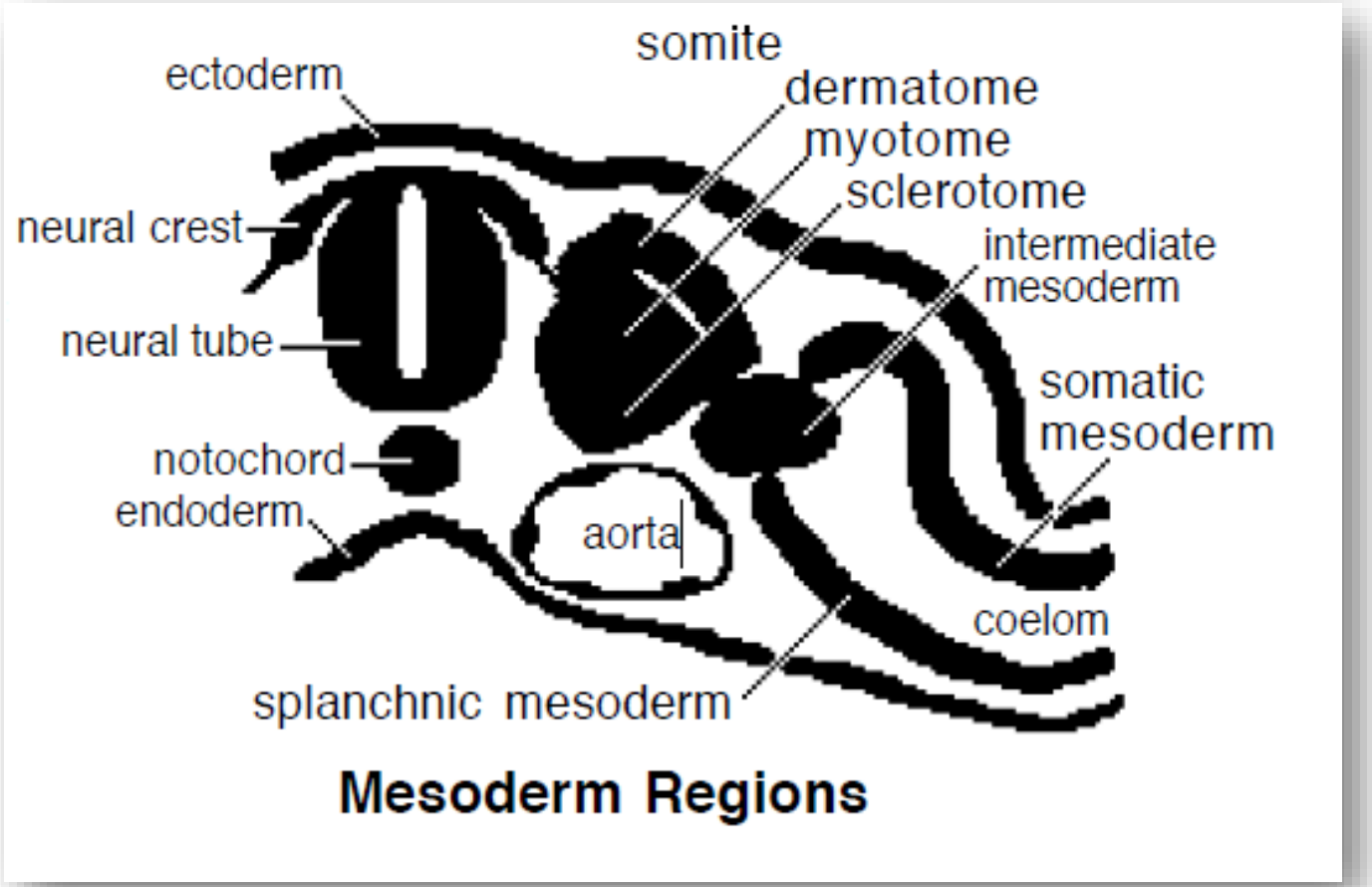
In the name of Allah

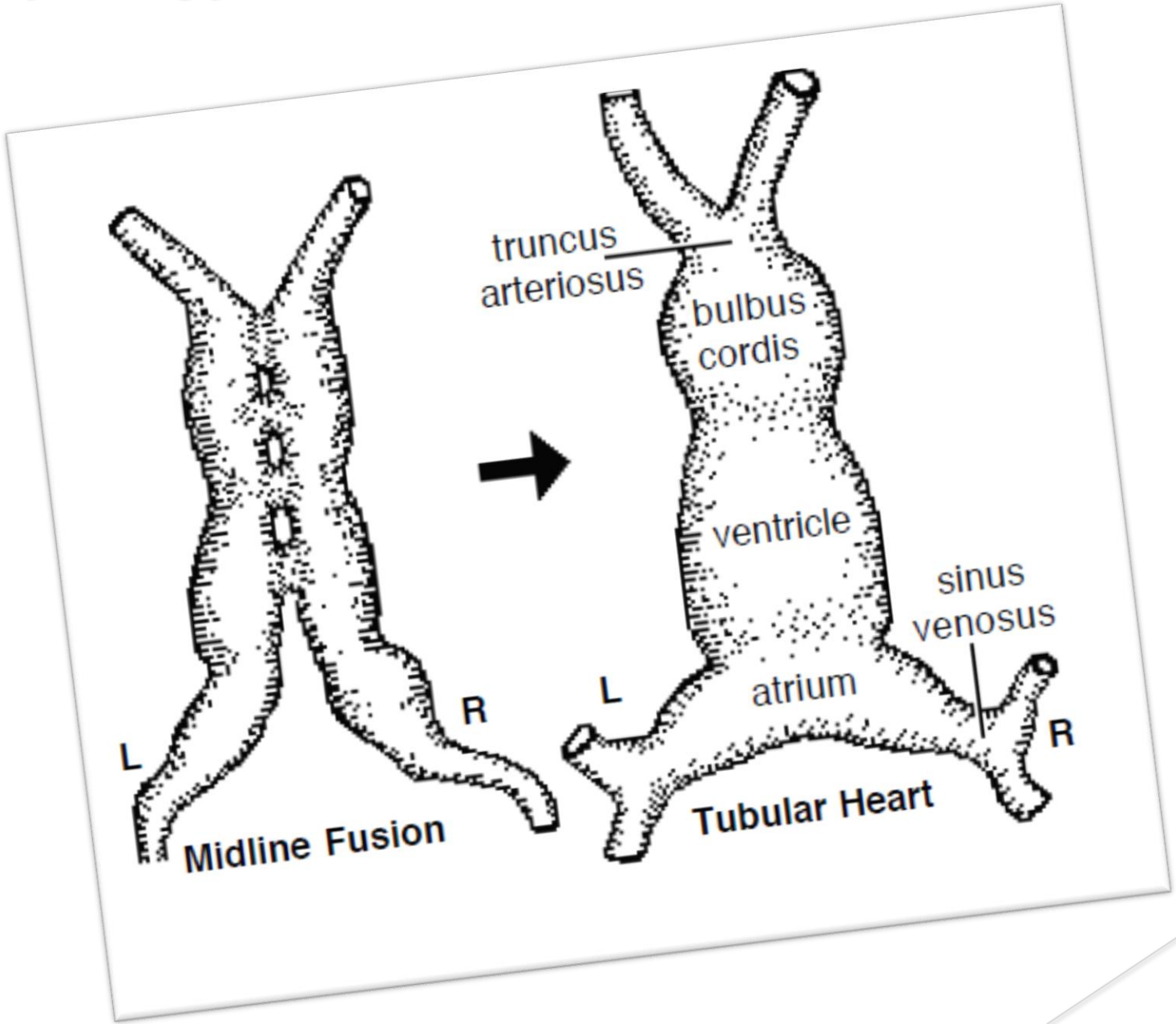
Histology of cardiovascular system

Embryology

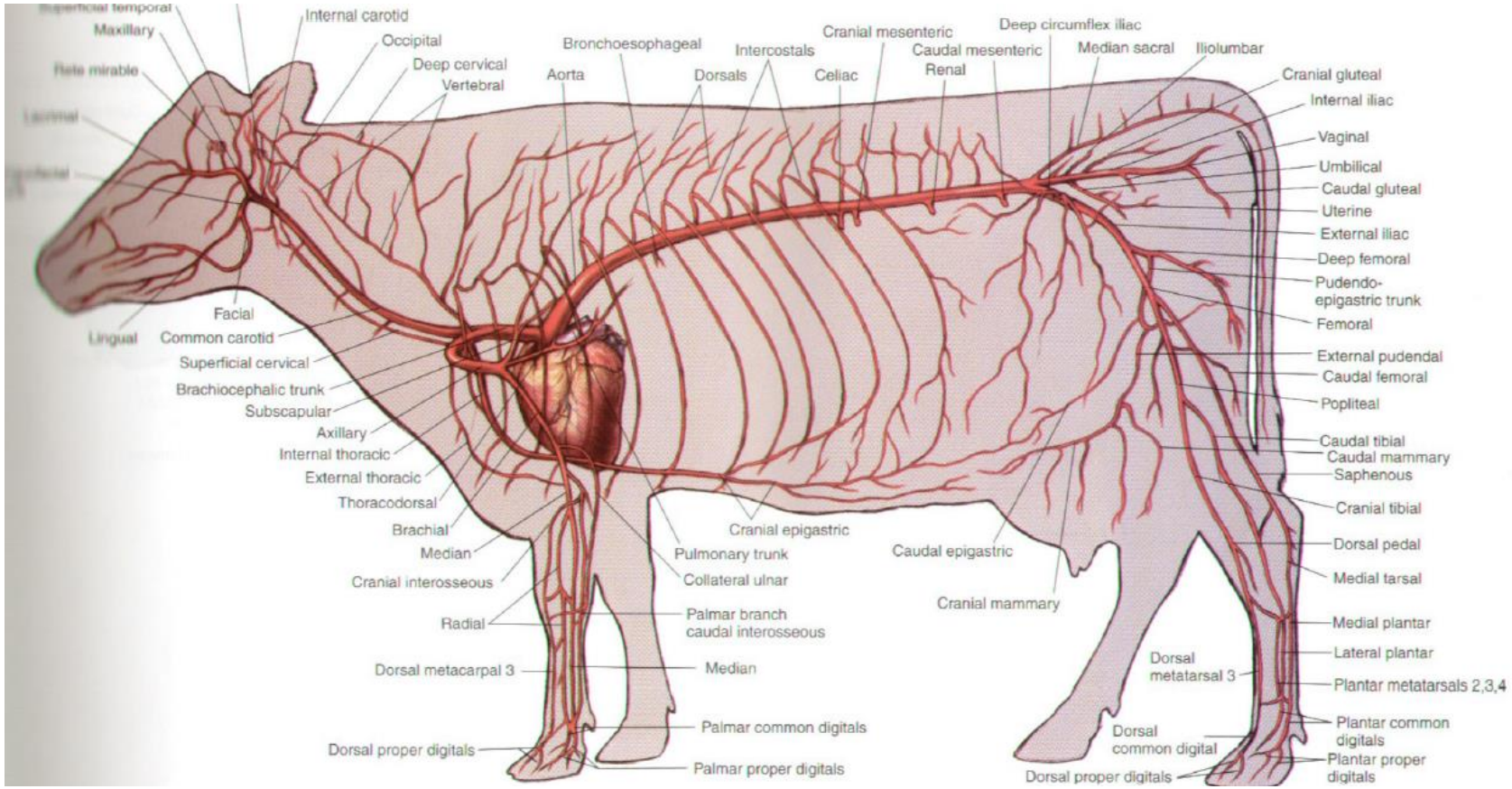


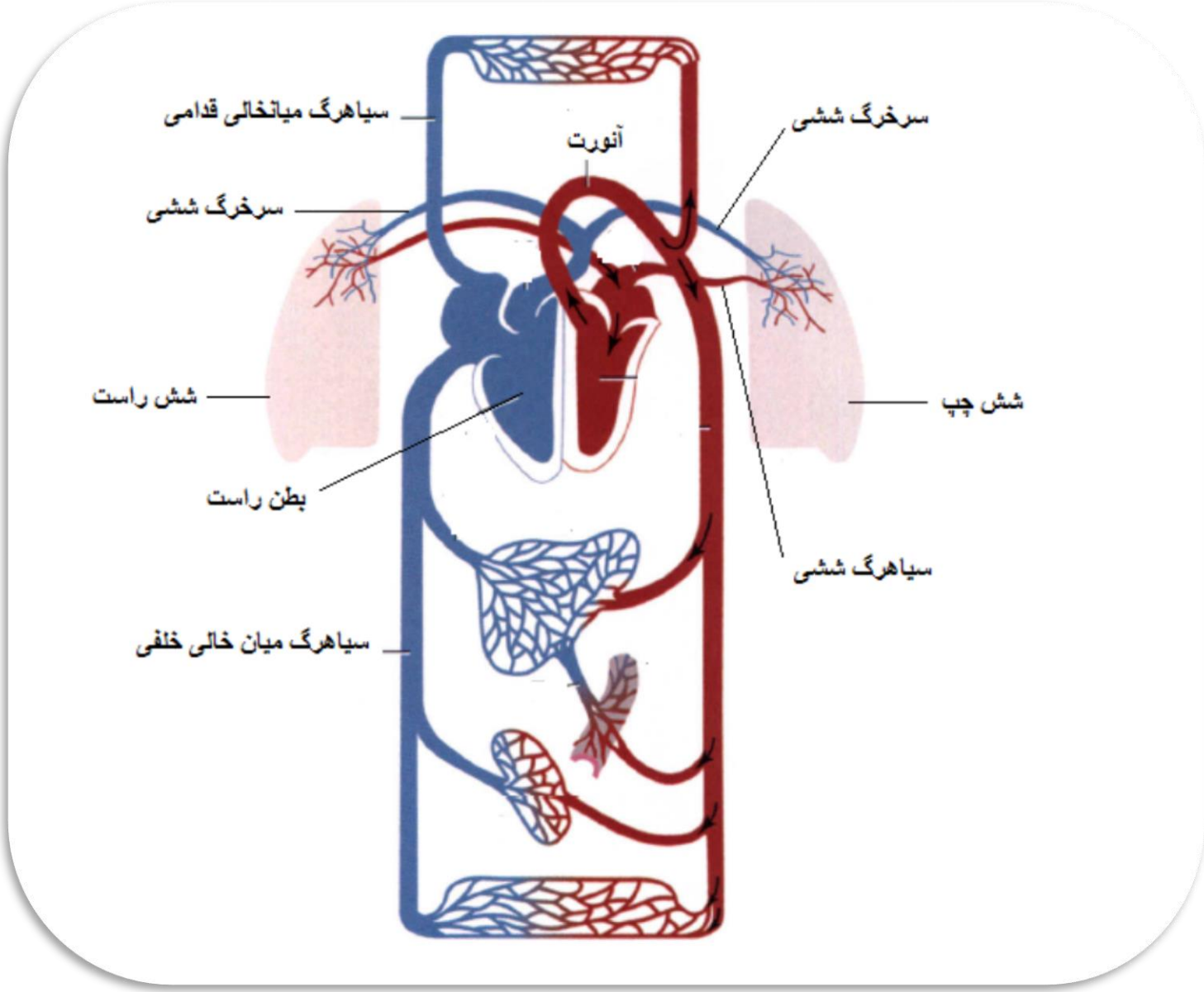
Mesoderm Regions

Embryology

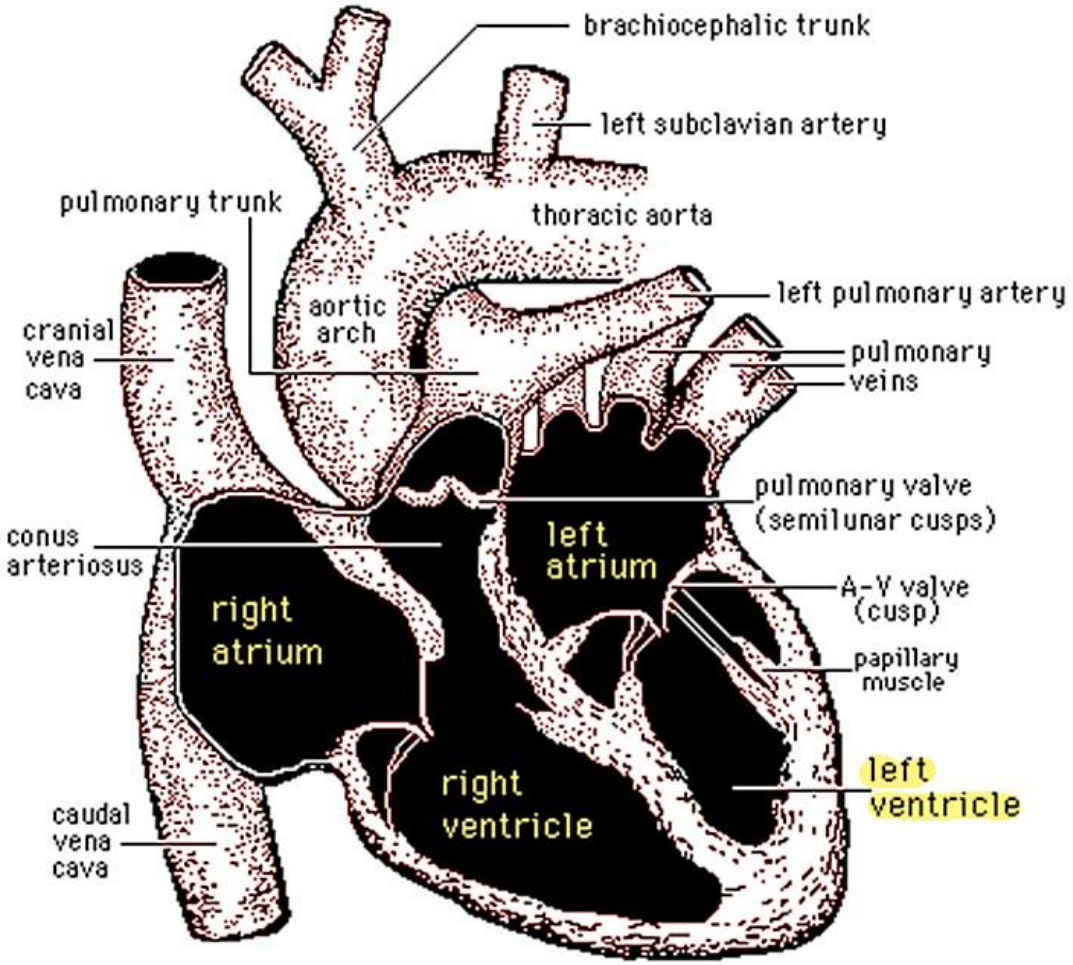

truncus
arteriosus
bulbus
cordis
ventricle
sinus
venosus
atrium
L
R
L
R
Midline Fusion
Tubular Heart

Anatomy

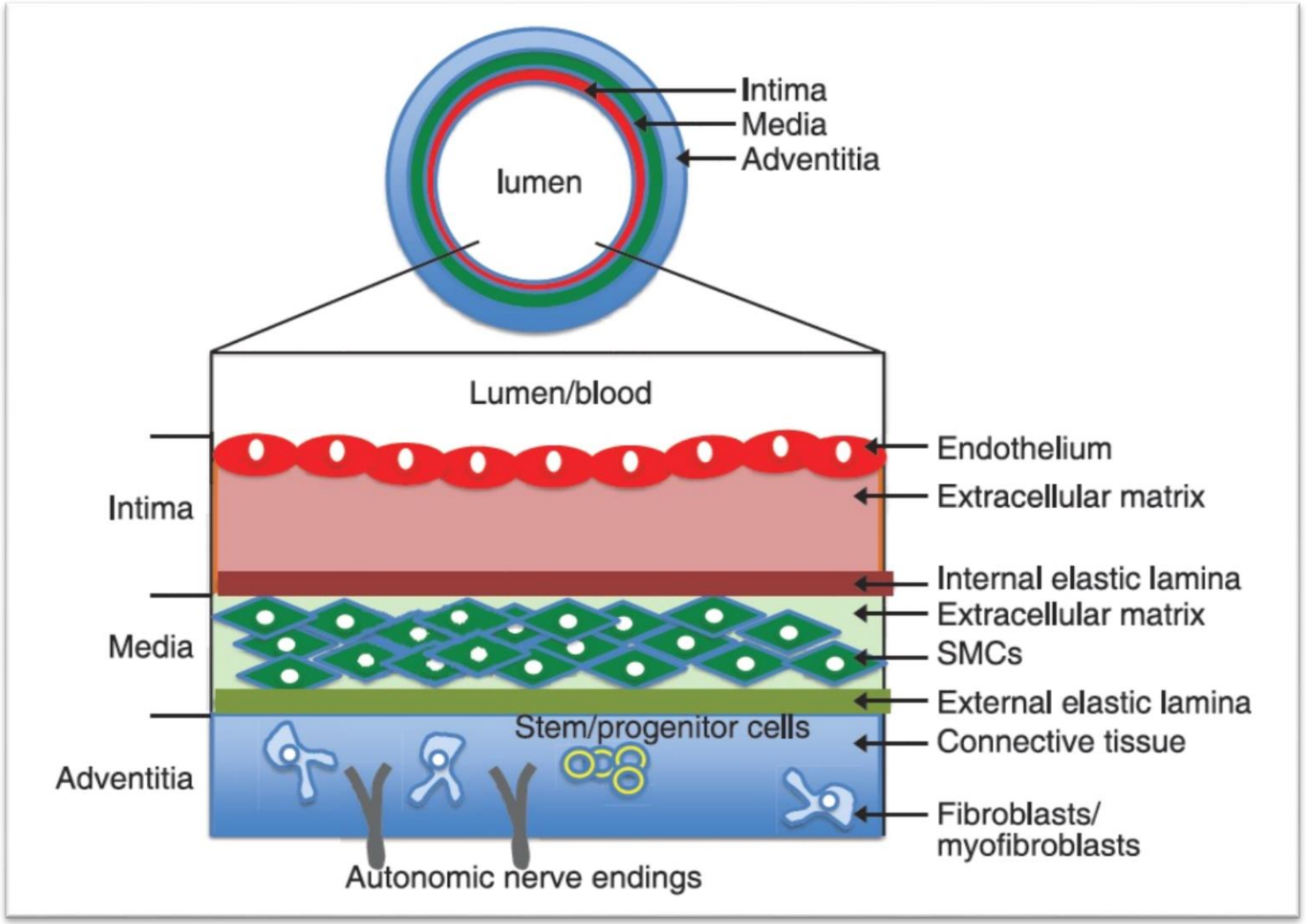

Maxillary
Internal carotid
Occipital
Deep cervical
Vertebral
Bronchoesophageal
Aorta
Intercostals
Dorsals
Cranial mesenteric
Celiac
Caudal mesenteric
Renal
Deep circumflex iliac
Median sacral
Iliolumbar
Cranial gluteal
Internal iliac
Vaginal
Umbilical
Caudal gluteal
Uterine
External iliac
Deep femoral
Pudendo-epigastric trunk
Femoral
External pudendal
Caudal femoral
Popliteal
Caudal tibial
Caudal mammary
Saphenous
Cranial tibial
Dorsal pedal
Medial tarsal
Medial plantar
Lateral plantar
Plantar metatarsals 2,3,4
Plantar common digitals
Plantar proper digitals
Facial
Lingual
Common carotid
Superficial cervical
Brachiocephalic trunk
Subscapular
Axillary
Internal thoracic
External thoracic
Thoracodorsal
Brachial
Median
Cranial interosseous
Radial
Dorsal metacarpal 3
Dorsal proper digitals
Cranial epigastric
Pulmonary trunk
Collateral ulnar
Palmar branch caudal interosseous
Median
Palmar common digitals
Palmar proper digitals
Caudal epigastric
Cranial mammary
Dorsal metatarsal 3
Dorsal common digital
Dorsal proper digitals


