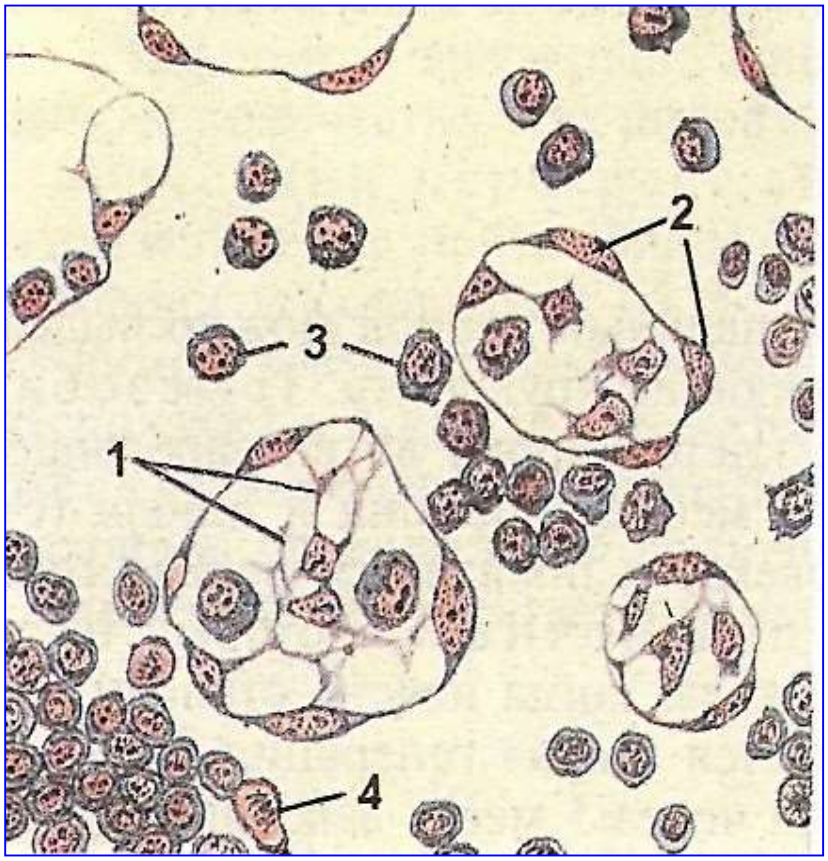
CARDIOVASCULAR SYSTEM

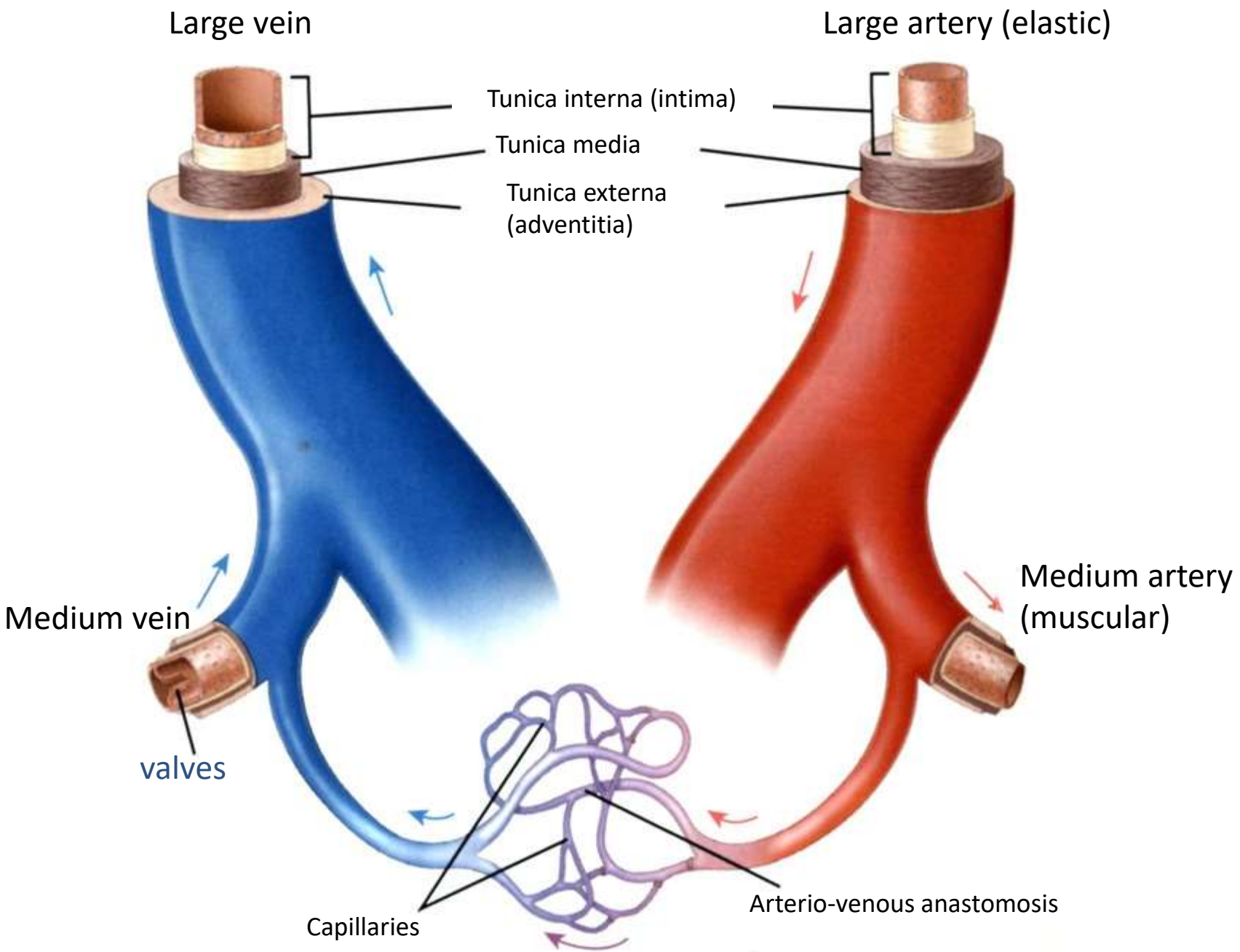
Department of Histology, Cytology and Embryology
of the General Medicine Faculty
Pirogov Russian National Research Medical University

DEVELOPMENT OF BLOOD VESSELS



In embryogenesis, blood vessels arise from mesenchyme derived from the visceral layer of the lateral plate mesoderm. Blood vessels initially appear in the yolk sac wall, later on in the chorion, and subsequently in the embryo proper. Formation of blood vessels from the non-differentiated mesenchyme cells is called *vasculogenesis*.

Vasculogenesis begins
on the 2nd to 3rd week
of the embryonic development
(in the wall of the yolk sac)


Large vein
Large artery (elastic)
Tunica interna (intima)
Tunica media
Tunica externa
(adventitia)
Medium vein
Medium artery
(muscular)
valves
Capillaries
Arterio-venous anastomosis

GENERAL STRUCTURE OF THE BLOOD VESSEL WALL

- 1. Tunica interna (intima)

- *Endothelium*
- *Subendothelial layer*
- *Internal elastic membrane*

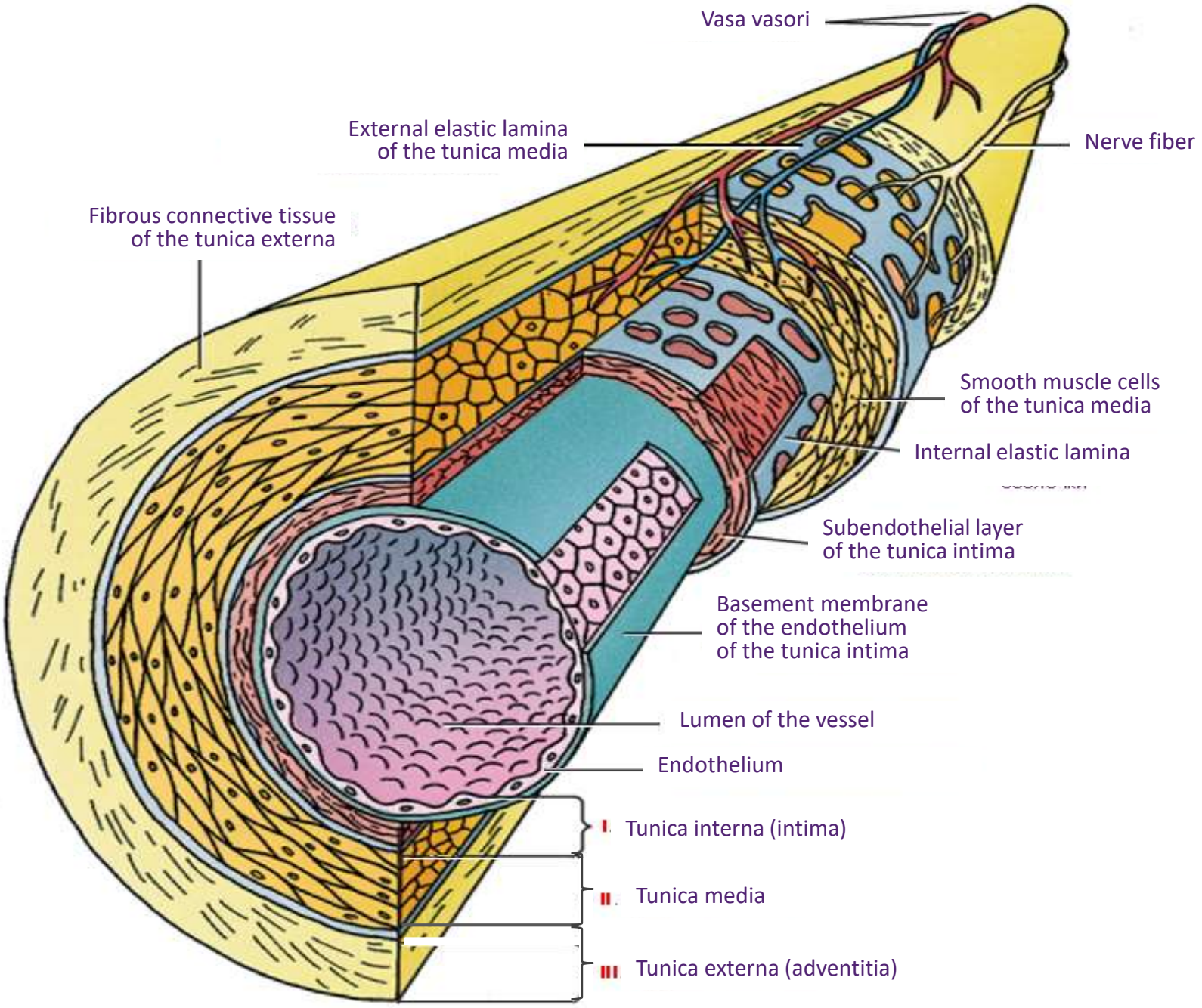
- 2. Tunica media

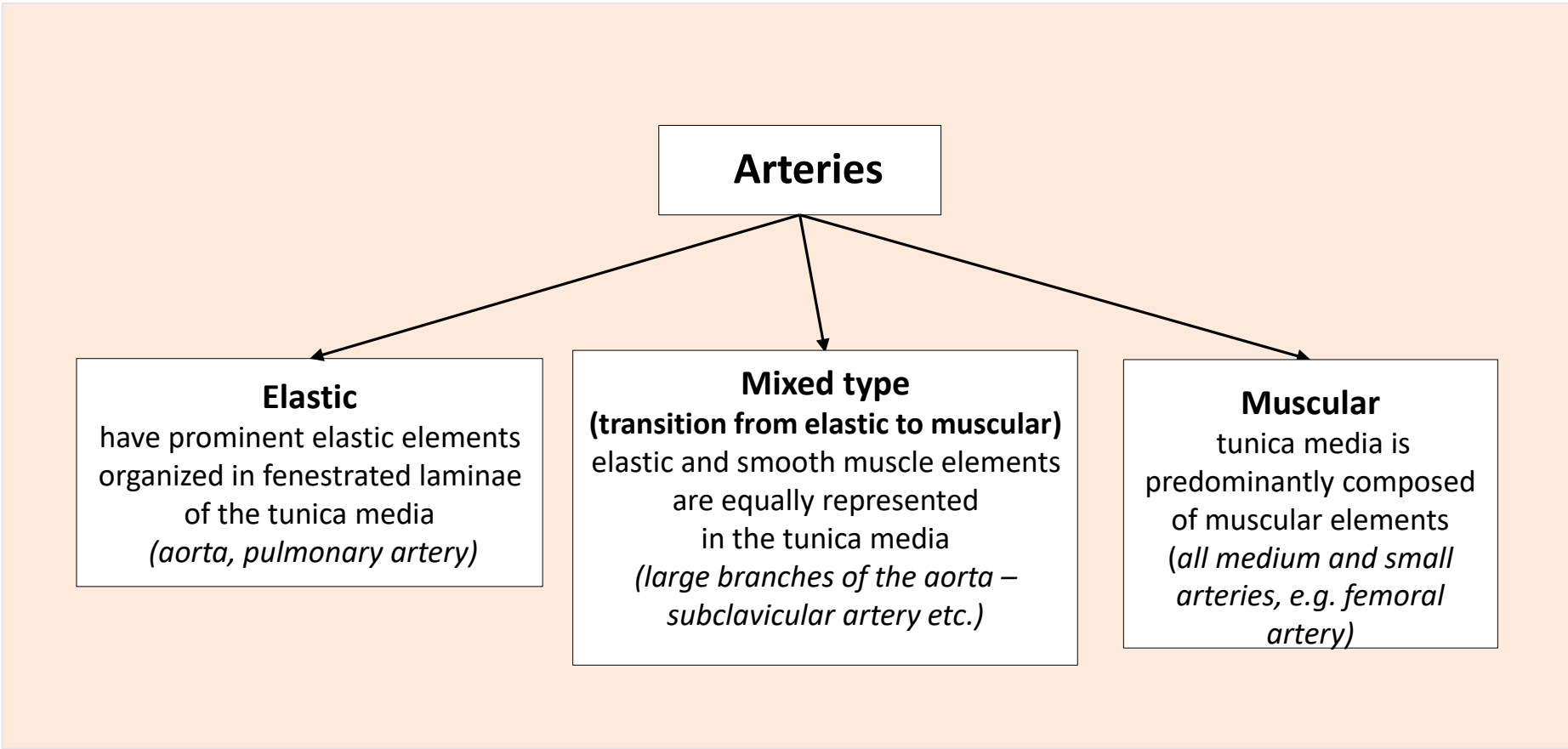
- *Smooth muscle cells, elastic fibers*

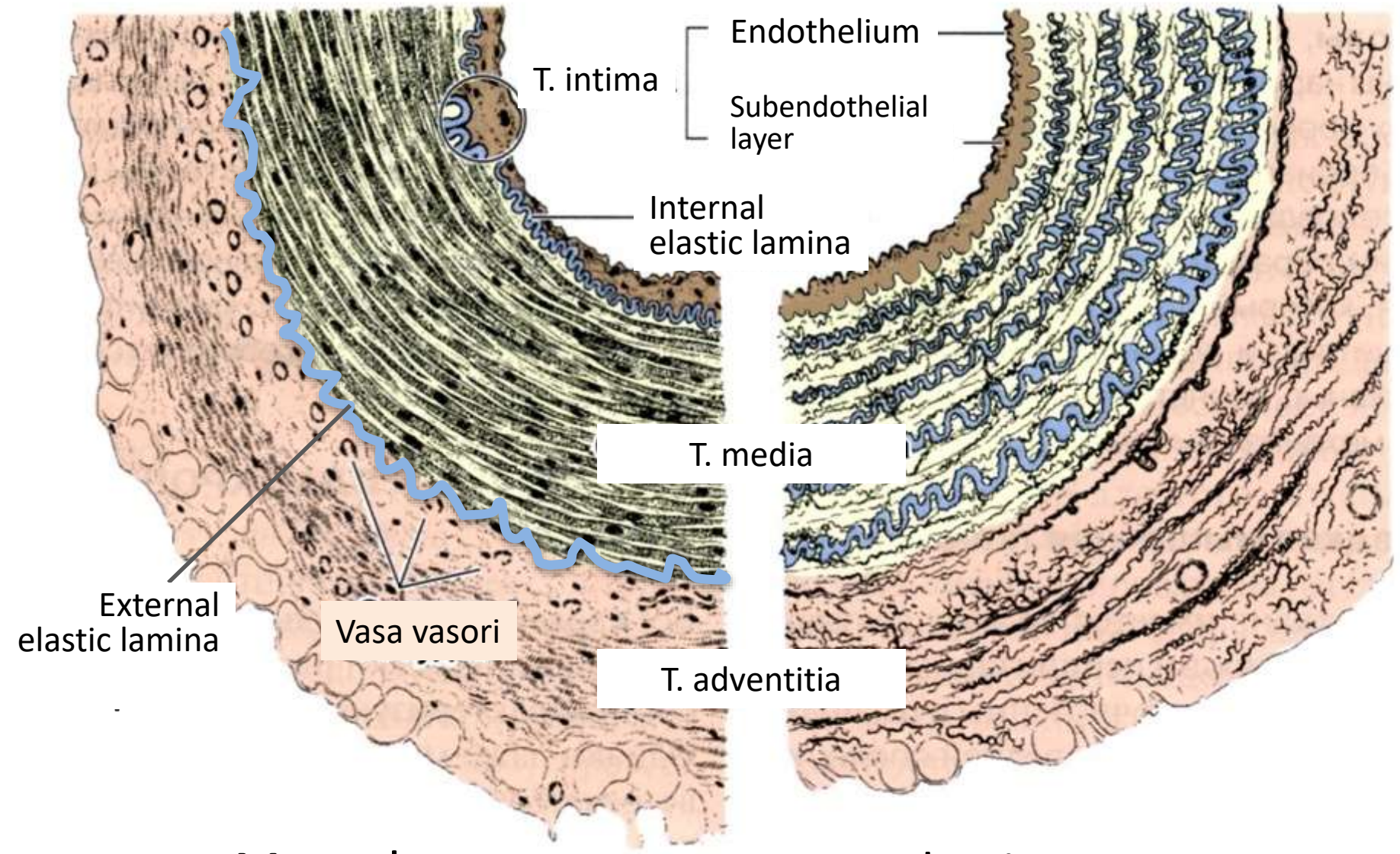
- 3. Tunica externa (adventitia)

- *External elastic l membrane*
- *Loose connective tissue*

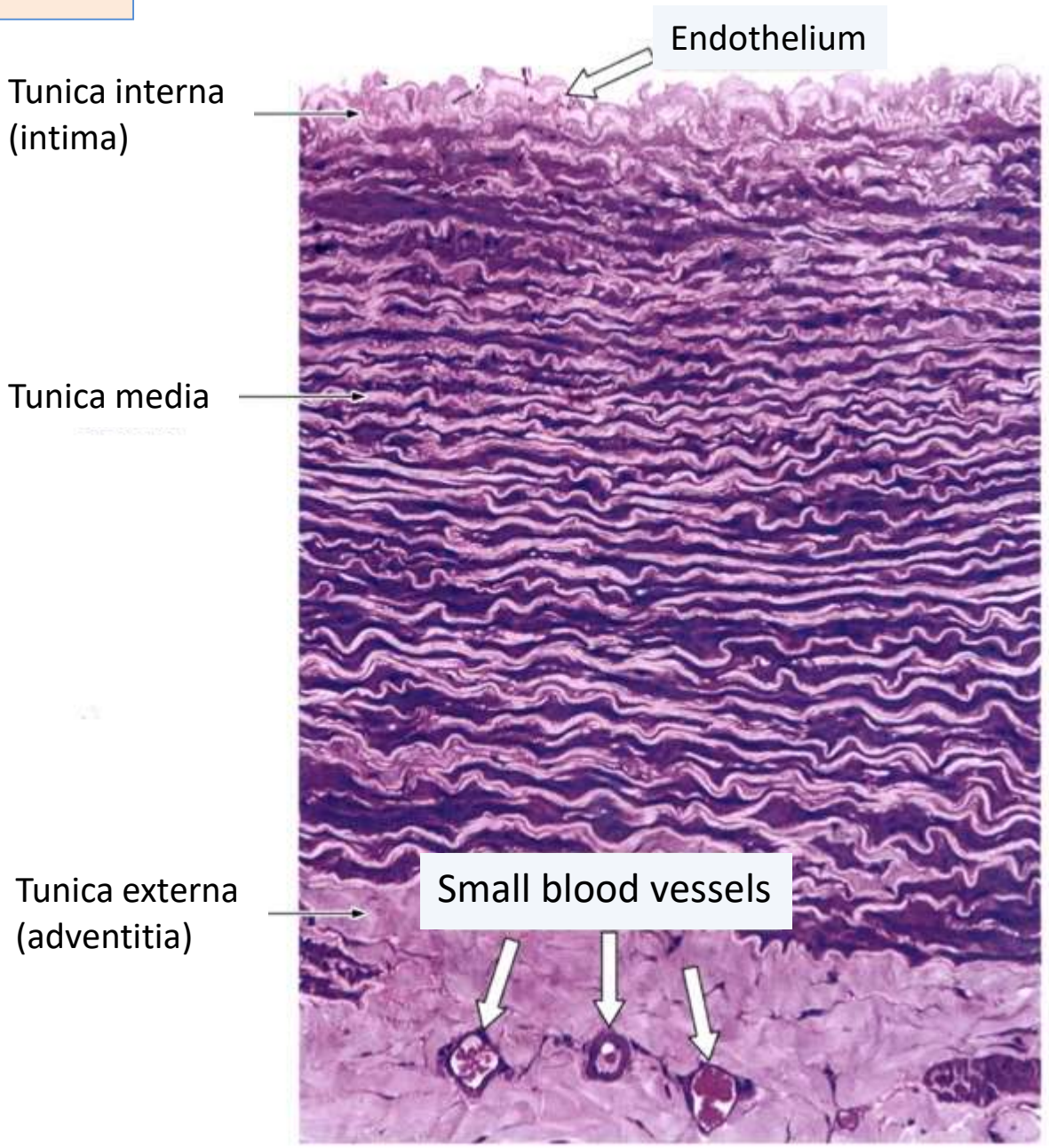
Specific details of the wall structure and tissue composition depend on type and diameter of the vessel

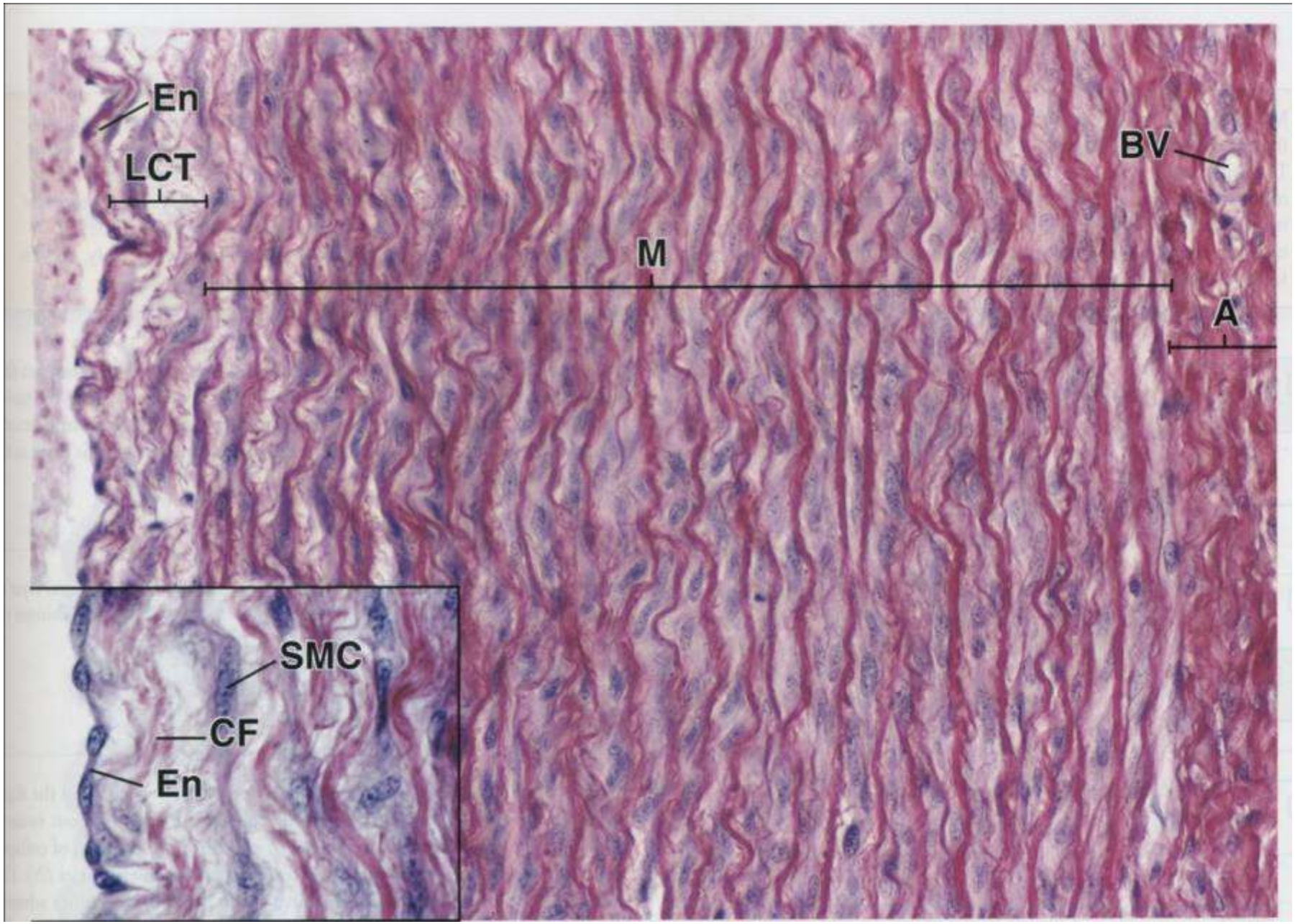

Vasa vasori
External elastic lamina of the tunica media
Nerve fiber
Fibrous connective tissue of the tunica externa
Smooth muscle cells of the tunica media
Internal elastic lamina
Subendothelial layer of the tunica intima
Basement membrane of the endothelium of the tunica intima
Lumen of the vessel
Endothelium
I. Tunica interna (intima)
II. Tunica media
III. Tunica externa (adventitia)


Arteries
Elastic
have prominent elastic elements organized in fenestrated laminae of the tunica media
(aorta, pulmonary artery)
Mixed type
(transition from elastic to muscular)
elastic and smooth muscle elements are equally represented in the tunica media
(large branches of the aorta – subclavicular artery etc.)
Muscular
tunica media is predominantly composed of muscular elements
(all medium and small arteries, e.g. femoral artery)

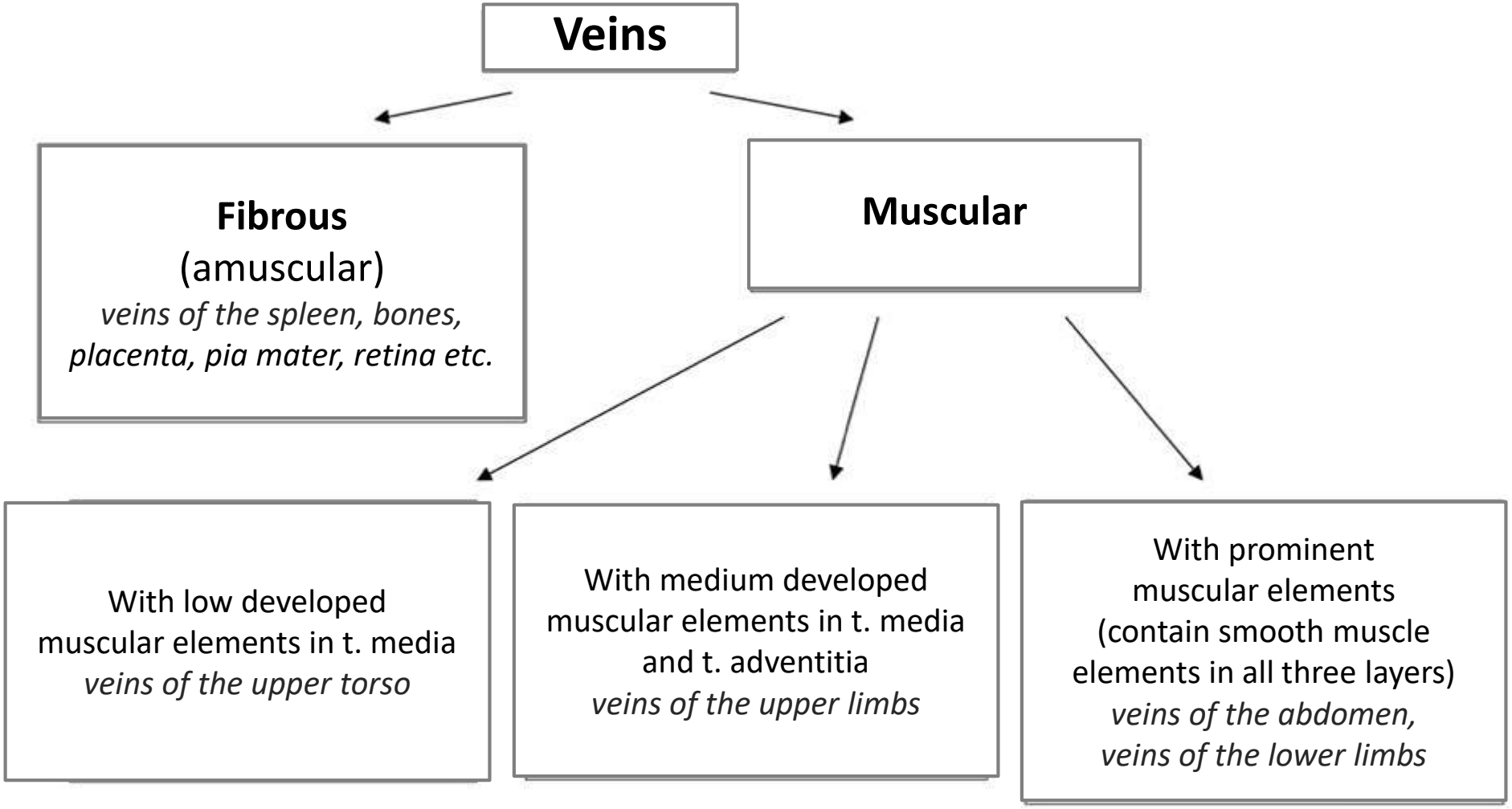

Endothelium
T. intima
Subendothelial layer
Internal elastic lamina
T. media
External elastic lamina
Vasa vasori
T. adventitia
Muscular artery
Elastic artery

