Histology of the Cardiac System

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Anatomy Department

Objectives

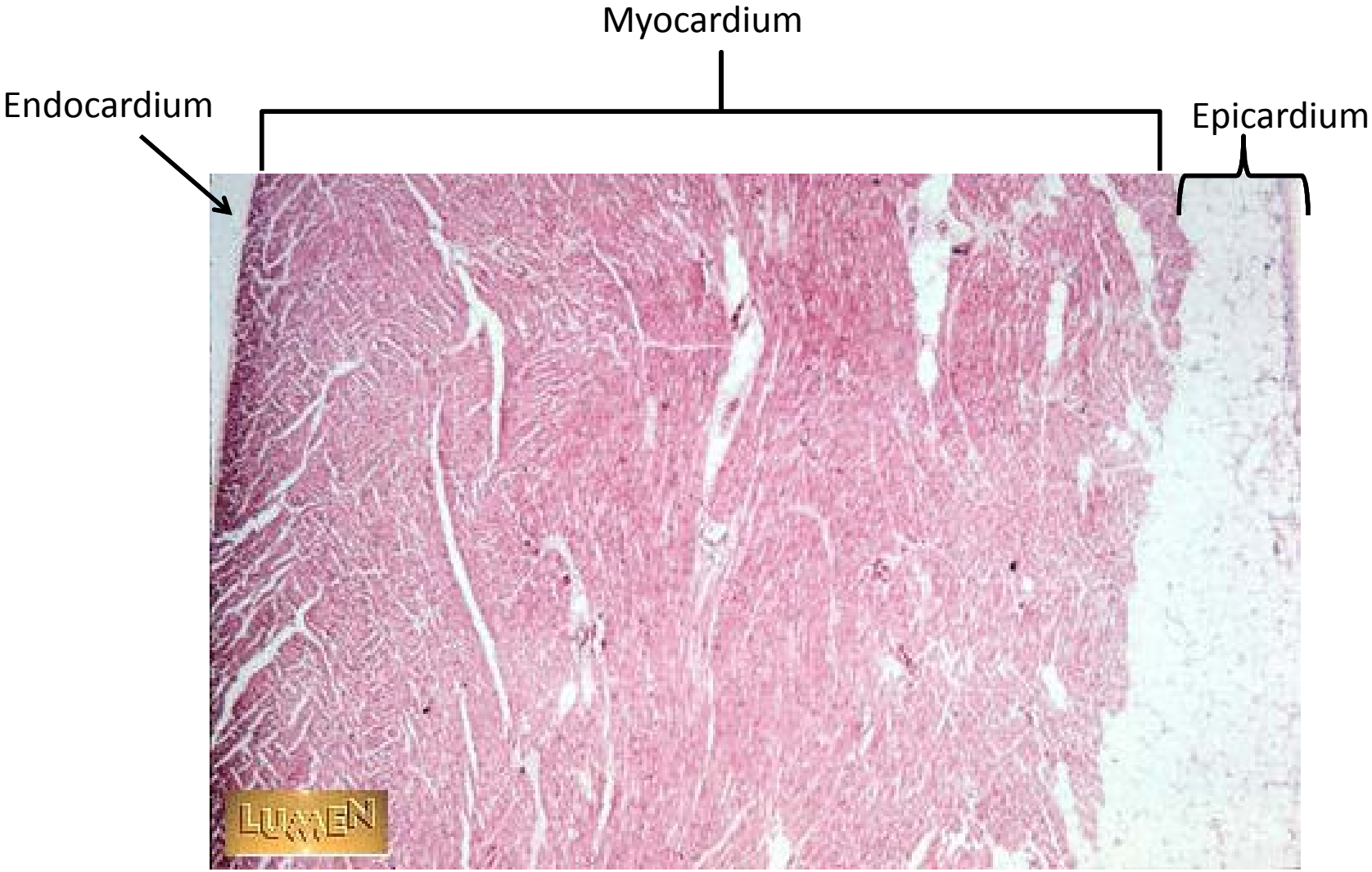
1. Identify the 3 layers of the heart – endocardium, myocardium, epicardium
2. Differentiate cardiacmuscle
3. Define “intercalated disc”
4. Name the layer of the heart in which Purkinje fibers are found and describe their function
5. Vessels Histology

- **1. The heart wall can be viewed as a three-layered structure.**
  - **a. Inner layer = Endocardium**
  - **b. Middle Layer = Myocardium**
  - **c. Outer layer = Epicardium (also called the pericardium)**

- **2. Except for the smallest vessels, blood and lymphatic vessel walls can also be viewed as**
  - **three-layered structures.**

  - **a. Inner layer = Tunica intima**
  - **b. Middle layer = Tunica media**
  - **c. Outer layer = Tunica adventita**

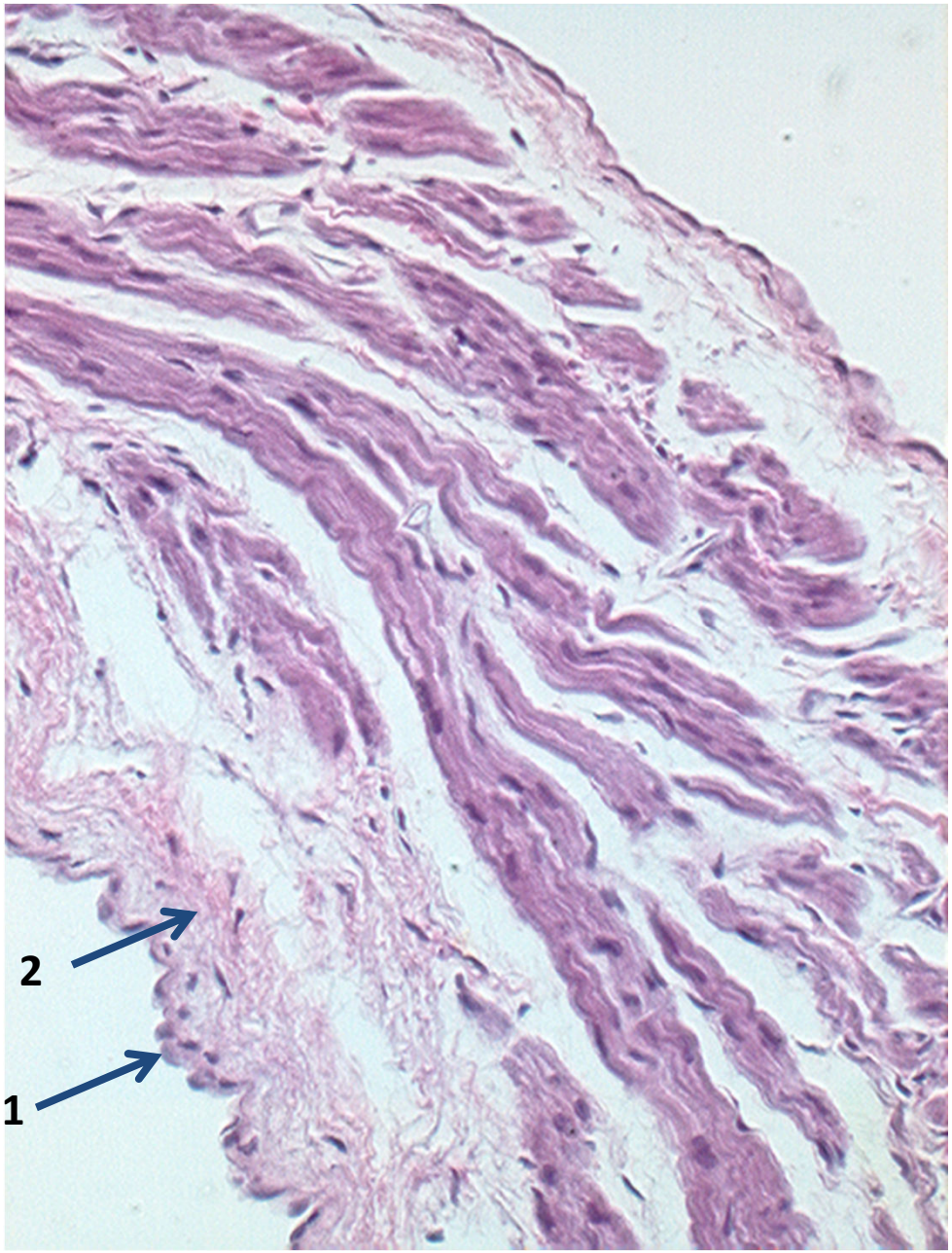
Heart Wall



Endocardium

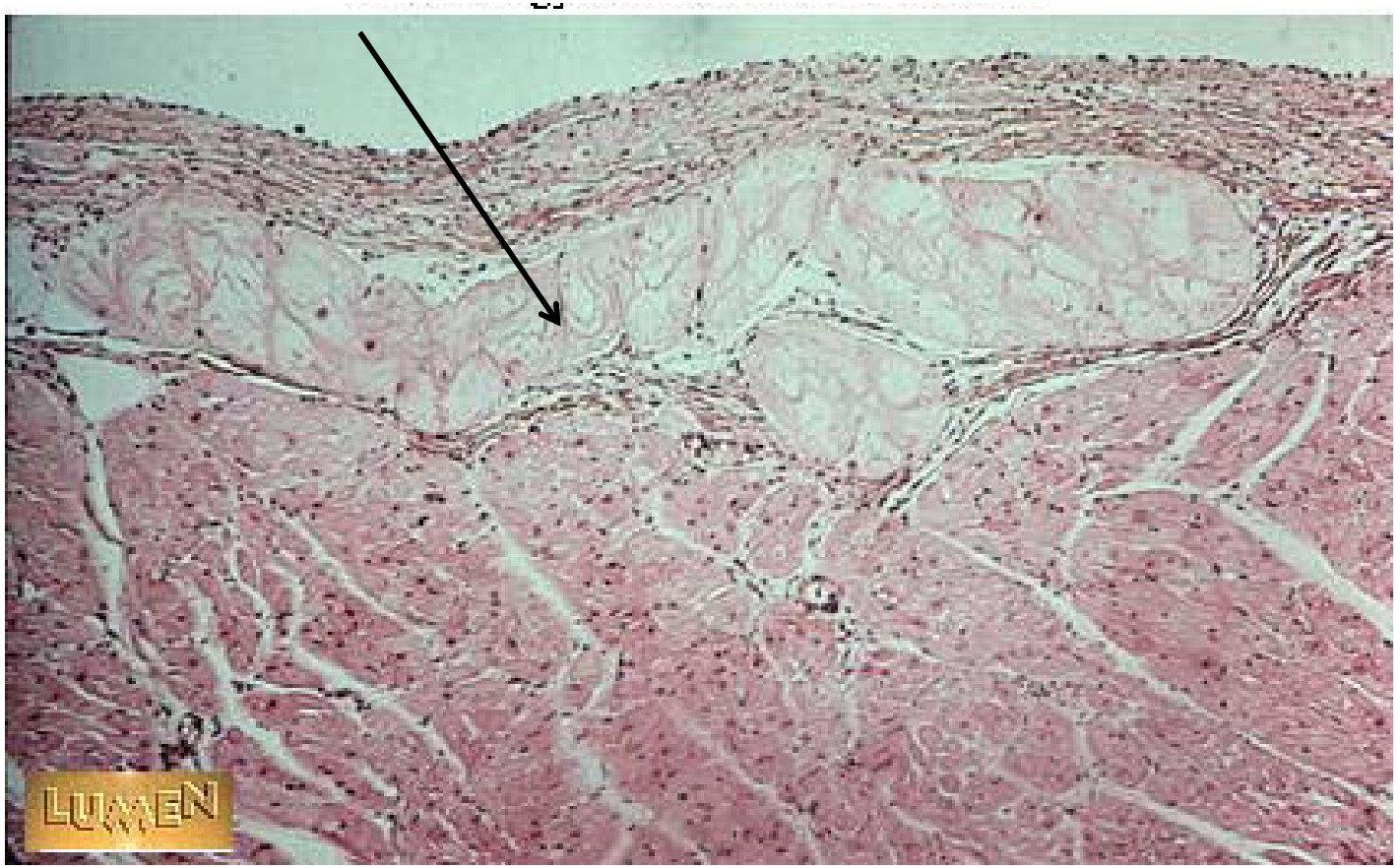
The endocardium is the inner layer of the heart wall and consists.

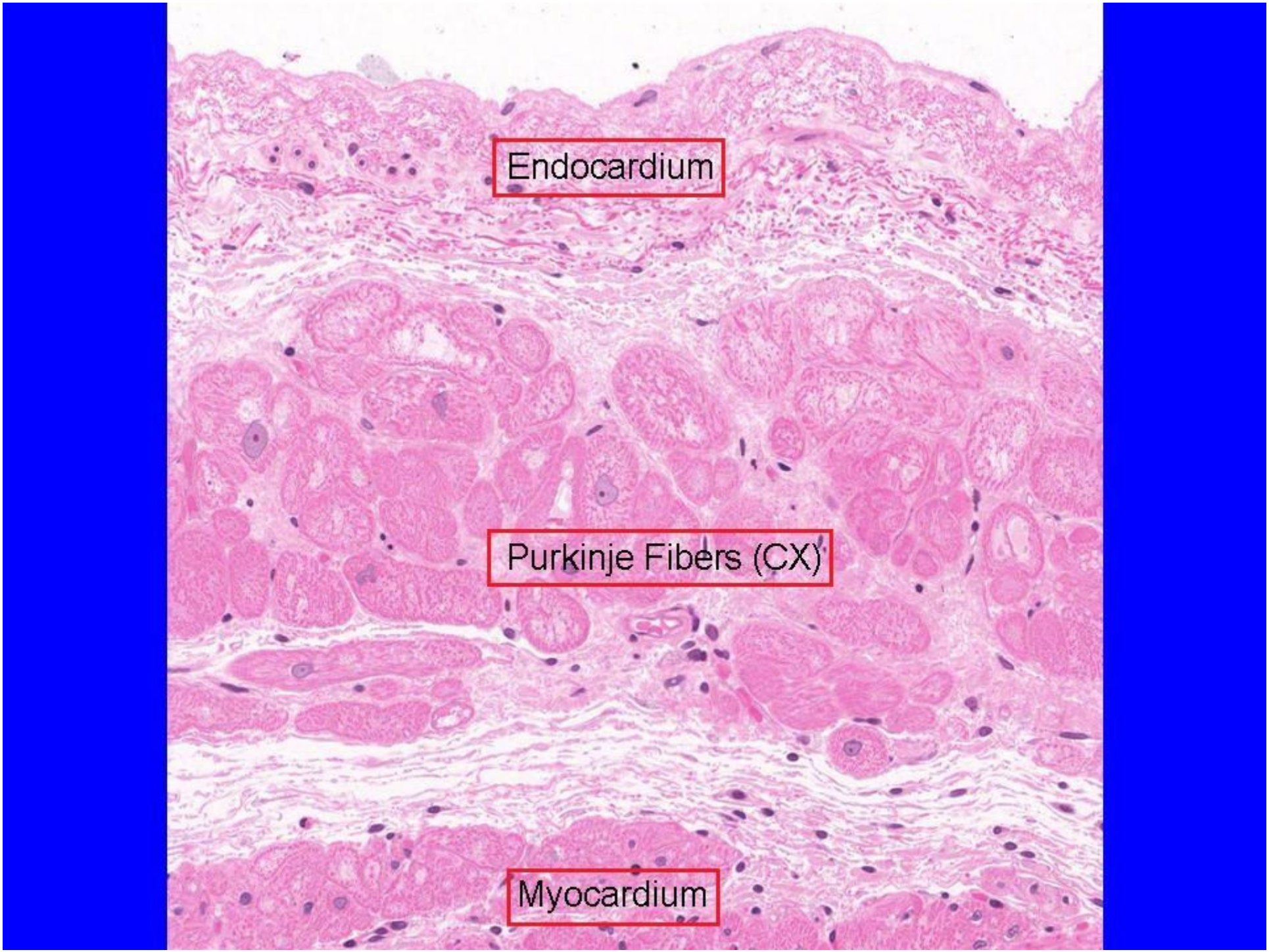
- Composed of:
  - **1. The endothelial lining made of** Simple squamous epithelium
  - **2. The underlying connective tissue layers**
  - **Subendocardium: Is in contact with cardiac muscle and contains small vessels, nerves, and Purkinje Fibers.**