سیاهرگ میانخالی قدامی
آنورت
سرخرگ ششی
سرخرگ ششی
شش راست
شش چپ
بطن راست
سیاهرگ ششی
سیاهرگ میان خالی خلفی

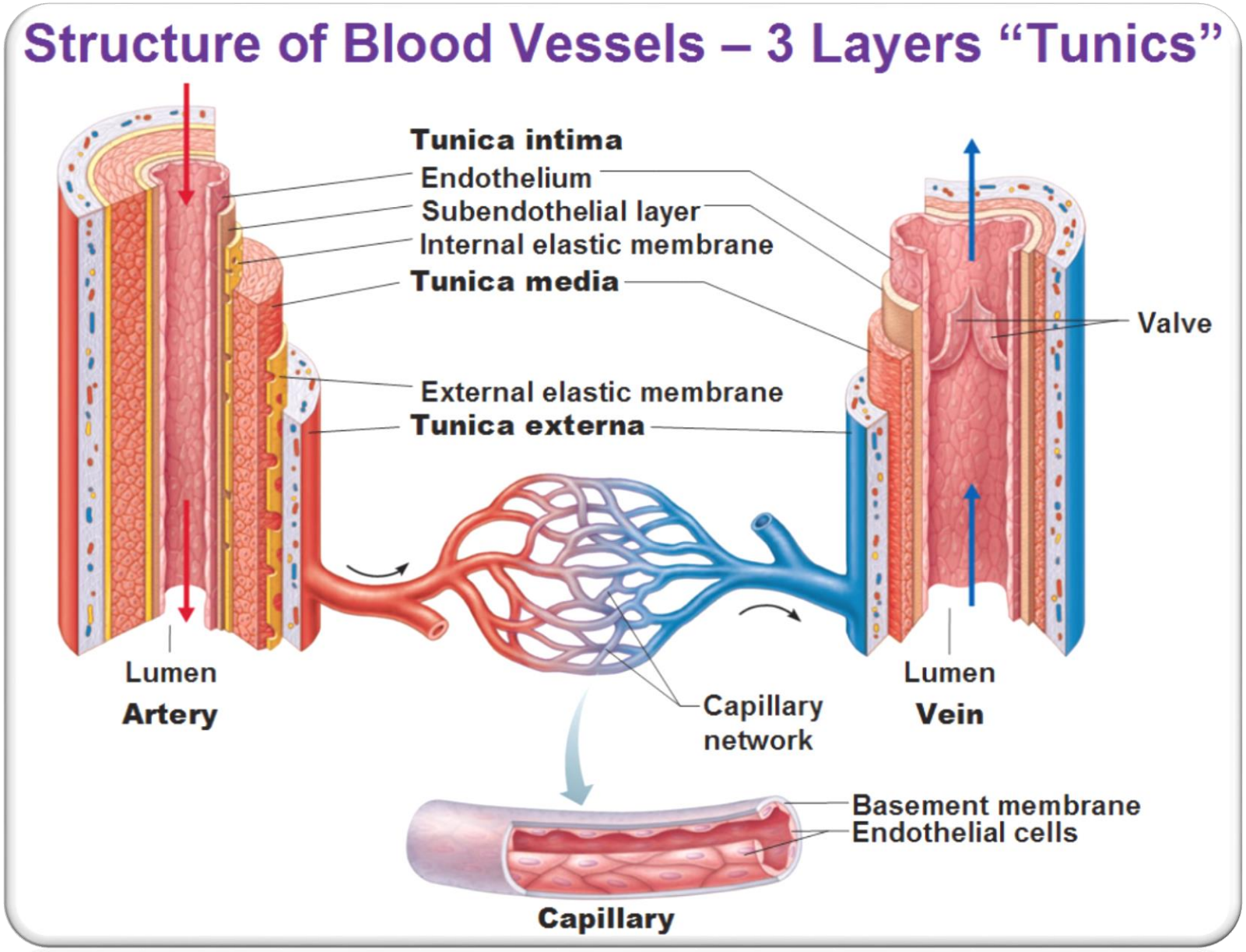
Anatomy

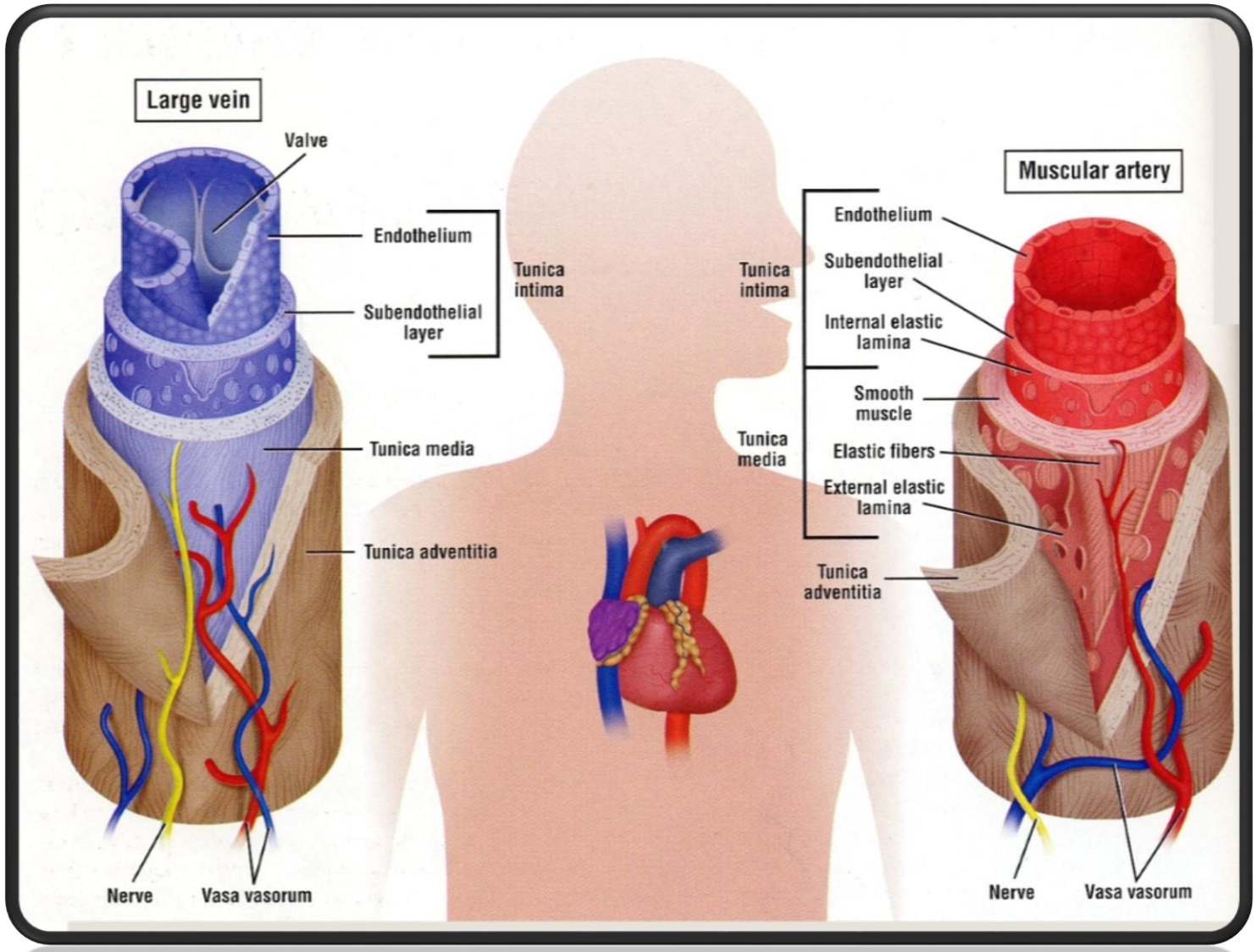

brachiocephalic trunk
left subclavian artery
pulmonary trunk
thoracic aorta
aortic arch
left pulmonary artery
cranial vena cava
pulmonary veins
pulmonary valve (semilunar cusps)
conus arteriosus
left atrium
A-V valve (cusp)
right atrium
papillary muscle
left ventricle
right ventricle
caudal vena cava

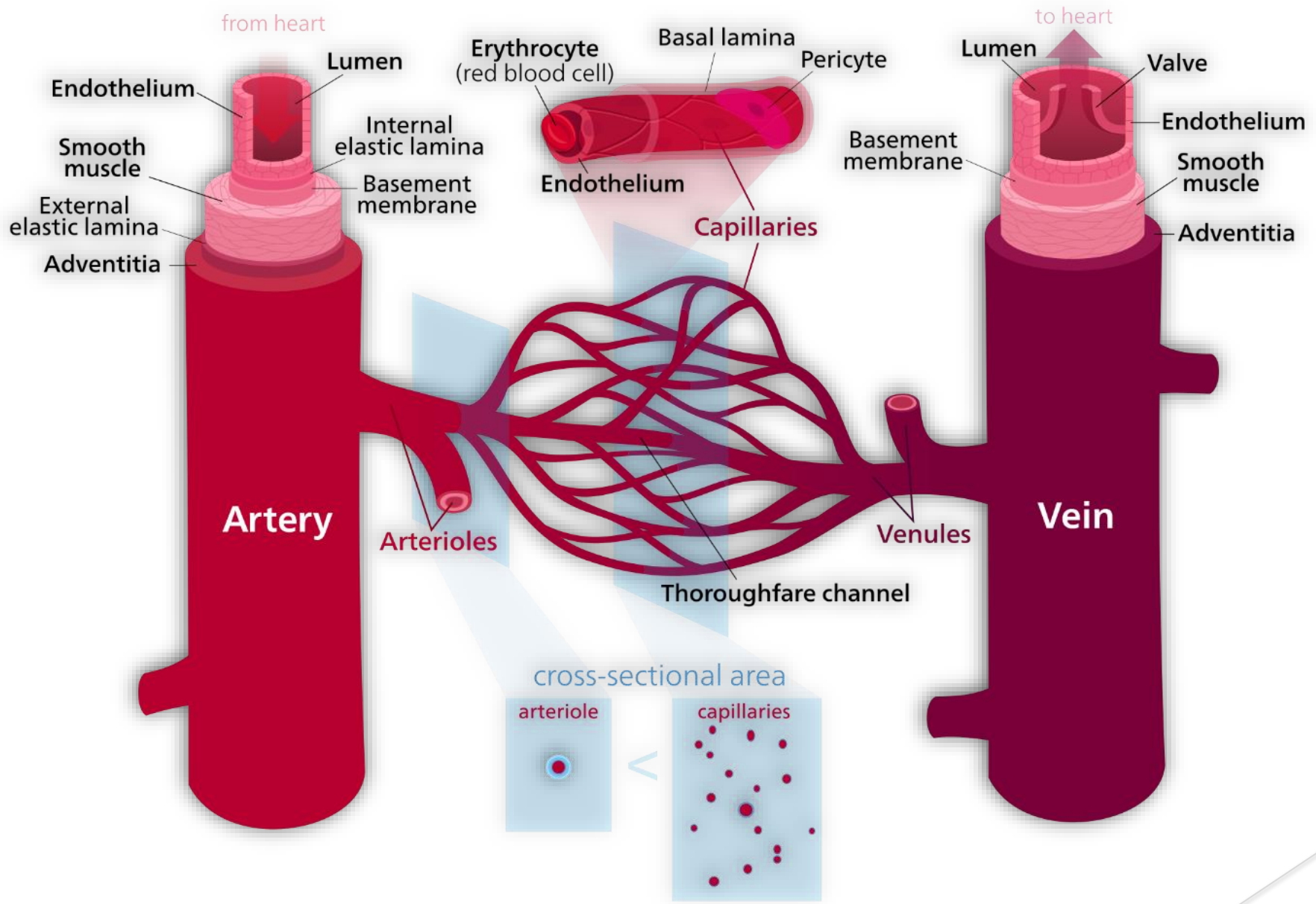
Vessels Layers



Structure of Blood Vessels – 3 Layers "Tunics"




Large vein
Valve
Endothelium
Subendothelial layer
Tunica intima
Tunica media
Tunica adventitia
Nerve
Vasa vasorum
Tunica intima
Tunica media
Muscular artery
Endothelium
Subendothelial layer
Internal elastic lamina
Smooth muscle
Elastic fibers
External elastic lamina
Tunica adventitia
Nerve
Vasa vasorum


from heart
Lumen
Endothelium
Internal elastic lamina
Smooth muscle
Basement membrane
External elastic lamina
Adventitia
Erythrocyte (red blood cell)
Basal lamina
Pericyte
Endothelium
Capillaries
Artery
Arterioles
Venules
Thoroughfare channel
Vein
to heart
Lumen
Valve
Endothelium
Basement membrane
Smooth muscle
Adventitia
cross-sectional area
arteriole
<
capillaries

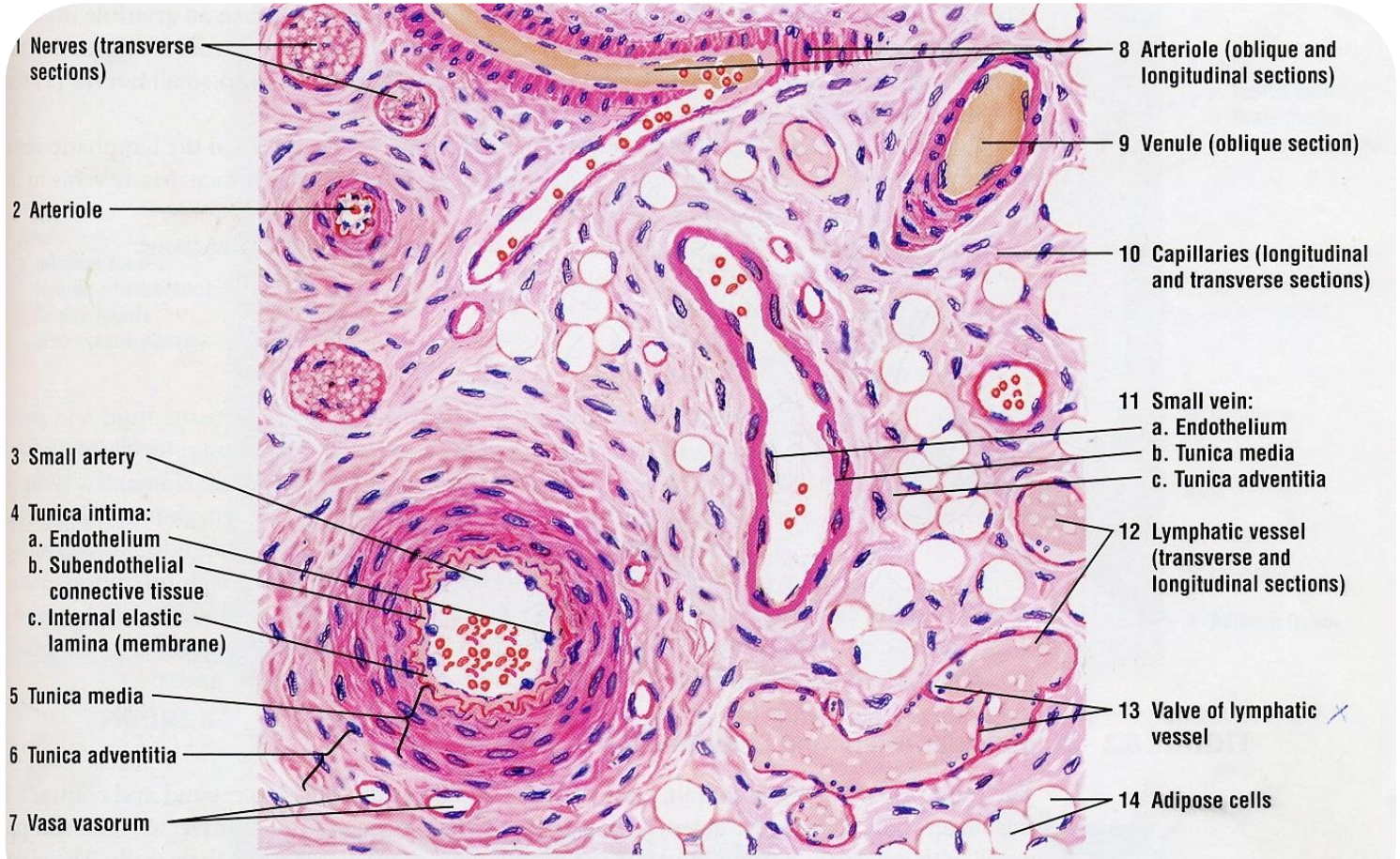
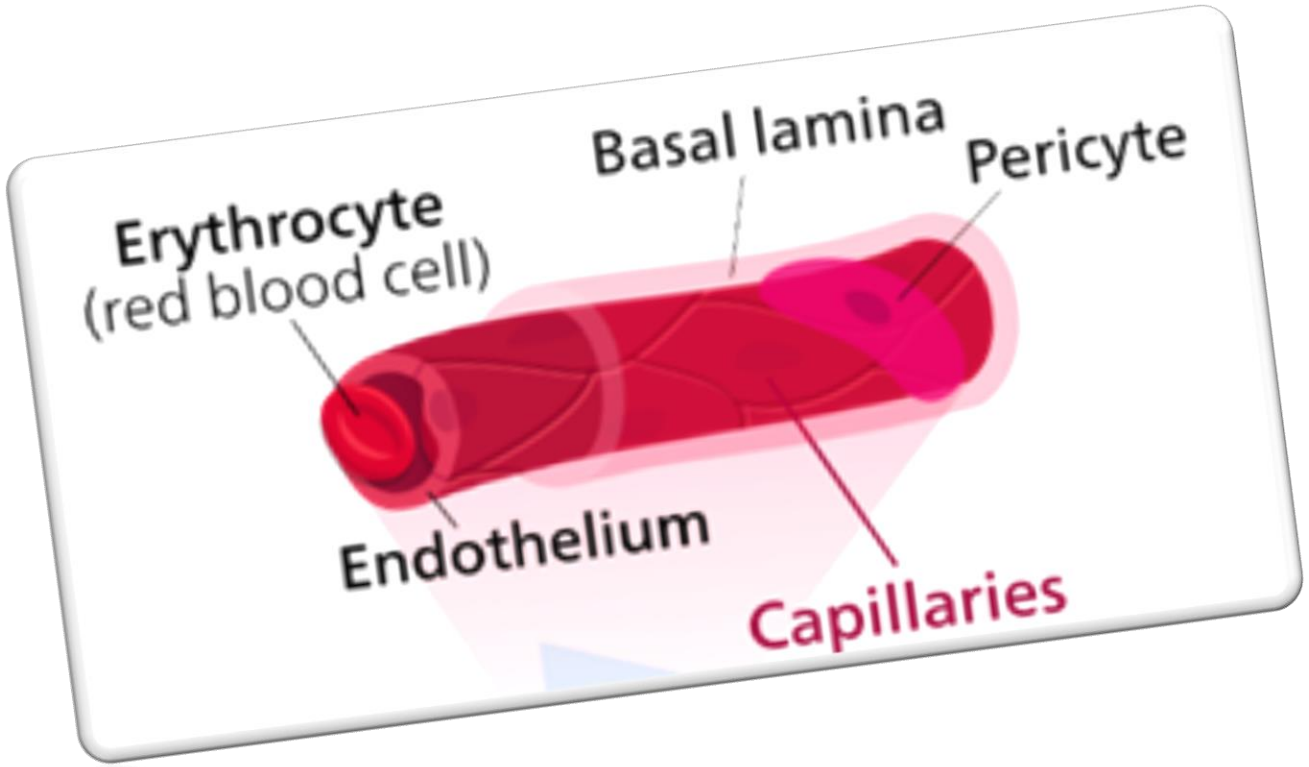
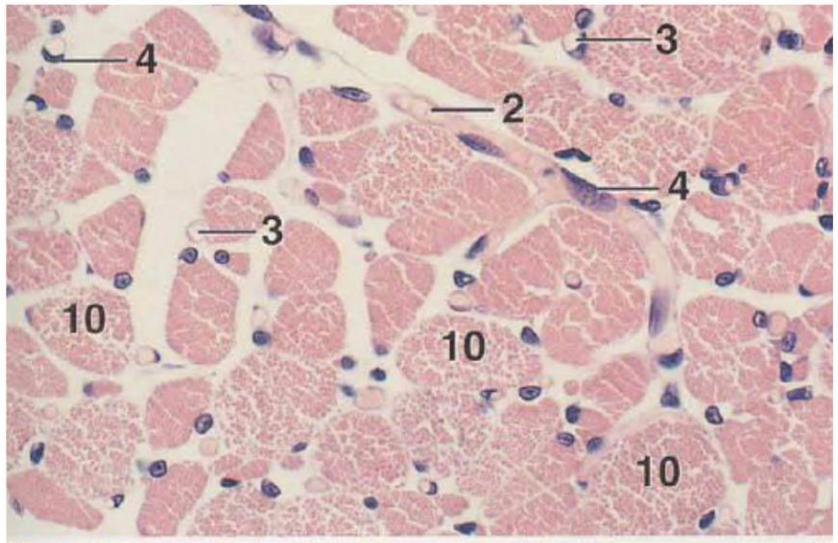


FIGURE 8.1 ■ Blood and lymphatic vessels in the connective tissue. Stain: hematoxylin and eosin. Low magnification.

Capillary


Basal lamina
Pericyte
Erythrocyte
(red blood cell)
Endothelium
Capillaries

Capillary



KEY

1. Arteriole, x.s.
2. Capillary, l.s.
3. Capillary, x.s.
4. Endothelial cell, nucleus
5. Endothelial cell, surface cut
6. Erythrocytes
7. Macrophage
8. Mast cell
9. Plasma cell
10. Skeletal muscle cell, x.s.
11. Small artery, x.s.
12. Small vein
13. Smooth muscle cell, nucleus
14. Uterine gland
15. Venule

Figure 10.2 × 625

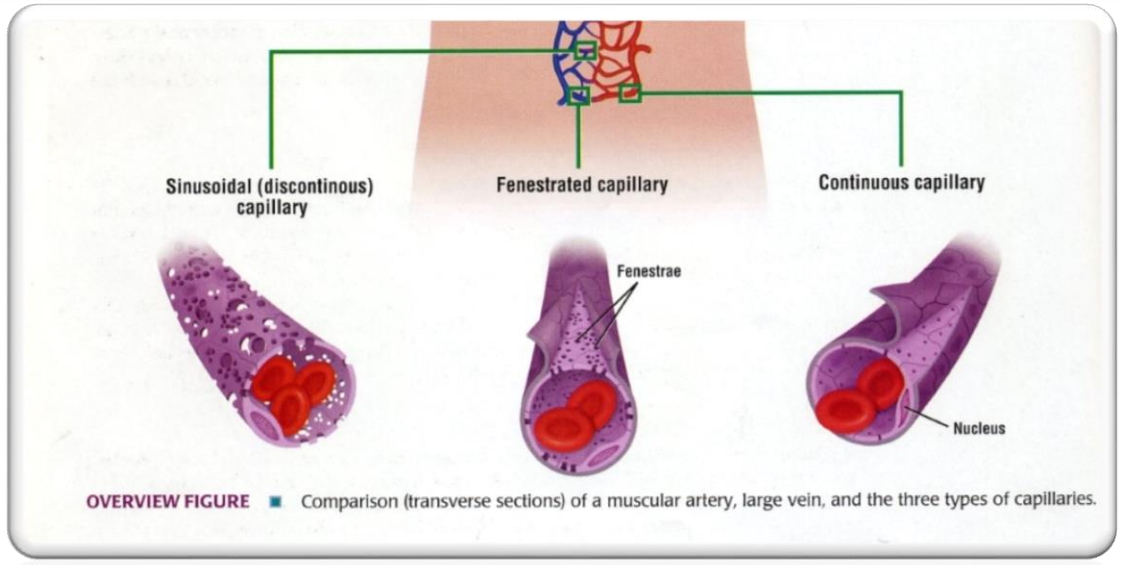
Types of Capillaries

Capillaries are the smallest blood vessels. Their average diameter is approximately 8 m, which is about the size of an **erythrocyte** (red blood cell). The human body contains three types of capillaries: continuous capillaries, fenestrated capillaries, and sinusoids. These structural variations allow different types of metabolic exchange between the blood and the surrounding tissues.