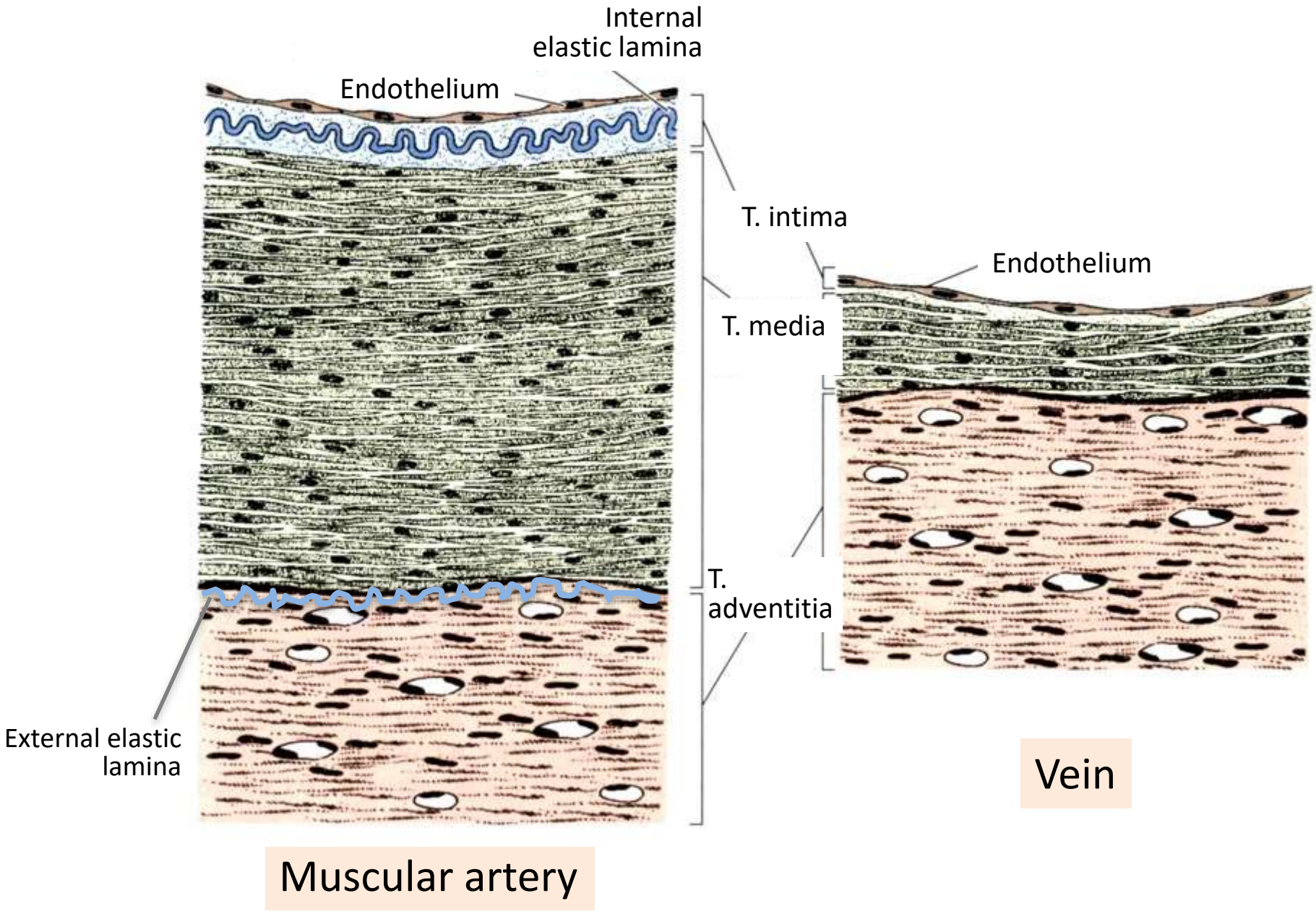
THE WALL OF ELASTIC ARTERY

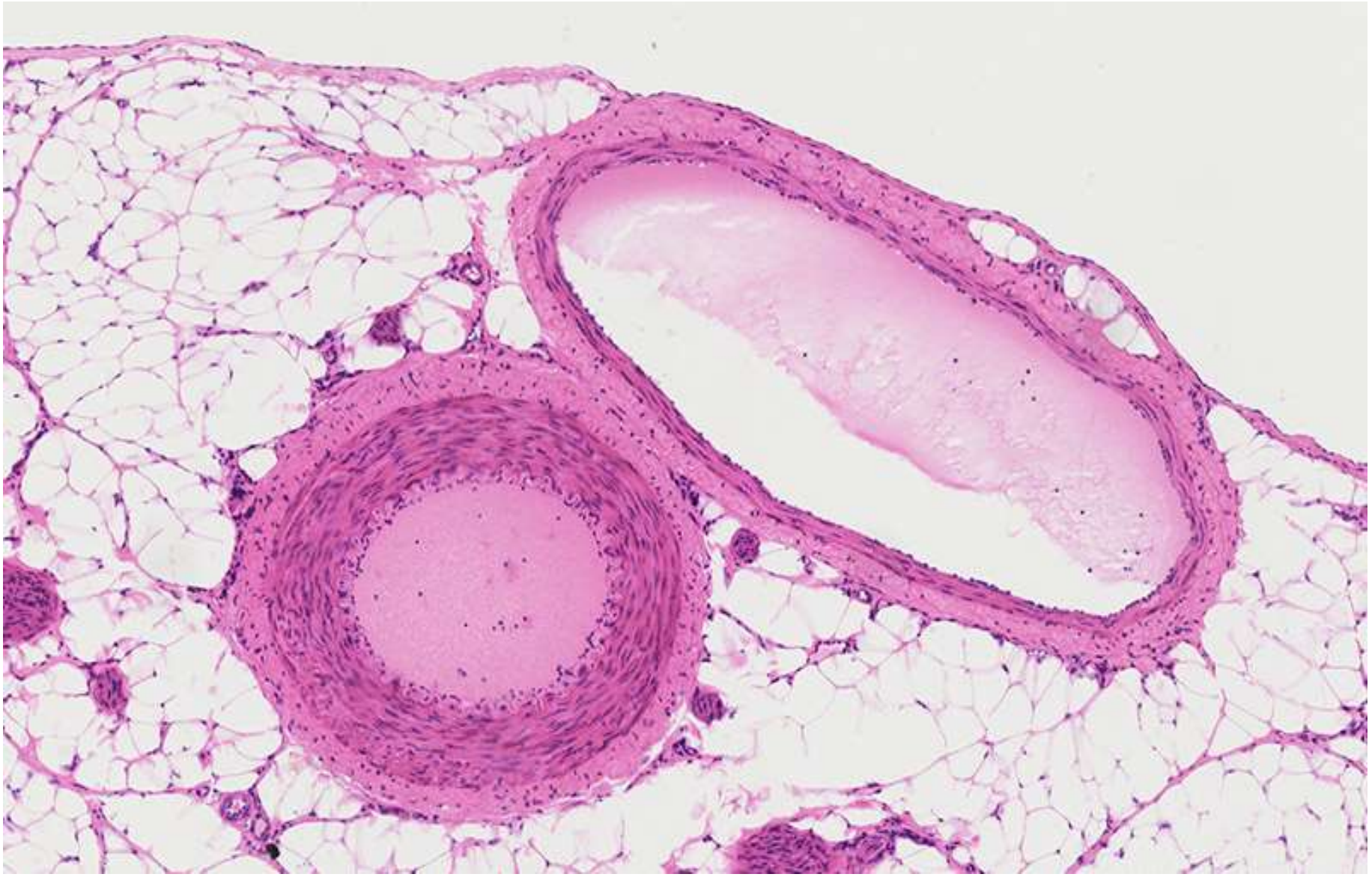


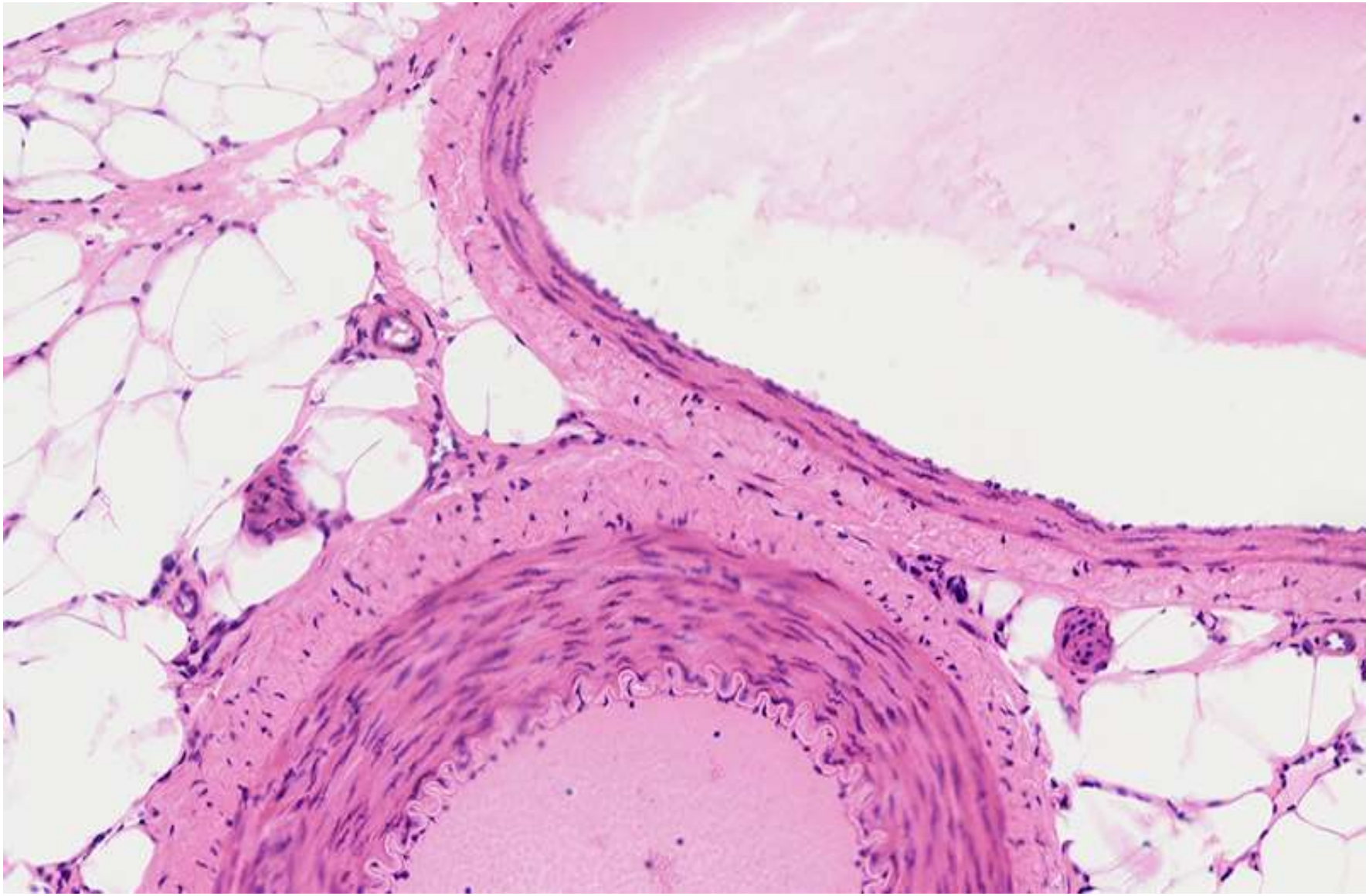


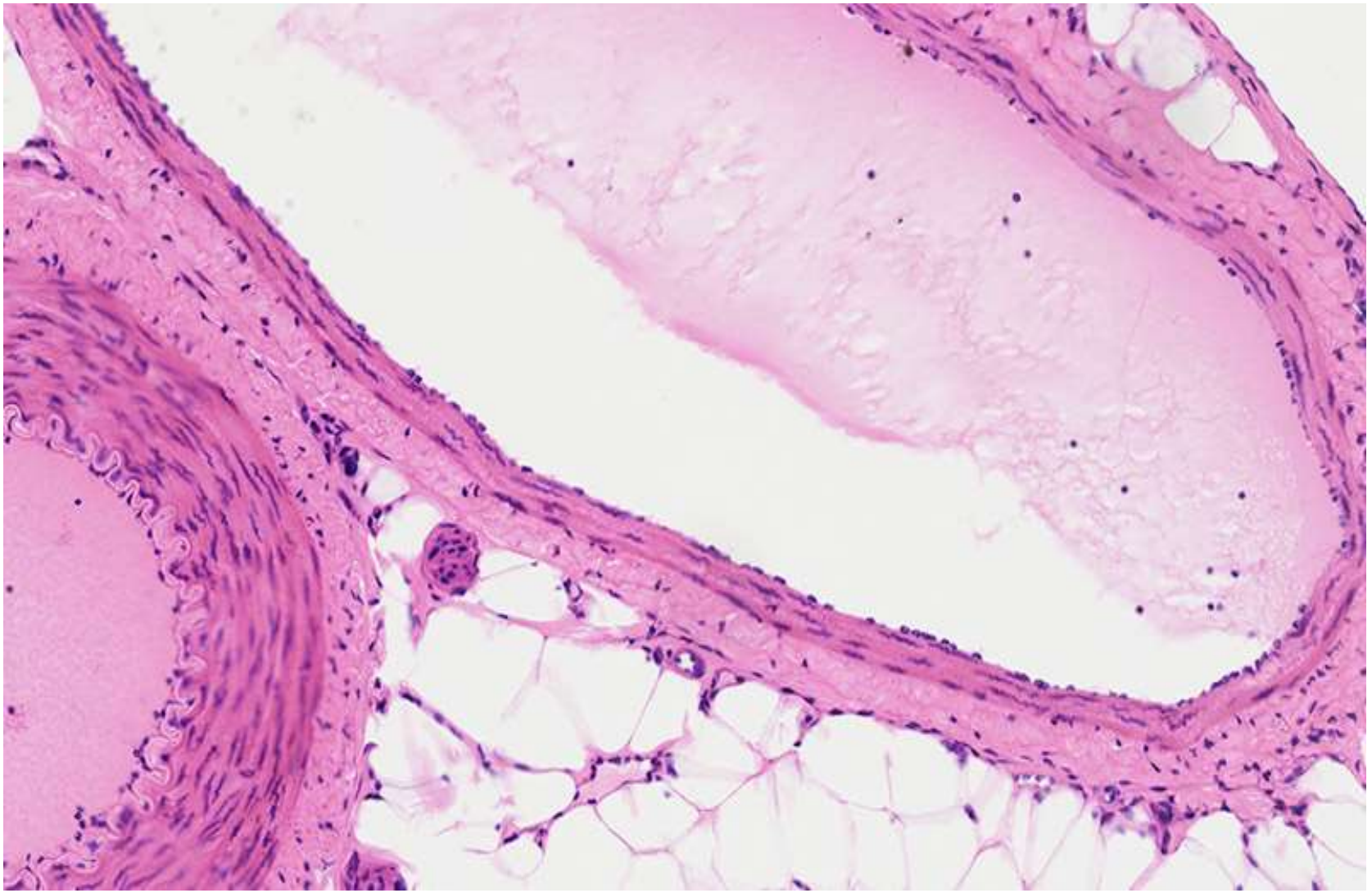
En- endothelium, LCT- loose connective tissue, M- t. media, A- t. adventitia, BV- blood vessel, CF- collagen fibers, SMC- smooth muscle cells

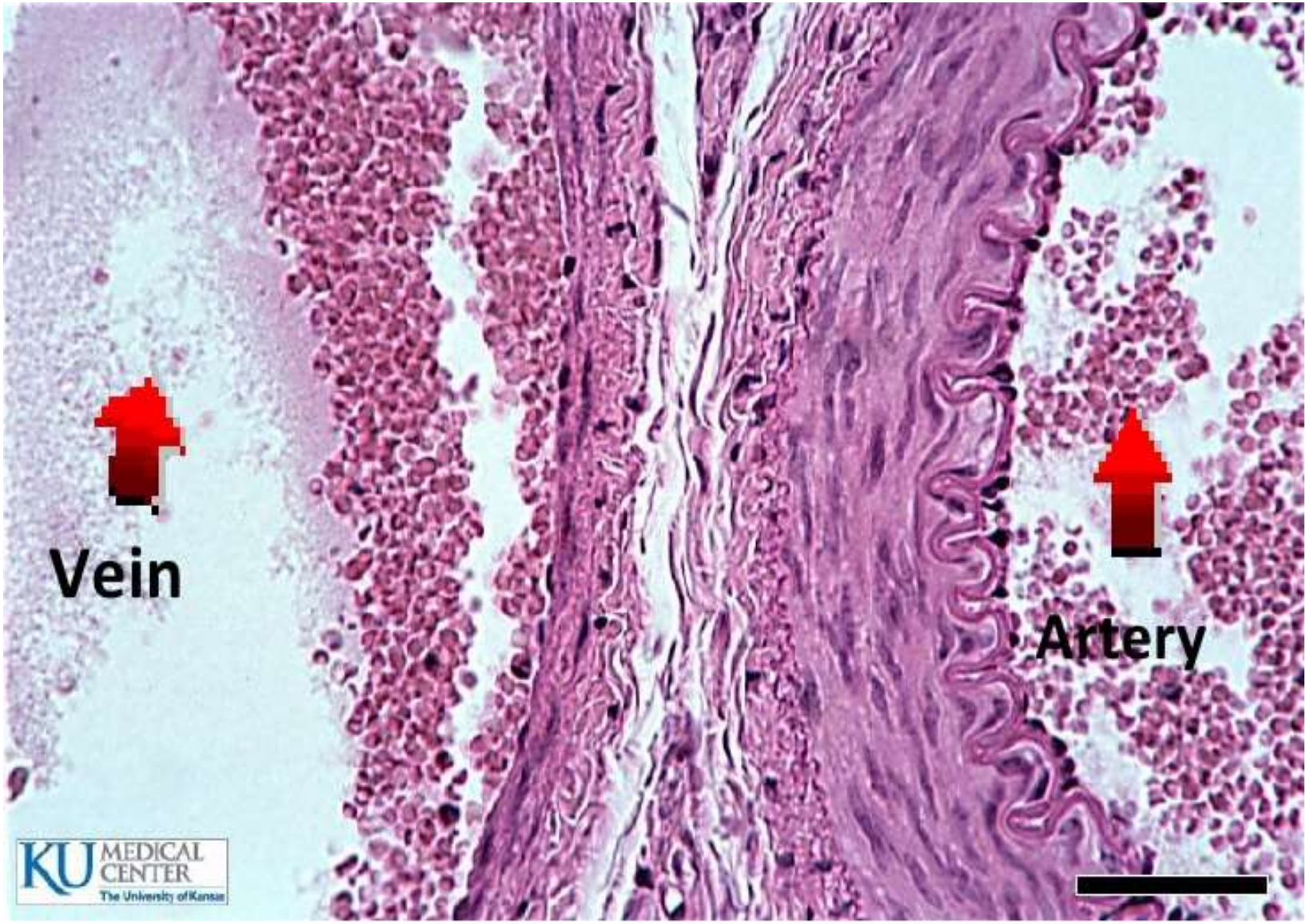

Veins
Fibrous
(amuscular)
veins of the spleen, bones, placenta, pia mater, retina etc.
Muscular
With low developed muscular elements in t. media
veins of the upper torso
With medium developed muscular elements in t. media and t. adventitia
veins of the upper limbs
With prominent muscular elements (contain smooth muscle elements in all three layers)
veins of the abdomen, veins of the lower limbs


Internal
elastic lamina
Endothelium
T. intima
T. media
T.
adventitia
External elastic
lamina
Endothelium
Muscular artery
Vein

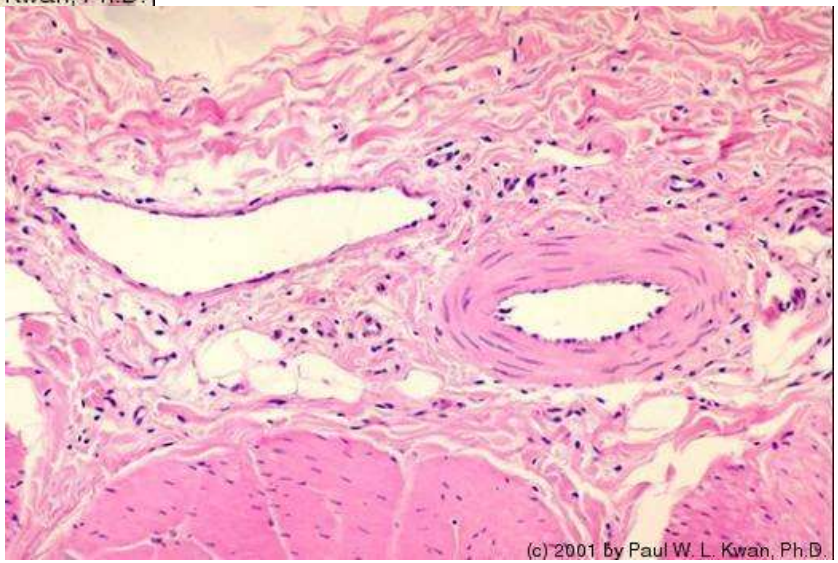


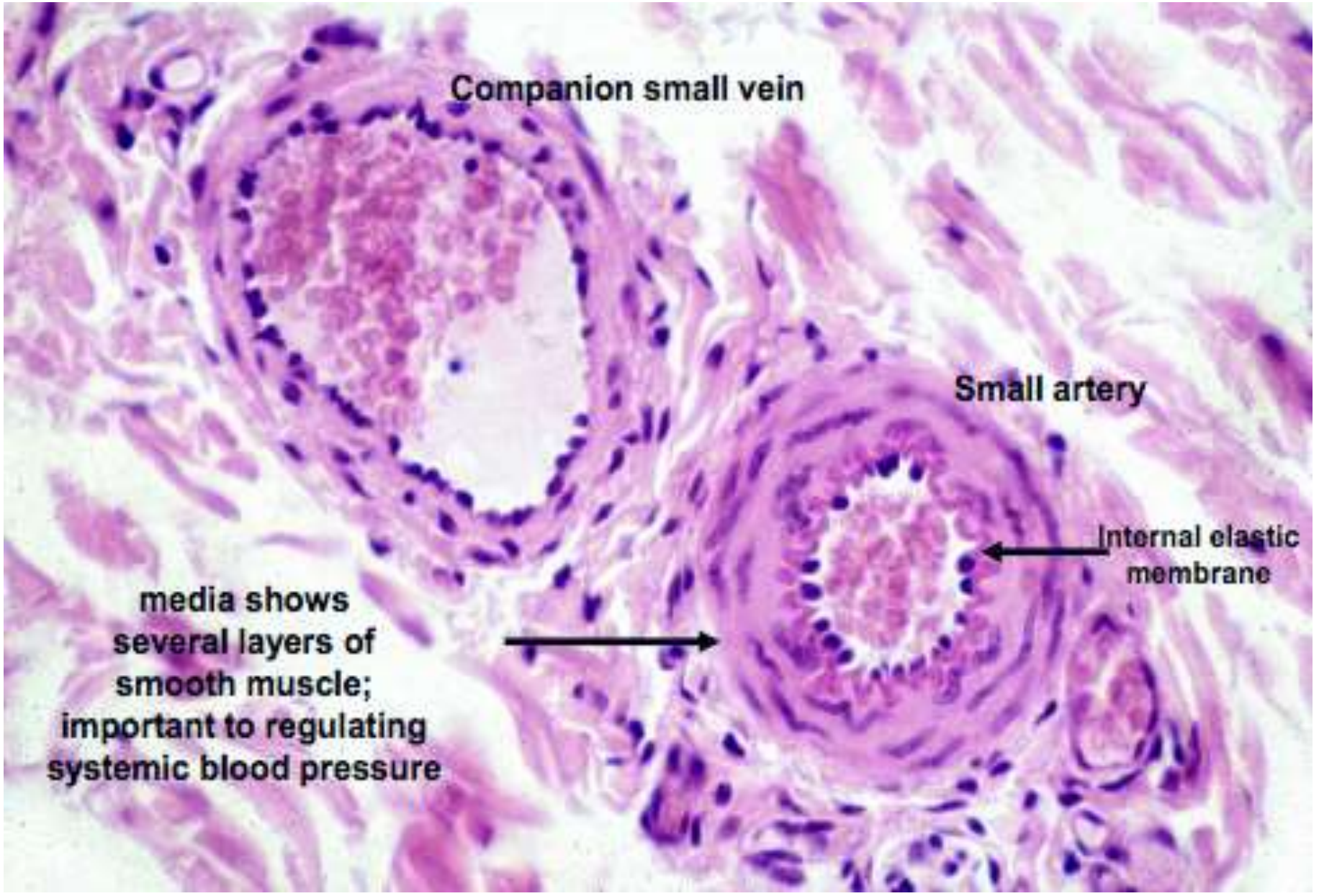




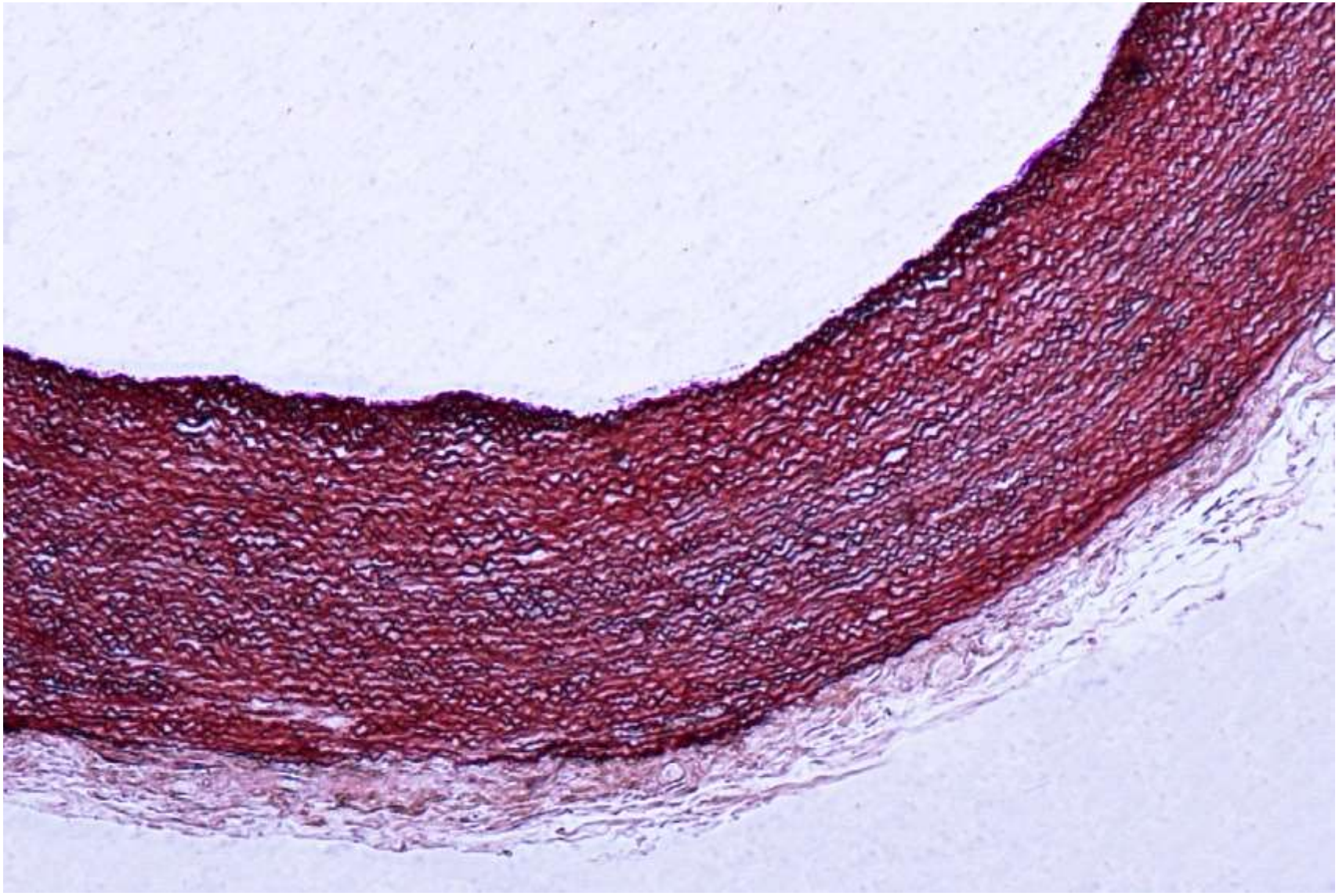

Vein
Artery
KU MEDICAL CENTER
The University of Kansas


(c) 2001 by Paul W. L. Kwan, Ph.D.

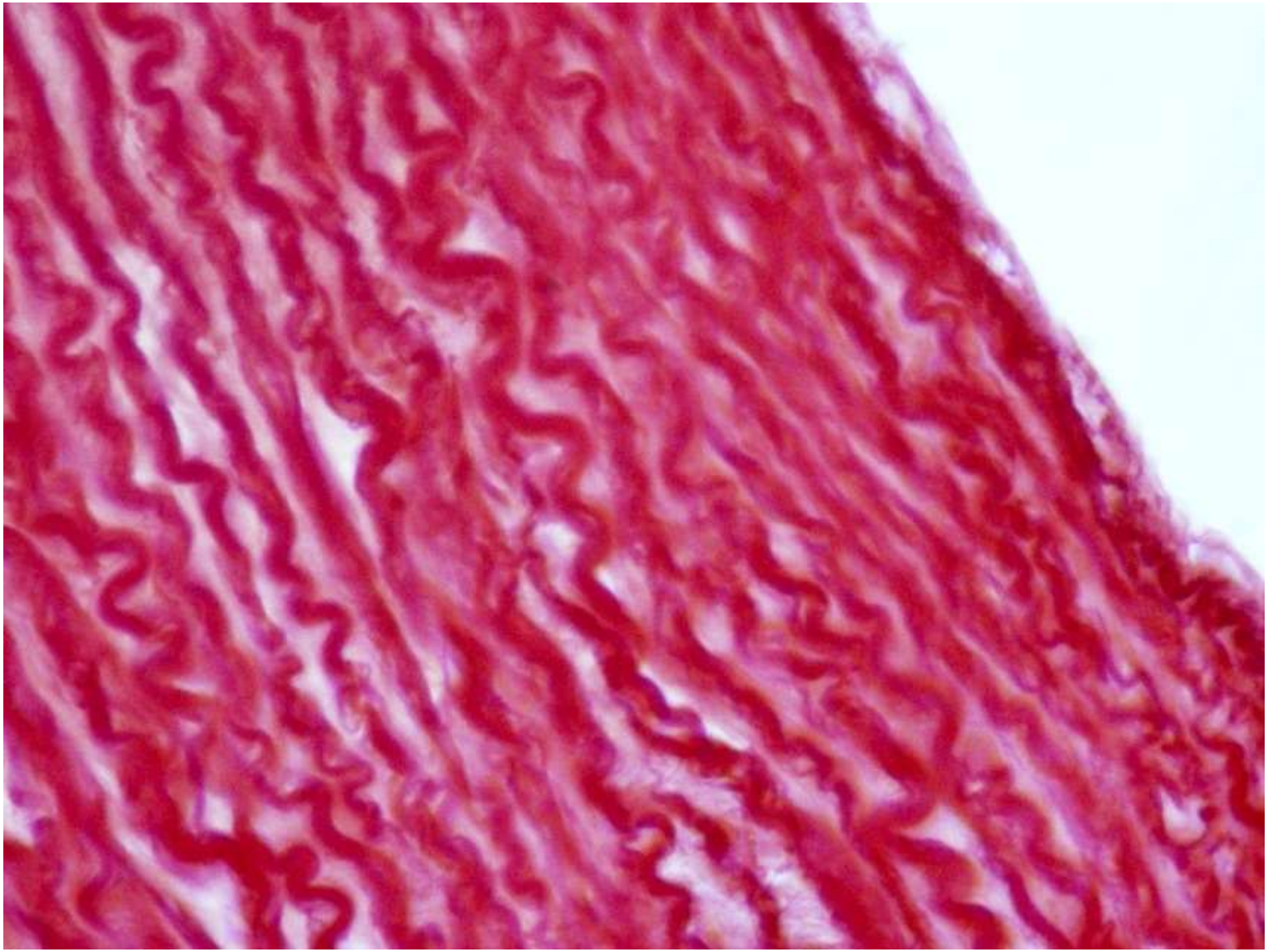

(c) 2001 by Paul W. L. Kwan, Ph.D.


Companion small vein
Small artery
Internal elastic membrane
media shows several layers of smooth muscle; important to regulating systemic blood pressure

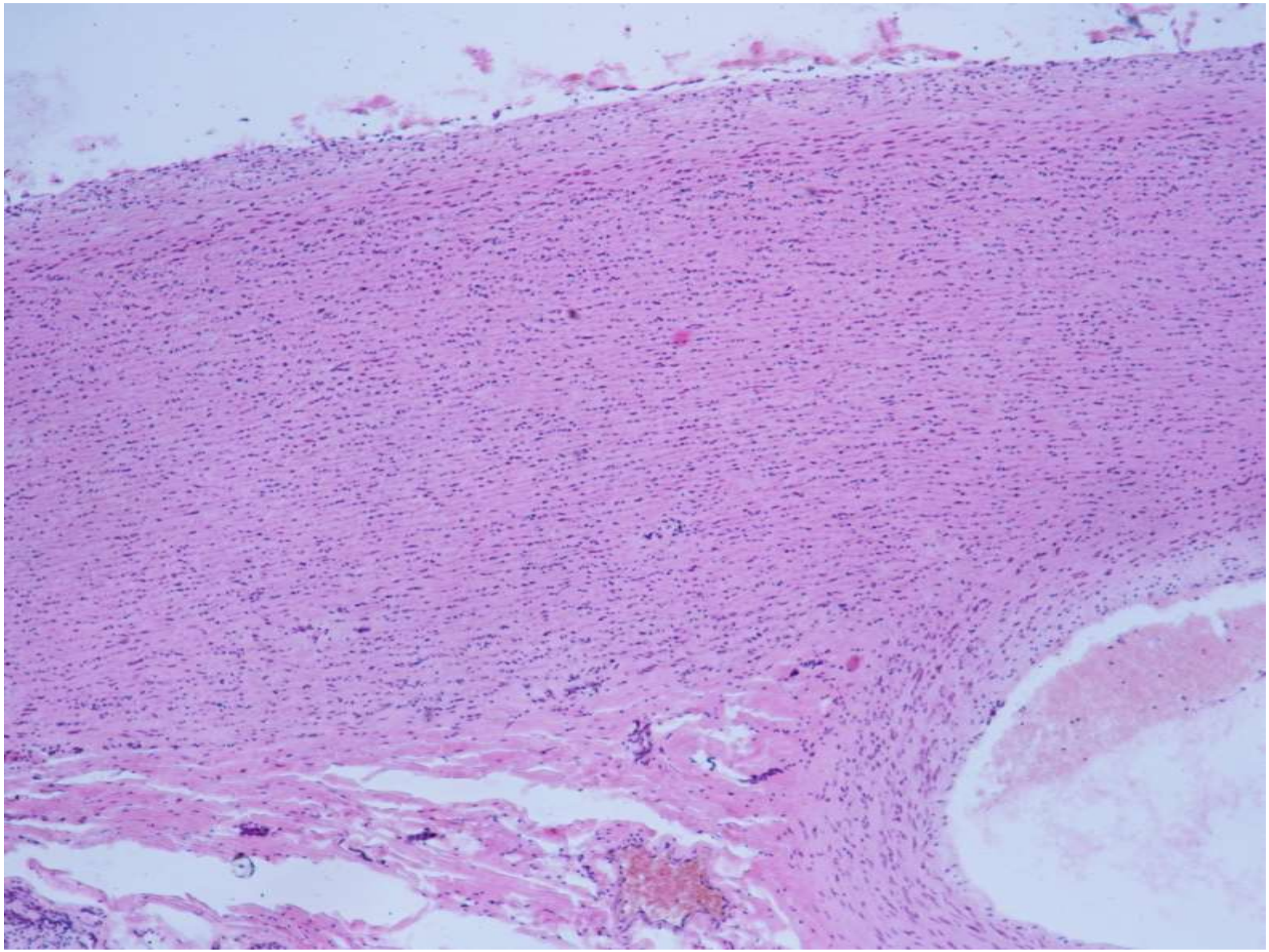
Slide №103a. «Aorta, cross section»
Orcein staining

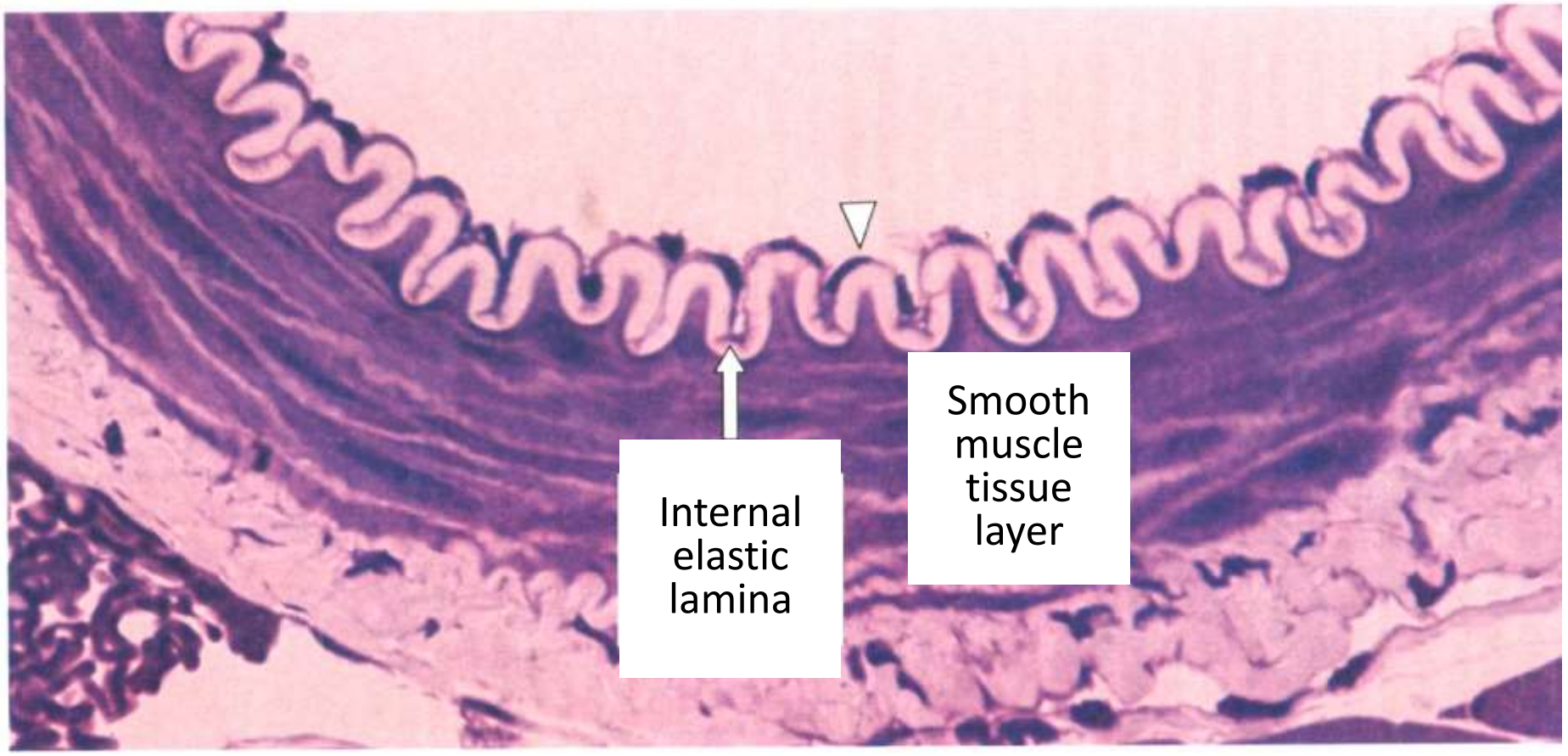


Slide №103a. «Aorta, cross section»
Orcein staining



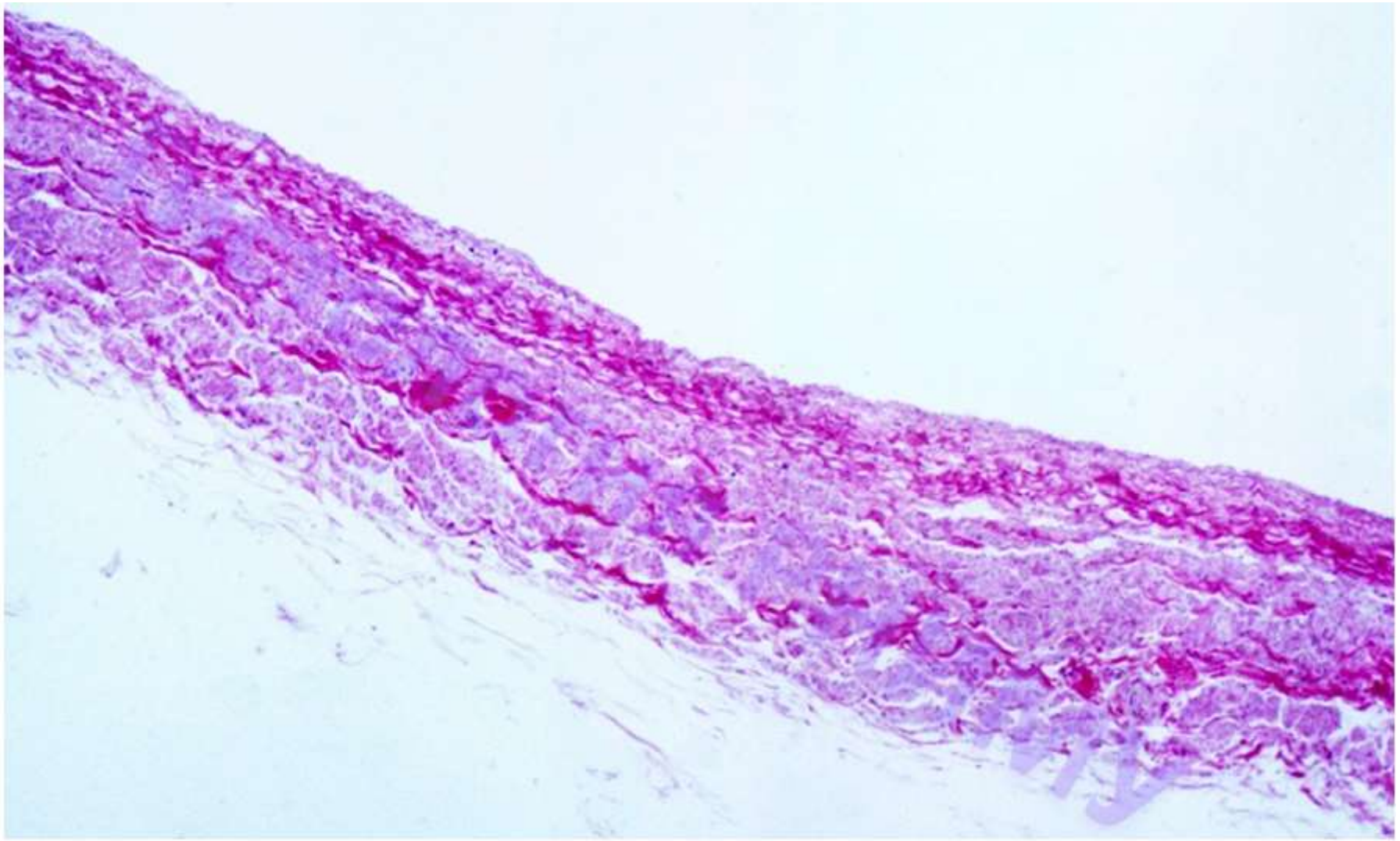
Slide №103. «Aorta, longitudinal section»
Hematoxylin-eosin staining



