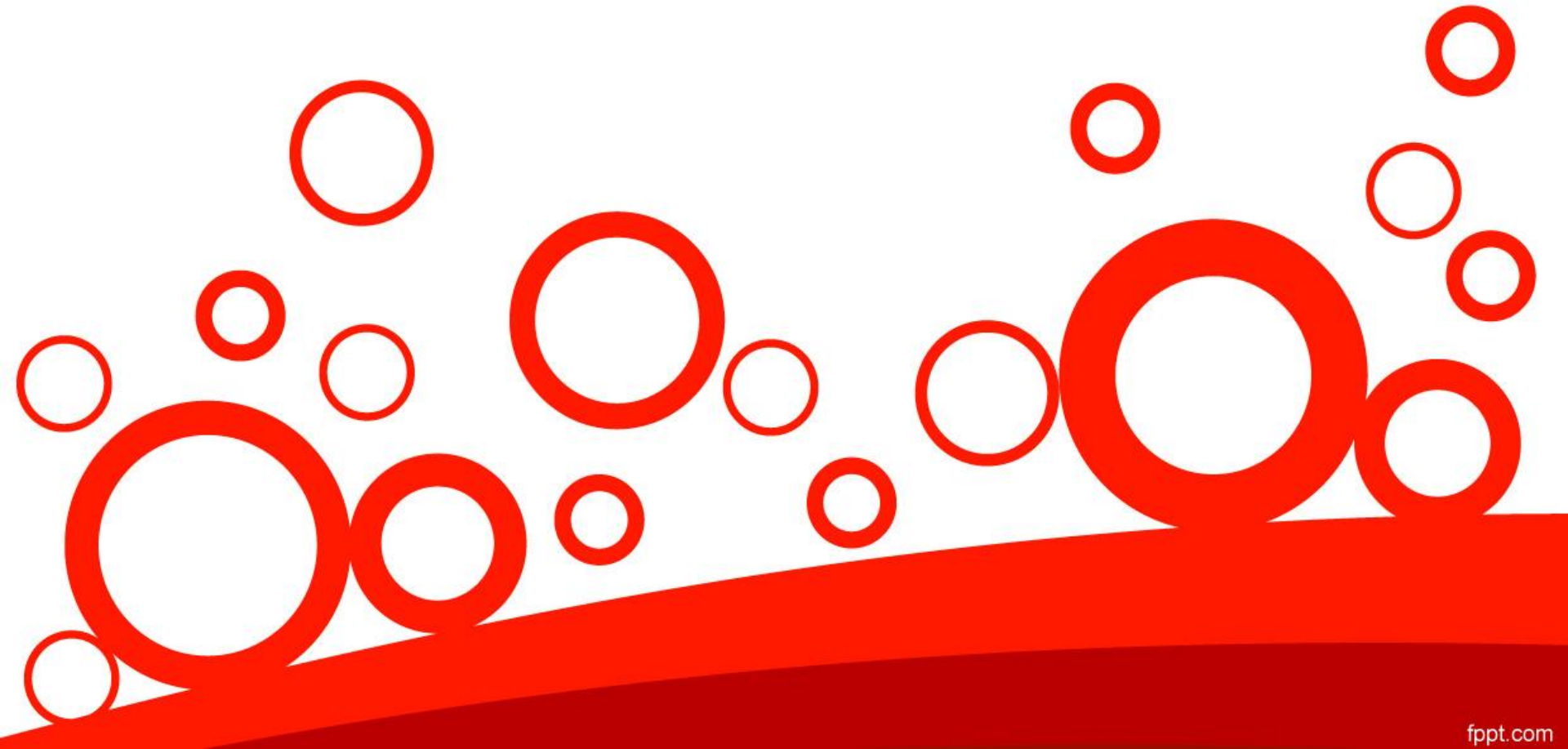
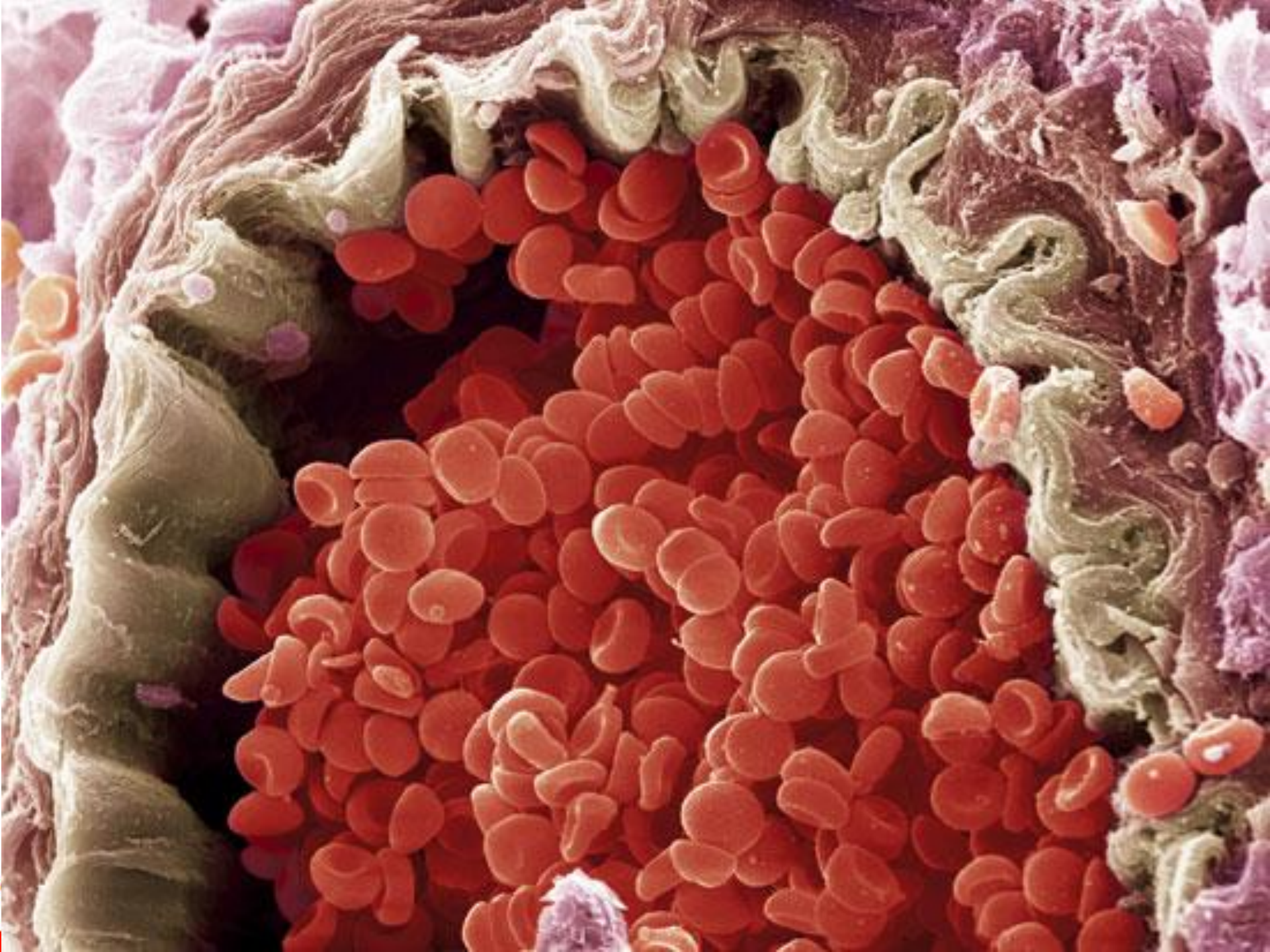




Circulatory system





General structure

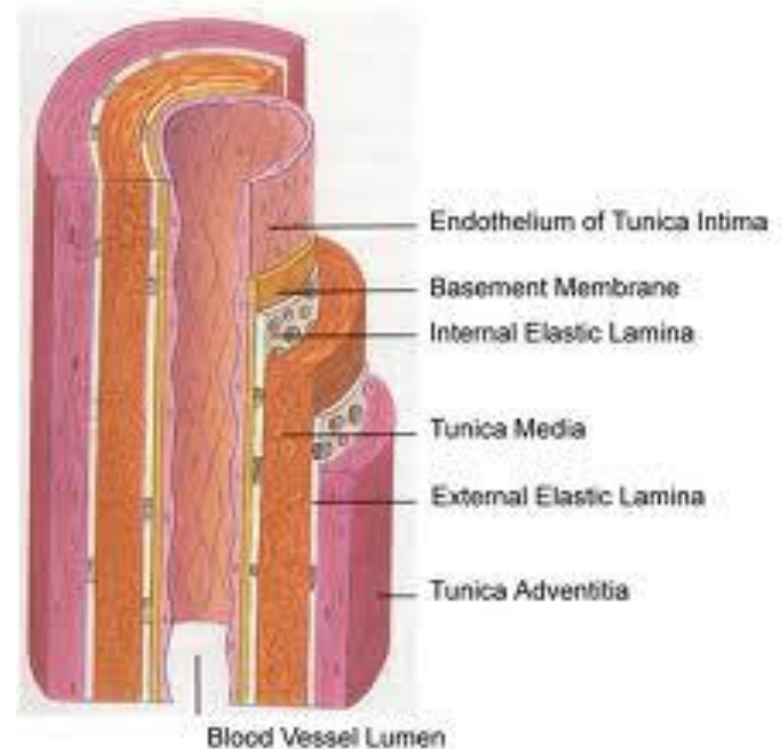
- **Tunica intima**

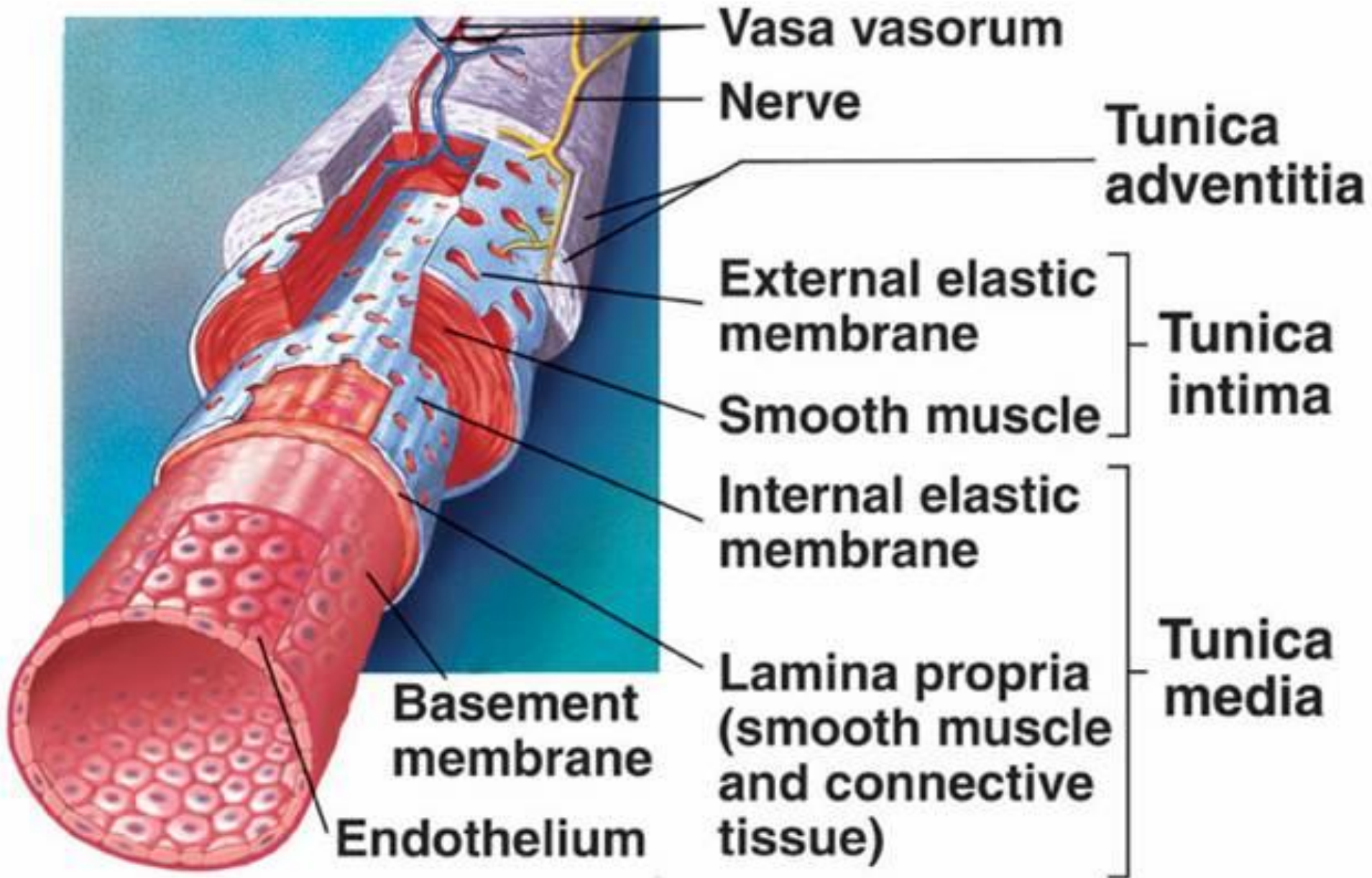
- Endothelium
- Basal lamina
- Subendothelial layer
- Membrana elastica interna

- **Tunica media**

- Smooth muscle
- Membrana elastica externa

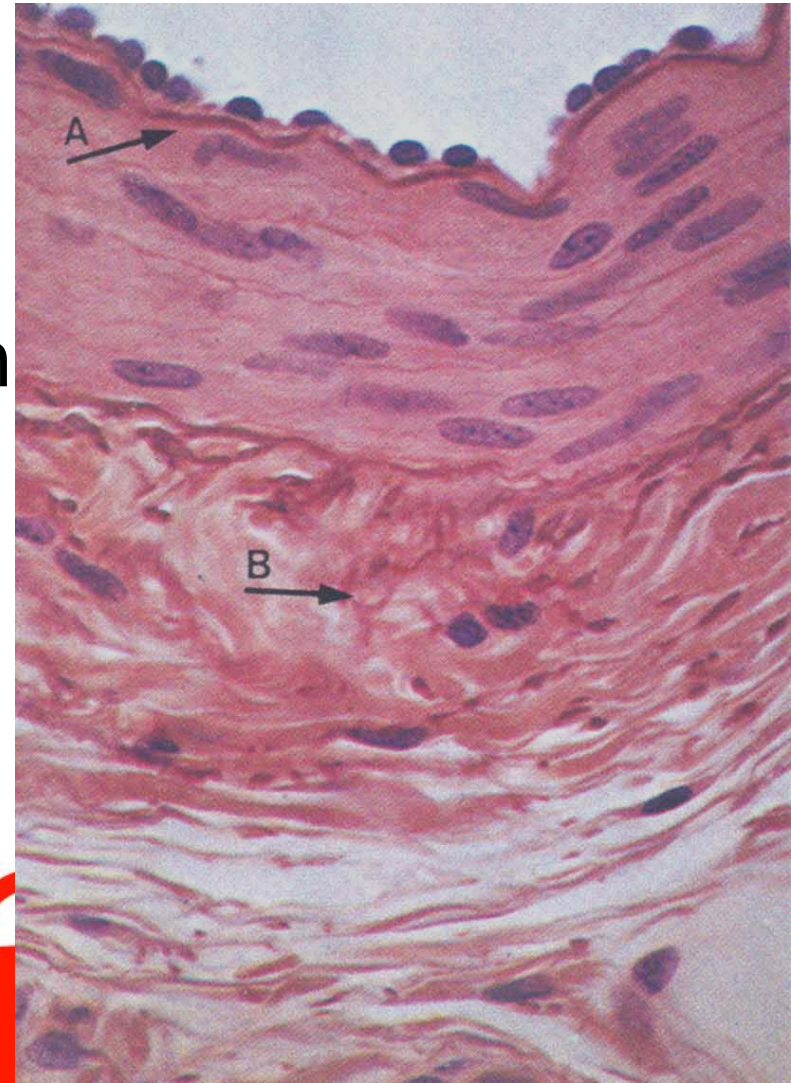
- **Tunica adventitia**





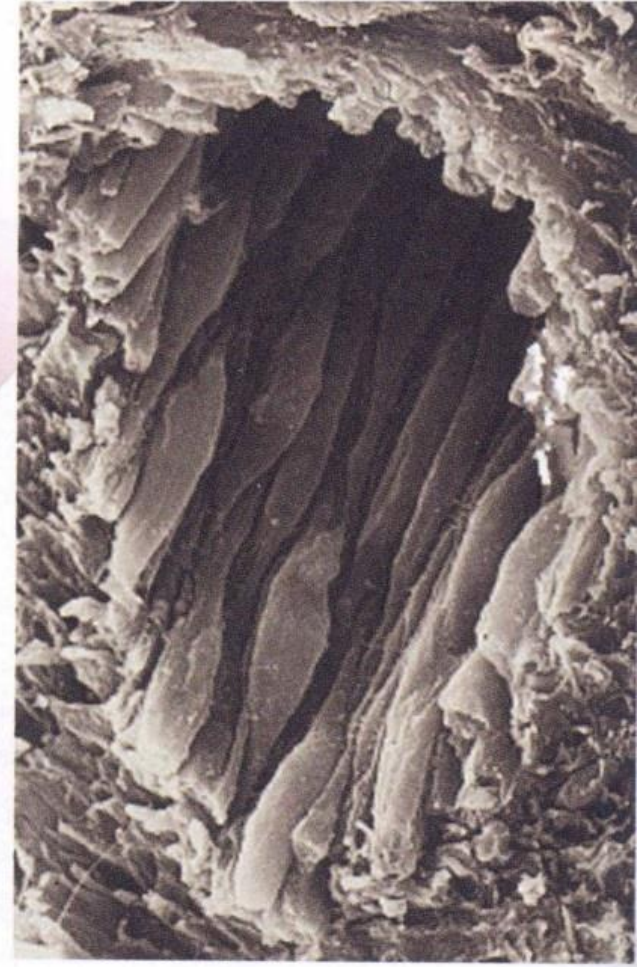
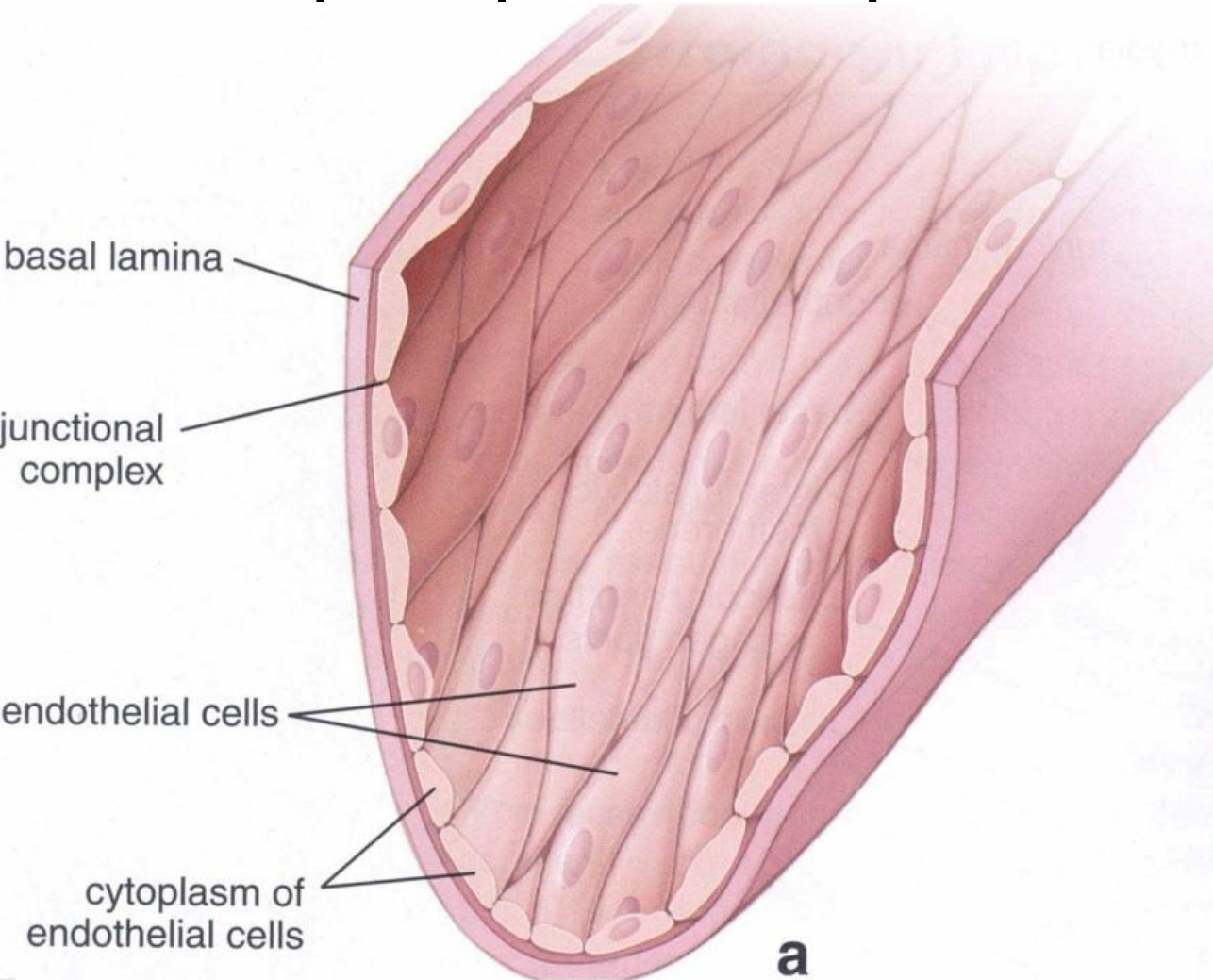
Tunica intima