Continuous capillaries are the most common type. They are found in muscle, connective tissue, nervous tissue, and exocrine glands. In these capillaries, the **endothelial cells** are joined and form an uninterrupted, solid endothelial lining.

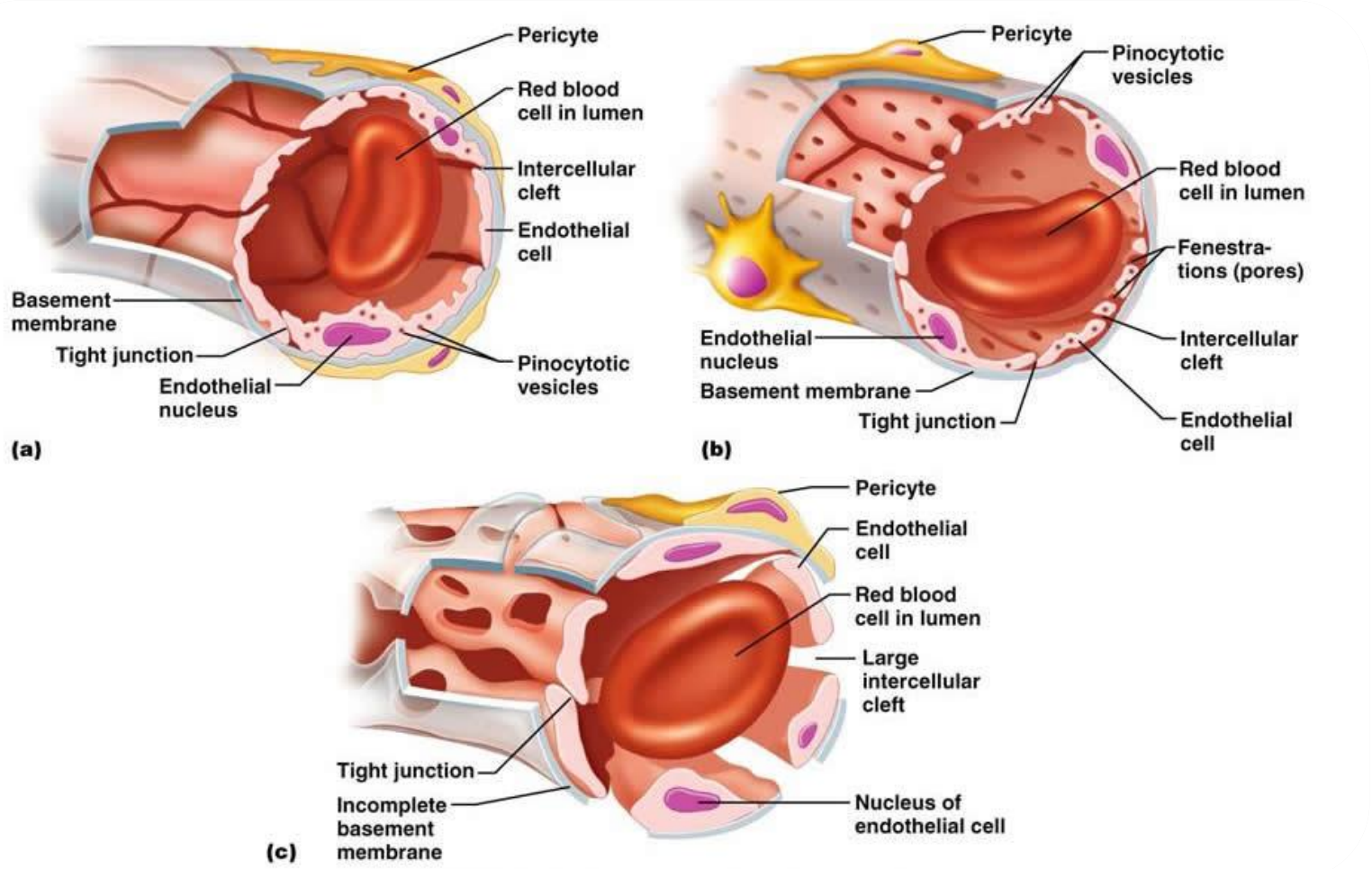
Fenestrated capillaries are characterized by large openings, or **fenestrations** (pores), in the cytoplasm of endothelial cells for rapid exchange of molecules between blood and tissues. Fenestrated capillaries are found in endocrine organs, small intestine, and kidney glomeruli.

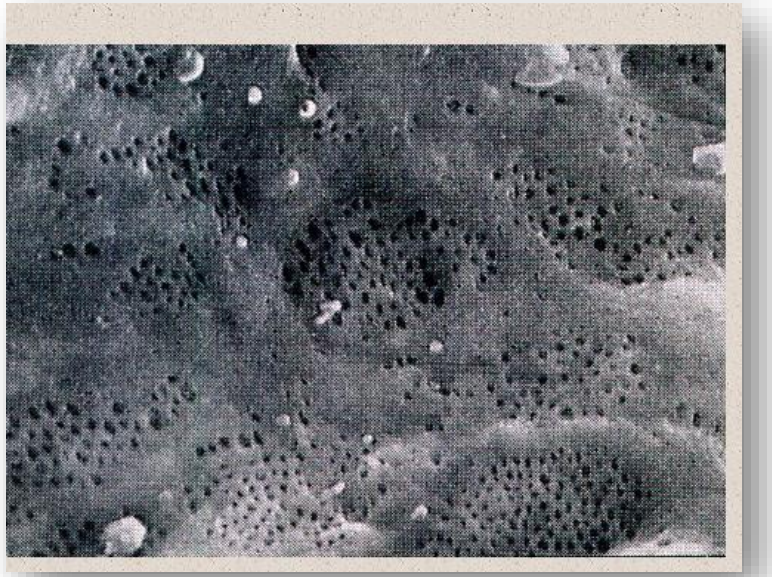
Sinusoidal (discontinuous) capillaries are blood vessels that exhibit irregular, tortuous paths. Their much wider diameters slow the flow of blood. Endothelial cell junctions are rare in sinusoidal capillaries, and wide gaps exist between individual endothelial cells. Also, because a **basement membrane** underlying the endothelium is either incomplete or absent, direct exchange of molecules occurs between blood contents and cells. Sinusoidal capillaries are found in the liver, spleen, and bone marrow (see the overview figure).

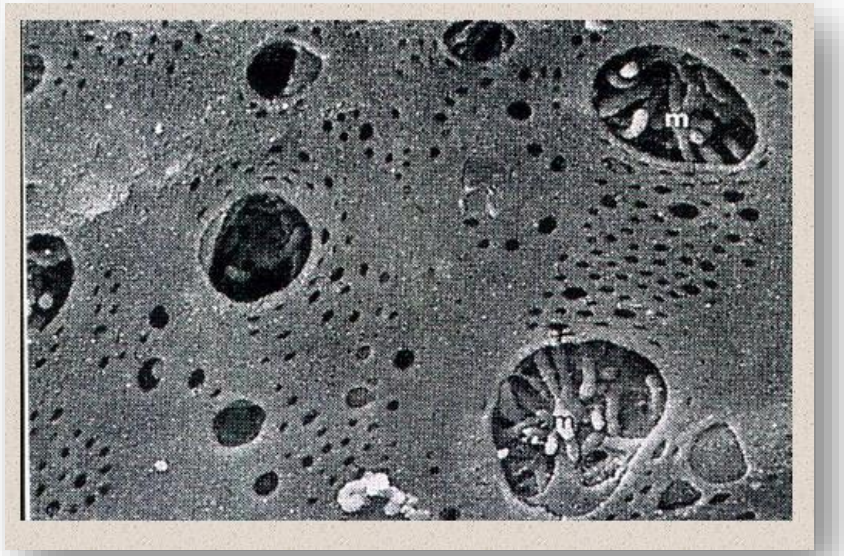


OVERVIEW FIGURE ■ Comparison (transverse sections) of a muscular artery, large vein, and the three types of capillaries.

Types of Capillaries

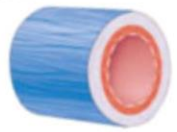





m
m

Artery

TABLE 20.1 Summary of Blood Vessel Anatomy

Vessel Type/Illustration*	Average Lumen Diameter (D) and Wall Thickness (T)	Relative Tissue Makeup			
		Endothelium	Elastic Tissues	Smooth Muscles	Fibrous (Collagenous) Tissues
 Elastic artery	D: 1.5 cm T: 1.0 mm				
 Muscular artery	D: 6.0 mm T: 1.0 mm				
 Arteriole	D: 37.0 µm T: 6.0 µm				
 Capillary	D: 9.0 µm T: 0.5 µm				
 Venule	D: 20.0 µm T: 1.0 µm				
 Vein	D: 5.0 mm T: 0.5 mm				

*Size relationships are not proportional. Smaller vessels are drawn relatively larger so detail can be seen. See column 2 for actual dimensions.

Artery

Elastic Artery (Large artery)

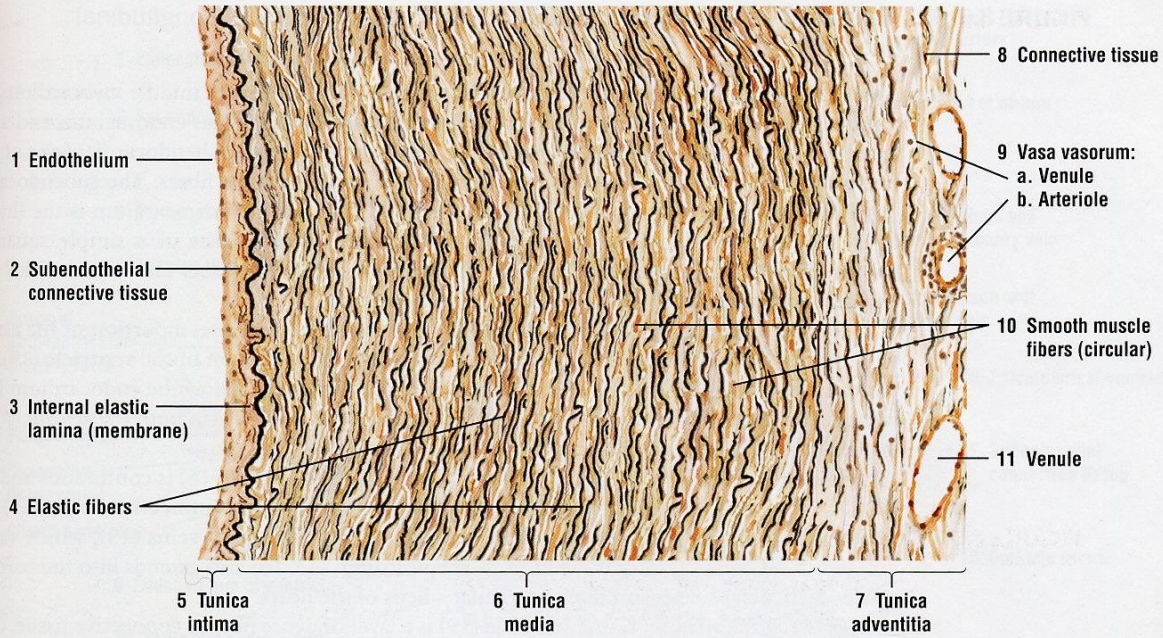
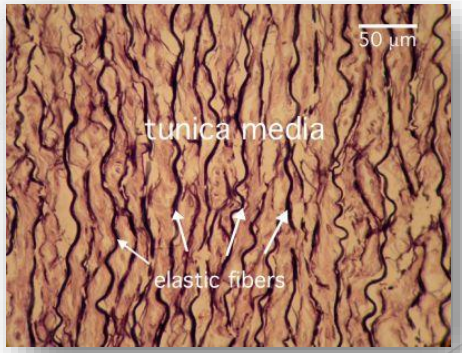


FIGURE 8.4 ■ Wall of an elastic artery: aorta (transverse section). Stain: elastic stain. Low magnification.



Artery

Elastic Artery (Large artery)

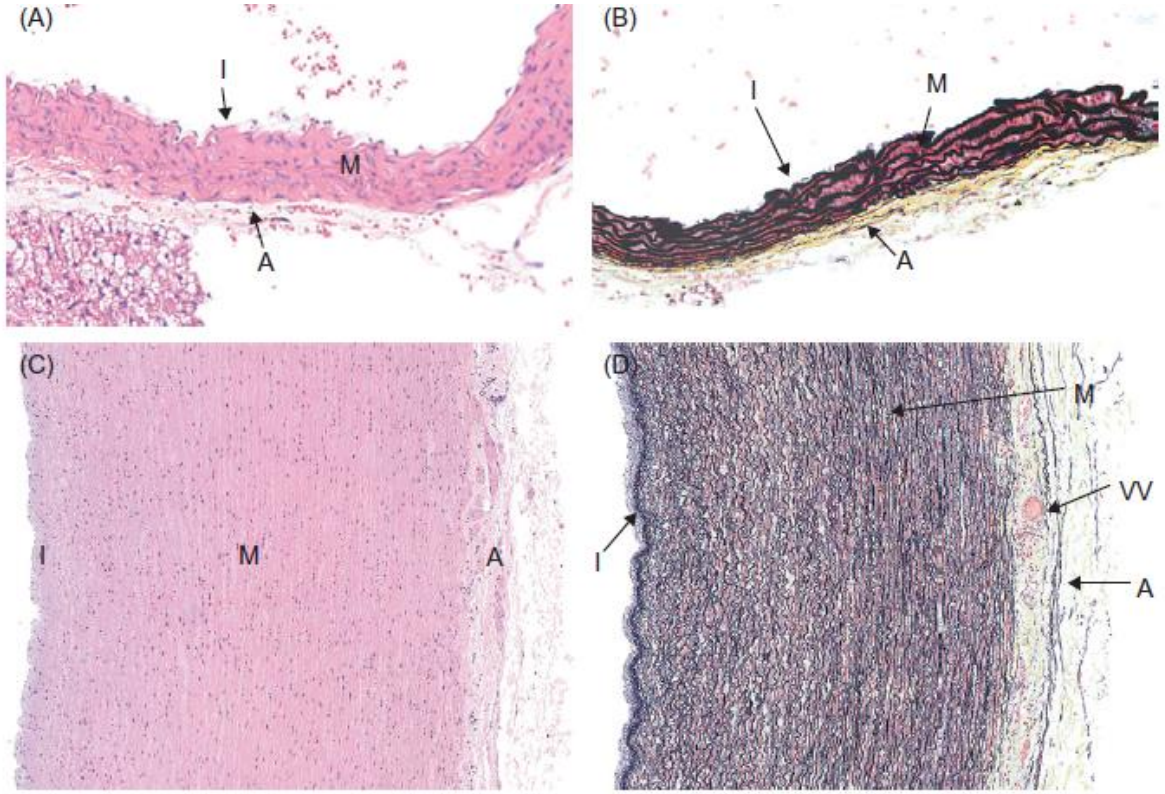
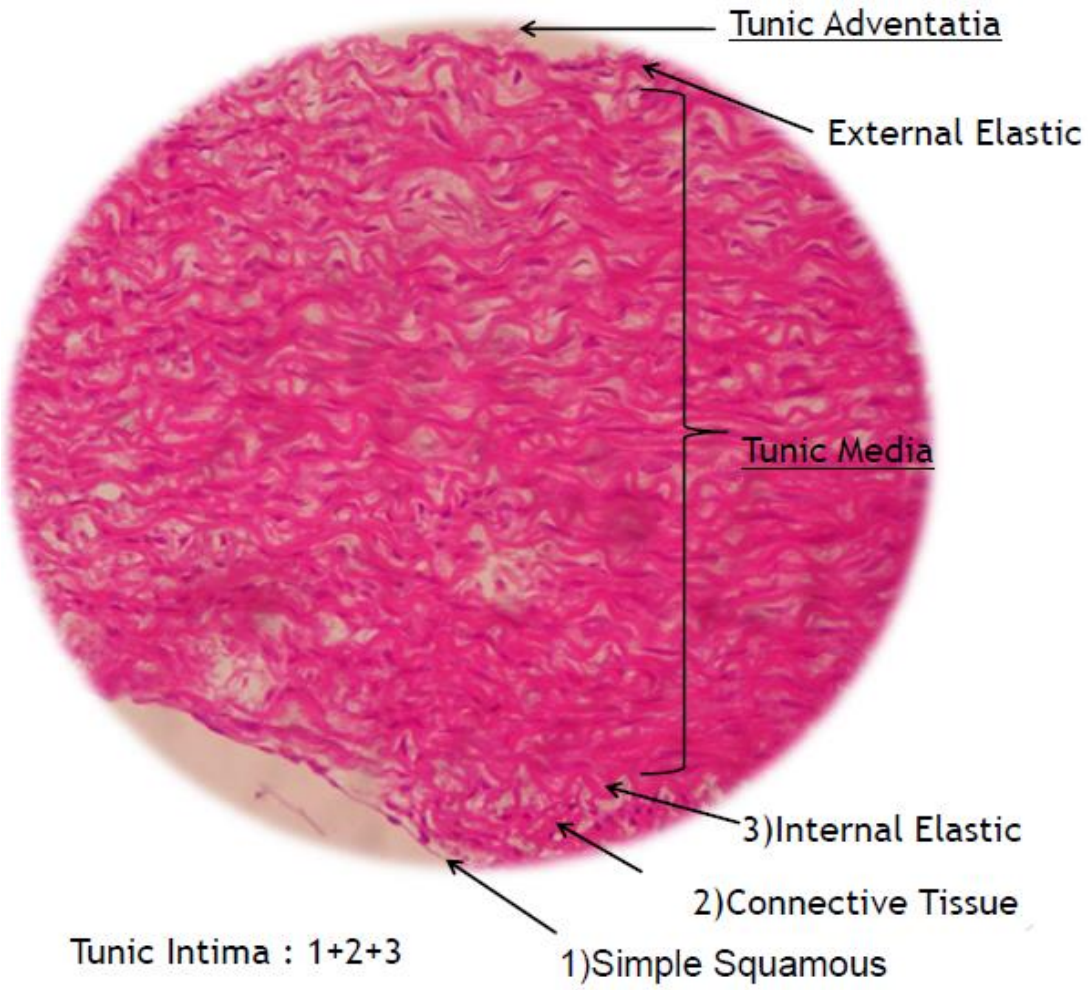


FIGURE 13 Histology of elastic artery. (A and B) Mouse aorta stained with H&E (A) or Movat's pentachrome (B). The aorta is an elastic artery. It is composed of the tunica intima (I), a flattened layer of endothelium; the tunica media (M), a layer of elastic fibers (black in panel C) and smooth muscle cells; and the tunica adventitia (A), fibrous connective tissue. In the adult mouse, there are typically fewer than 10 elastic lamellae (with somewhat more lamellae near the aortic root). (C and D) Human aorta stained with H&E (C) or Movat's pentachrome (D). The histological features of the human aorta are similar to those of the mouse, but the human aorta has far more elastic lamellae (~50) and more prominent vasa vasorum (VV), which are vessels that arise in the adventitia and periodically extend into the adjacent media.

Artery

Elastic Artery (Large artery)



Artery

Muscular Artery (Middles sized artery)

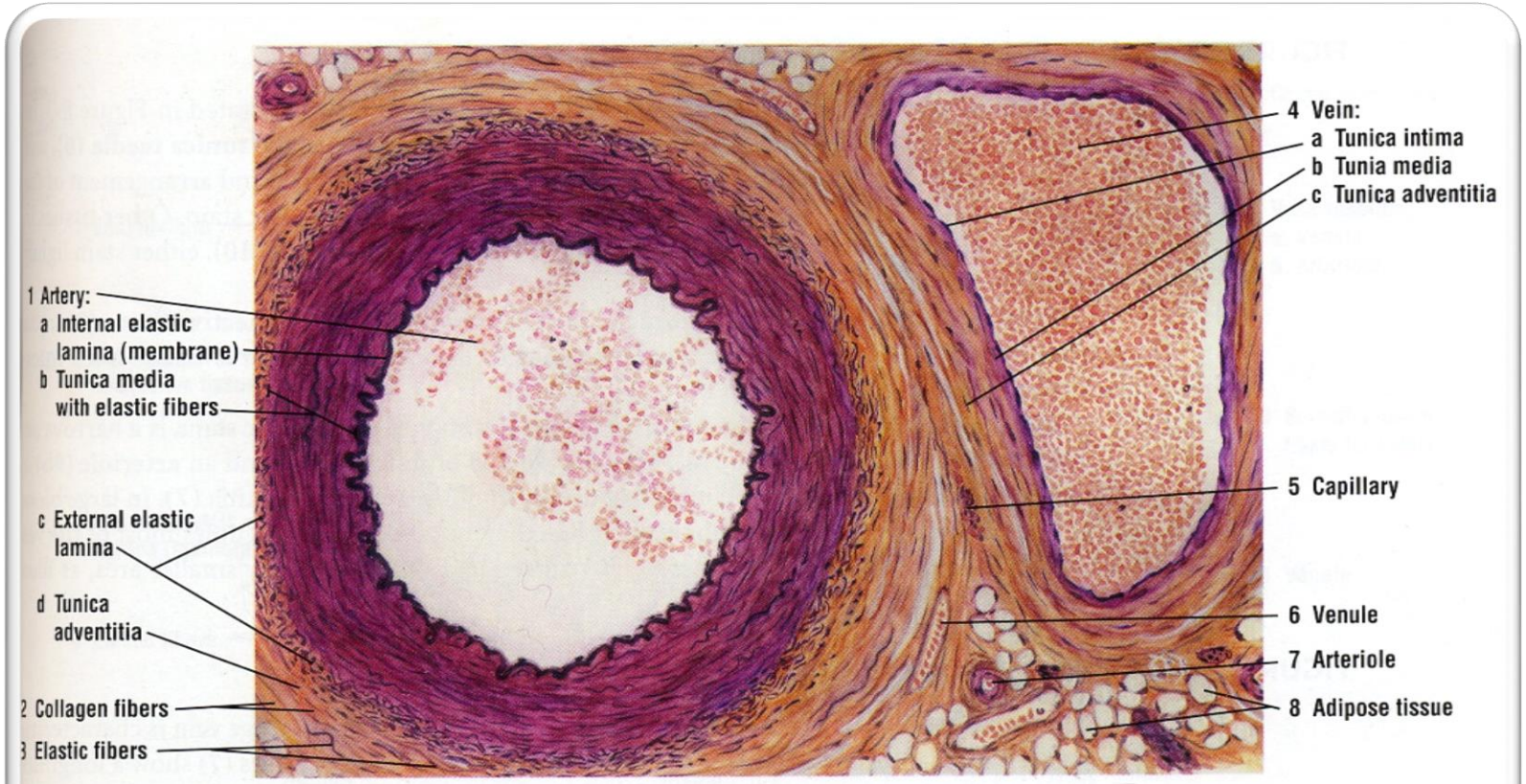


FIGURE 8.2 ■ Muscular artery and vein (transverse section). Stain: elastic stain. Low magnification.