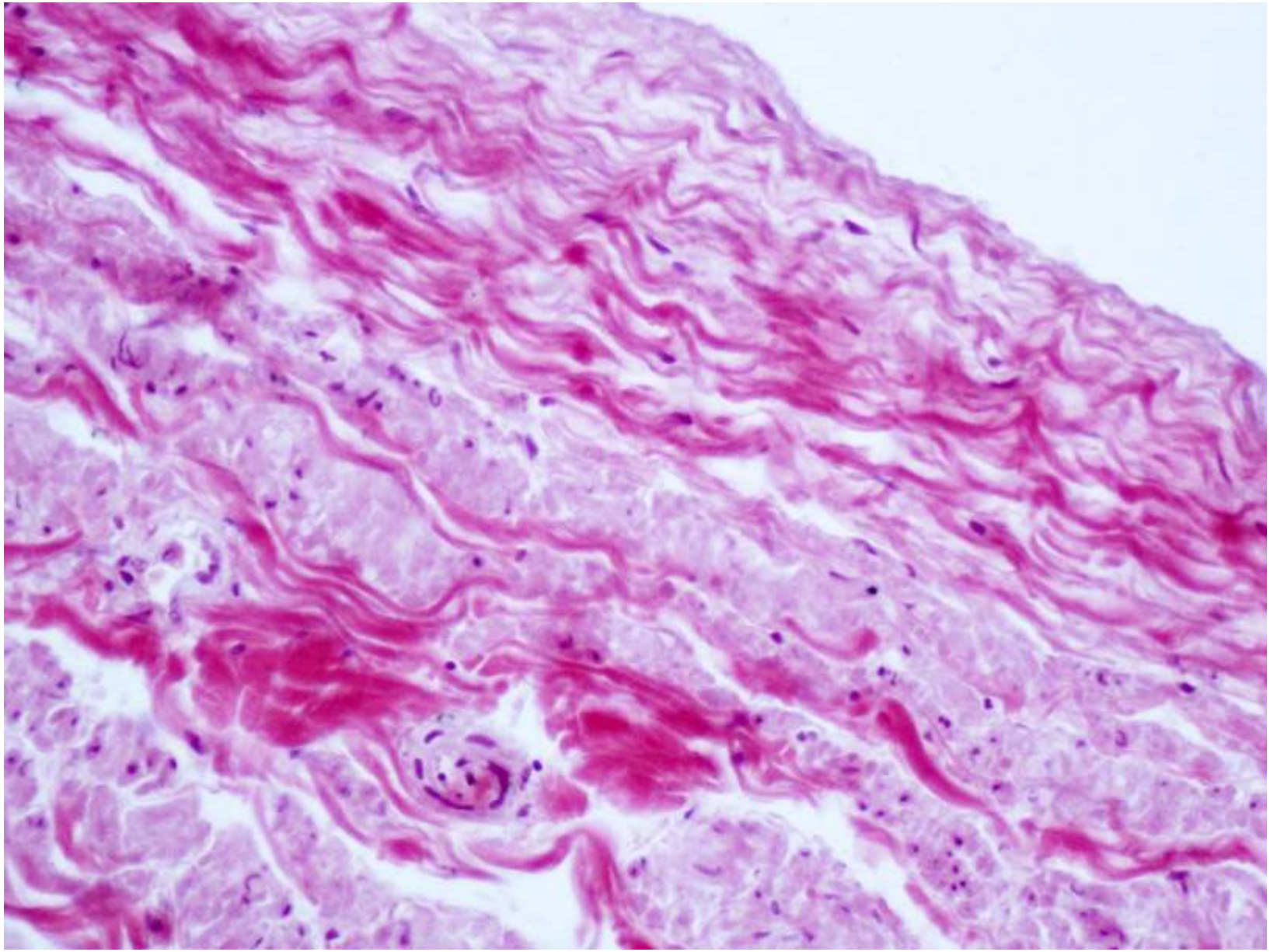


The wall of small artery

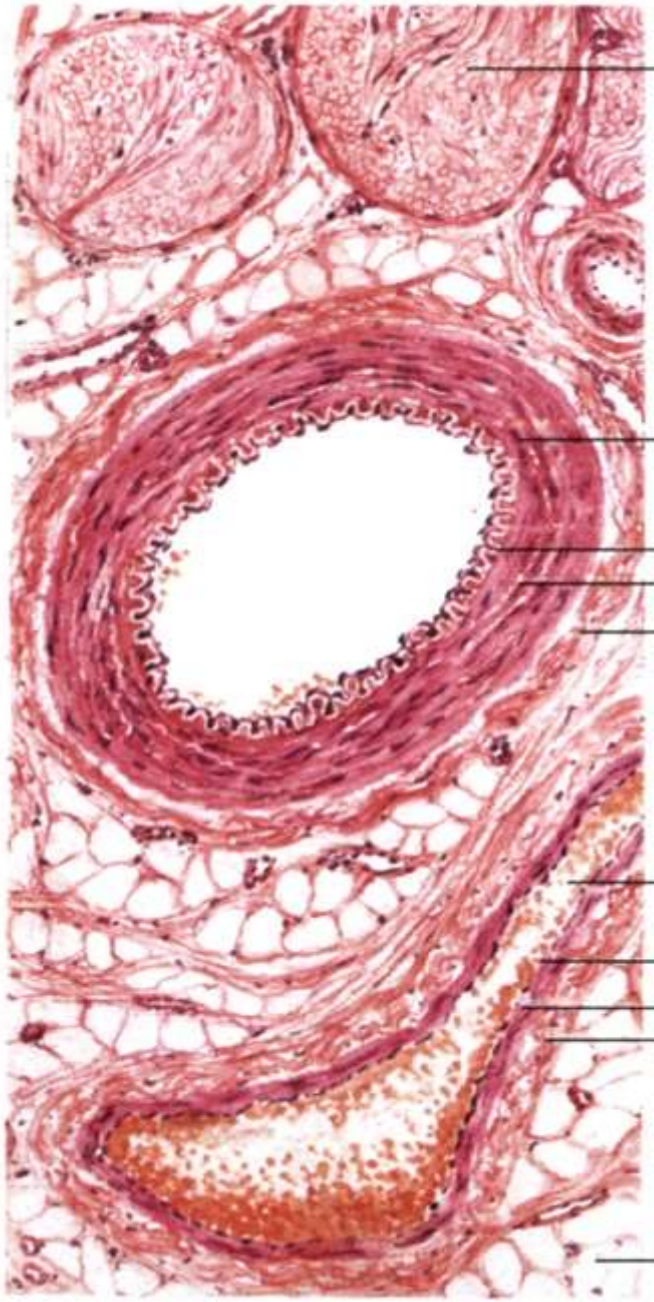
Slide №105. «Section of a vein»
Hematoxylin-eosin staining



Slide №105. «Section of a vein»
Hematoxylin-eosin staining



NEUROVASCULAR BUNDLE



a nerve (composed of myelinated nerve fibers)

a muscular artery

tunica interna (intima)

tunica media

tunica externa (adventitia)

a muscular vein

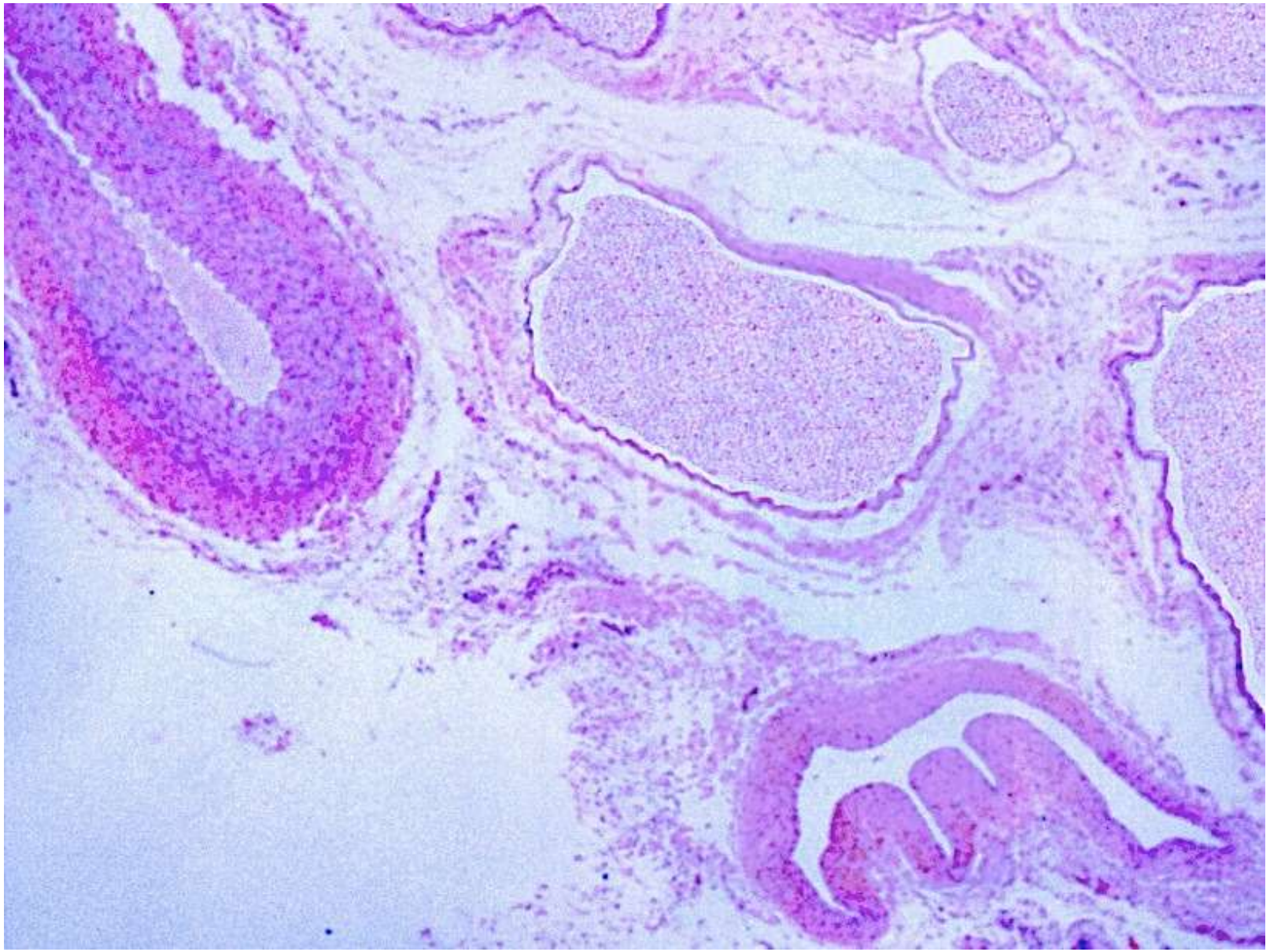
tunica interna (intima)

tunica media

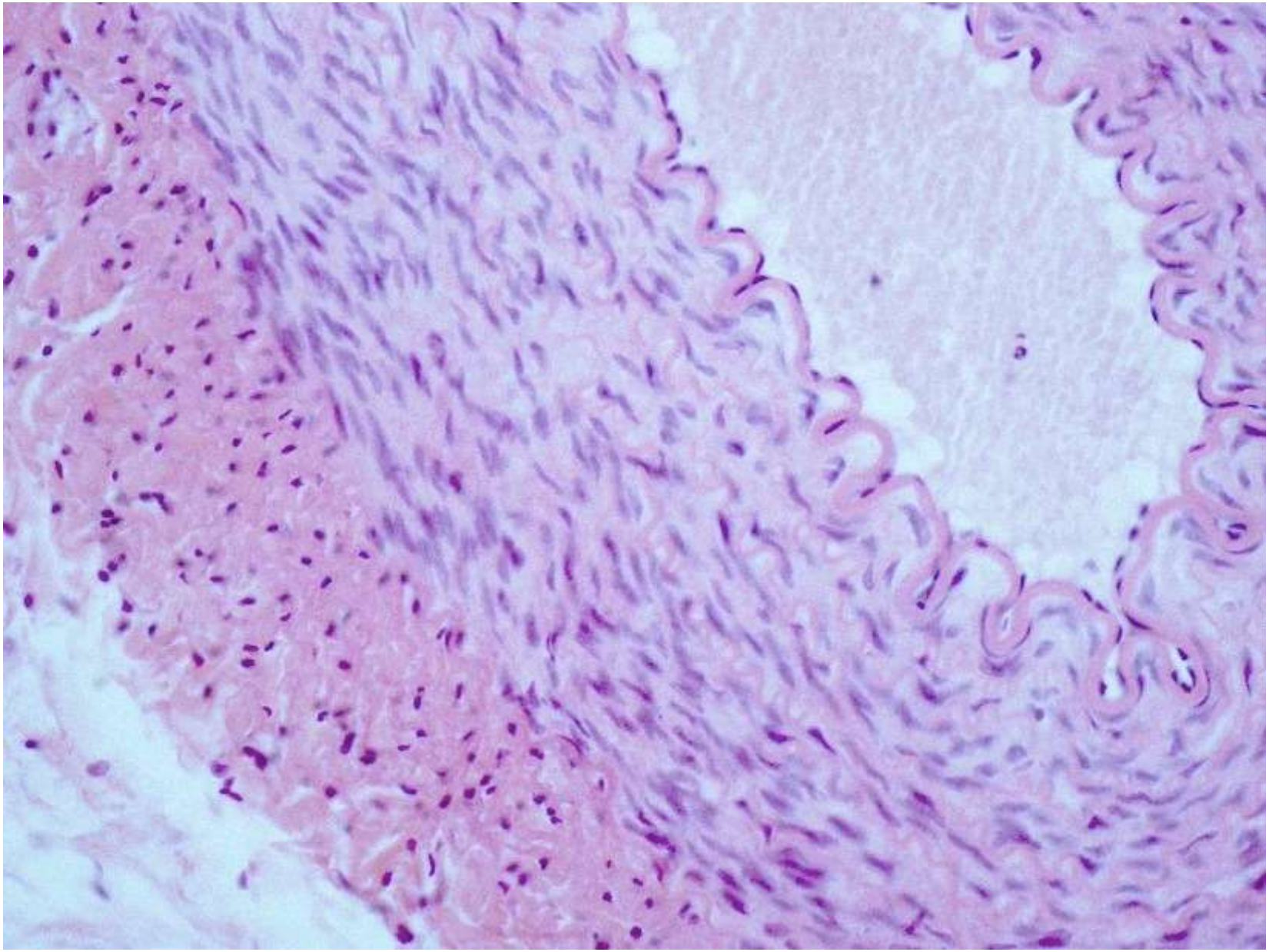
tunica externa (adventitia)

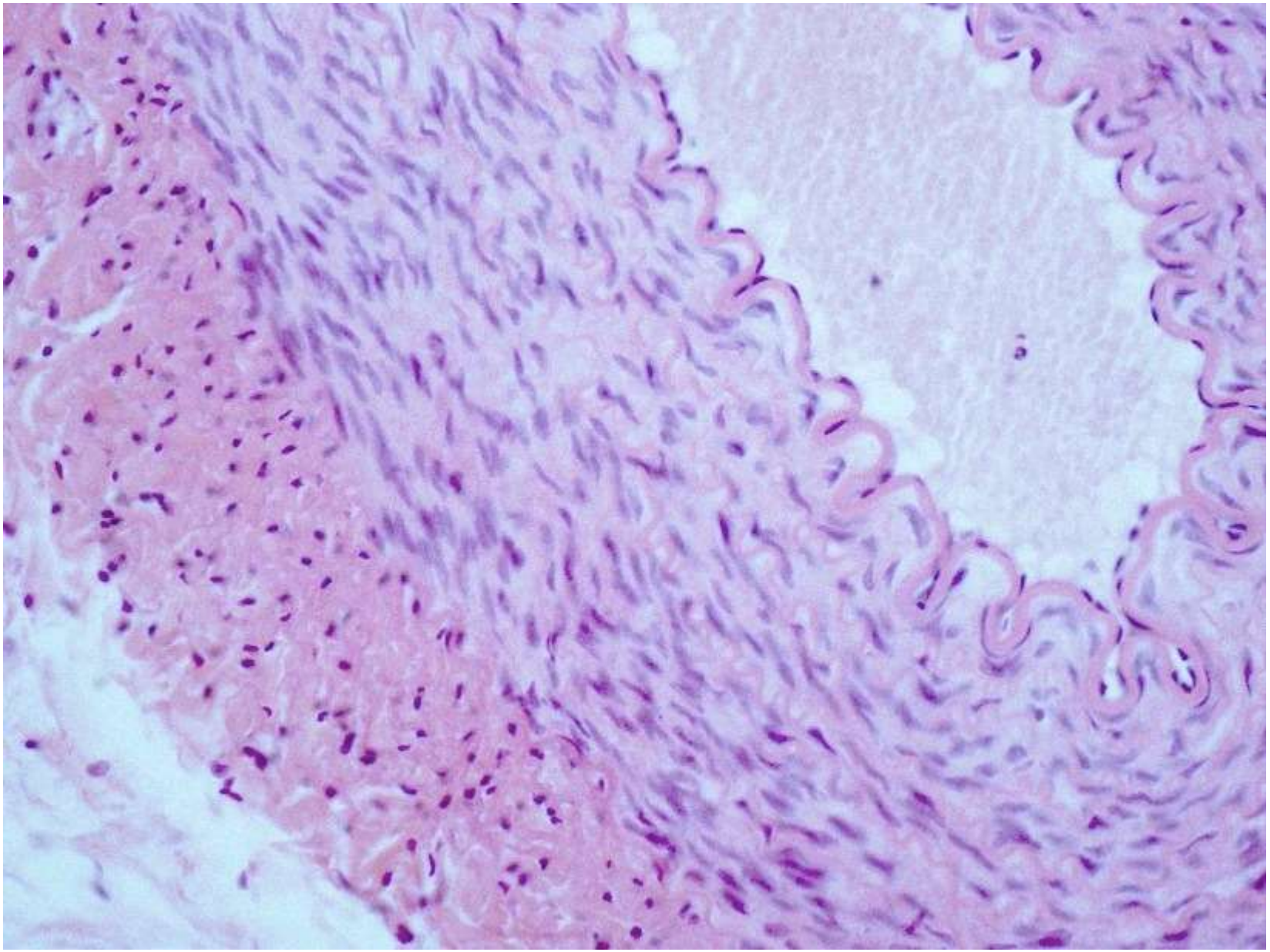
adipose cells (adipocytes)

Slide №102. «Neurovascular bundle»
Hematoxylin-eosin staining

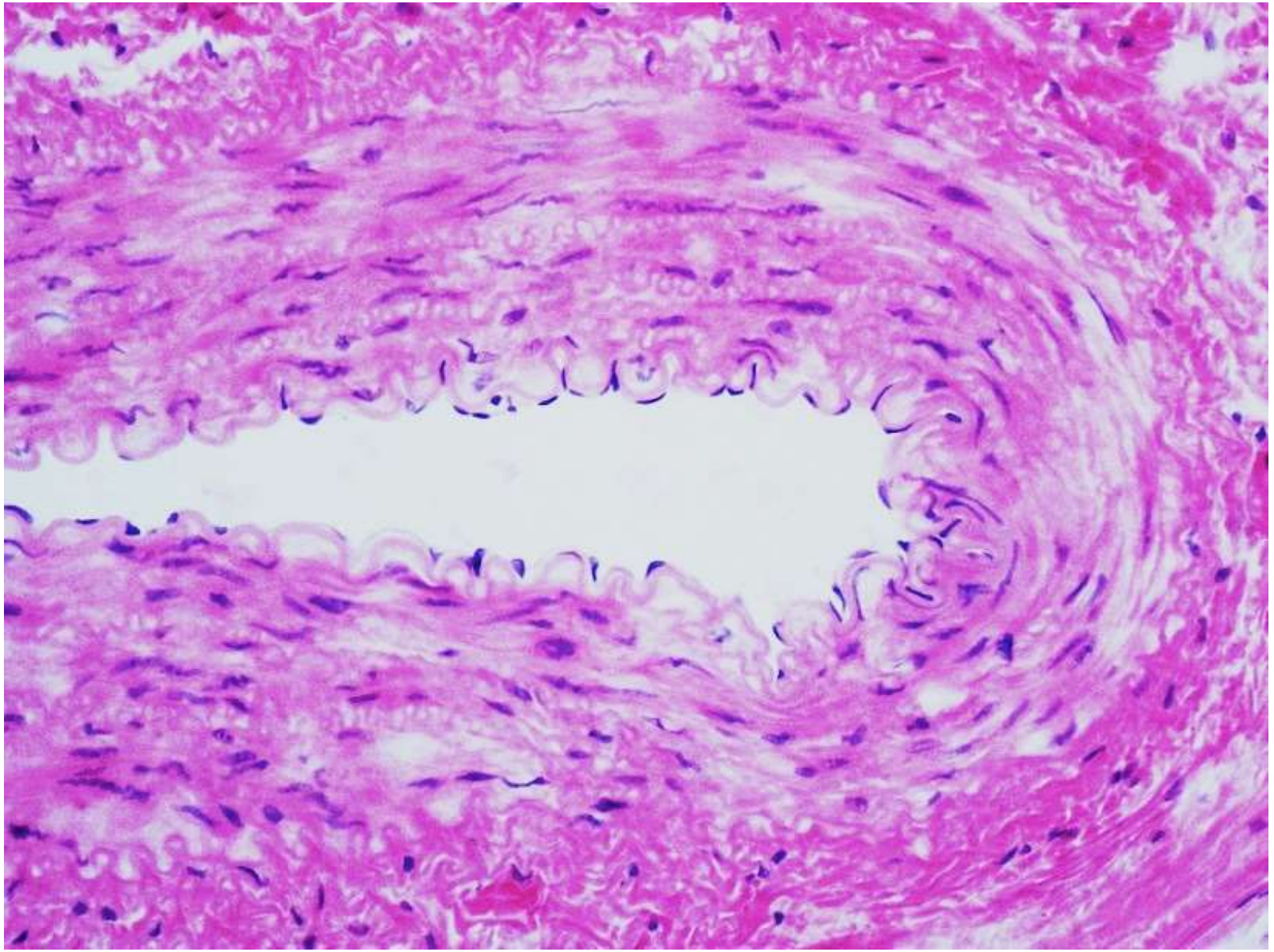


Slide №102. «Neurovascular bundle»
Hematoxylin-eosin staining

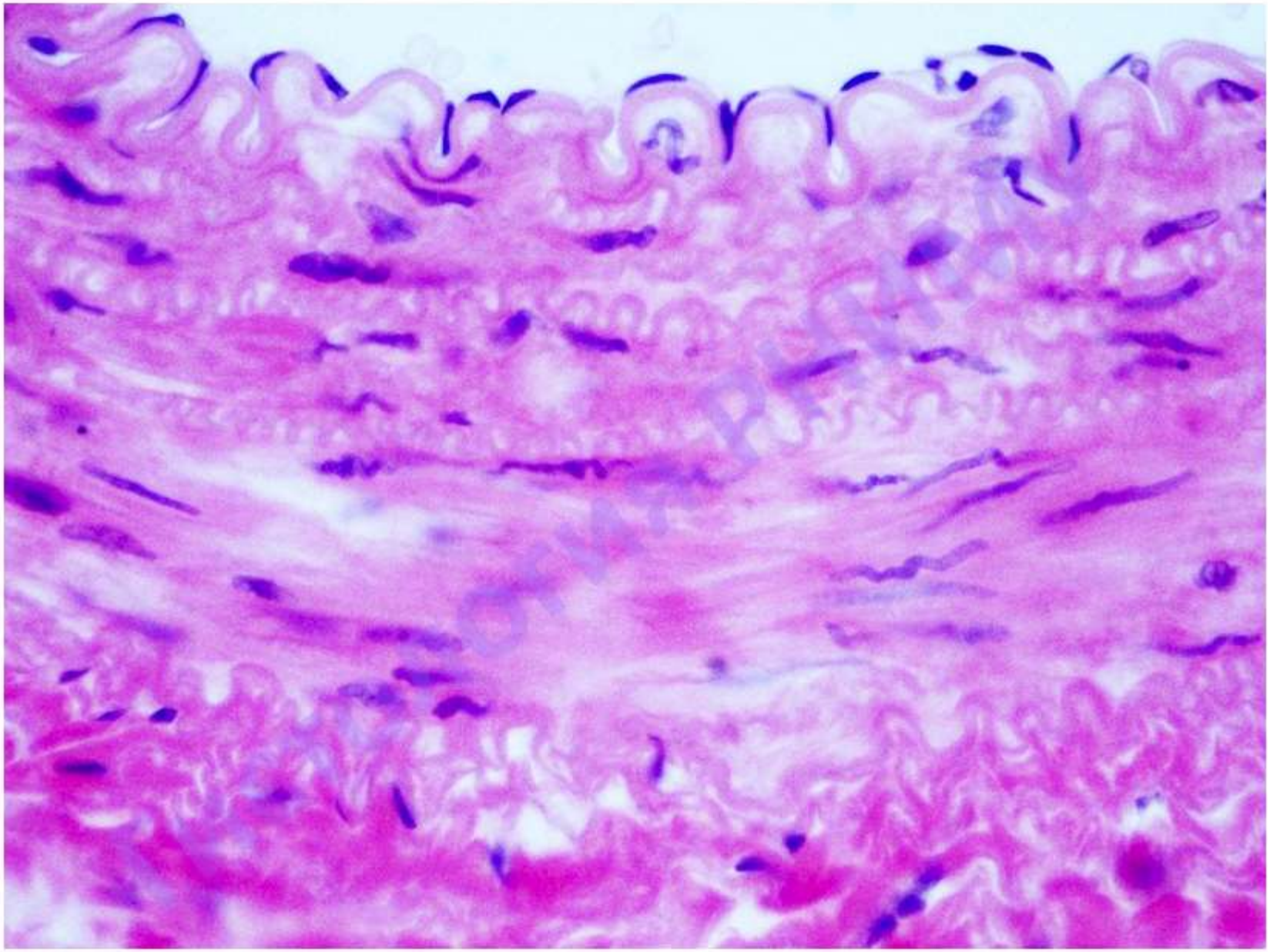




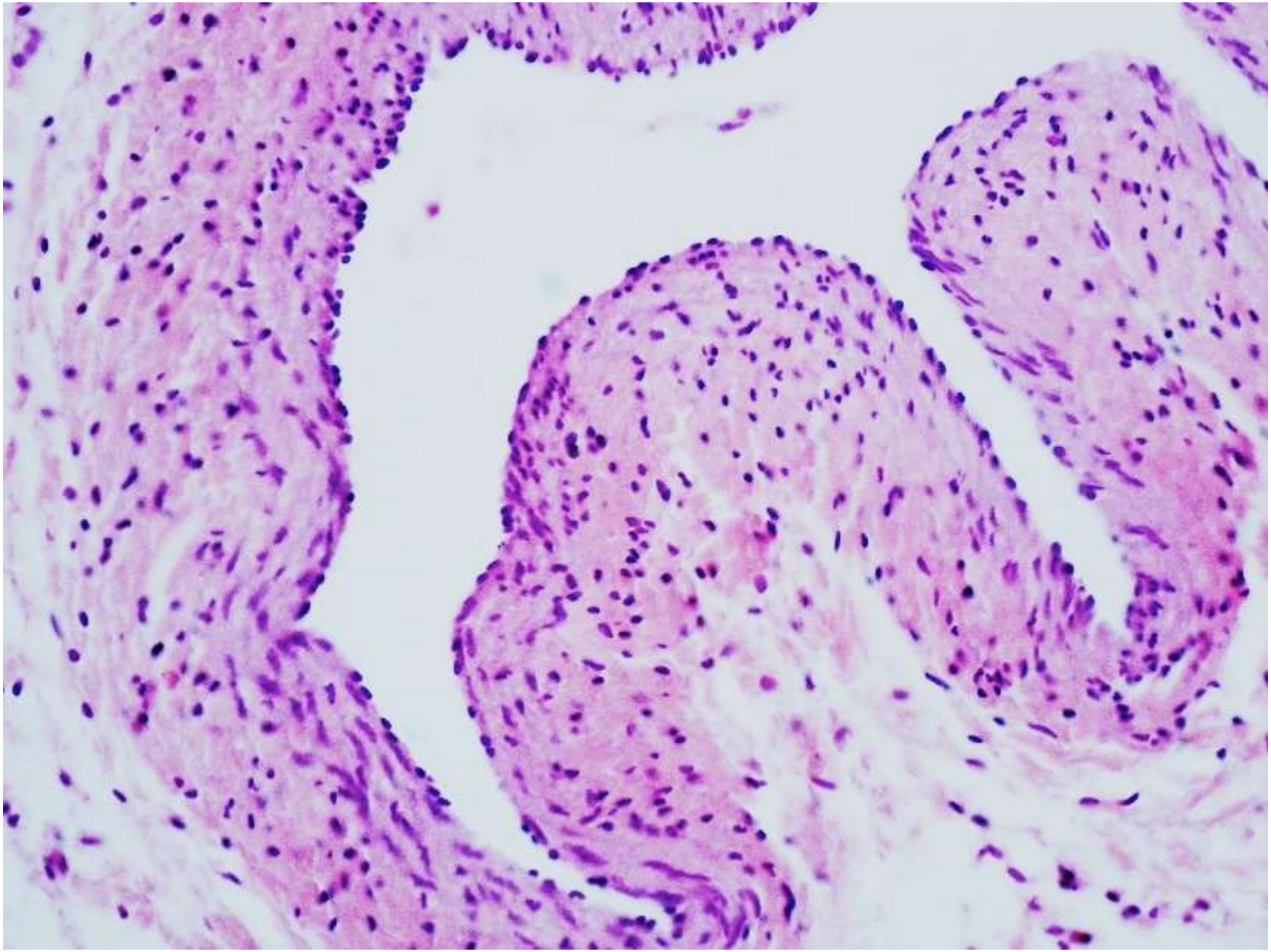
Slide №102. «Neurovascular bundle»
Hematoxylin-eosin staining

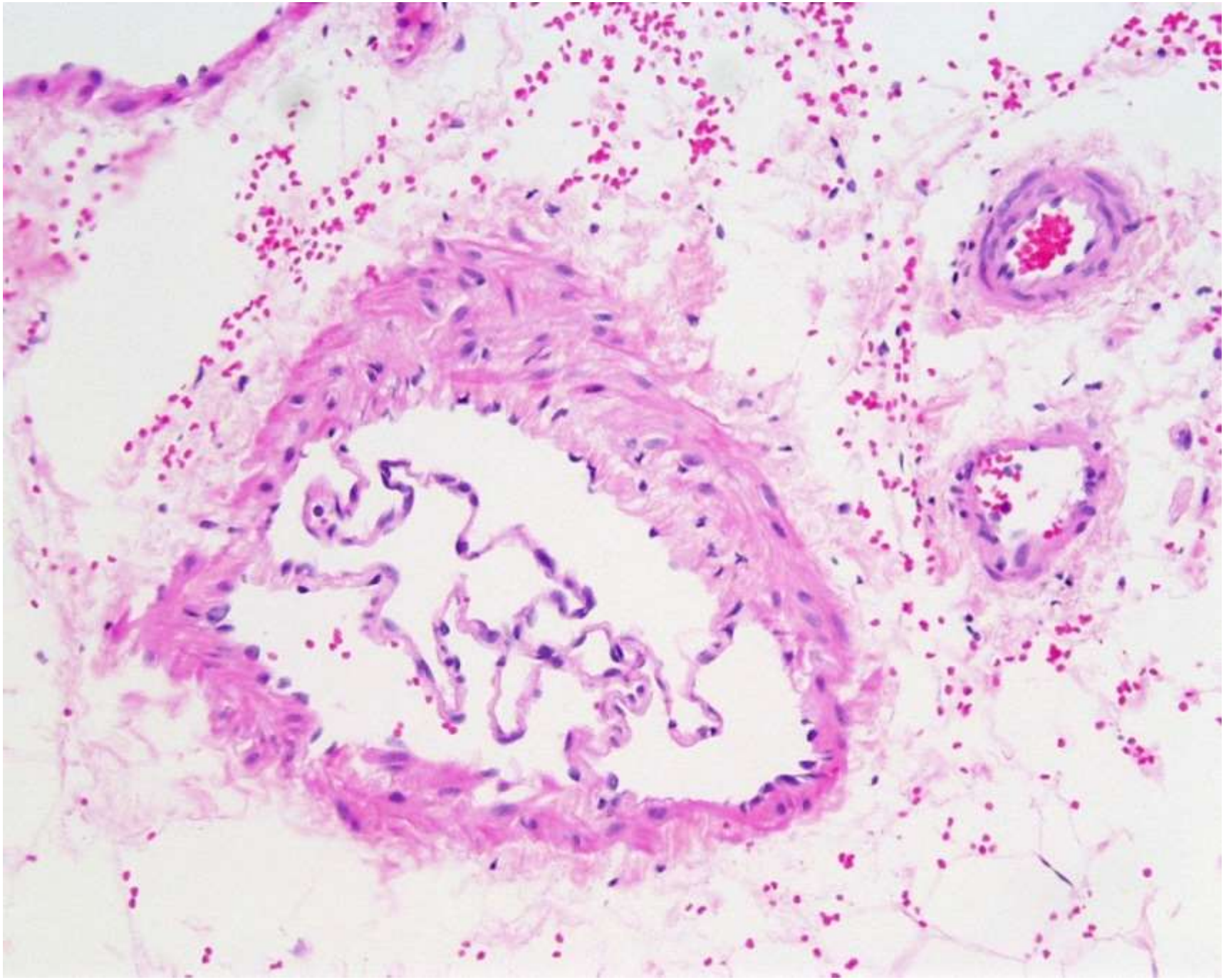


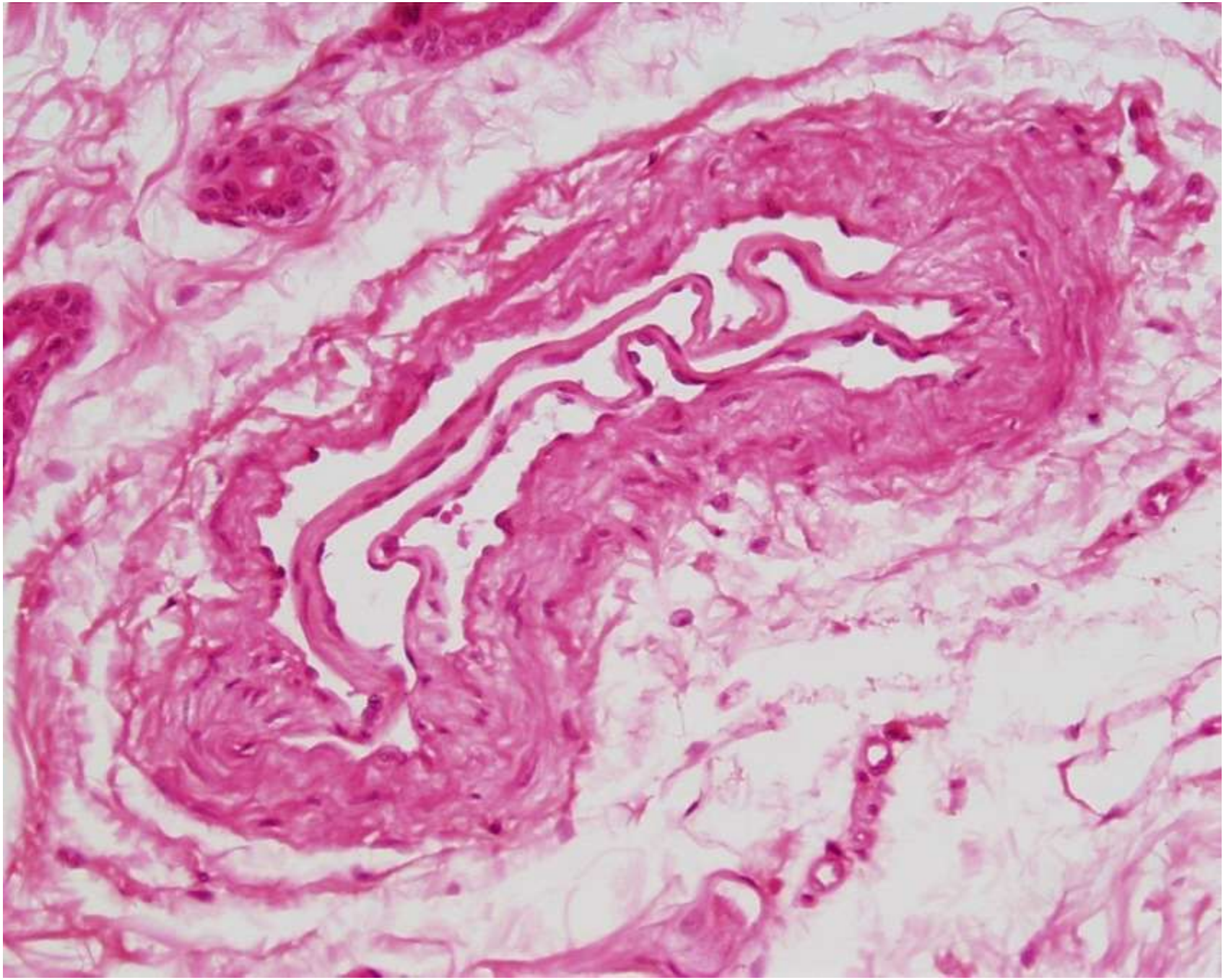
Slide №102. «Neurovascular bundle»
Hematoxylin-eosin staining