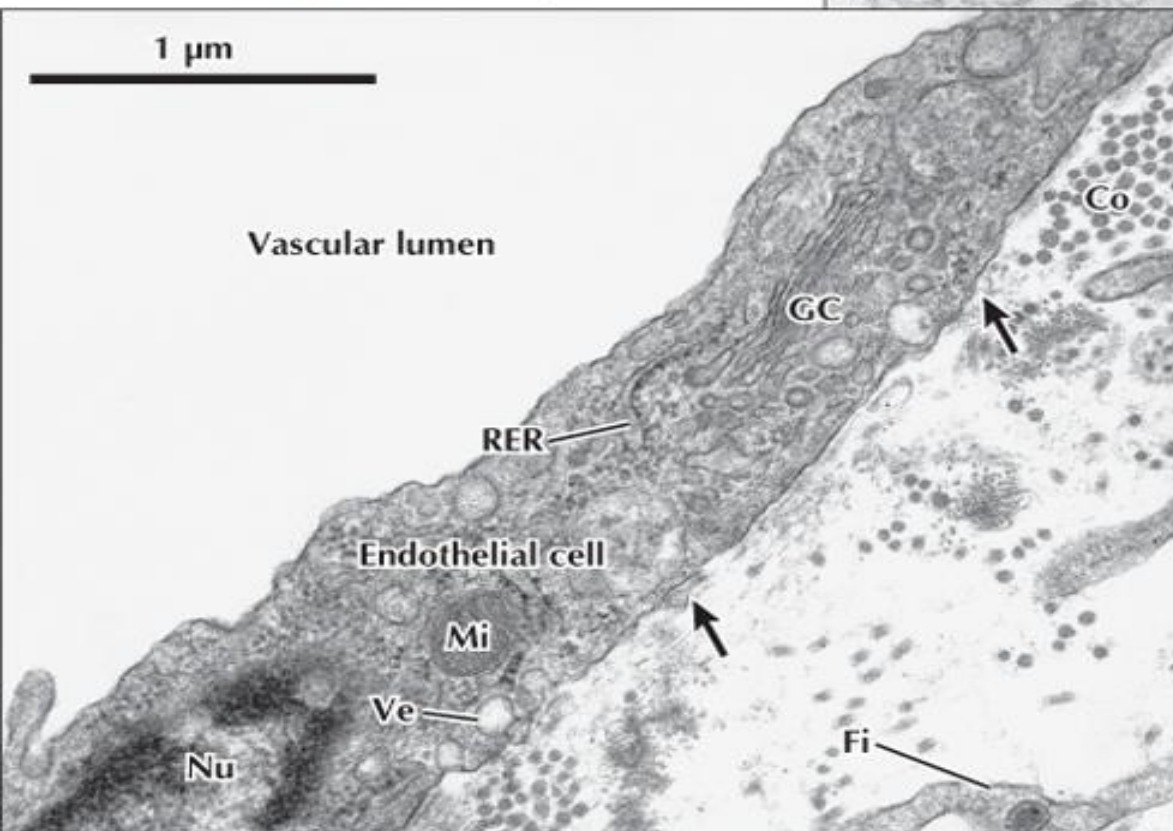
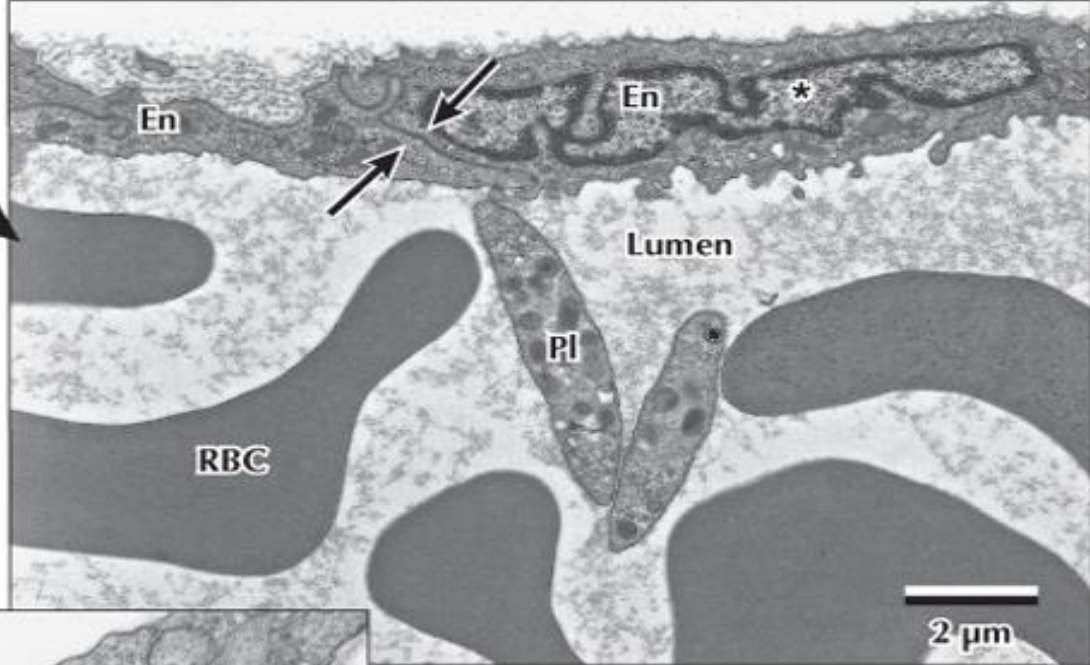
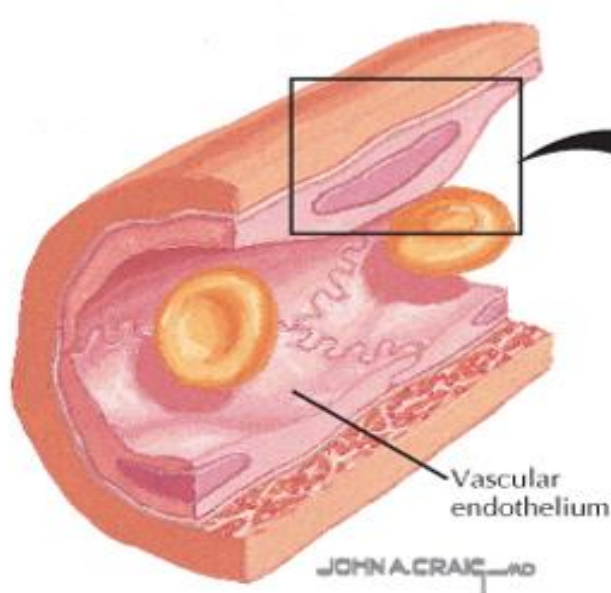
- Endothelium
- Basal lamina
- Subendothelial layer
- Membrana elastica interna



Endothelium

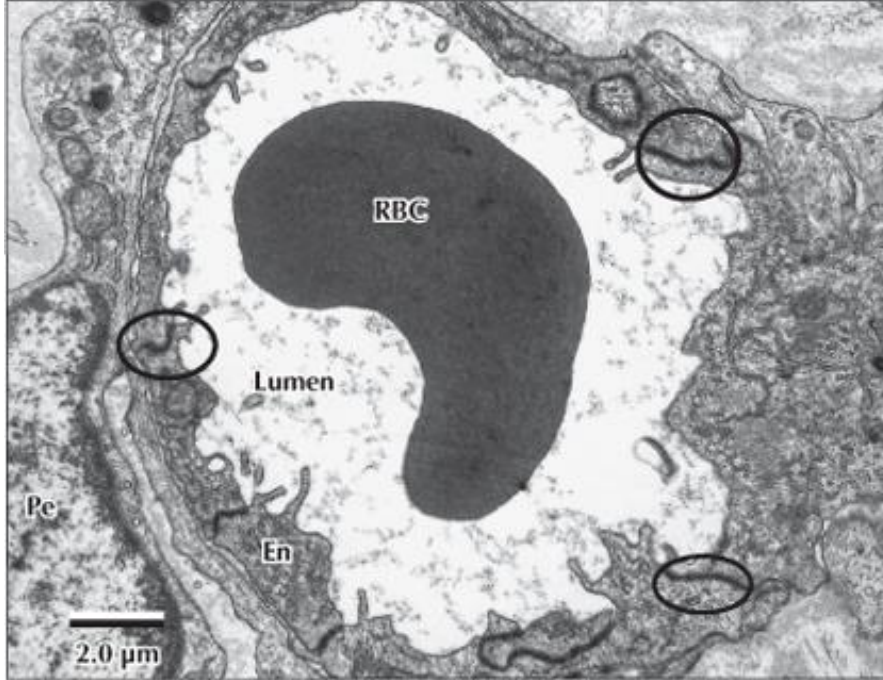
- Simple squamous epithelium





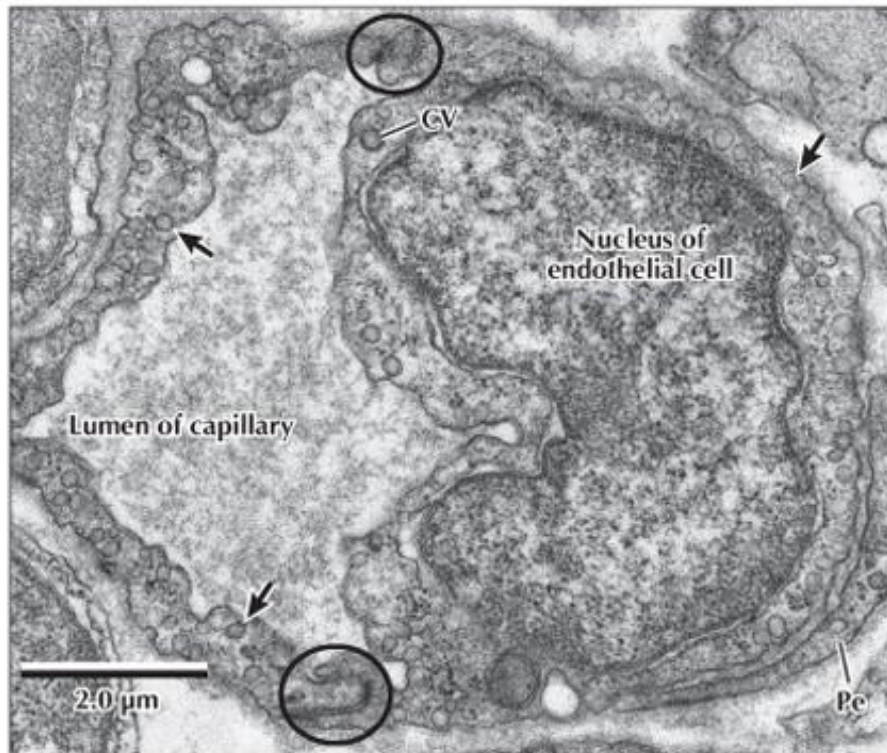
▲ **EM of part of an arteriole.** The lumen, lined by endothelial cells (En), contains erythrocytes (RBC) and platelets (Pl). The nucleus (★) of one endothelial cell looks corrugated because of cell contraction. Ends of two closely apposed endothelial cells (arrows) are joined by intercellular junctions. 6000×.

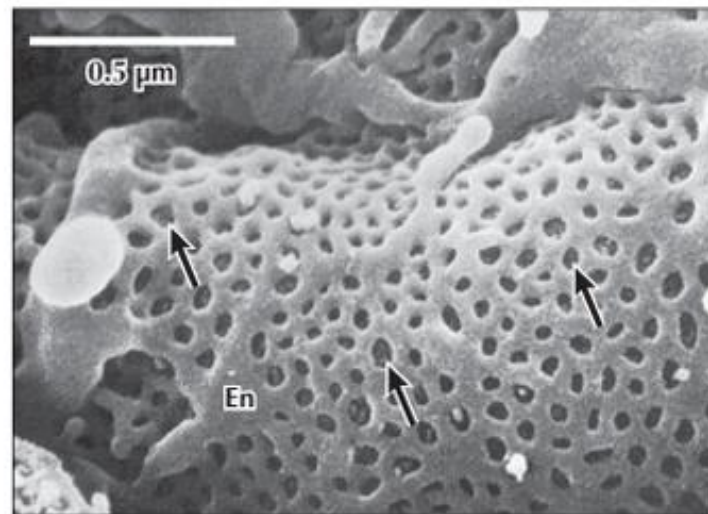
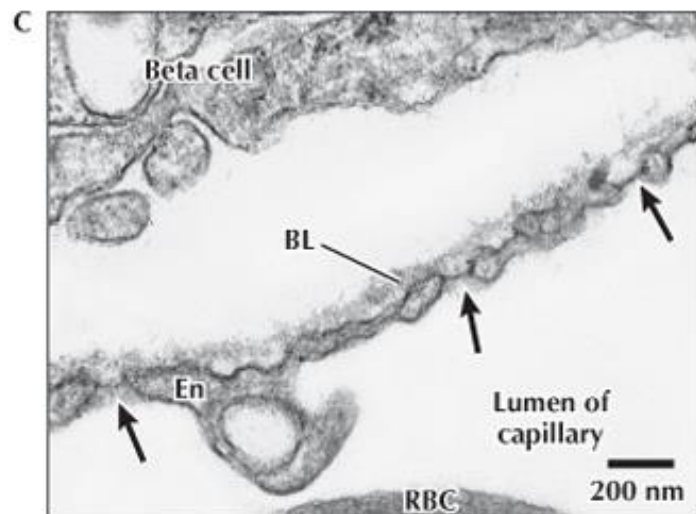
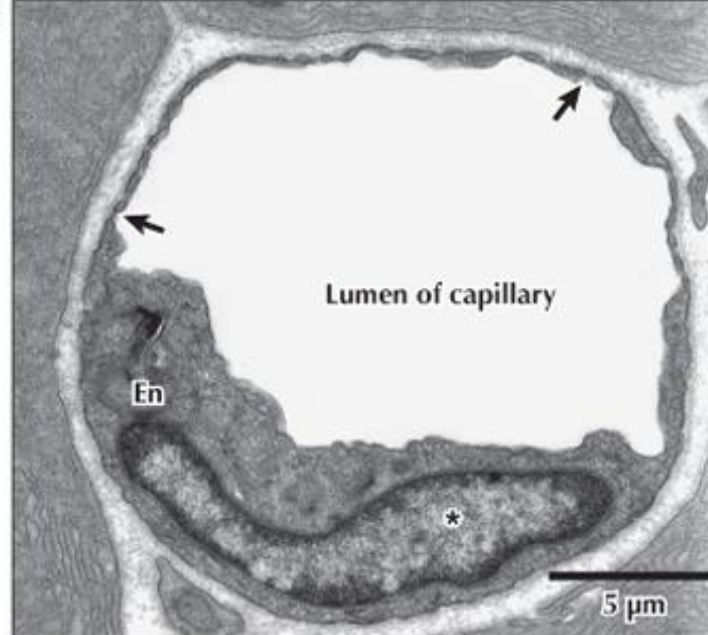
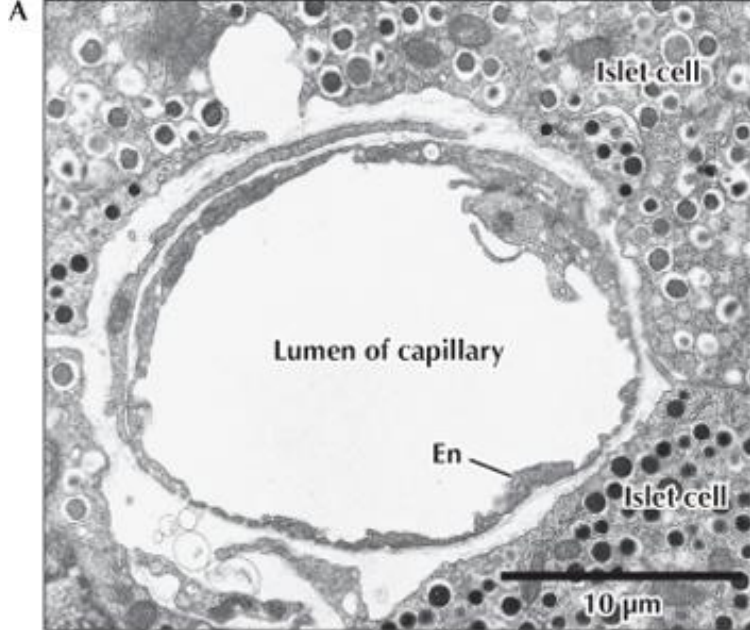
◀ **EM of part of a vascular endothelial cell.** The elongated cell rests on a thin basal lamina (arrows) and contains many transcytotic vesicles (Ve), which are especially numerous in the abluminal part of the cell. Part of the nucleus (Nu) can be seen. A Golgi complex (GC), rough endoplasmic reticulum (RER), and mitochondria (Mi) are also in the cytoplasm. Underlying connective tissue shows collagen fibrils (Co) and processes of fibroblasts (Fi). 33,000×.



◀ **EM of a tight capillary in the central nervous system.** The lumen contains an erythrocyte (RBC); endothelial cells (En) form an uninterrupted, complete lining (parts of several cells are seen). Endothelial cells are linked by intercellular junctions, most of which are tight junctions (circles) that are linear densities between adjacent cells. A grazing section through one endothelial cell (to the right) reveals abundant, tightly packed organelles in the cytoplasm. A pericyte (Pe) surrounds the endothelium on its abluminal aspect and shares the same basal lamina. Unlike endothelial cells, pericytes do not completely encircle the capillary lumen. 6000x.

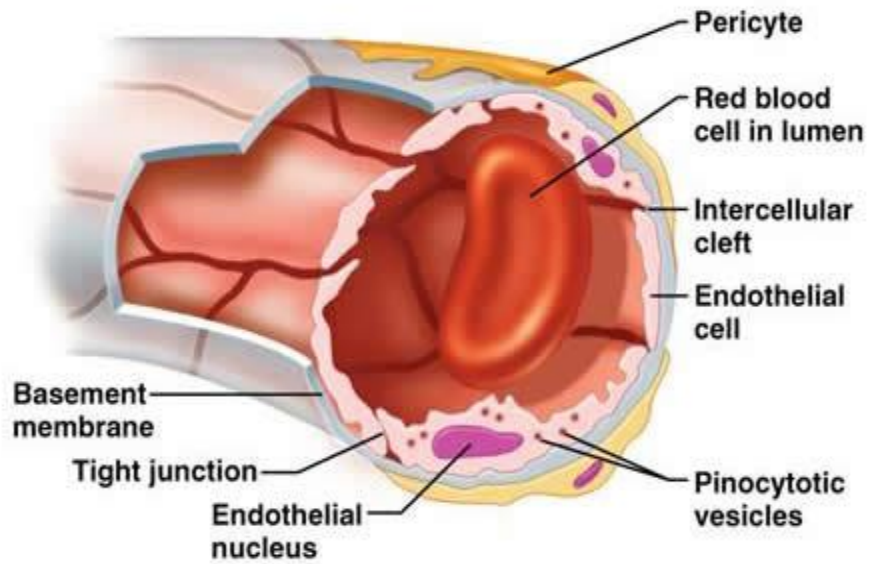
▶ **EM of a skeletal muscle tight capillary sectioned transversely.** The vessel has a signet ring appearance. Parts of two endothelial cells line the lumen and are held together by tight junctions (circles). One cell is sectioned at the level of its euchromatic nucleus, which has an irregular contour. Cytoplasm of both cells contains abundant organelles, including many spherical transcytotic vesicles (arrows). In contrast to more numerous transcytotic vesicles, the less common coated vesicles (CV) are usually on the luminal side of the endothelium. The process of a pericyte (Pe) adheres to the outer aspect of the endothelium, with which it shares a basal lamina. 12,000x.



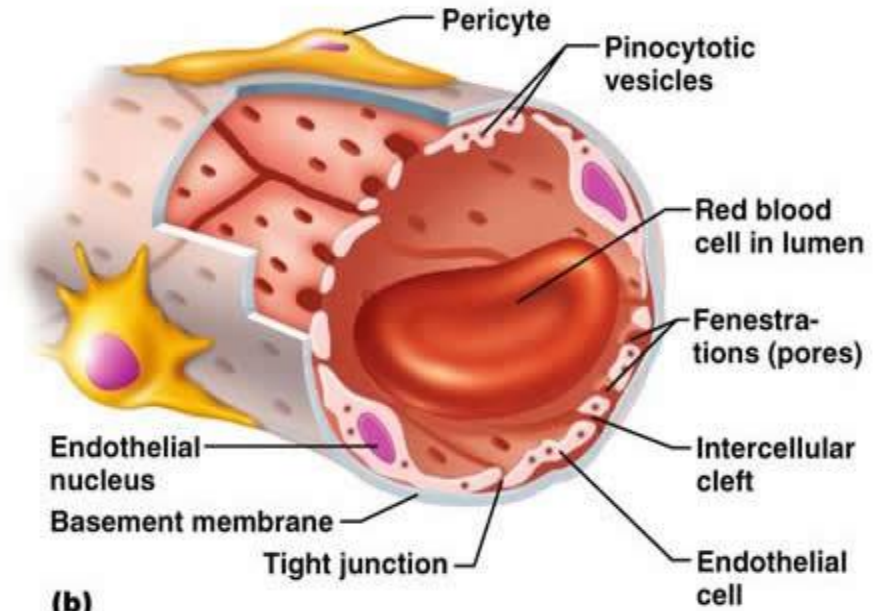


▲ EMs of fenestrated capillaries in the endocrine pancreas in transverse section. Thin endothelium (En) lines wide capillary lumina. The endothelium of one capillary is close to islet cells (A) and an endothelial cell nucleus (*) is in the plane of section of another (B). Higher magnification (C) better shows endothelium and several fenestrae (arrows), each spanned by a thin diaphragm. A surrounding basal lamina (BL) and a beta cell are also seen. A: 3000 \times ; B: 4000 \times ; C: 40,000 \times .

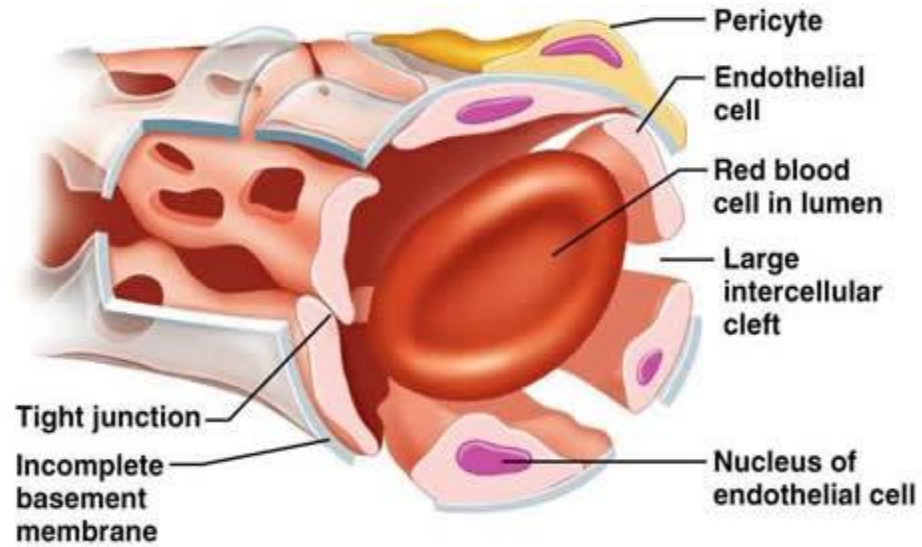
▲ High-resolution scanning EM of a glomerular capillary in the renal corpuscle. This surface view of endothelium (En), from inside the lumen, shows circular fenestrae (arrows). 50,000 \times . (Courtesy of Dr. M. J. Hallenberg)



(a)



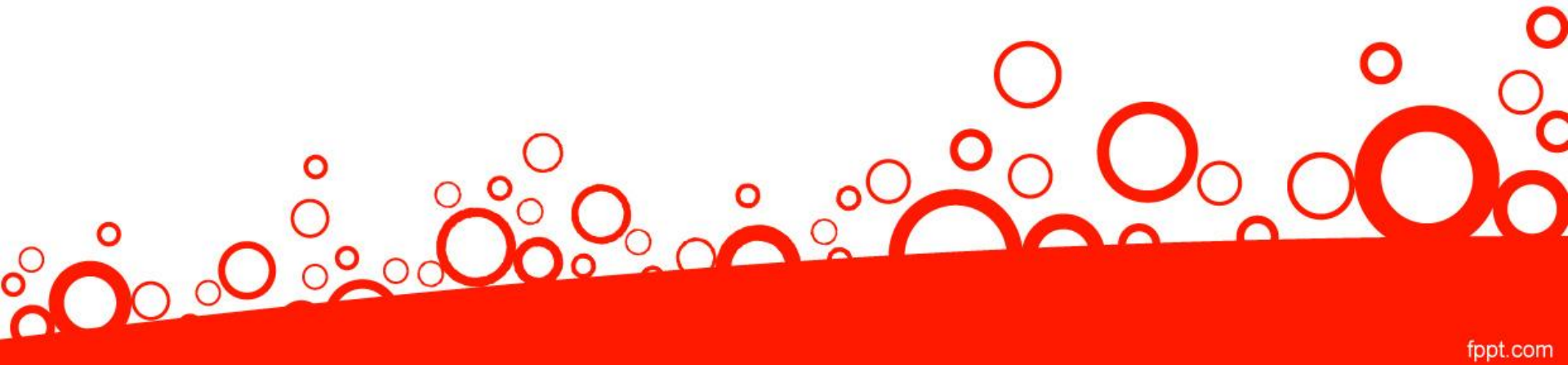
(b)



(c)

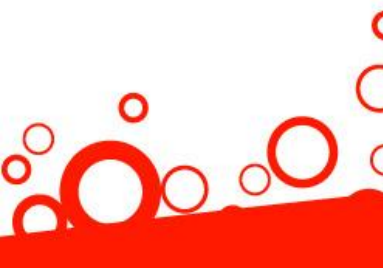
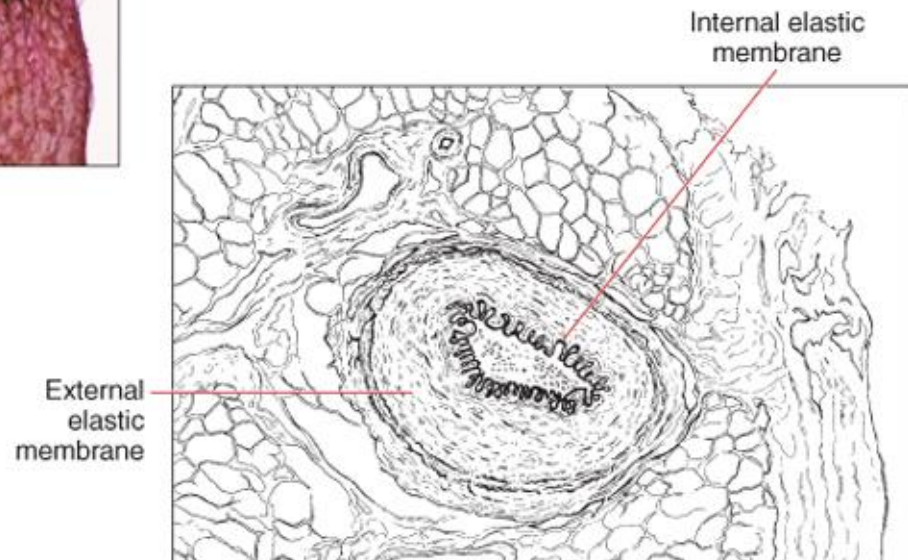
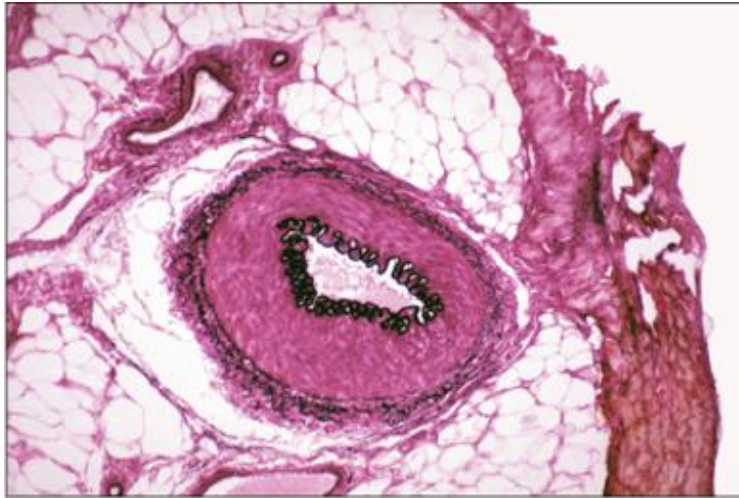
Subendothelial layer