Purkinje Fibers

- Impulse conducting fibers
- Large modified muscle cells
  - Cell Cluster in groups together
  - 1-2 nuclei and stain pale due to fewer myofibrils
- Terminal branches of the AV bundle branches located in the subendocardial connective tissue

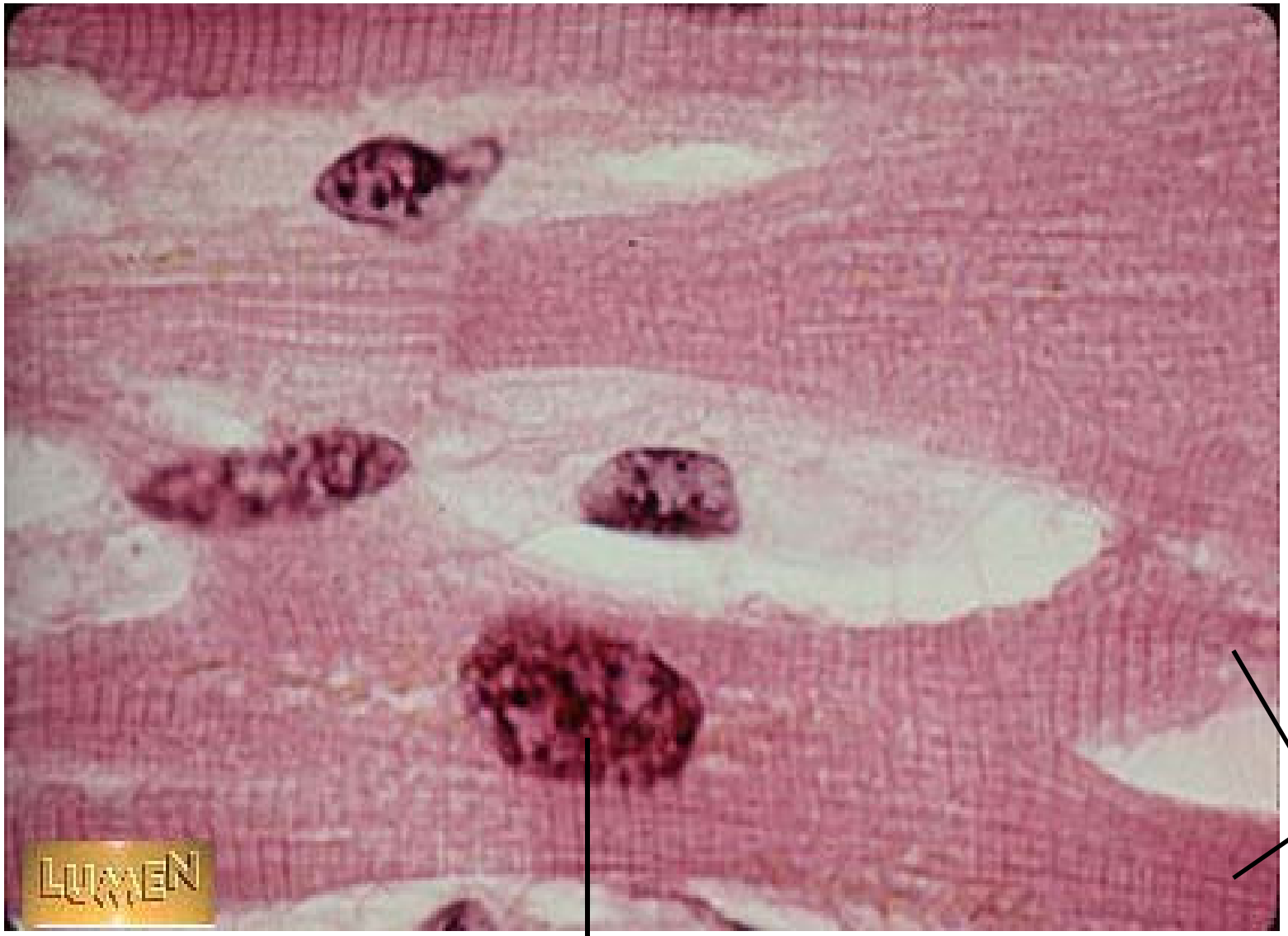



Endocardium
Purkinje Fibers (CX)
Myocardium

Myocardium

- Thickest layer of the heart
- Thickest in left ventricle because must pump hard to overcome high pressure of systemic circulation
- Right atrium the thinnest because of low resistance to back flow

- Consist of cardiac muscle cells = Myocytes
  - Different from smooth or skeletal muscle cells due to placement of nuclei, cross striations, and intercalated disks
    - communication.
      - Bind myocytes and allow ion exchange to facilitate electrical impulses to pass



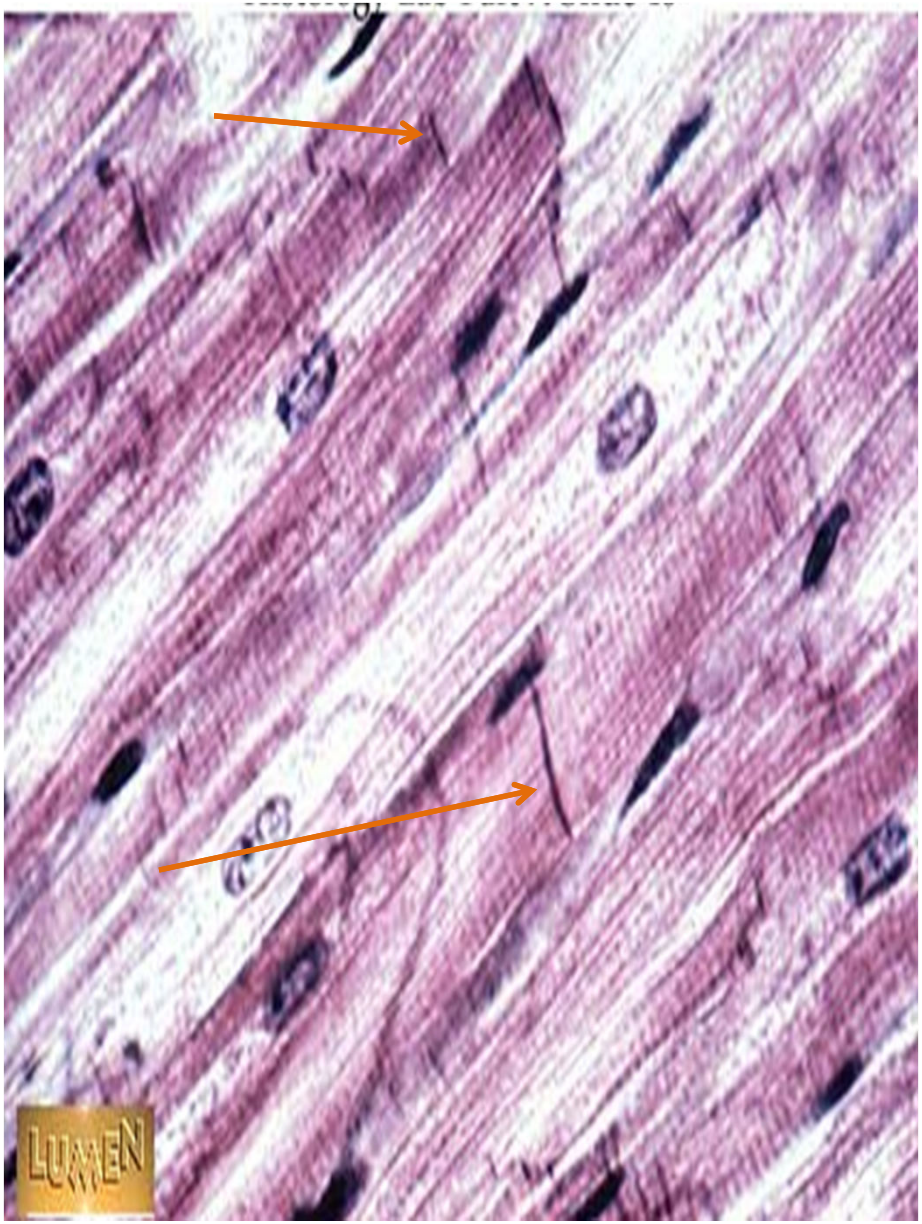
Branching
myocytes

Central nuclei
Fibers with **Cross Striations**

Intercalated disks

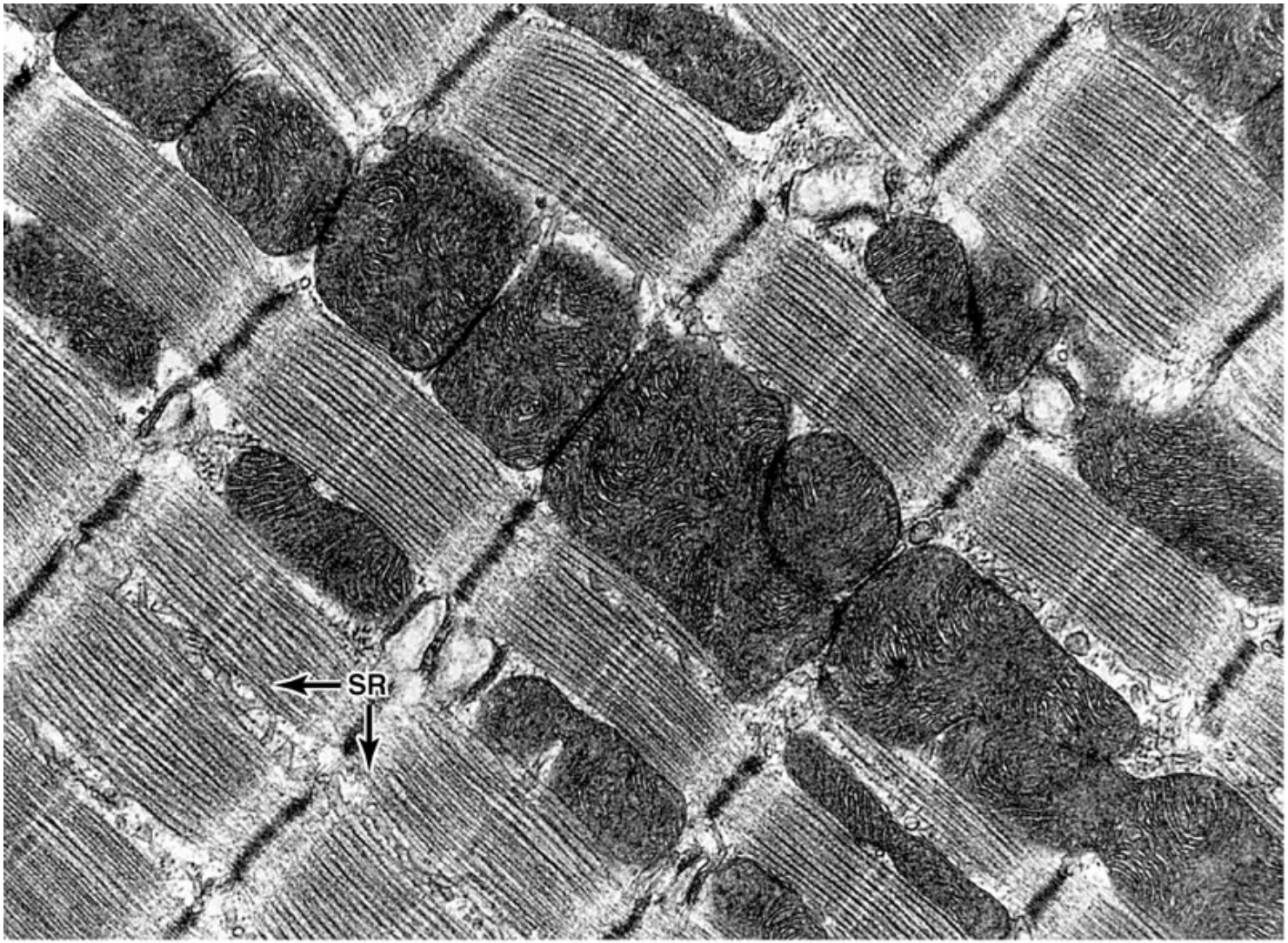
Junctional complexes that contain fascia adherens, desmosomes, and gap junction to provide connection and connect the ends of cardiac muscle fibers to one another

- **Allow muscle action potentials to spread from one cardiac muscle fiber to another**



Cardiac Muscle Tissue

- **Principal tissue in the heart wall**
  - **Cardiac muscle tissue contracts when stimulated by its own autorhythmic muscle fibers**
    - **Continuous, rhythmic activity is a major physiological difference between cardiac and skeletal muscle tissue**
  - **Contractions lasts longer than a skeletal muscle twitch**
  - **Have the same arrangement of actin and myosin as skeletal muscle fibers**
  - **Mitochondria are large and numerous**
  - **Depends on aerobic respiration to generate ATP**
    - **Requires a constant supply of oxygen**
    - **Able to use lactic acid produced by skeletal muscle fibers to make ATP**



Electron micrograph of a longitudinal section of heart muscle. Note the striation pattern and the alternation of myofibrils and mitochondria rich in cristae. Note the sarcoplasmic reticulum (SR), which is the specialized calcium-storing smooth endoplasmic reticulum. x30,000.

