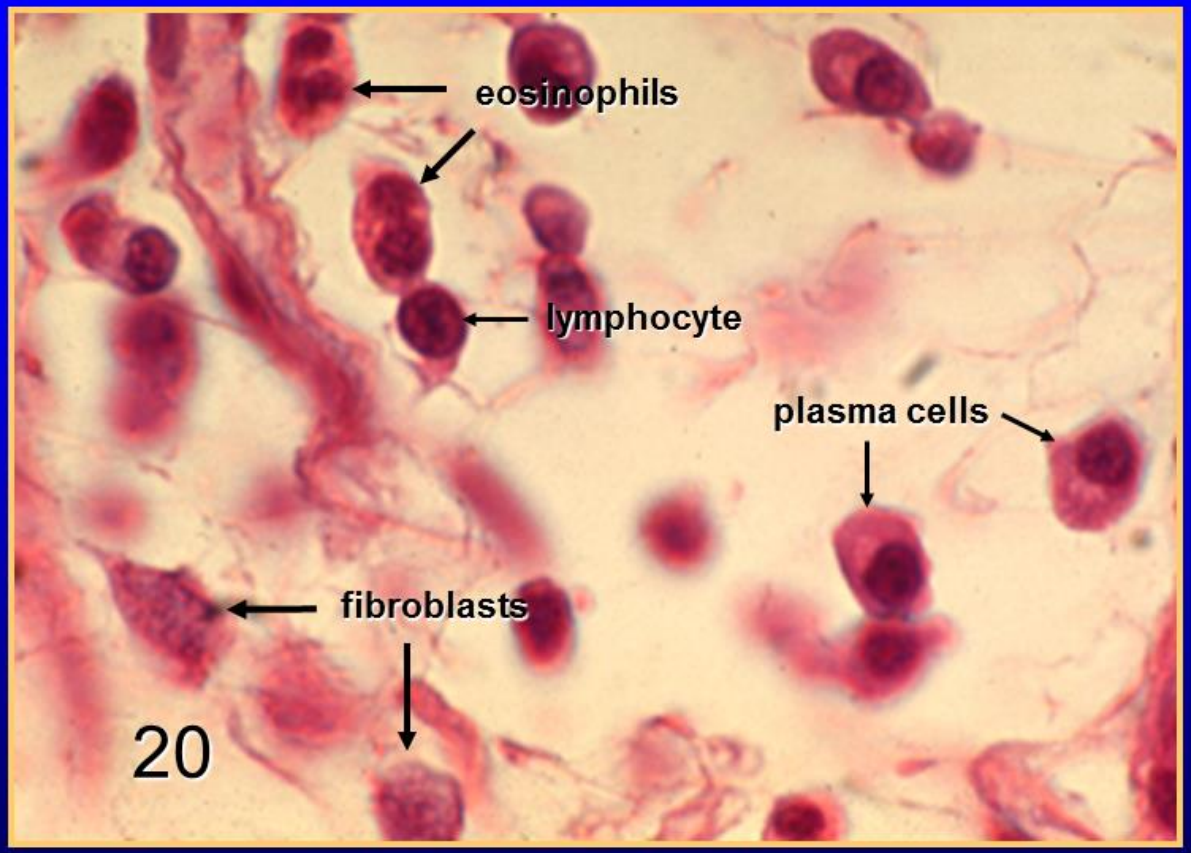


figure 2-7

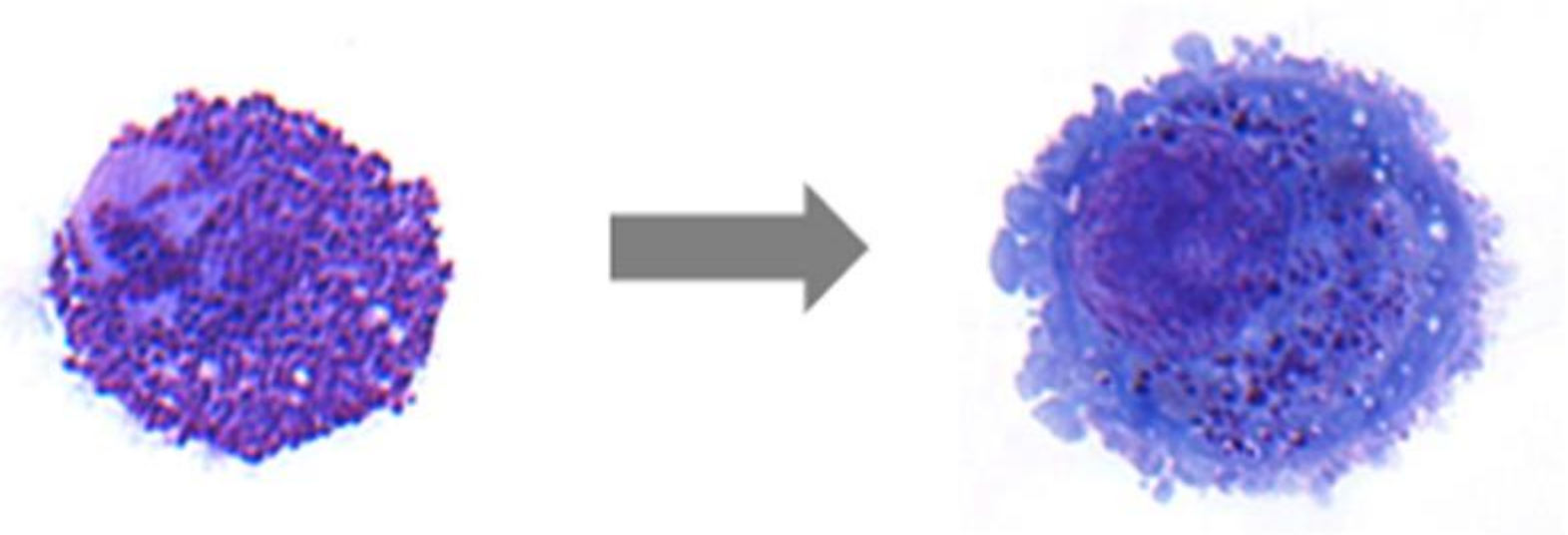
Loose Connective Tissue



gure 20. Plasma cells and eosinophils. 400X. Plasma cells have an eccentrically ated and heterochromic nucleus and a basophilic cytoplasm with a pale staining ea (negative Golgi image) adjacent to the nucleus. Eosinophils have a lobated cleus and acidophilic granules in the cytoplasm. Two pale staining fibroblast clei are also shown in the lower left corner of the figure.