- **ECM** (collagen, elastic fibers, proteoglycans...)
- **Smooth muscle cells**
- Thicker in muscular arteries
- Atherosclerosis



Membranae elasticae

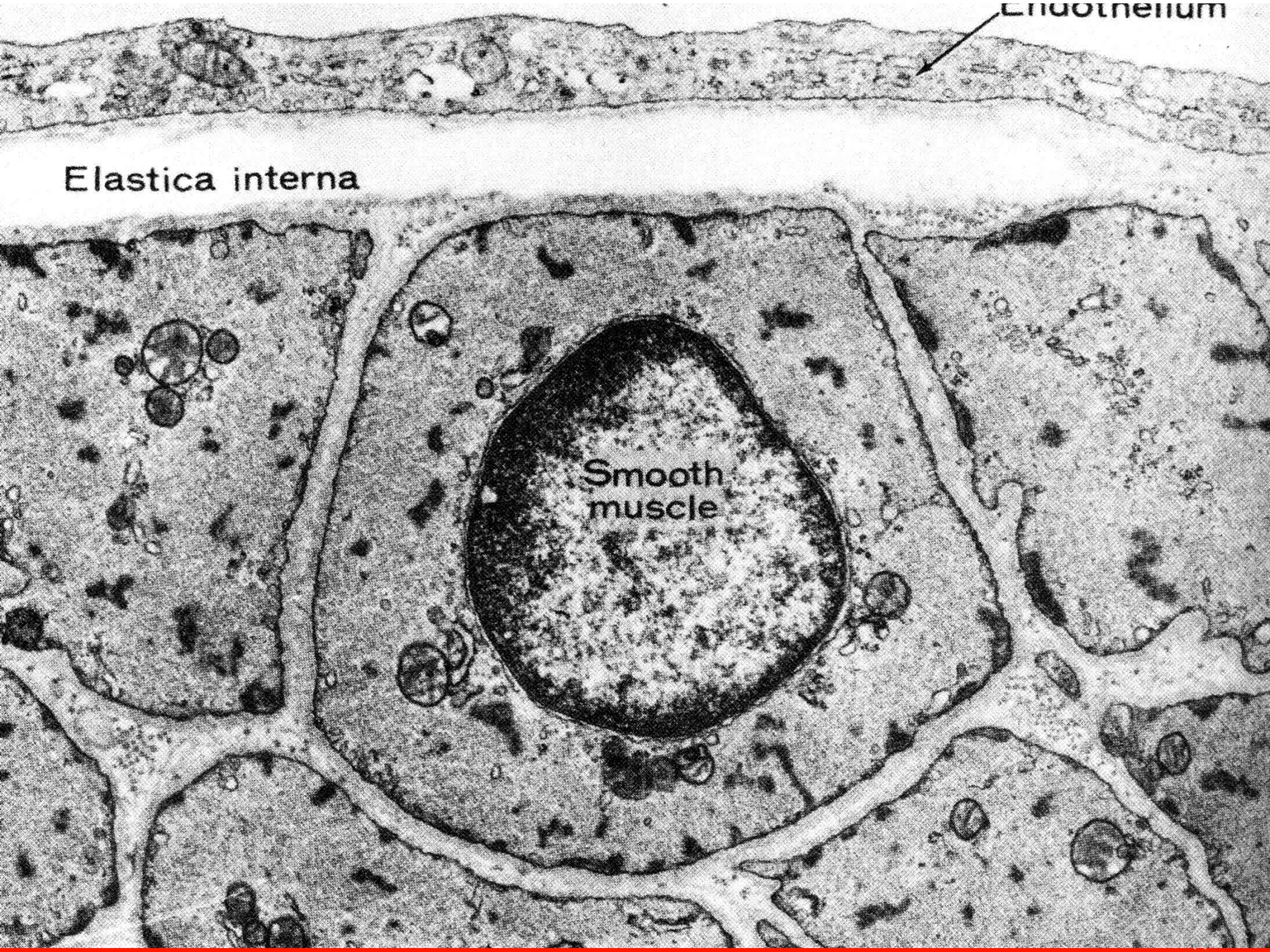
- Fenestrated elastic lamellae
- Externa – in the great arteries

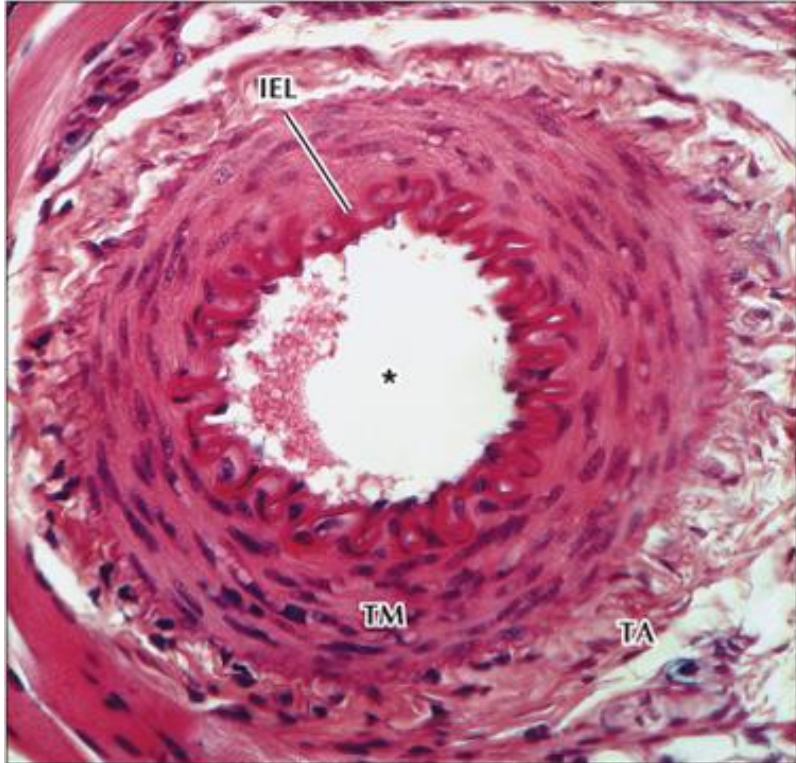


Endothelium

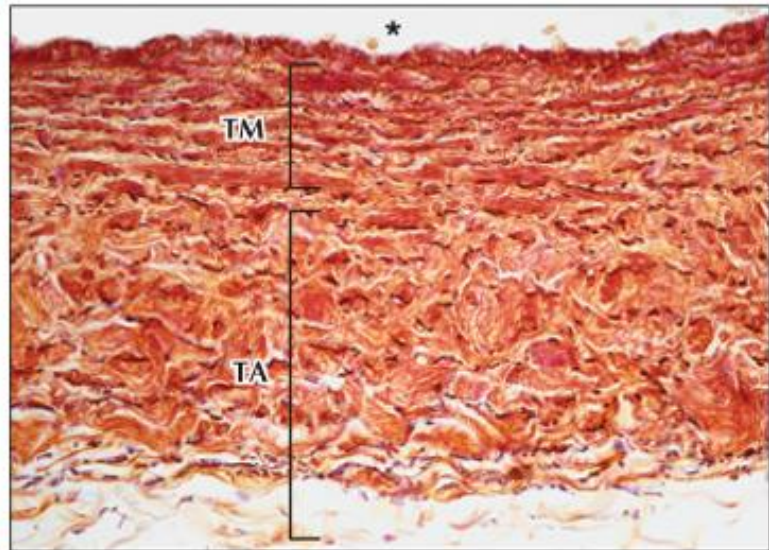
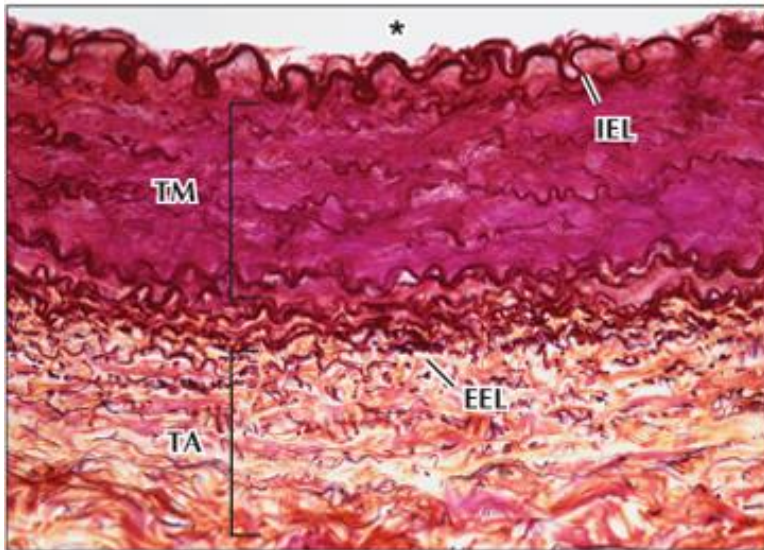
Elastica interna

Smooth muscle

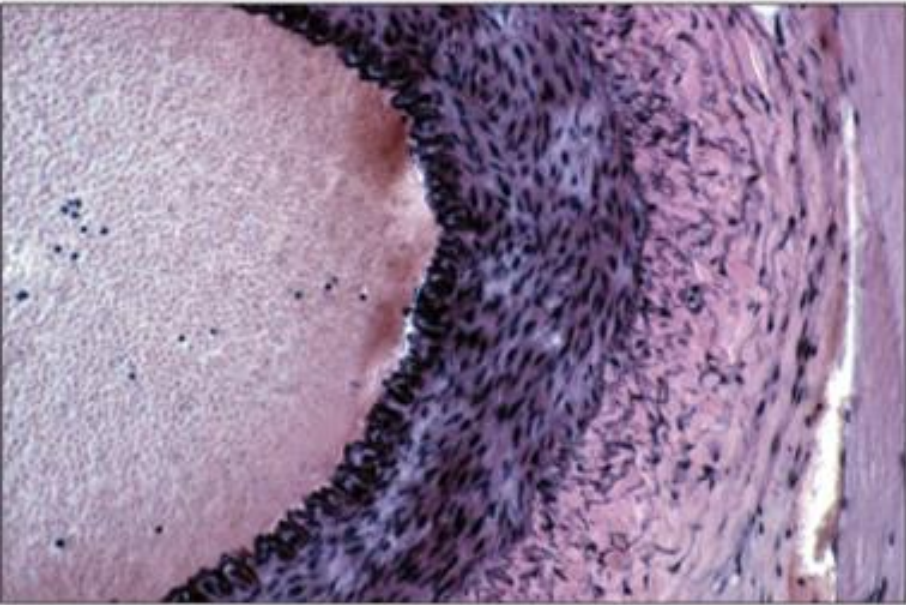




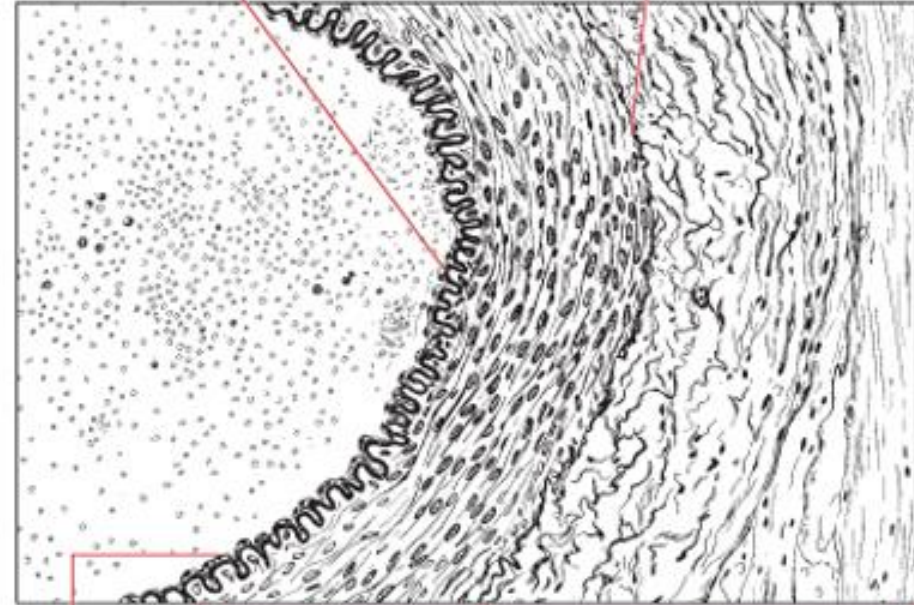
◀ **LM of the wall of a muscular artery.** In this partly constricted artery, the lumen (*) caliber is small relative to the muscular wall thickness. A prominent internal elastic lamina (IEL) looks corrugated. Several layers of circular smooth muscle occupy the media (TM); loose connective tissue, the adventitia (TA). 320×. H&E.



▲ **LMs of the wall of a muscular artery (Left) and muscular vein (Right).** The arterial wall has more elastic fibers (in black), whereas the vein has more collagen (in orange). Smooth muscle in the artery imparts an intense eosinophilia to the media (TM). Internal elastic lamina (IEL), external elastic lamina (EEL), adventitia (TA), and lumen (*) are indicated. 320×. Gomori aldehyde fuchsin.



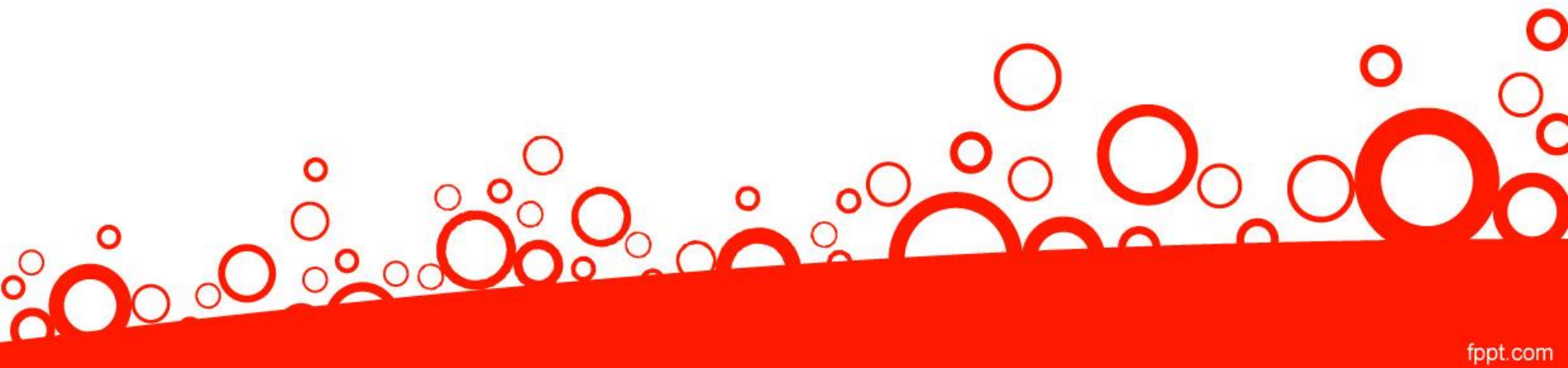
Internal elastic membrane External elastic membrane