Epicardium

- Outermost layer of the heart
- Composed of connective tissue with nerves, vessels, adipocytes and an outer layer of mesothelium
- Mesothelium secretes pericardial fluid
- Covers and protects the heart

Generalized Structure of Blood Vessels

- Arteries and veins are composed of three tunics –
  - tunica interna
  - tunica media
  - tunica externa
- Lumen – central blood-containing space surrounded by tunics
- Capillaries are composed of endothelium with sparse basal lamina

Tunica intima

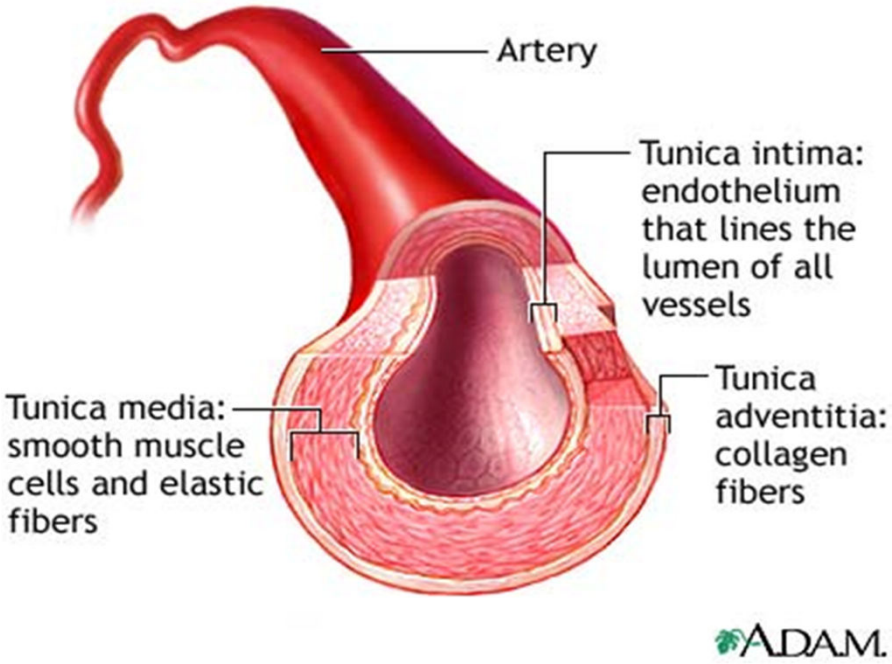
1. Endothelial cell lining
2. Subendothelial CT layer
3. Internal elastic lamina

Tunica media

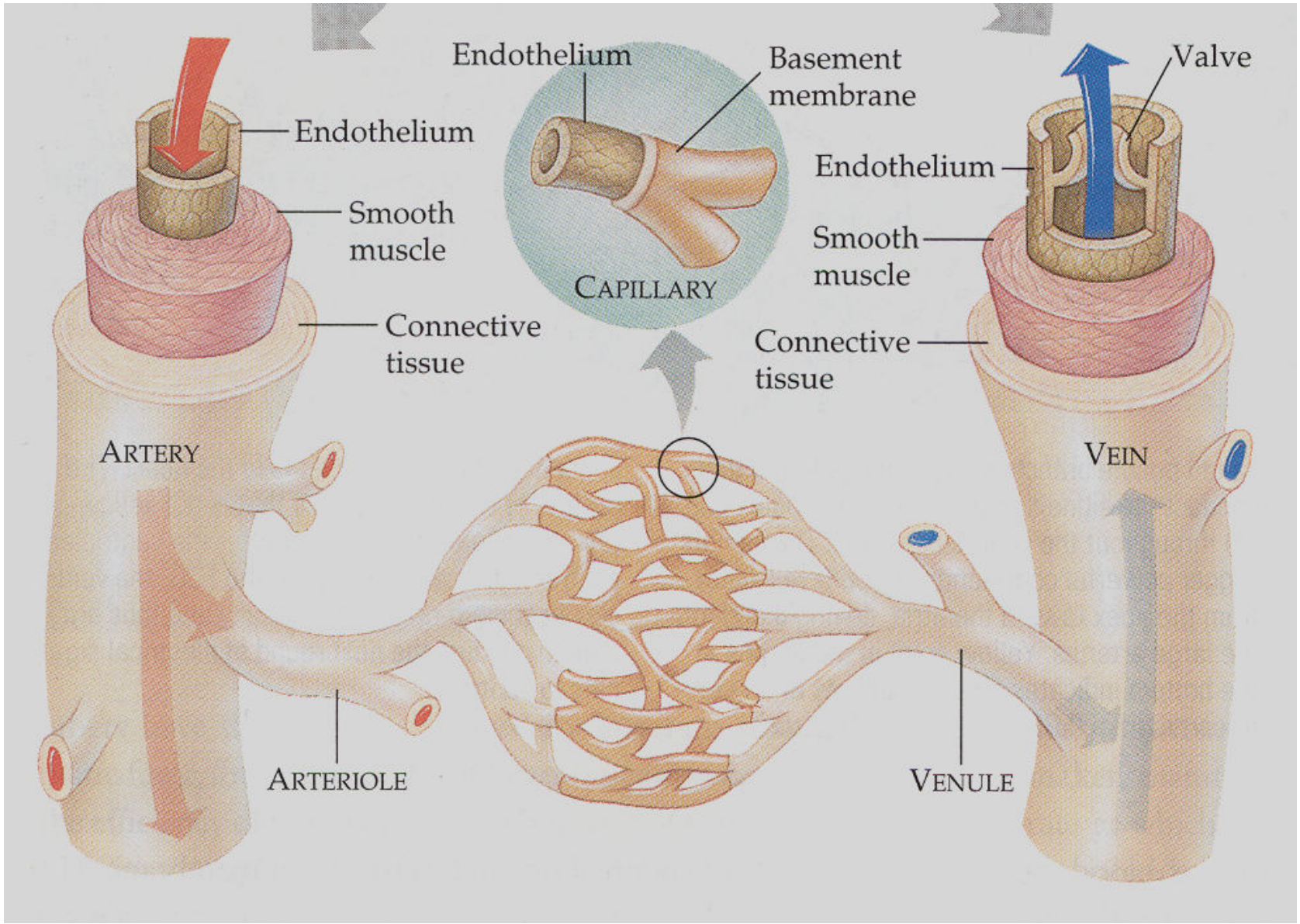
1. Smooth muscle cells, collagen fibers, and ground substance
2. Elastin in the form of fenestrated elastic lamellae (esp elastic arteries)
3. External elastic lamina

Tunica adventitia

1. Mostly collagenous fibers
2. Elastic fibers (not lamellae)
3. Fibroblasts and macrophages
4. Vasa vasorum



Structure of Vessels



Types of Blood vessels: Arteries

Elastic Arteries:

- Thick-walled arteries near the heart; the aorta and its major branches.
- Large lumen allows low-resistance conduction of blood.
- Contain elastin fibers in all three tunics.
- walls stretch and recoil to propel blood
- Withstand and regulate large blood pressure fluctuations.

□ Allow blood to flow fairly continuously through the body

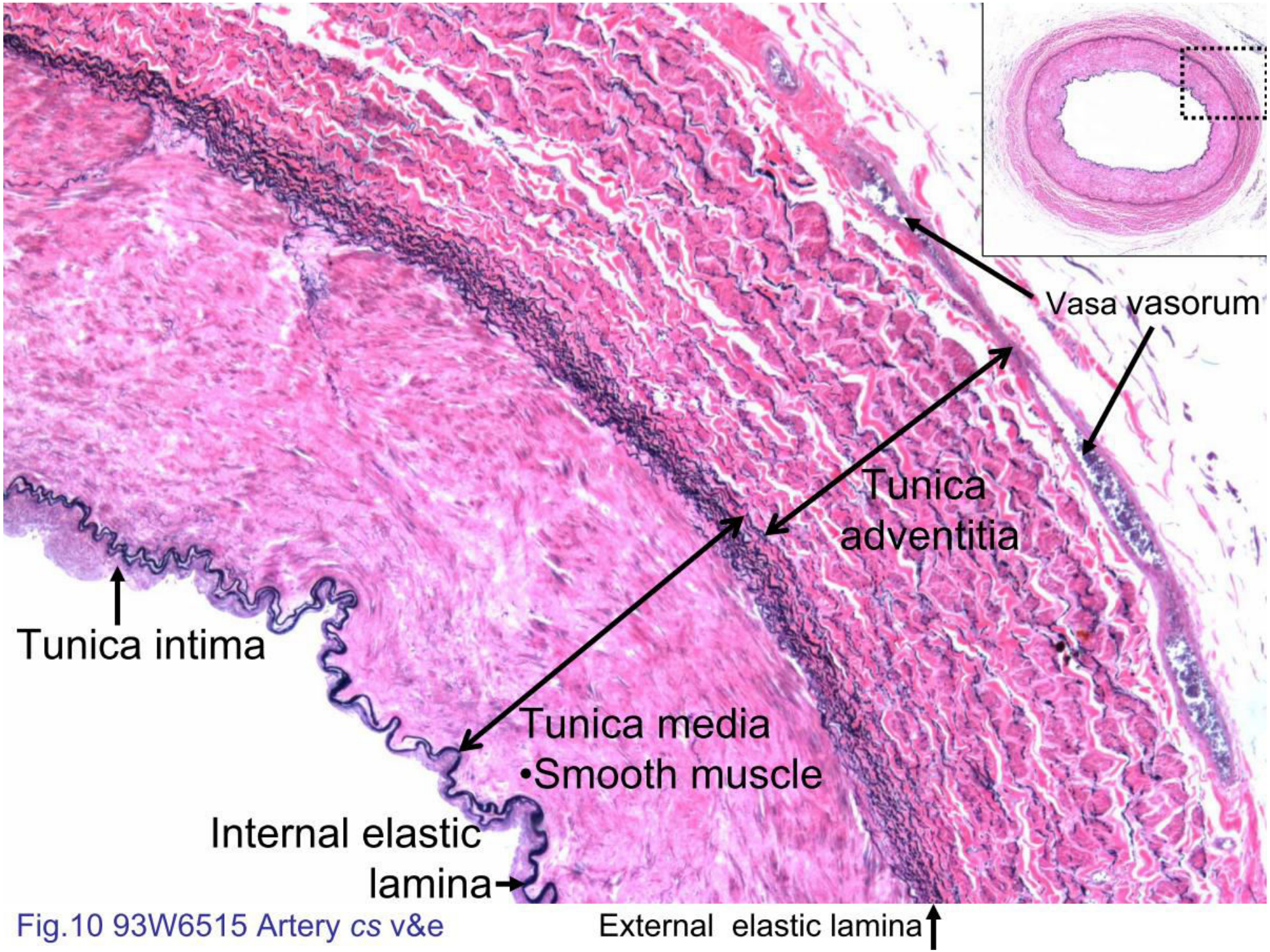
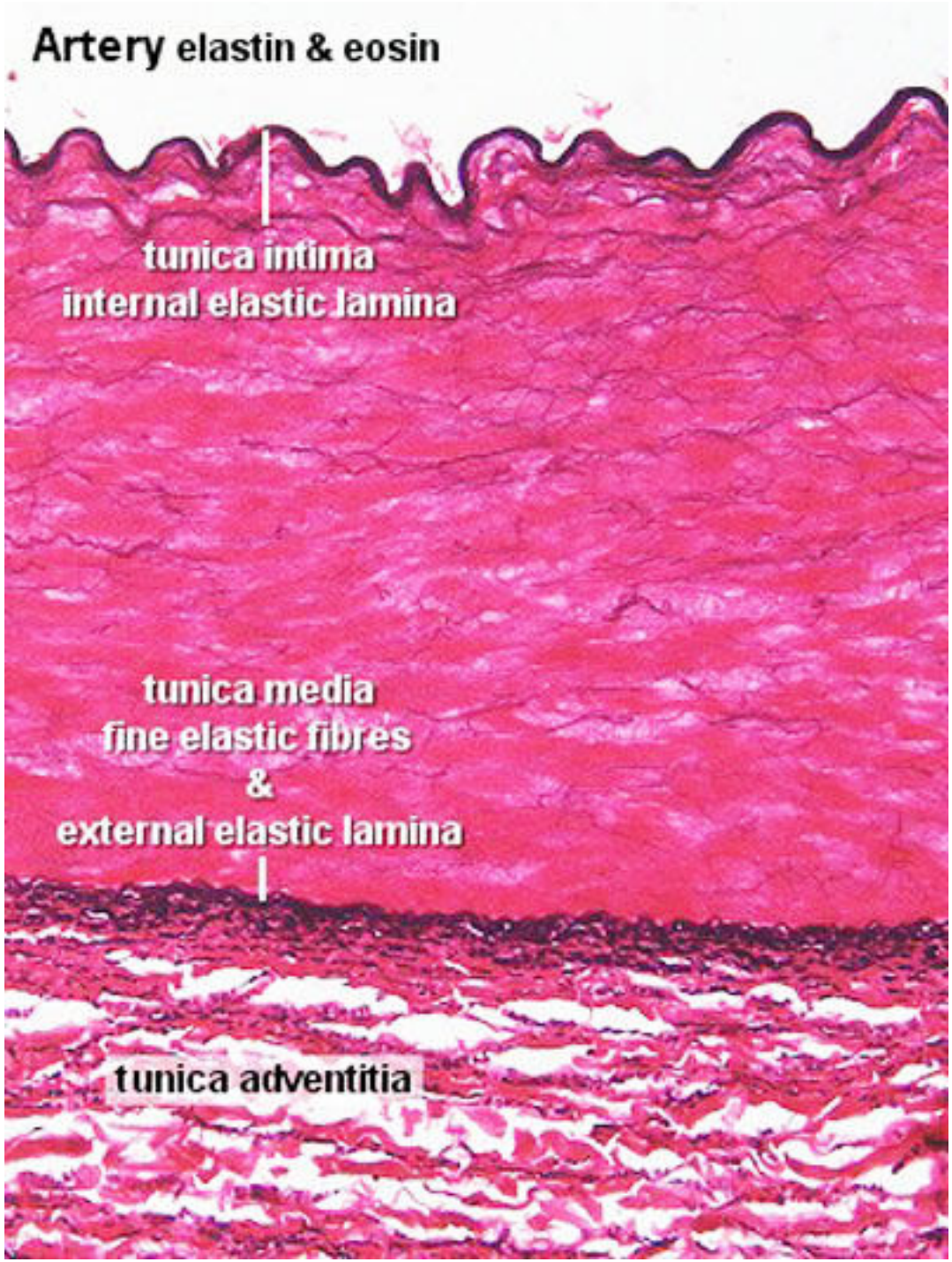
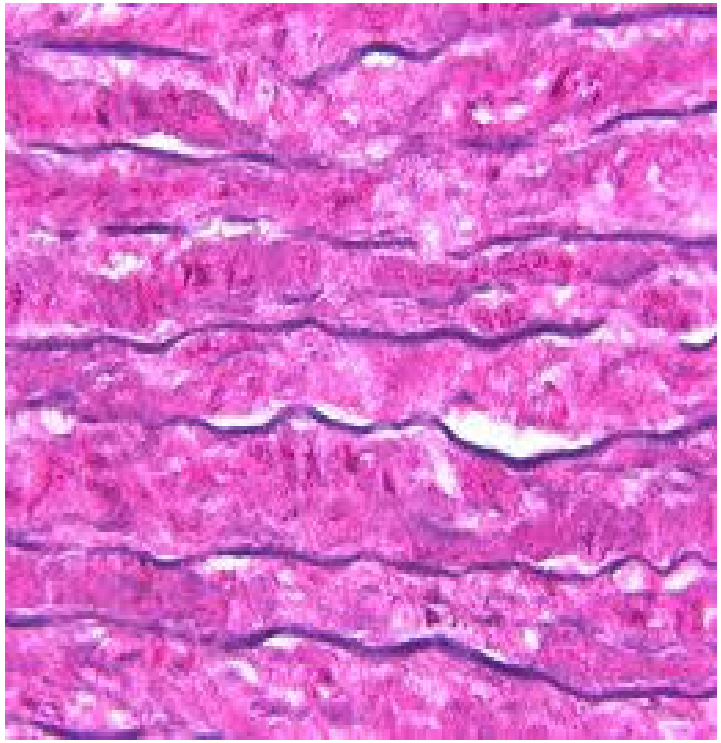


Fig.10 93W6515 Artery *cs* v&e


Artery elastin & eosin
tunica intima
internal elastic lamina
tunica media
fine elastic fibres
&
external elastic lamina
tunica adventitia