Resting mast cell

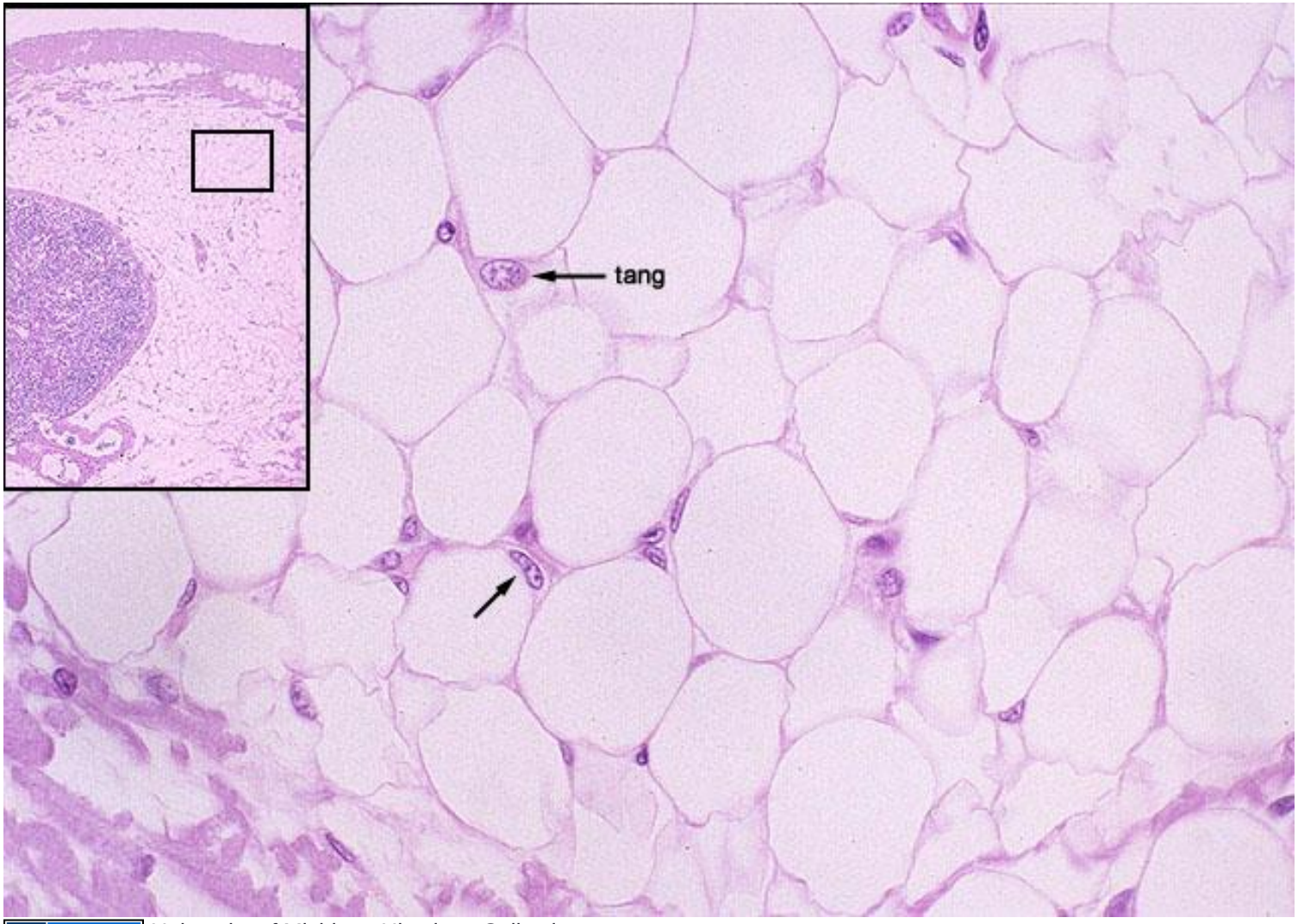
Activated mast cell



Loose Connective Tissue

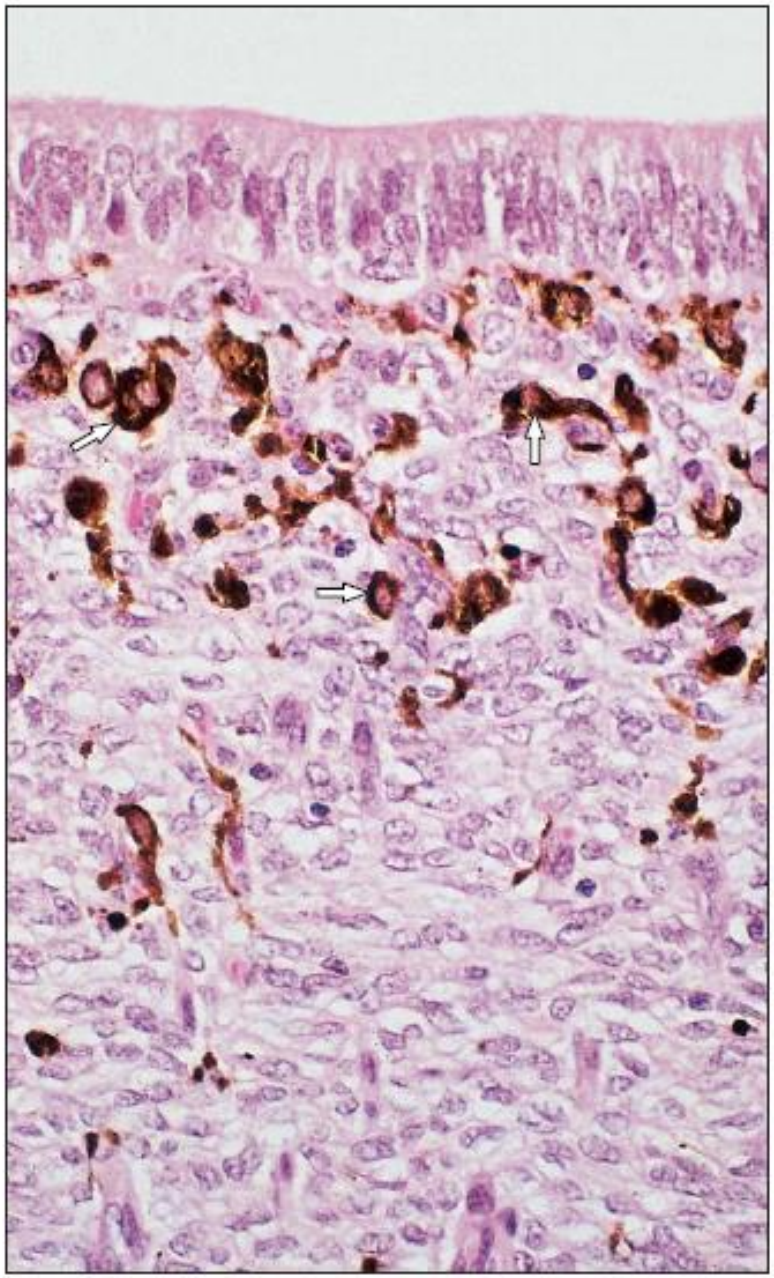
Figure 8. Mast cells in perivascular connective tissue. 160X.

Adipose tissue



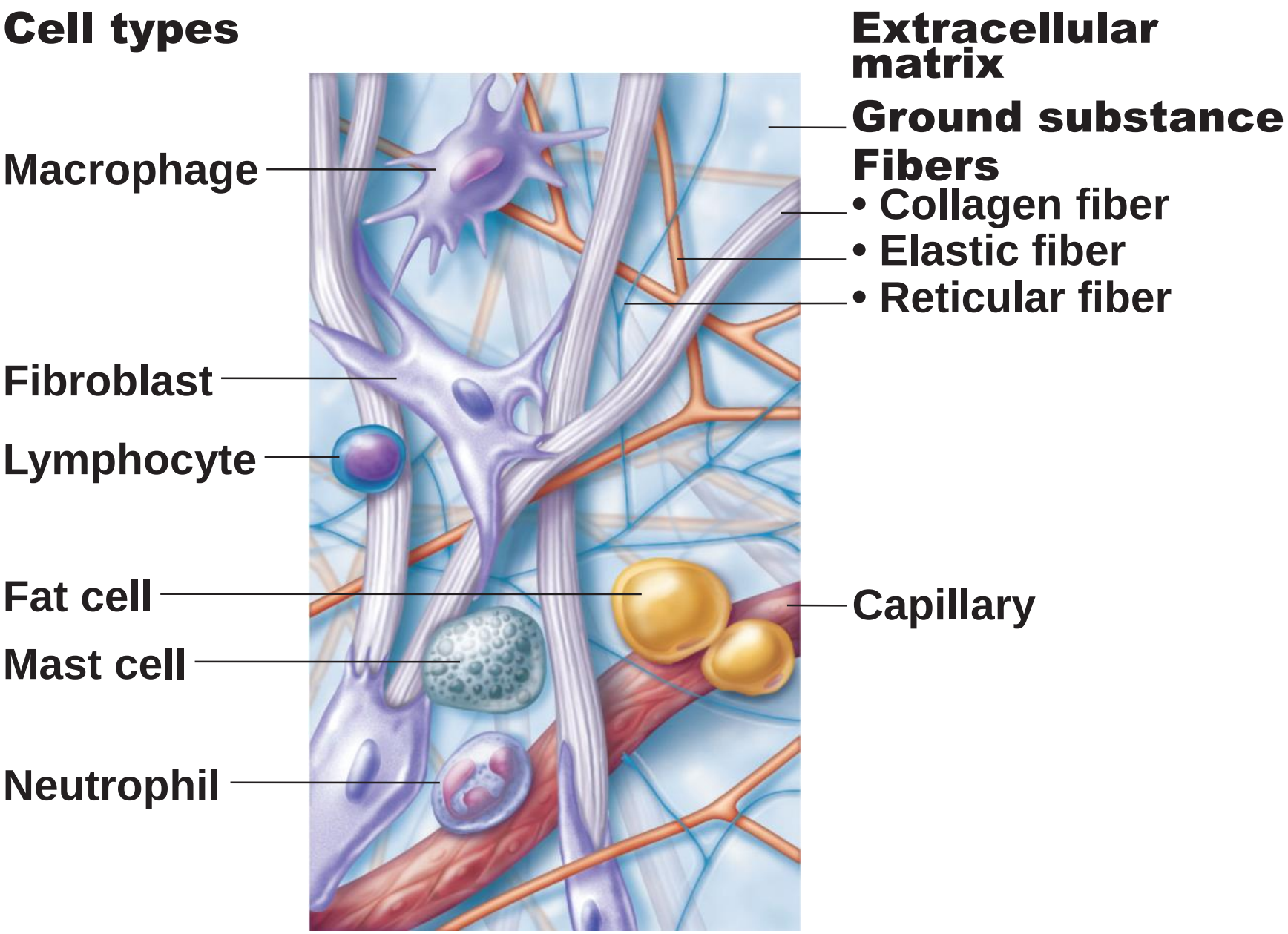
Adipose tissue in mesentery;