Artery

Muscular Artery (Middles sized artery)

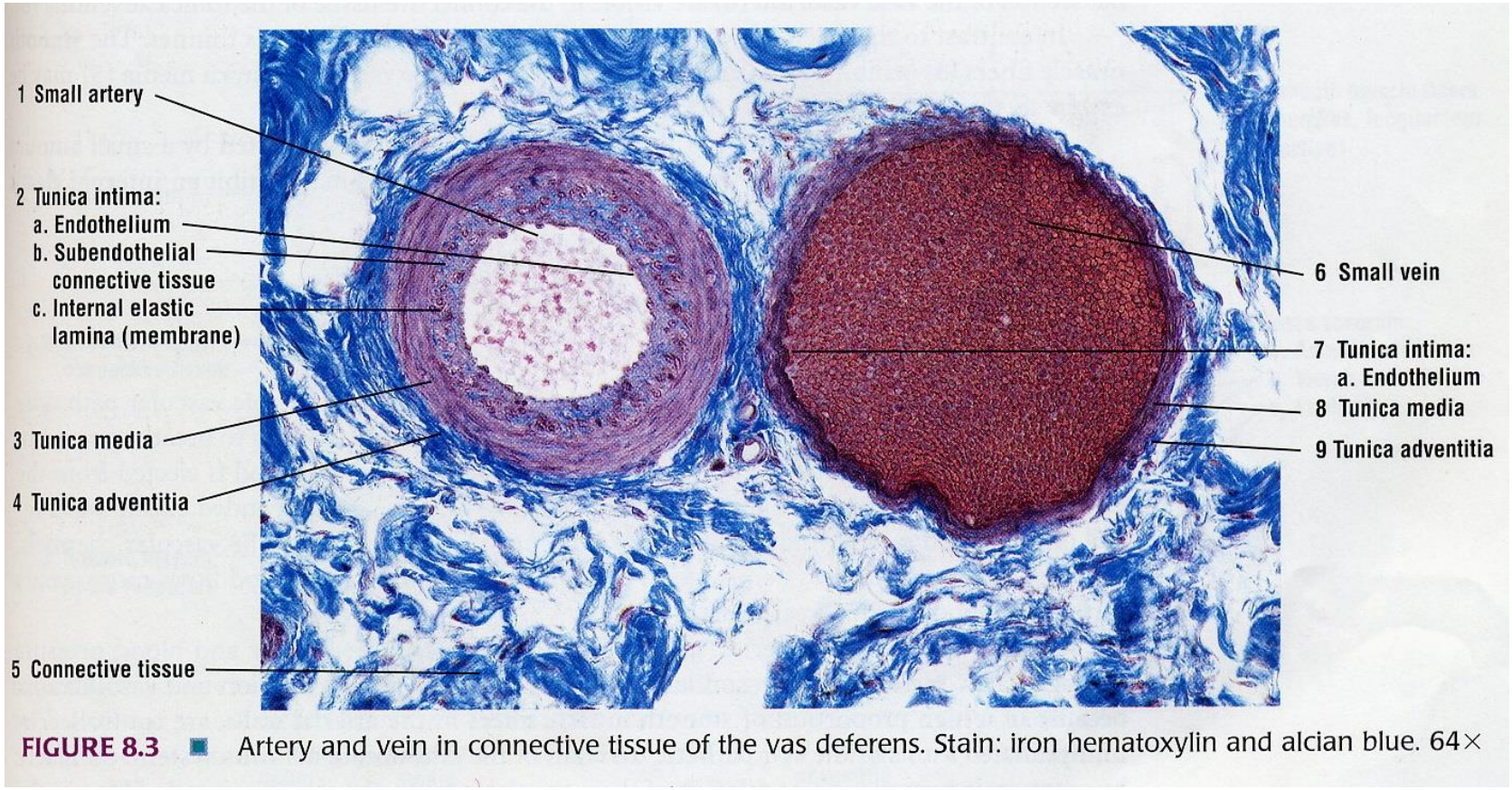


FIGURE 8.3 ■ Artery and vein in connective tissue of the vas deferens. Stain: iron hematoxylin and alcian blue. 64×

Artery

Muscular Artery

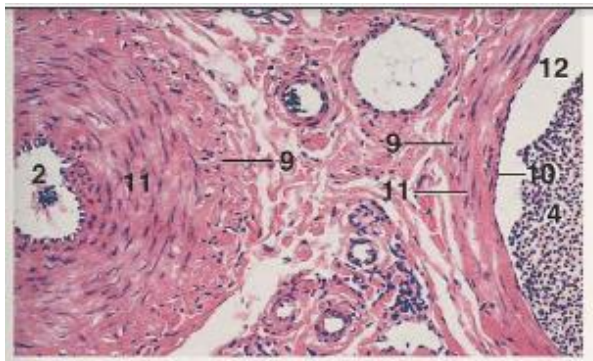


Figure 10.12 × 125

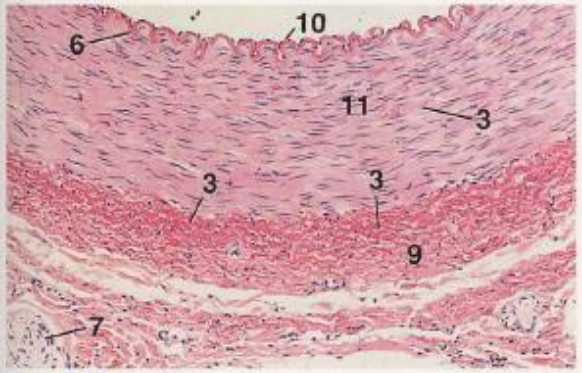


Figure 10.13 × 62.5

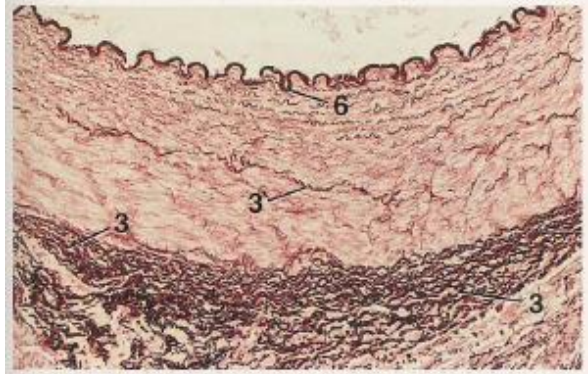


Figure 10.14 × 62.5

KEY

1. Adipose tissue	7. Nerve
2. Artery	8. Pancreas
3. Elastic fiber	9. Tunica adventitia
4. Erythrocytes	10. Tunica intima, endothelium
5. External elastic membrane	11. Tunica media
6. Internal elastic membrane	12. Vein

Figure 10.11. Small Artery, Vein, and Nerve, x.s., Pancreas, Cat. Note that both of the vessels have a sparse adventitia.

Figure 10.12. Artery and Vein, x.s., Wattle, Rooster. Note the especially thick tunica media of the artery.

Figure 10.13. Medium Artery, x.s., Lymph Node, Pig. The rich-pink color of the elastic fibers contrasts with the paler-pink color of the collagenous fibers and smooth muscle.

Figure 10.14. Medium Artery, x.s., Lymph Node, Pig (Orcein). Elastic fibers are stained reddish brown with orcein.

Figure 10.15. Medium Vein, l.s., Lymph Node, Pig. This vein accompanied the artery in Figures 10.13 and 10.14.

Artery

Muscular Artery

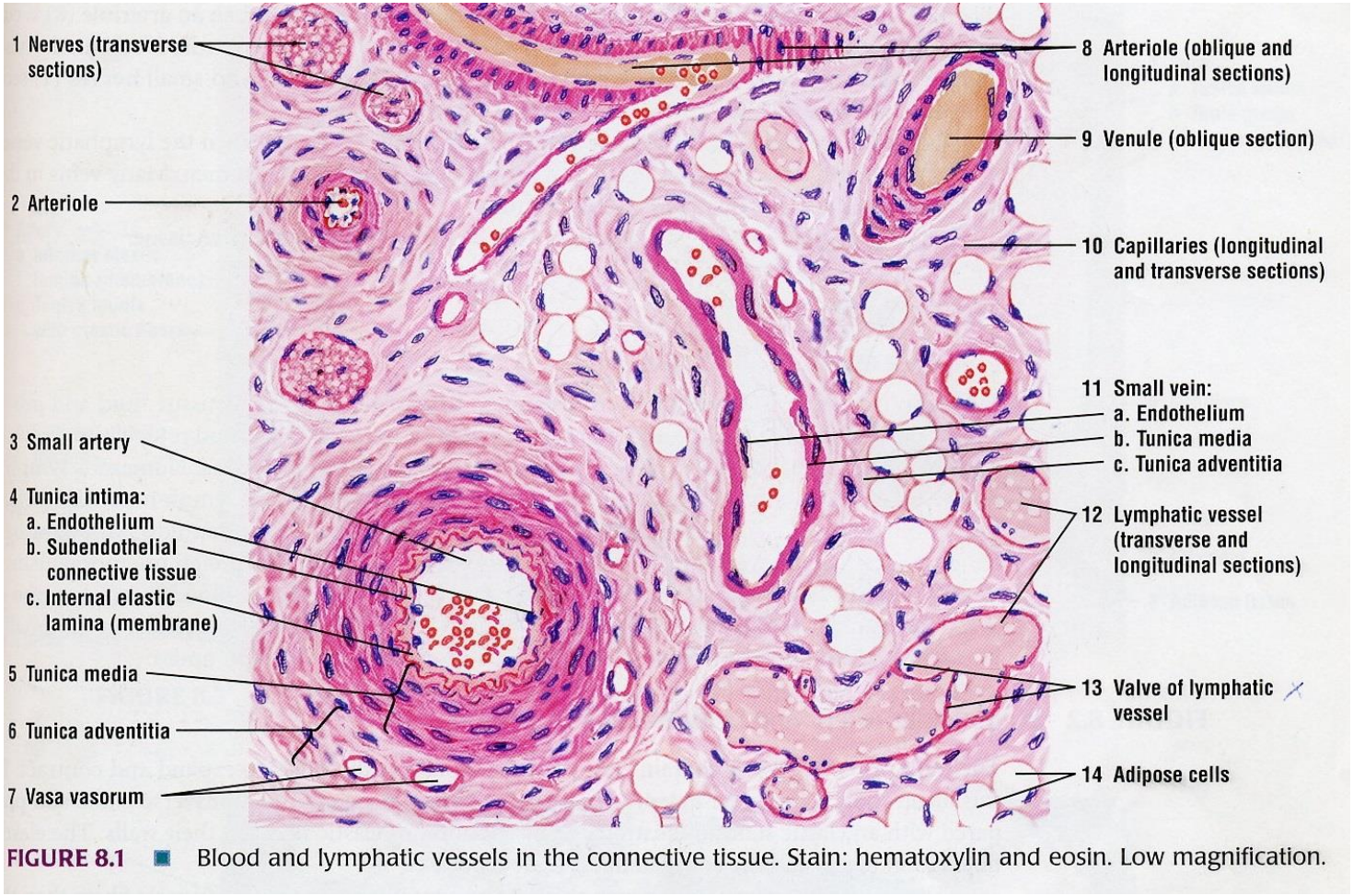


FIGURE 8.1 ■ Blood and lymphatic vessels in the connective tissue. Stain: hematoxylin and eosin. Low magnification.

Arteriole

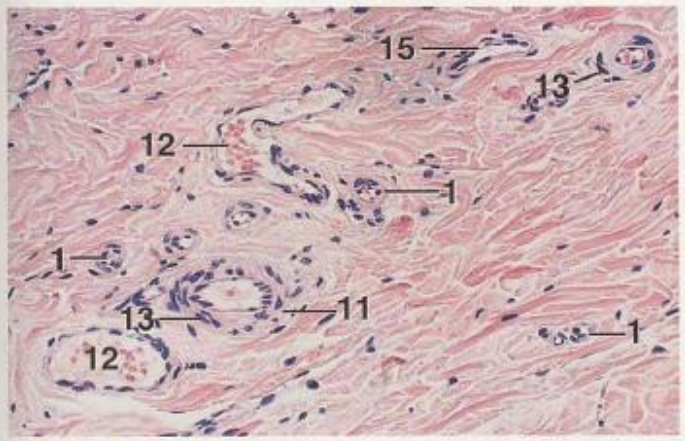


Figure 10.3 × 125

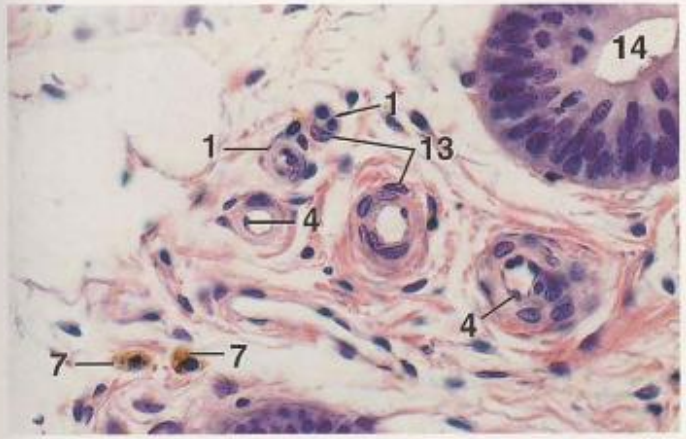


Figure 10.4 × 250

Figure 10.3. Arterioles and Venules, Eyelid, Pig. Small blood vessels of various sizes are present in the dermis.

Figure 10.4. Arterioles, x.s., Endometrium, Uterus, Dog. The smallest of the arterioles shown have only one layer of smooth muscle in their walls.

Figure 10.5. Venule, l.s., Connective Tissue, Epiglottis, Goat. The wall of the venule consists of an endothelium surrounded by a small amount of connective tissue.

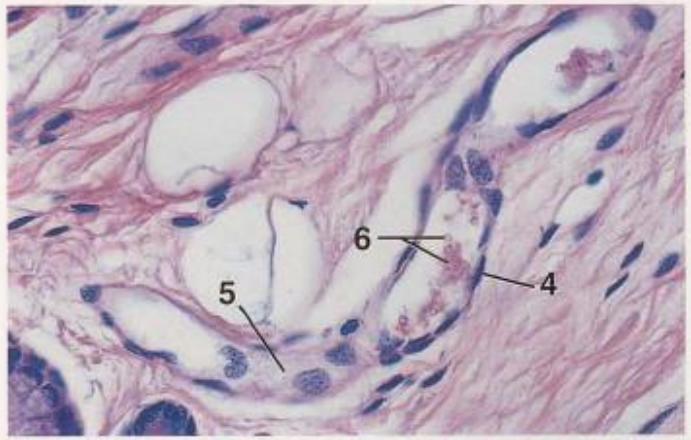
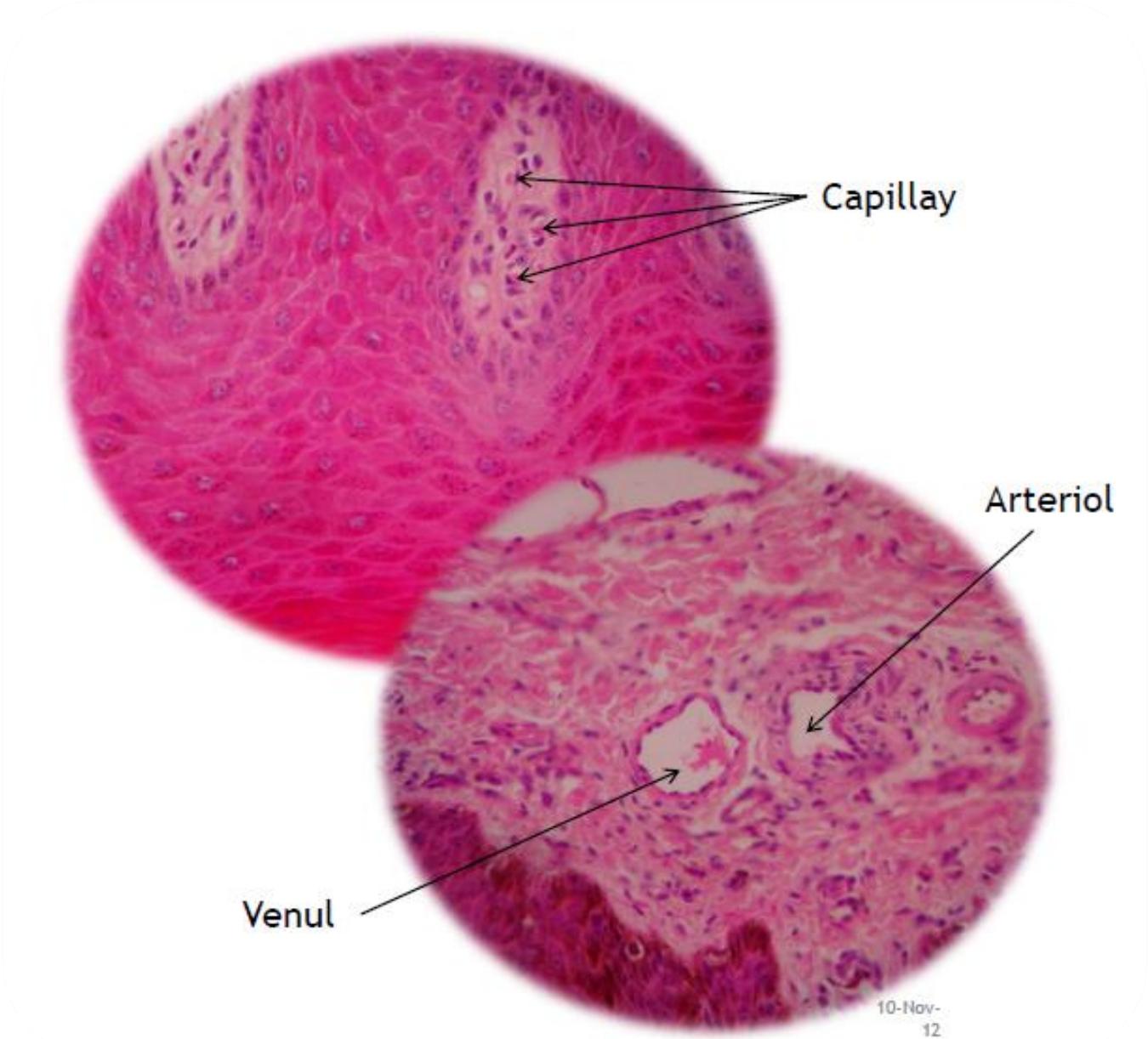


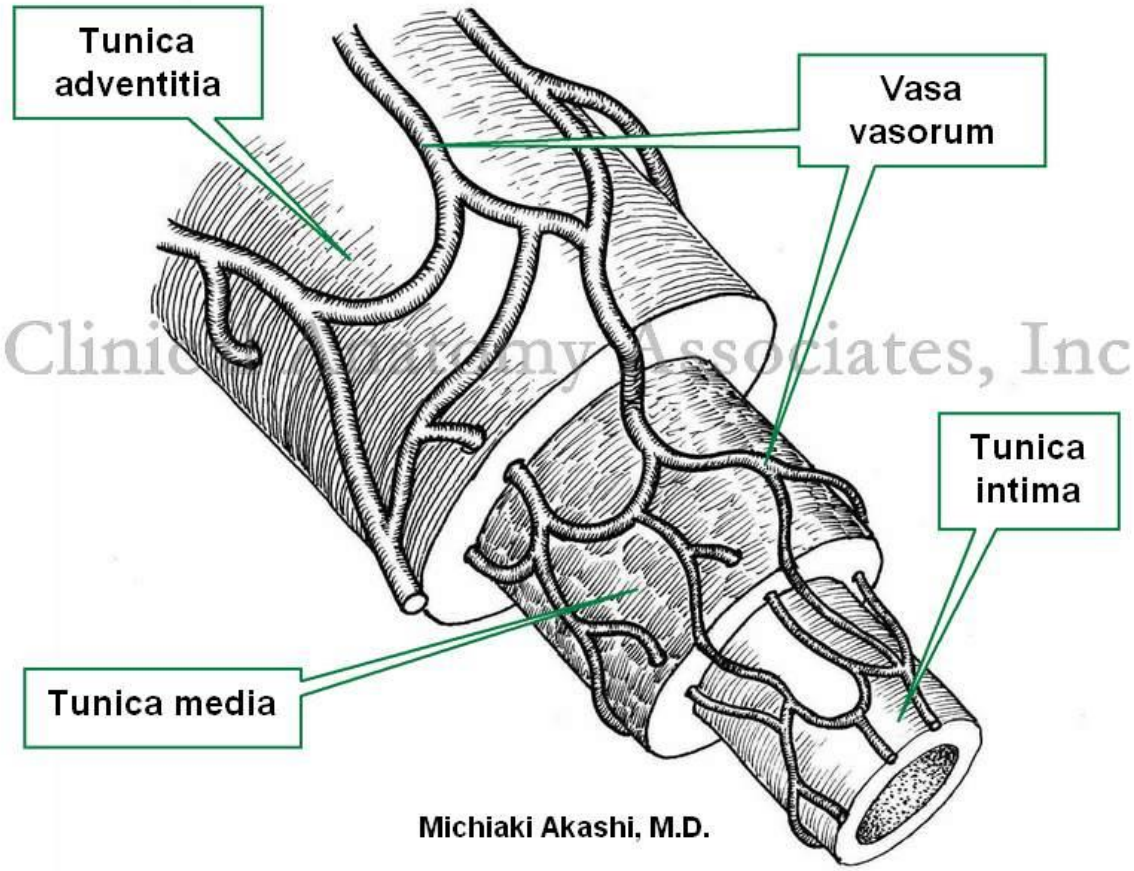
Figure 10.5 × 250

KEY

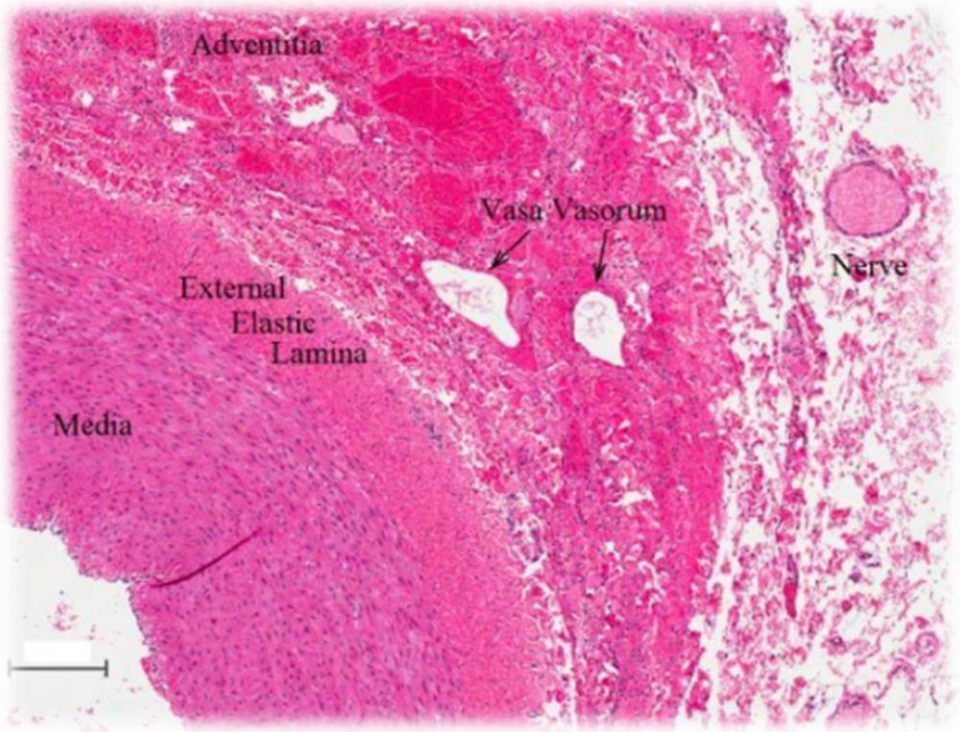
1. Arteriole, x.s.
2. Capillary, l.s.
3. Capillary, x.s.
4. Endothelial cell, nucleus
5. Endothelial cell, surface cut
6. Erythrocytes
7. Macrophage
8. Mast cell
9. Plasma cell
10. Skeletal muscle cell, x.s.
11. Small artery, x.s.
12. Small vein
13. Smooth muscle cell, nucleus
14. Uterine gland
15. Venule