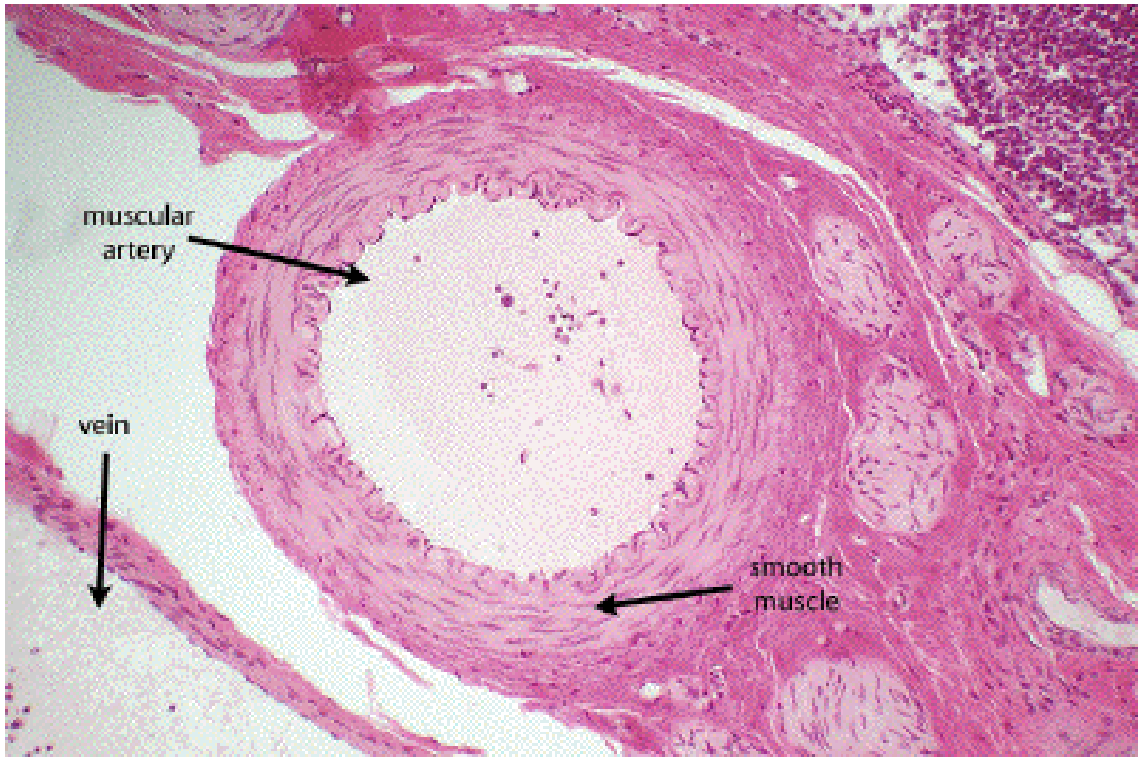
Muscular (Distributing) Arteries and Arterioles

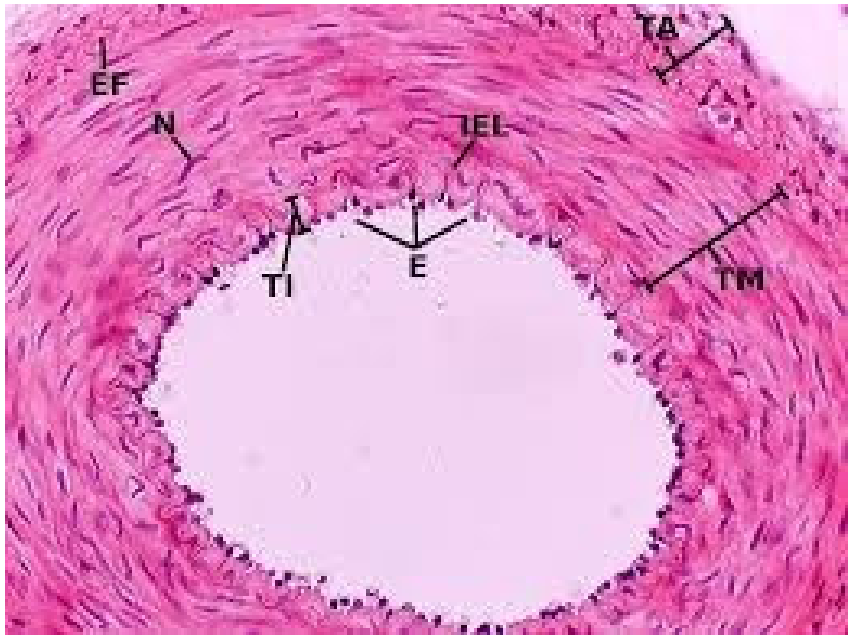
- **Muscular arteries** – distal to elastic arteries; deliver blood to body organs
  - Have thick tunica media with more smooth muscle and less elastic tissue
  - Active in vasoconstriction
- Arterioles – smallest arteries; lead to capillary beds
  - Control flow into capillary beds via vasodilation and constriction

Types of Blood vessels: Arteries

Muscular (distributing) arteries

- medium sized vessels
- tunica media contain more smooth muscle; less elastin
- major area of vaso-constriction & dilation to regulate blood flow

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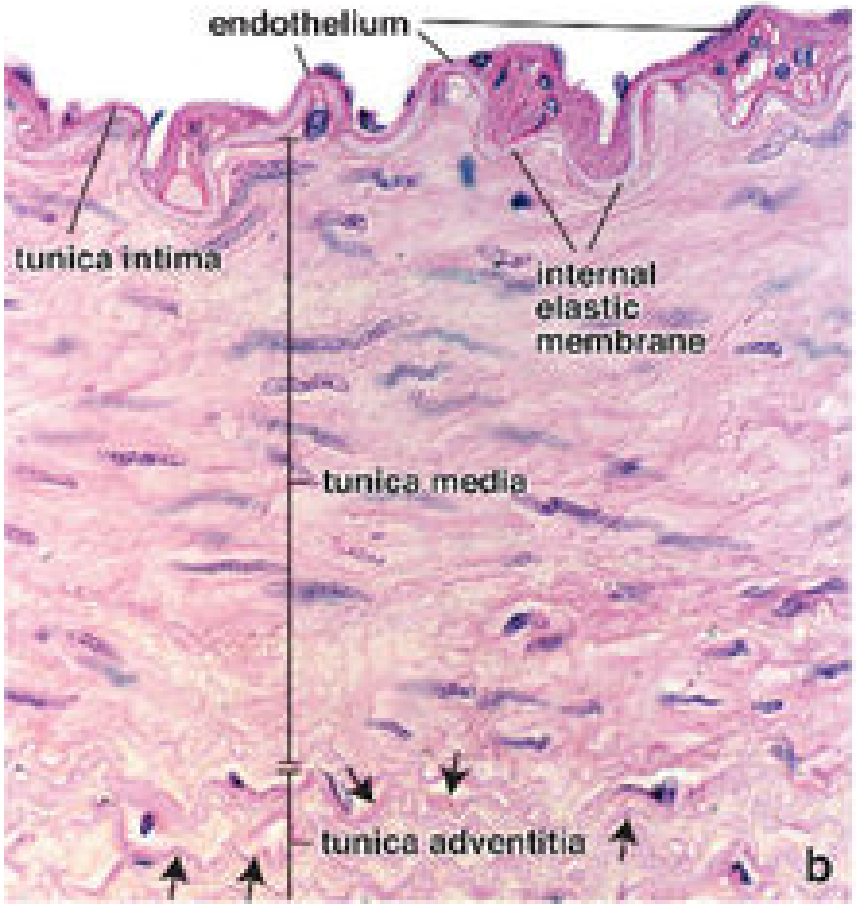
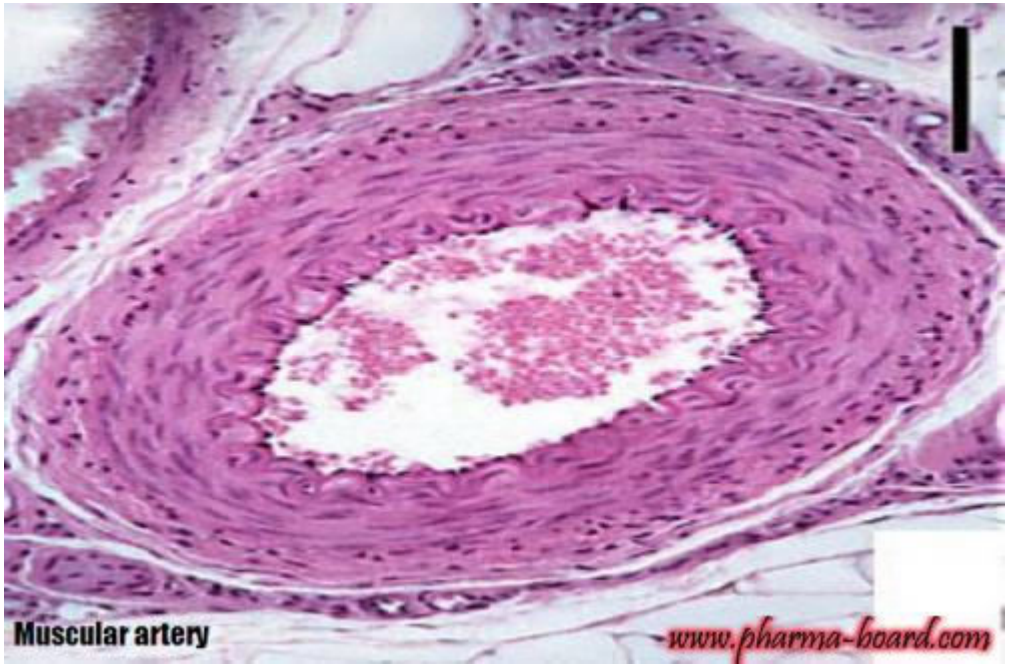

endothelium
tunica intima
internal
elastic
membrane
tunica media
tunica adventitia
b


Muscular artery
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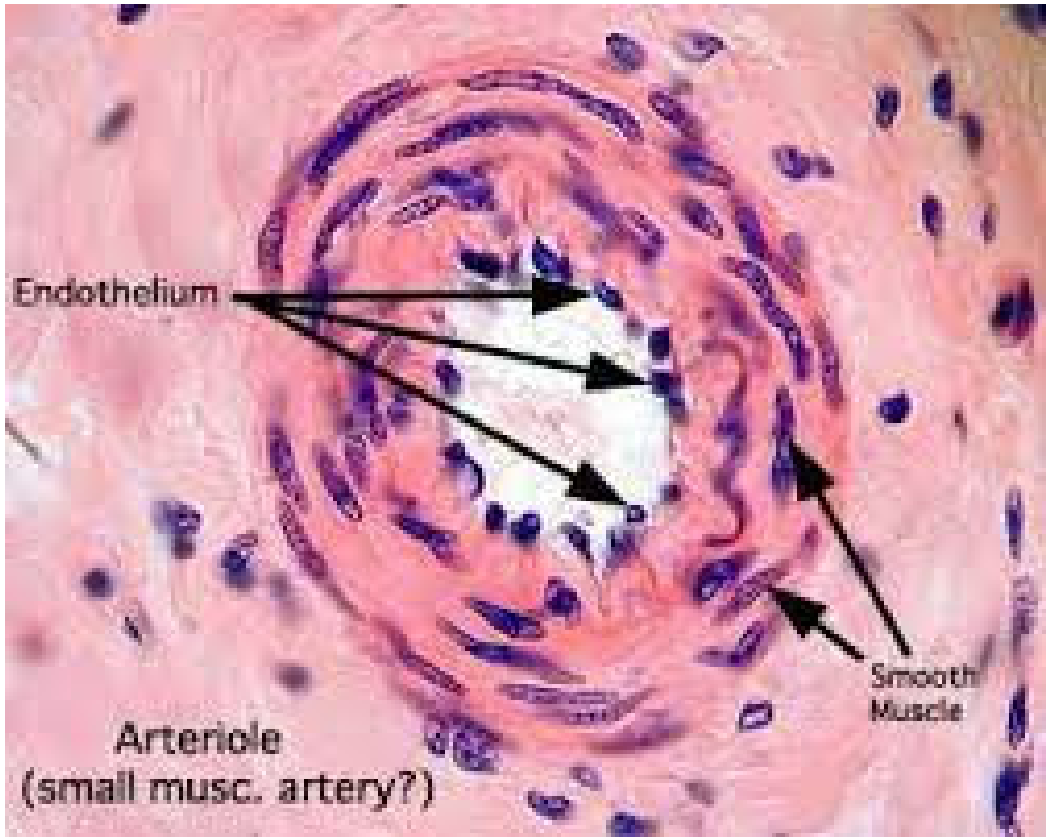
Arteriole

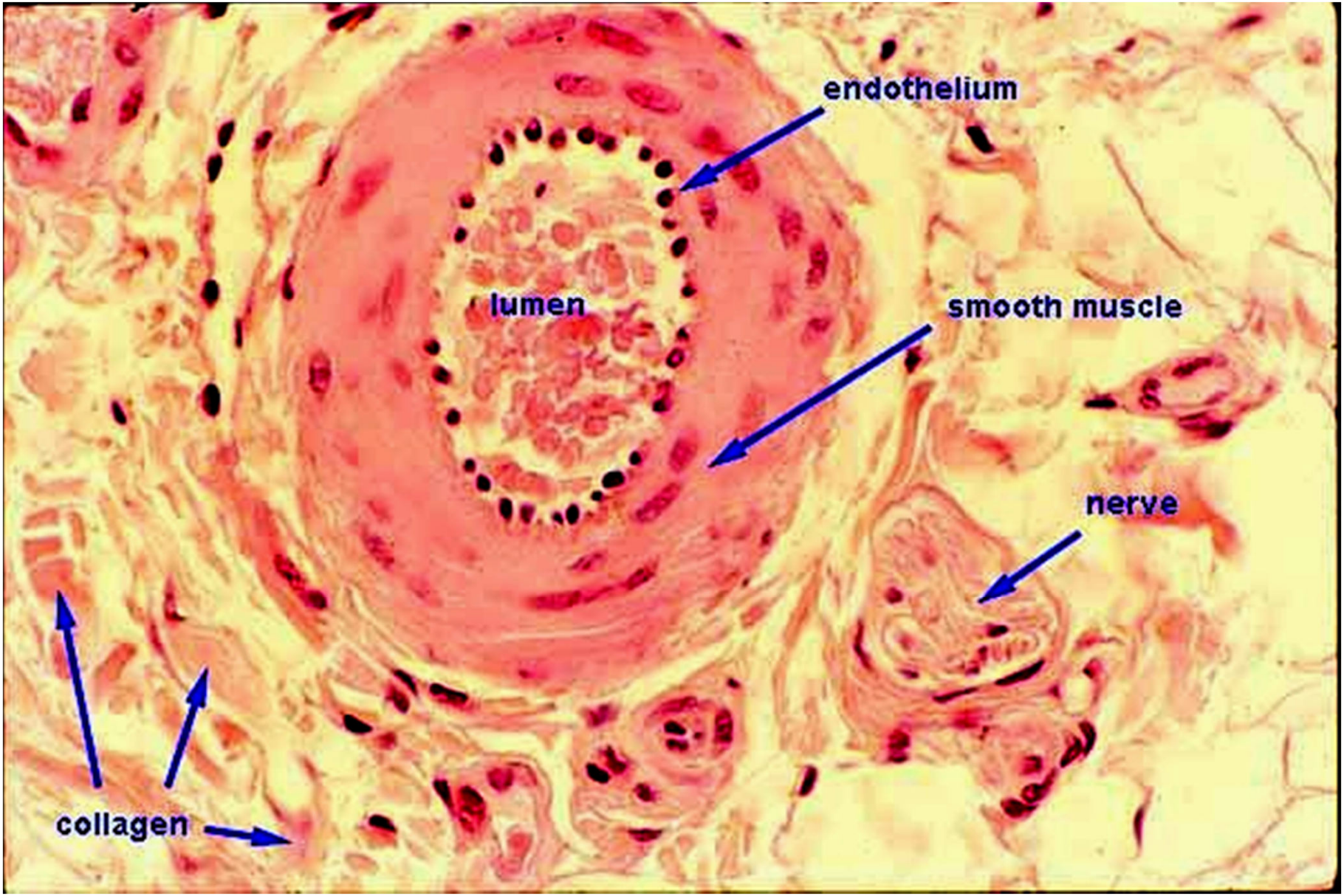
- The intima of the small artery is visible only as a "dotted line" of nuclei of endothelial cells, exactly at the edge of the arterial lumen. These nuclei look round rather than flat because post-mortem contraction of smooth muscle in the media has caused longitudinal wrinkles in the endothelium.
- The internal elastic lamina is present.
- The media is the thickest layer, in which nuclei of individual smooth muscle fibers are clearly visible.
- The adventitia is not a distinct layer but merges with surrounding connective tissue.