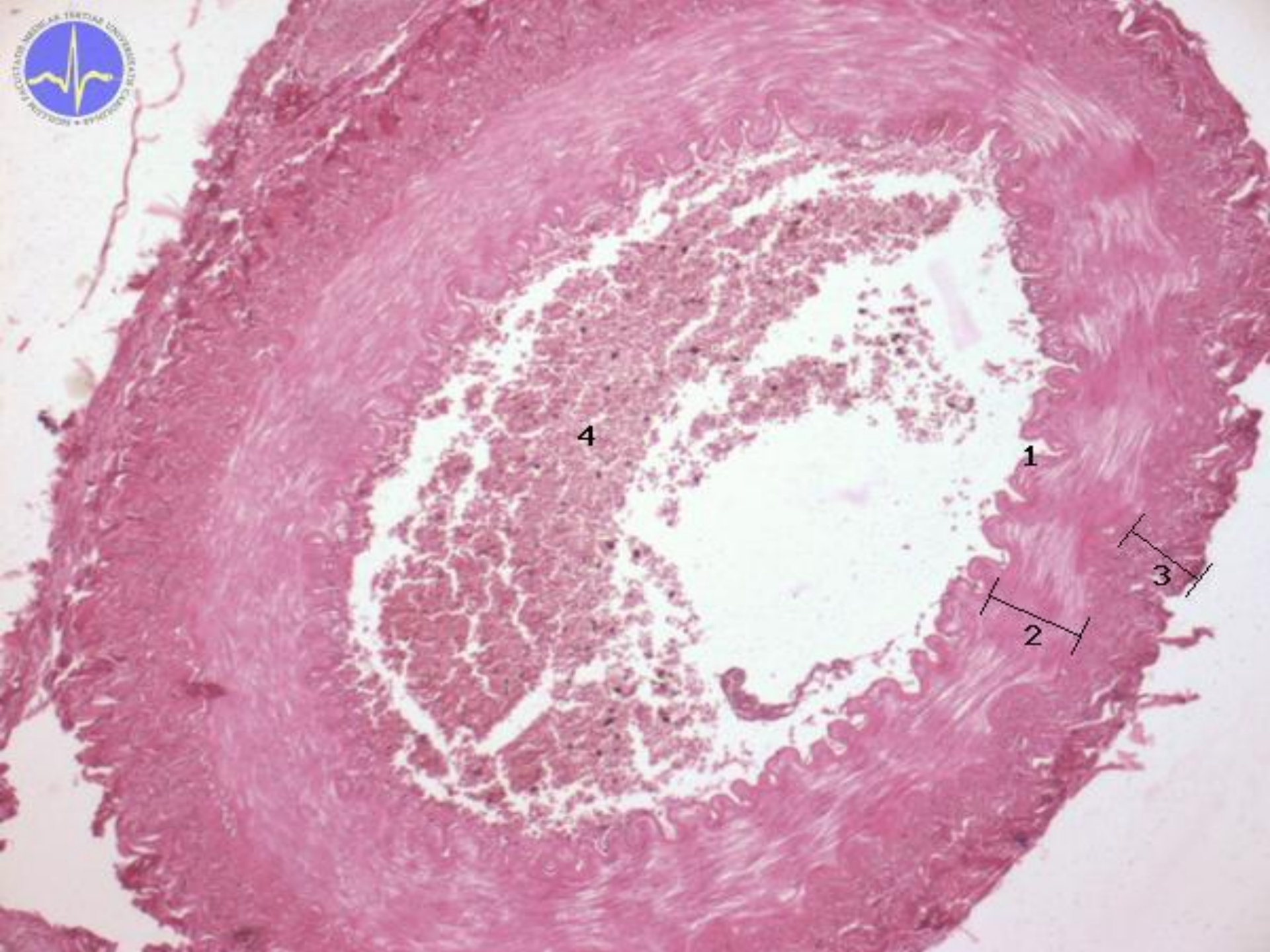


Endothelium

Media

Adventitia



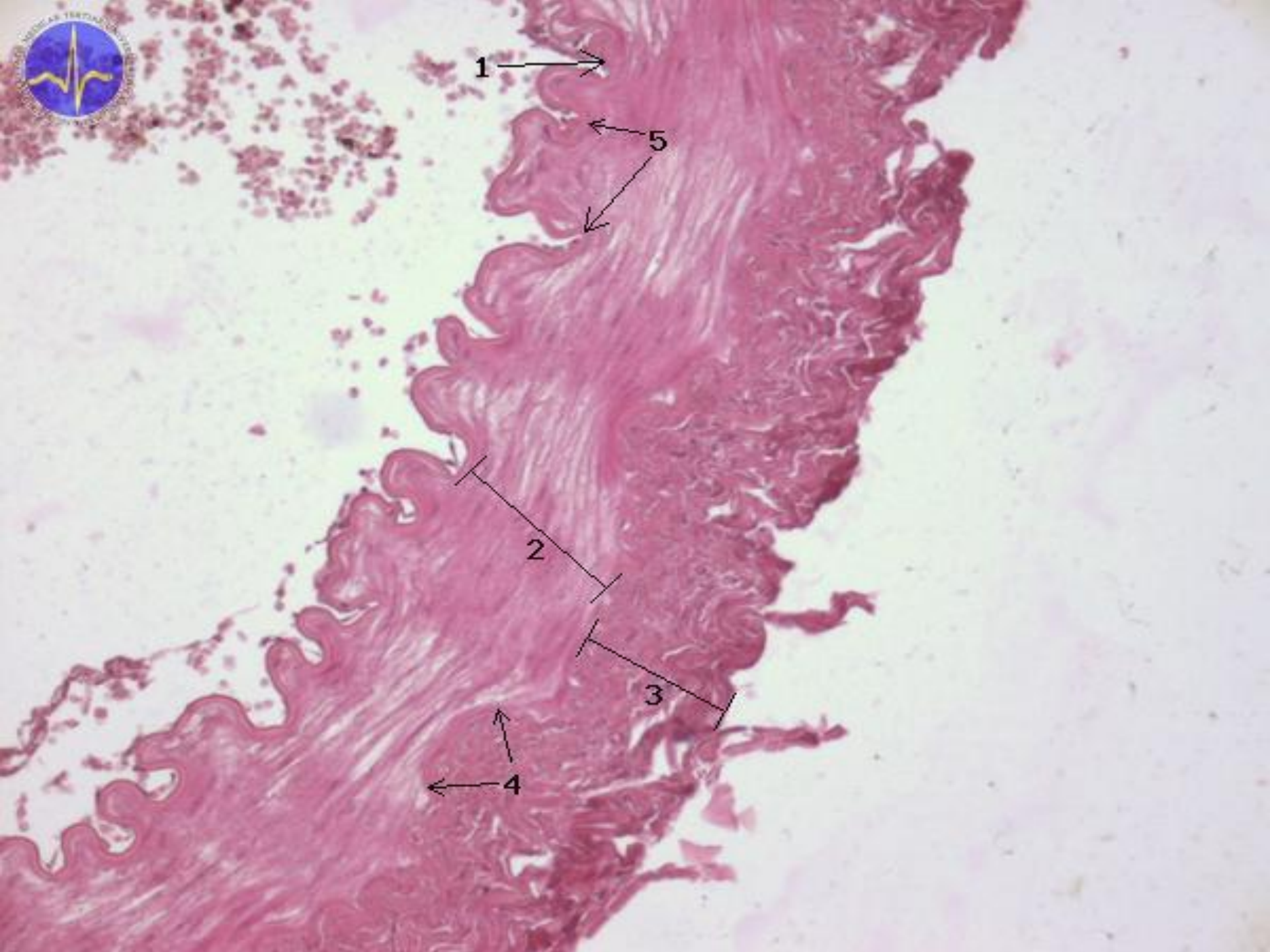


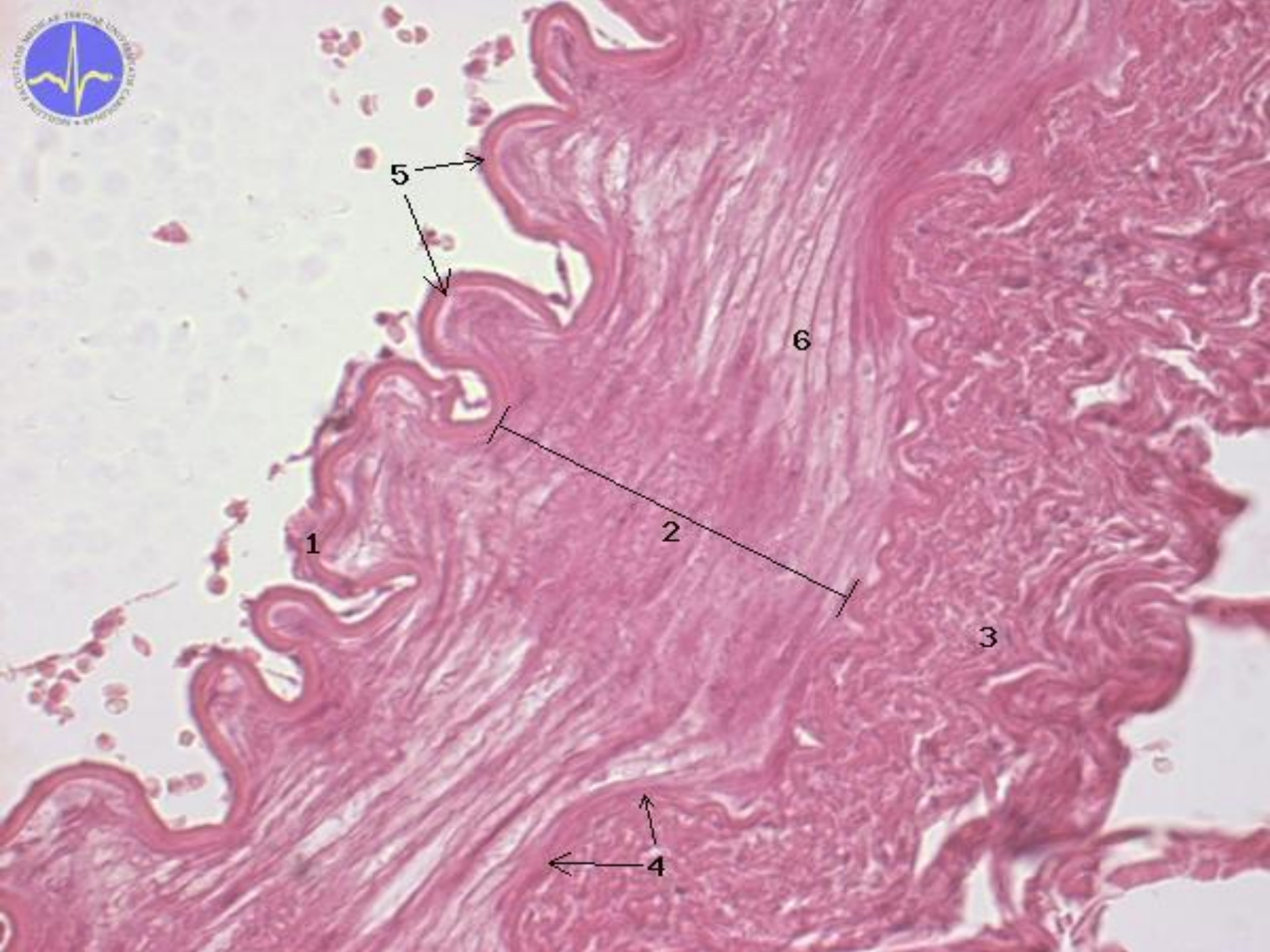
4

1

2

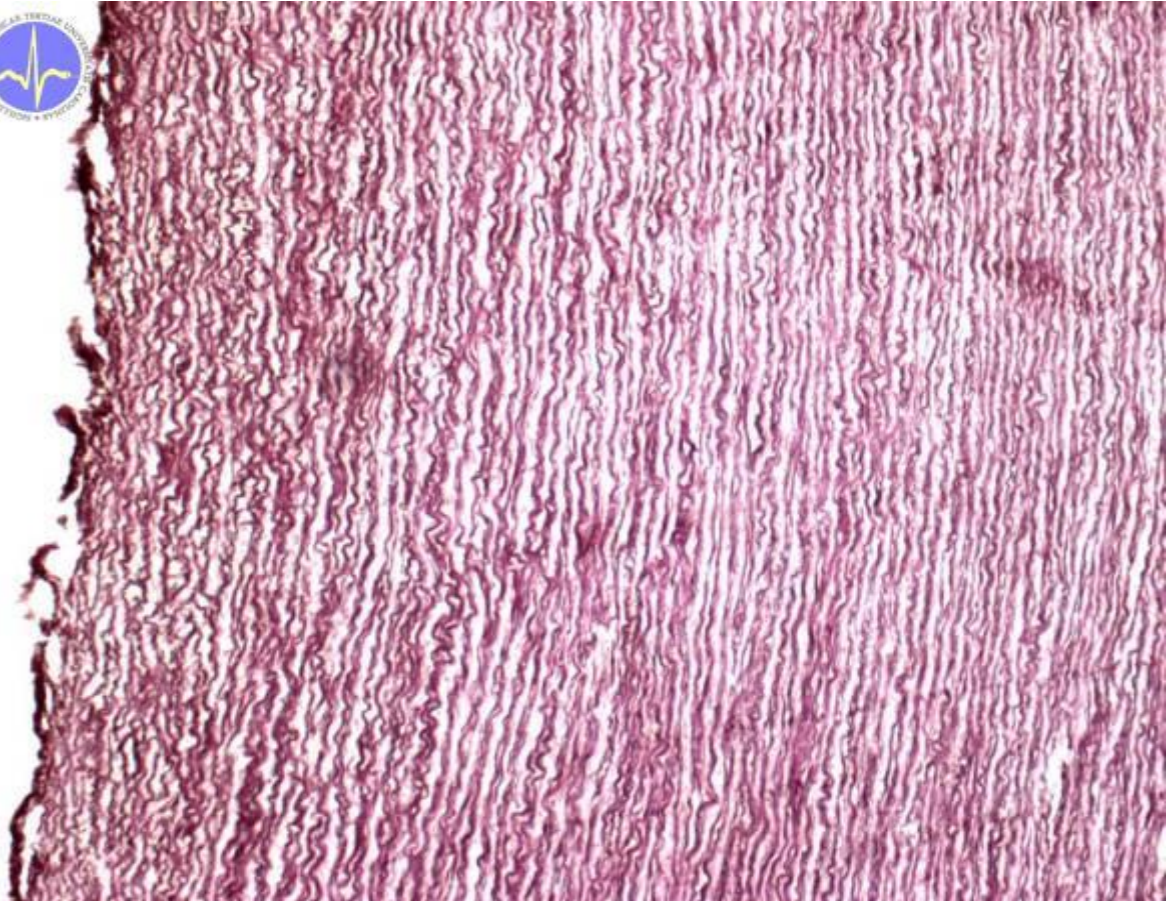
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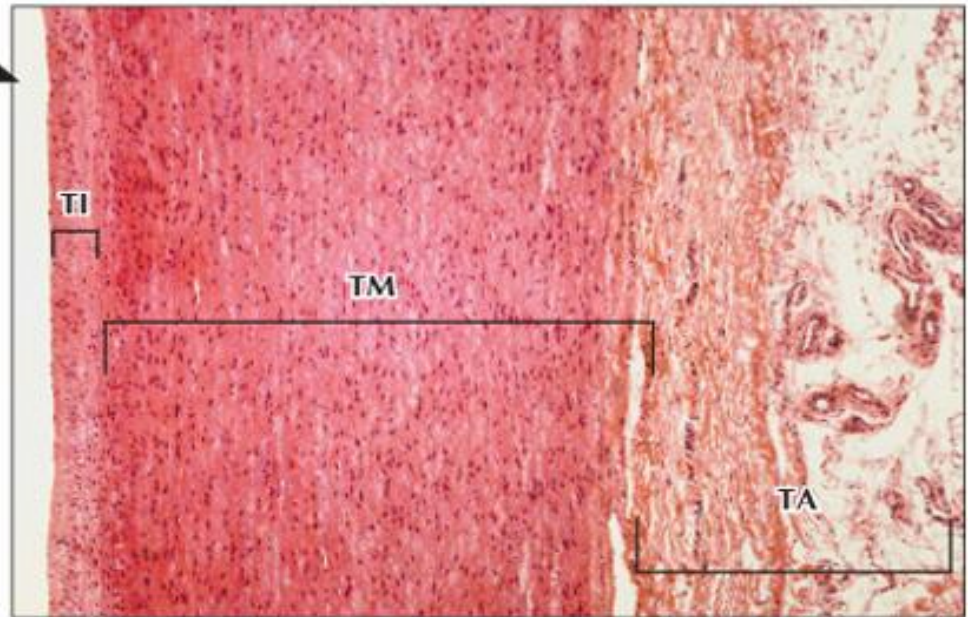
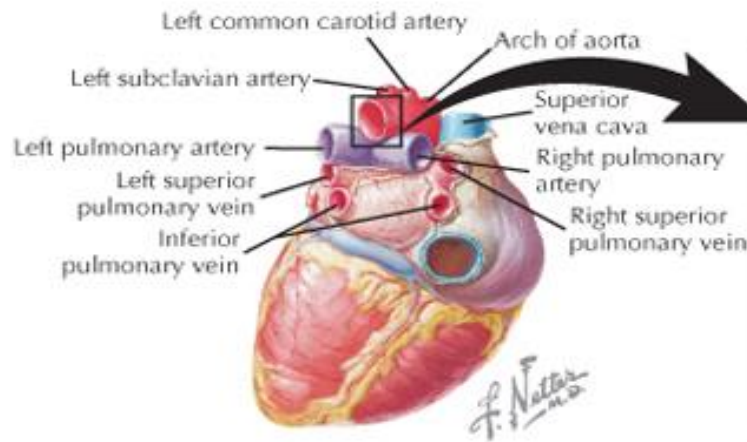


Tunica media - EA

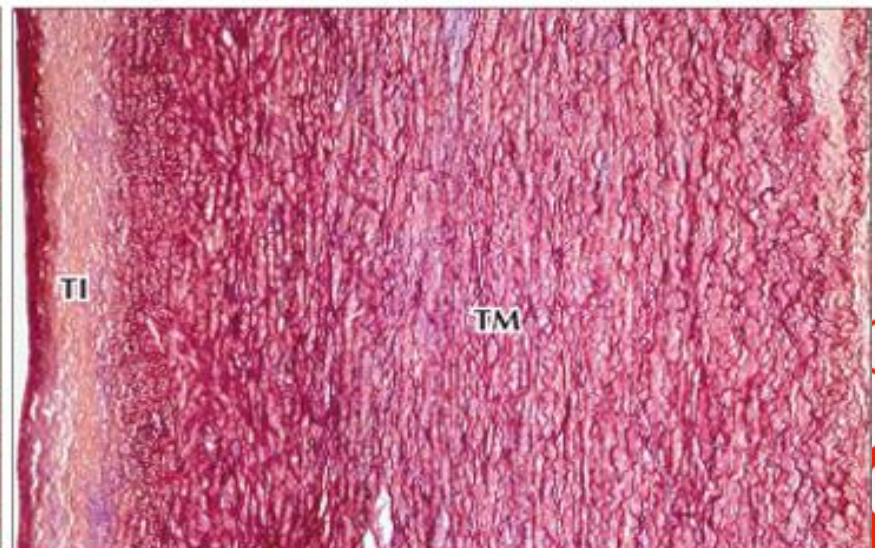
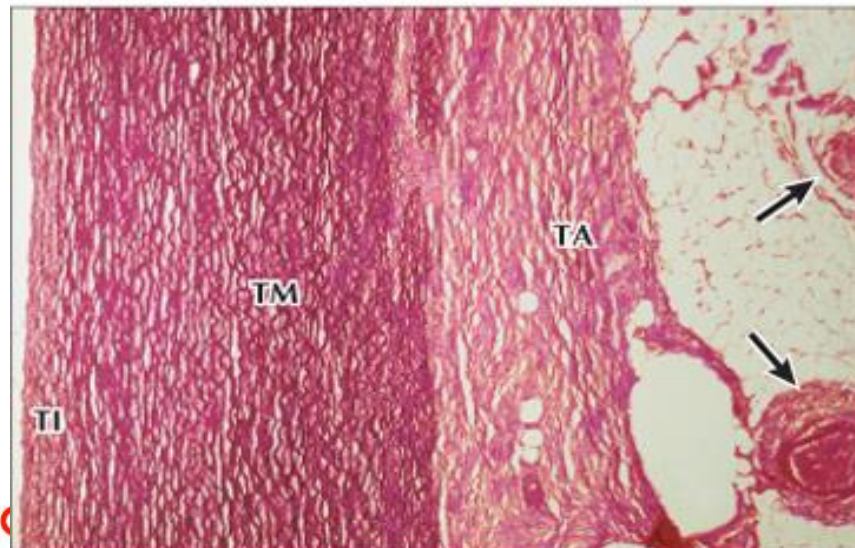
- **Elastic lamellae** – concentrically arranged
- Smooth muscle cells



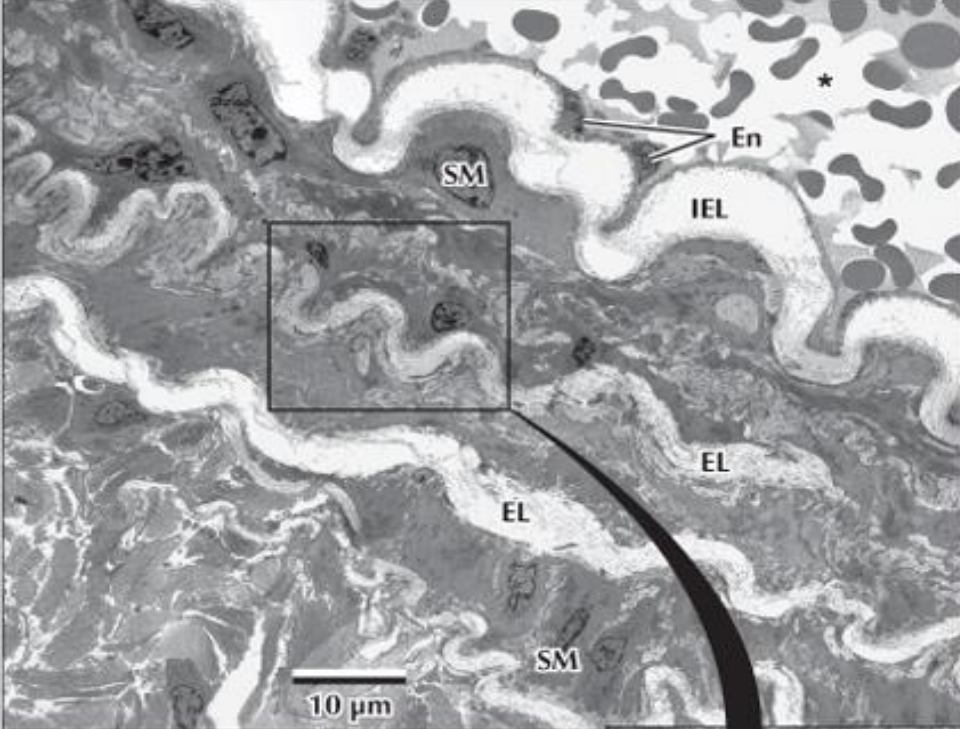
Heart viewed from below and behind.



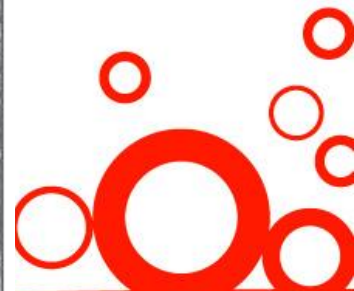
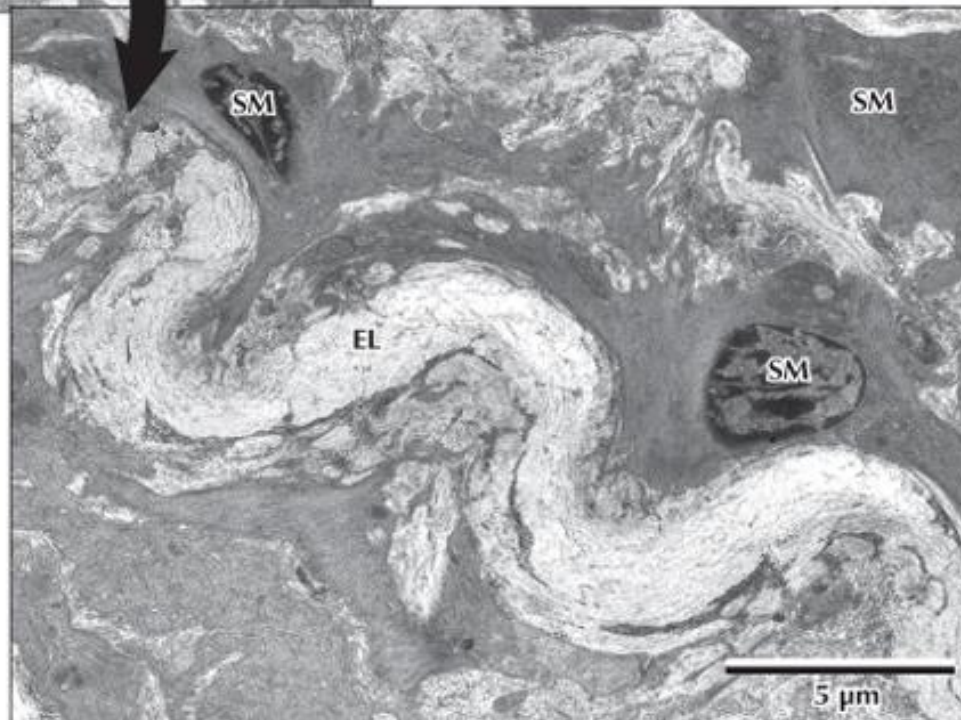
► **LM of part of the aortic wall.** The intima (TI) abuts the lumen (left). A thick media (TM) and an outer adventitia (TA) are also shown. Nuclei in the media at this magnification are mostly those of smooth muscle cells. Elastic laminae are not easily seen with this stain and need special preparative and staining methods for elucidation. 60×. H&E.

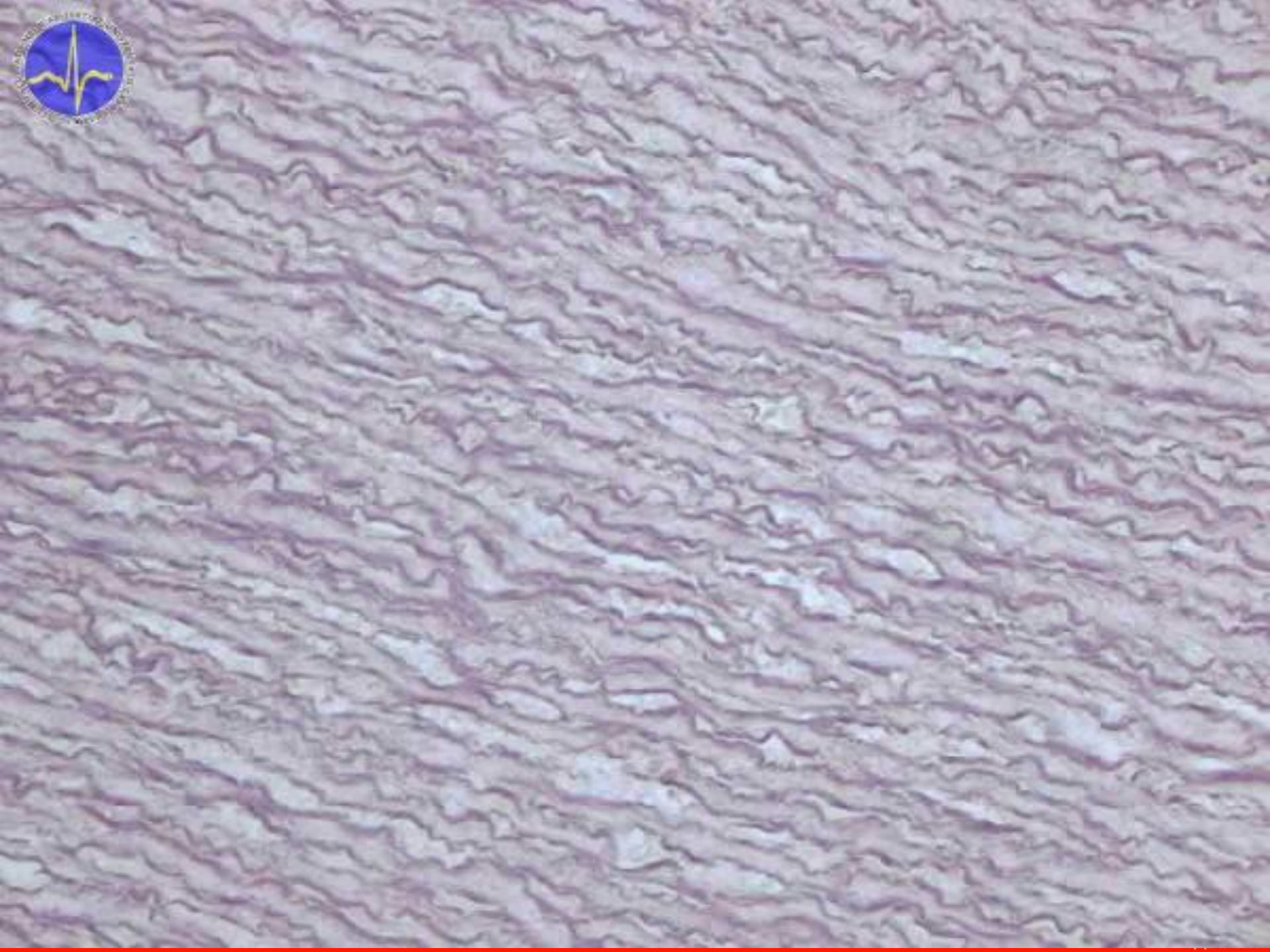


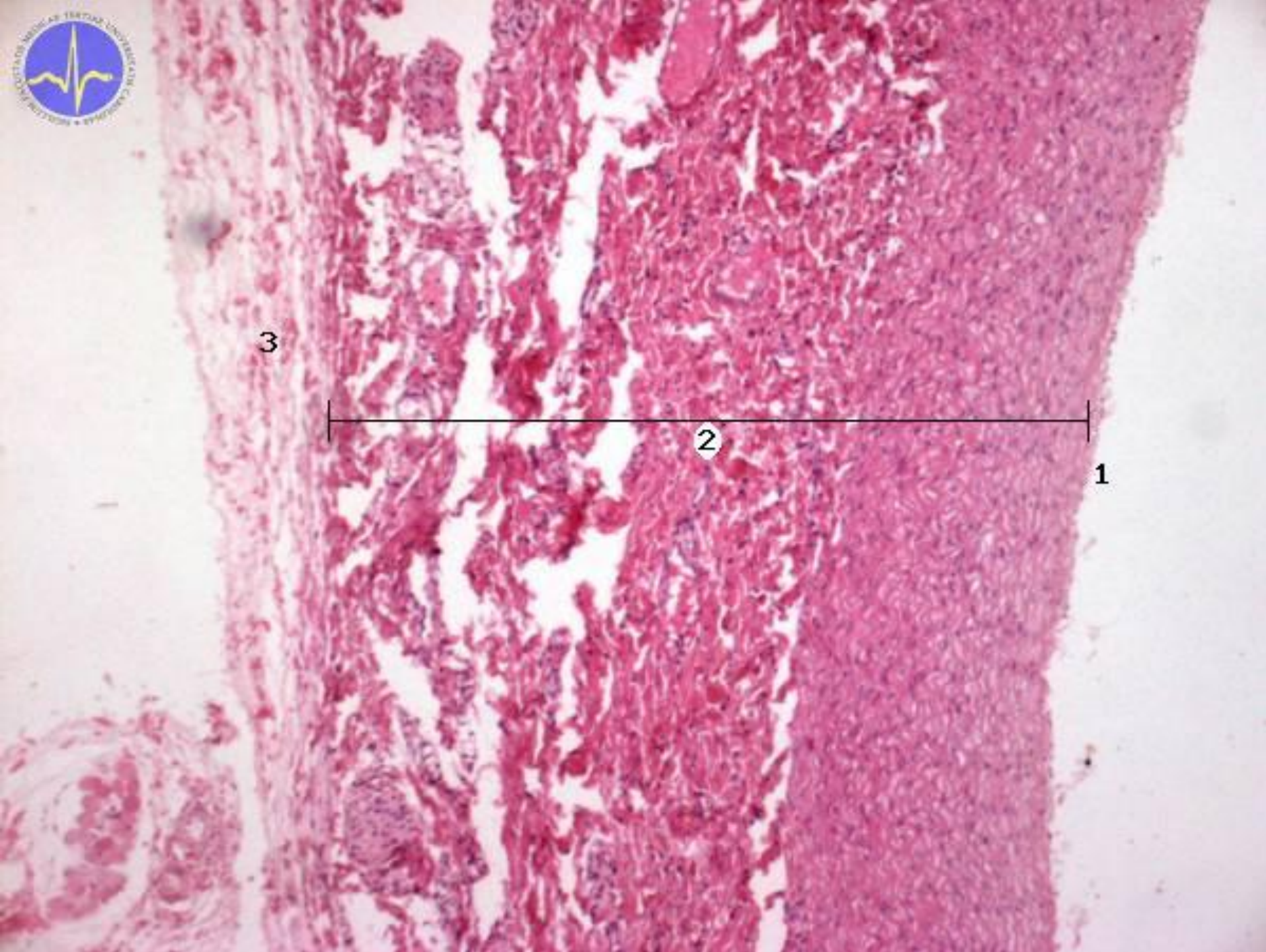
▲ **Comparative LMs of the wall of the aorta of a newborn (Left) and 25-year-old (Right).** In both vessels, a relatively thin tunica intima (TI) merges with a prominent tunica media (TM). This stain specifically demonstrates elastic tissue, a prominent feature of these arteries. The number of elastic laminae—the dark, wavy bands—increases with age. Vasa vasorum (arrows) occupy loose connective tissue of the adventitia (TA). 60×. Gomori aldehyde fuchsin.