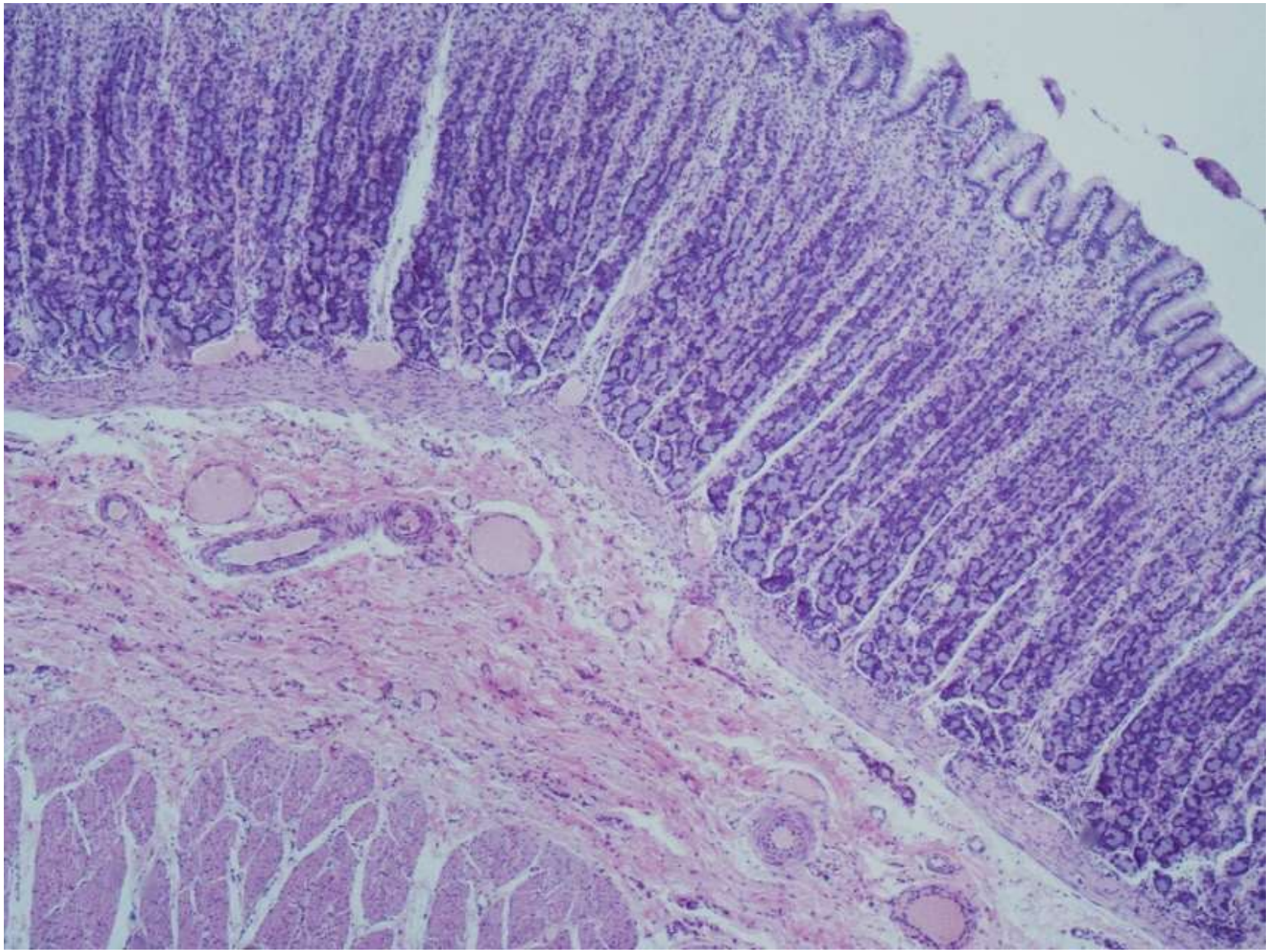
Slide №102. «Neurovascular bundle»
Hematoxylin-eosin staining





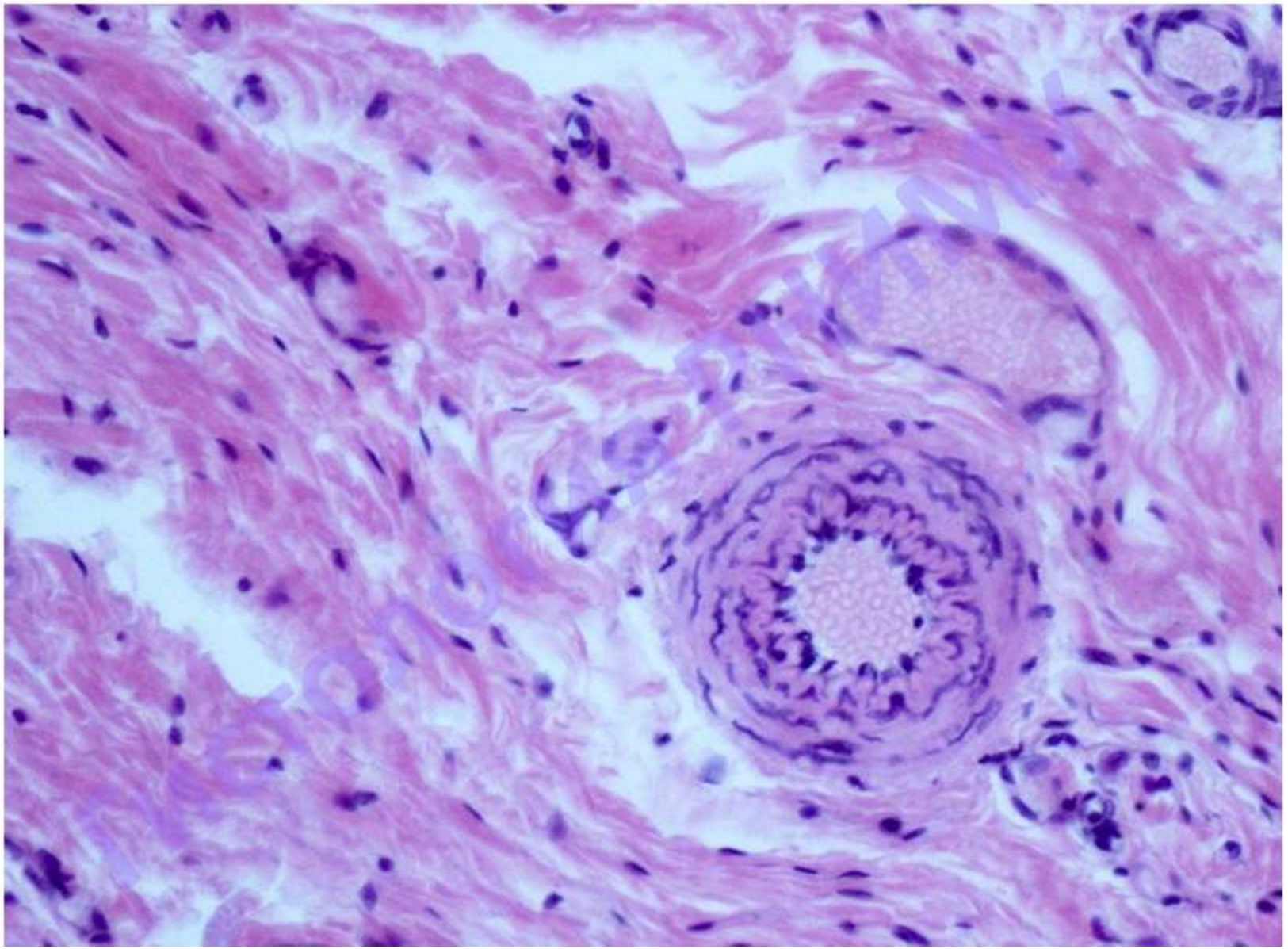


Slide «Wall of the stomach»
Hematoxylin-eosin staining

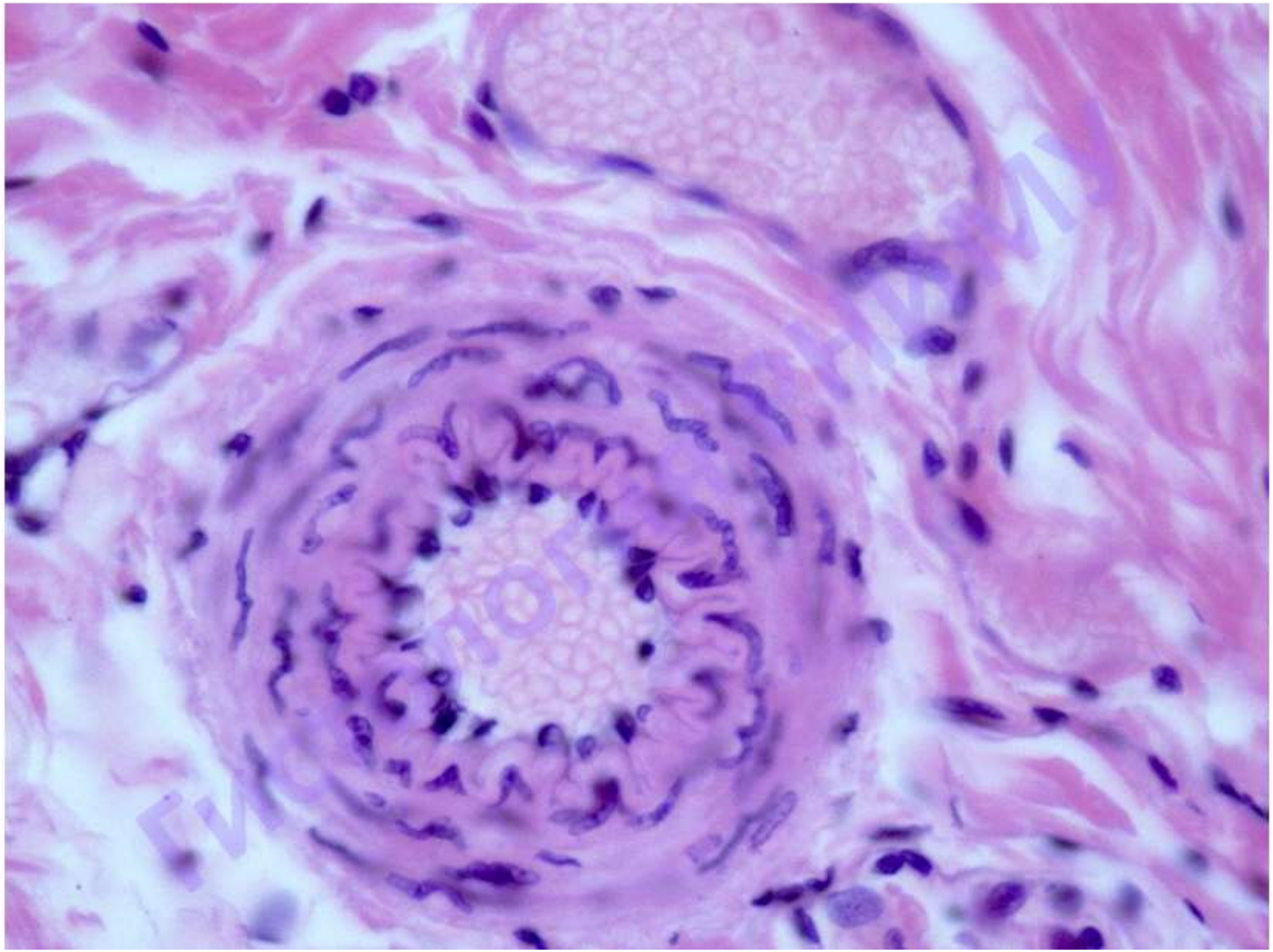


Slide «Wall of the stomach»

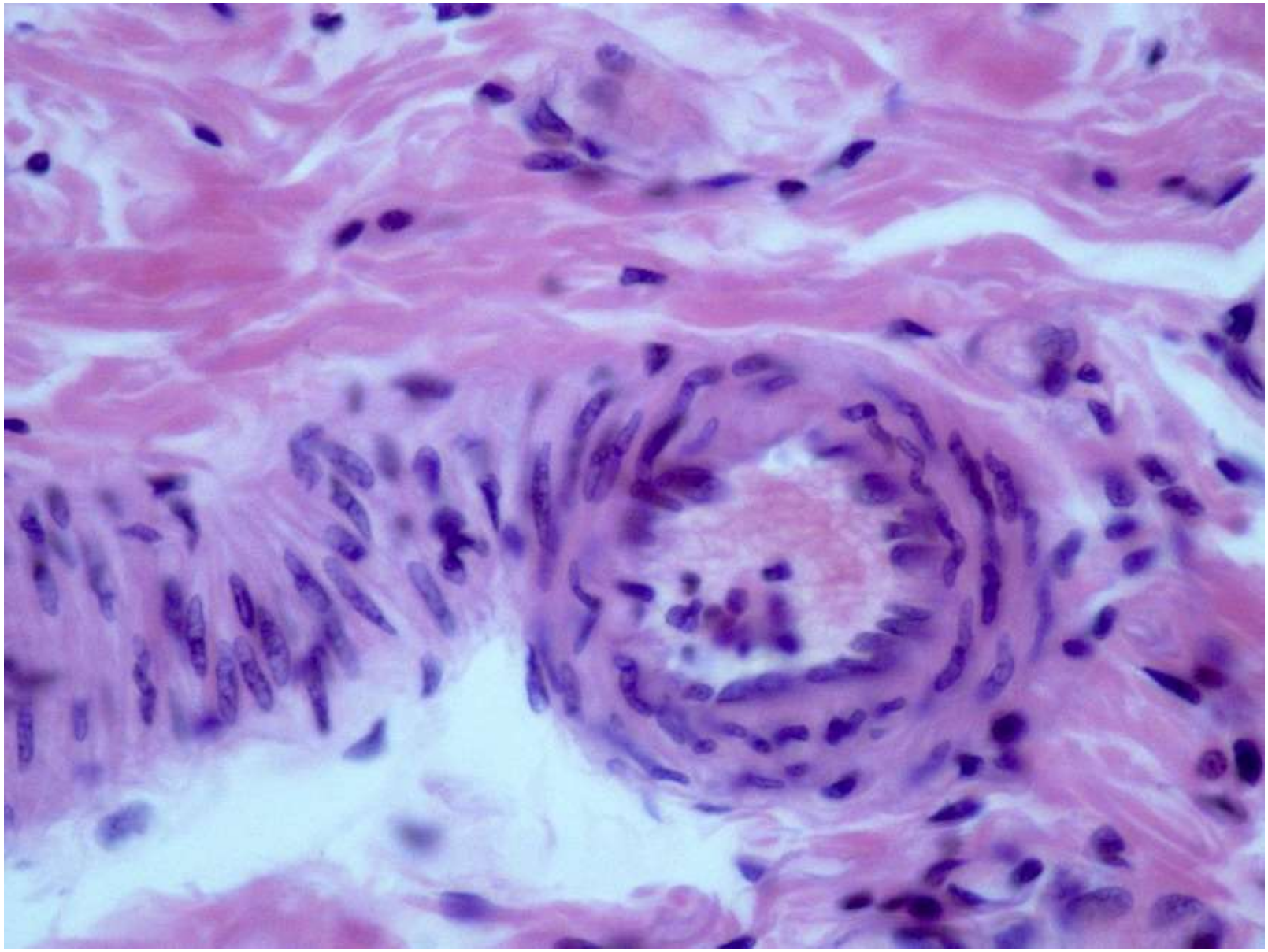
Hematoxylin-eosin staining



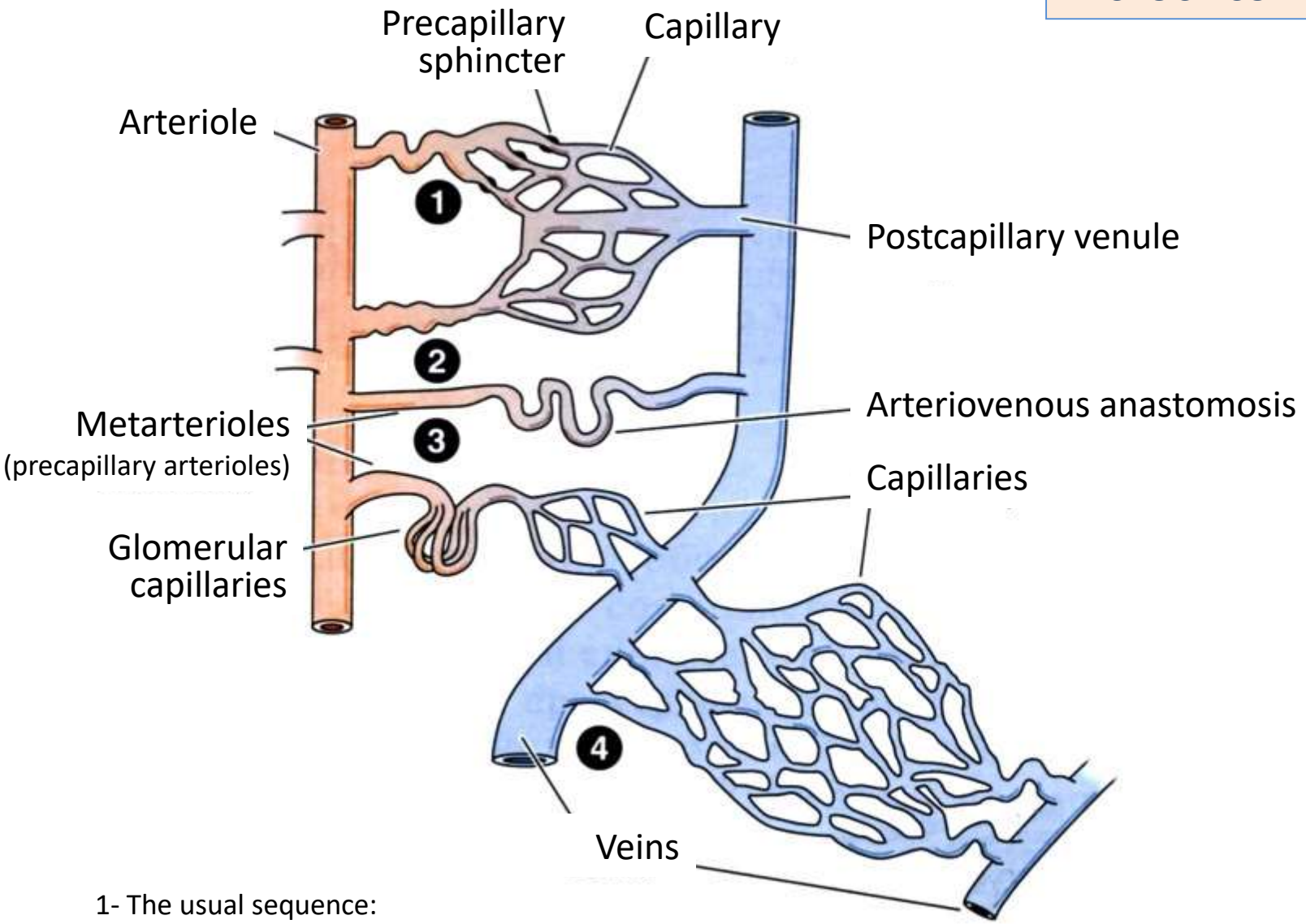
Slide «Wall of the stomach»
Hematoxylin-eosin staining



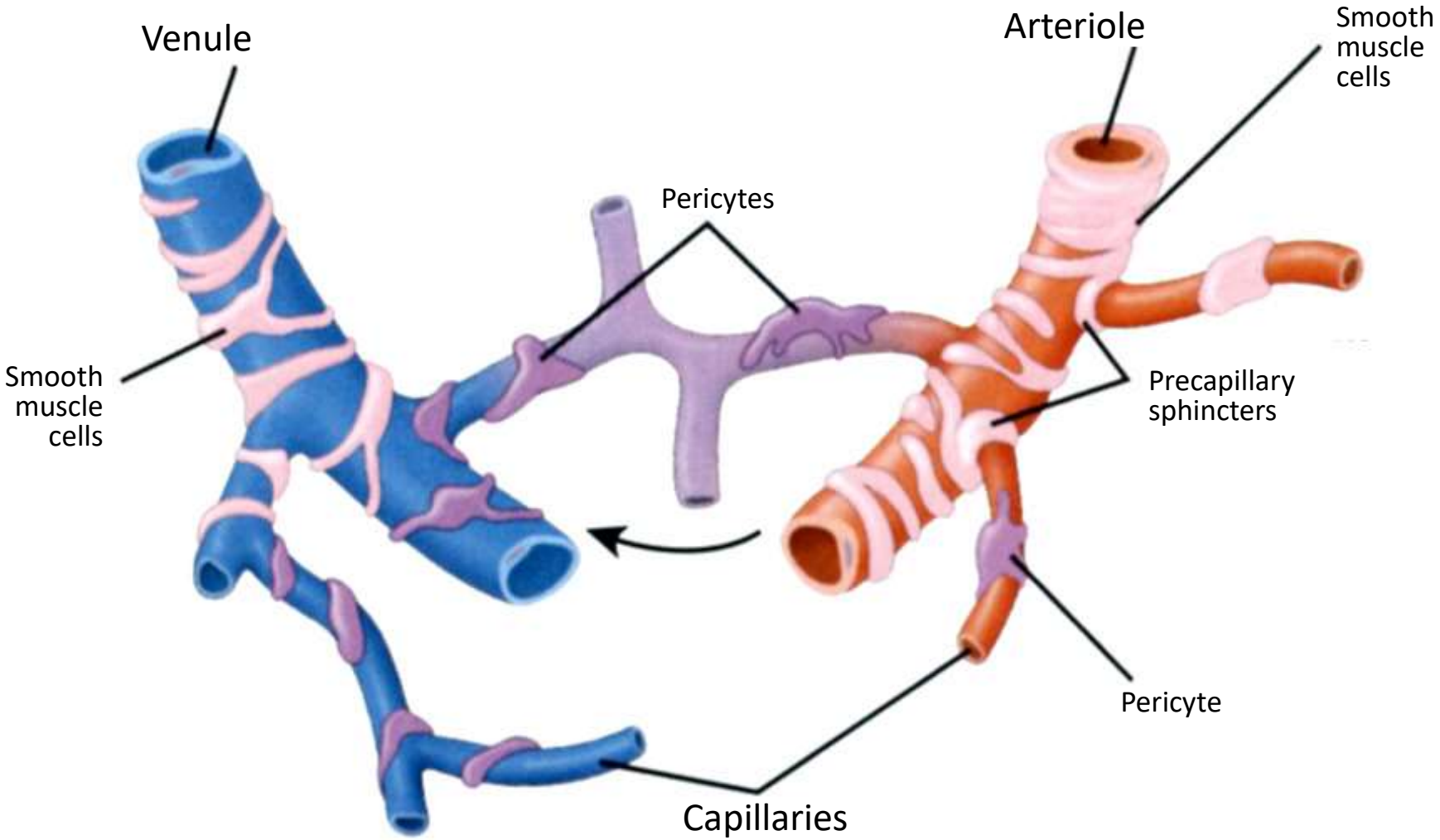
Slide «Wall of the stomach»
Hematoxylin-eosin staining



MICROCIRCULATORY BED



1- The usual sequence:
arteriole —> metarteriole -> capillary -> venule and vein
2- Arteriovenous anastomosis
3- Arterial portal system, e.g. in the renal glomeruli
4- Venous portal system, e.g. in the liver


Venule
Arteriole
Smooth muscle cells
Pericytes
Smooth muscle cells
Precapillary sphincters
Pericyte
Capillaries

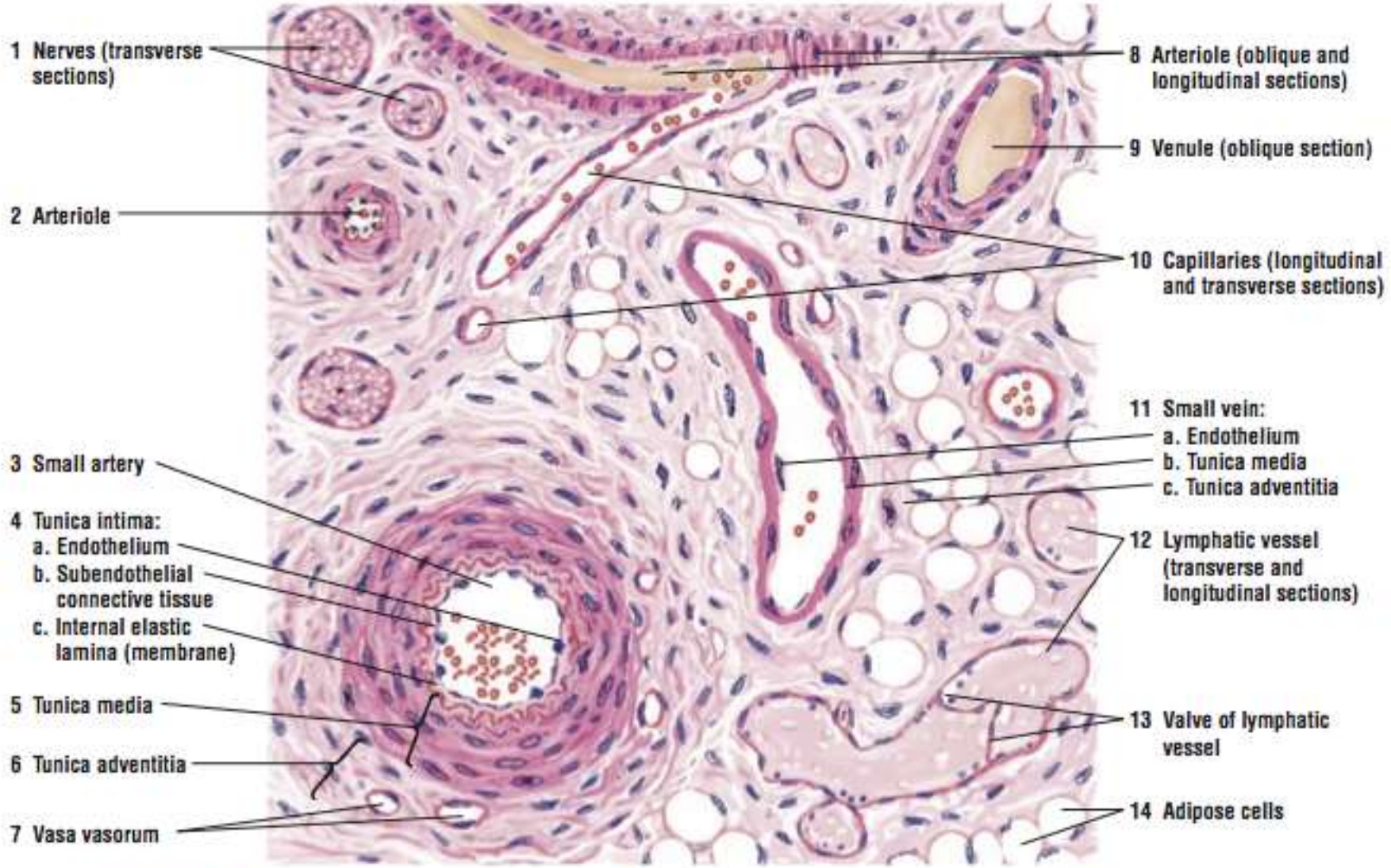
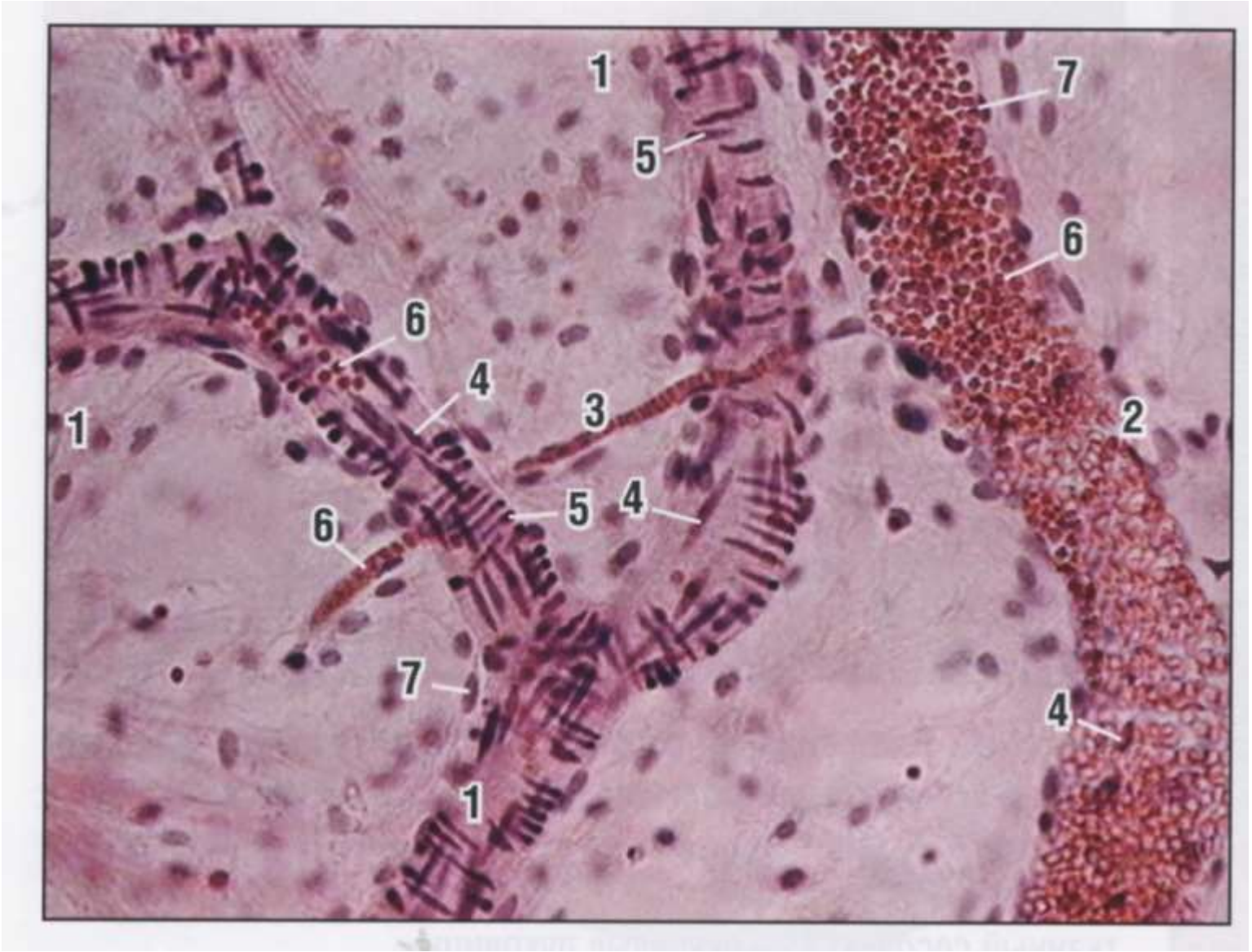


FIGURE 8.1 ■ Blood and lymphatic vessels in the connective tissue. Stain: hematoxylin and eosin. Low magnification.



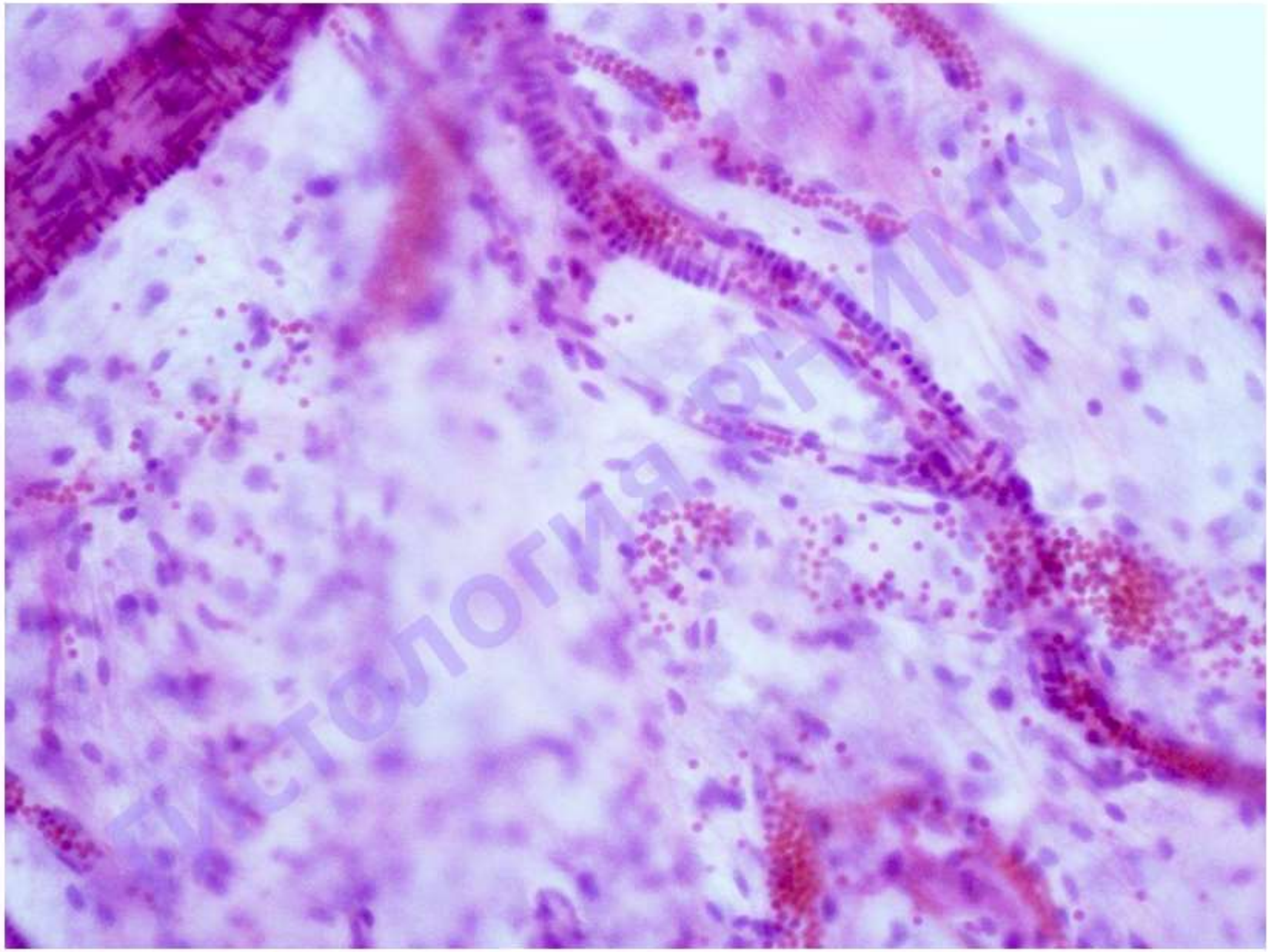
1- arterioles; 2- venule; 3- capillary; 4- endothelial cell nuclei; 5- smooth muscle cell nuclei;
6- erythrocytes; 7- elements of the adventitia

Slide 101 «Microcirculatory bed»

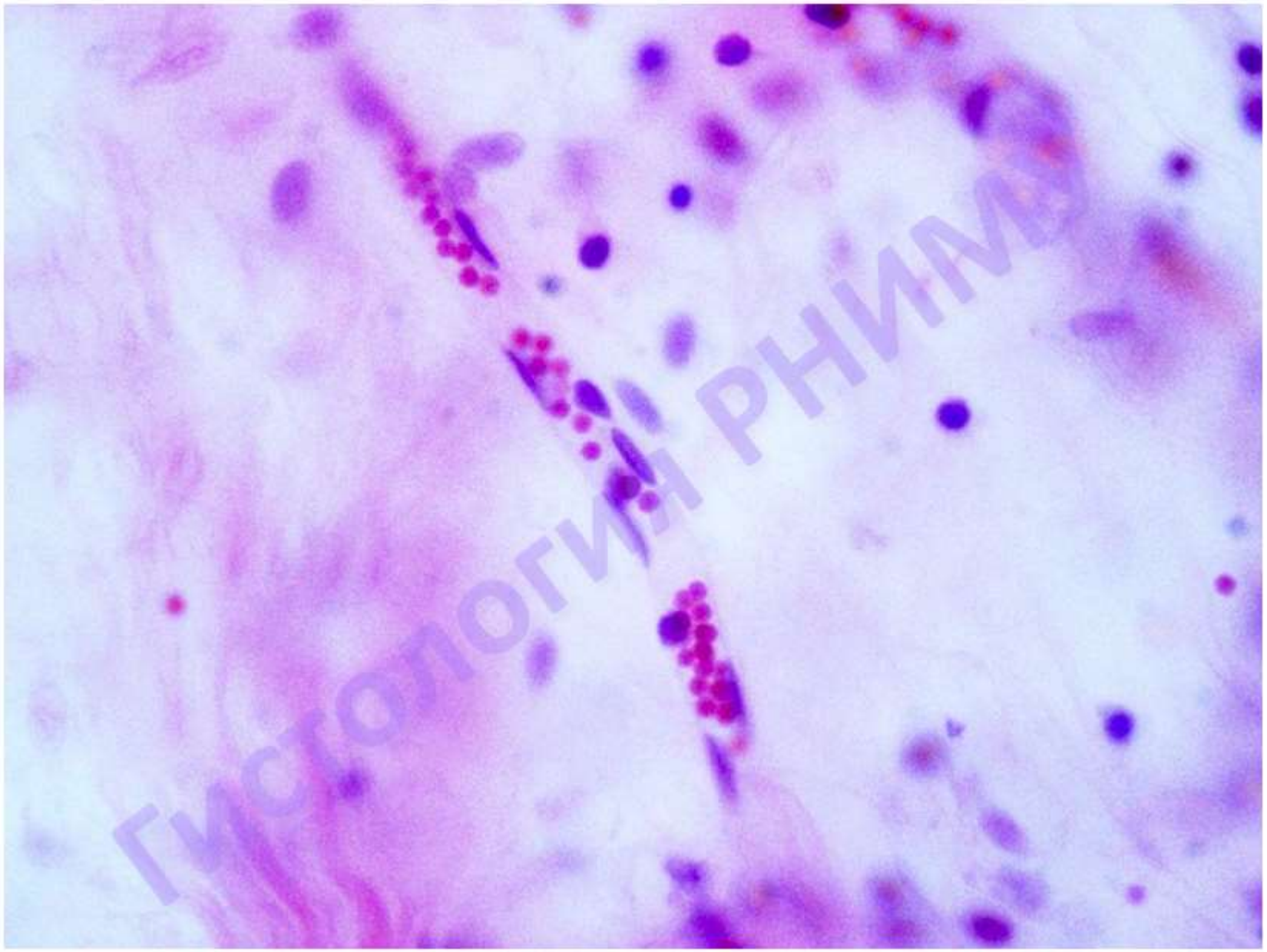
Hematoxylin-eosin staining

Slide 101 «Microcirculatory bed»