The Vessels

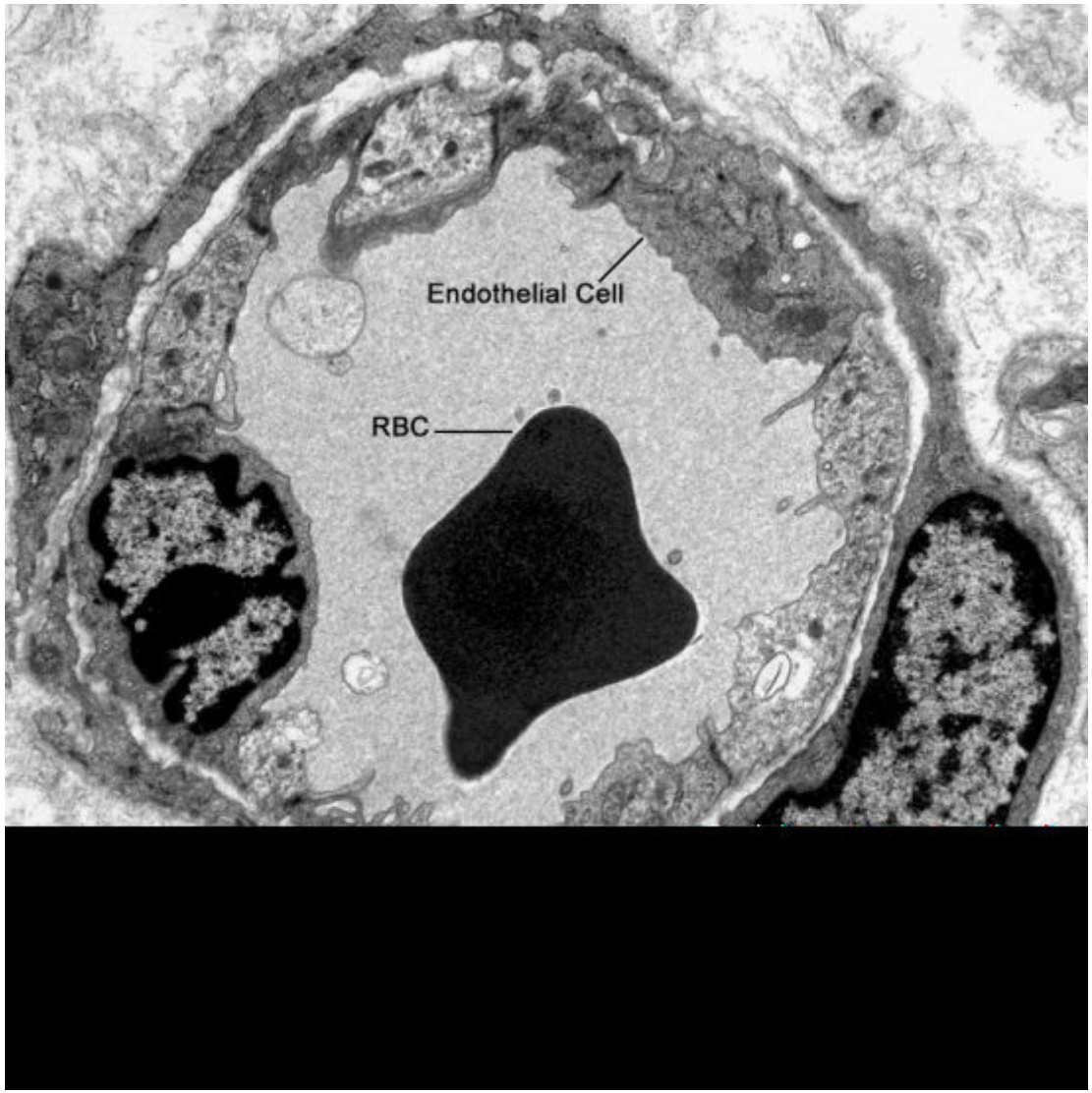
Arterioles (diameter of 0.3 mm or less)

- smallest arteries; lead to capillary beds.
- close to capillaries - single layer of muscle spiralling around the endothelial lining
- regulates blood flow to capillary




endothelium
lumen
smooth muscle
nerve
collagen

Capillary



Types of Capillaries

- Continuous capillaries.
  - No gaps between endothelial cells.
  - Adjacent cells held together with tight junctions. Less permeable to large molecules than other capillary types.
  - Capillaries found in muscle, nervous tissue, adipose tissue
- Fenestrated capillaries
  - Have pores (fenestrae).
  - Highly permeable.
  - Found in intestinal villi, ciliary process of eye, choroid plexus, glomeruli of kidney
- Sinusoids capillaries.
  - Large diameter fenestrated capillaries
  - Very leaky with large lumens. E.g.,
  - Blood flows sluggishly, allowing for modification in various ways
  - Found liver, bone marrow, lymphoid tissue and some endocrine organs.
  - Venous sinuses are similar in structure but even larger. E.g., spleen

Structure of Capillary Walls

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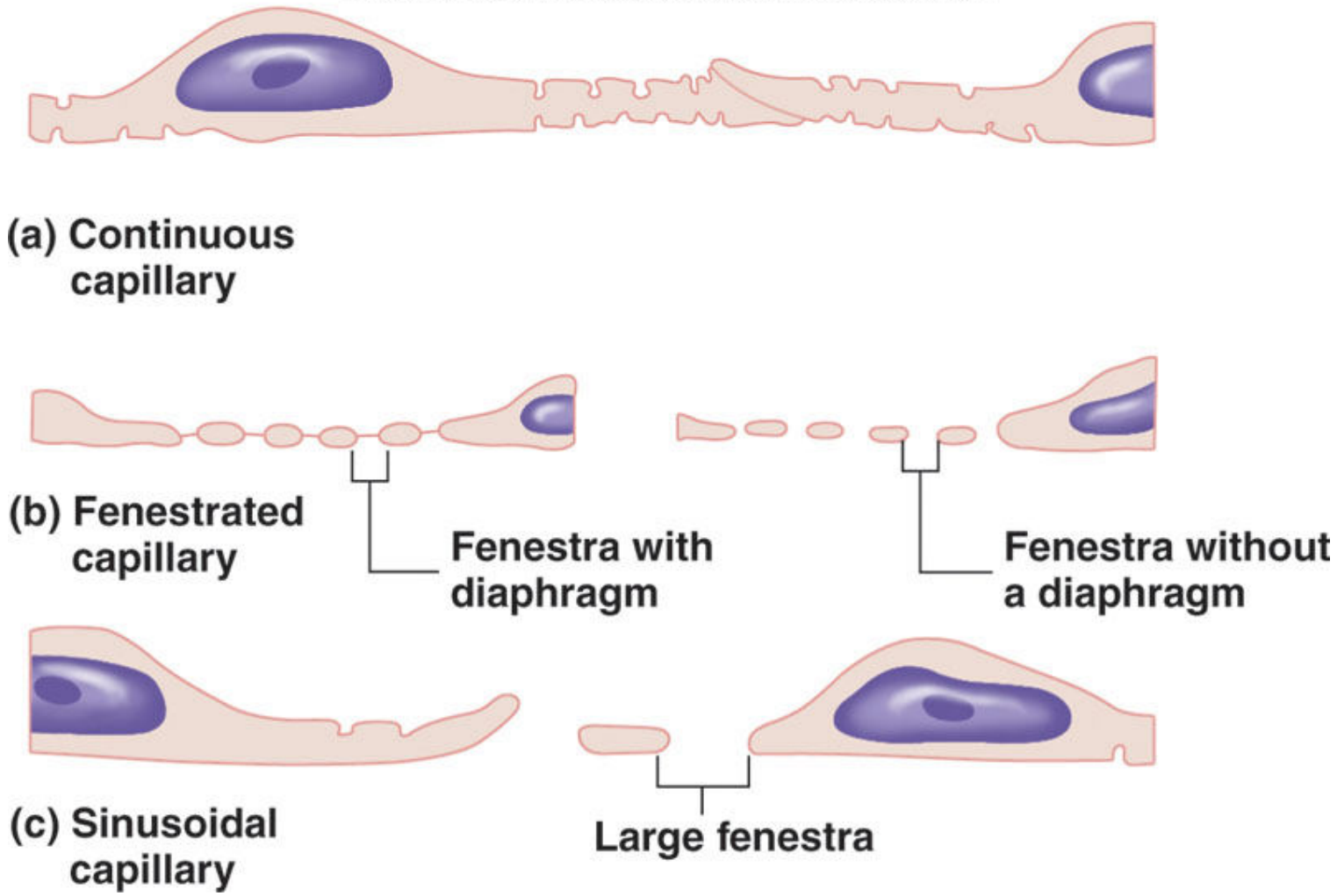


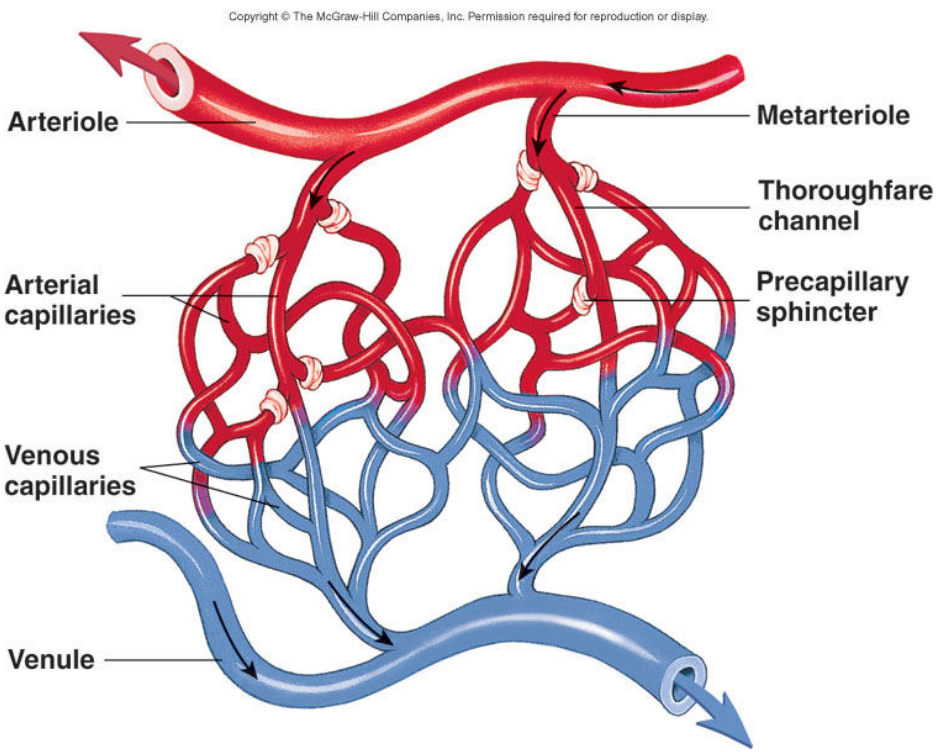
Capillary Beds

- A microcirculation of interwoven networks of capillaries, consisting of:
  - Vascular shunts – metarteriole–thoroughfare channel connecting an arteriole directly with a postcapillary venule
  - True capillaries – 10 to 100 per capillary bed, capillaries branch off the metarteriole and return to the thoroughfare channel at the distal end of the bed

Blood Flow Through Capillary Beds

- Precapillary sphincter
  - Cuff of smooth muscle that surrounds each true capillary
  - Regulates blood flow into the capillary
- Blood flow is regulated by vasomotor nerves and local chemical conditions, so it can either bypass or flood the capillary bed

Capillary Network



- Blood flows from arterioles through **metarterioles**, then through capillary network
- Flow through **thoroughfare channel** fairly consistent while flow through arterial capillaries is intermittent
- Smooth muscle in arterioles, metarterioles, precapillary sphincters regulates blood flow

Structure of Capillary Walls

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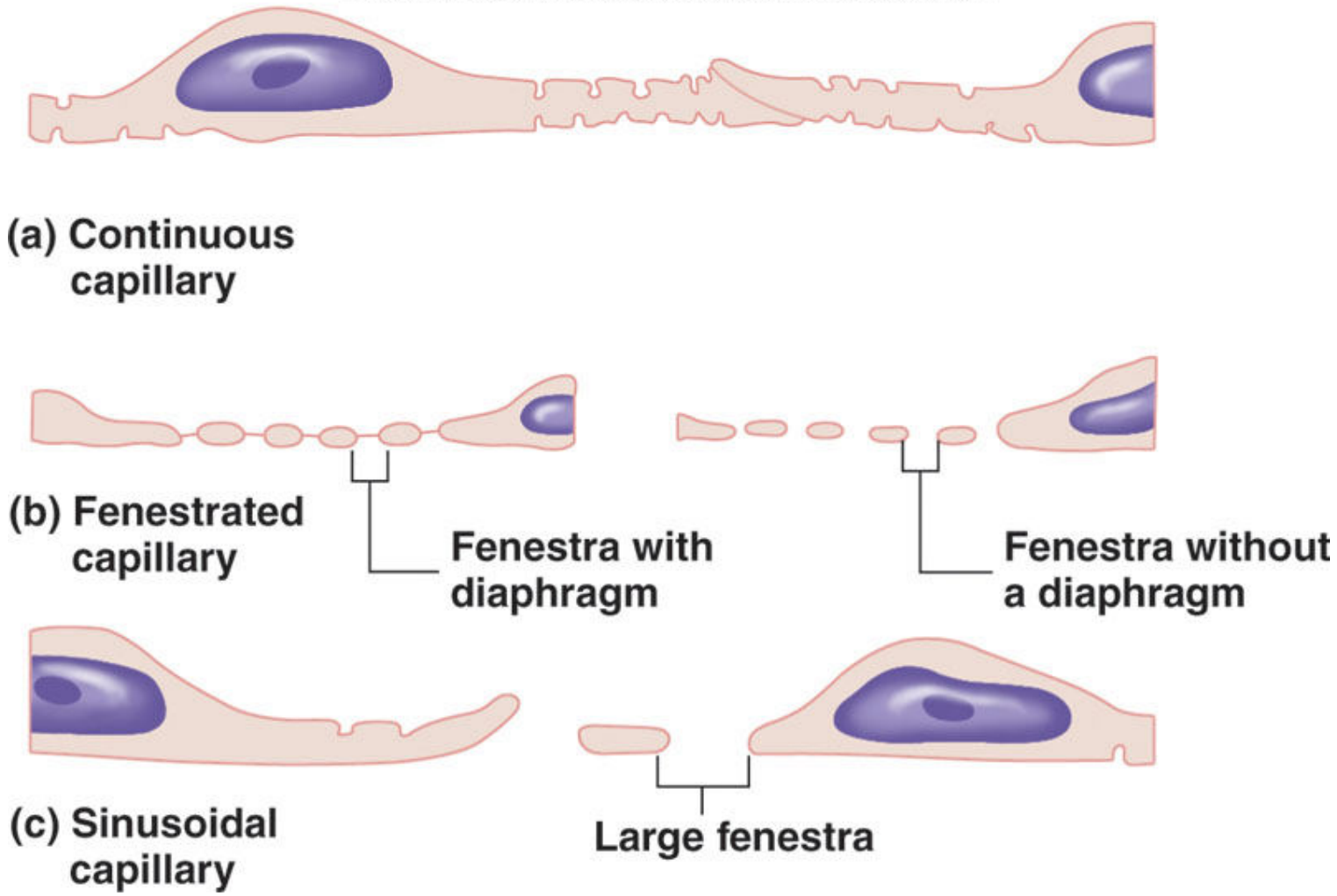


Sinusoids

- Resemble fenestrated capillaries, yet
  1. irregular shapes
  2. have longer pores
  3. thinner (or no) basement membranes
- Blood movement very slow
- Found in the liver, heart, etc. sometimes called sinusoidal capillary.