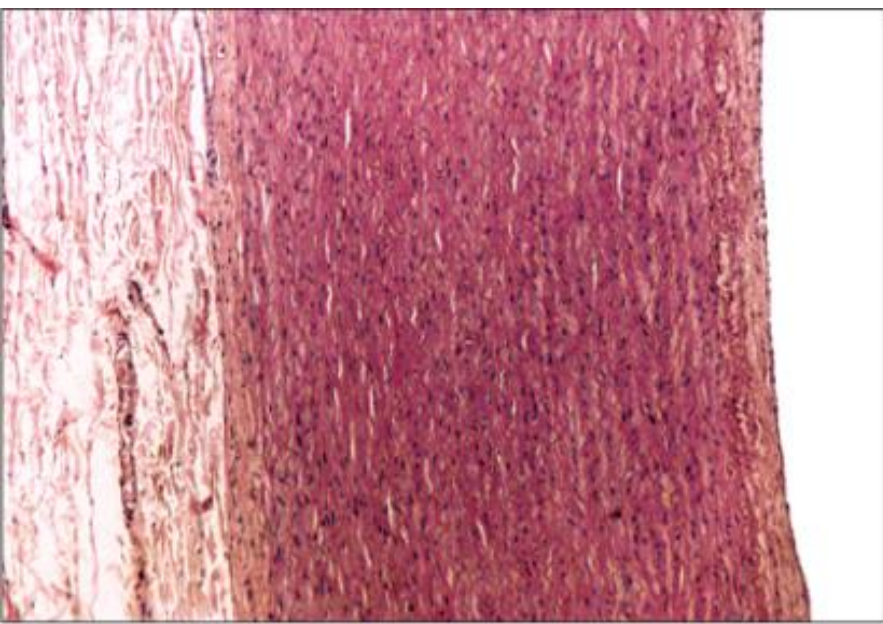


◀ ▼ **Electron micrographs (EMs) of parts of the aortic wall at low (Left) and medium (Below) magnification.** The endothelium (**En**) lining the lumen (★) consists of elongated cells, some of which are sectioned at the level of the nuclei. The underlying internal elastic lamina (**IEL**) is thick and electron lucent. The mononucleated smooth muscle cells (**SM**) alternate with multiple, concentric elastic laminae (**EL**) in the media. These muscle cells are branched and touch other muscle cells. The elastic laminae look corrugated because of partial constriction of the vessel at the time of fixation. **Left:** 1100×; **Below:** 4250×.





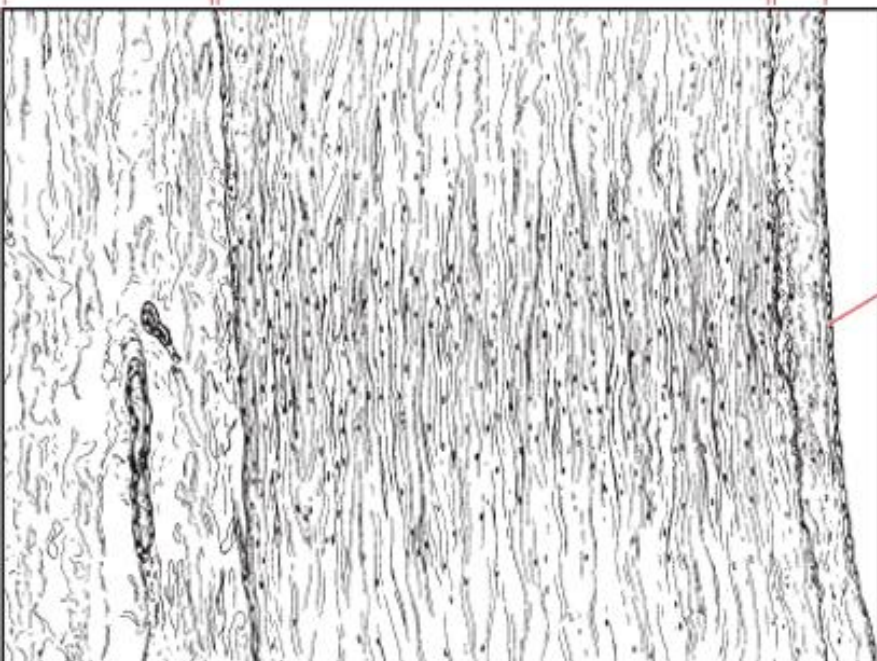




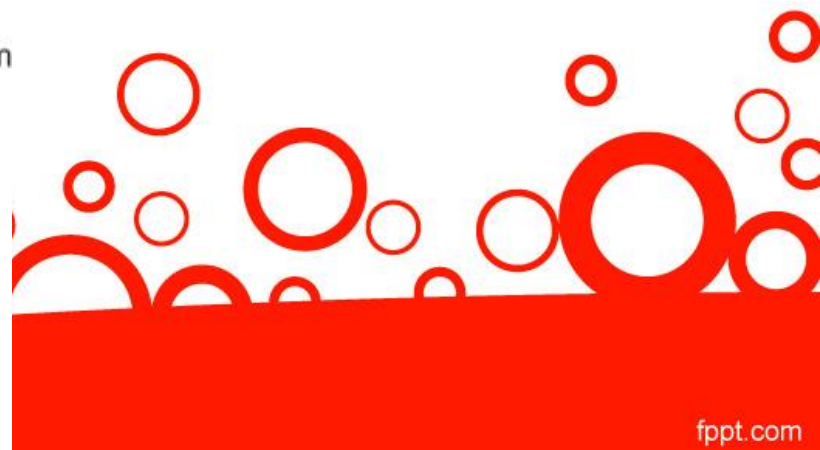
Adventitia

Media

Intima

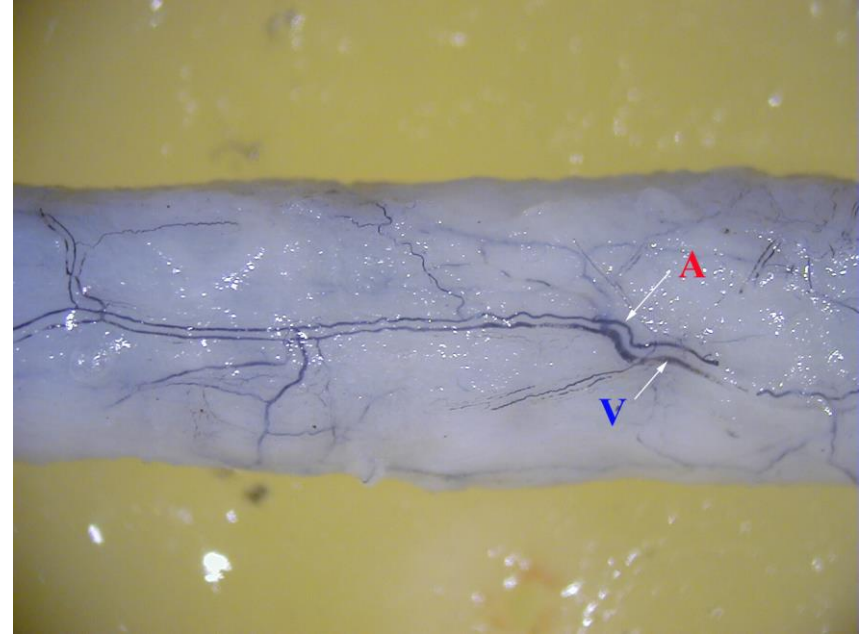


Endothelium



Tunica adventitia

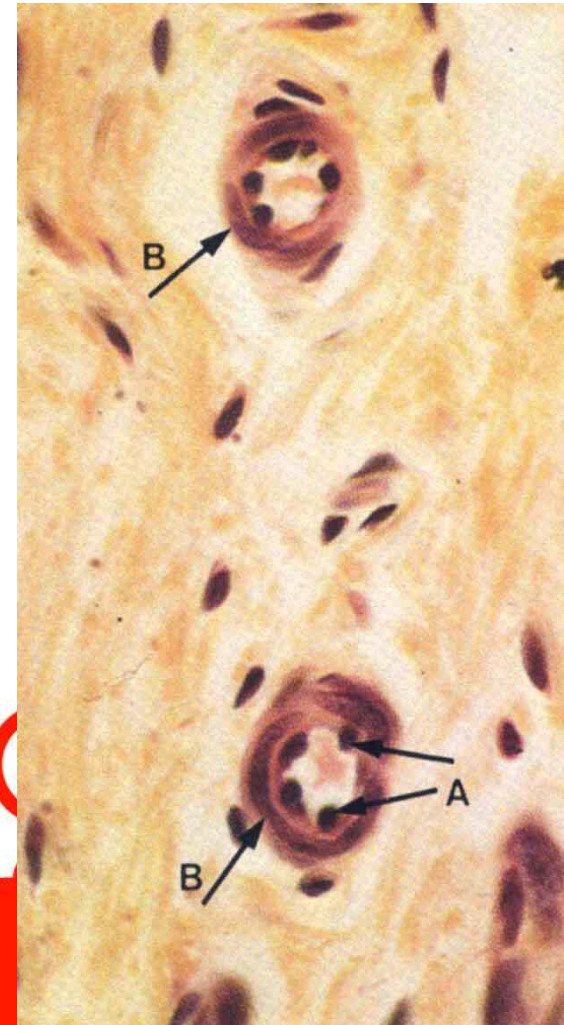
- Fibroblasts
- Collagen fibers (I)
- Proteoglycans
- Elastic fibers



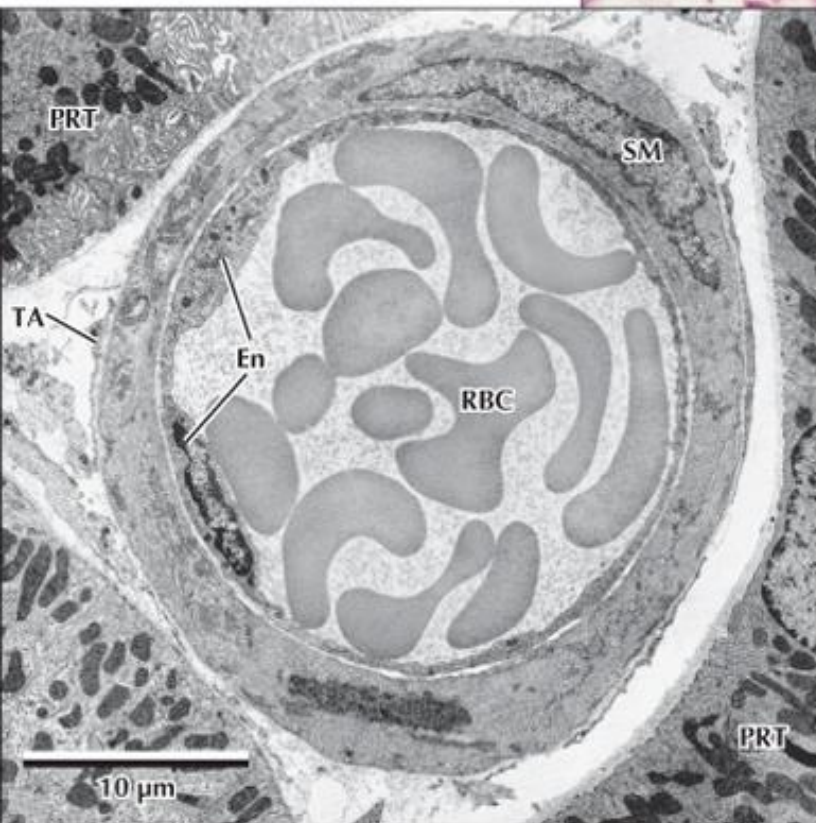
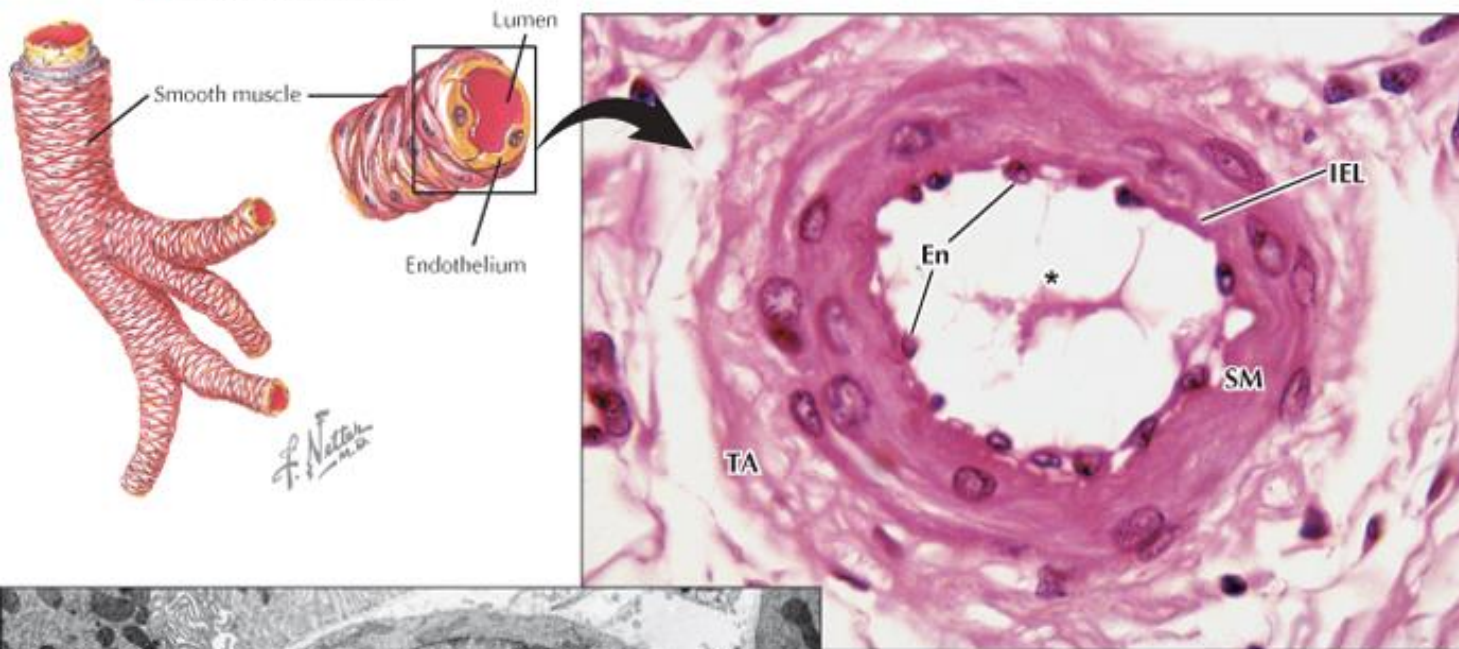
- Vasa vasorum – outer 1/2 of tunica media
- Nerve supply

Arterioles

- 1-5 layers of smooth muscle cells, diameter $< 500 \mu\text{m}$
- MEI is missing
- Precapillary sphincters
- Peripheral vascular resistance

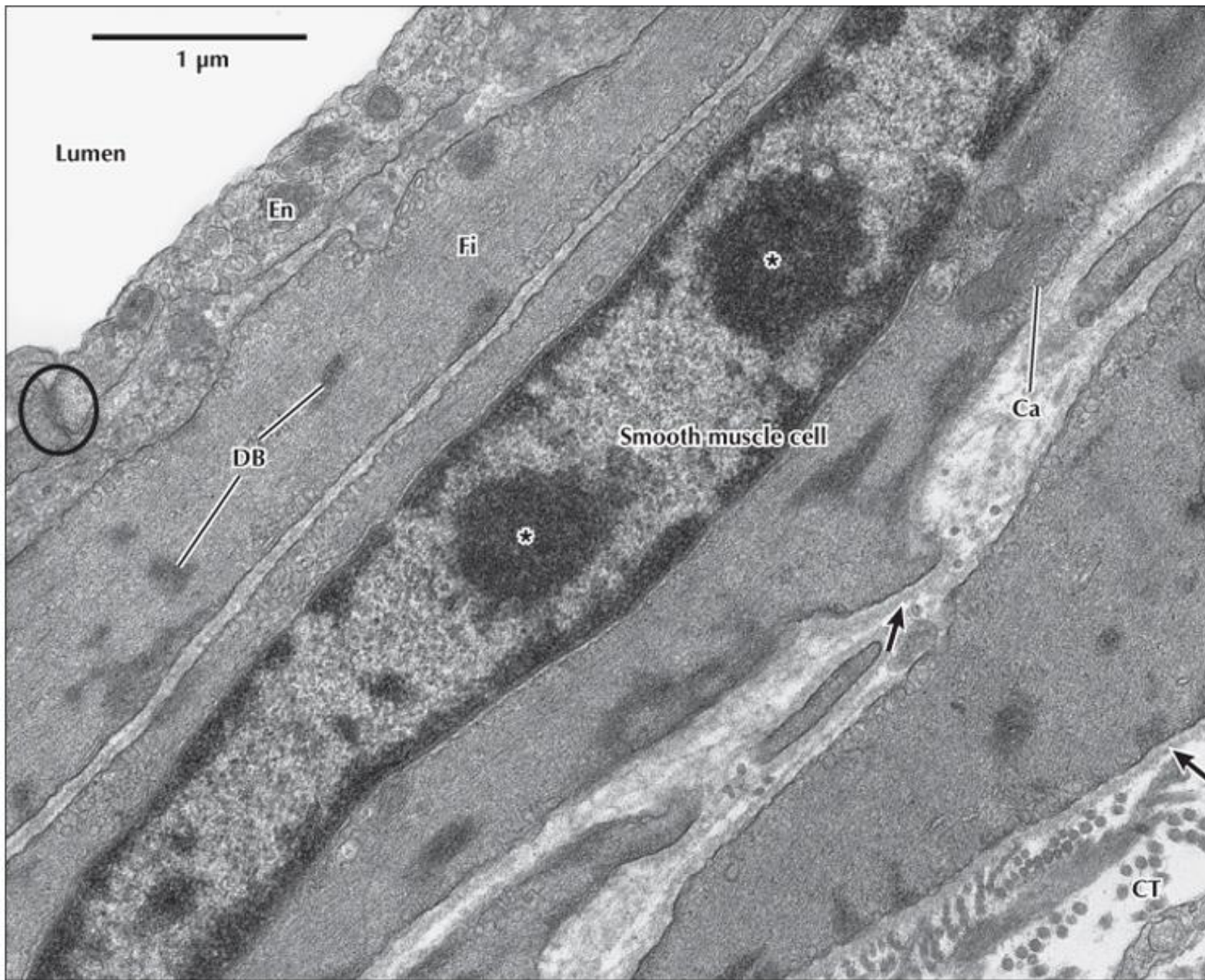


▼ Structure of arterioles.



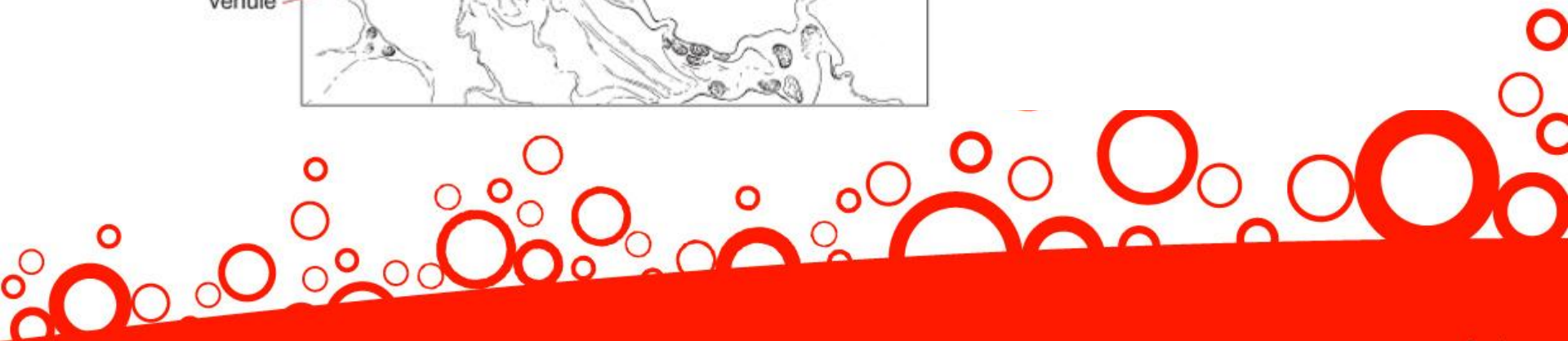
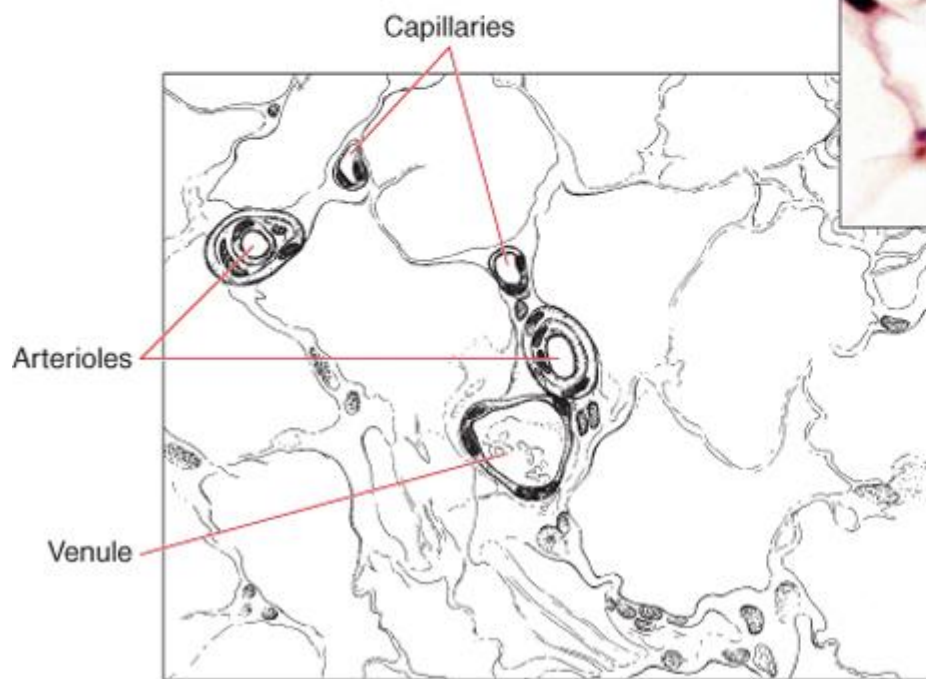
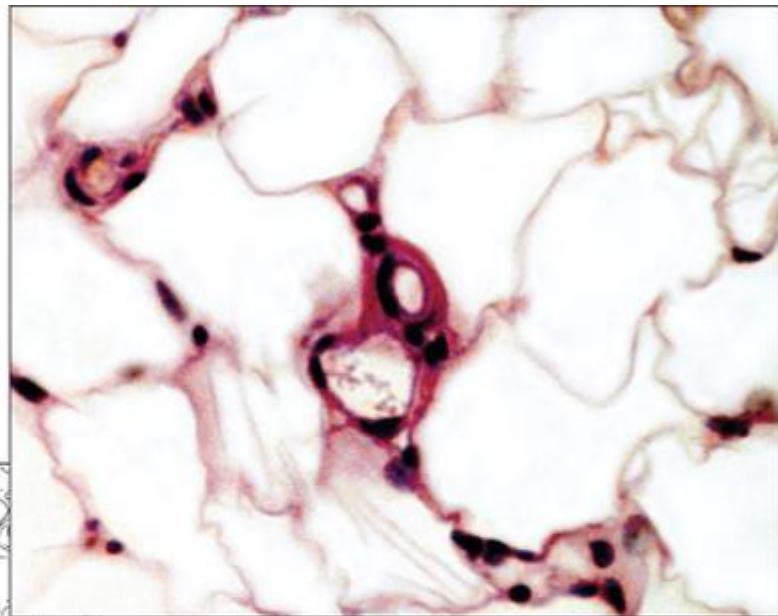
▲ **LM of an arteriole in transverse section.** Tightly arranged smooth muscle cells (**SM**) are oriented more or less circularly relative to the lumen (*). Their contraction causes the internal elastic lamina (**IEL**) to appear corrugated and endothelial cell (**En**) nuclei to bulge into the lumen. The adventitia (**TA**) contains connective tissue cells (mostly fibroblasts) and collagen fibers. 720×. H&E.

◀ **EM of an arteriole in the kidney in transverse section.** The lumen, filled with erythrocytes (**RBC**), is lined by one layer of endothelial cells (**En**). An inconspicuous adventitia (**TA**) surrounds circularly arranged smooth muscle cells (**SM**) in the media. Parts of proximal renal tubules (**PRT**) are in surrounding areas. 2800×. (Courtesy of Dr. W. A. Webber)



▲ **EM of the wall of an arteriole.** Endothelium (**En**) lines the lumen, and an intercellular junction (**circle**) lies between two endothelial cells. Cytoplasm of several smooth muscle cells, sectioned longitudinally, shows filaments (**Fi**), dense bodies (**DB**), and caveolae (**Ca**). A basal lamina (**arrows**) surrounds each cell. The elongated nucleus of one muscle cell contains two nucleoli (*). Connective tissue (**CT**) occupies intervening areas. 31,000 \times .