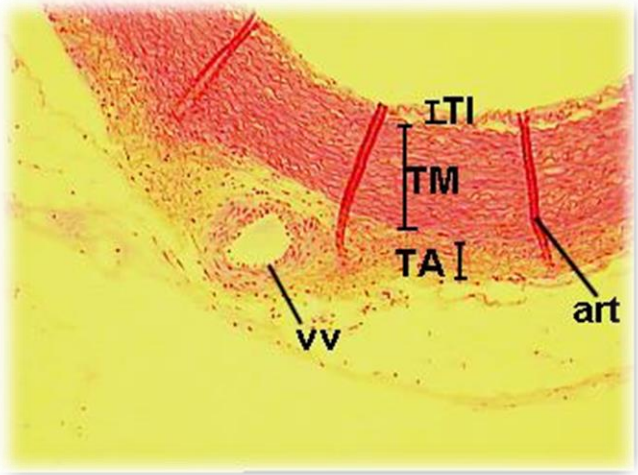

Capillay
Arteriol
Venul
10-Nov-12

Vasa vasorum

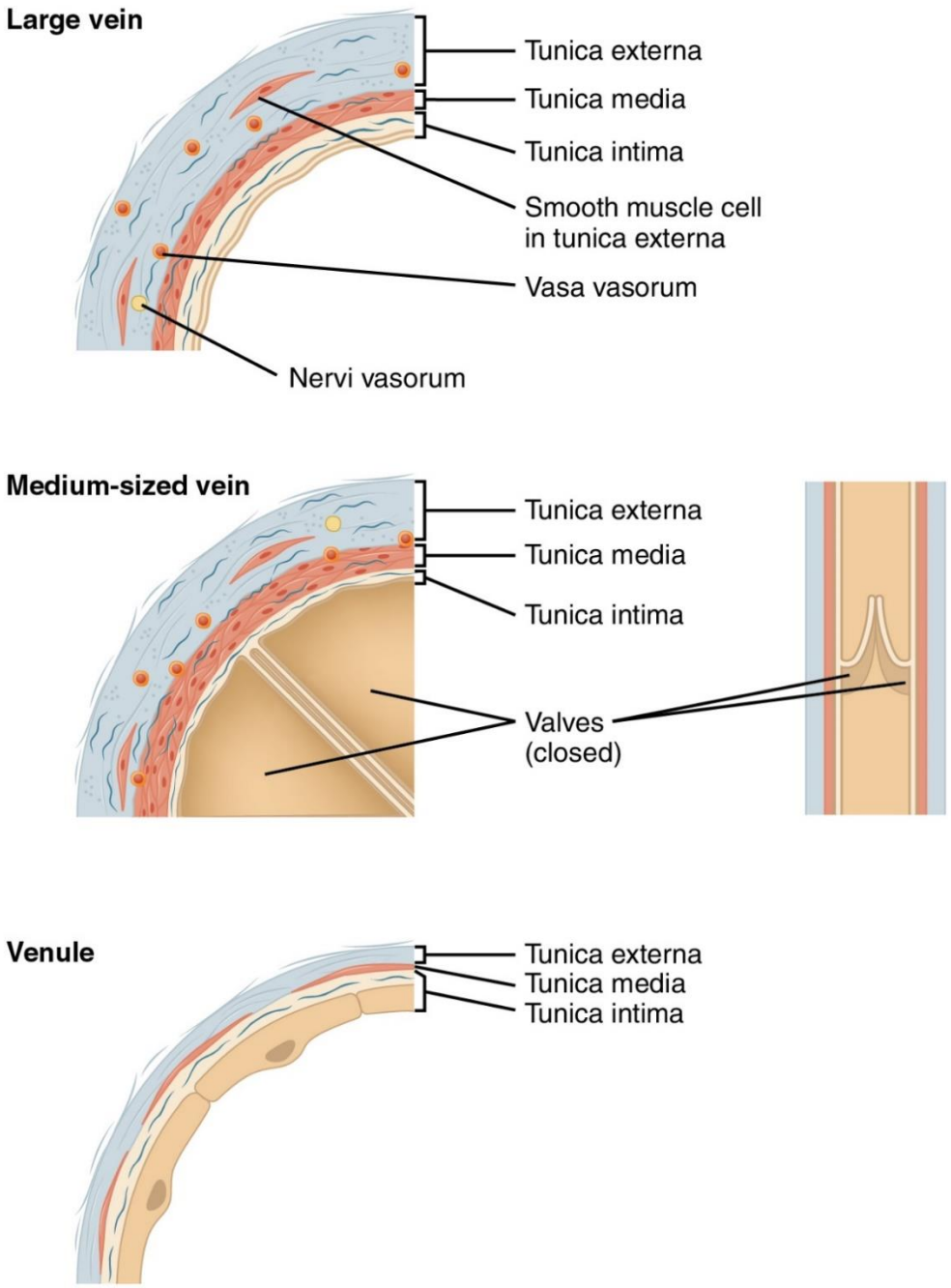


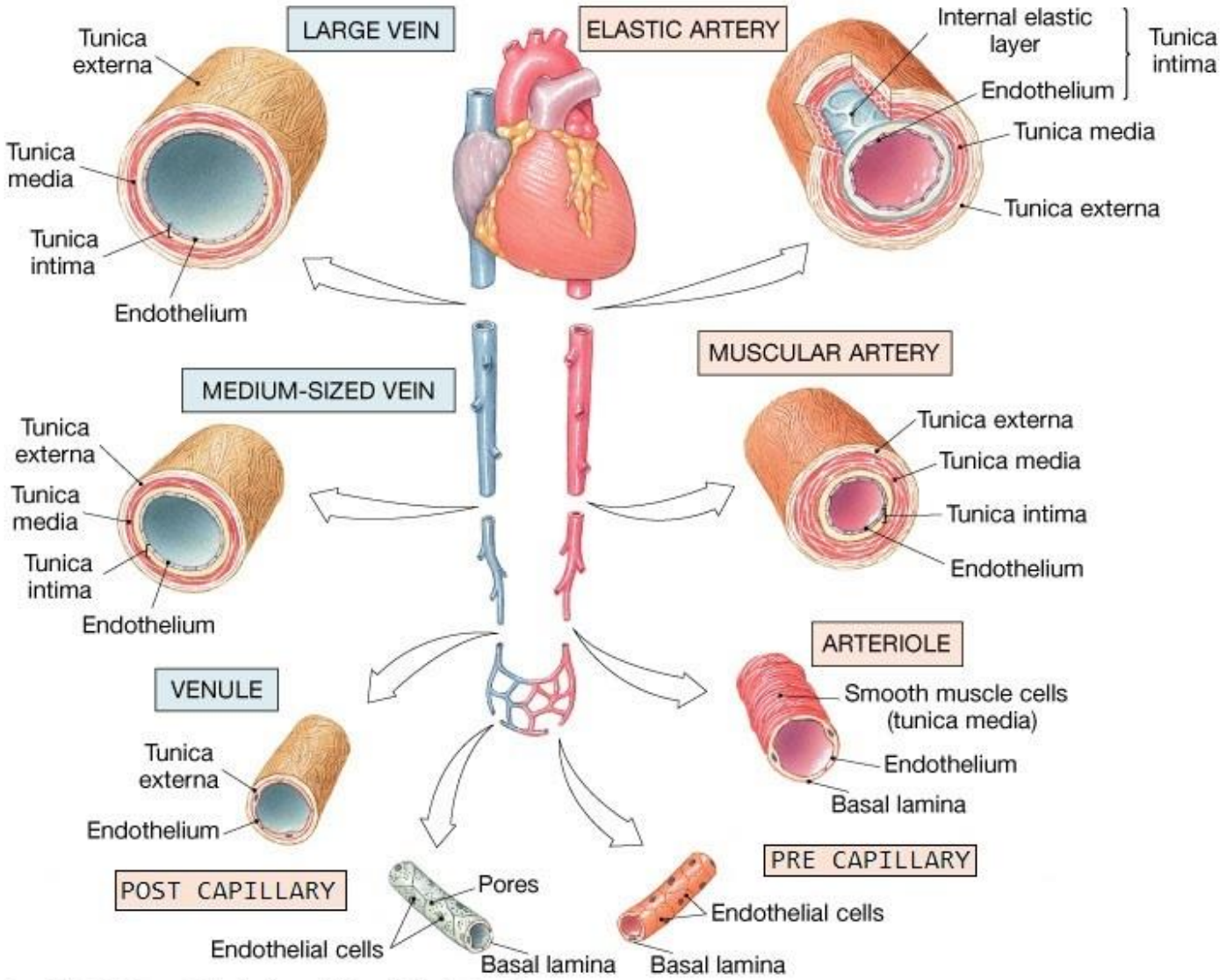
Vasa vasorum

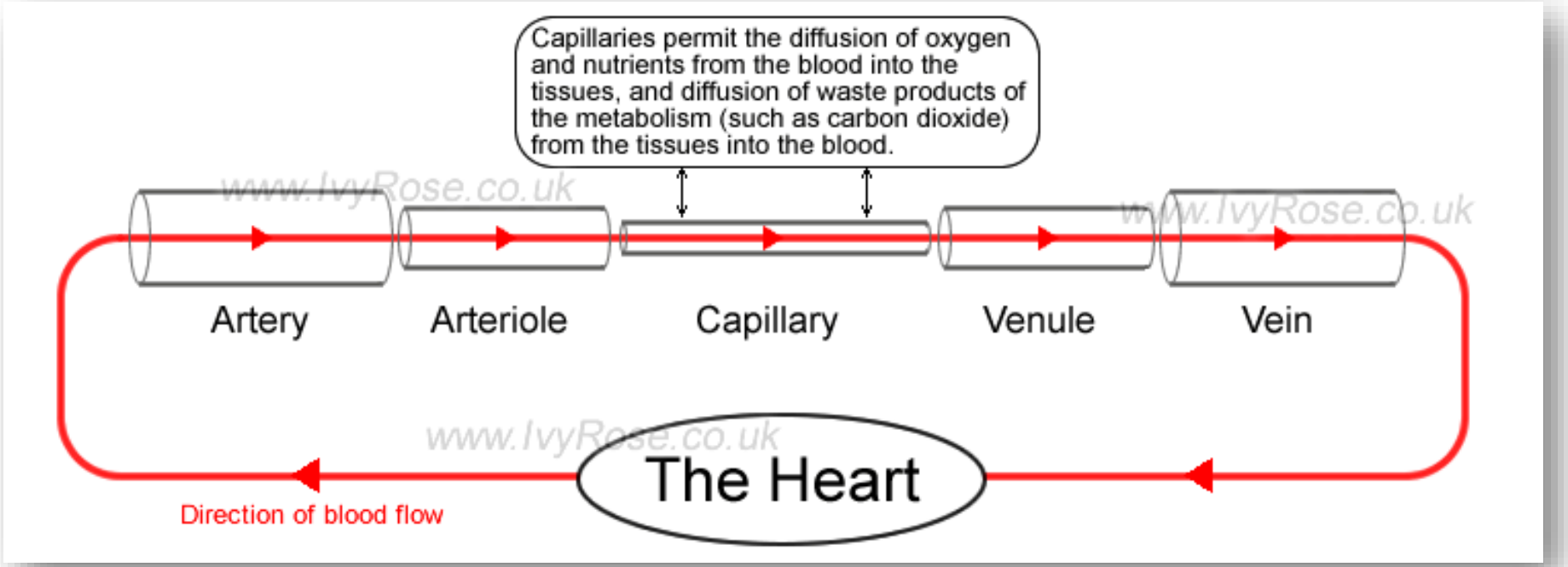


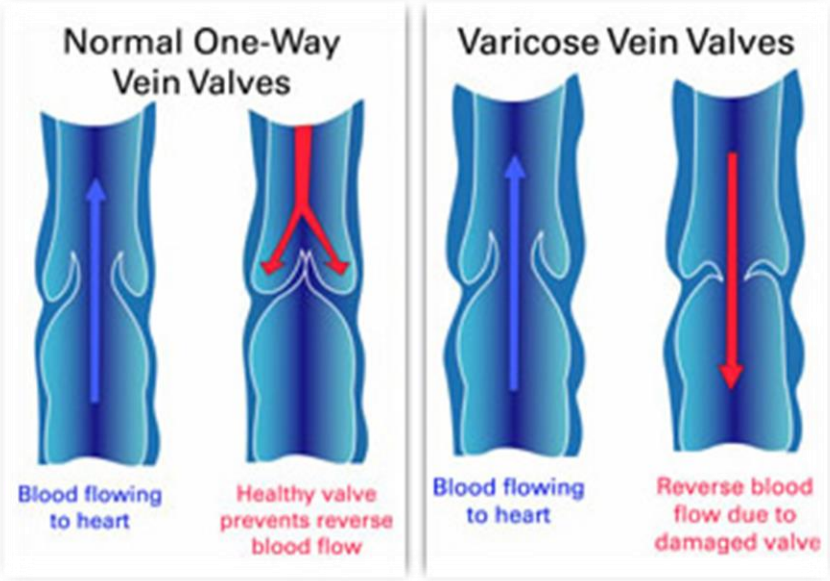


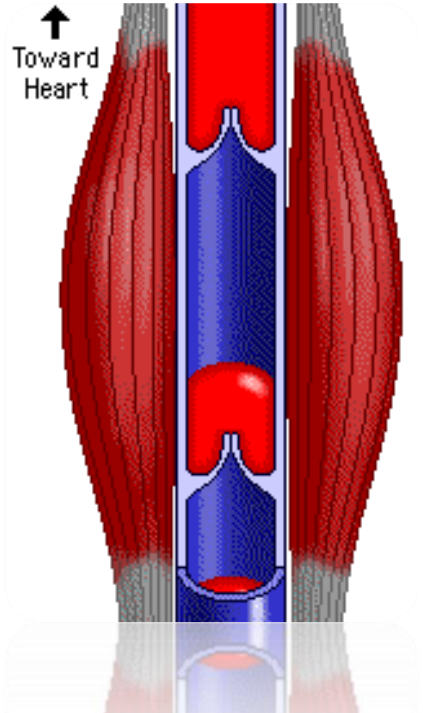
Veins

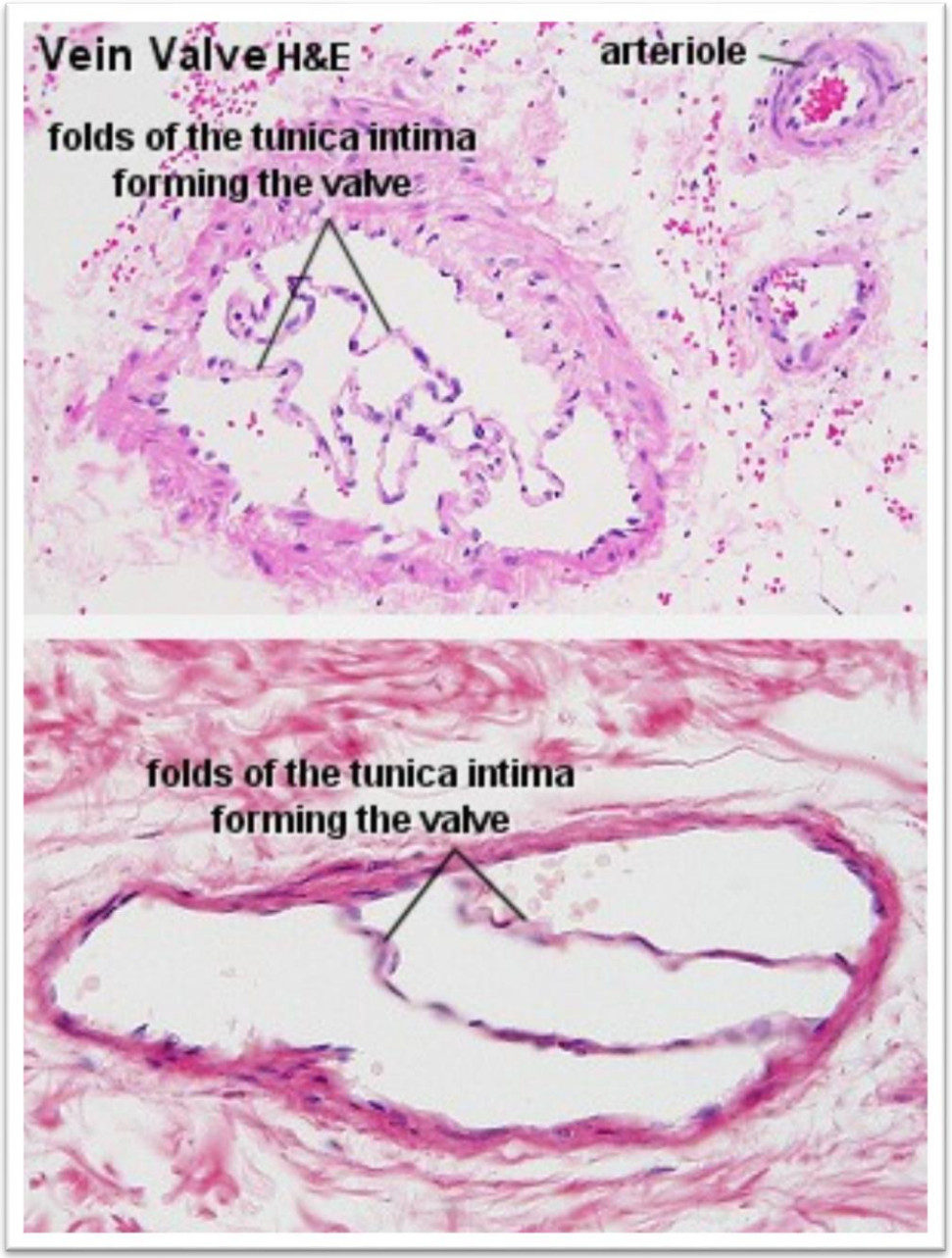

Large vein
Tunica externa
Tunica media
Tunica intima
Smooth muscle cell in tunica externa
Vasa vasorum
Nervi vasorum
Medium-sized vein
Tunica externa
Tunica media
Tunica intima
Valves (closed)
Venule
Tunica externa
Tunica media
Tunica intima

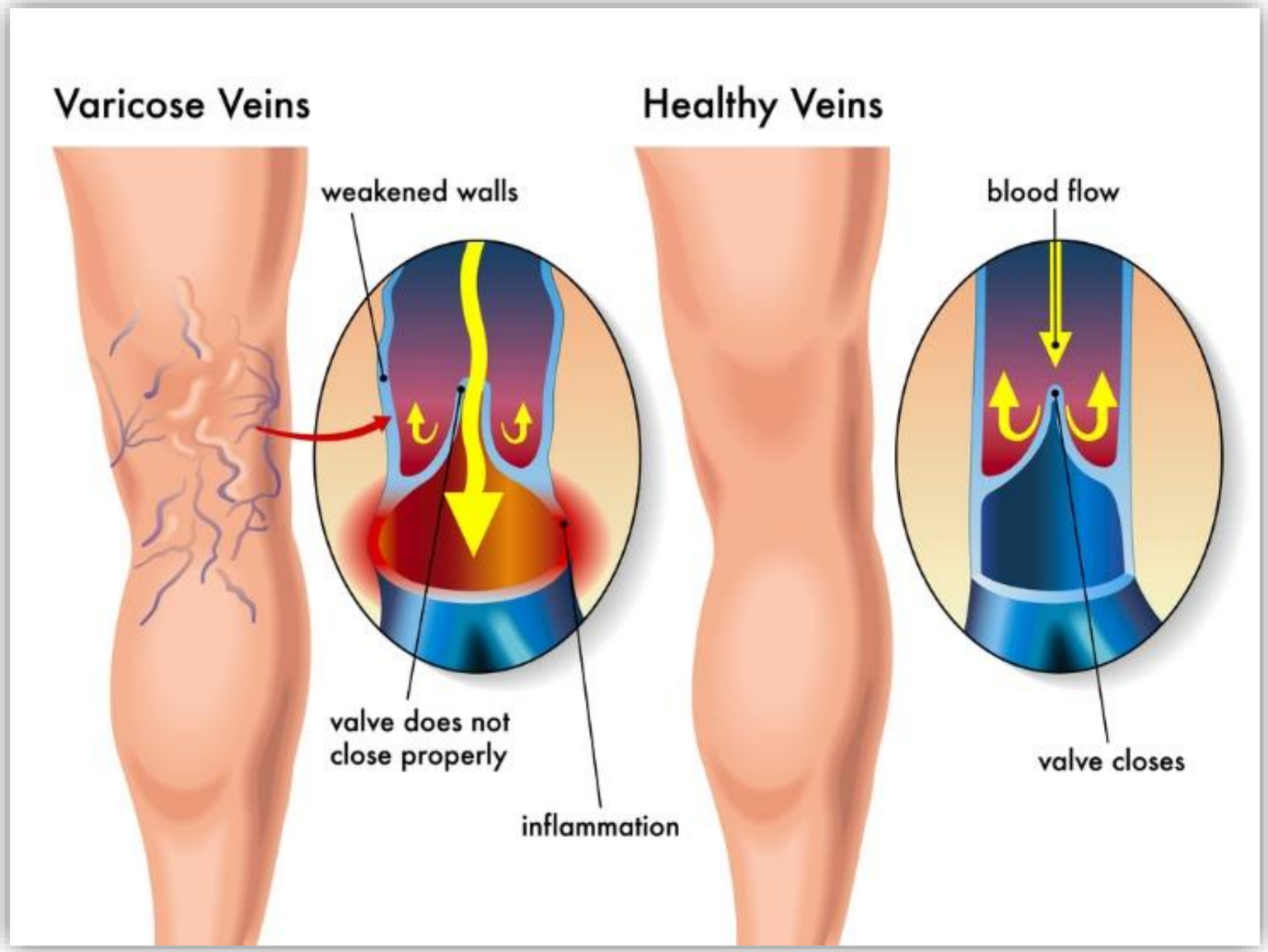


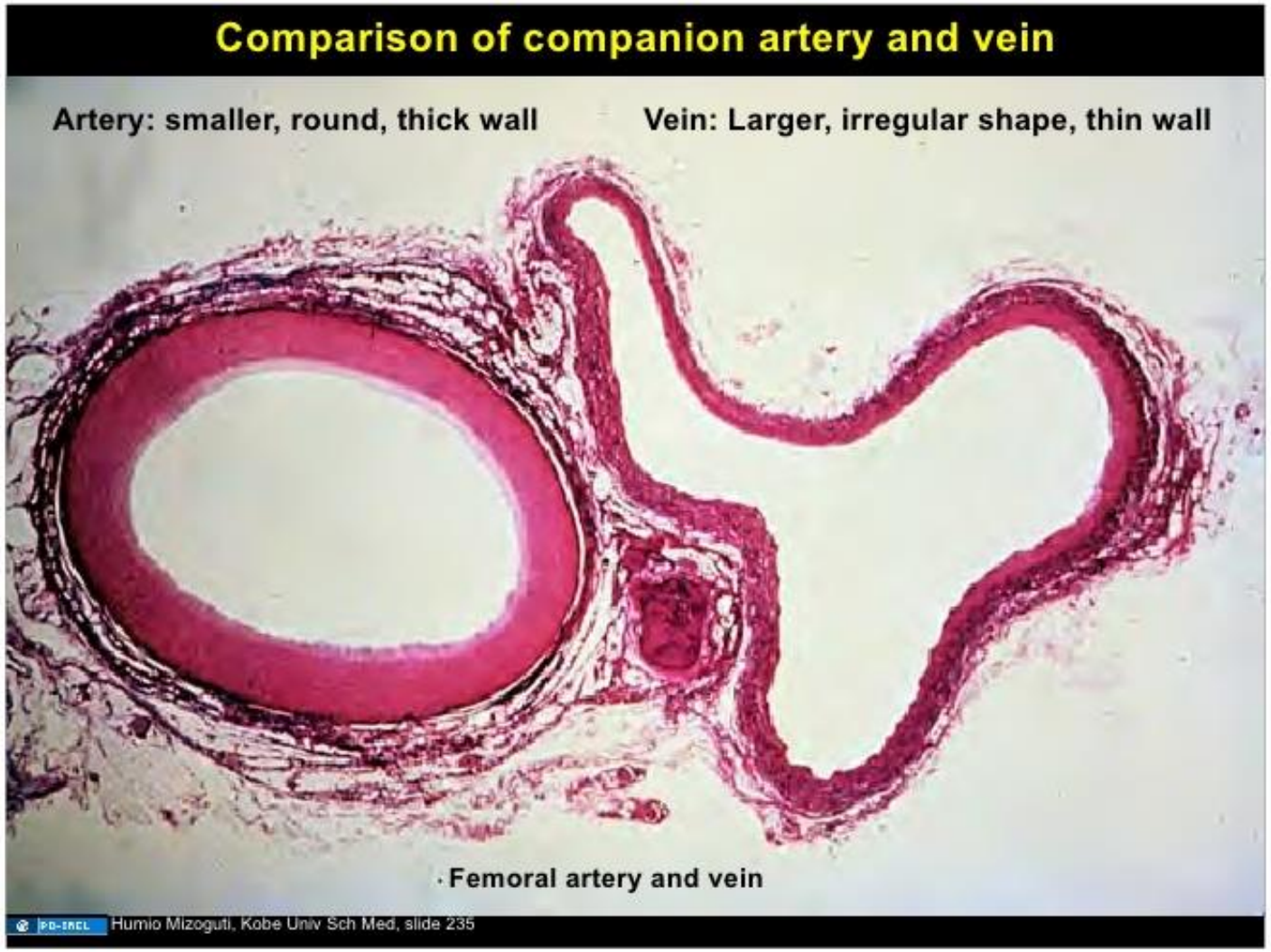

Capillaries permit the diffusion of oxygen and nutrients from the blood into the tissues, and diffusion of waste products of the metabolism (such as carbon dioxide) from the tissues into the blood.
Artery
Arteriole
Capillary
Venule
Vein
The Heart
Direction of blood flow