Venules and Small Veins

- Venules drain capillary network
  - Endothelial cells and basement membrane with a few smooth muscle cells.
  - As diameter of venules increases, amount of smooth muscle increases.
- Small veins. Smooth muscle cells form a continuous layer. Addition of tunica adventitia made of collagenous connective tissue

Venous System: Venules

- Are formed when capillary beds unite
  - Allow fluids and WBCs to pass from the bloodstream to tissues
- Postcapillary venules – smallest venules, composed of endothelium and a few pericytes
- Large venules have one or two layers of smooth muscle (tunica media)

Venules and Small Veins

Venules drain capillary network

- **Endothelial cells and basement membrane with a few smooth muscle cells.**
- **As diameter of venules increases, amount of smooth muscle increases.**

- **Small veins. Smooth muscle cells form a continuous layer. Addition of tunica adventitia made of collagenous connective tissue**

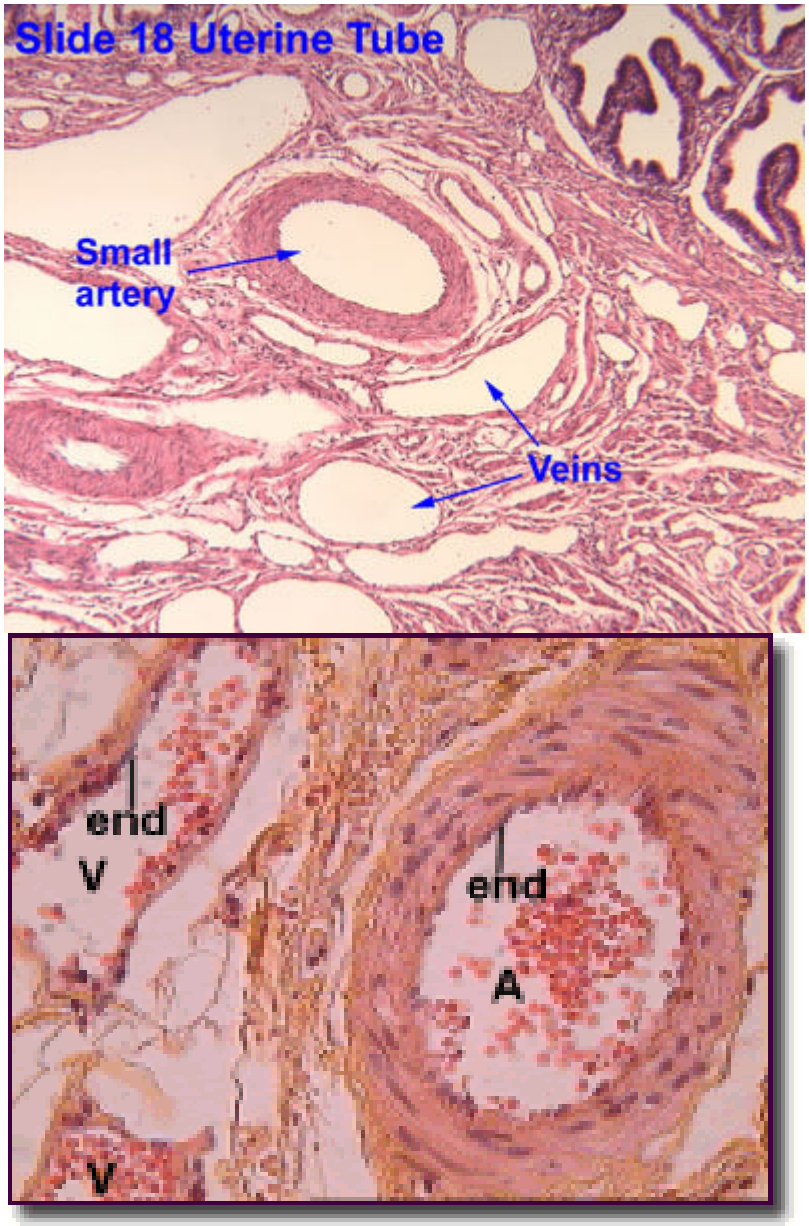


Fig. 24 Small artery and vein.

Veins and Venules (Contrasted to Arteries)

- Thinner walls
- Larger diameter
- Closer to skin
- Less muscle
- Less elastic

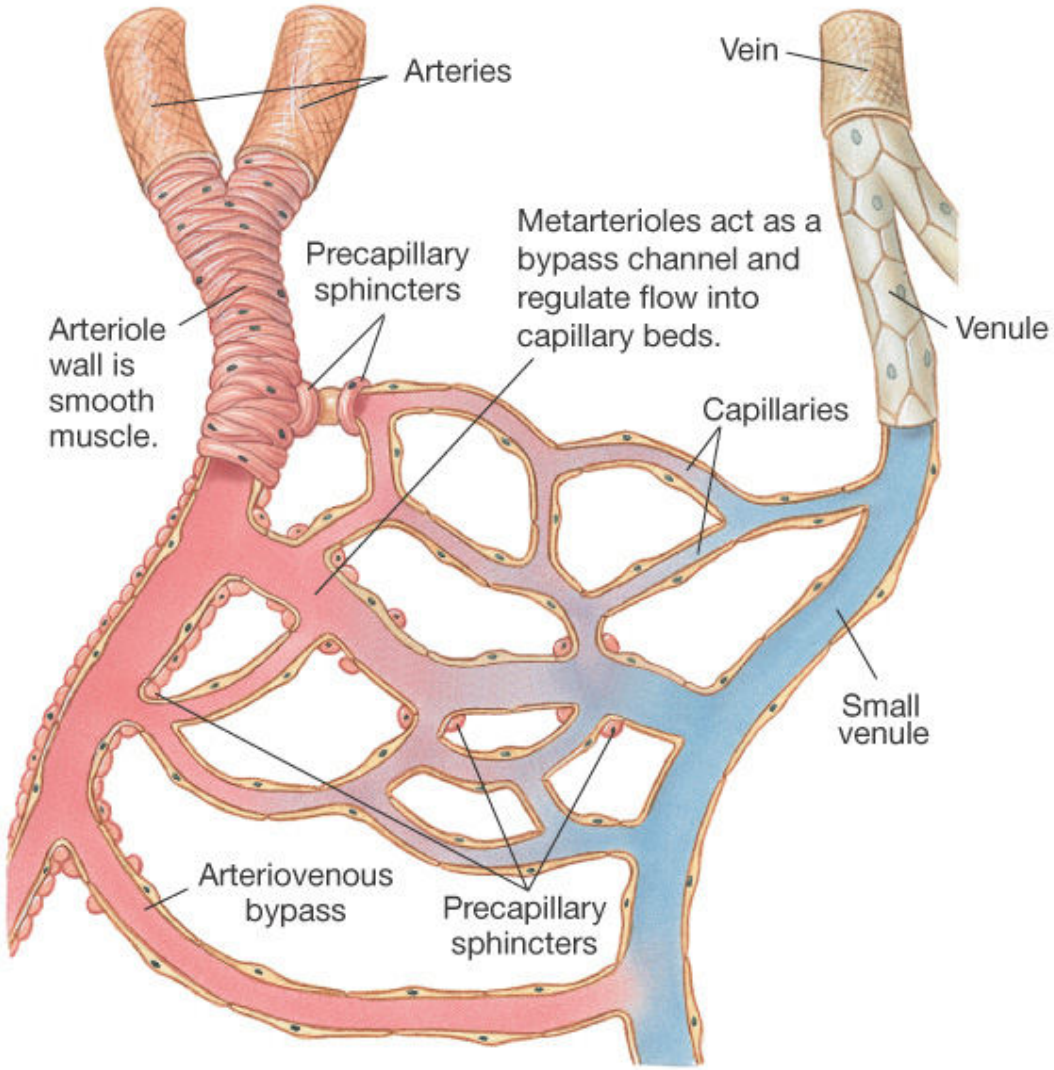
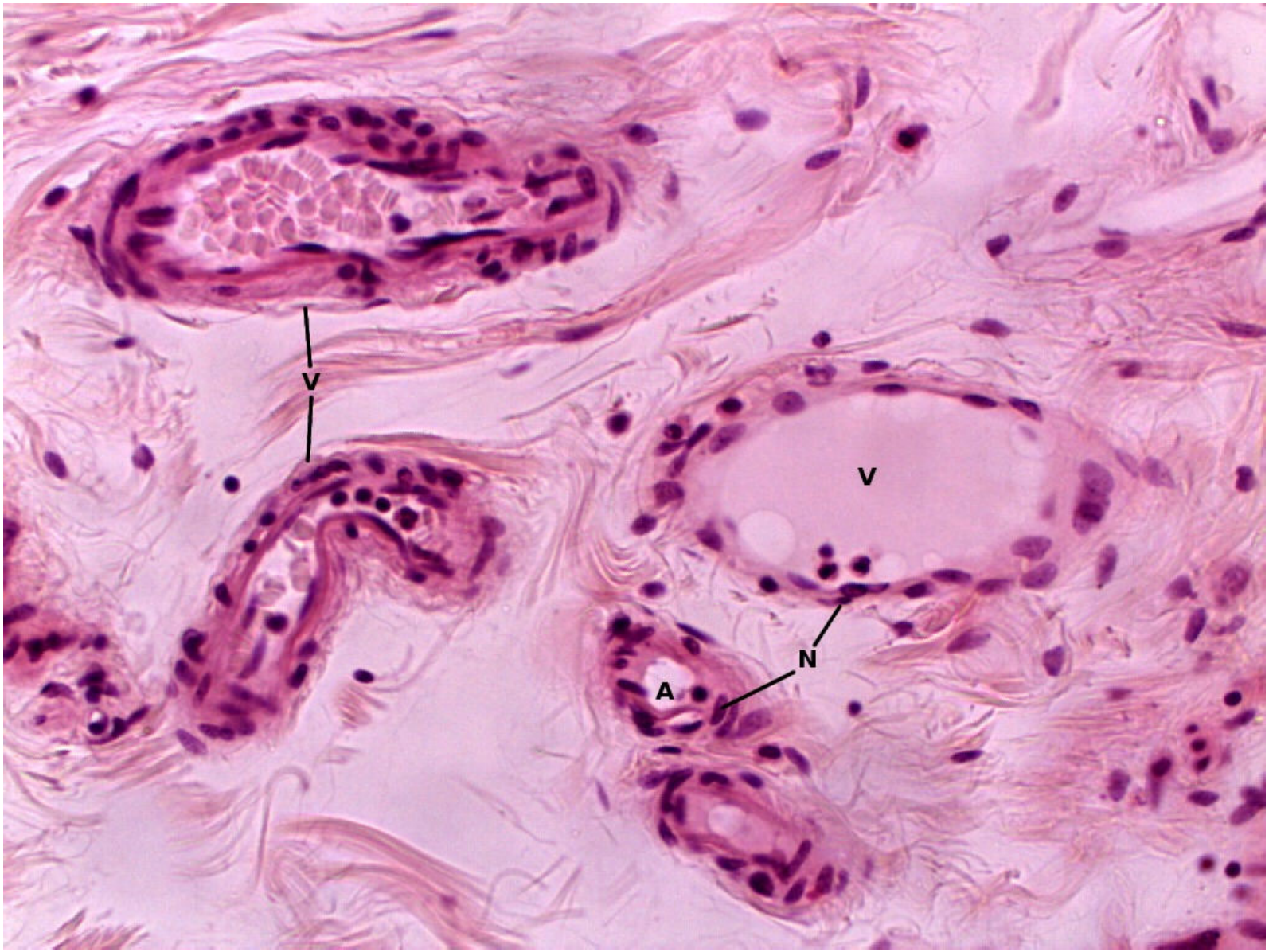