3.17



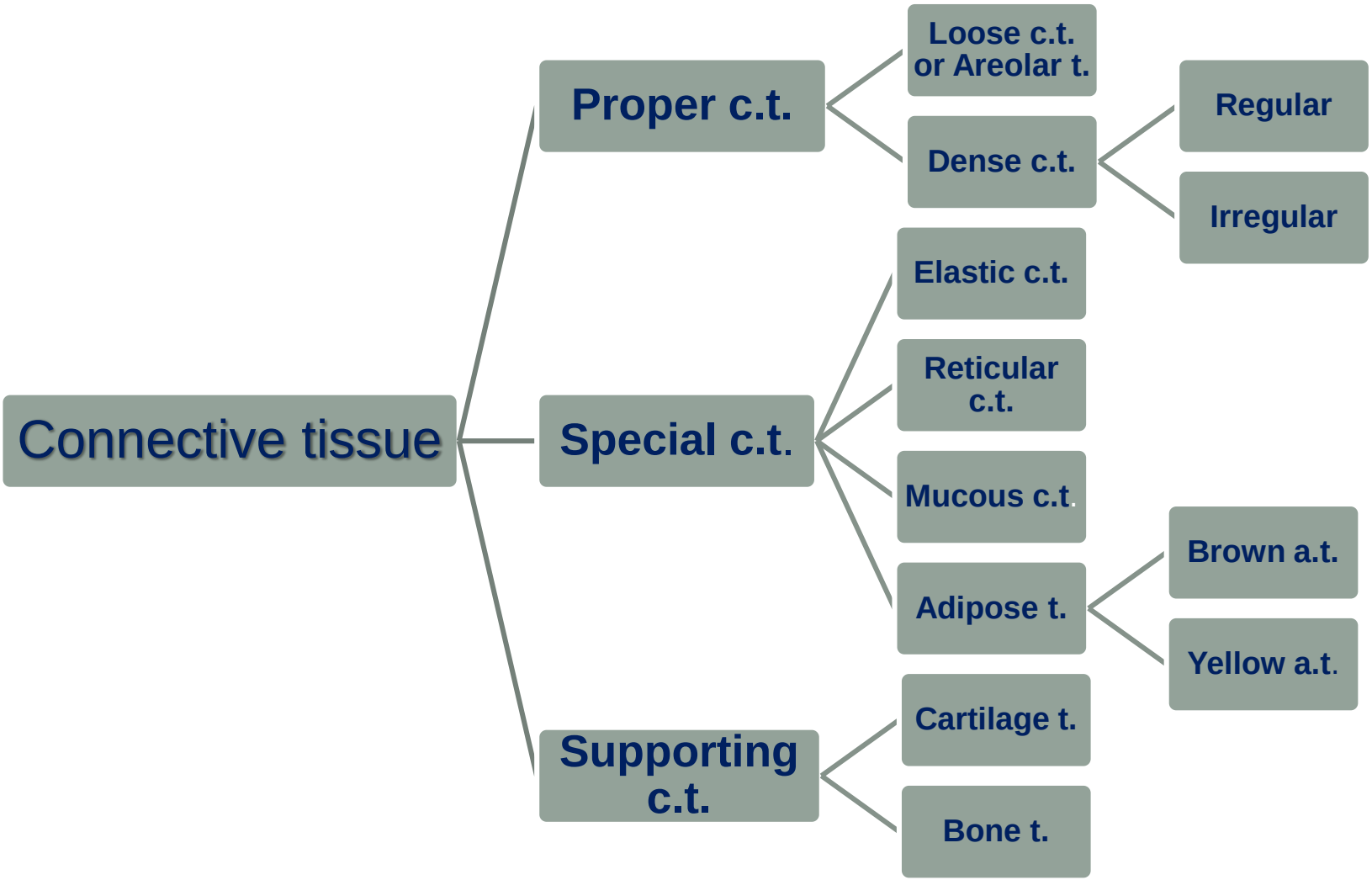
3.17 Melanocytes. Uterus (ewe). The melanocytes are arrowed. H & E. ×200.

FIGURE 4.7 AREOLAR CONNECTIVE TISSUE: A PROTOTYPE (MODEL) CONNECTIVE TISSUE.



Types of connective tissue

Loose connective tissue	Dense connective tissue	Blood	Lymph	Cartilage	Bone
Fibers create loose, open framework	Fibers densely packed	Contained in circulatory system	Contained in lymphatic system	Solid, rubbery matrix	Solid, crystalline matrix

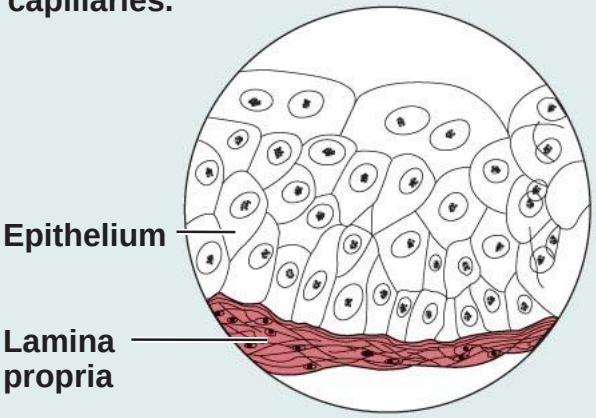

Connective tissue
Proper c.t.
Loose c.t. or Areolar t.
Dense c.t.
Regular
Irregular
Special c.t.
Elastic c.t.
Reticular c.t.
Mucous c.t.
Adipose t.
Brown a.t.
Yellow a.t.
Supporting c.t.
Cartilage t.
Bone t.

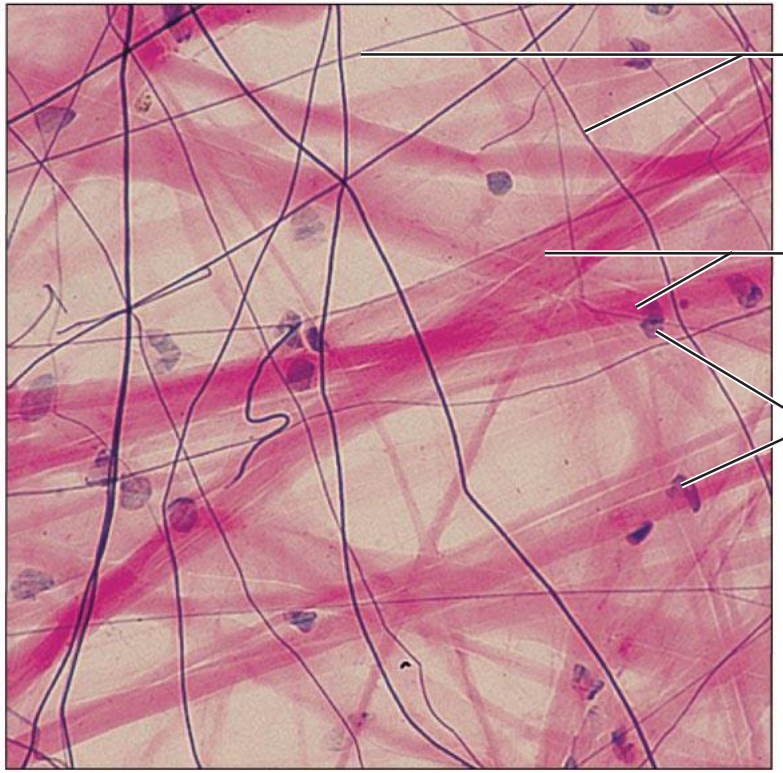
Loose connective tissue, areolar

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.