Hematoxylin-eosin staining



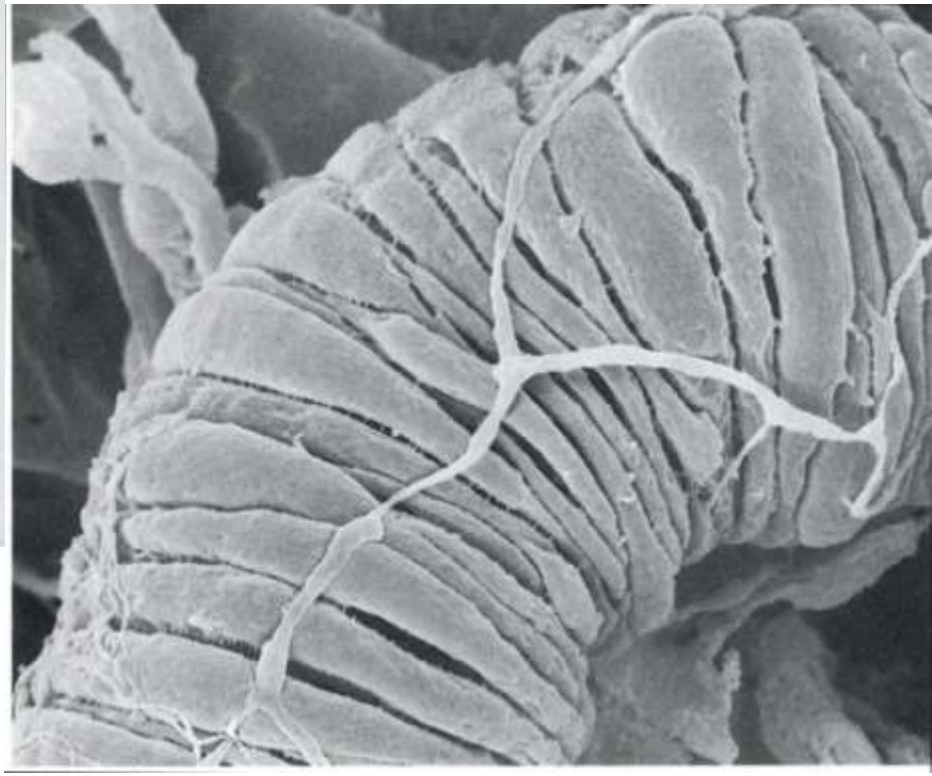
Slide 101 «Microcirculatory bed»
Hematoxylin-eosin staining



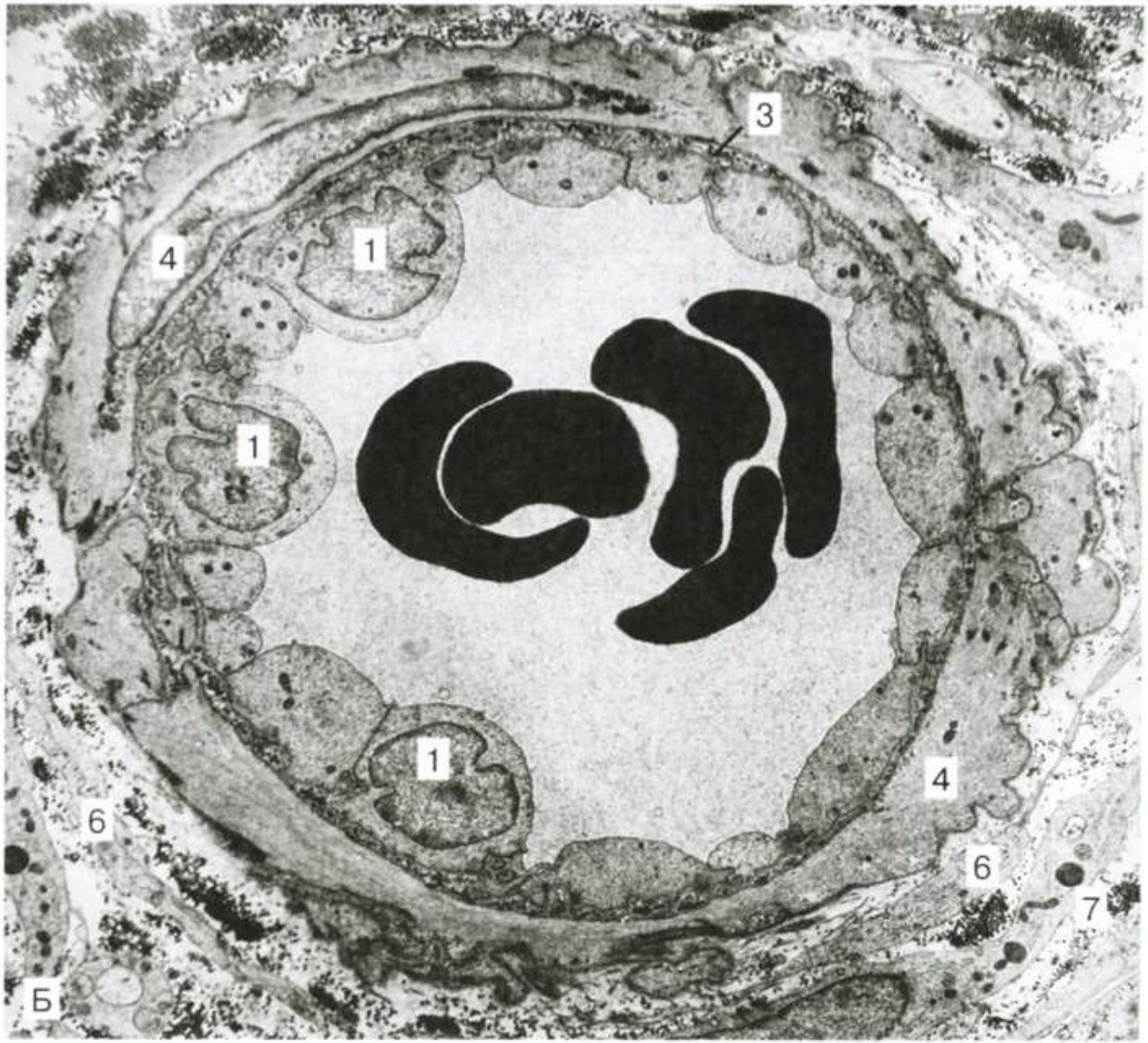
ARTERIOLE

Arteriole

Smooth muscle cells and a nerve in the tunica media of an arteriole



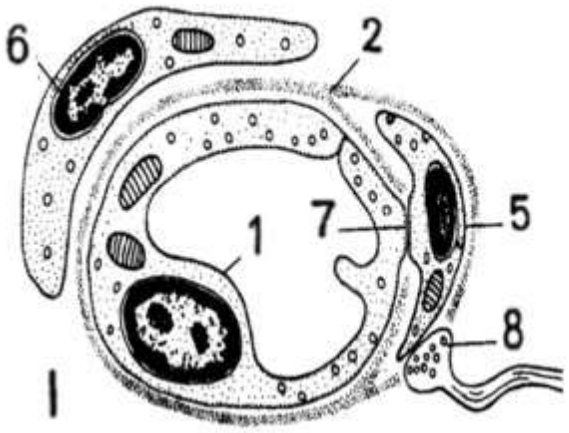
ARTERIOLE



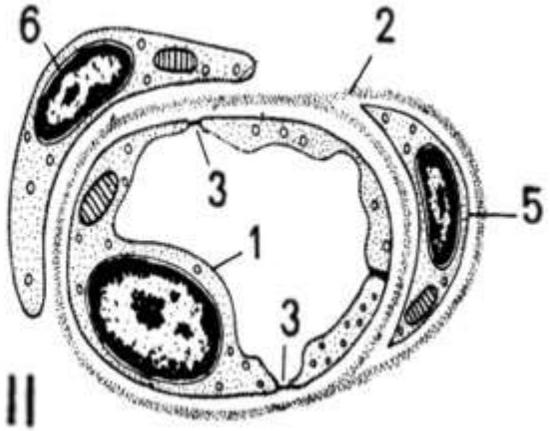
1- endothelial cells; 3- elastic lamina; 4- smooth muscle cells; 5- contact between a smooth muscle cell and an endothelial cell; 6- adventitial cells; 7- connective tissue extracelliular matrix fibers

TYPES OF BLOOD CAPILLARIES

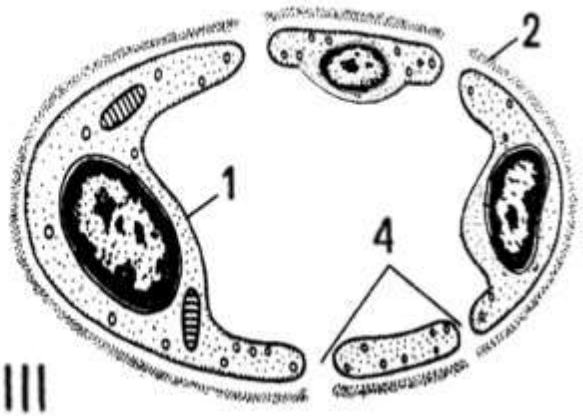
somatic



visceral

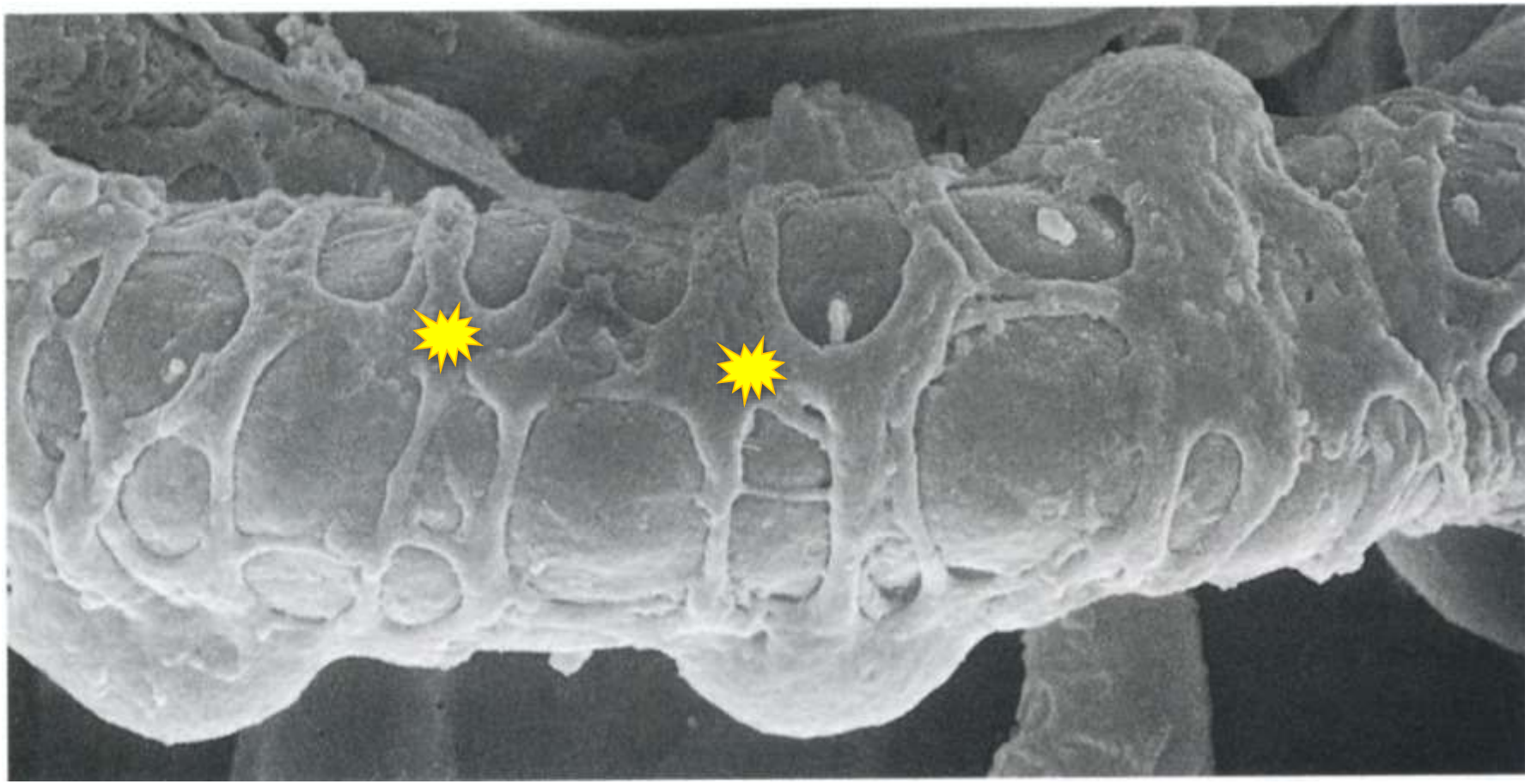


sinusoidal



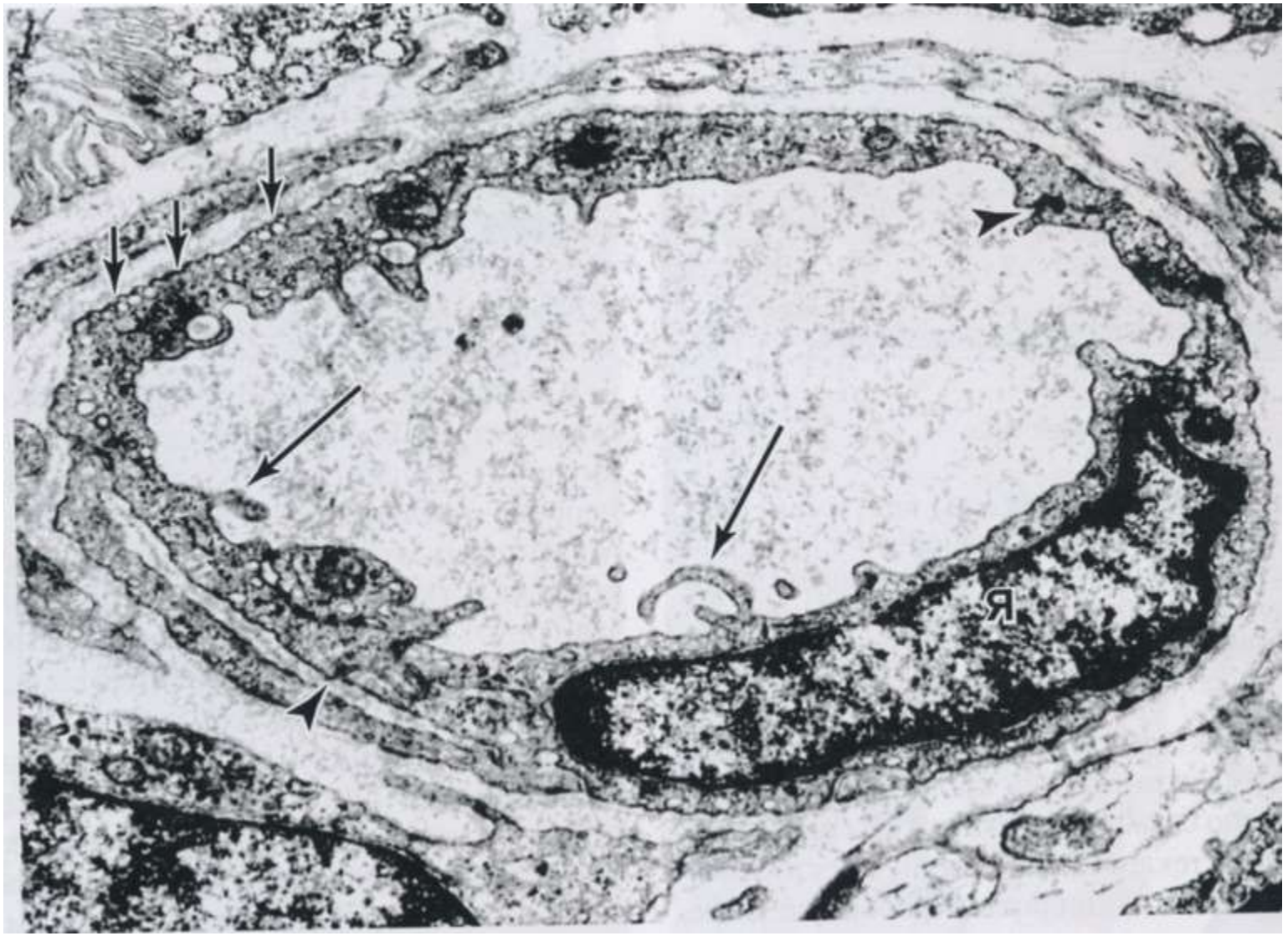
I- capillary with continuous endothelial lining and continuous basement membrane,
II- capillary with fenestrated endothelium and continuous basement membrane,
III- capillary with the pores in endothelium and discontinuous basement membrane

1- endothelial cell, 2- basement membrane, 3- fenestrae, 4- slits (pores), 5 -pericyte,
6- adventitial cells, 7- contact between endotheliocyte and pericyte, 8- nerve ending

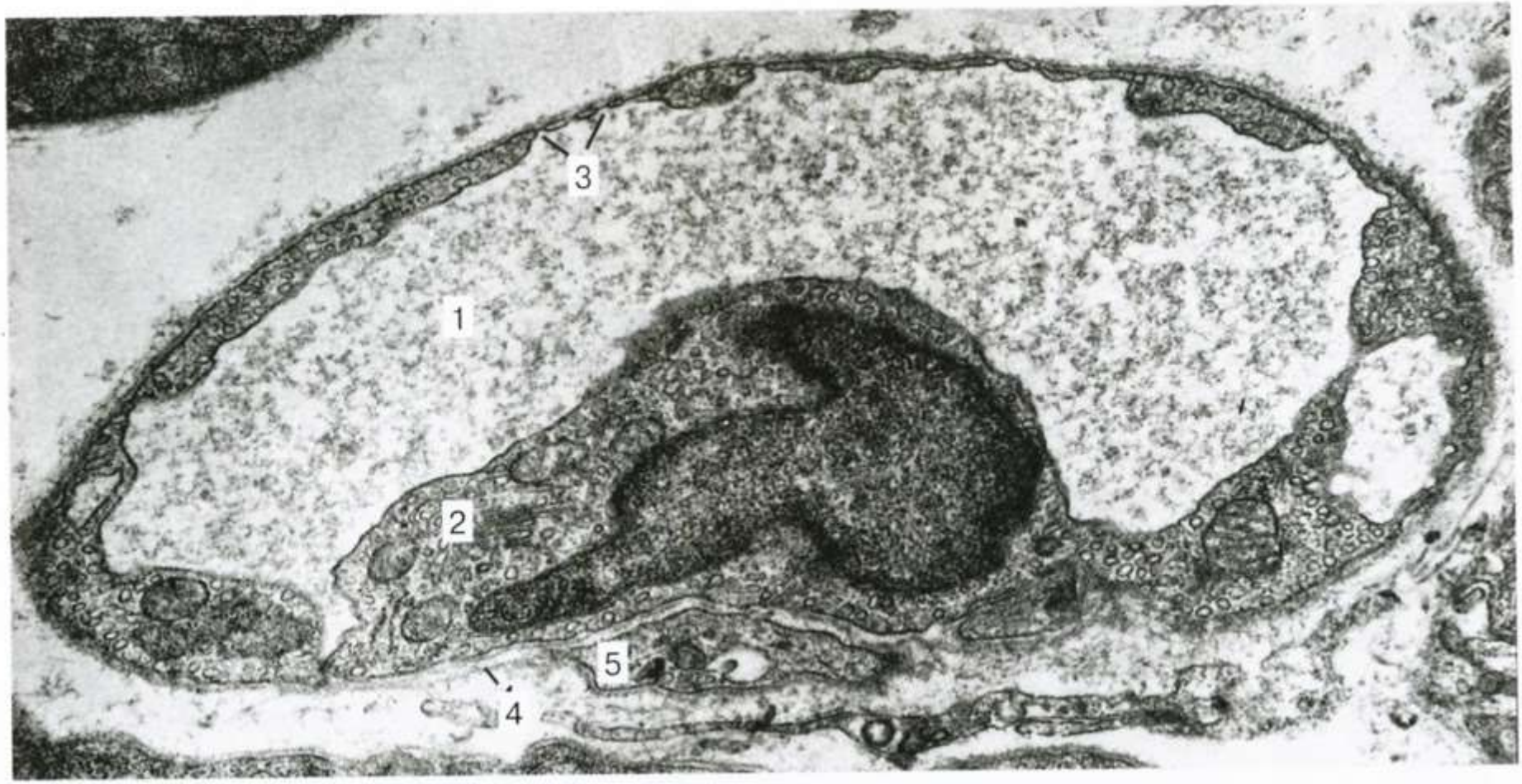


Pericytes of the capillary wall

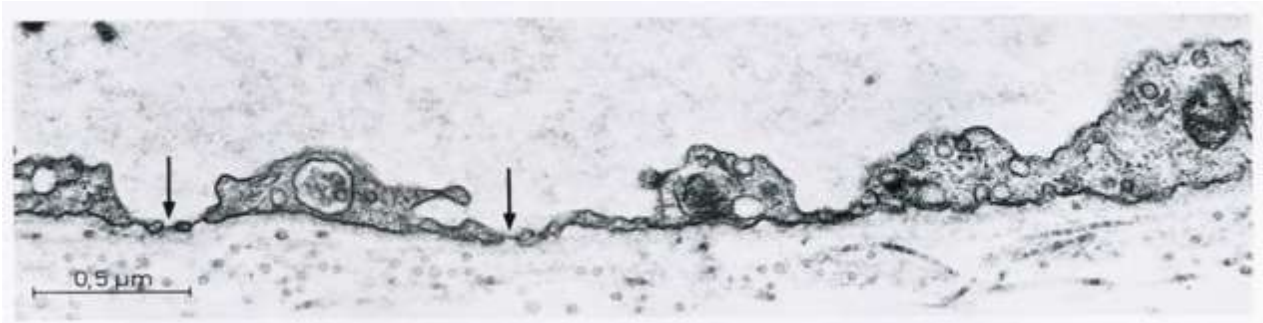
CAPILLARY OF SOMATIC TYPE



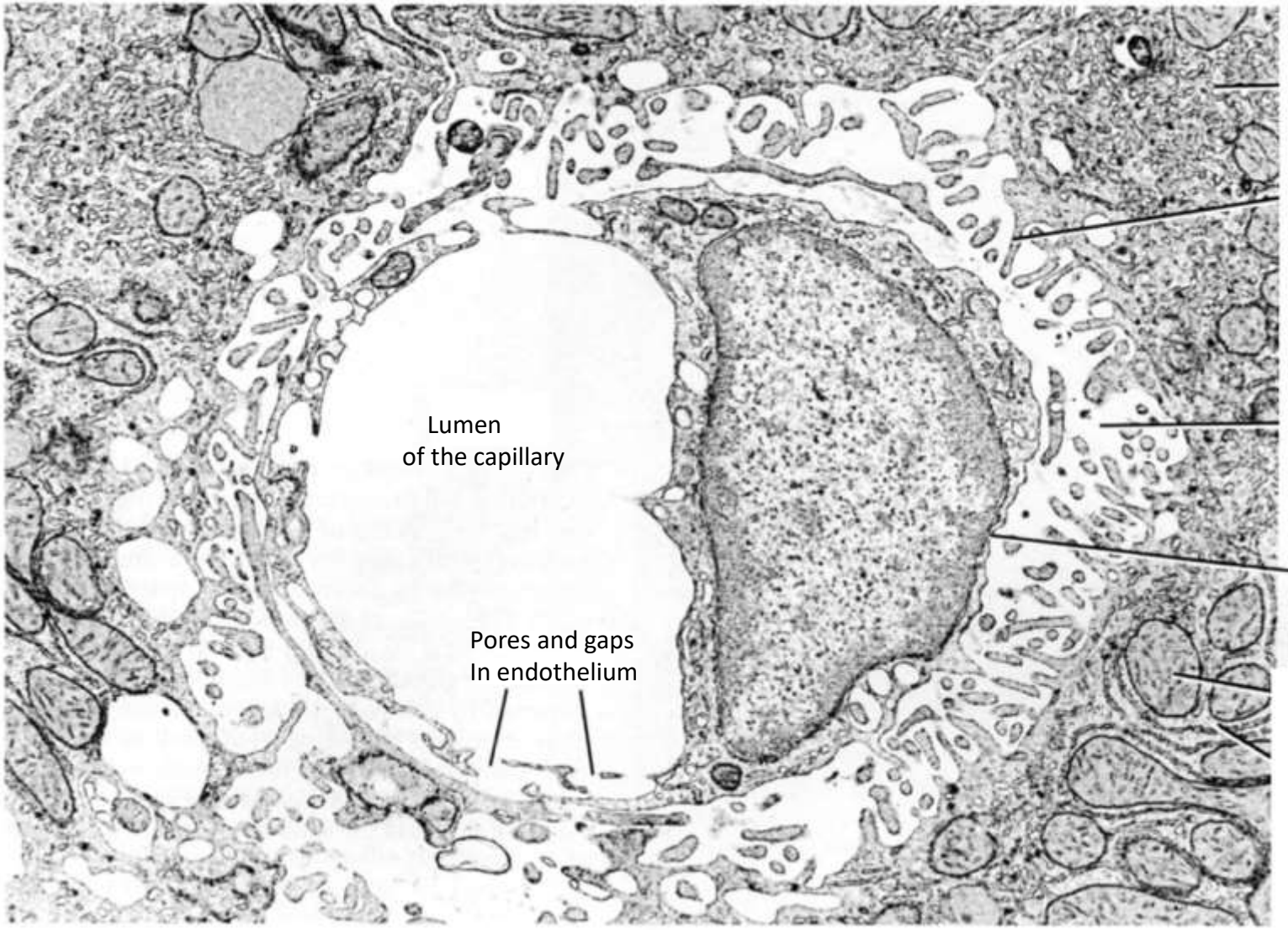
CAPILLARY OF VISCERAL TYPE, WITH FENESTRATED ENDOTHELIUM



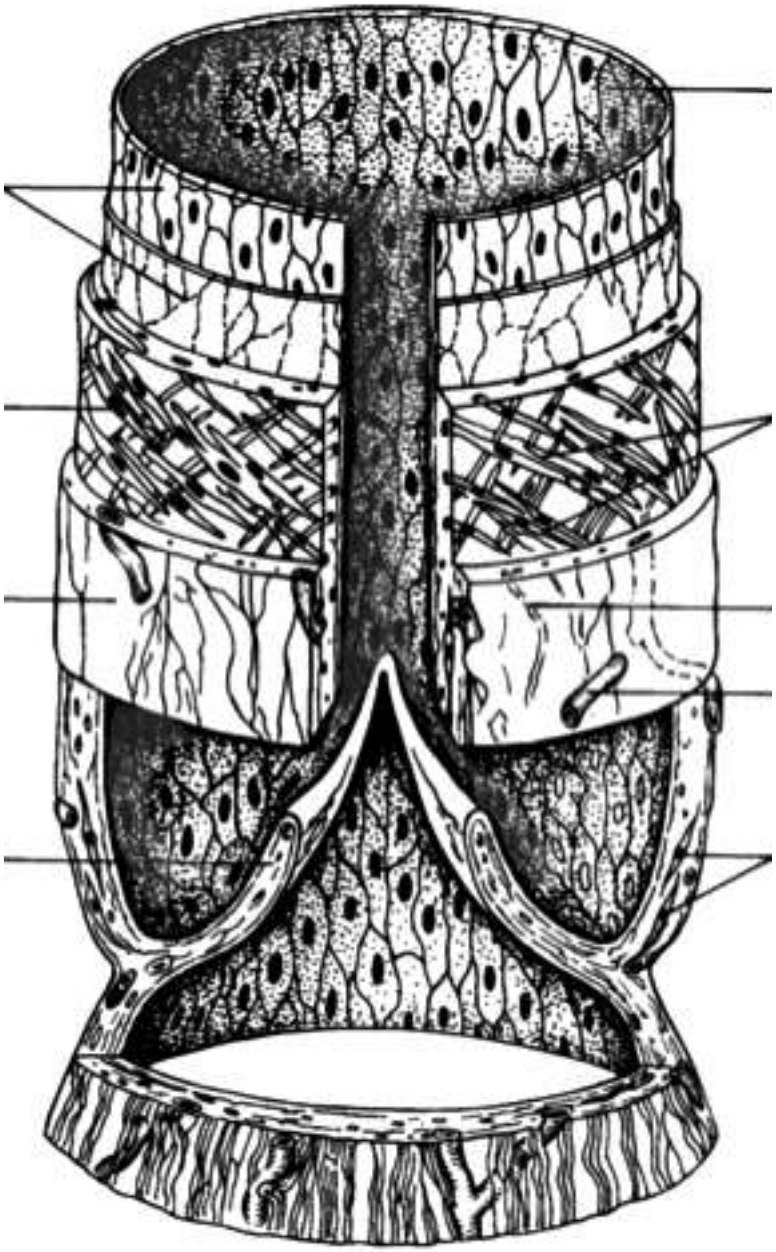
1- lumen of the capillary, 2- cytoplasm of the endothelial cell, 3- fenestrae (indicated by arrows), 4- basement membrane, 5- pericyte



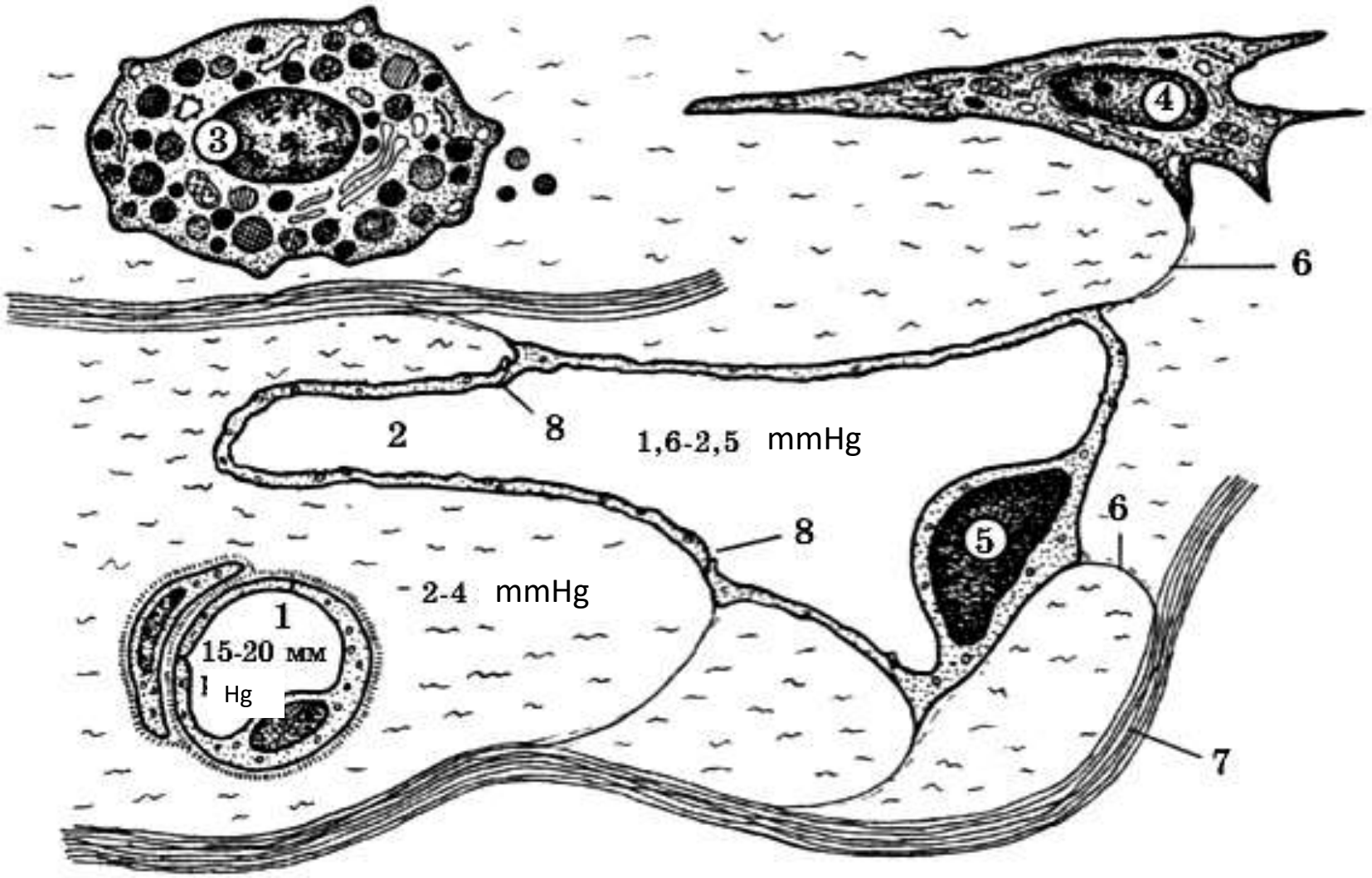
CAPILLARY OF SINUSOIDAL TYPE



STRUCTURE OF THE LYMPH VESSEL

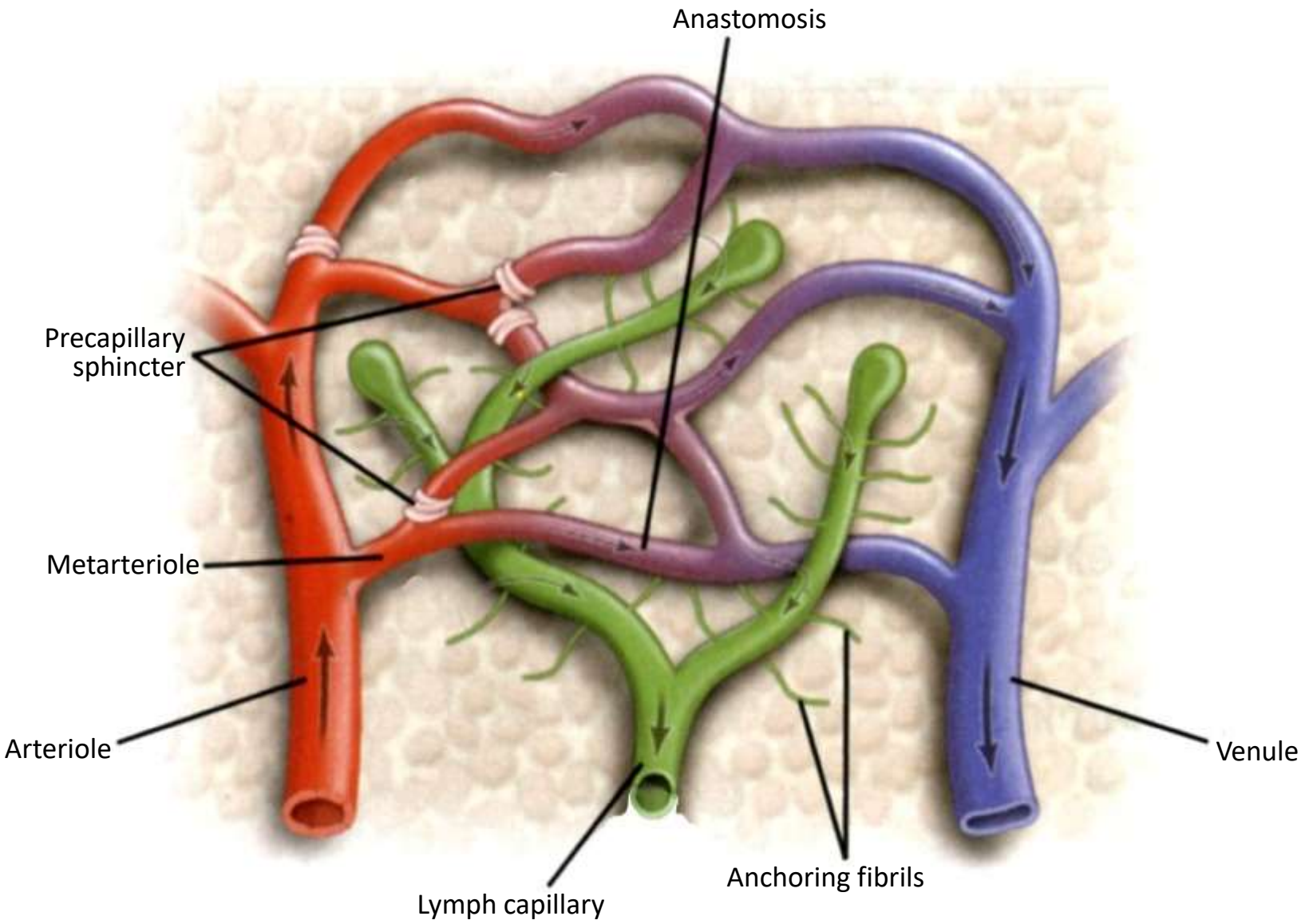


COMPARATIVE STRUCTURE OF THE BLOOD AND LYMPH CAPILLARIES

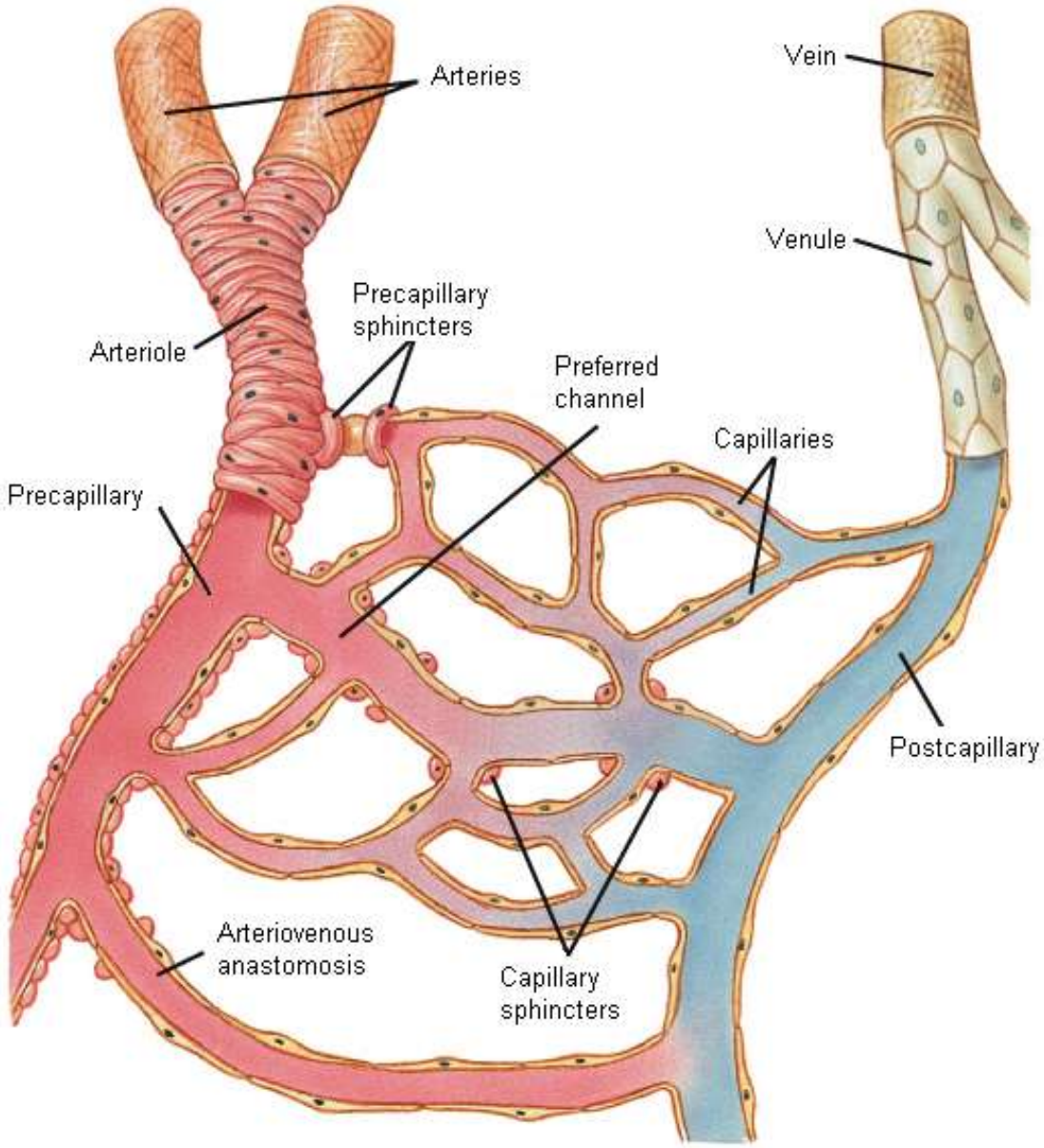


1- blood capillary, 2- lymph capillary, 3- tissue basophil, 4- fibroblast, 5- endothelial cell of the lymph capillary, 6- anchoring fibrils, 7- collagen fibers, 8- cell junctions between endothelial cells of the lymph capillary, мм рт. ст.- mm Hg (approximate pressure values)