Figure 15-3: Metarterioles

Venules In Small Intestine



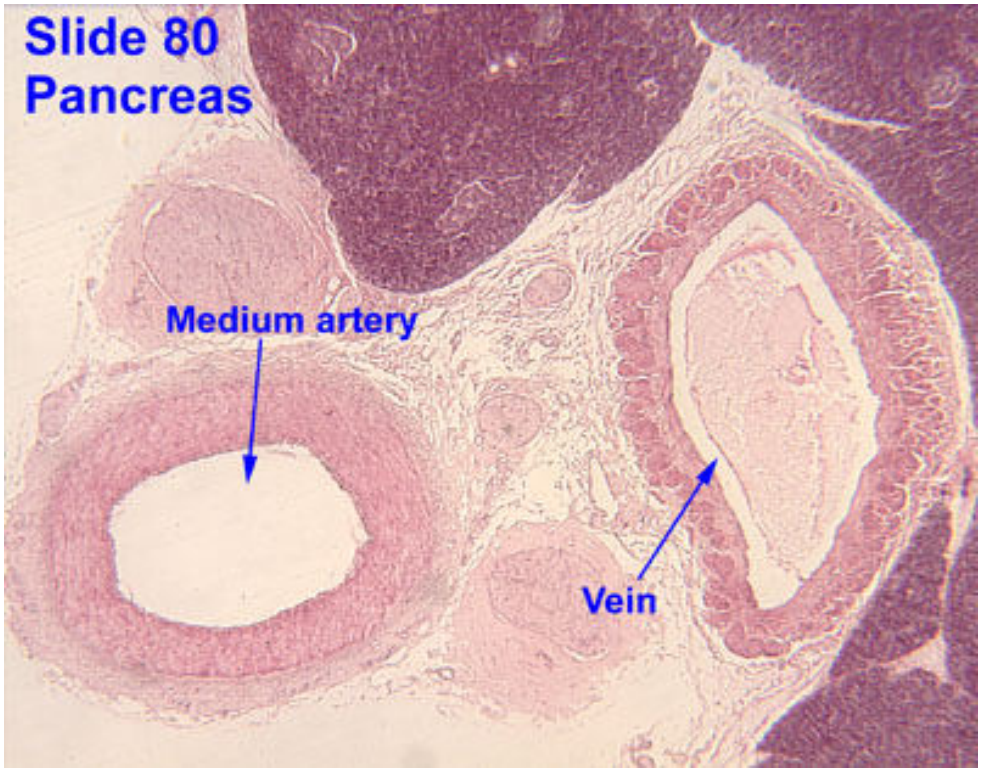
Venous System: Veins

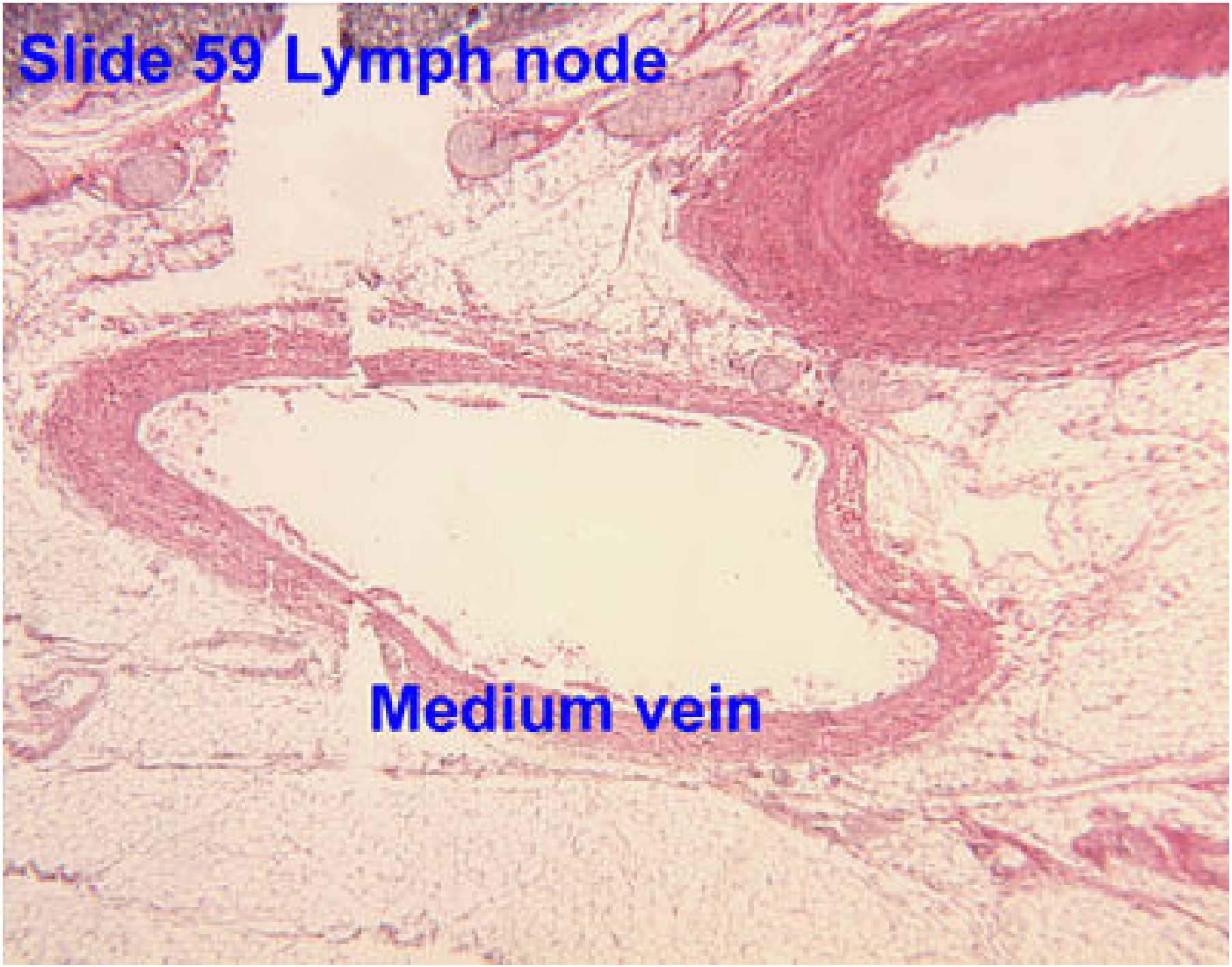
- **Veins are:**
  - **Formed when venules converge**
  - **Composed of three tunics, with a thin tunica media and a thick tunica externa consisting of collagen fibers and elastic networks**
  - **Capacitance vessels (blood reservoirs) that contain 65% of the blood supply**

Medium size veins

Medium size veins.

Veins in these locations have a well developed muscular adventitia (muscle cells are oriented longitudinally). This is also the typical structure of large veins such as the vena cava.




Slide 59 Lymph node
Medium vein

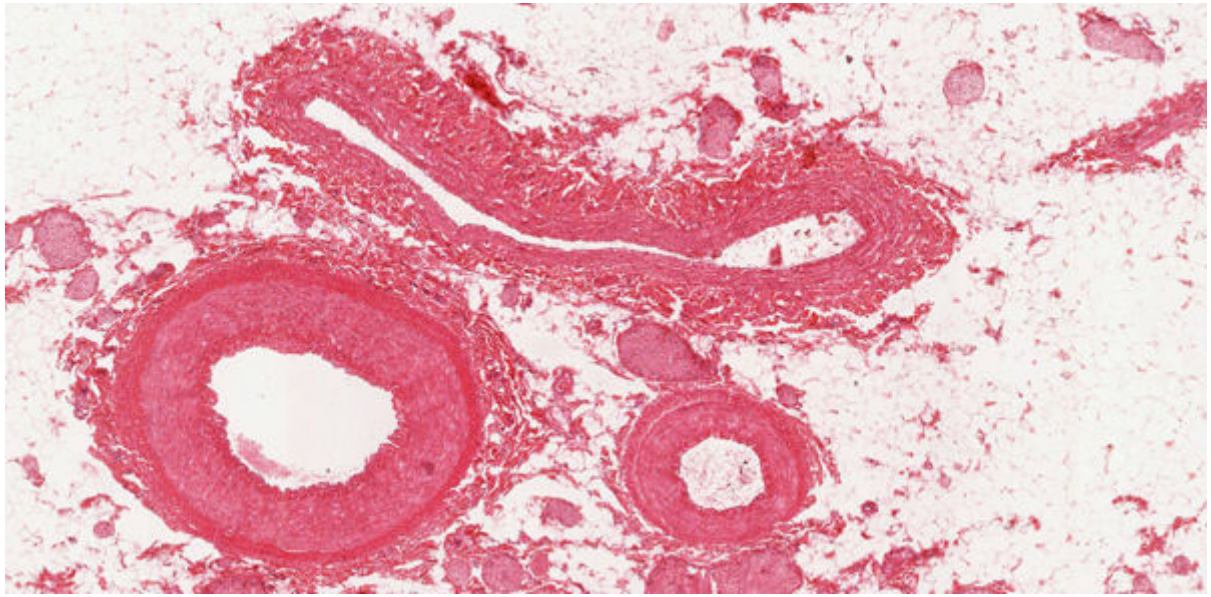
Veins

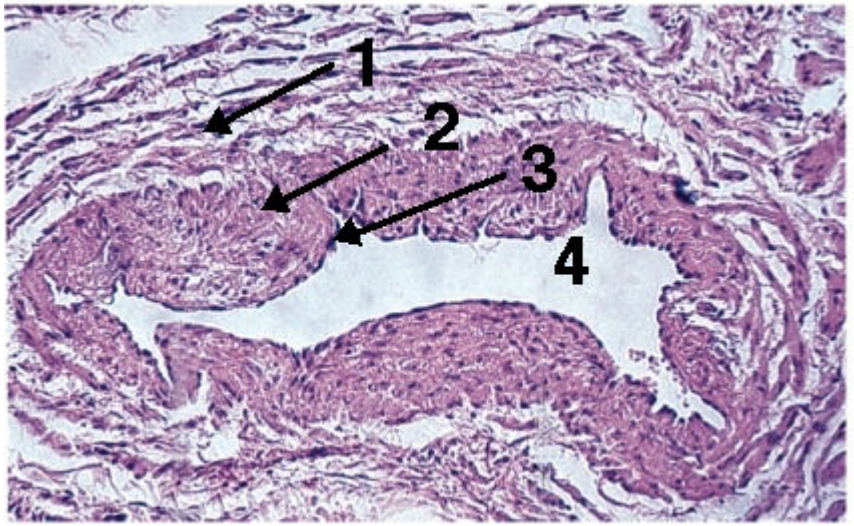
- Large veins.
  - Formed when venules converge
  - Composed of 3 tunics
    - Thin tunica media with circularly arranged smooth muscle cells.
    - Thick tunica externa consisting of collagen fibers and elastic networks
  - Capacitance vessels (blood reservoirs) that contain about 65% of the blood supply

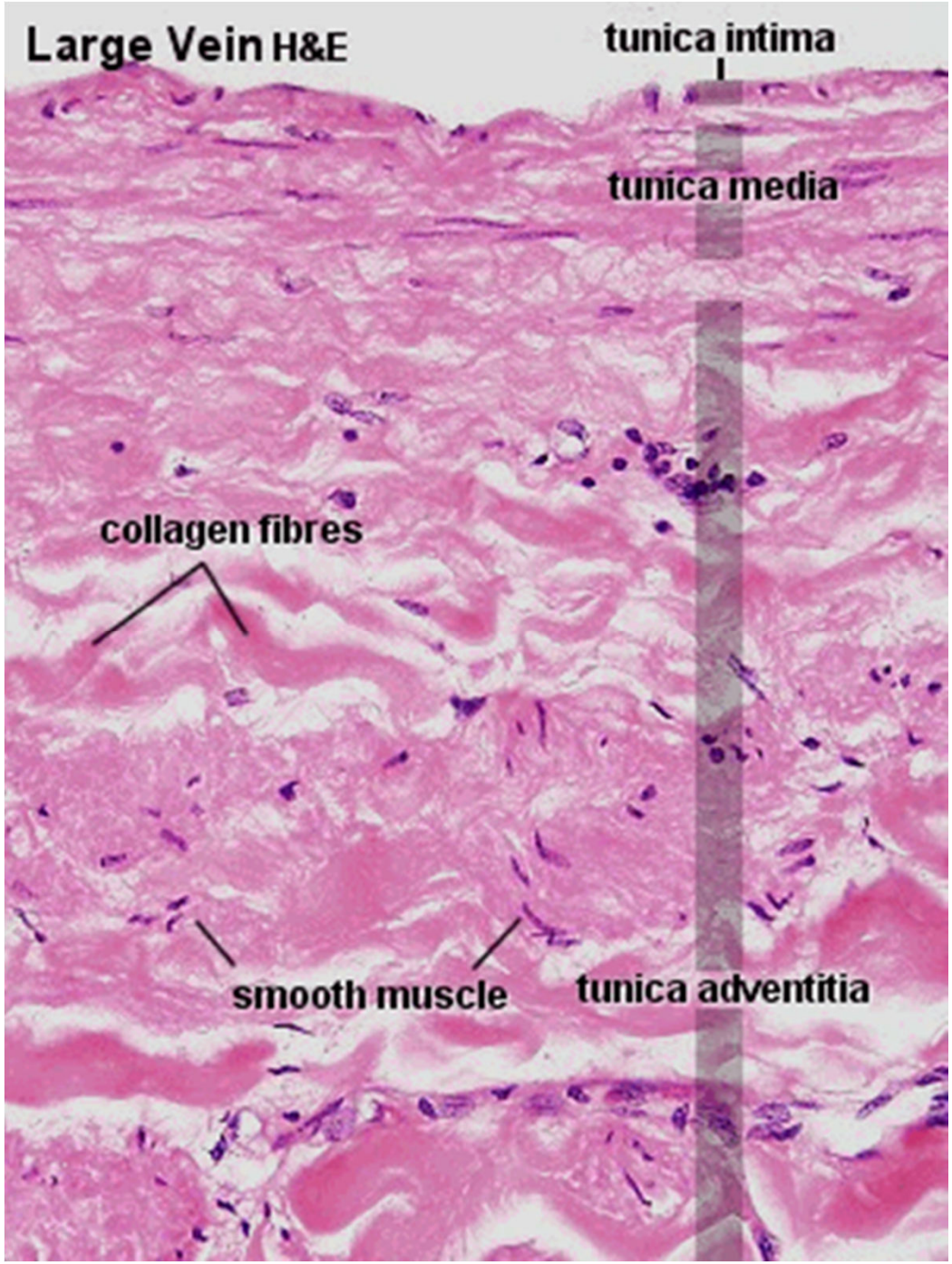
Large Veins

Large veins.

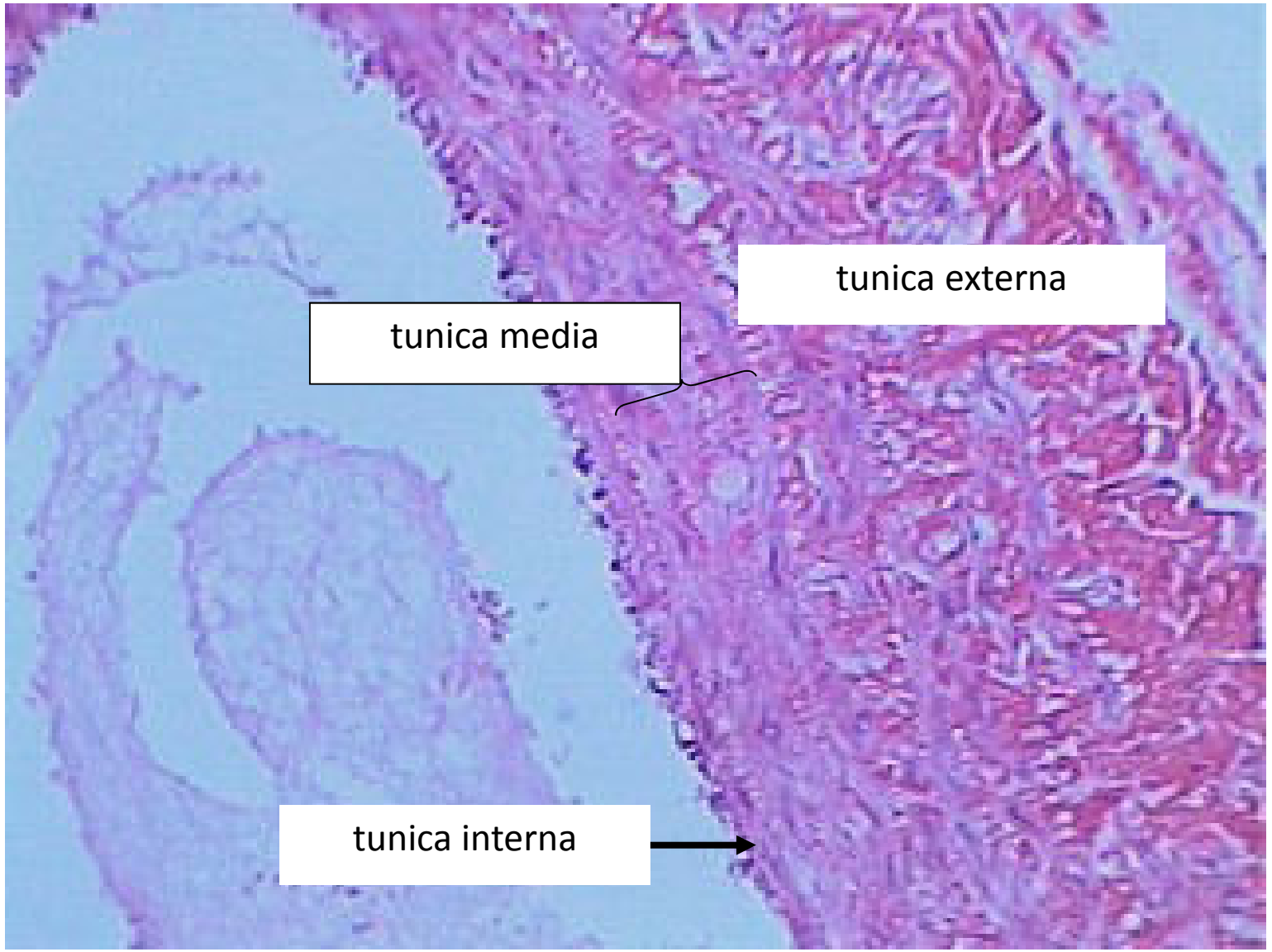
- **Formed when venules converge**
- **Composed of 3 tunics**
  - **Thin tunica media with circularly arranged smooth muscle cells.**
  - **Thick tunica externa consisting of collagen fibers and elastic networks**
- **Capacitance vessels (blood reservoirs) that contain about 65% of the blood supply**






Large Vein H&E
tunica intima
tunica media
collagen fibres
smooth muscle
tunica adventitia

* Vein 400X



Venous System: Valves

- Veins have much lower blood pressure and thinner walls than arteries
- To return blood to the heart, veins have special adaptations
  - Large-diameter lumens, which offer little resistance to flow
  - Valves (resembling semilunar heart valves), which prevent backflow of blood
- Venous sinuses – specialized, flattened veins with extremely thin walls (e.g., coronary sinus of the heart and dural sinuses of the brain)

Normal Vein with Correctly Working Valves and Blood Flow

Valves open to allow blood to move up towards the heart and then close, preventing blood from flowing back down the leg again.