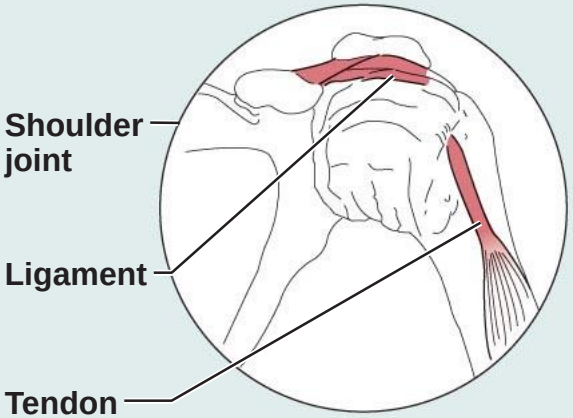
Photomicrograph: Areolar connective tissue, a soft packaging tissue of the body (300x).

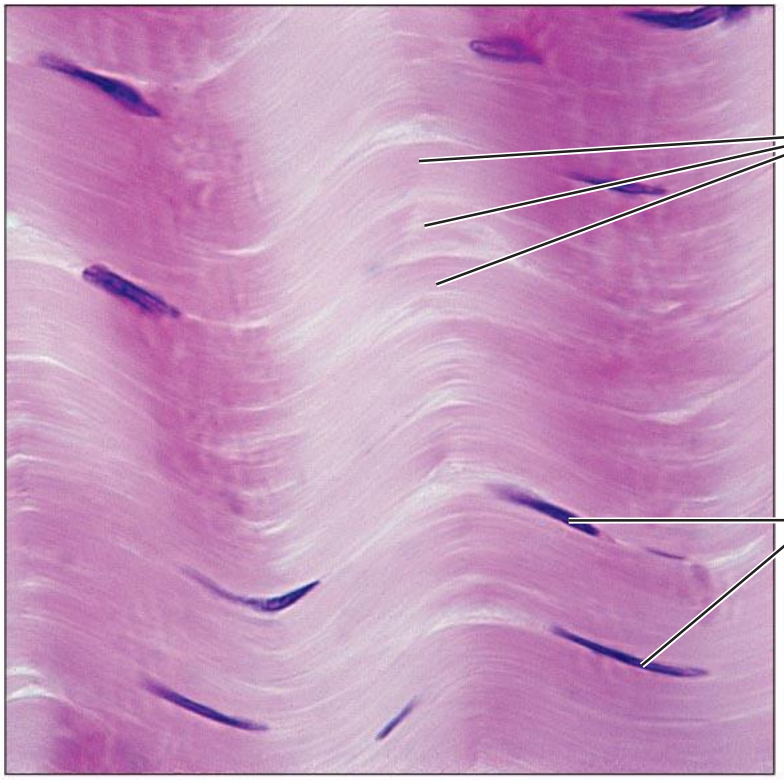
Dense connective tissue, dense regular

Description: Primarily parallel collagen fibers; a few elastic 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.





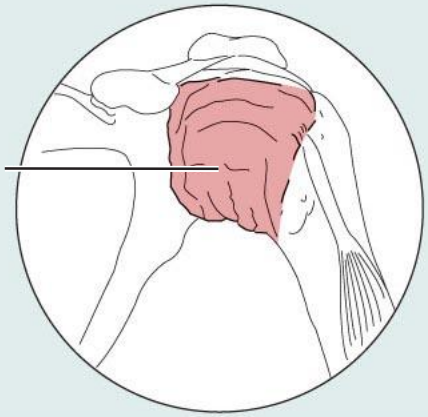
Photomicrograph: Dense regular connective tissue from a tendon (500x).

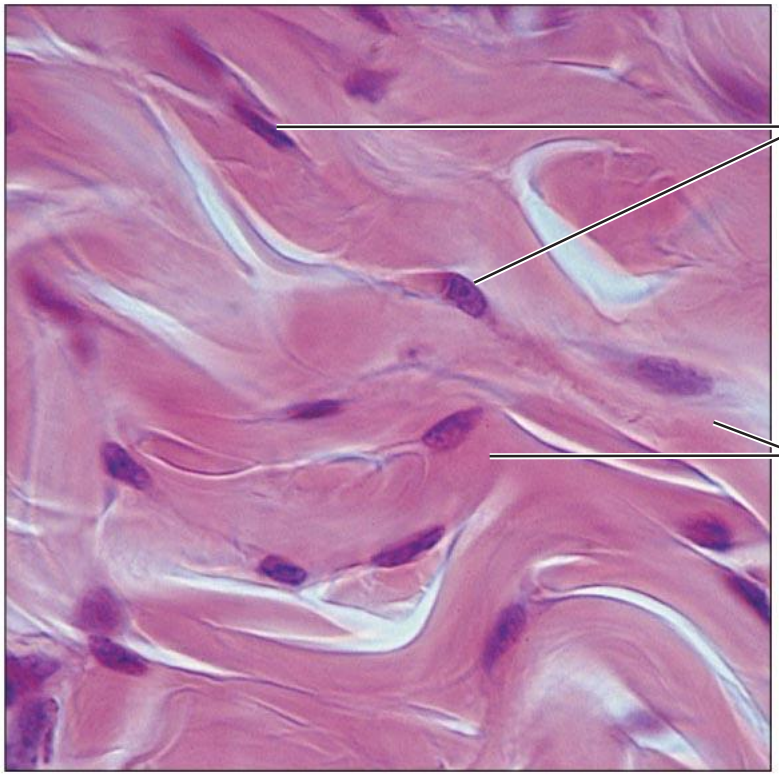
Dense connective tissue, dense irregular

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: Fibrous capsules of organs and of joints; dermis of the skin; submucosa of digestive tract.