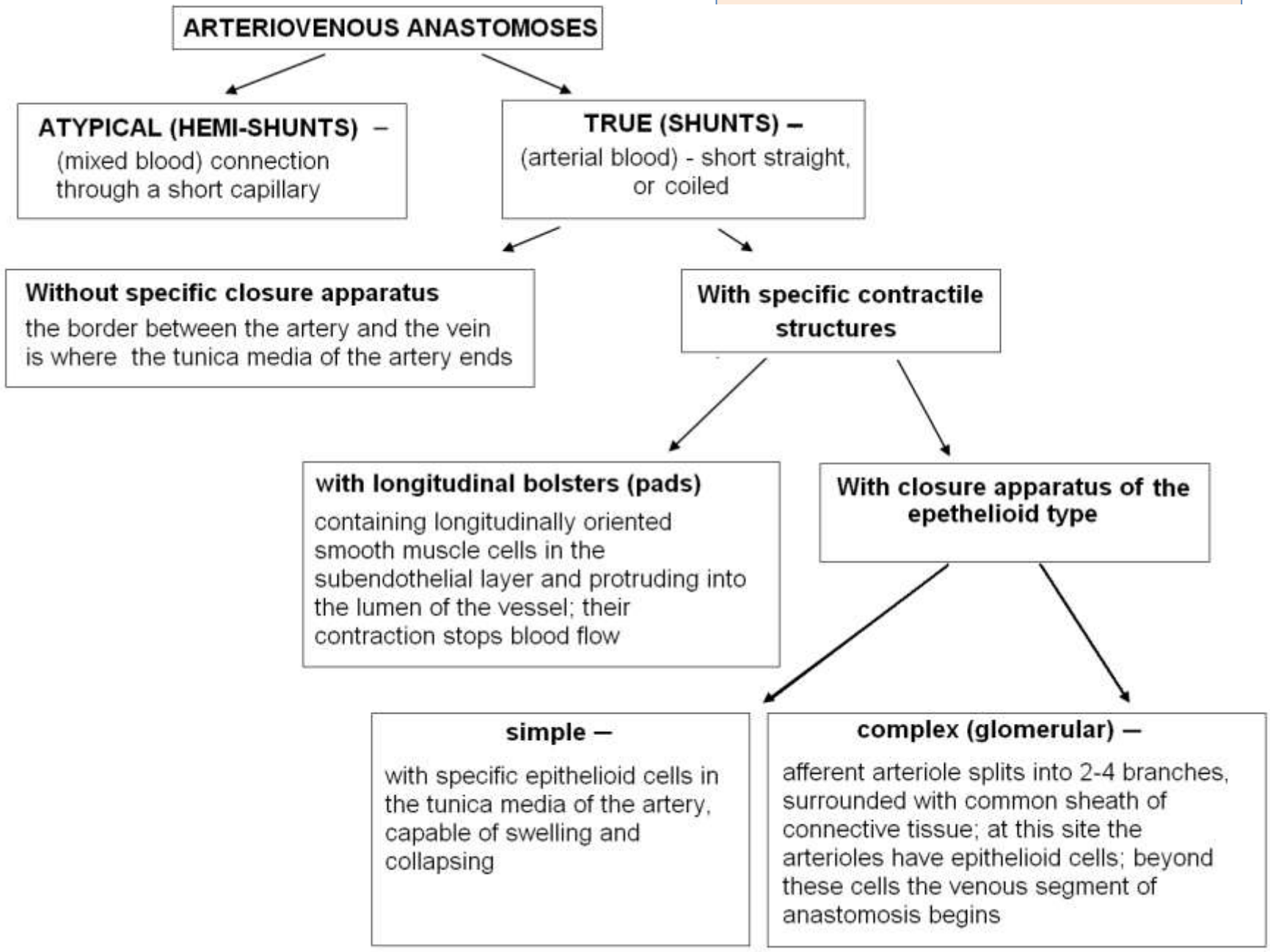
BLOOD VESSELS OF MICROCIRCULATORY BED AND LYMPH CAPILLARIES



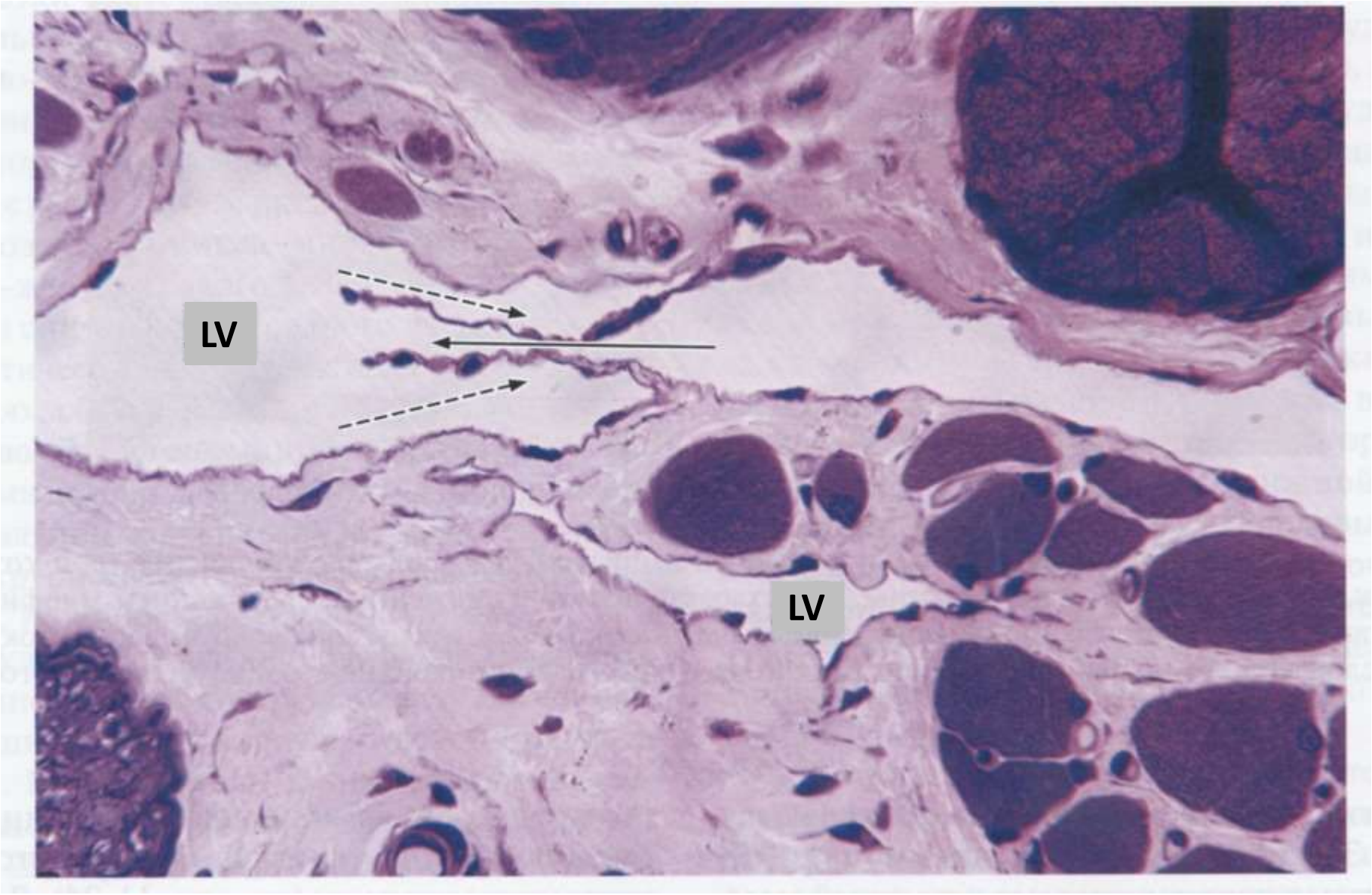
BLOOD VESSELS OF MICROCIRCULATORY BED



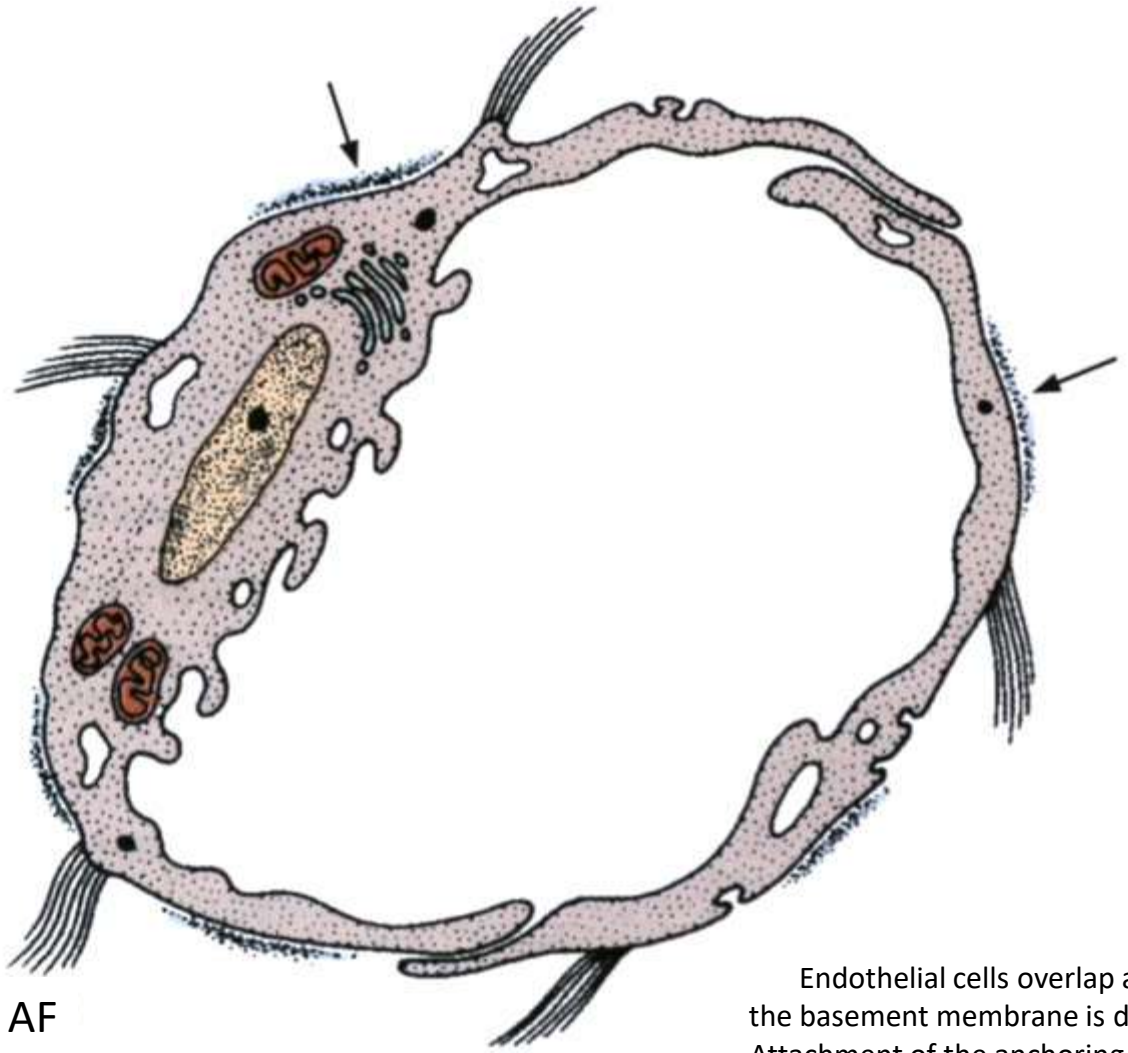
ARTERIOVENOUS ANASTOMOSES



LYMPH VESSEL

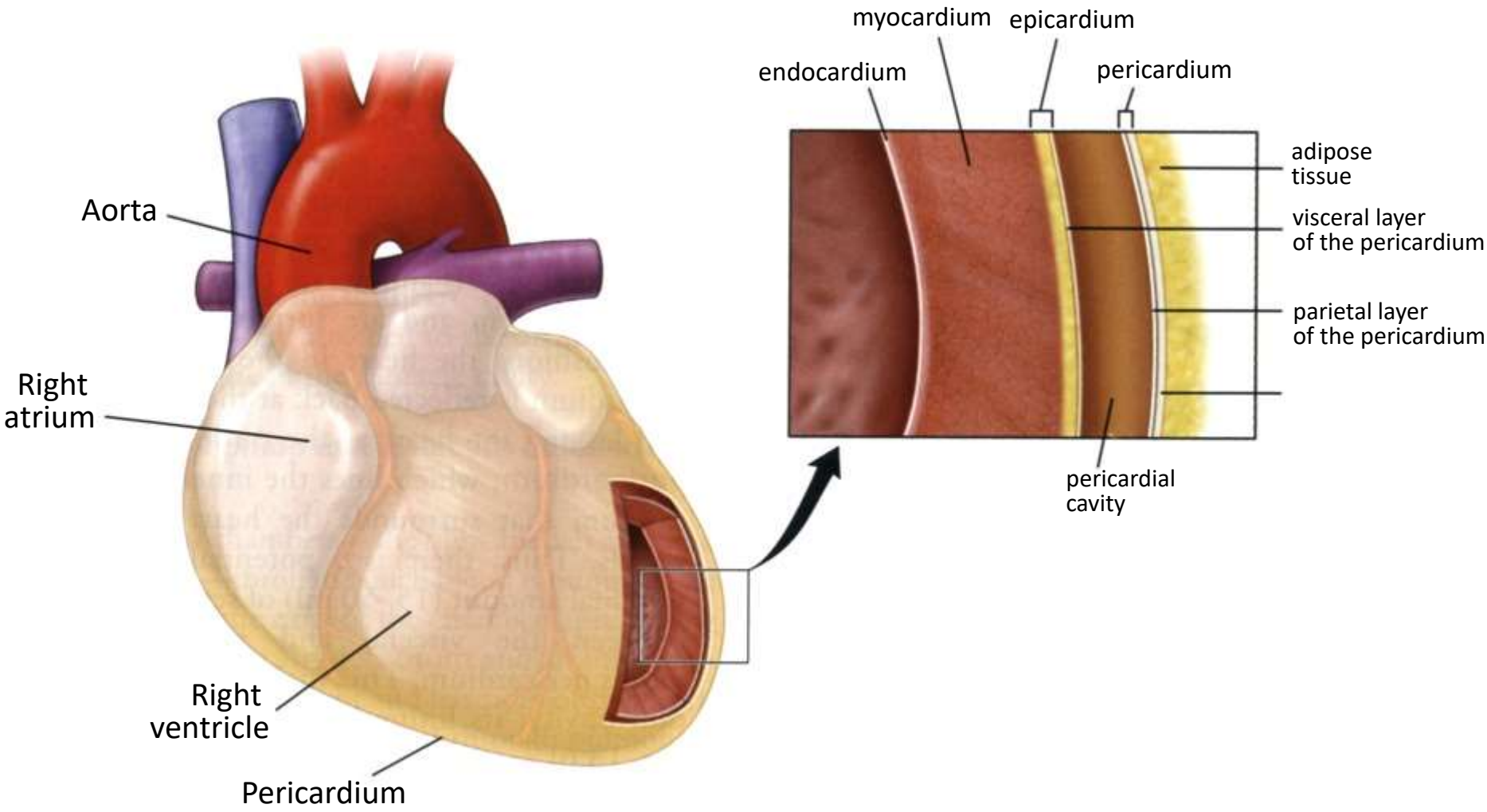


LYMPH CAPILLARY

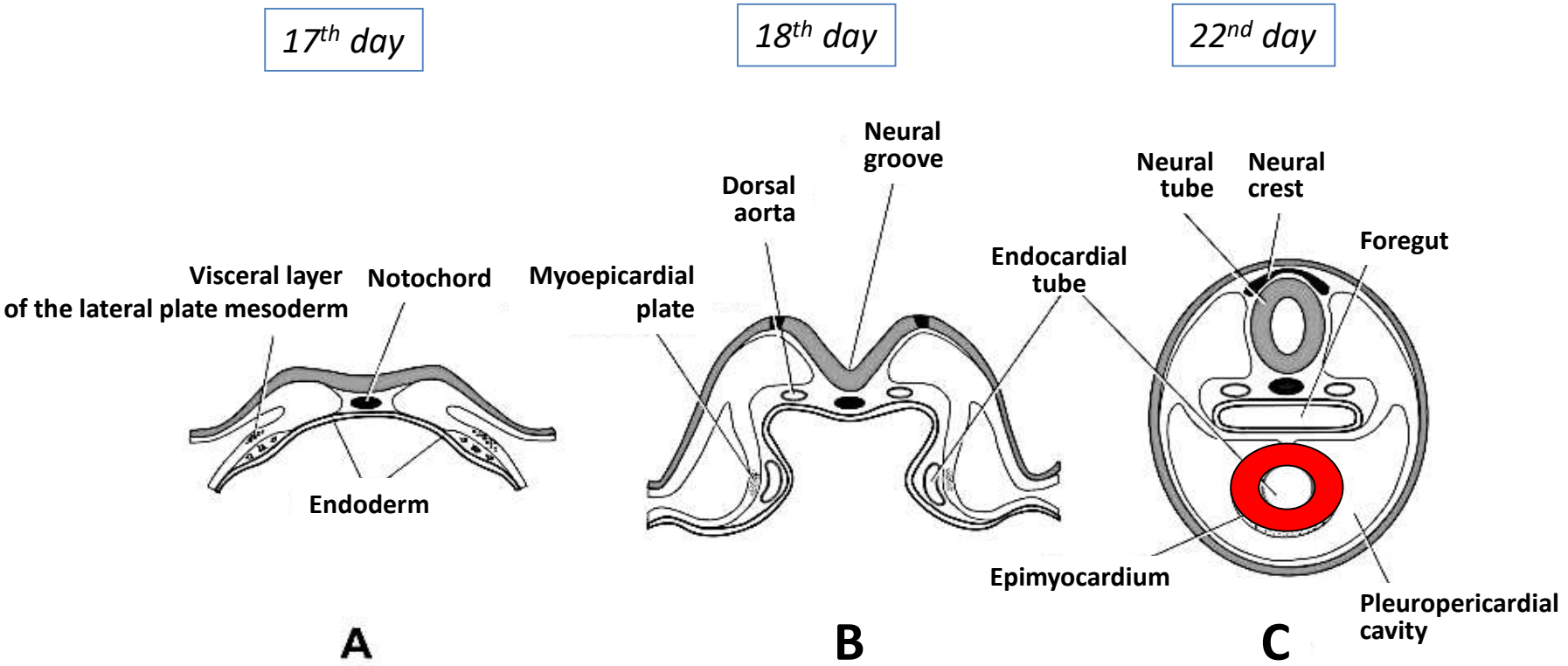


Endothelial cells overlap at their free edges,
the basement membrane is discontinuous (arrows).
Attachment of the anchoring fibrils is indicated (AF)

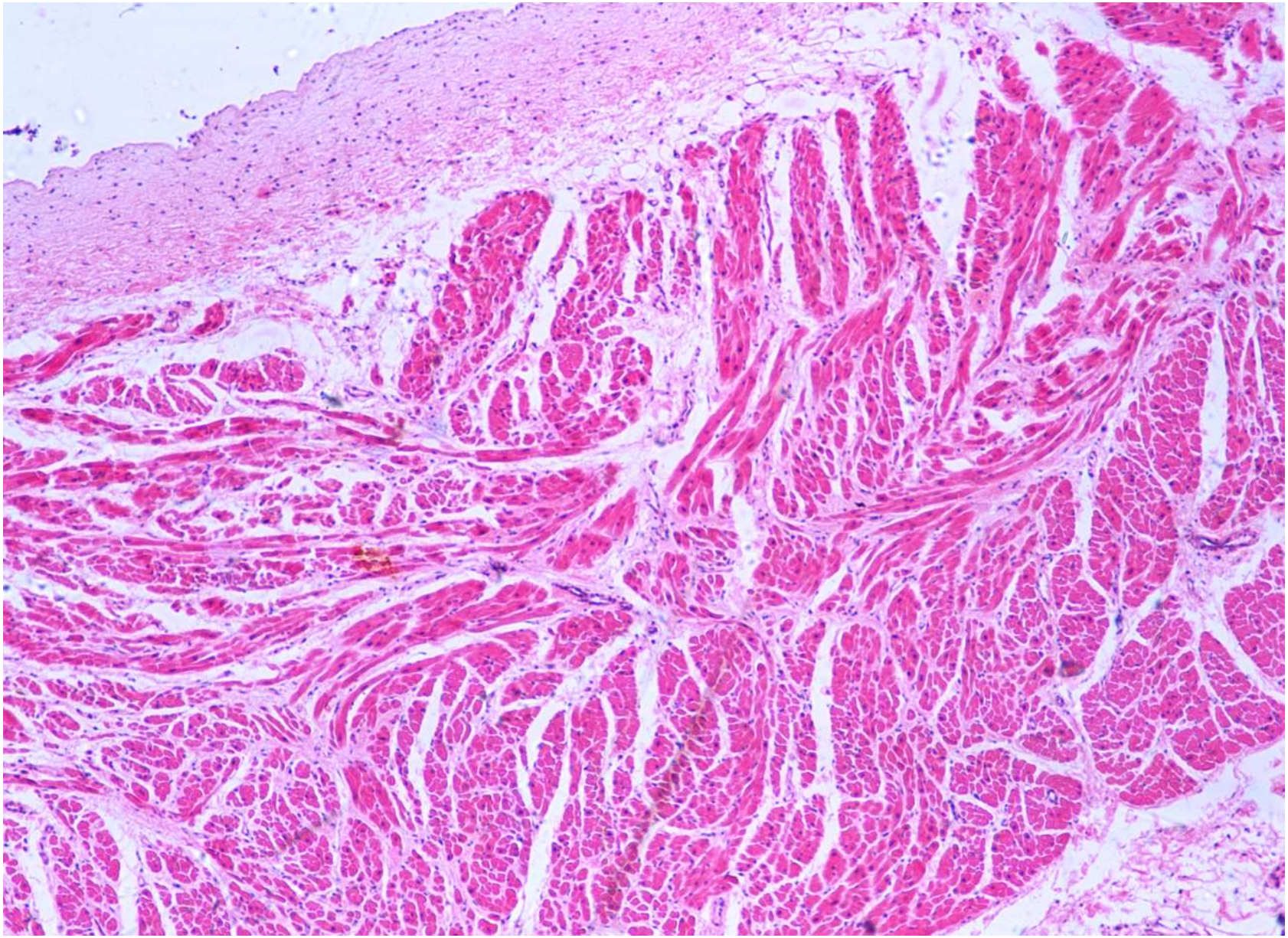
STRUCTURE OF THE HEART WALL



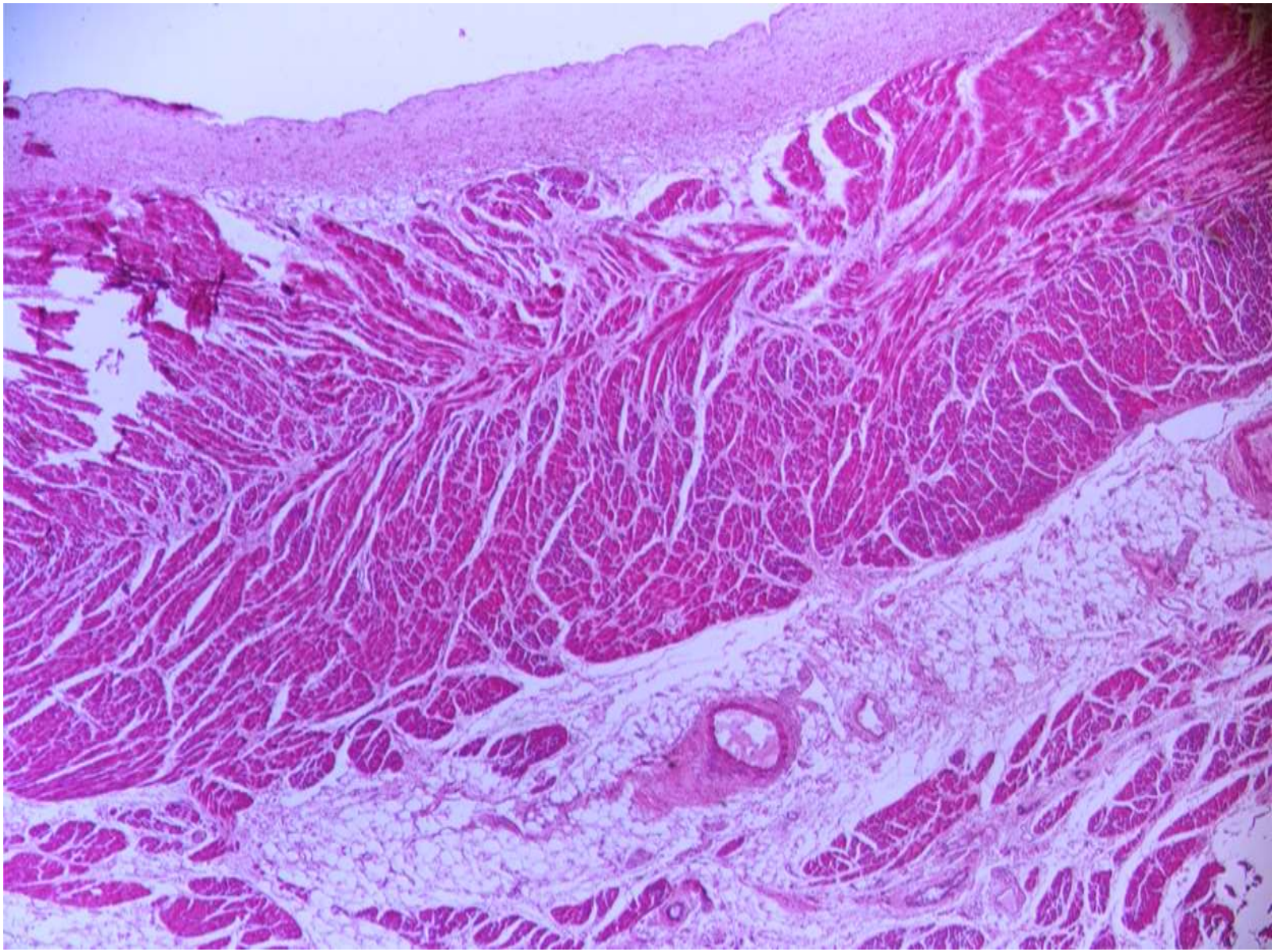
Endocardium develops from the mesenchyme – like a blood vessel.
Myocardium develops from the myoepicardial plate
of the visceral (splanchnic) layer of the lateral plate mesoderm



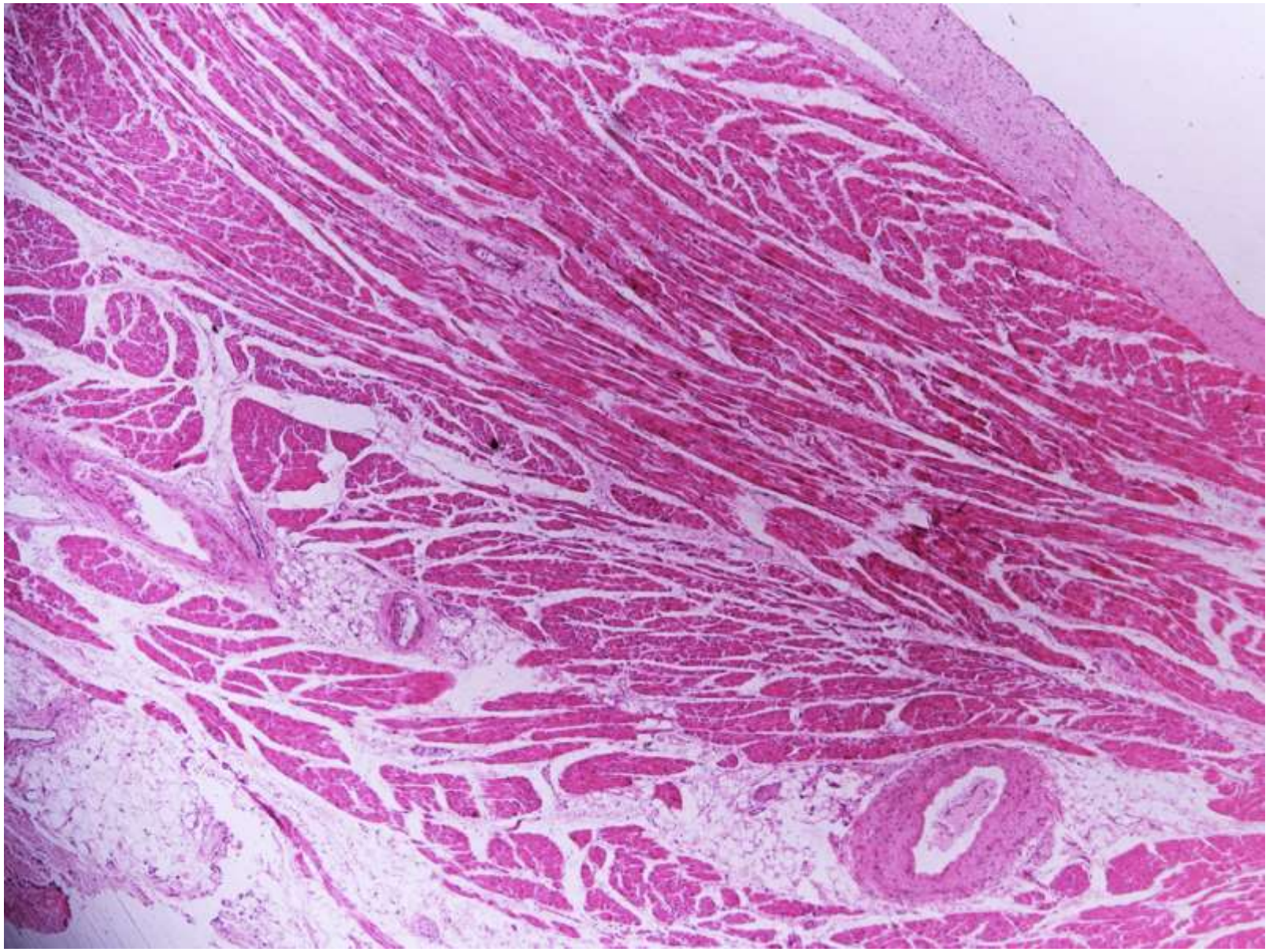
Slide 107 «Wall of the heart»
Hematoxylin-eosin staining



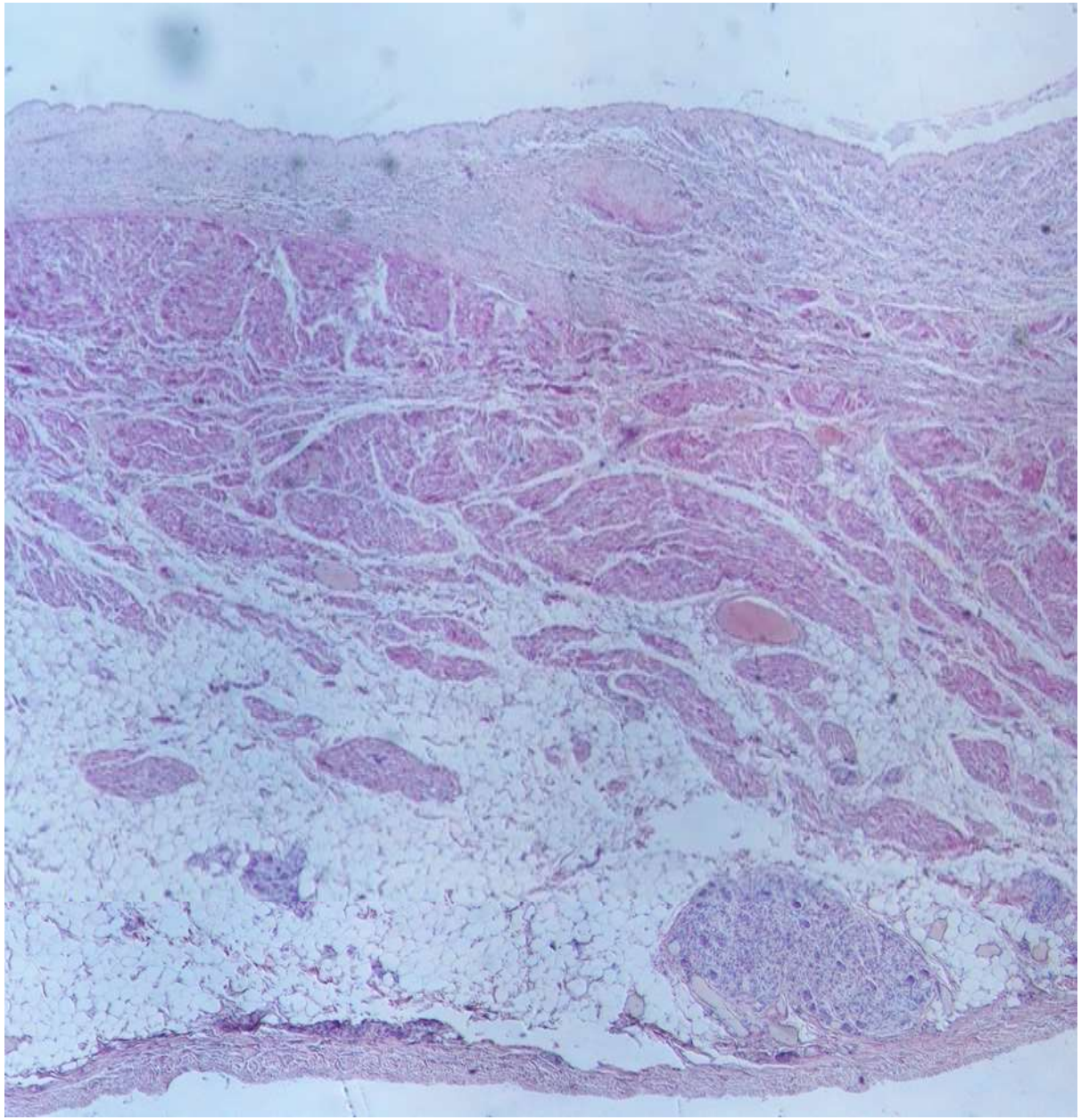
Slide 107. «Wall of the heart»
Hematoxylin-eosin staining