Varicose Vein with Abnormal Vein Valves and Blood Flow

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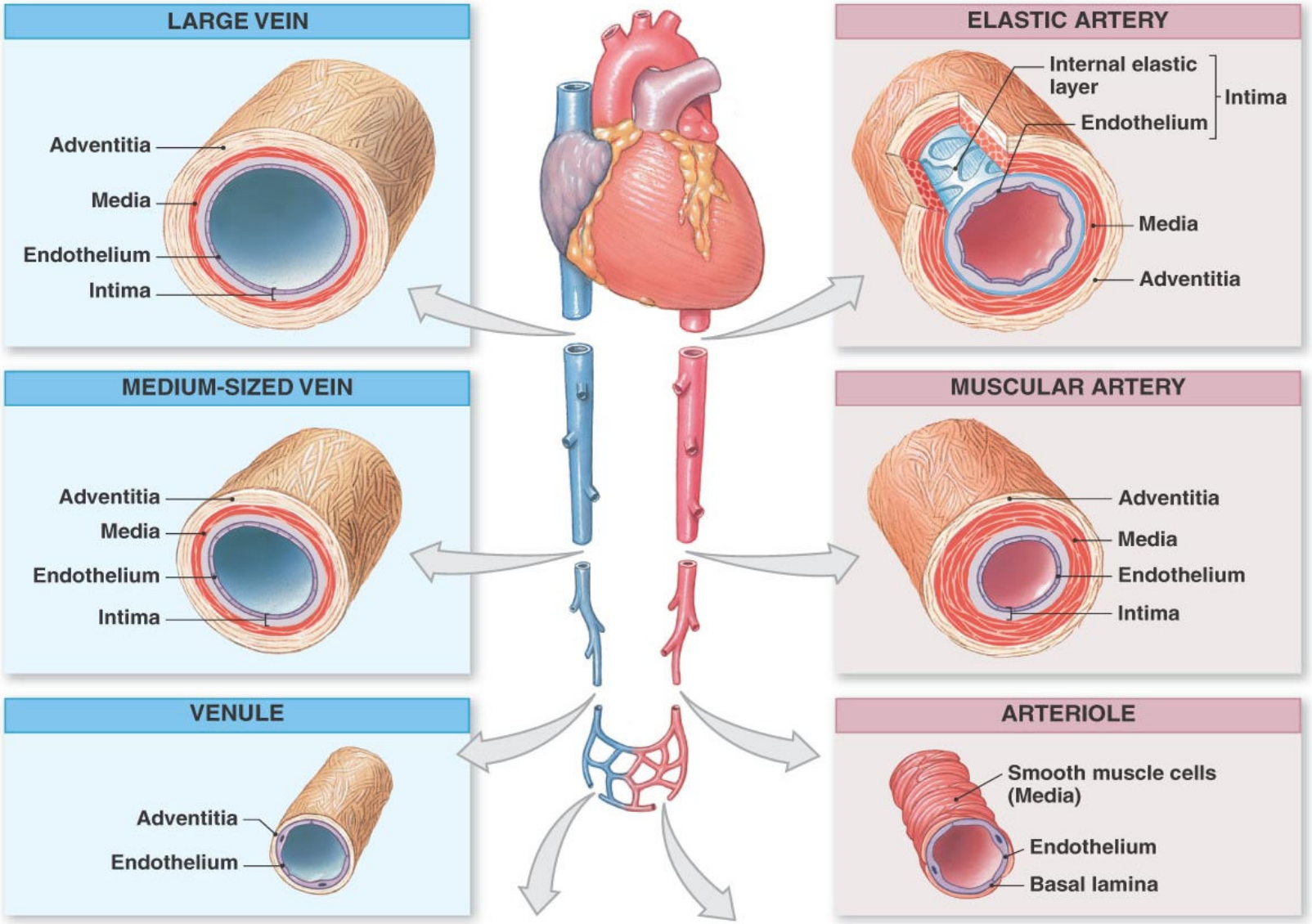
Damaged valves allow blood to flow backwards down the leg.



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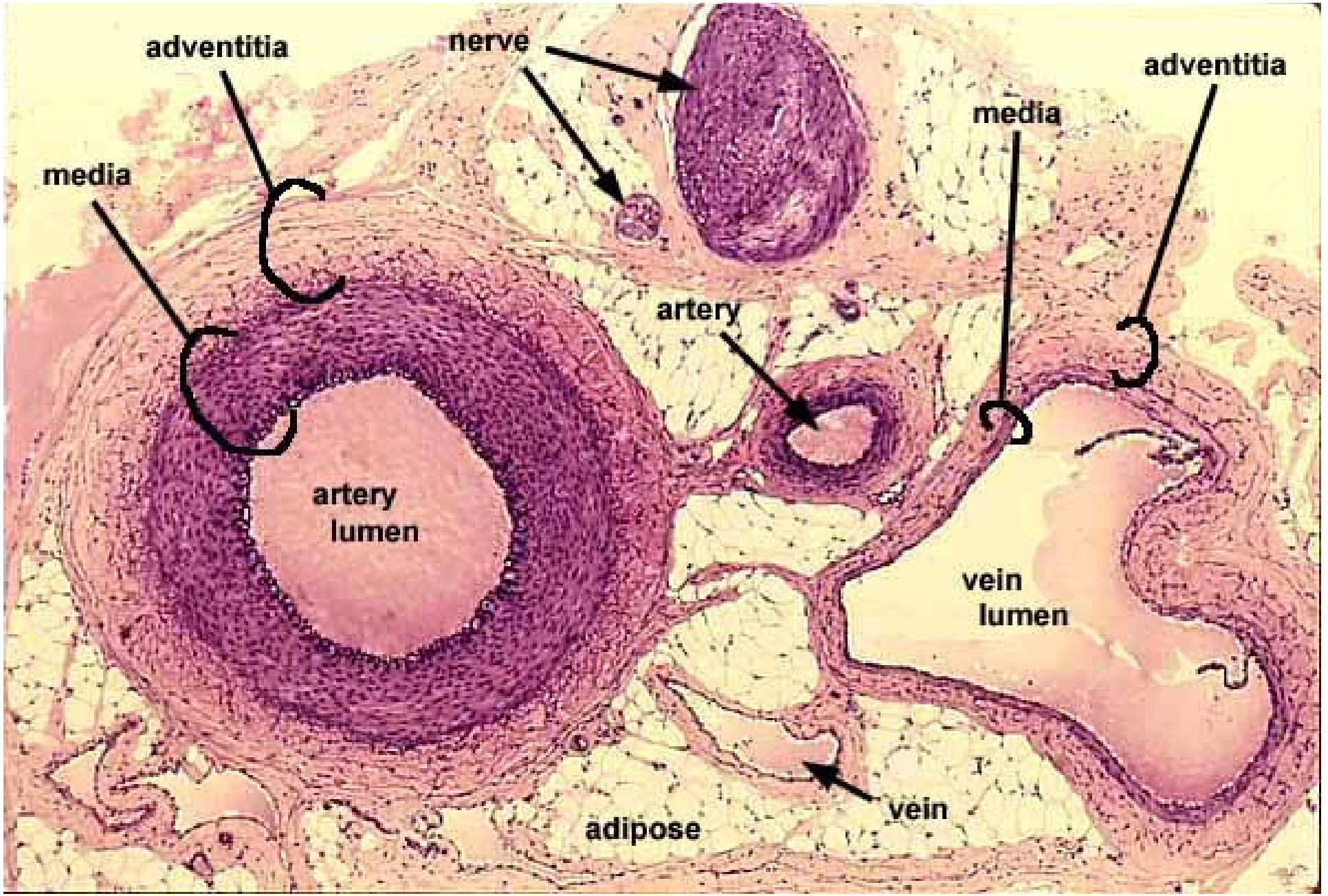
adventitia
nerve
adventitia
media
media
artery
artery
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vein
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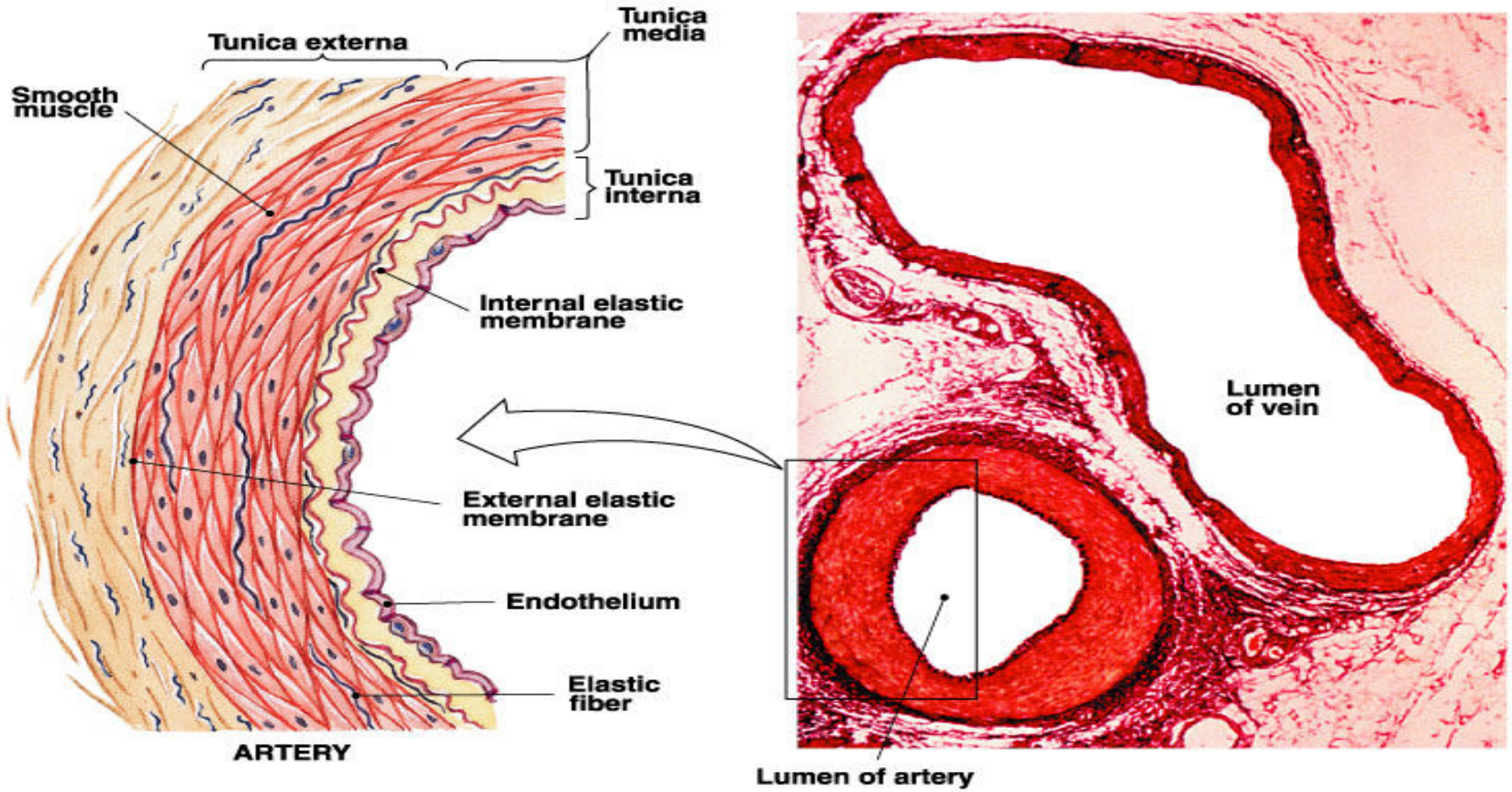
adipose

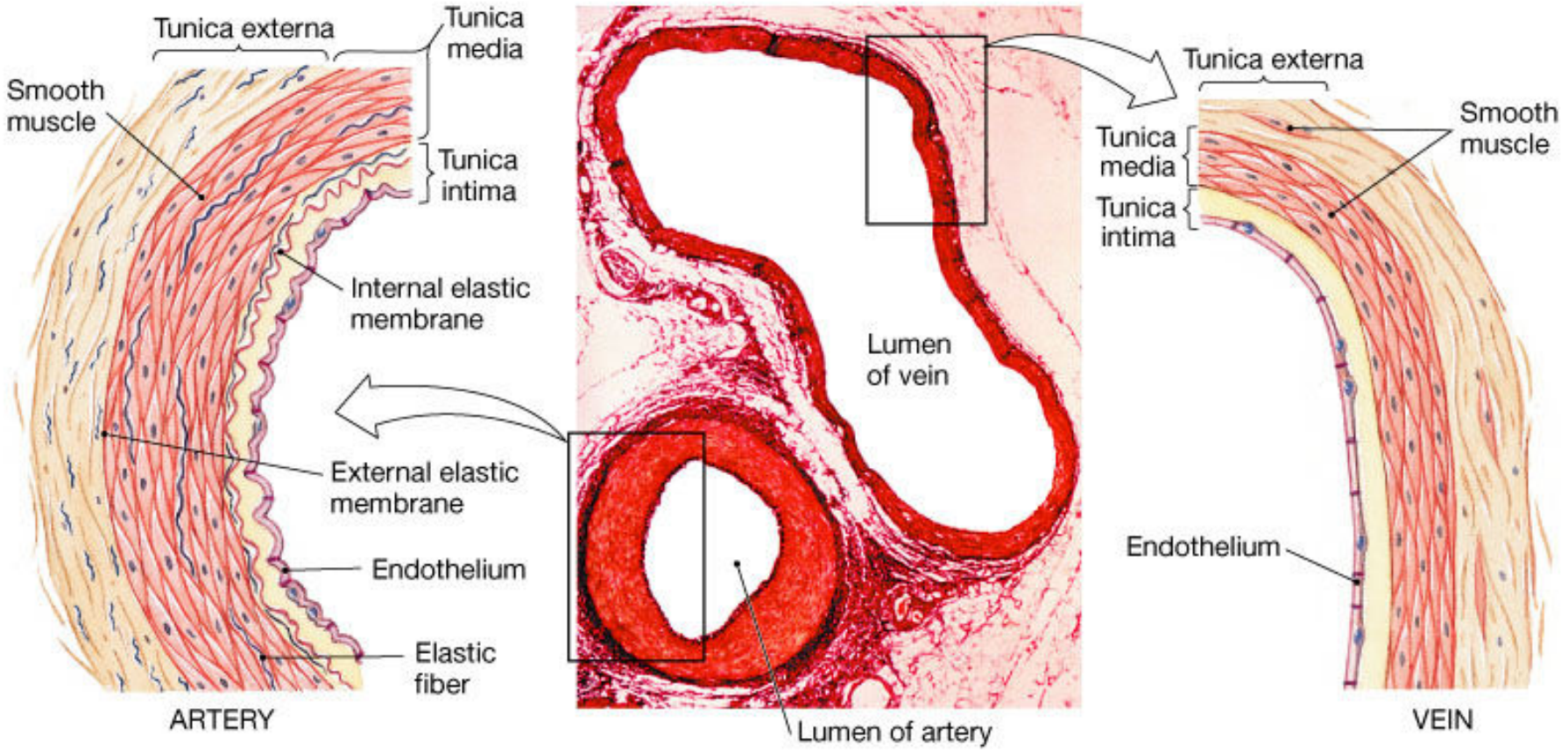
Comparison of Veins and Arteries



Arteries:

Veins:

Artery Vs veins



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