Normal One-Way Vein Valves
Blood flowing to heart
Healthy valve prevents reverse blood flow
Varicose Vein Valves
Blood flowing to heart
Reverse blood flow due to damaged valve


Toward Heart


Vein Valve H&E
arteriole
folds of the tunica intima
forming the valve
folds of the tunica intima
forming the valve


Varicose Veins
Healthy Veins
weakened walls
blood flow
valve does not close properly
inflammation
valve closes


Comparison of companion artery and vein
Artery: smaller, round, thick wall
Vein: Larger, irregular shape, thin wall
· Femoral artery and vein
PD-1REL
Humio Mizoguti, Kobe Univ Sch Med, slide 235

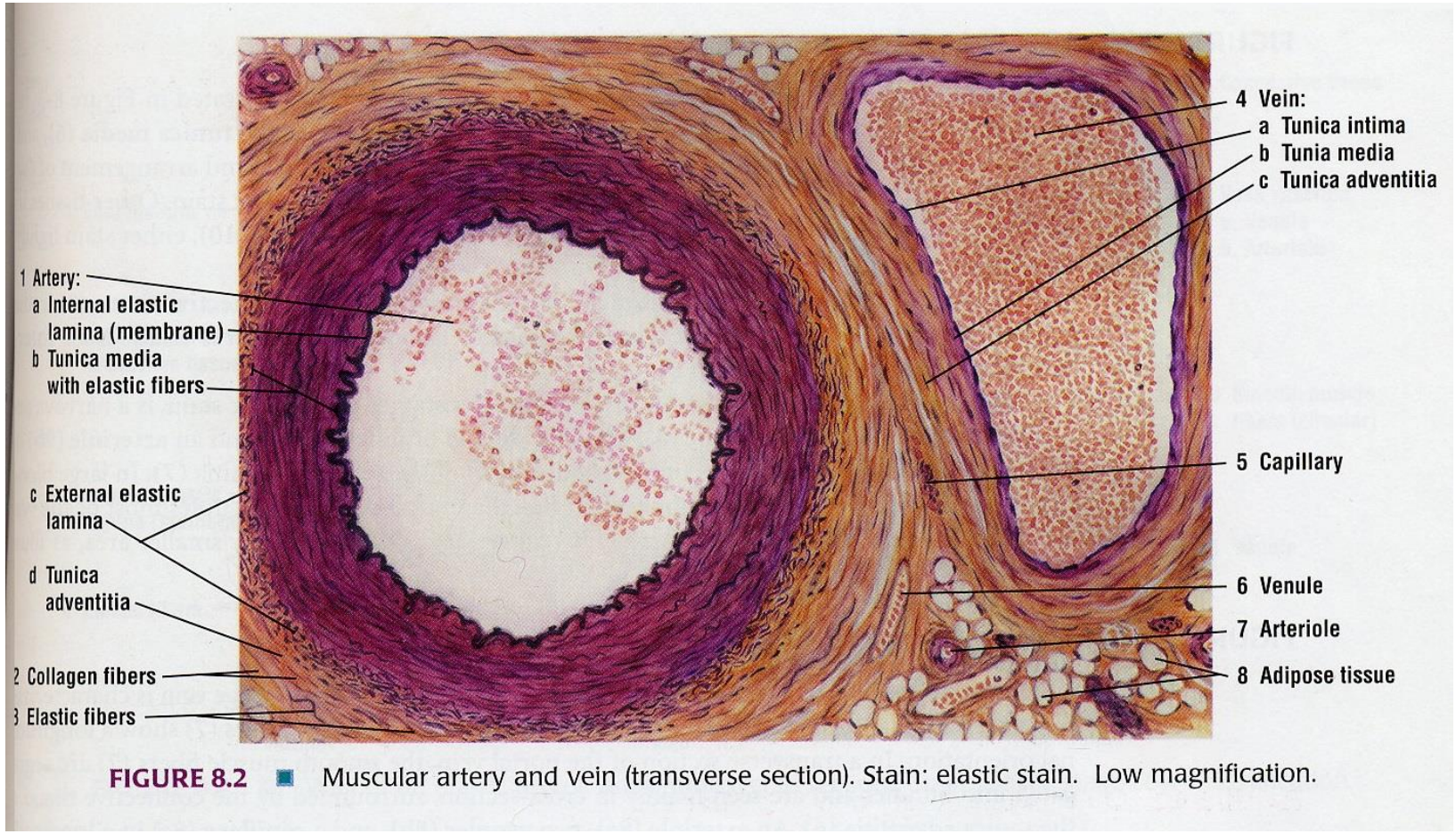
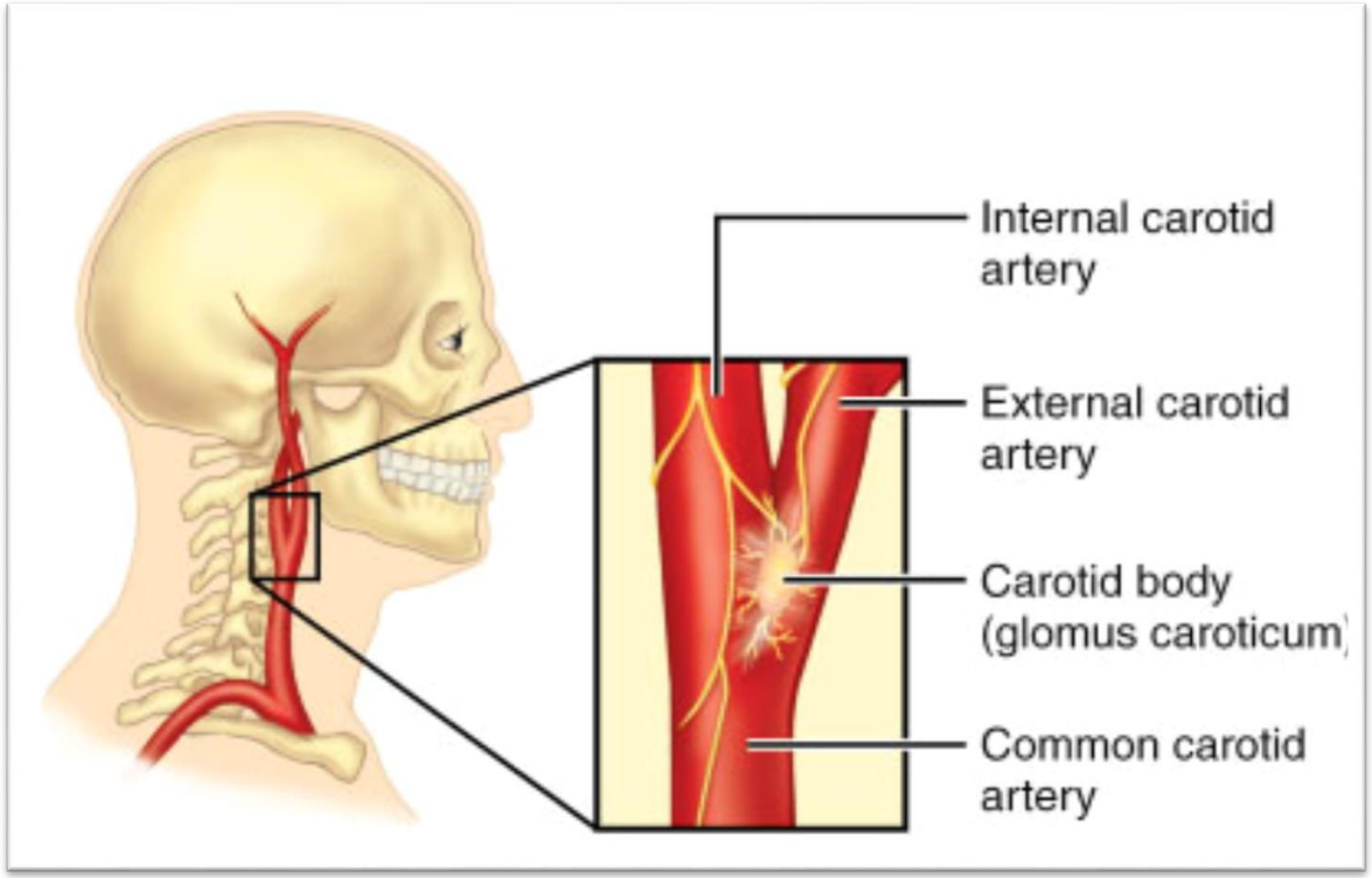
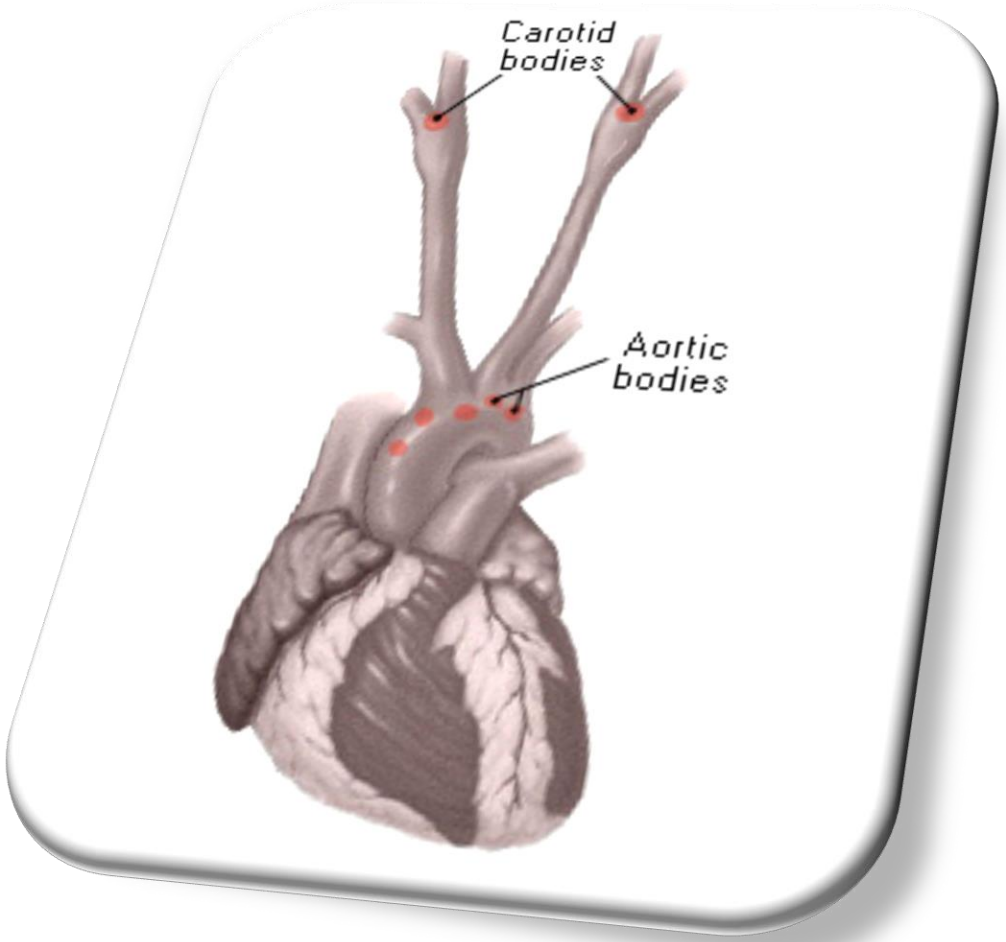


FIGURE 8.2 ■ Muscular artery and vein (transverse section). Stain: elastic stain. Low magnification.

Carotid body



Aortic body



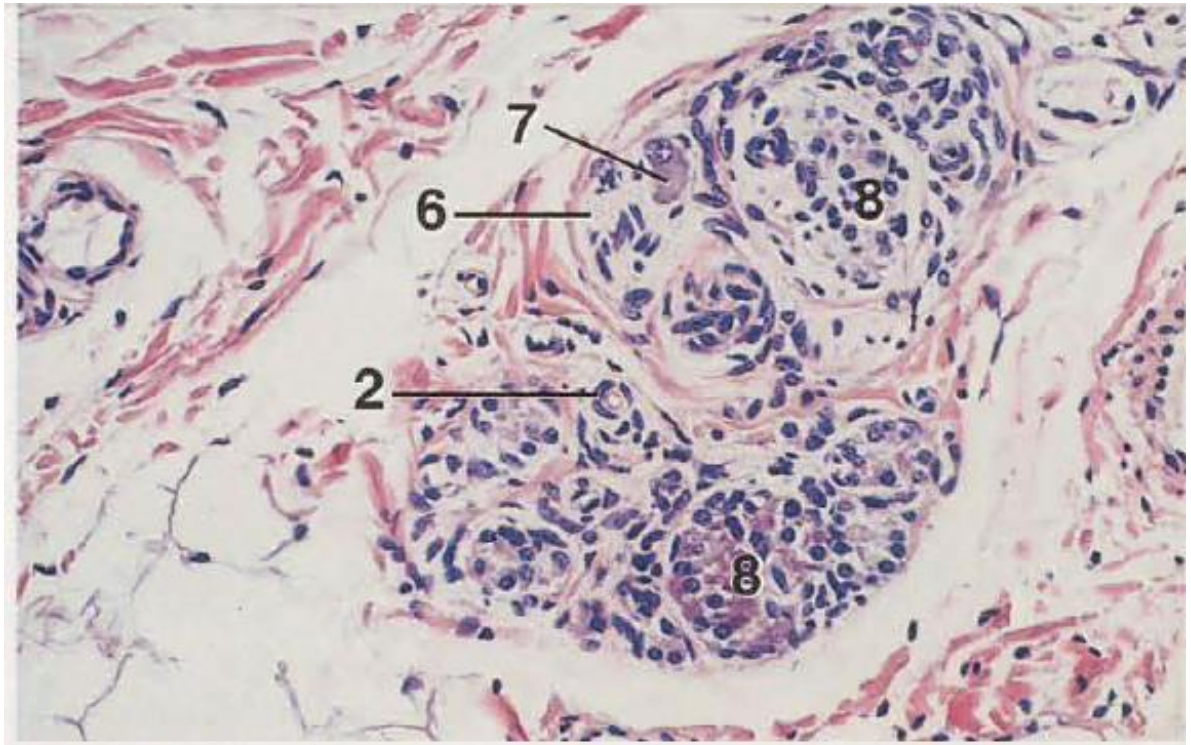
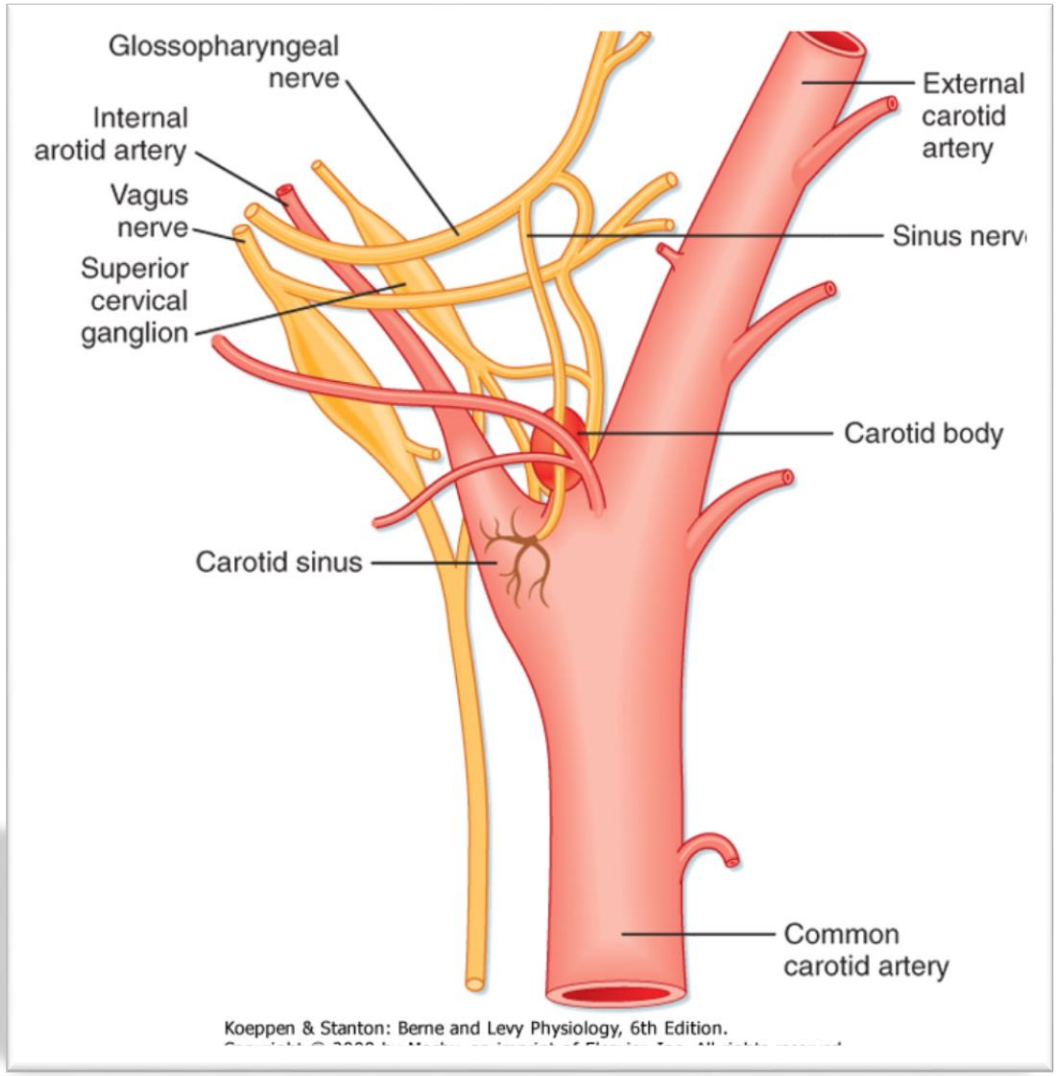


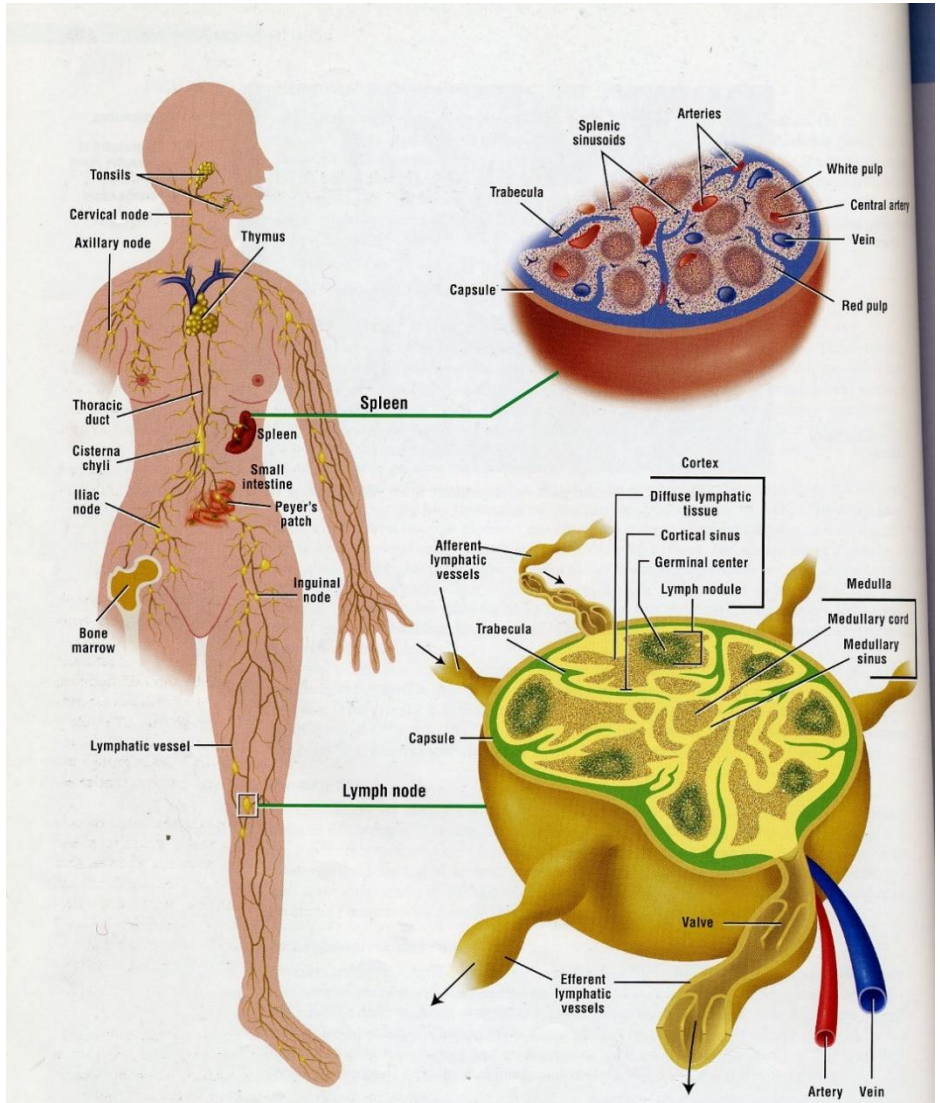
Figure 10.38. Aortic Body, Pig. The aortic body is located between the pulmonary artery and aorta. It is a small, encapsulated structure containing blood vessels, nerves, and two types of parenchyma cells (see Fig. 10.39).