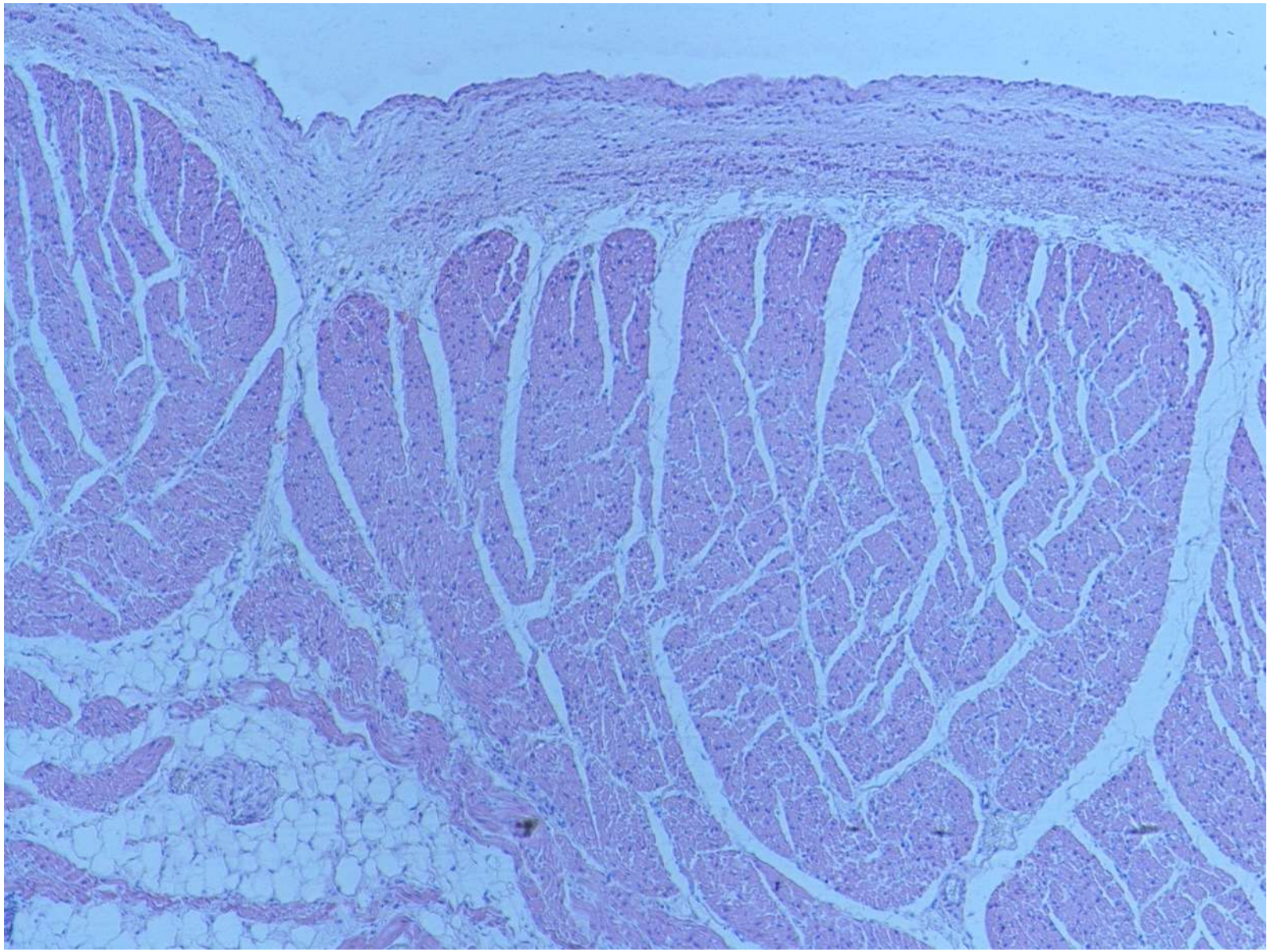
Slide 107. «Wall of the heart»
Hematoxylin-eosin staining



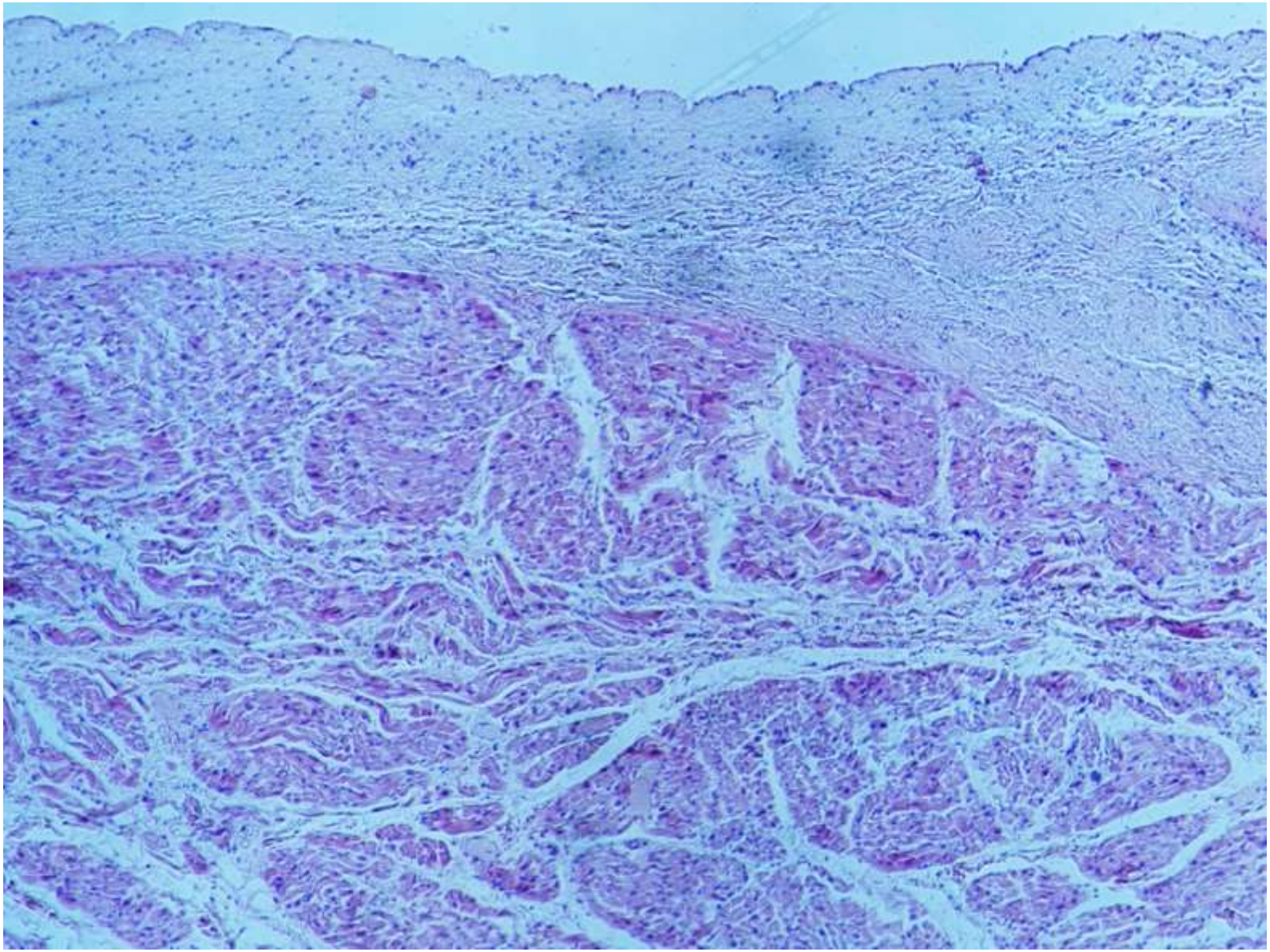
Slide 107. «Wall of the heart»
Hematoxylin-eosin staining



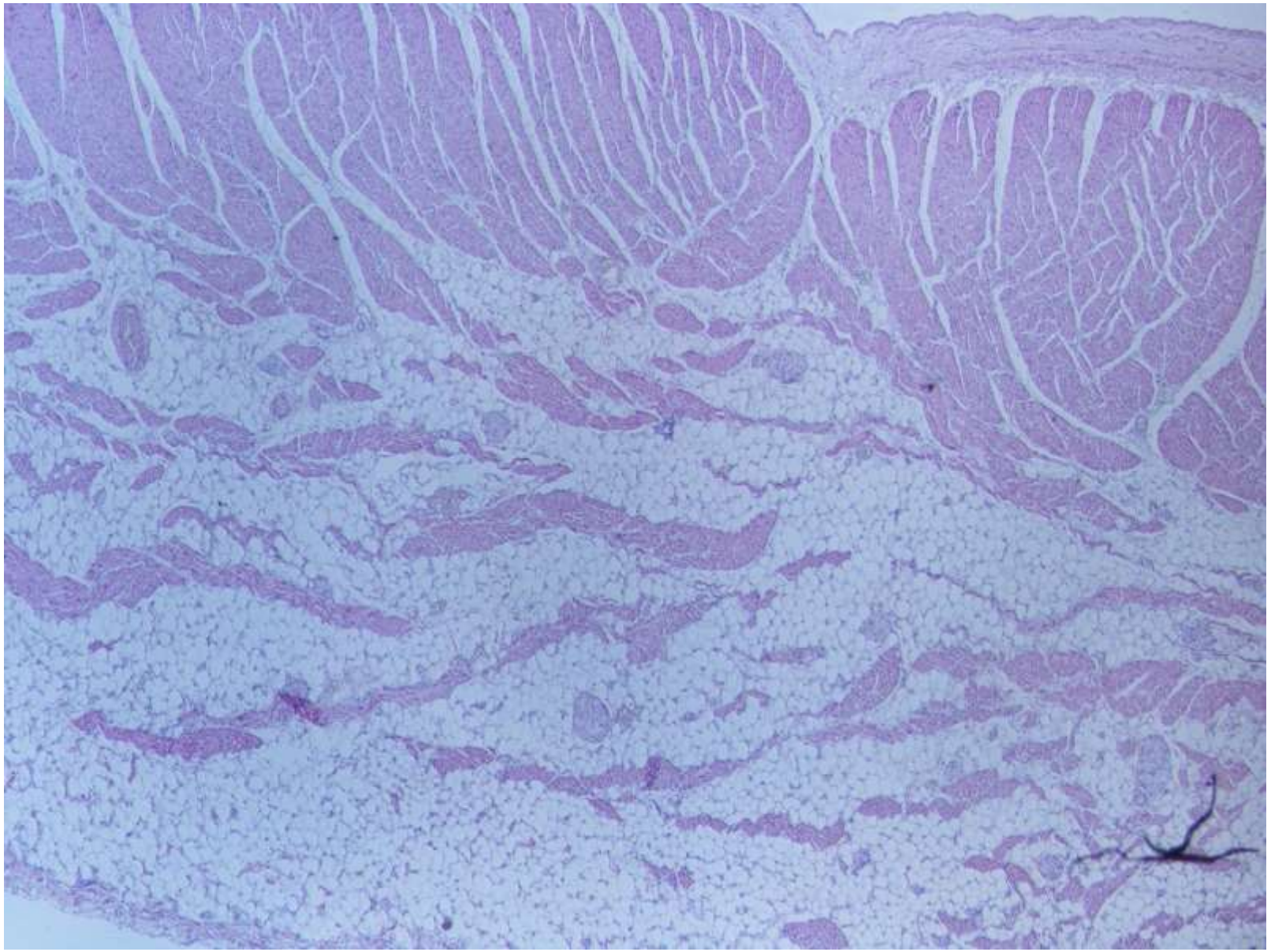
Slide 107. «Wall of the heart»
Hematoxylin-eosin staining



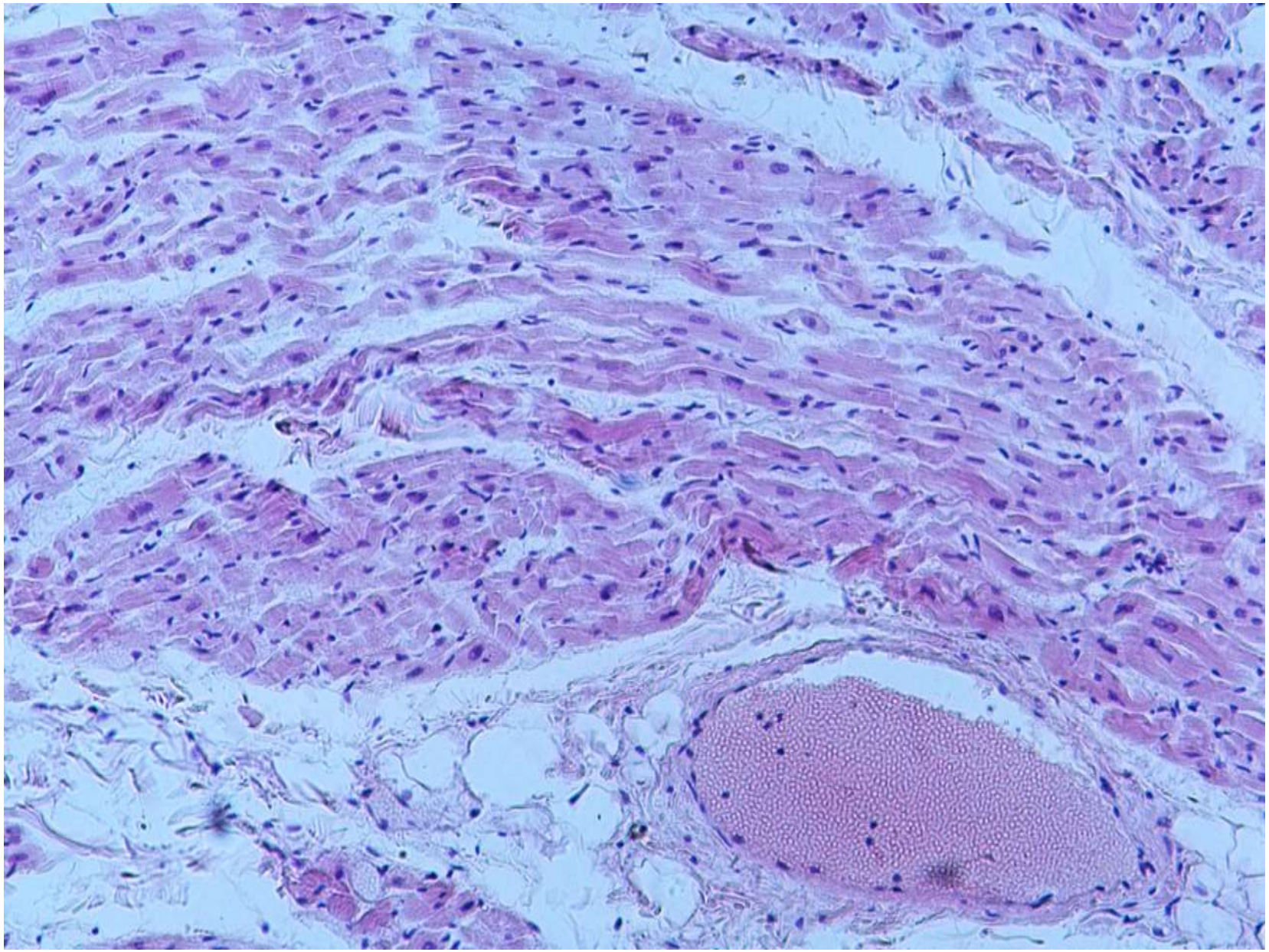
Slide 107. «Wall of the heart»
Hematoxylin-eosin staining



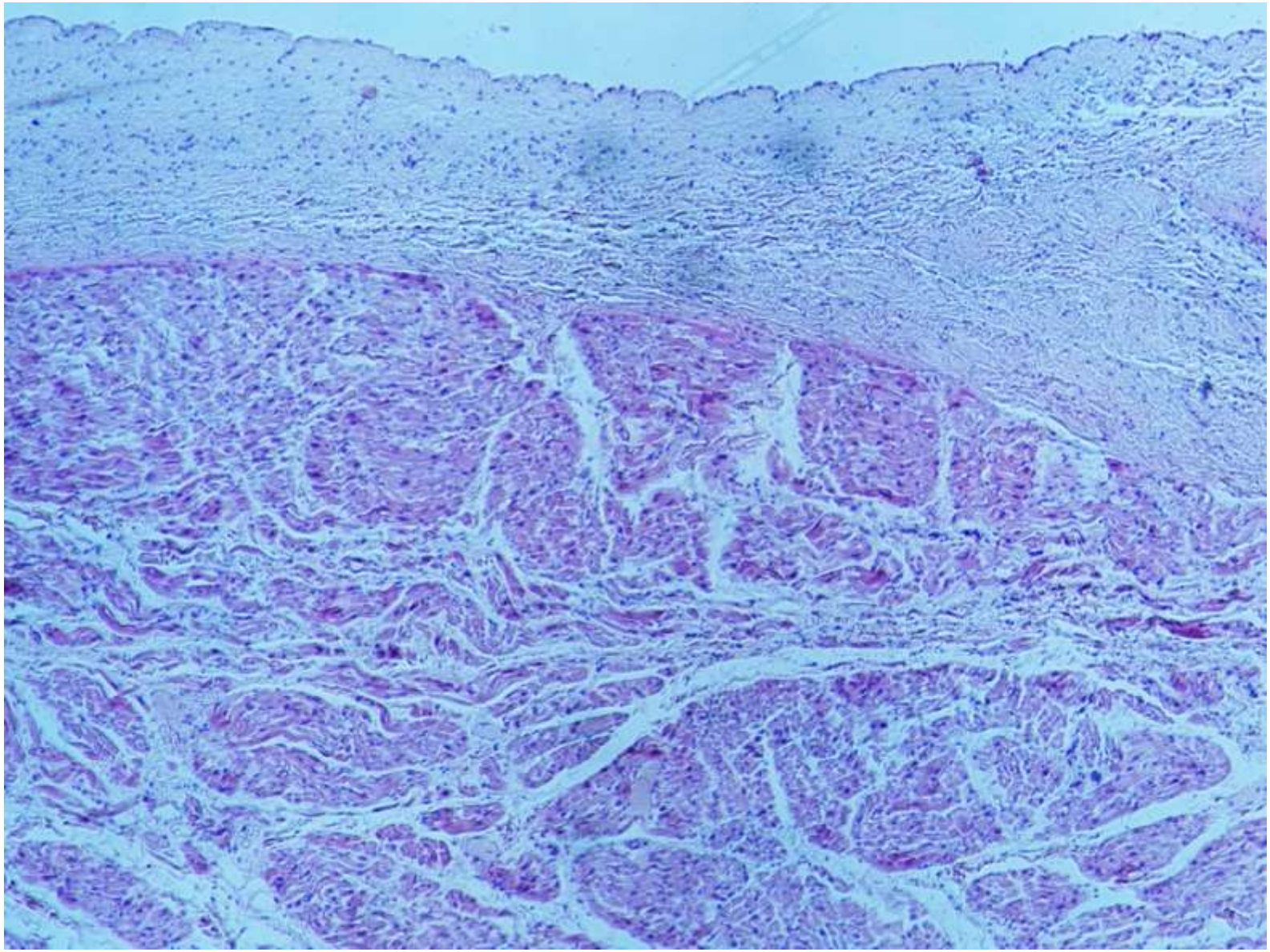
Slide 107. «Wall of the heart»
Hematoxylin-eosin staining



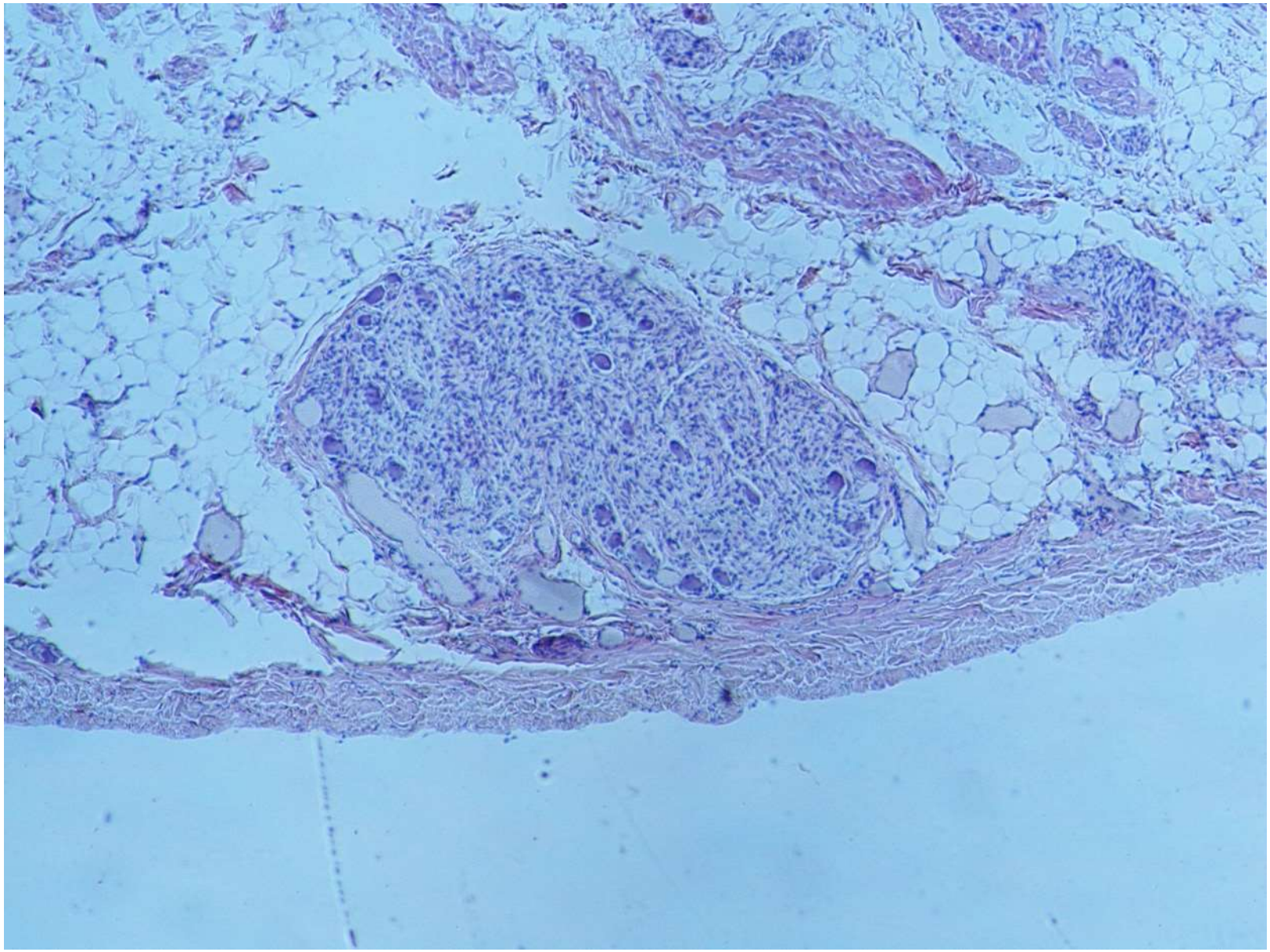
Slide 107. «Wall of the heart»
Hematoxylin-eosin staining



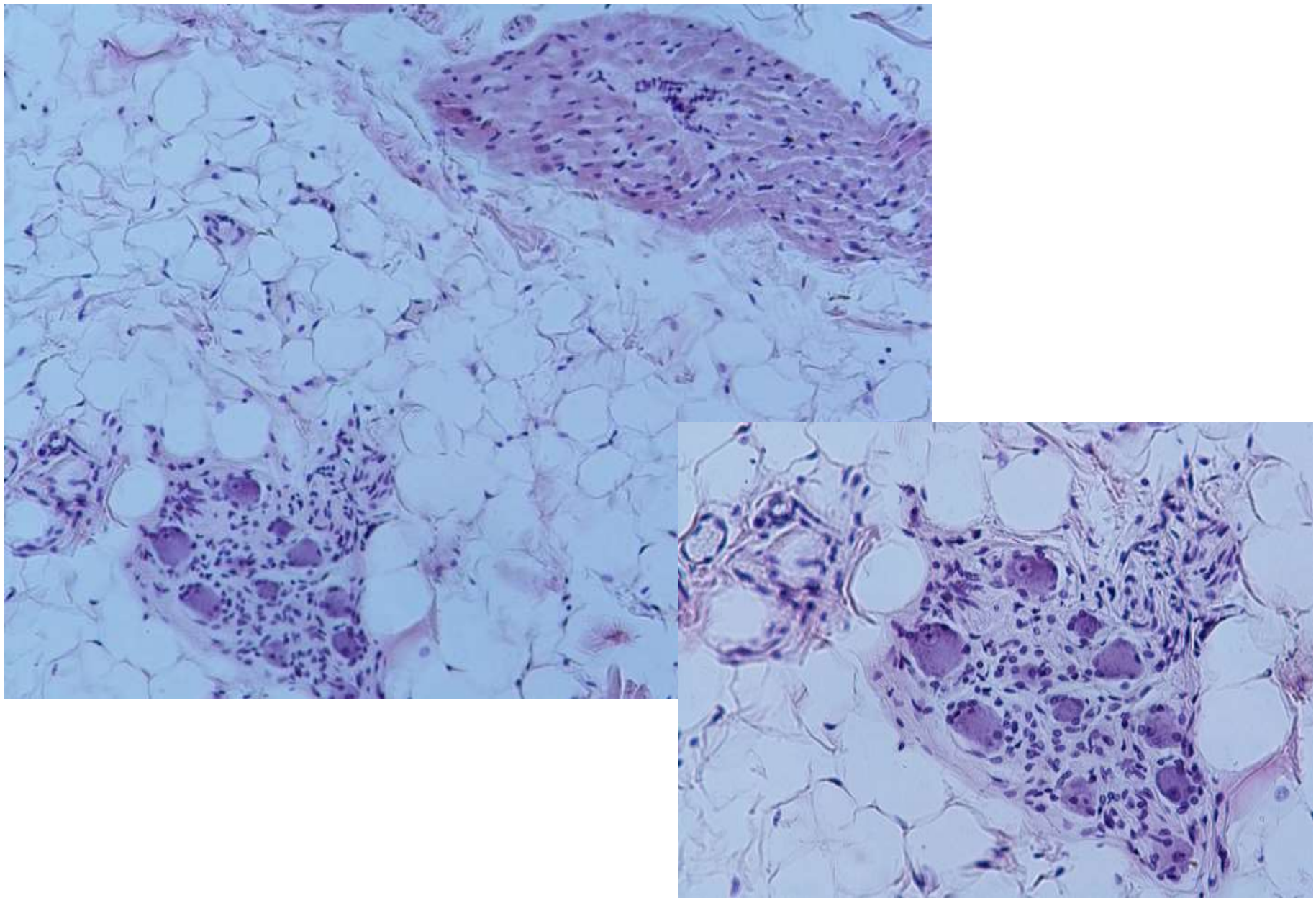
Slide 107. «Wall of the heart»
Hematoxylin-eosin staining



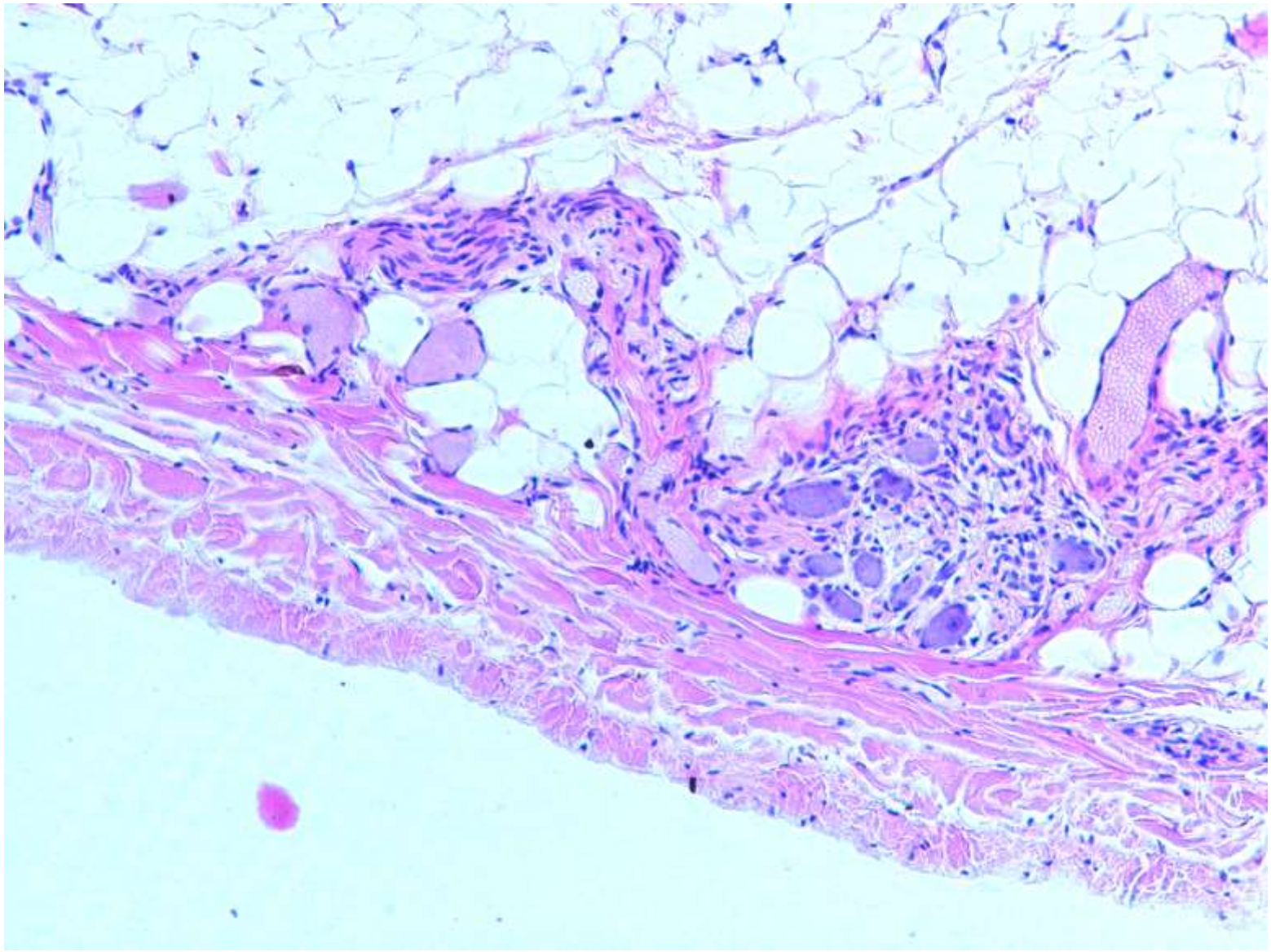
Slide 107. «Wall of the heart»
Hematoxylin-eosin staining



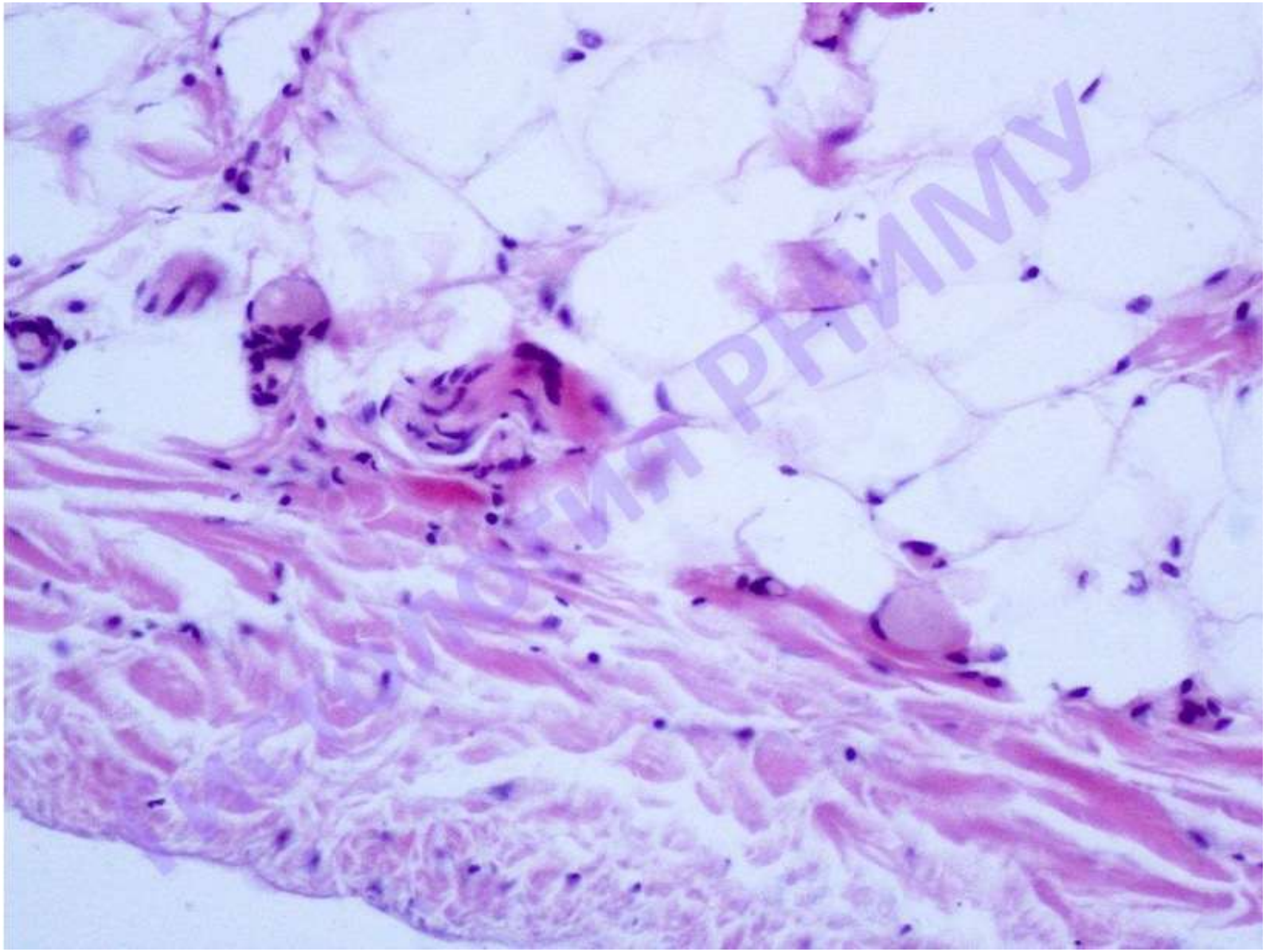
Slide 107. «Wall of the heart»
Hematoxylin-eosin staining



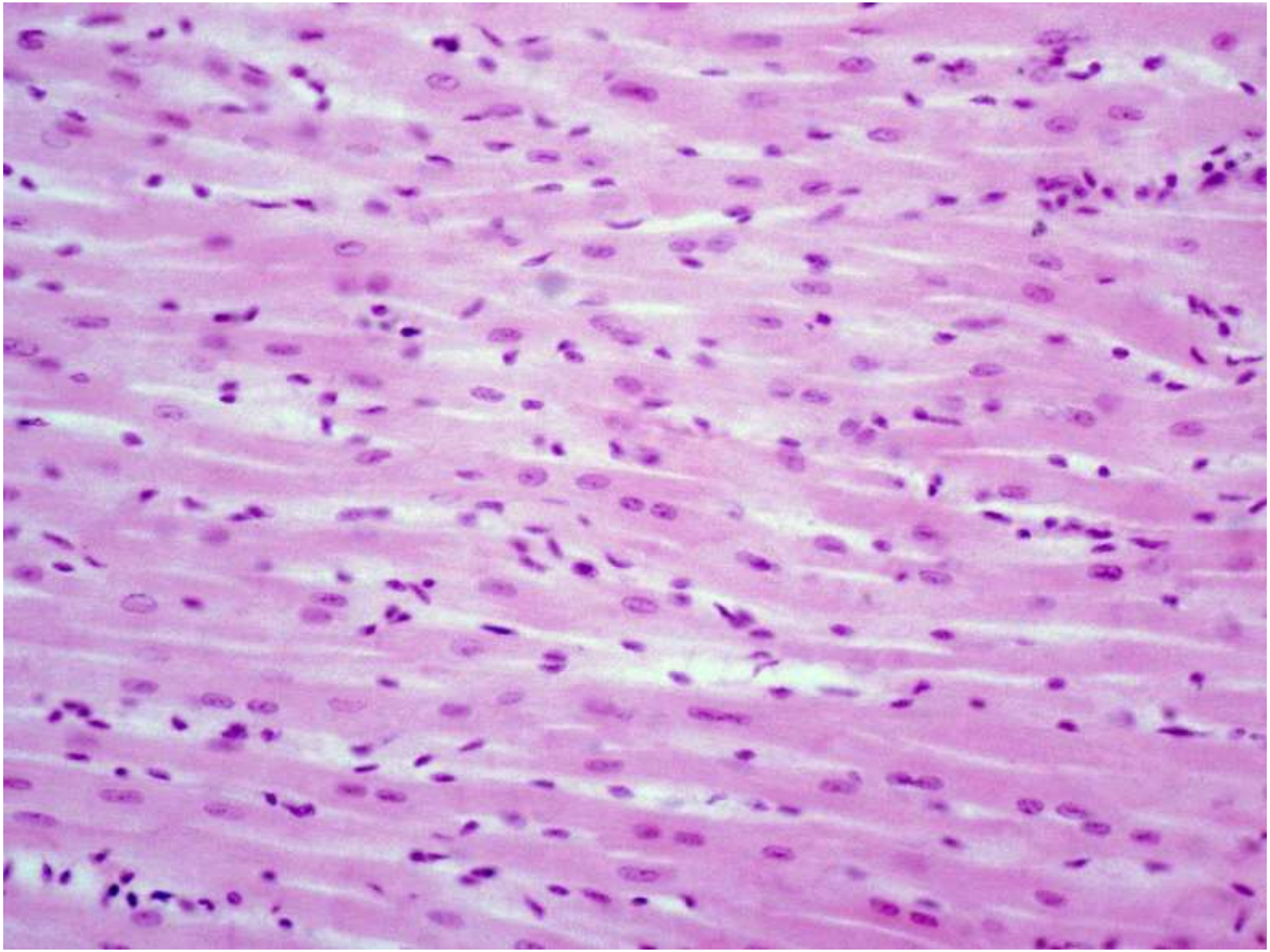
Slide 107. «Wall of the heart»
Hematoxylin-eosin staining