Capillaries

- Endothelium on basal lamina, occasionally **pericytes** (Rouget cells)
 - Vascular support
 - Contractility
- 1. Continuous endothelium
- 2. Fenestrated endothelium
- 3. Endothelium with pores
- 4. Sinusoid discontinuous endothelium

capillaries
- typical

1. KAPILÁRY

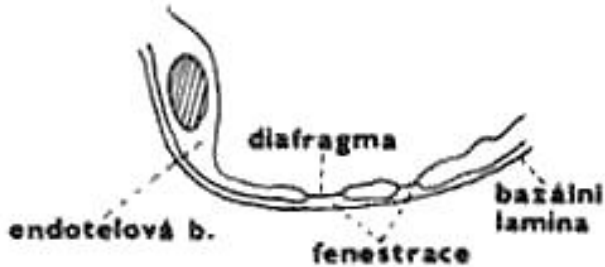
A. typické

a) se souvislou endotelovou výstelkou



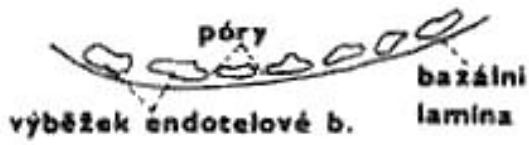
continuous
(somatic)

b) fenestrovaná



fenestrated
(visceral)

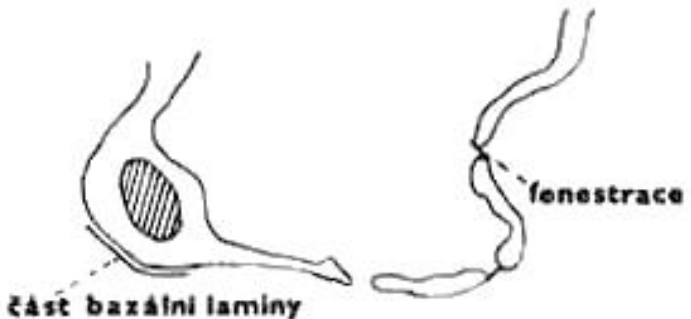
c) s póry



with pores

B. atypické

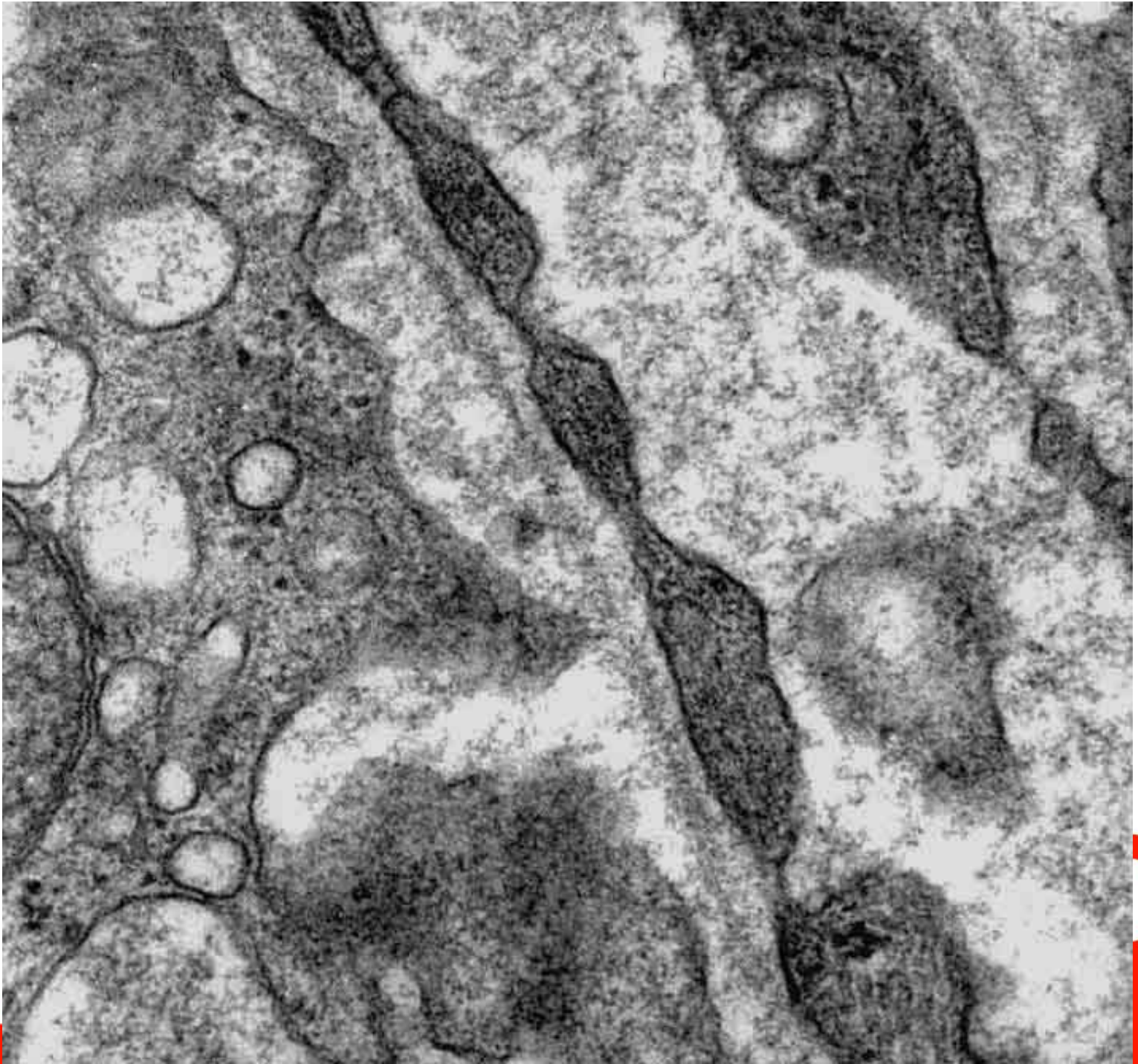
sinusoida

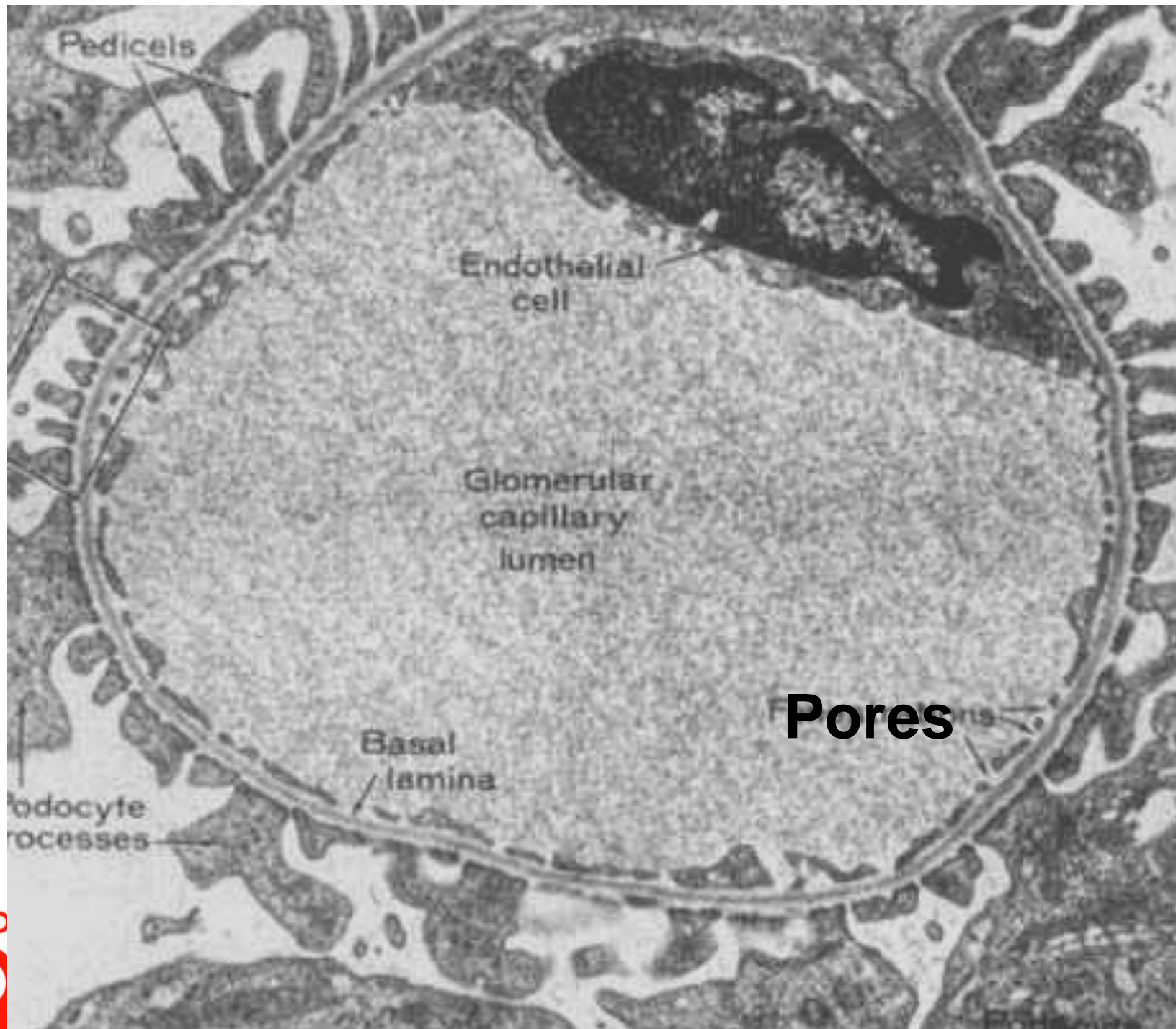


sinusoidal
(discontinuous)

- atypical







Pores

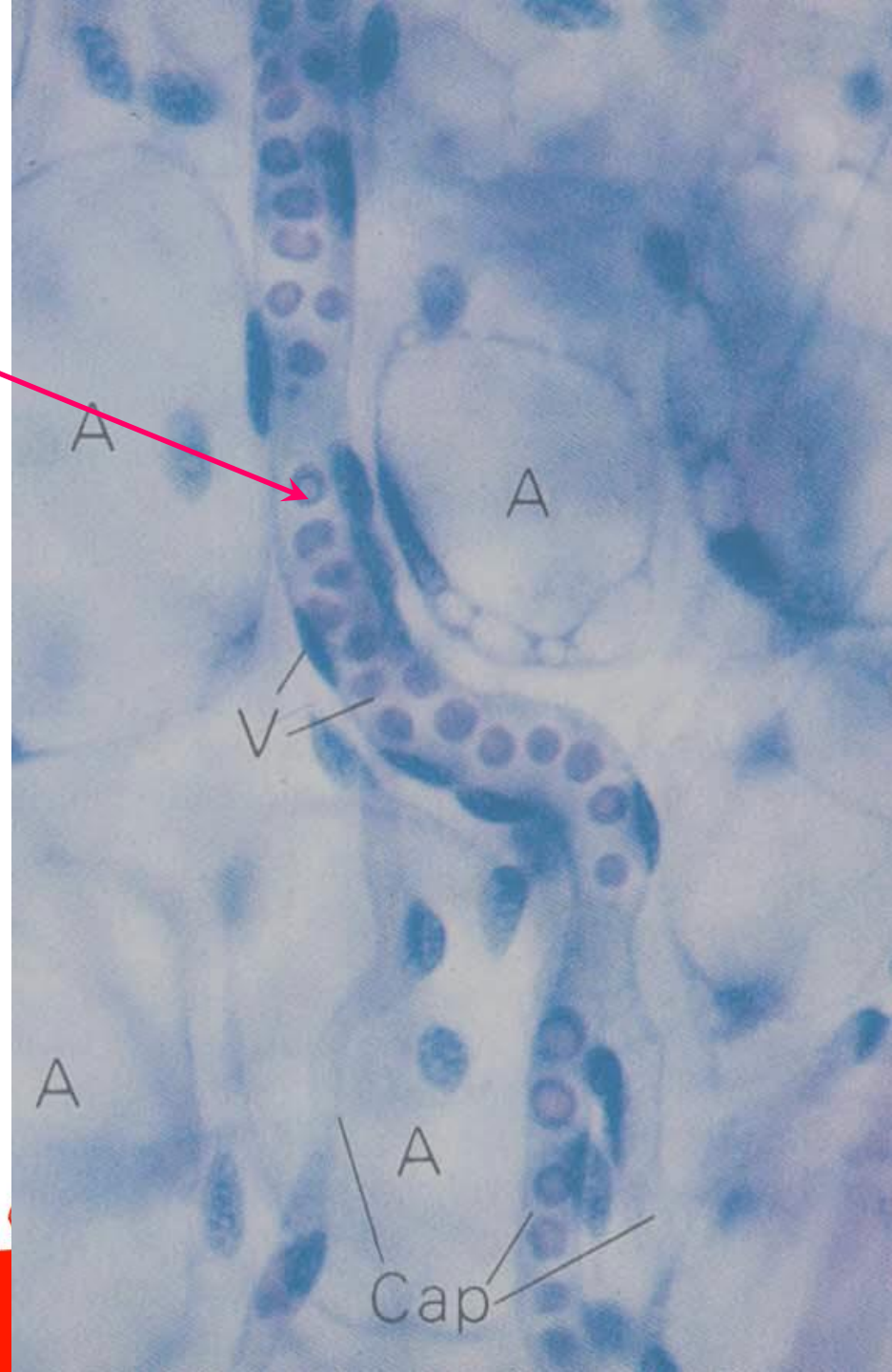


Veins

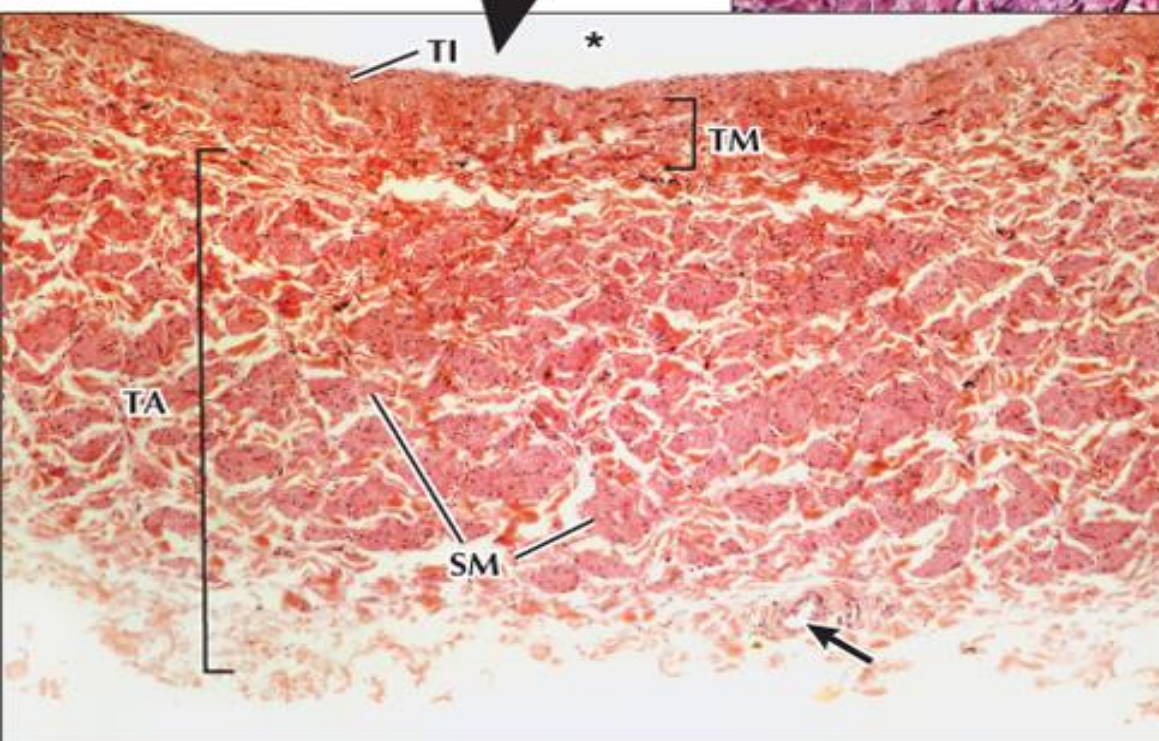
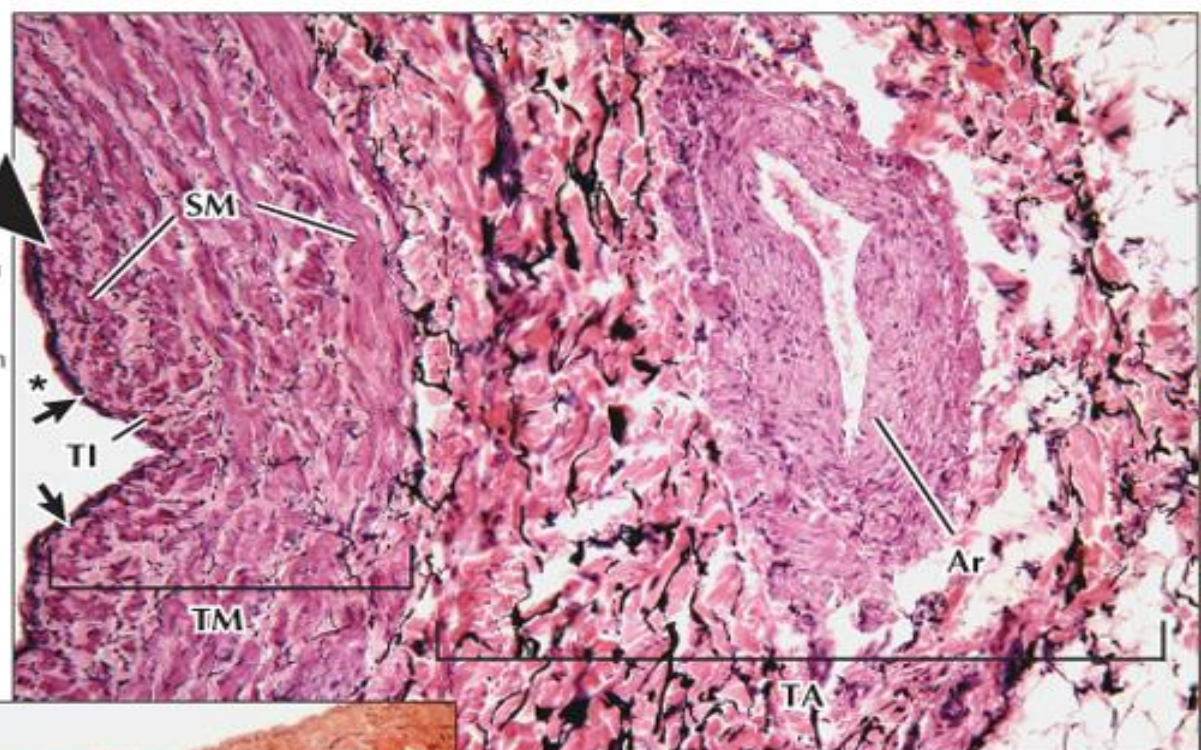
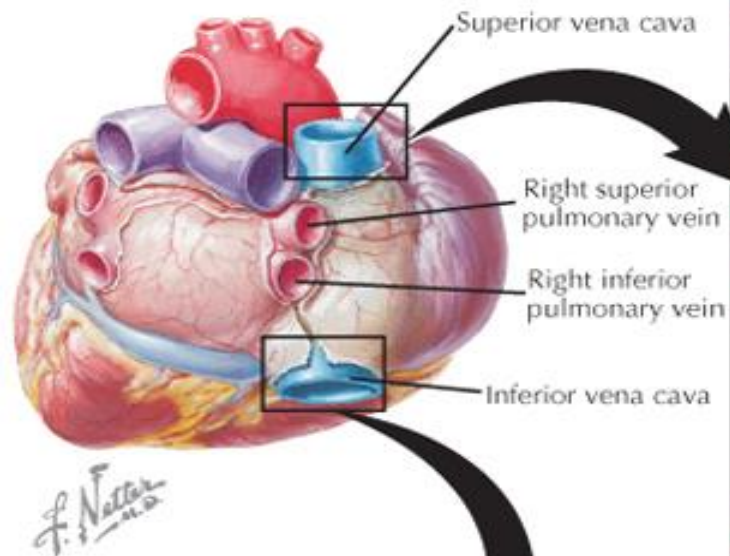
- Thinner wall
- MEI – discontinuous, variable
- Tunica intima – valves
- Tunica media – thin
- Tunica adventitia – thickest layer of venous wall

Venules

- postcapillary < 50 μm
- collecting 50 - 100 μm
- muscular 100 - 200 μm
- venules 200 μm - 1 mm

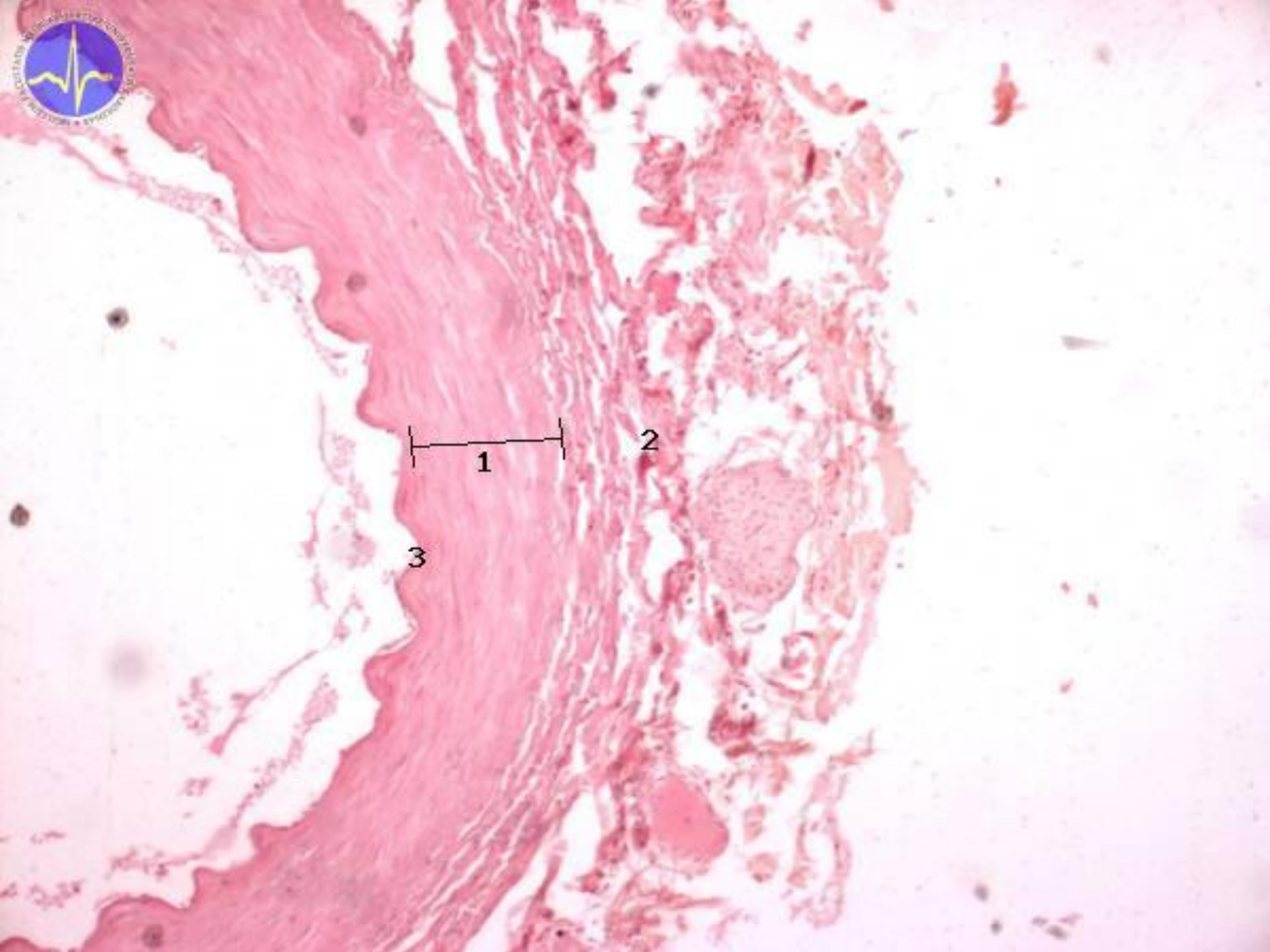


▼ Posterior aspect (base) of heart.



▲ **LM of the wall of the superior vena cava.** Elastic fibers stain black and are seen in the intima (**arrows**) and scattered in the media (**TM**) and adventitia (**TA**). The media also contains layers of smooth muscle (**SM**) oriented in different directions. A small muscular artery (**Ar**) is part of the rich vasa vasorum feature of veins of this caliber. The intima (**TI**) is indicated, and lumen of the vessel (*) is at the left. 100×. *Verhoeff-van Gieson*.