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

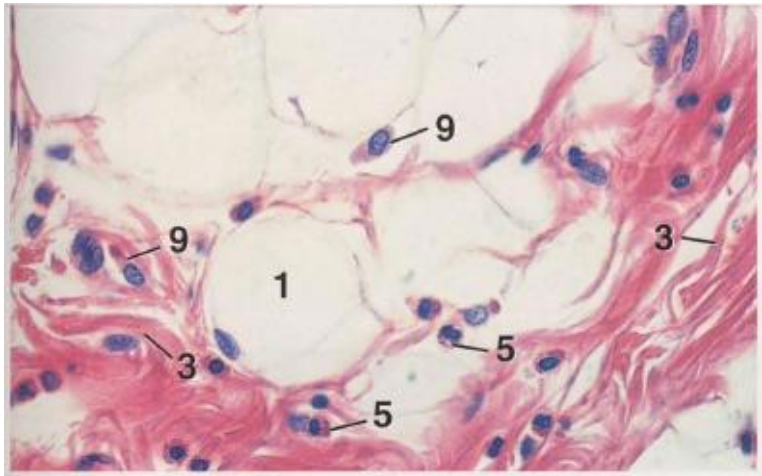


Figure 3.7 × 250

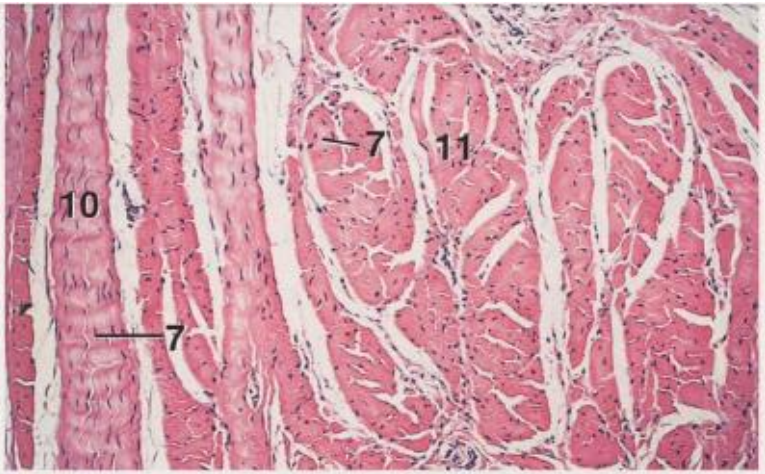
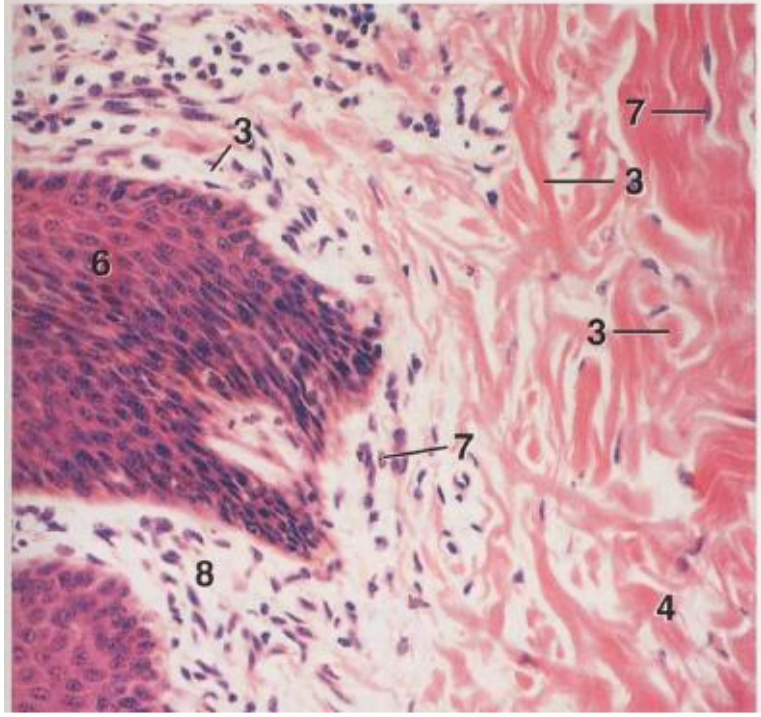


Figure 3.10 × 62.5

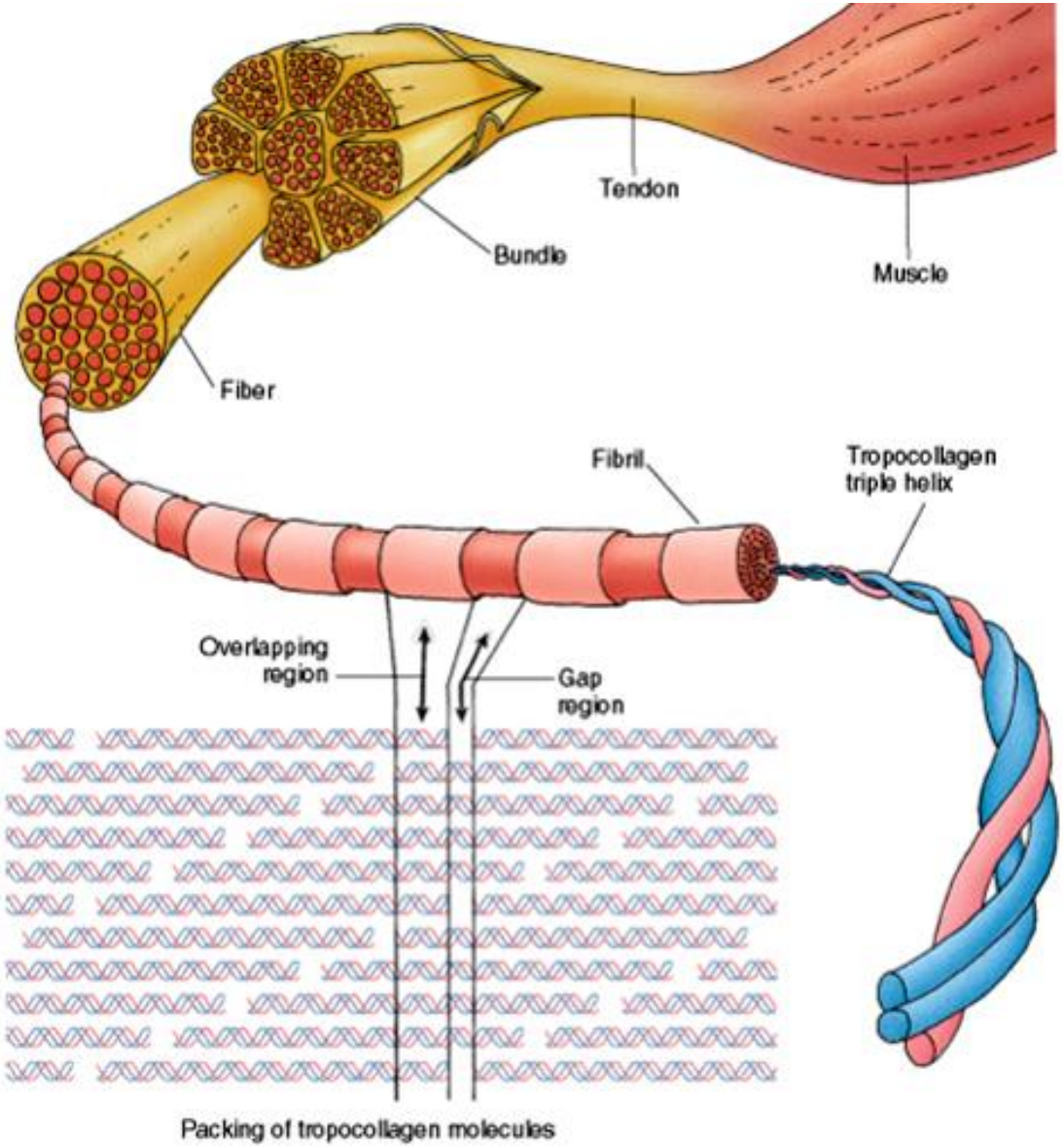


KEY	
1. Adipocyte	7. Fibroblast nucleus
2. Arteriole	8. Loose connective tissue
3. Collagenous fiber	9. Macrophage
4. Dense irregular connective tissue	10. Tendon, l.s.
5. Eosinophil	11. Tendon, x.s.
6. Epithelium, planum	

Figure 3.7. Macrophages, Loose Connective Tissue, Colon, Pig. Wandering macrophages are characterized by their oval shape. The cytoplasm of these cells often contains ingested particles and appears dirty. Eosinophils of the pig contain oval or bilobed nuclei.

Figure 3.8. Loose and Dense Irregular Connective Tissue, Dermis, Planum Nasolabiale, Cow. Note that the loose connective tissue of the papillary layer of the dermis contains finer fibers and more cells than the dense irregular connective tissue of the reticular layer.

Figure 3.9. Dense Irregular Connective Tissue, Dermis, Horse. Note the coarse, interwoven, collagenous fibers.

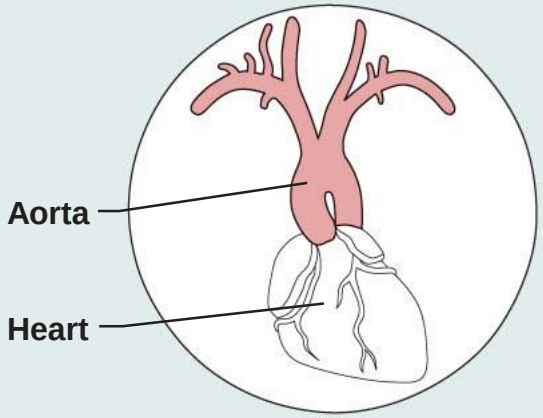


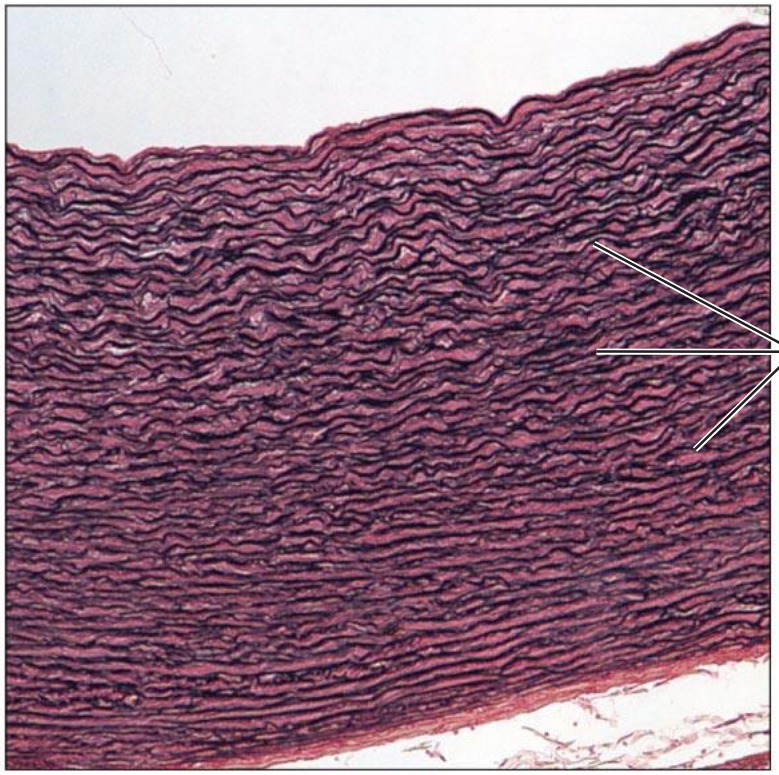
Elastic tissue

Description: Dense regular connective tissue containing a high proportion of elastic fibers.