KEY	
1. Adipose tissue	8. Parenchyma cells
2. Arteriole	9. Pericardial cavity
3. Chondrocyte	10. Pericardium, parietal
4. Myocardium, right ventricle	11. Pericardium, visceral
5. Myofibrils	12. Purkinje cell, l.s.
6. Nerve	13. Purkinje cell, x.s.
7. Neuron cell body	

Carotid sinus

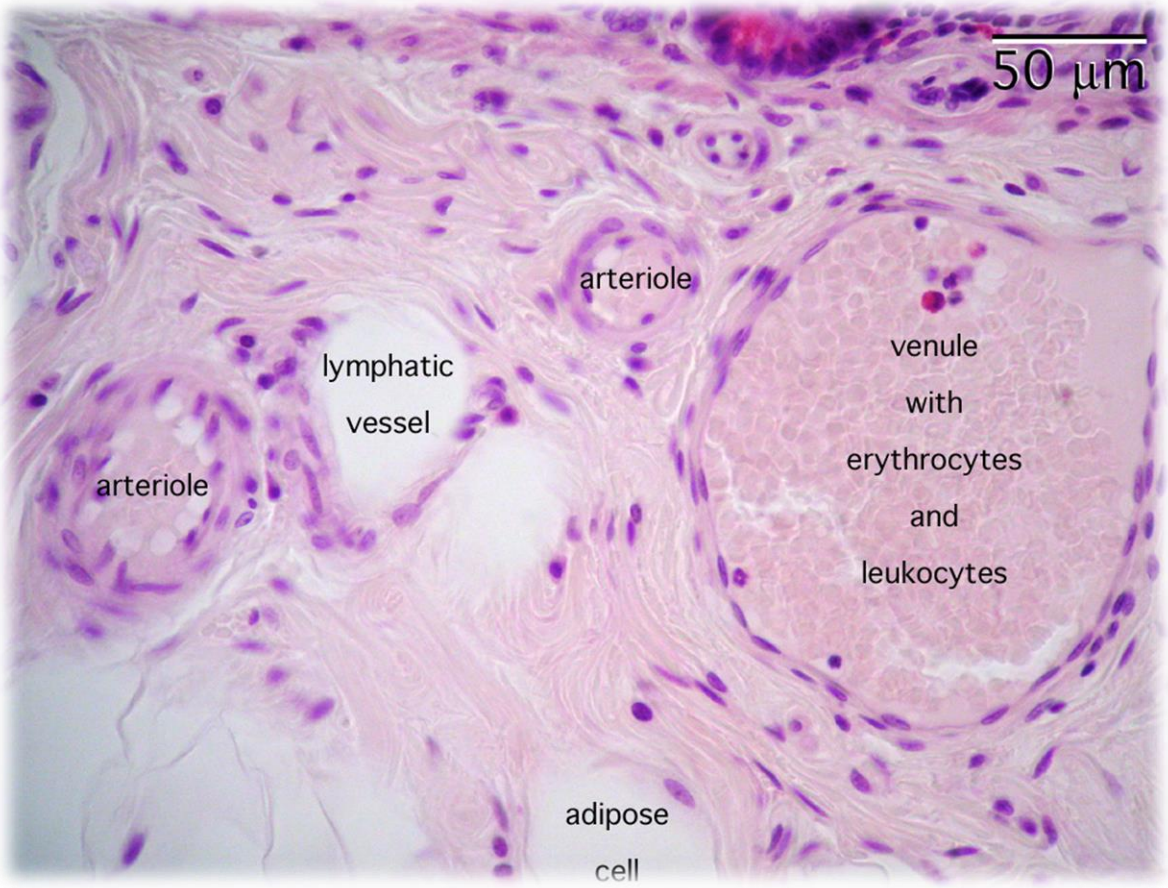


Lymphatic vessel

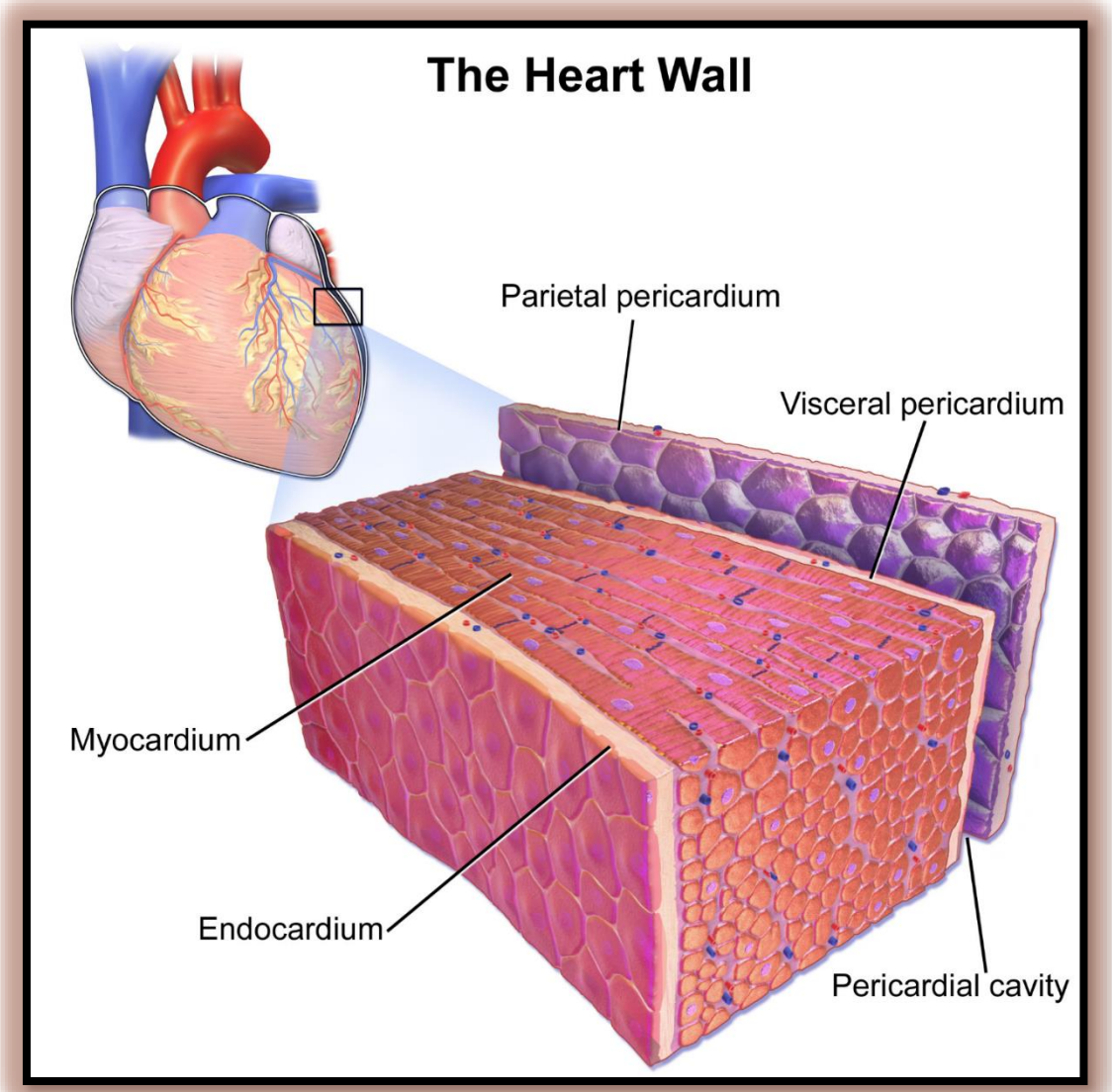


OVERVIEW FIGURE ■ Location and distribution of the lymphoid organs and lymphatic channels in the body. Internal contents of the lymph node and spleen are illustrated in greater detail.

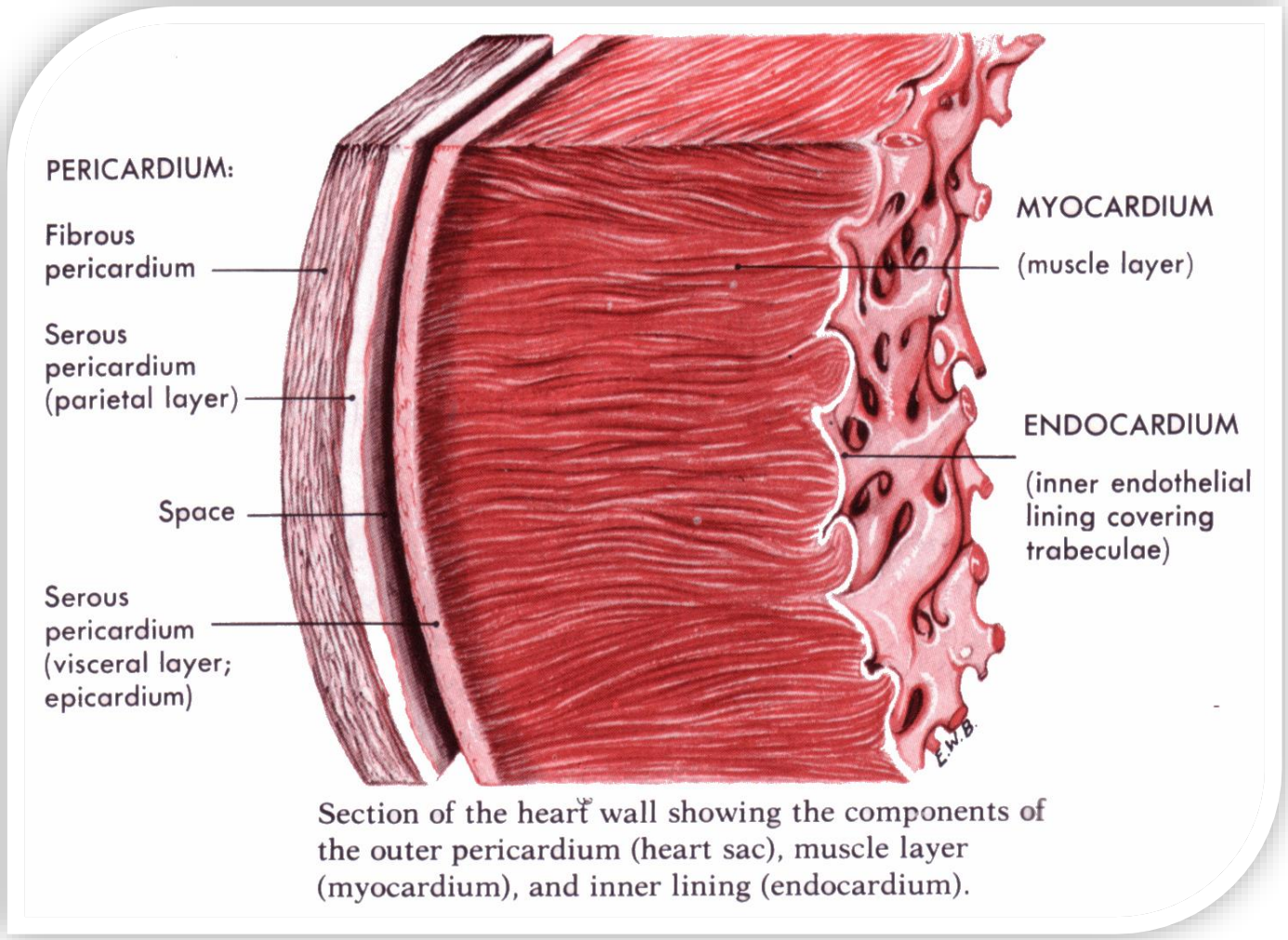
Lymphatic vessel



Heart


The Heart Wall
Parietal pericardium
Visceral pericardium
Myocardium
Endocardium
Pericardial cavity

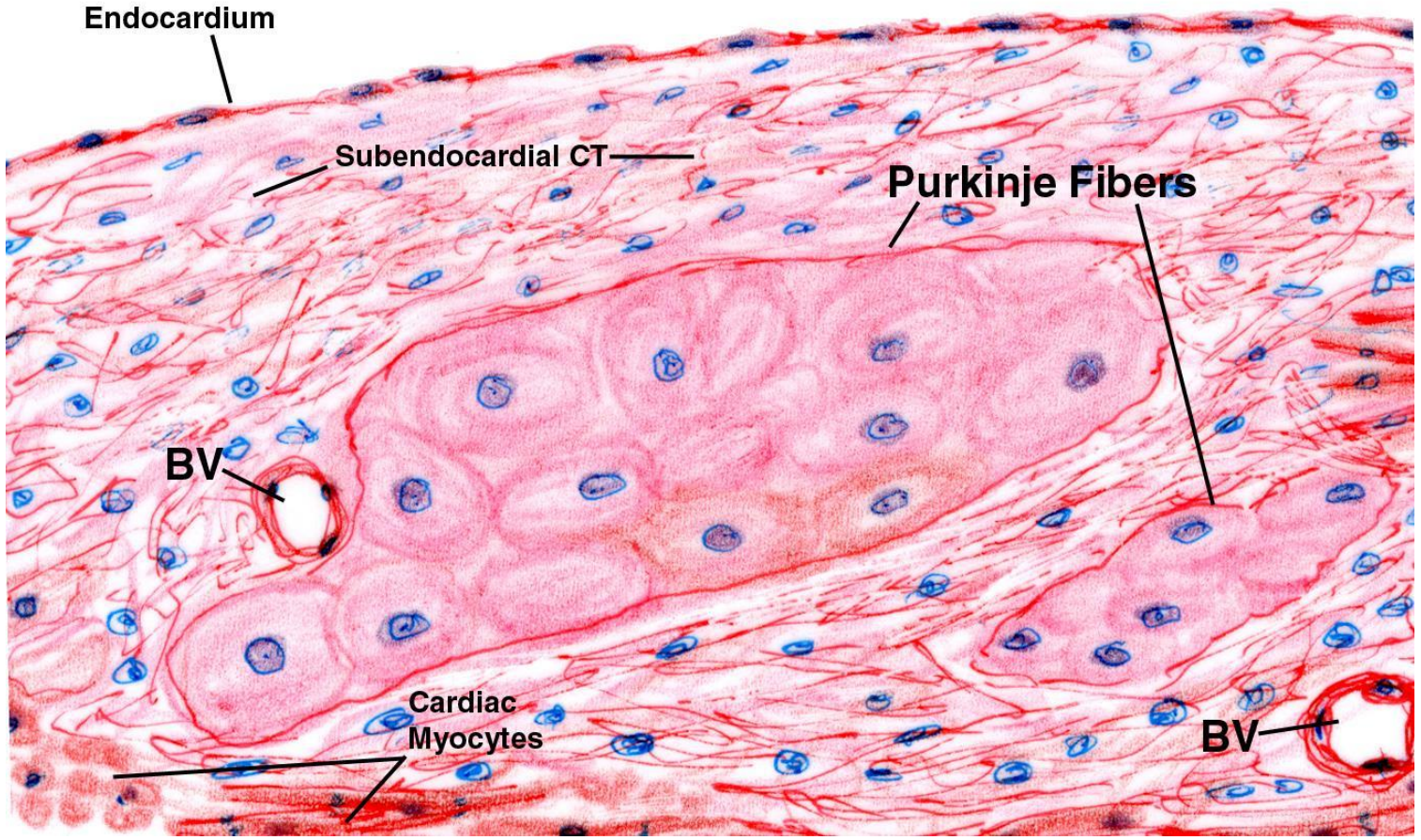
Endocardium

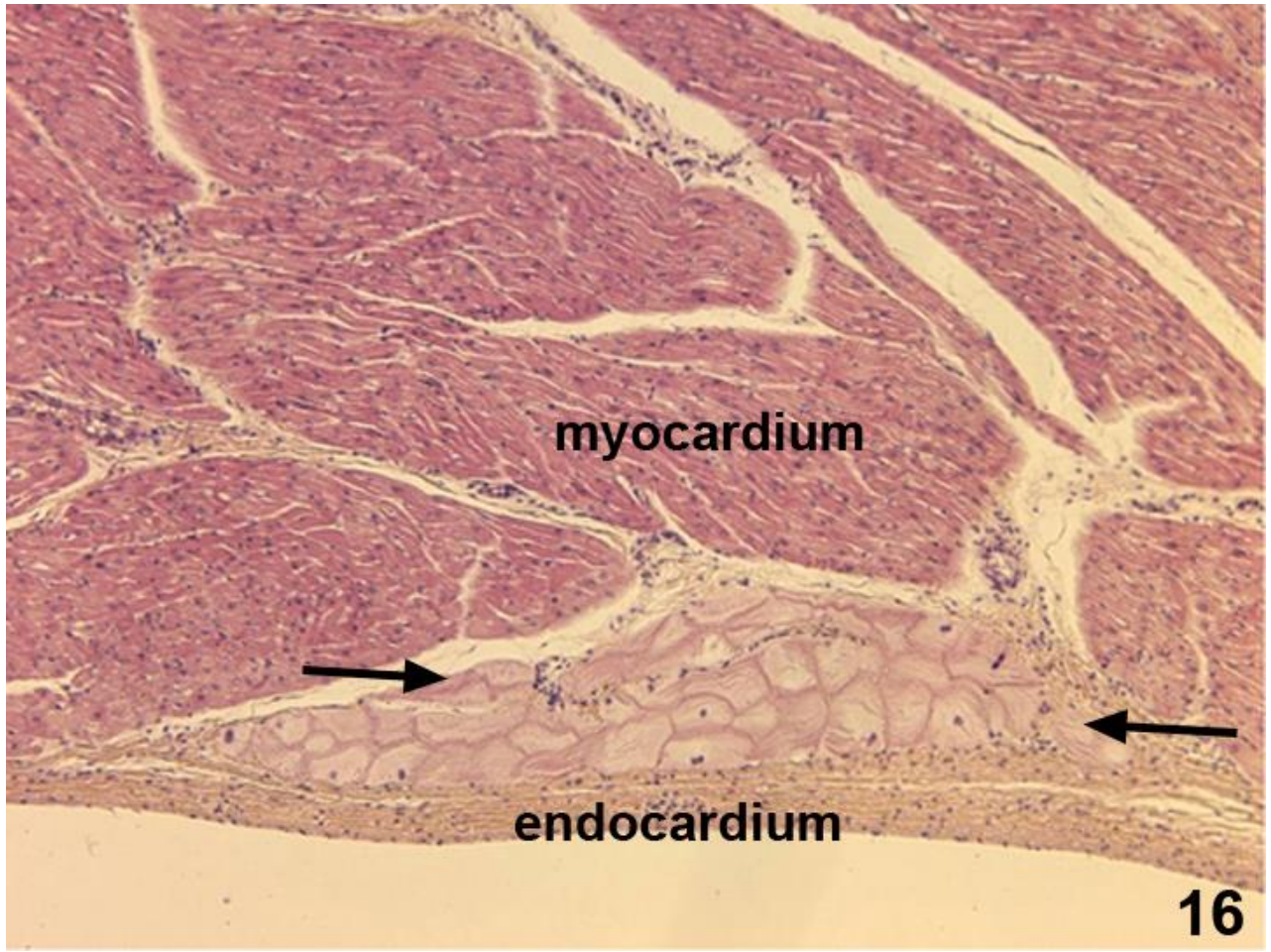


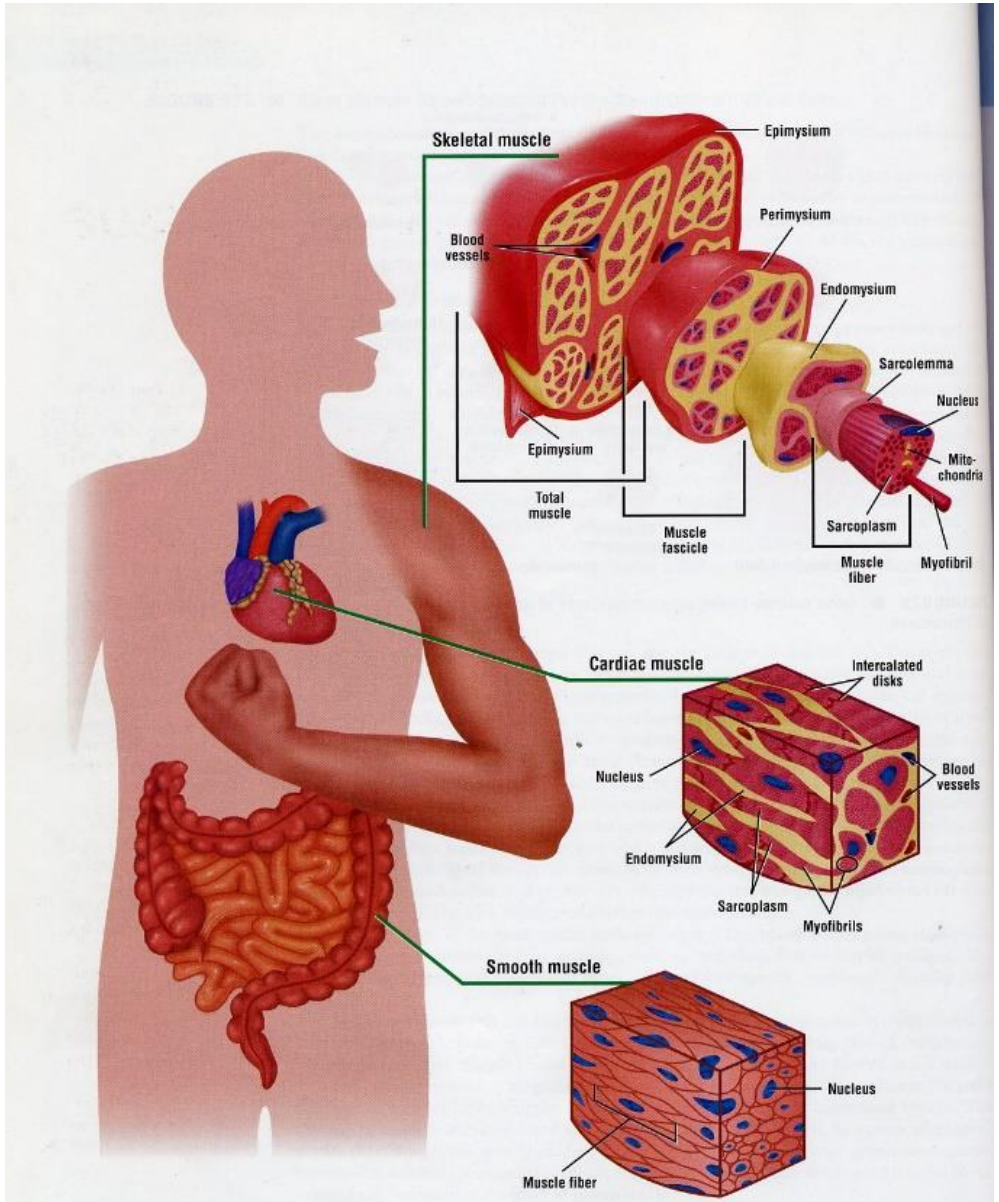
Section of the heart wall showing the components of the outer pericardium (heart sac), muscle layer (myocardium), and inner lining (endocardium).

Purkinje Fibres:-

- modified cardiac muscle cells. Compared to ordinary cardiac muscle cells:
  - contain large amounts of glycogen.
  - fewer myofibrils.
  - thicker cells.
- extend from the atrioventricular node, pierces the fibrous body, divides into left and right bundles, and travels, beneath the endocardium, towards the apex of the heart.
- conduct stimuli faster than ordinary cardiac muscle cells (2-3 m/s vs. 0.6 m/s).
- discovered in 1839 by Jan Evangelista Purkyně)


Endocardium
Subendocardial CT
Purkinje Fibers
BV
Cardiac
Myocytes
BV


myocardium
endocardium
16



OVERVIEW FIGURE ■ Microscopic illustrations of the three types of muscles: skeletal, cardiac, and smooth.