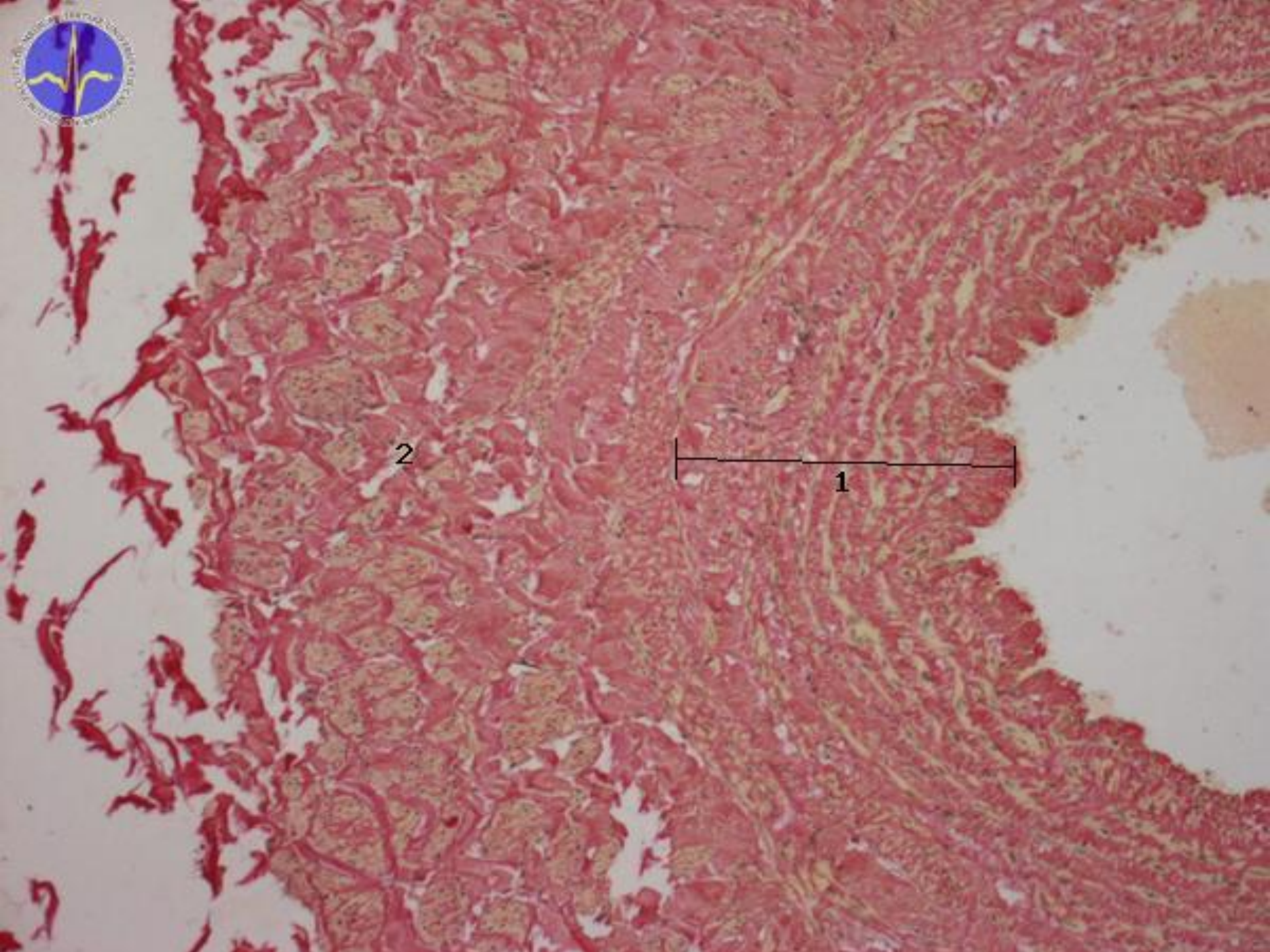
◀ **LM of the wall of the inferior vena cava.** The lumen (*) is lined by an attenuated intima (**TI**). A few layers of circular smooth muscle cells occupy the thin media (**TM**). The adventitia (**TA**), the thickest layer, contains longitudinal bundles of smooth muscle (**SM**) interspersed with collagen fibers, as well as vasa vasorum (**arrow**). 60×. *H&E*.



1

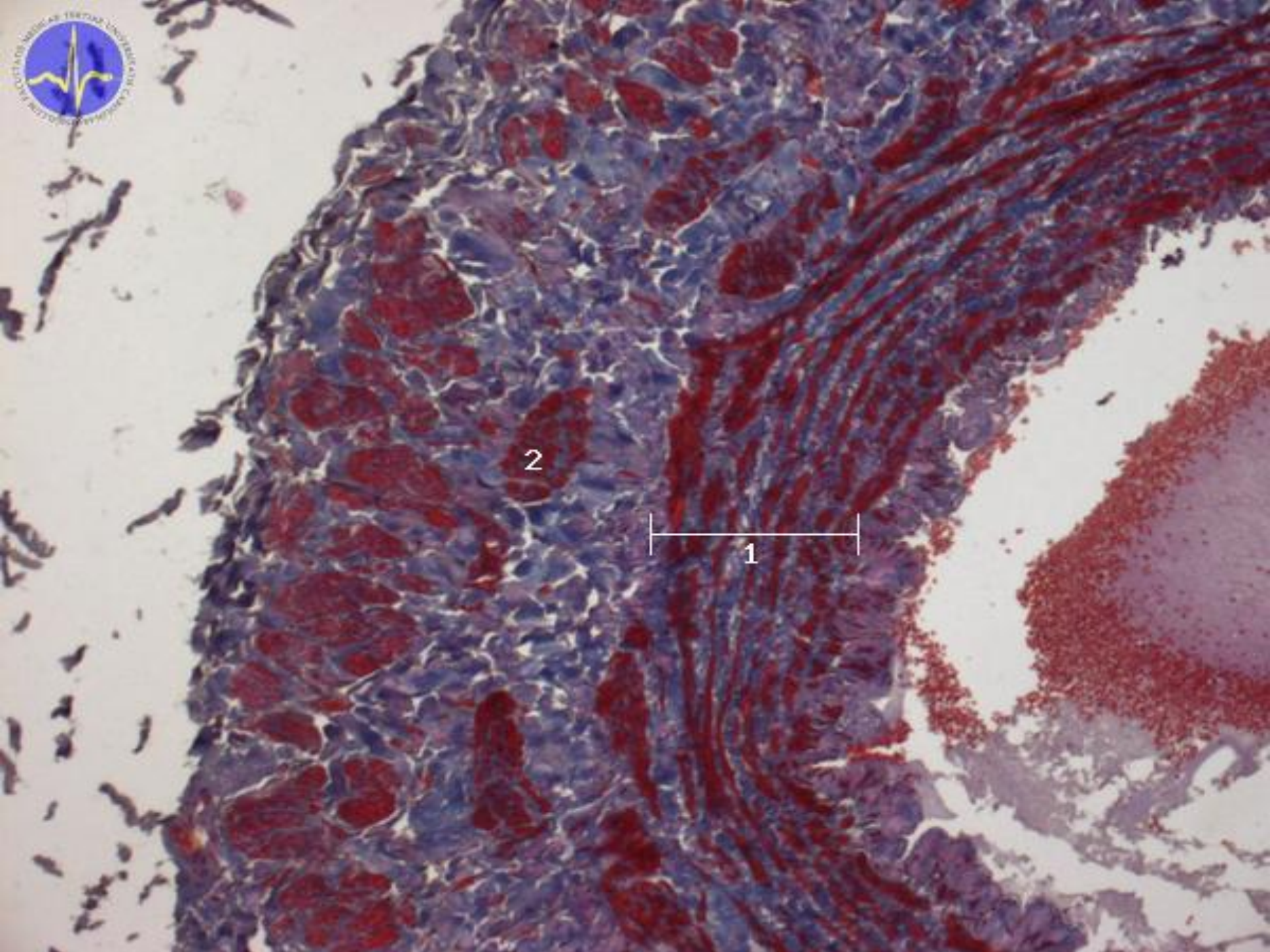
2

3



2

1



2

1

Artery

Vein

Tunica externa
(adventitia, contains
vaso vasorum)

Tunica media
(smooth muscle)

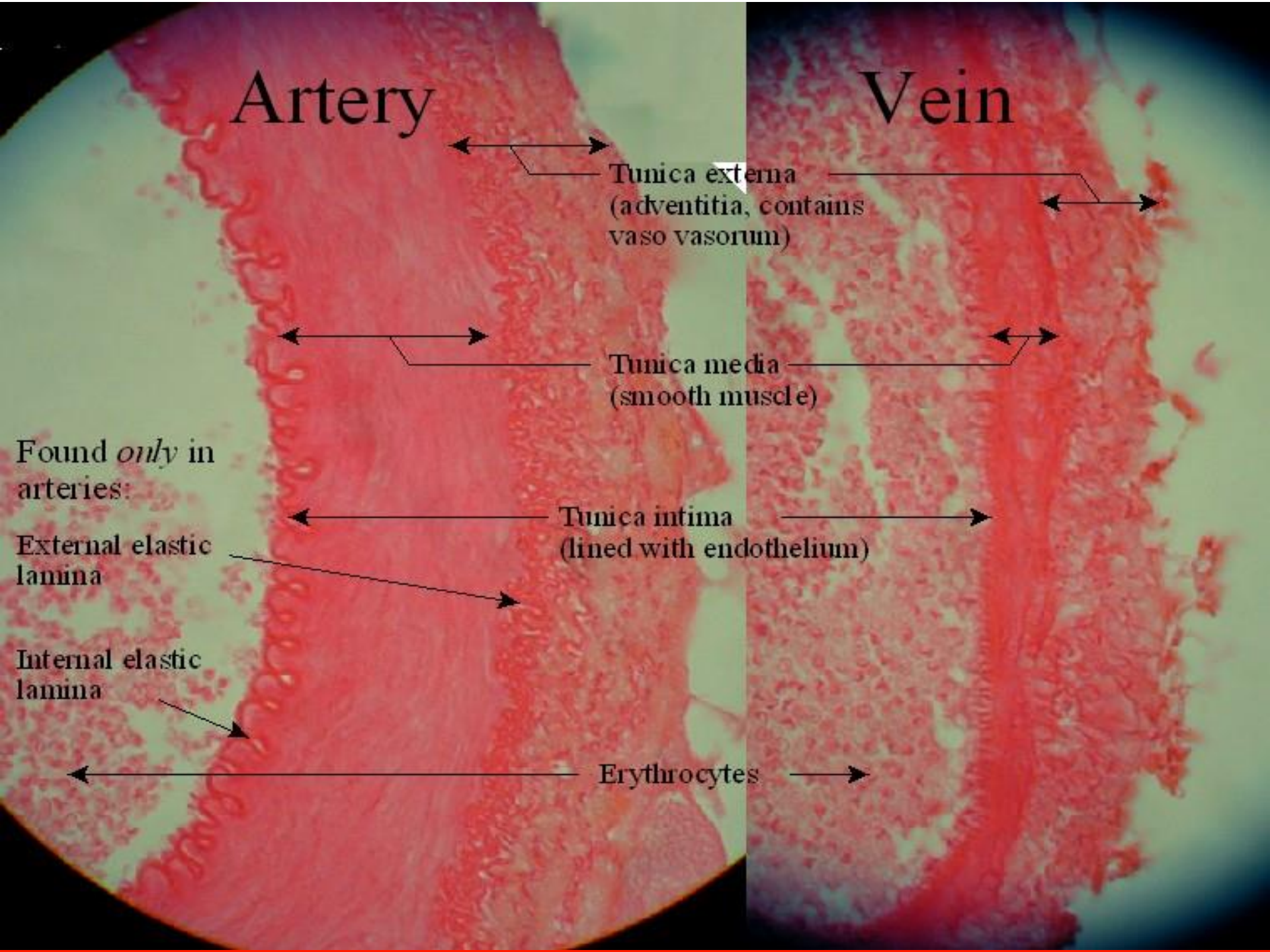
Tunica intima
(lined with endothelium)

Erythrocytes

Found *only* in
arteries:

External elastic
lamina

Internal elastic
lamina

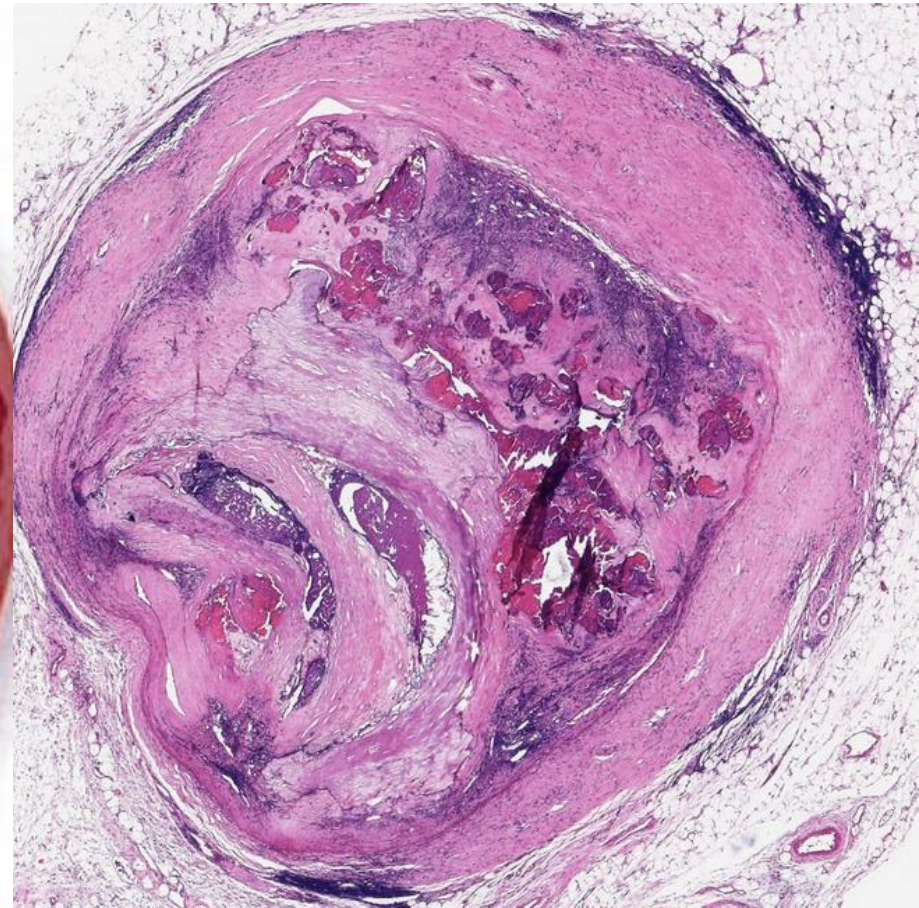
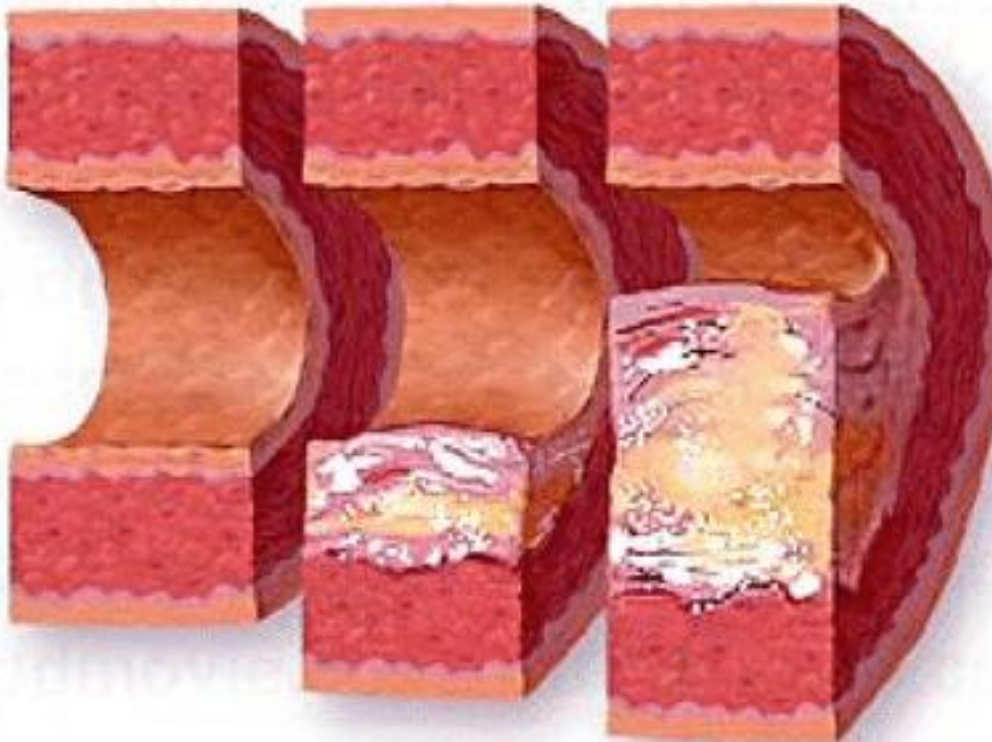


Atherosclerosis

Normal artery

Mild atherosclerosis

Severe atherosclerosis



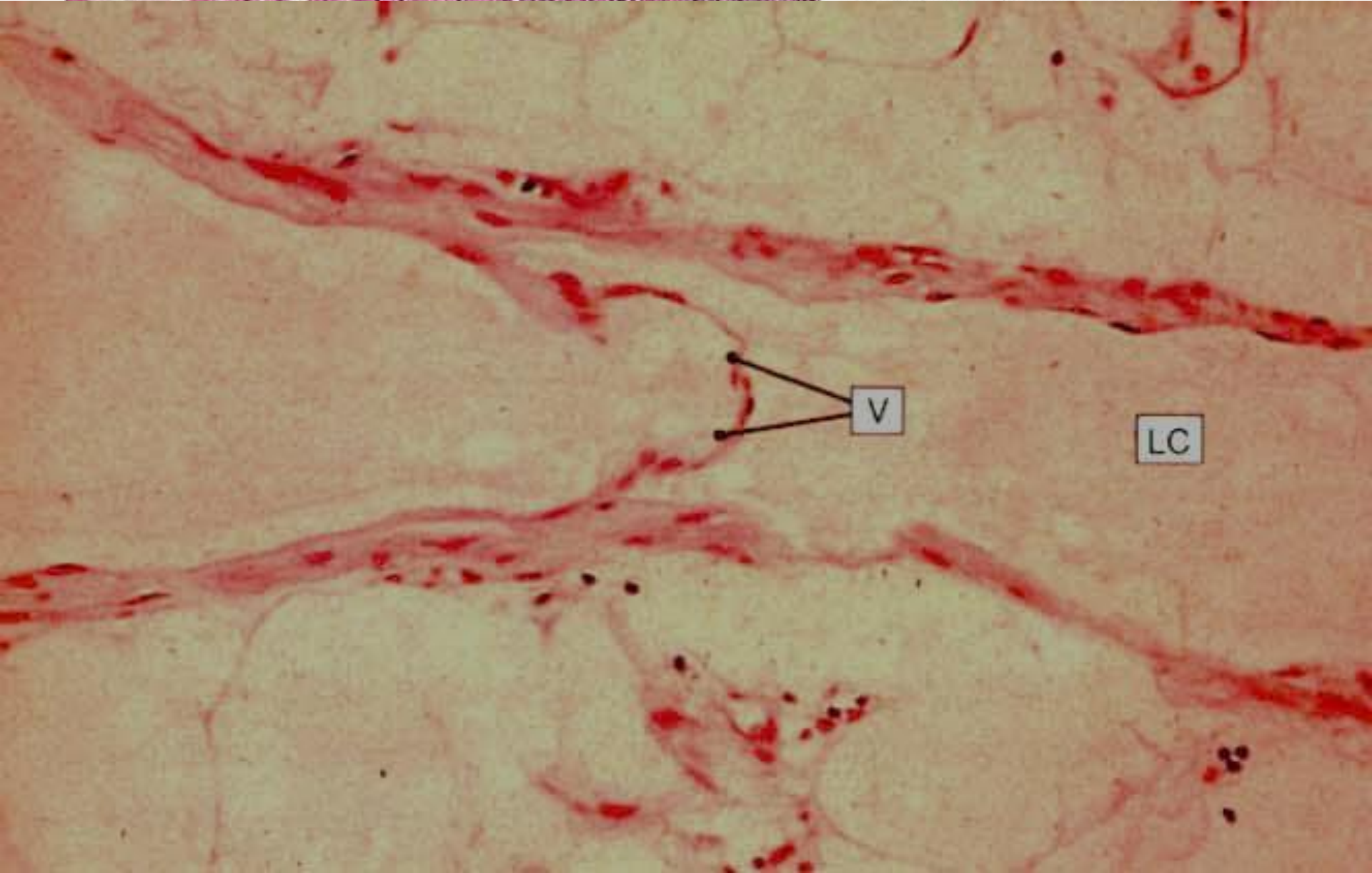
Lymphatic vessels

- Lymphatic capillaries
 - Endothelium, discontinuous basal lamina
 - Anchoring fibrils – collagen fibers

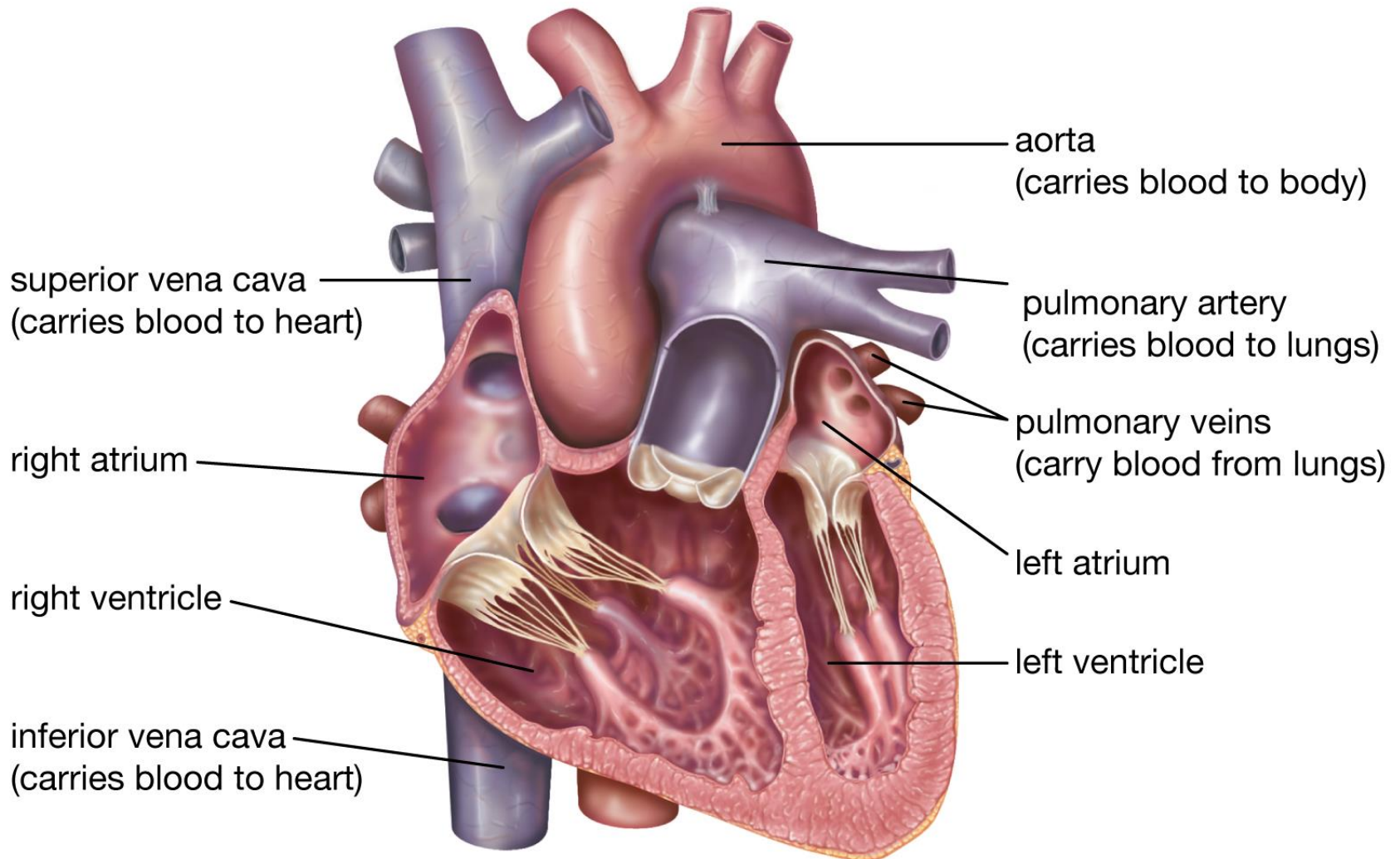
- Lymphatic vessels
 - Thicker wall – connective tissue + smooth muscle cells
 - Numerous valves