Function: Allows recoil of tissue following stretching; maintains pulsatile flow of blood through arteries; aids passive recoil of lungs following inspiration.

Location: Walls of large arteries; within certain ligaments associated with the vertebral column; within the walls of the bronchial tubes.





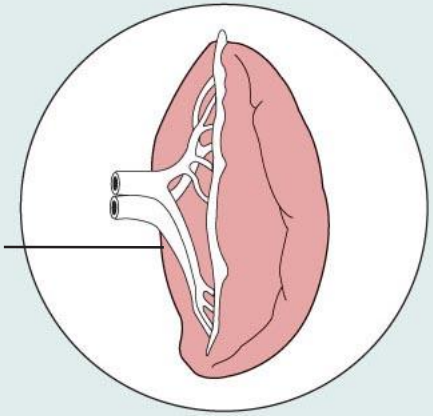
Photomicrograph: Elastic connective tissue in the wall of the aorta (250x).

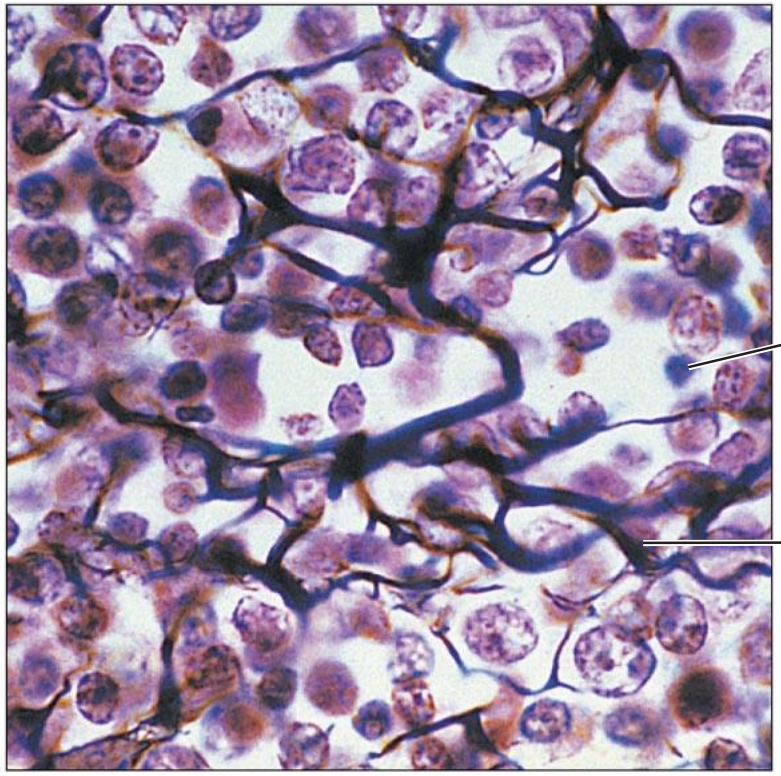
Reticular tissue

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 (350x).

Reticular connective tissue

LIVER: SLIDE 198 ODD, SILVER STAIN, 40X OBJ

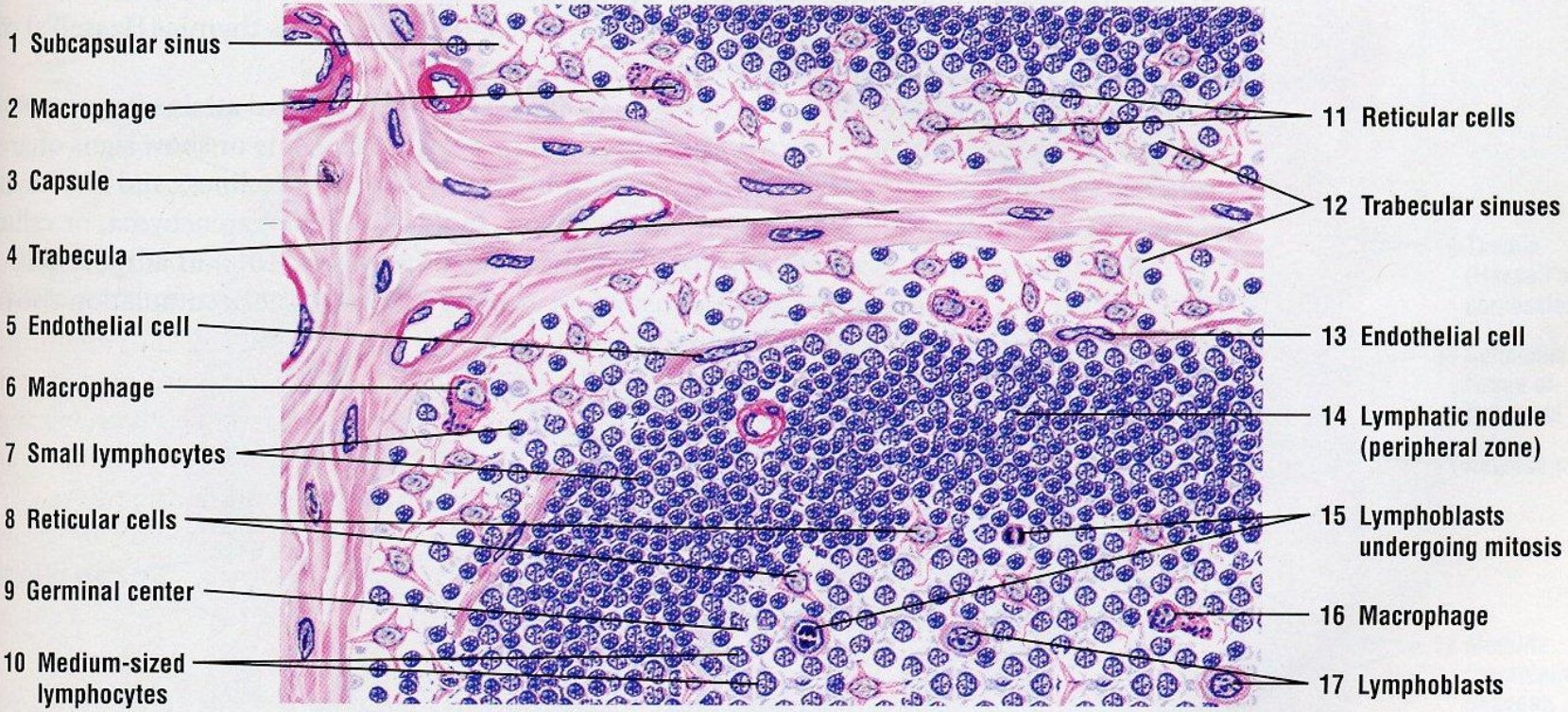


FIGURE 9.4 ■ Lymph node: subcortical sinus and lymphatic nodule. Stain: hematoxylin and eosin. High magnification.