Myocardium

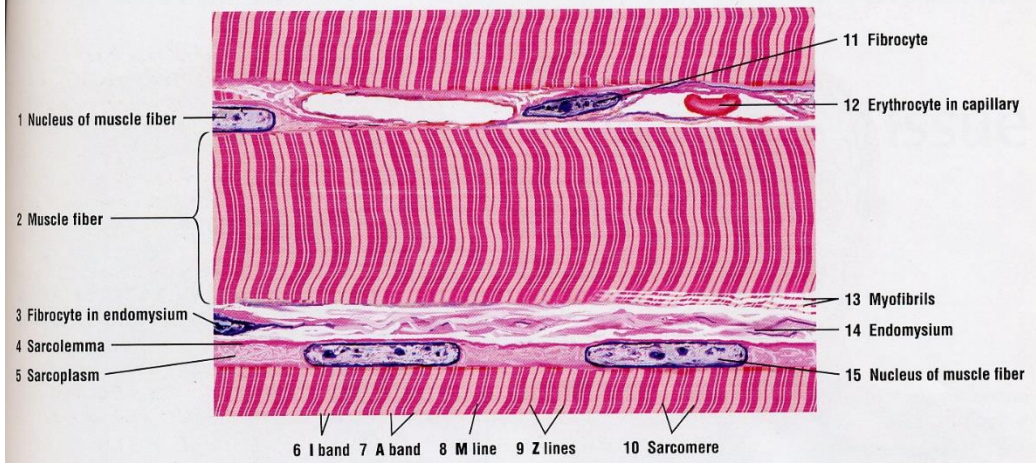


FIGURE 6.9 ■ Skeletal muscle fibers (longitudinal section). Stain: hematoxylin and eosin. Plastic section. High magnification.

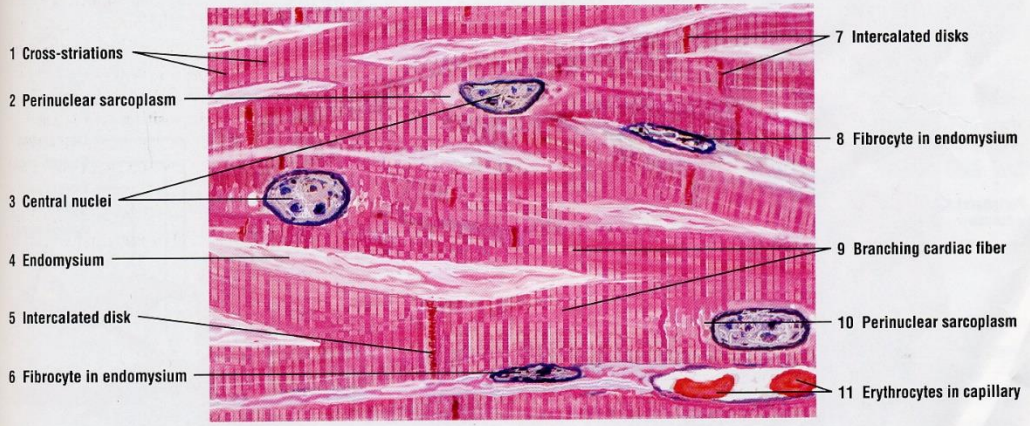
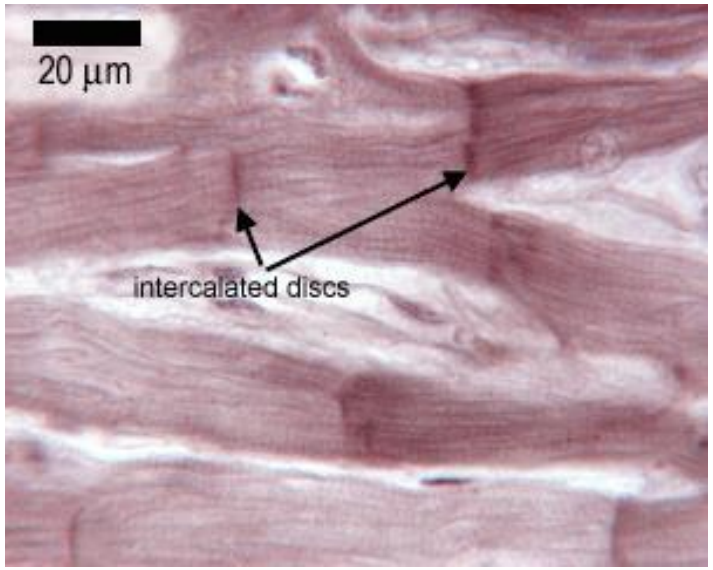


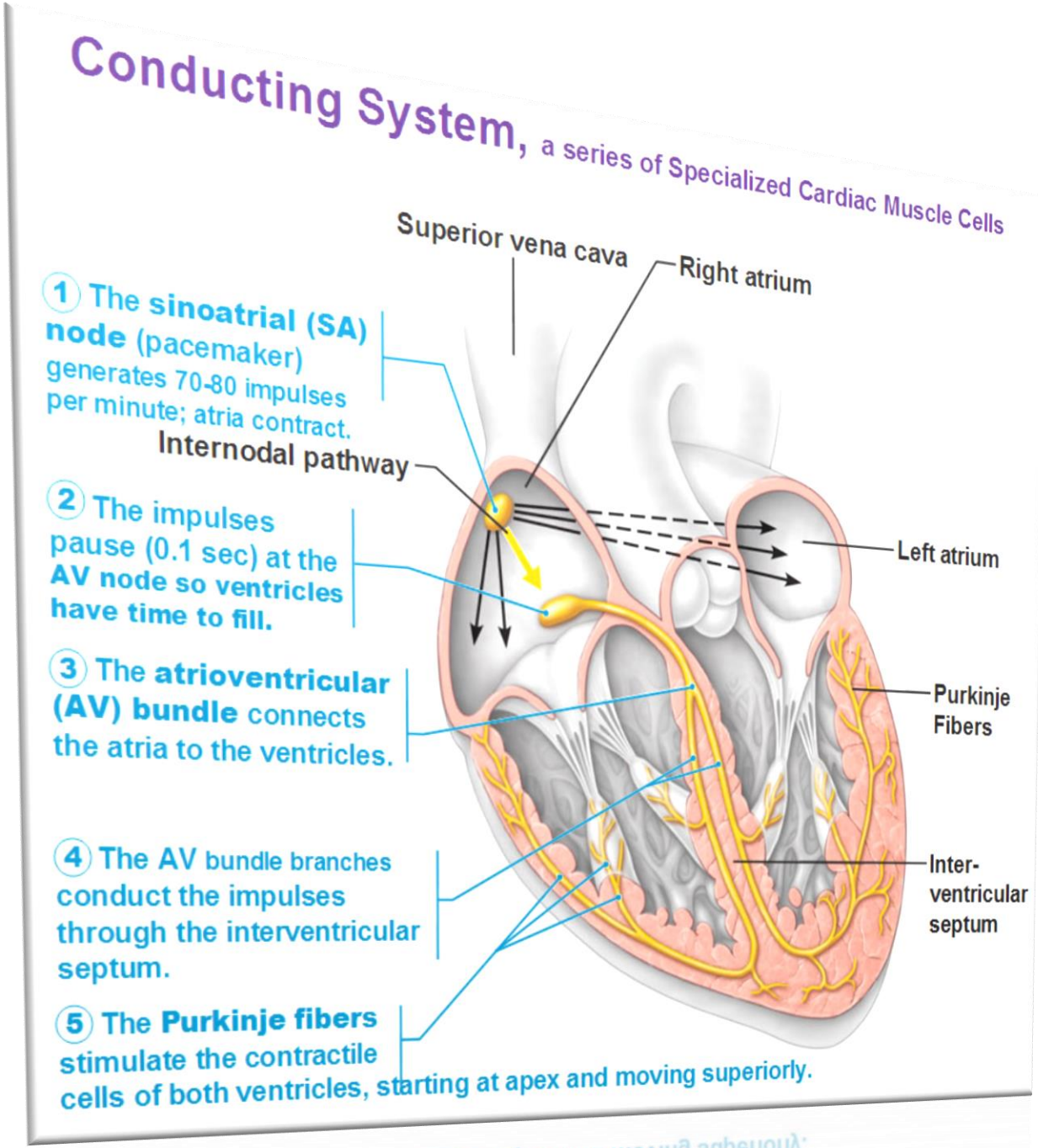
FIGURE 6.10 ■ Cardiac muscle (longitudinal section). Stain: hematoxylin and eosin. High magnification.

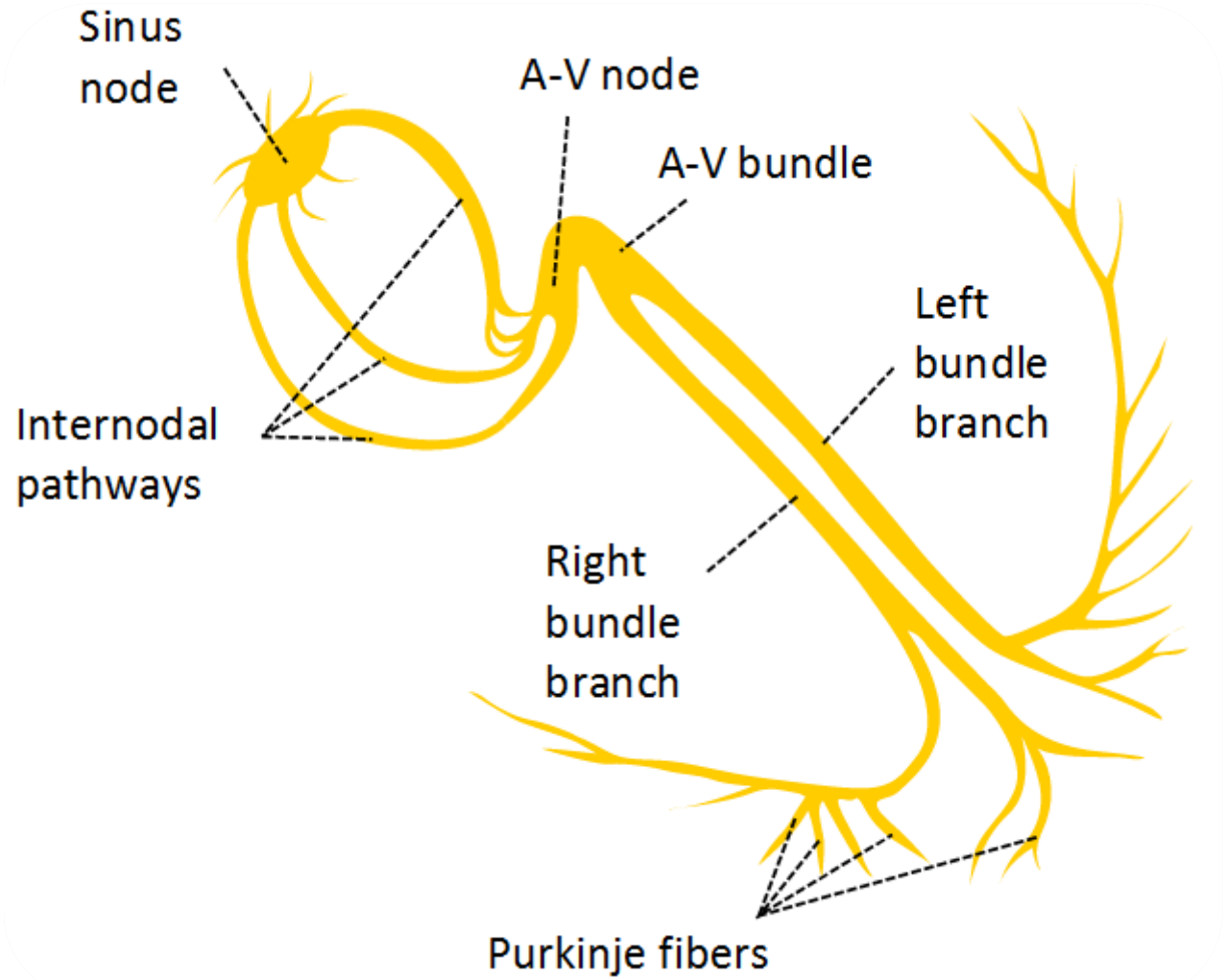
FIGURE 6.7 ■ Cardiac muscle (longitudinal and transverse sections). Stain: hematoxylin and eosin. High magnification.

FIGURE 6.8 ■ Cardiac muscle (longitudinal section). Stain: Masson's trichrome. 130×



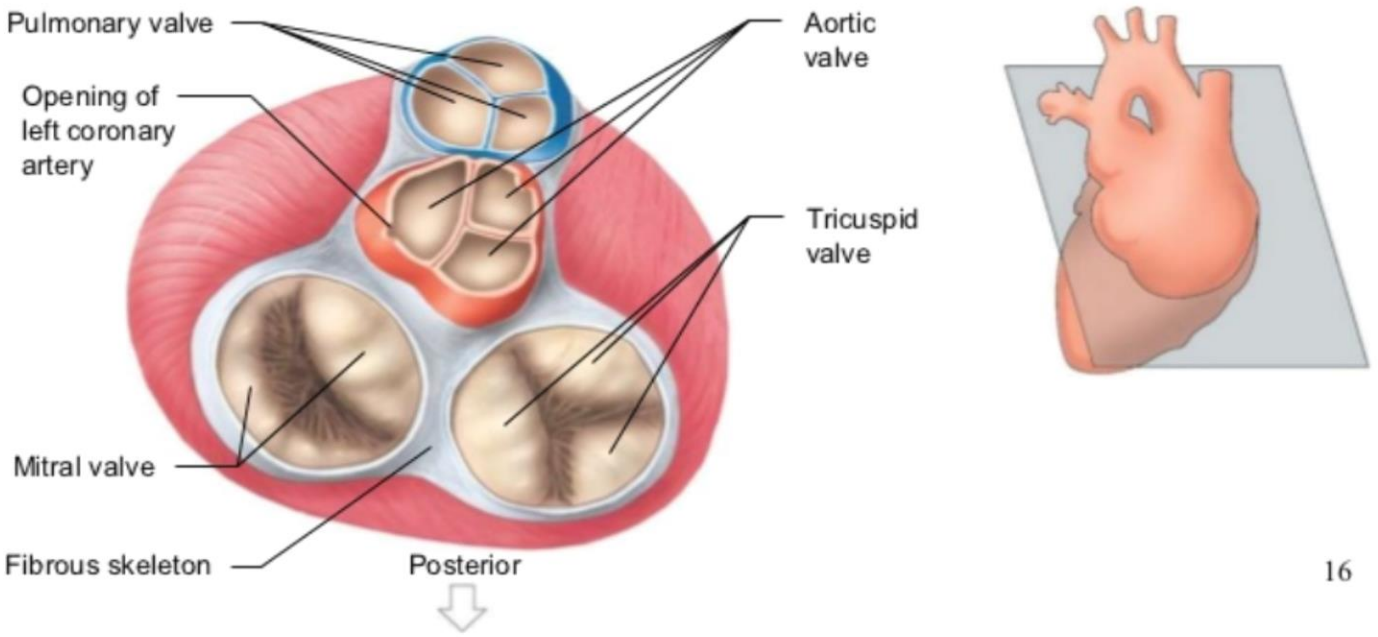
Conducting System, a series of Specialized Cardiac Muscle Cells

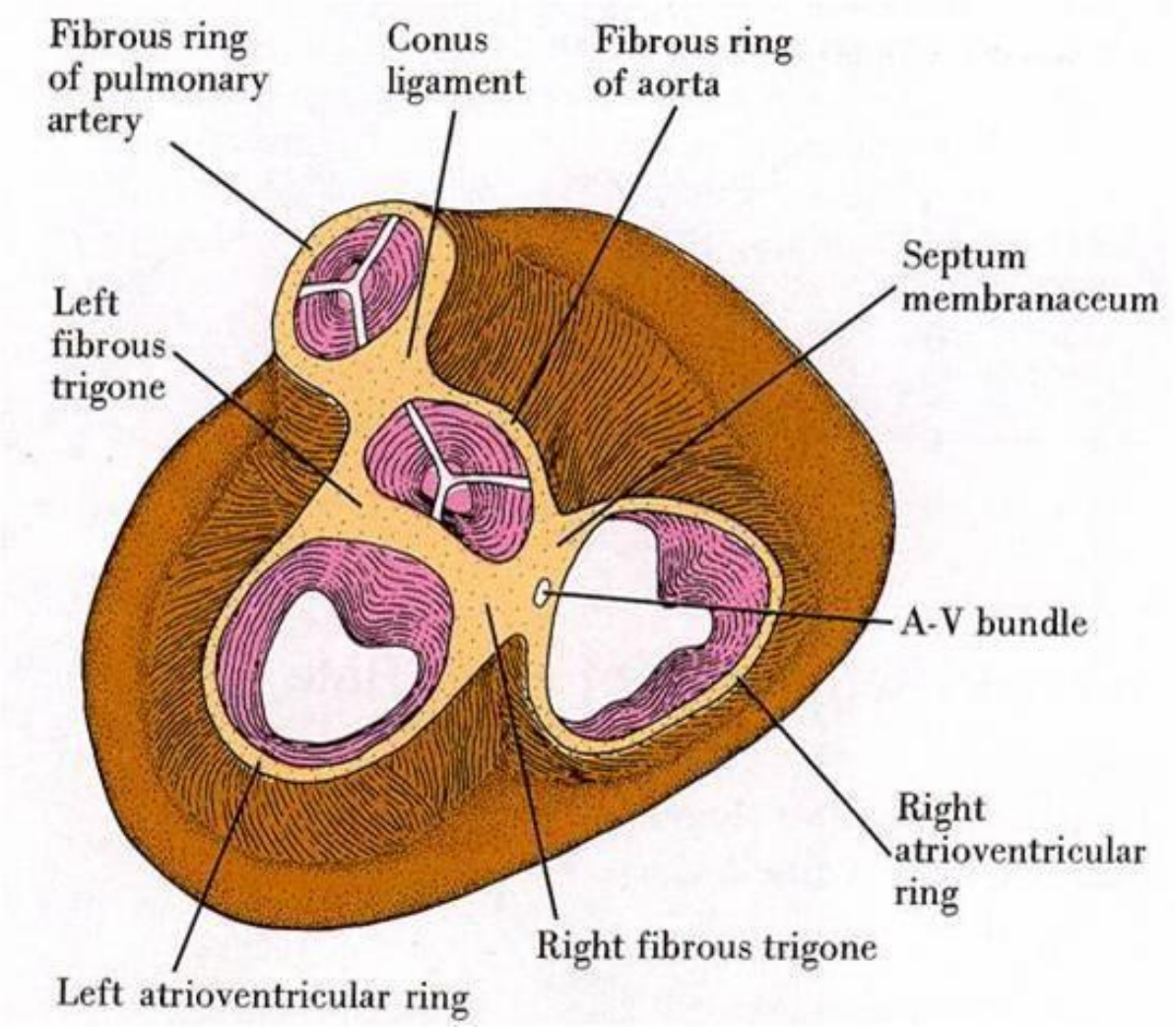


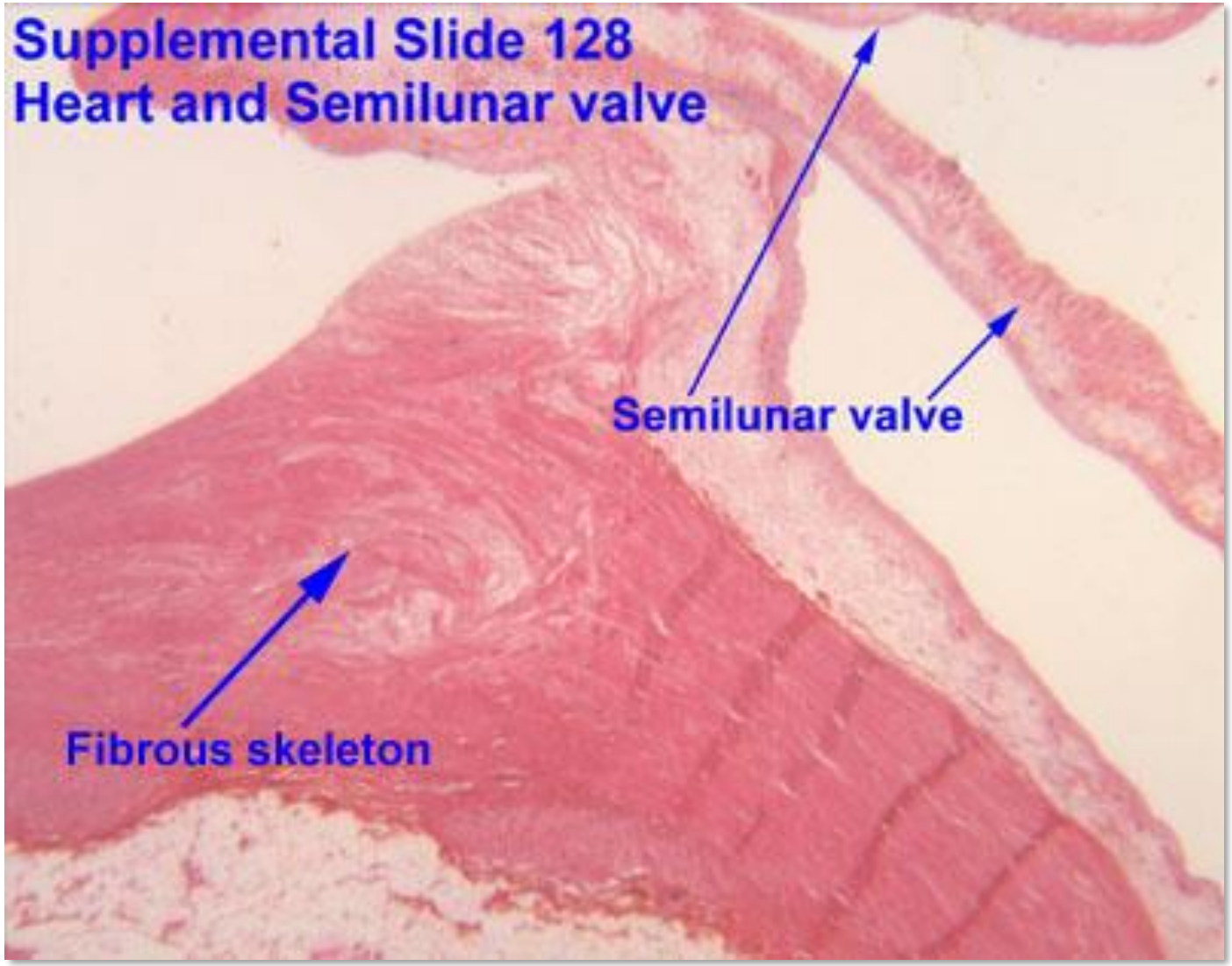

Sinus node
A-V node
A-V bundle
Left bundle branch
Internodal pathways
Right bundle branch
Purkinje fibers

Skeleton of the Heart

- The fibrous rings, together with other masses of dense connective tissue in the portion of the septum between the ventricles (interventricular septum), constitute the skeleton of the heart




Fibrous ring of pulmonary artery
Conus ligament
Fibrous ring of aorta
Septum membranaceum
Left fibrous trigone
A-V bundle
Right atrioventricular ring
Right fibrous trigone
Left atrioventricular ring


Supplemental Slide 128
Heart and Semilunar valve
Semilunar valve
Fibrous skeleton


Good Luck