◀ **LM of a lymphatic capillary in longitudinal section.** This narrow, thin-walled vessel (**arrows**) has a uniform caliber, and its lumen contains a row of lymphocytes. It courses through connective tissue (**CT**), gradually increases in size, and drains into a larger lymphatic channel (*****), which has an irregular contour and



Heart



General structure of heart

- **Epicardium**

- Mesothelium – simple squamous epithelium
- Submesothelial layer

- **Myocardium**

- Cardiac muscle

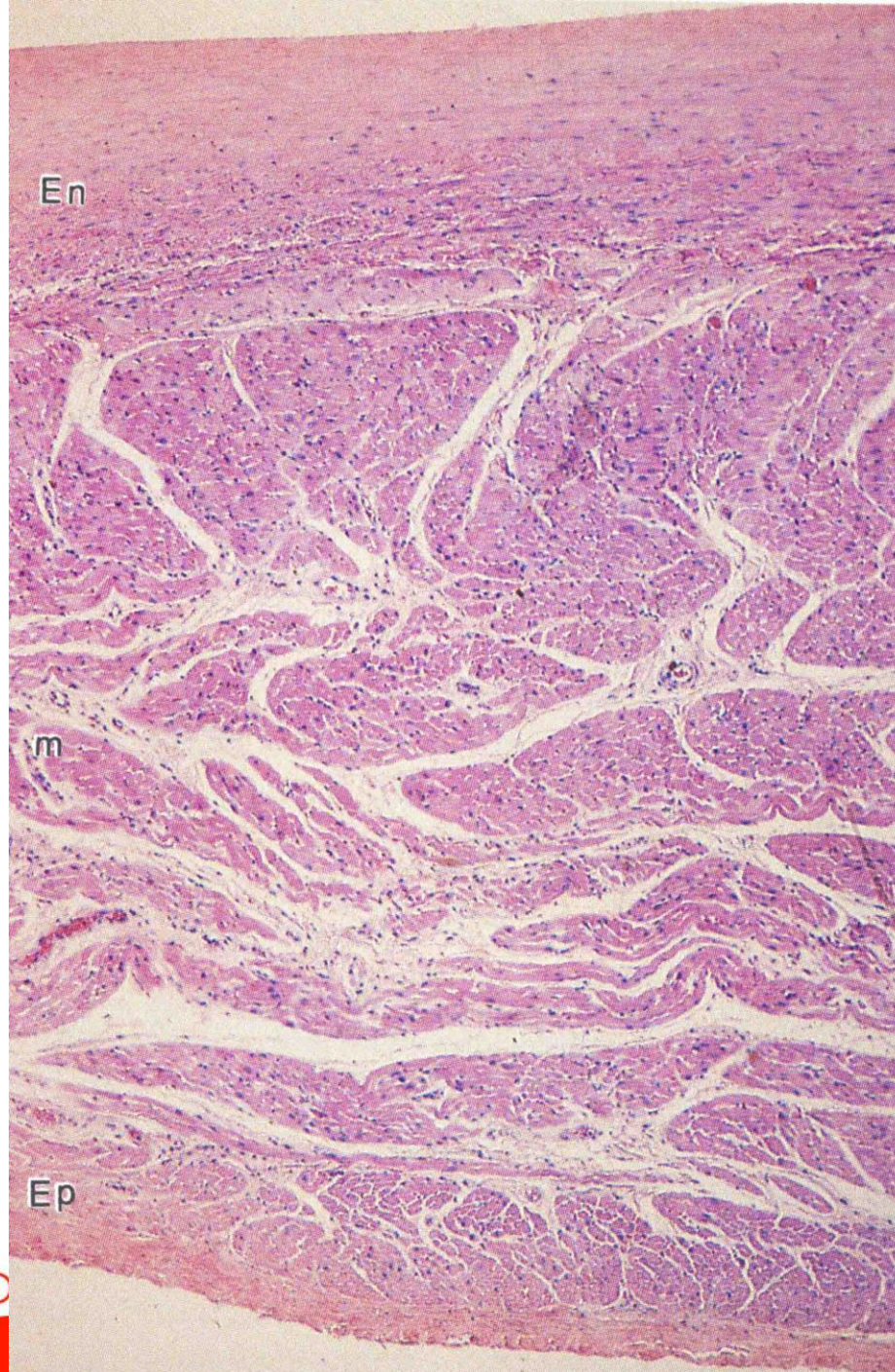
- **Endocardium**

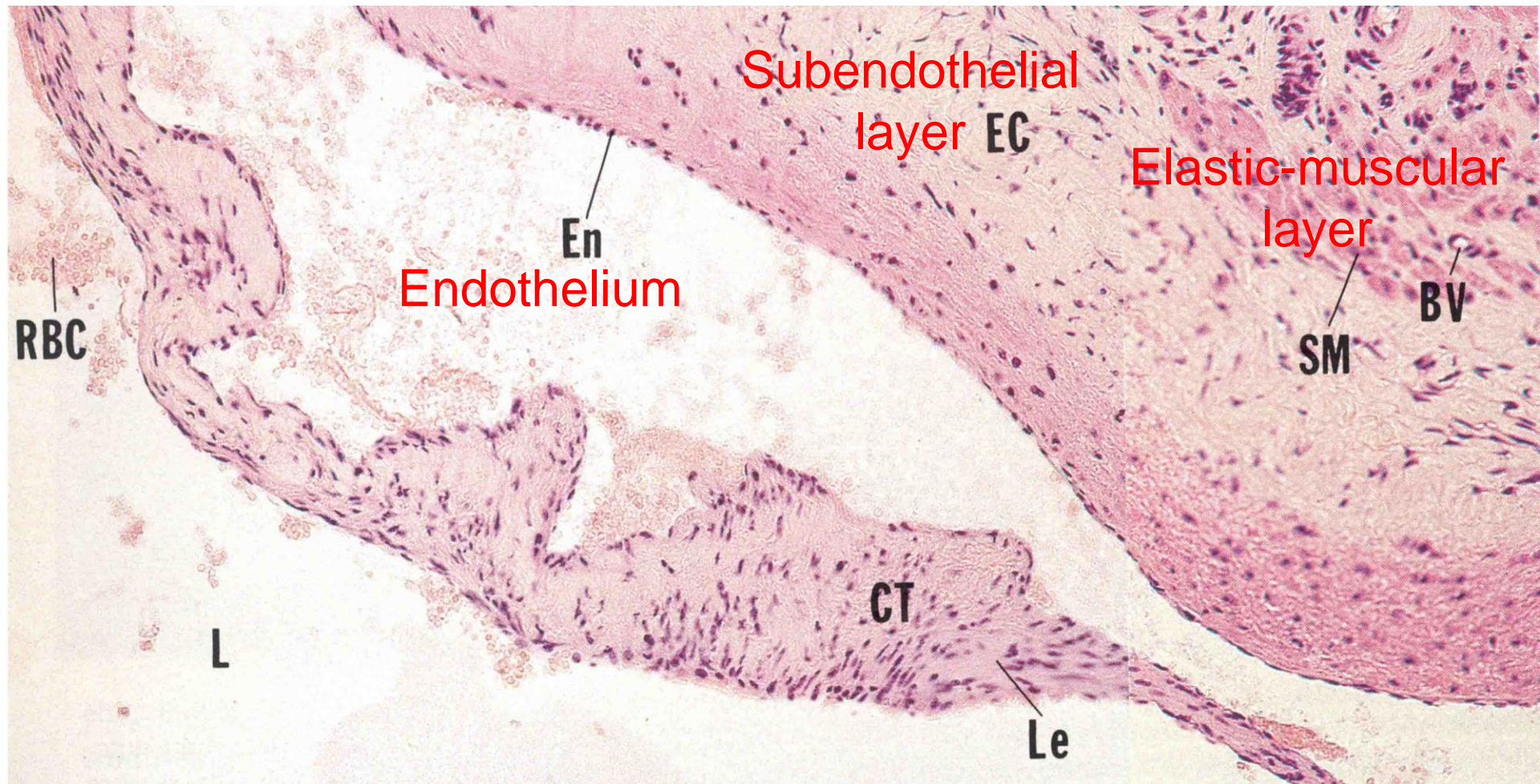
- Endothelium
- Subendothelial layer
- Elastic-muscular layer
- Subendocardial layer – conducting system

endocardium

myocardium

epicardium





Subendothelial layer EC

Elastic-muscular layer

Endothelium

RBC

En

BV

SM

CT

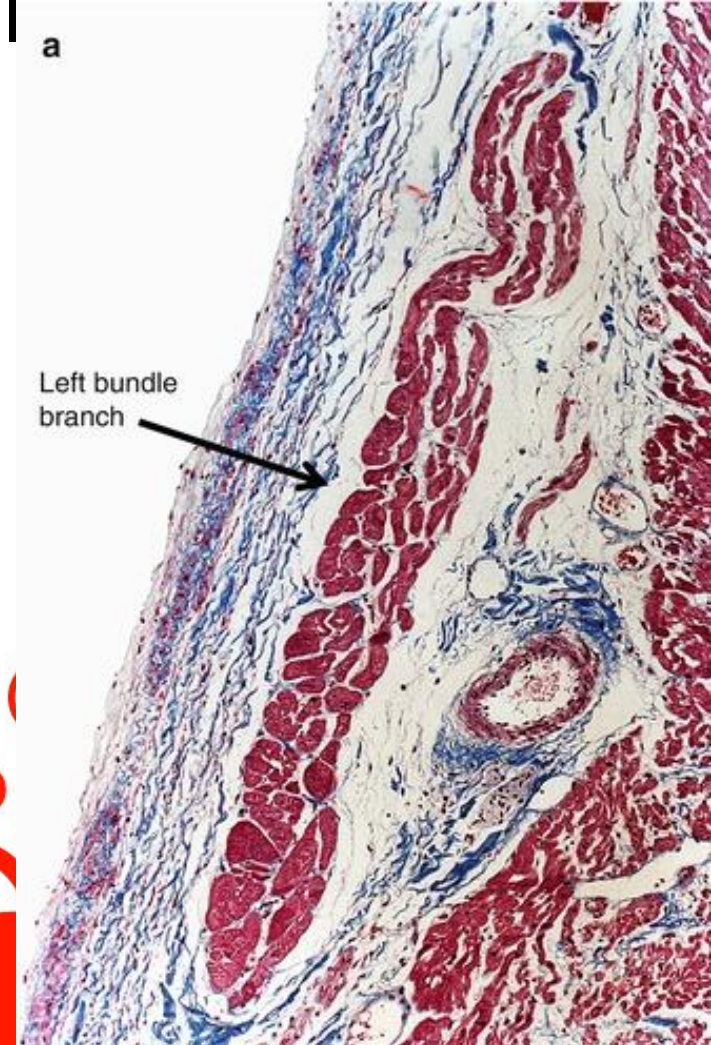
Le

L



Conducting system

- Modified cardiac muscle cell^a
 - Less myofibrils
 - More glycogen storage
 - No intercalated discs
 - Numerous nexuses



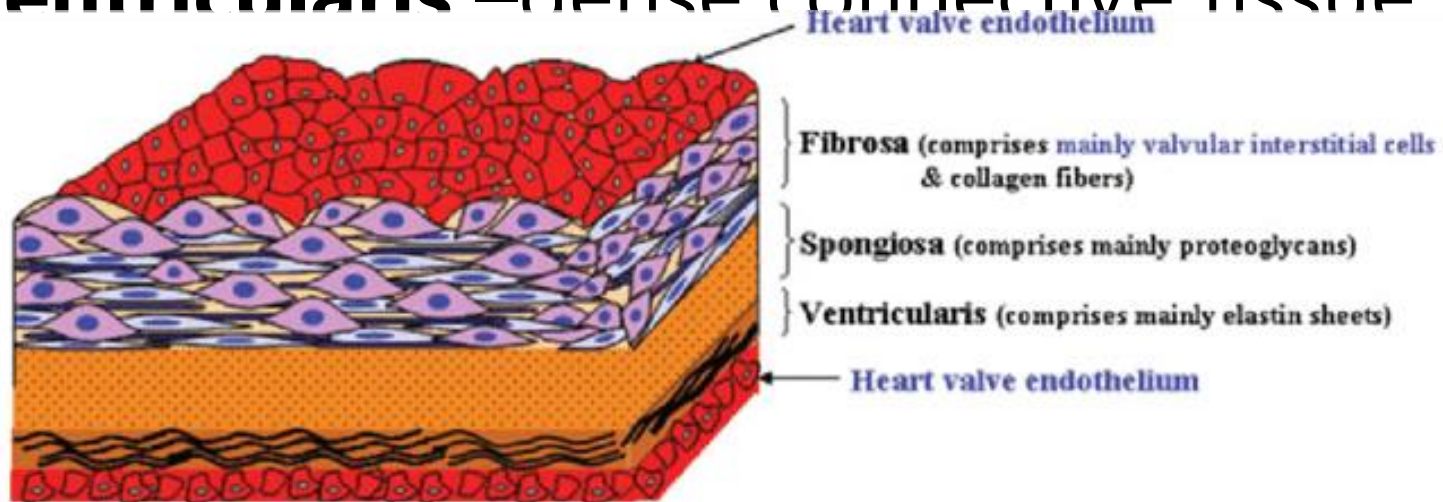
Conducting system



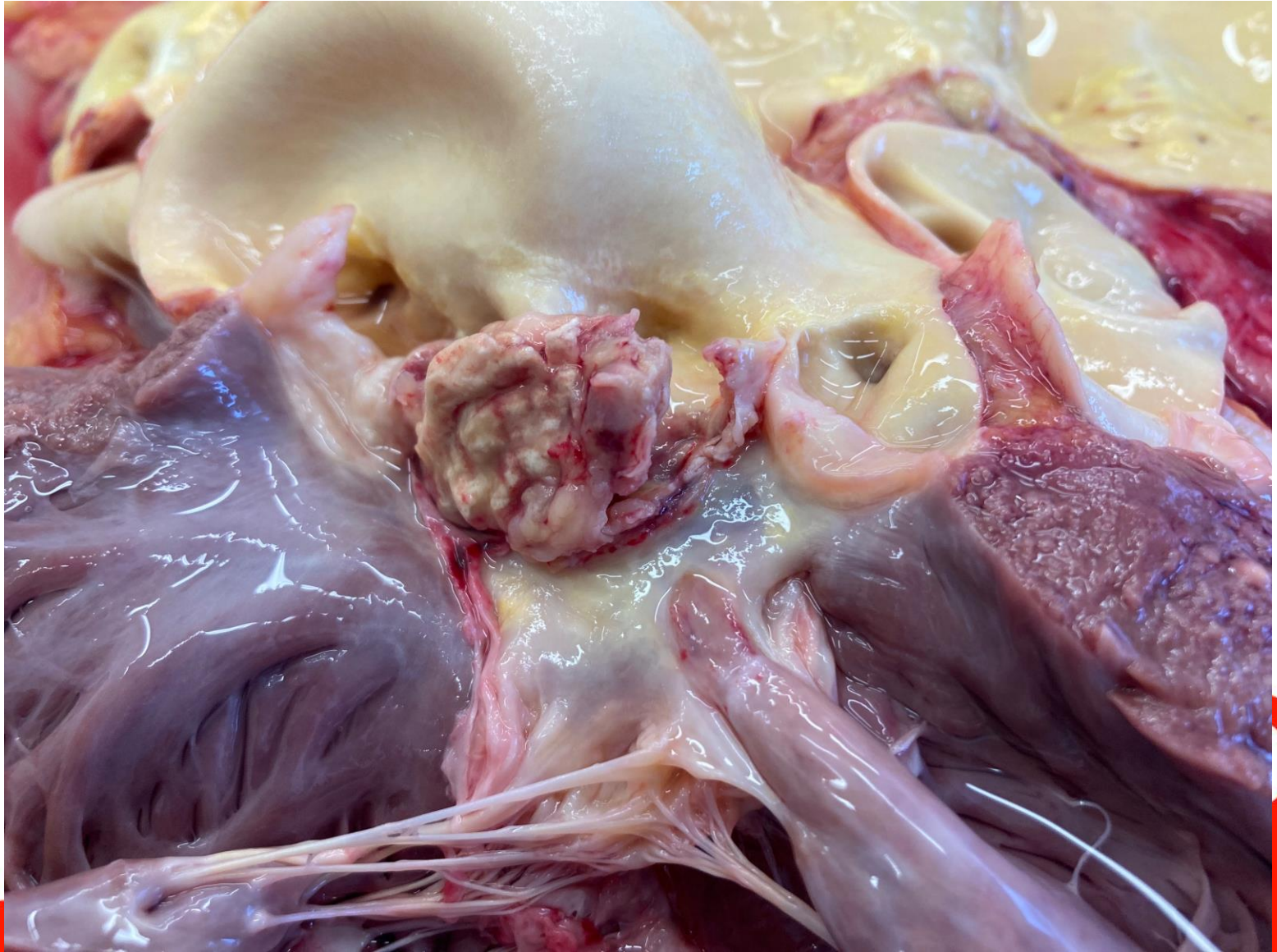
Purkynje fiber

Valves

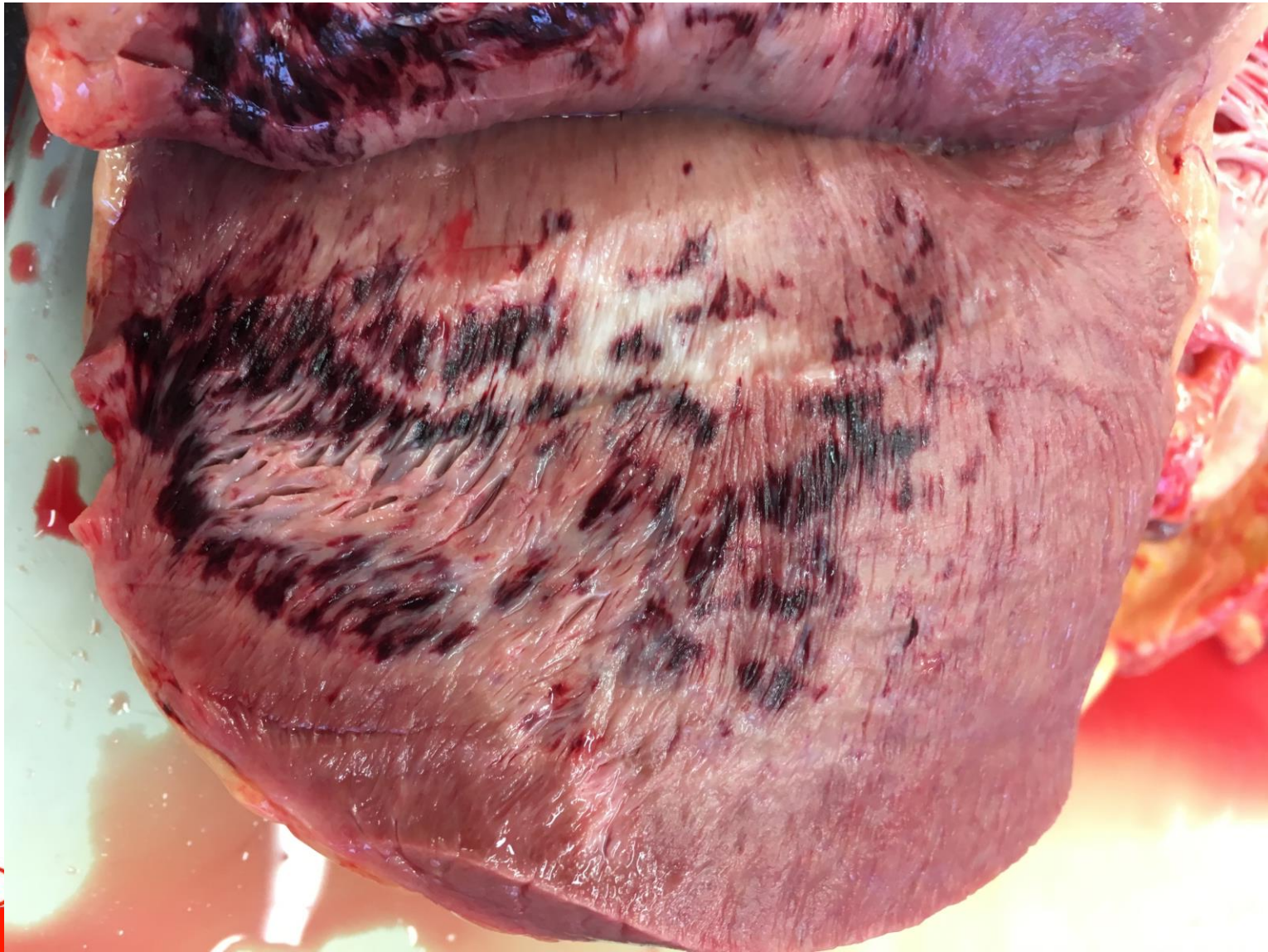
- Framework of dense connective tissue
- **Fibrosa** – core extending from skeletal rings
- **Spongiosa** – loose collagen and elastic tissue
- **Ventricularis** – dense connective tissue

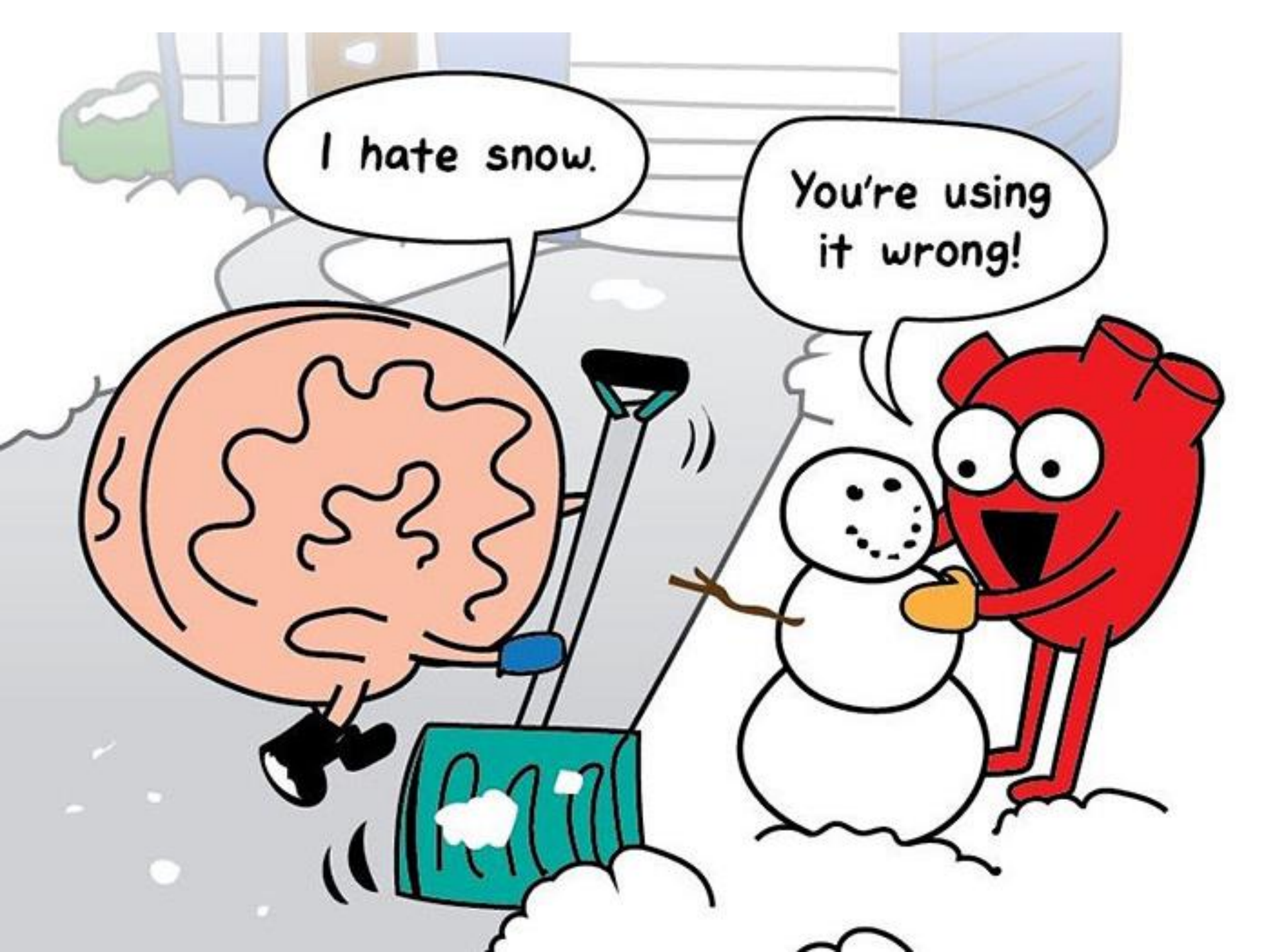


Endocarditis



Acute myocardial infarction





I hate snow.

You're using
it wrong!