Mucous connective tissue

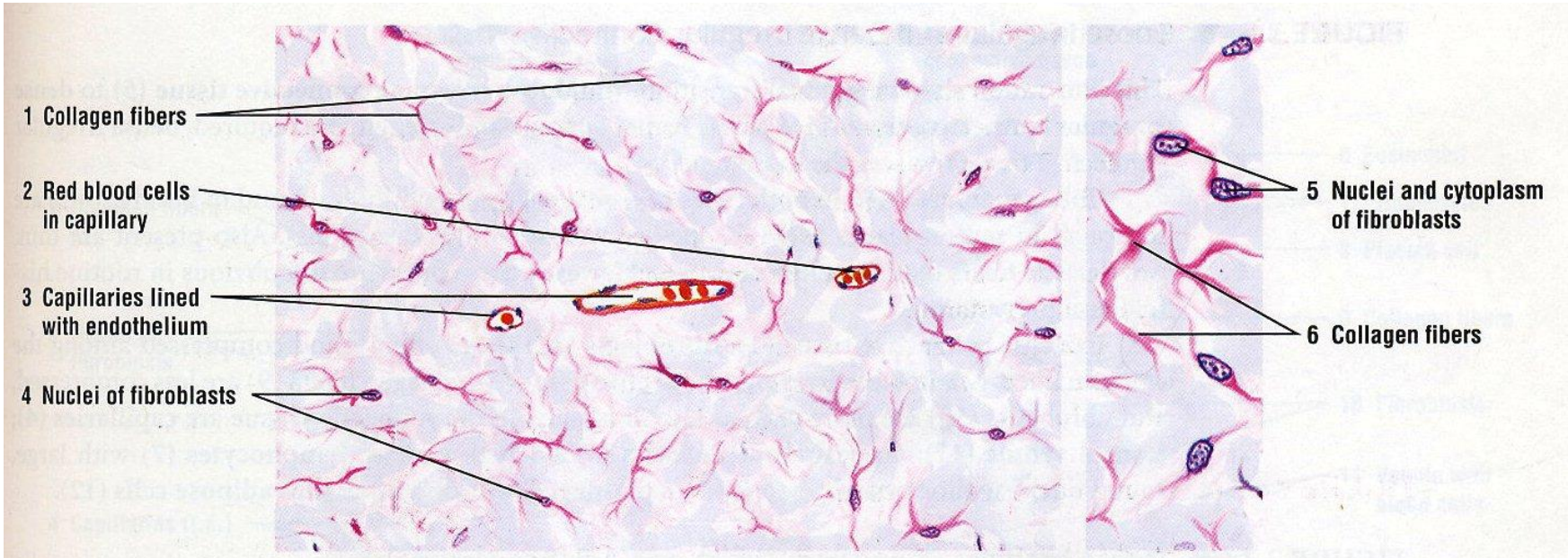
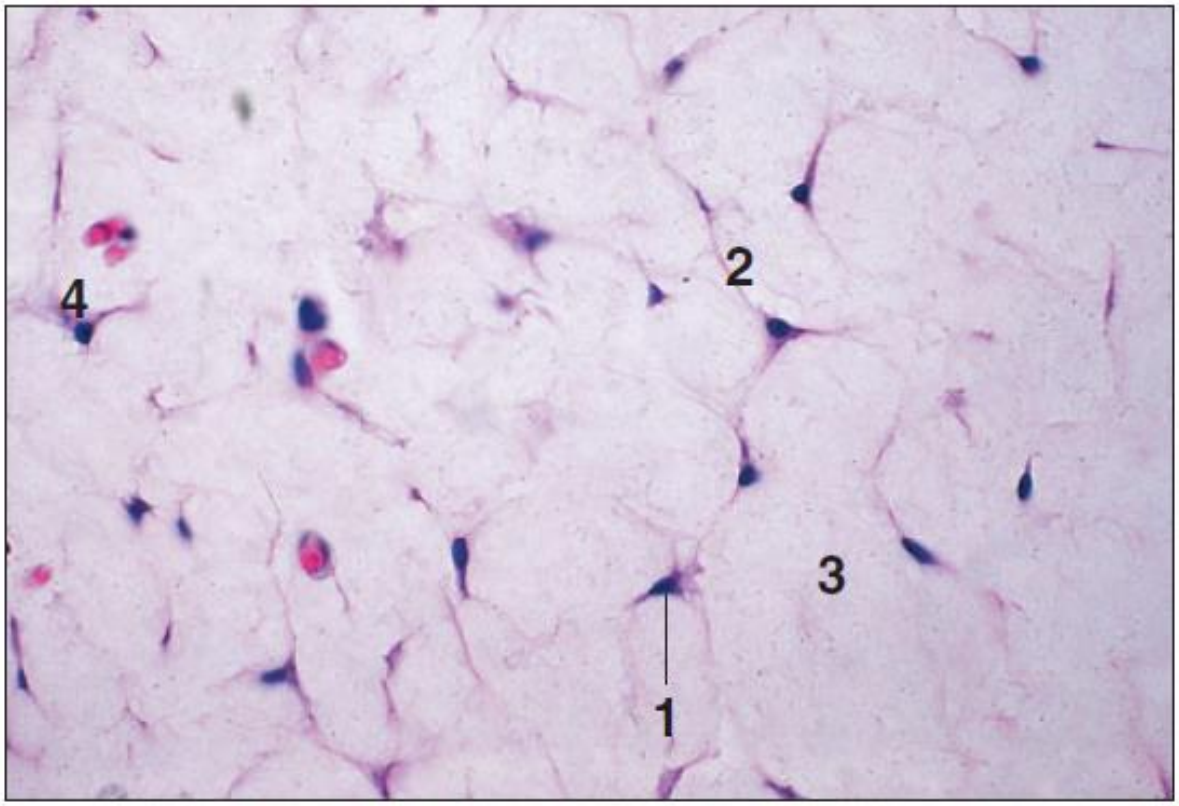


FIGURE 3.3 ■ Embryonic connective tissue. Stain: hematoxylin and eosin. Left, low magnification; right, high magnification.



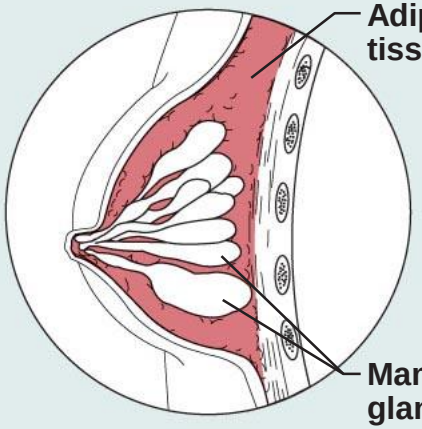
3.1 Umbilical cord (foal). (1) Nucleus of the stellate mesenchymal cell. (2) Long cell processes. (3) Extracellular matrix. (4) Blood vessels. H & E. ×125.

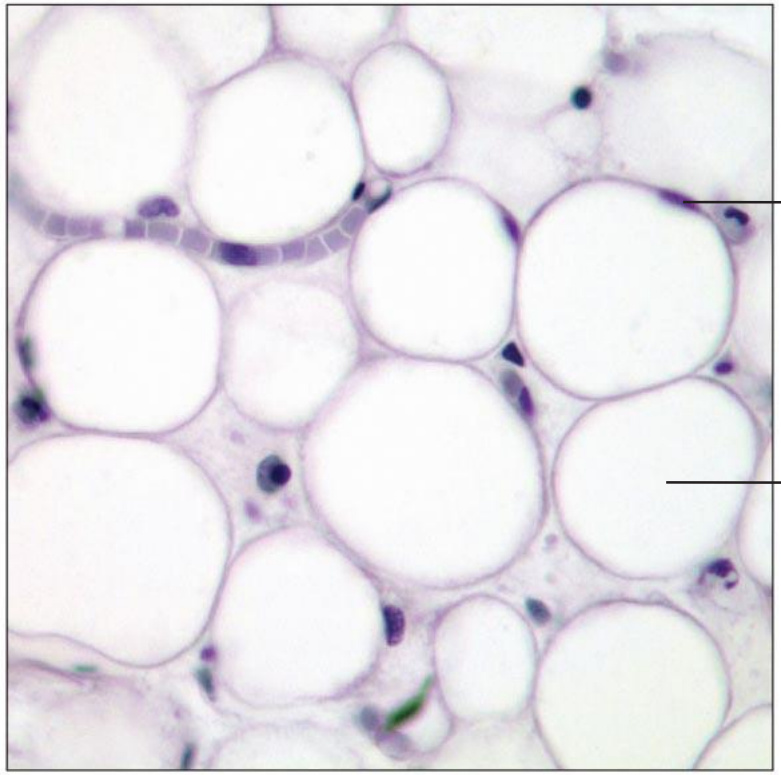
Adipose tissue

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

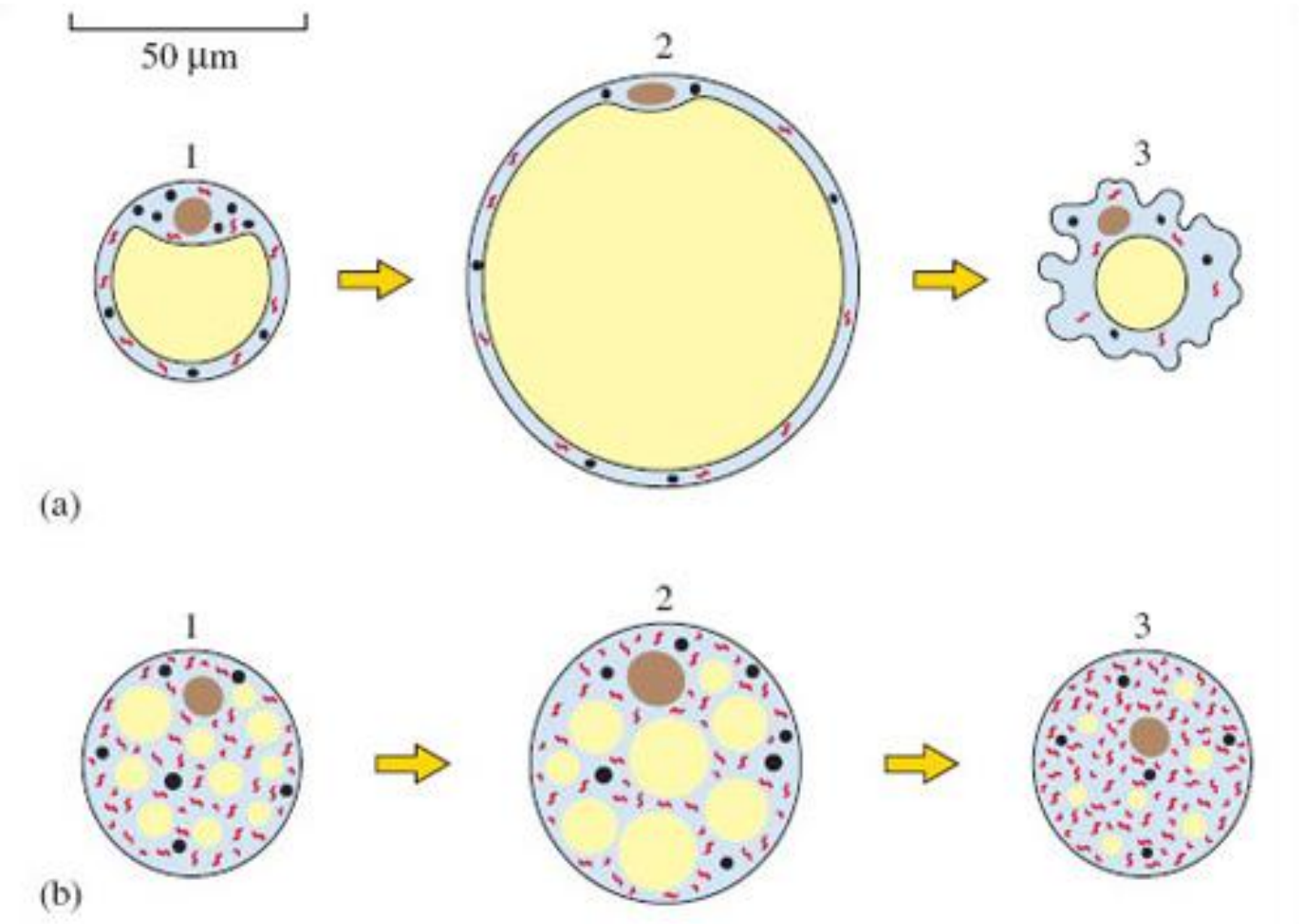
Function: Provides reserve food fuel; insulates against heat loss; supports and protects organs.

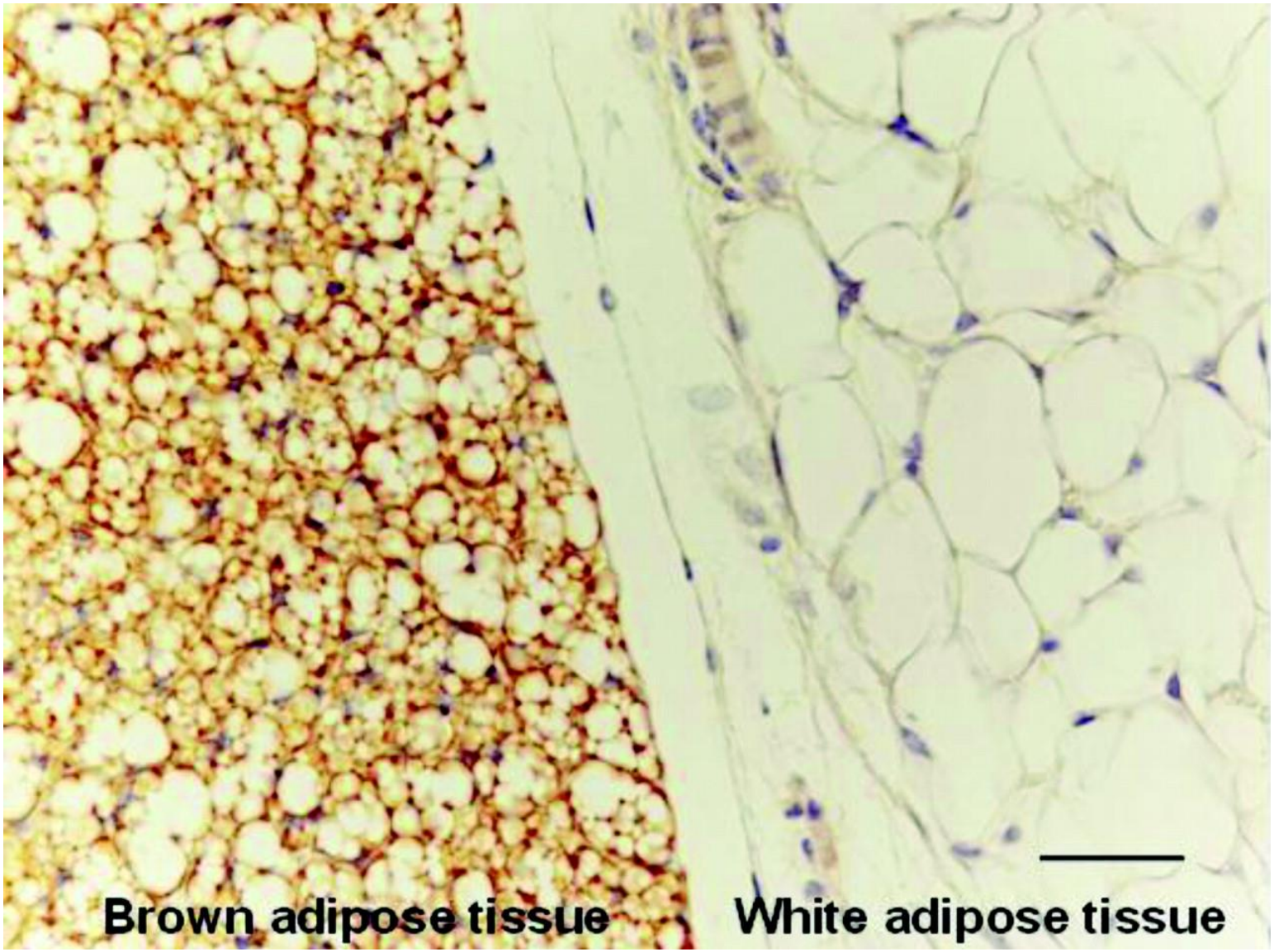
Location: Under skin in the hypodermis; around kidneys and eyeballs; within abdomen; in breasts.





Photomicrograph: Adipose tissue from the subcutaneous layer under the skin (350x).


50 µm
1
2
3
(a)
1
2
3
(b)


Brown adipose tissue
White adipose tissue