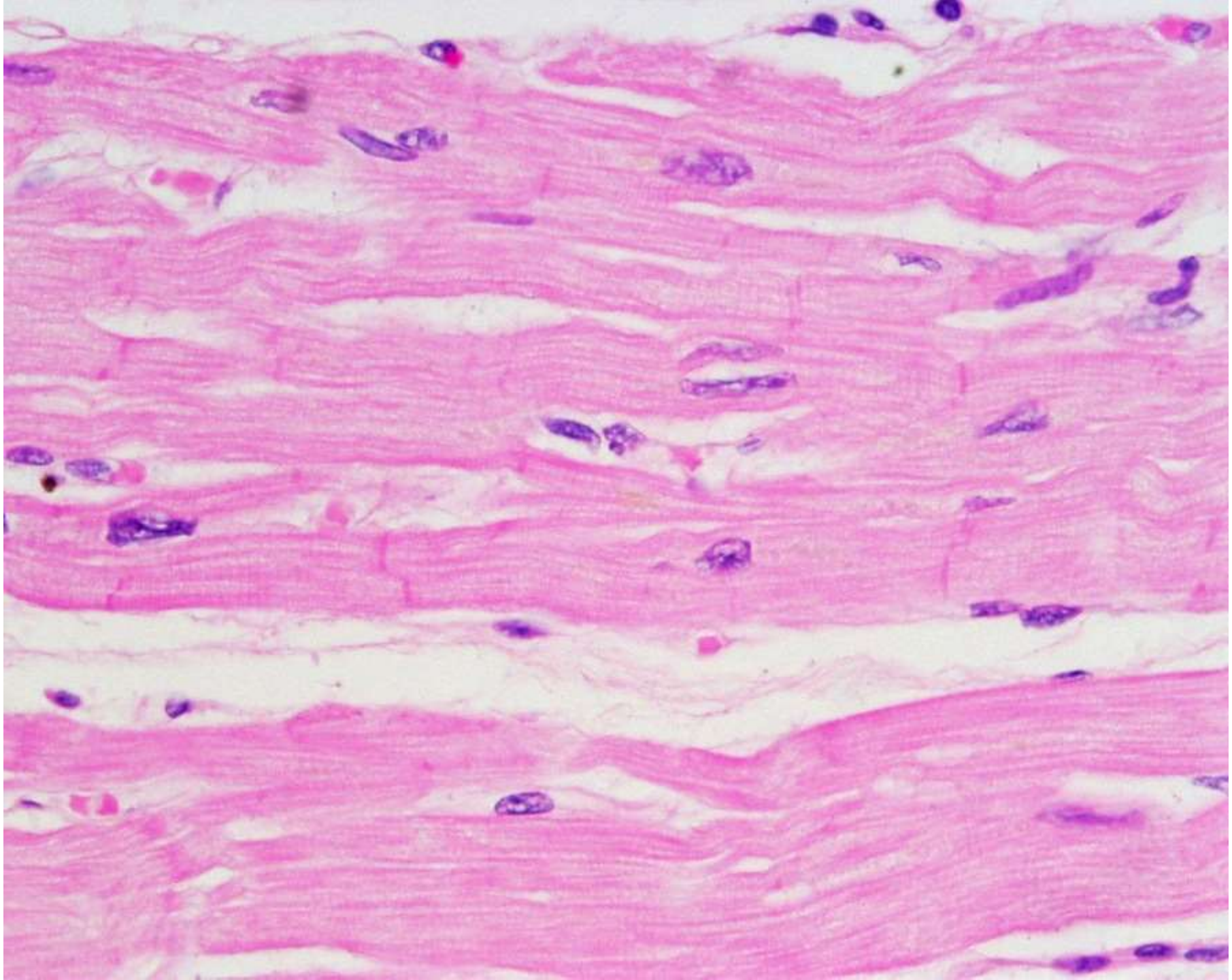


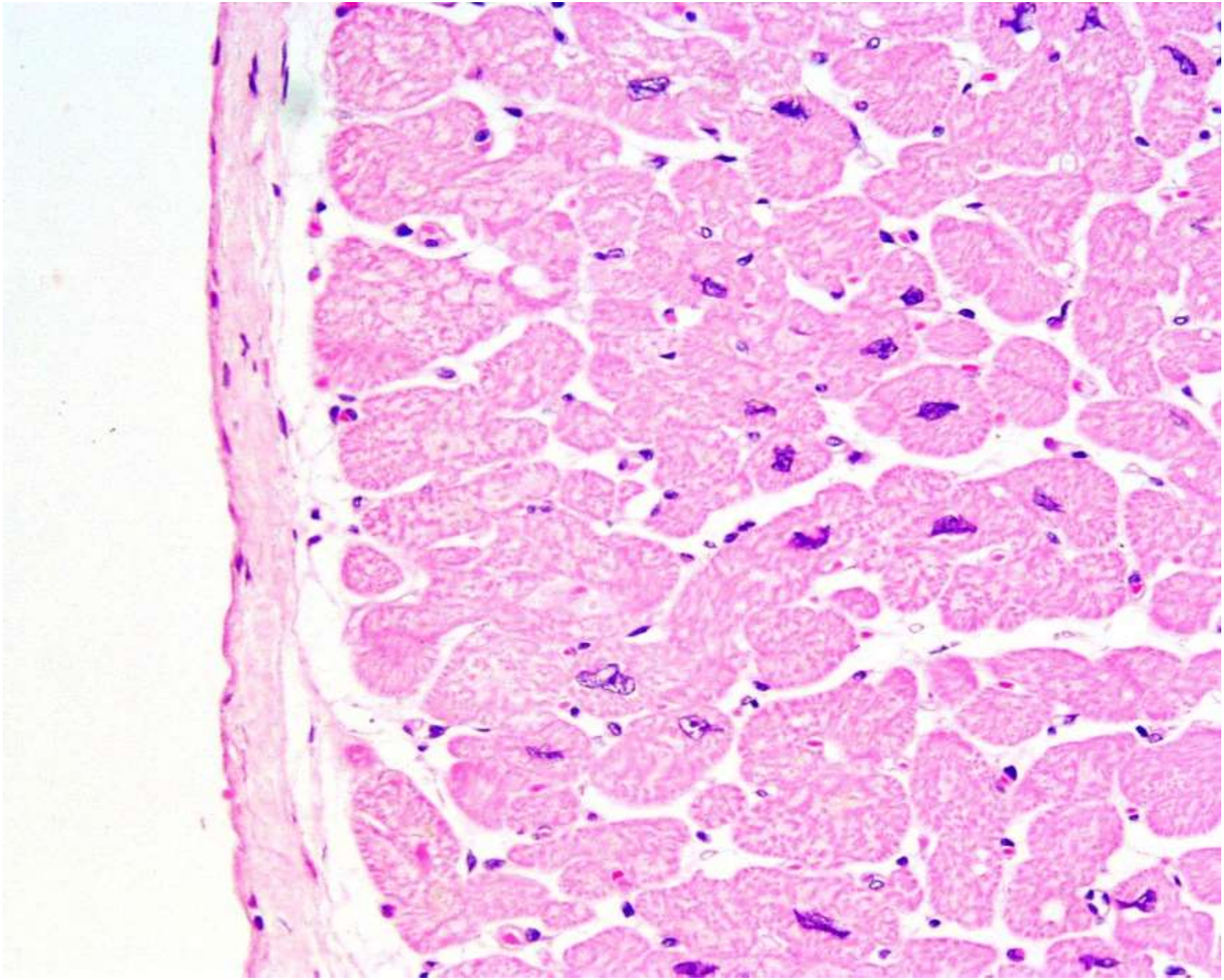
Slide 107. «Wall of the heart»
Hematoxylin-eosin staining

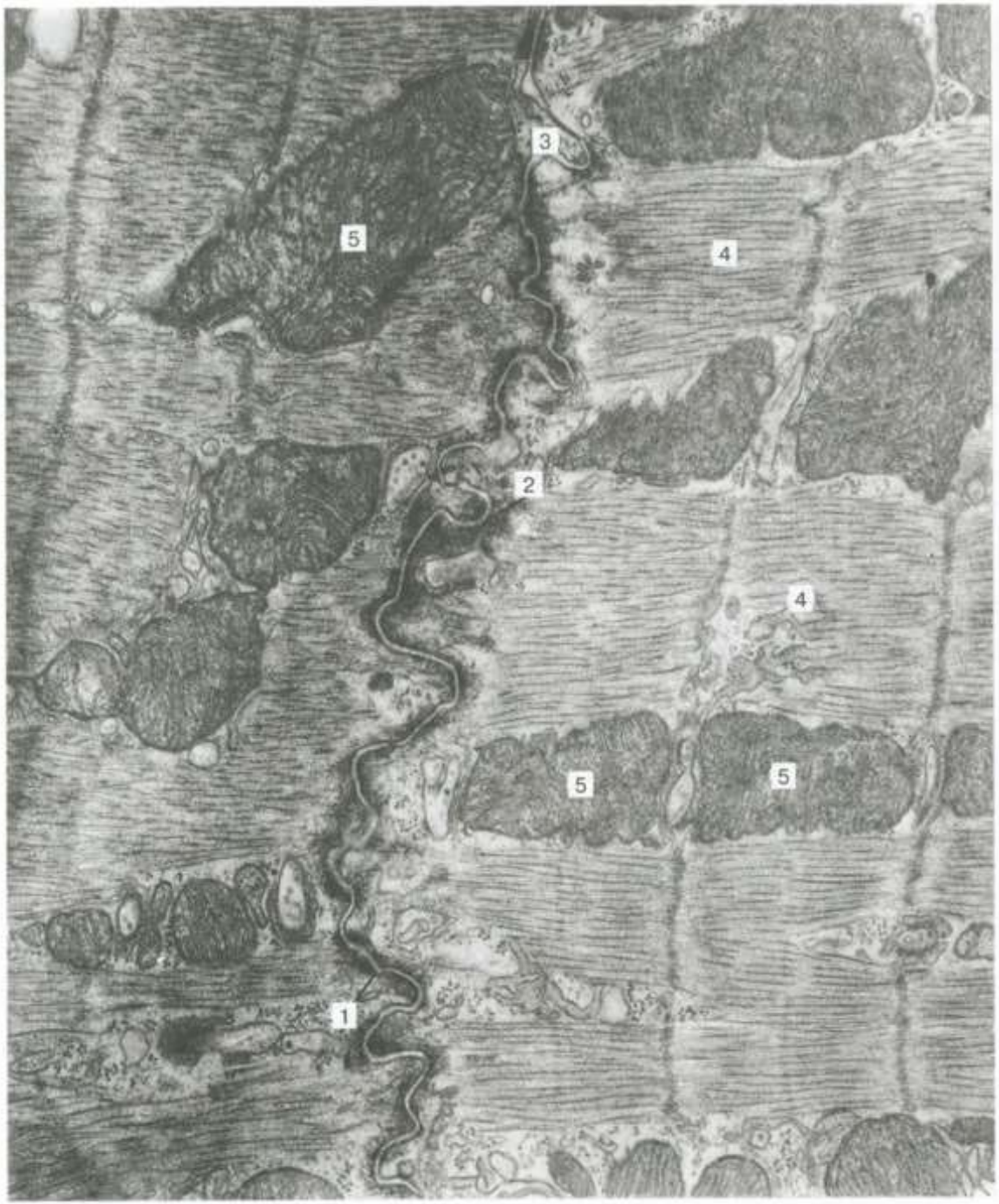


Slide 107. «Wall of the heart»
Hematoxylin-eosin staining





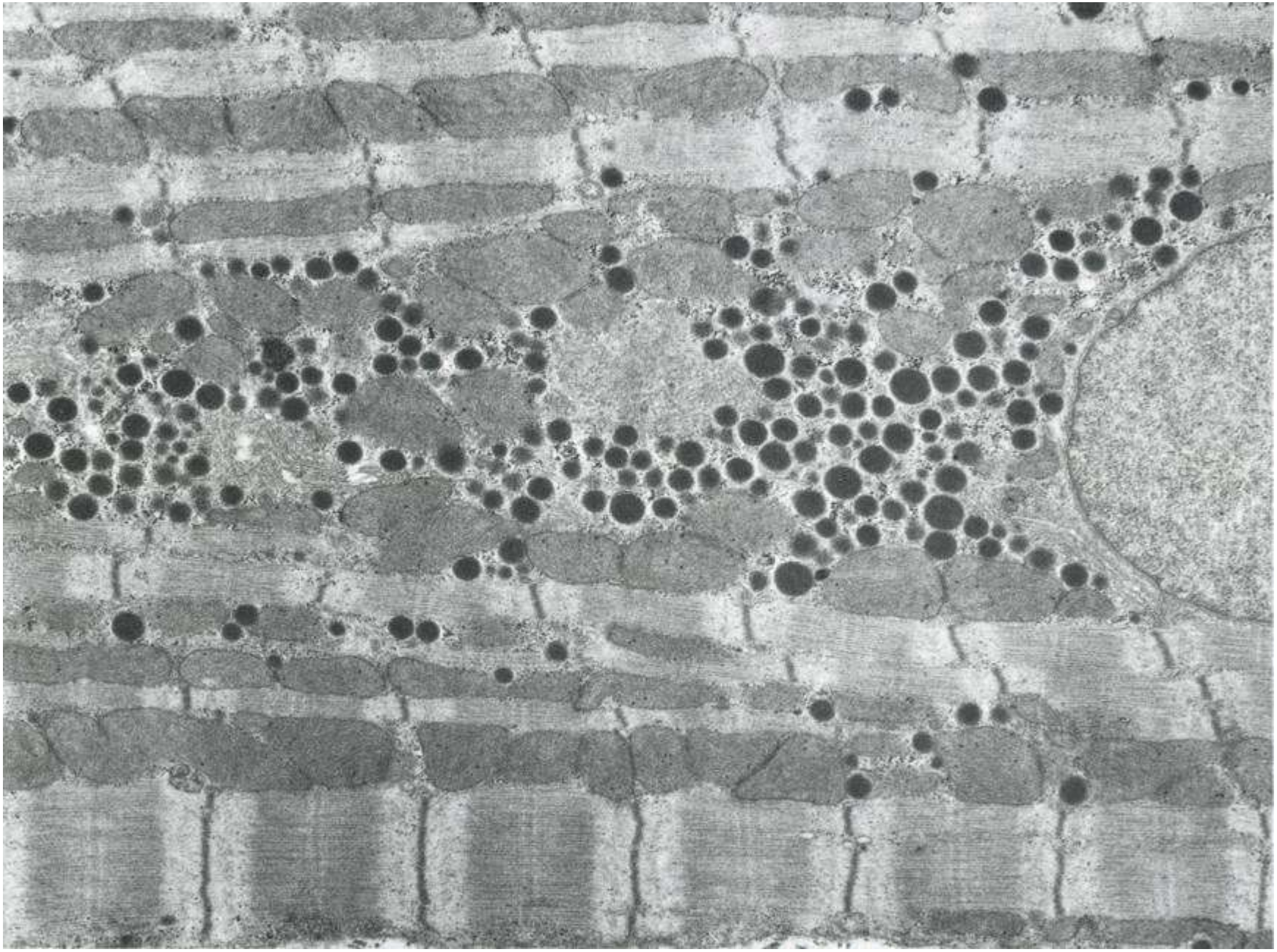




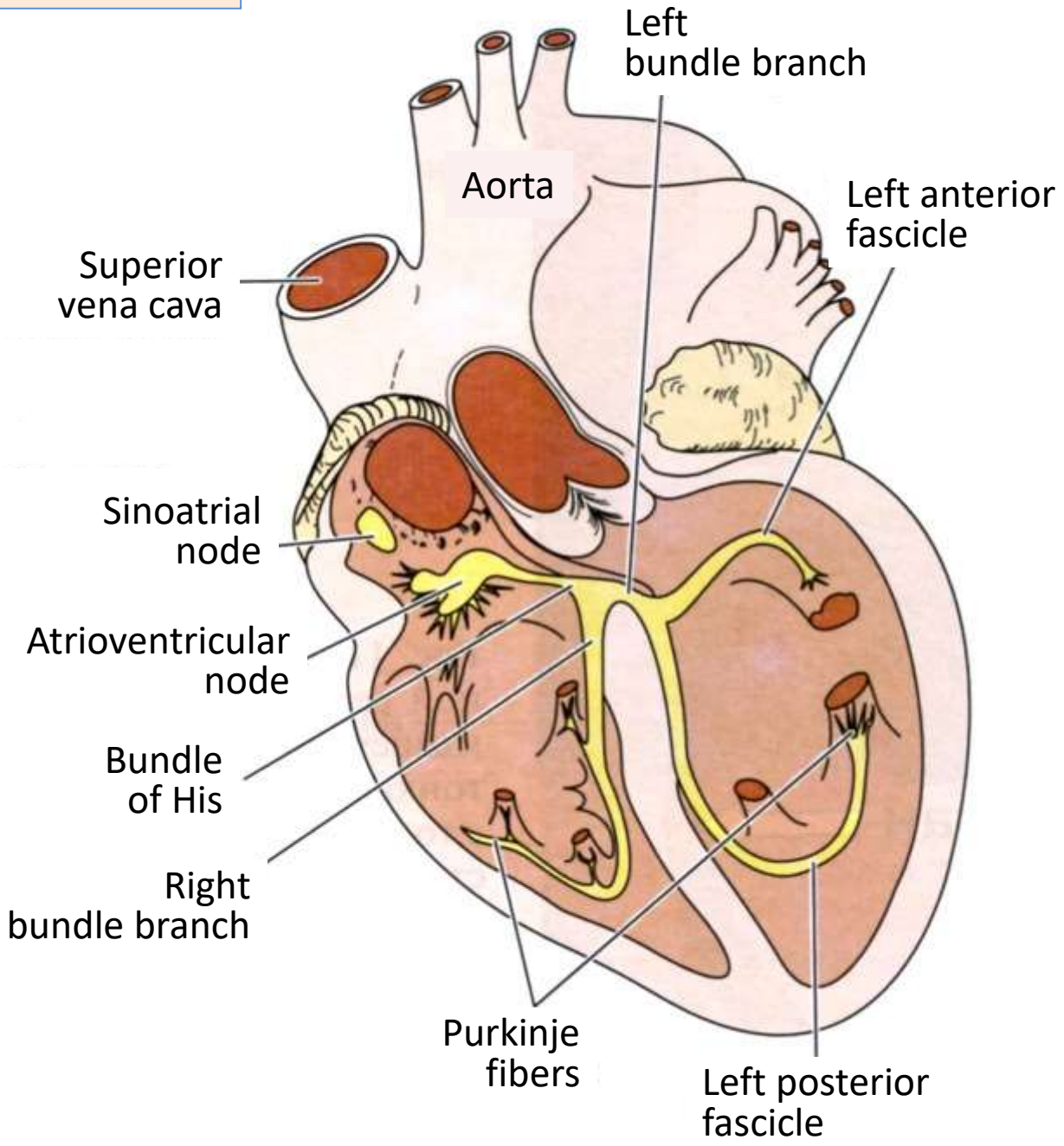
INTERCALATED DISC BETWEEN TYPICAL CARDIOMYOCYTES

1- intercalated disc;
2- zones of attachment of the myofibrils;
3- gap junction (nexus);
4- myofibrils;
5- mitochondria

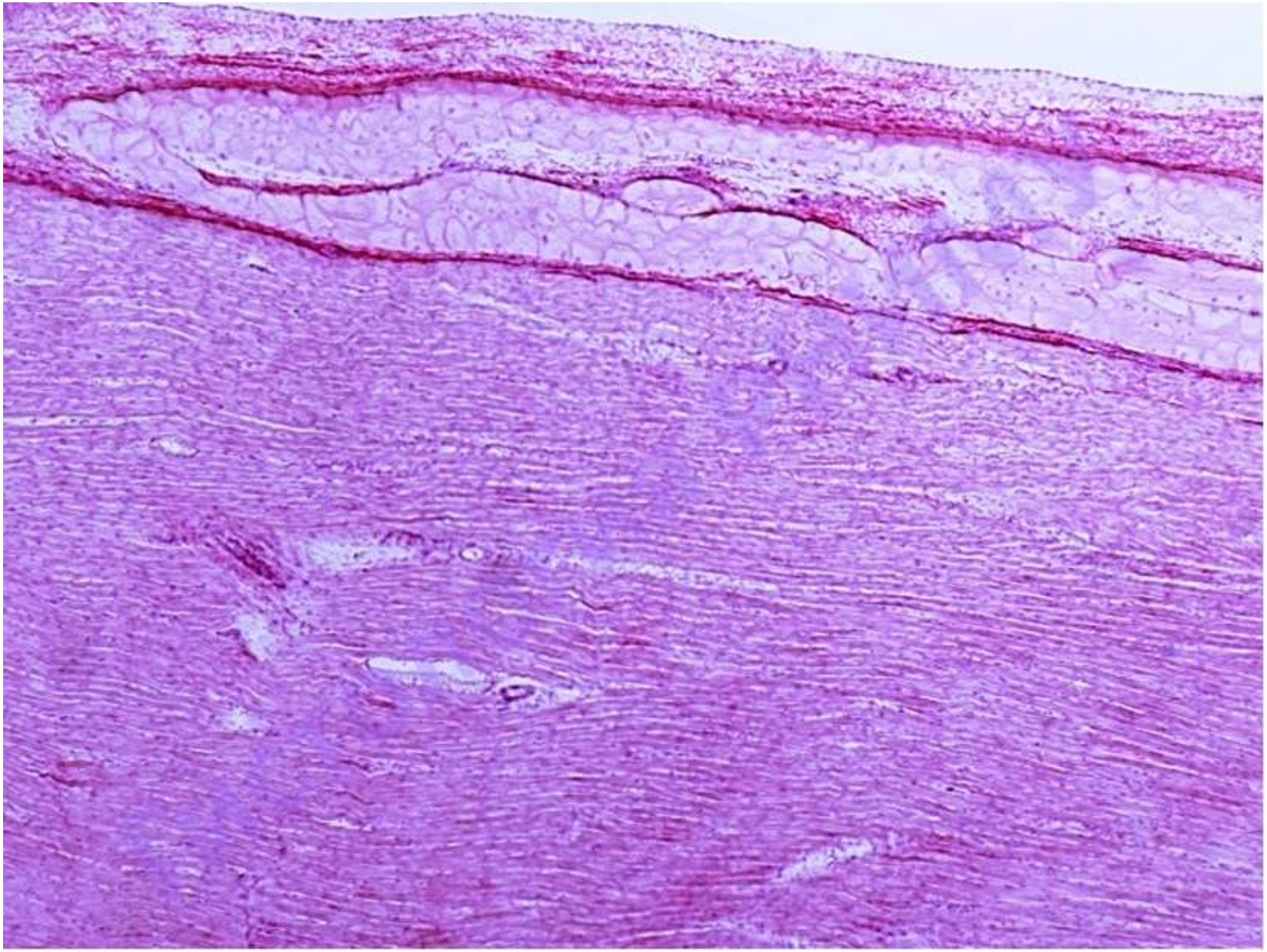
SECRETORY CARDIOMYOCYTE



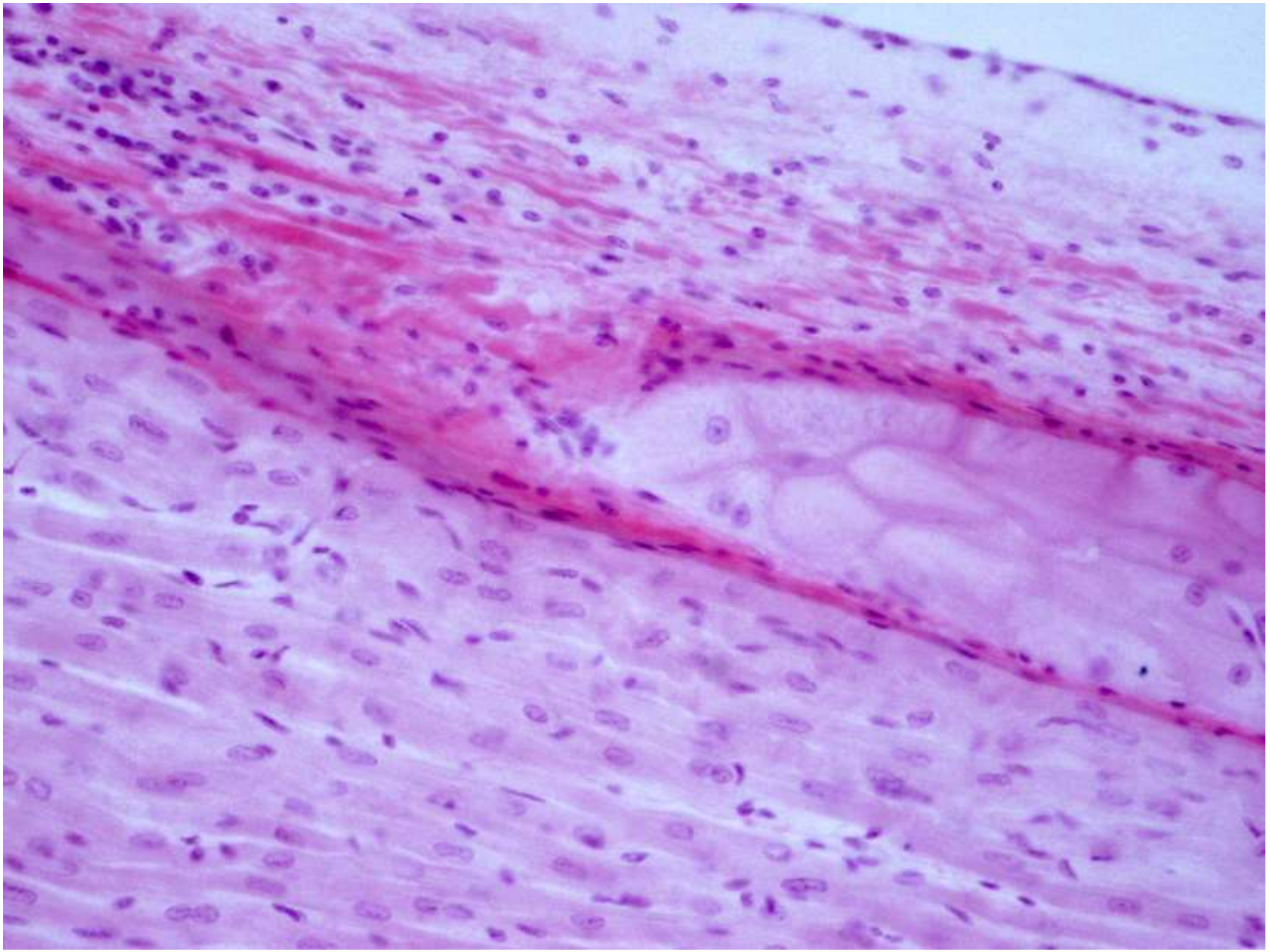
CARDIAC CONDUCTION SYSTEM



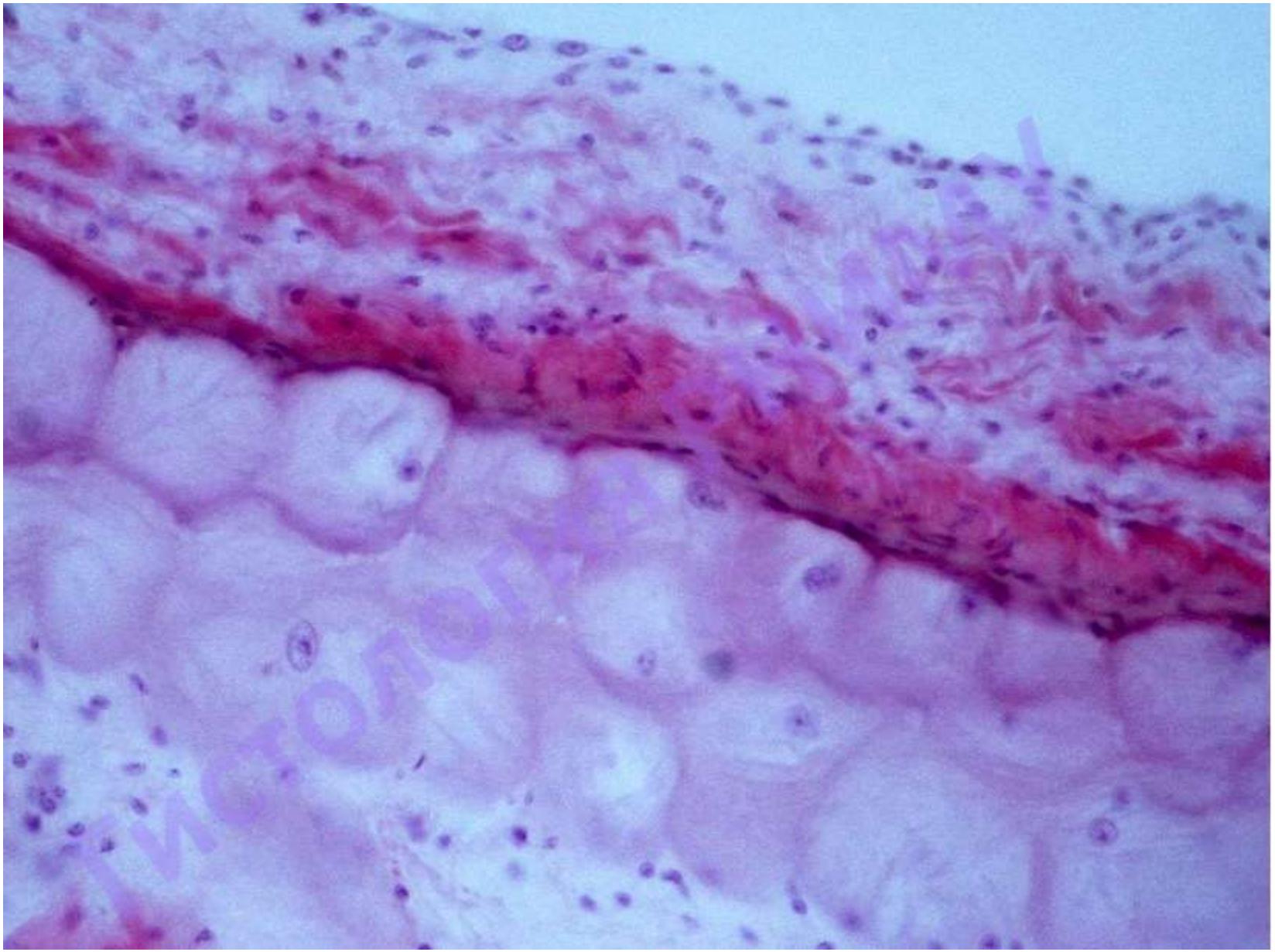
Slide 107a. «Wall of the heart. Conducting cardiomyocytes»
Hematoxylin-eosin staining



Slide 107a. «Wall of the heart. Conducting cardiomyocytes»
Hematoxylin-eosin staining

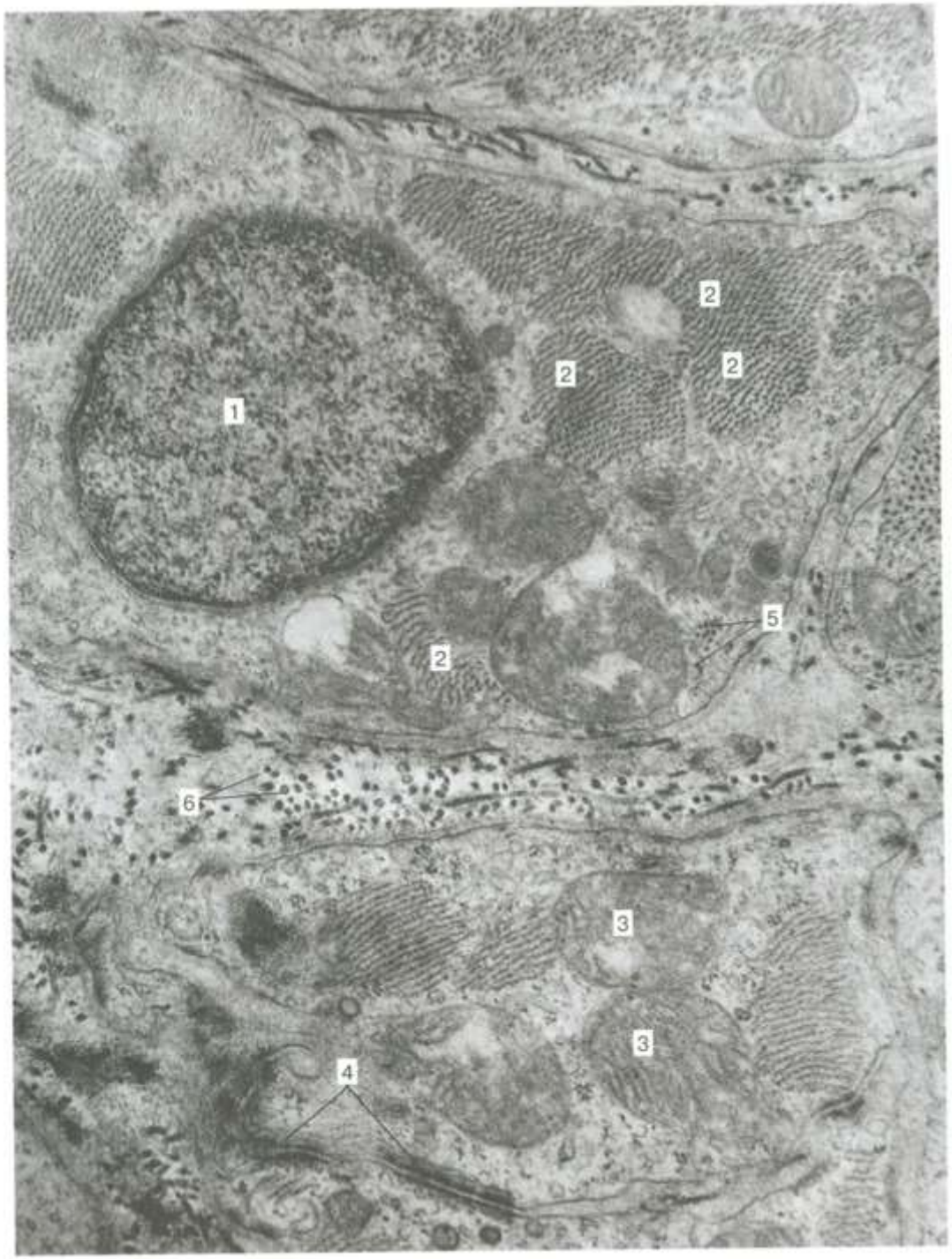


Slide 107a. «Wall of the heart. Conducting cardiomyocytes»
Hematoxylin-eosin staining

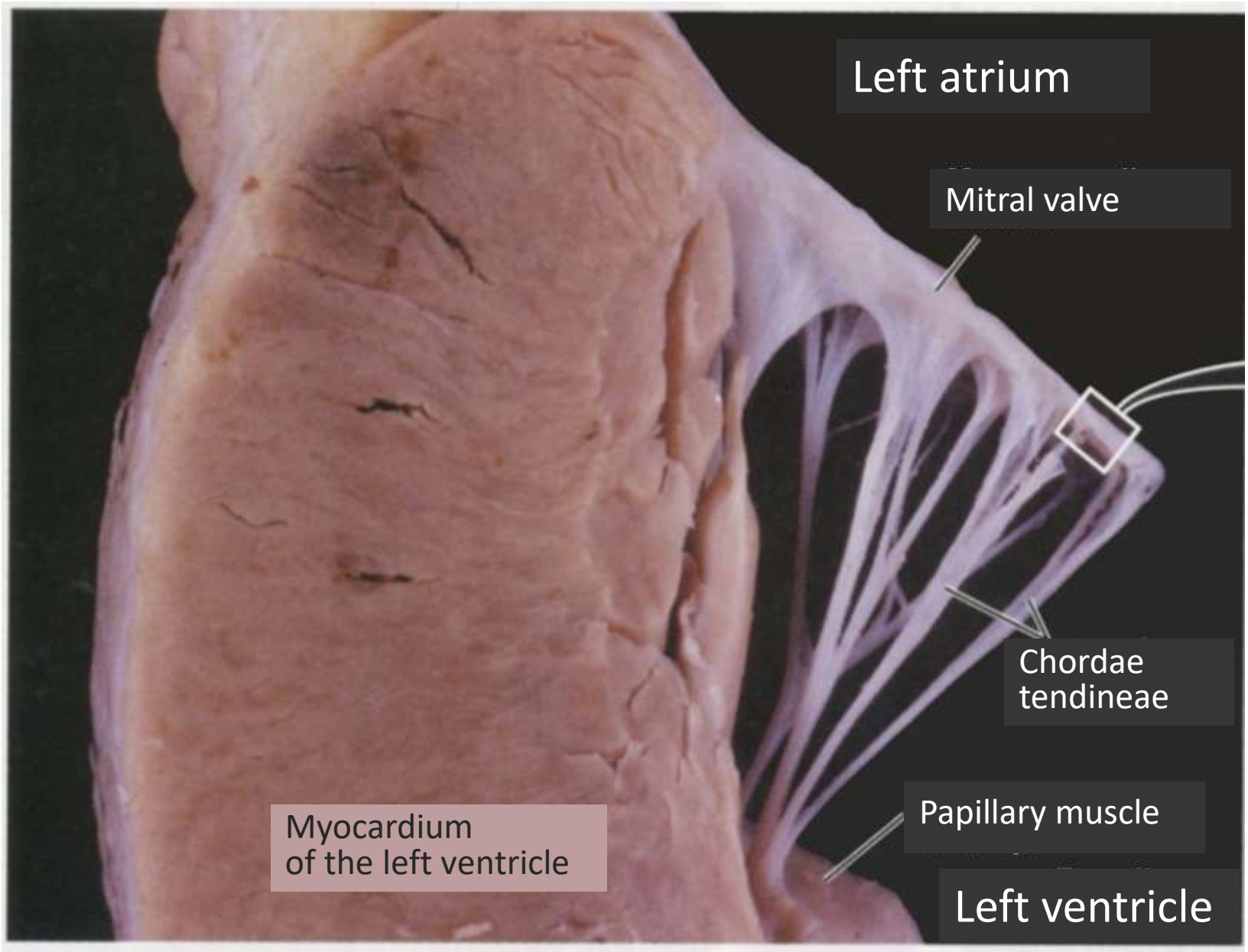


ATYPICAL CONDUCTING CARDIOMYOCYTE

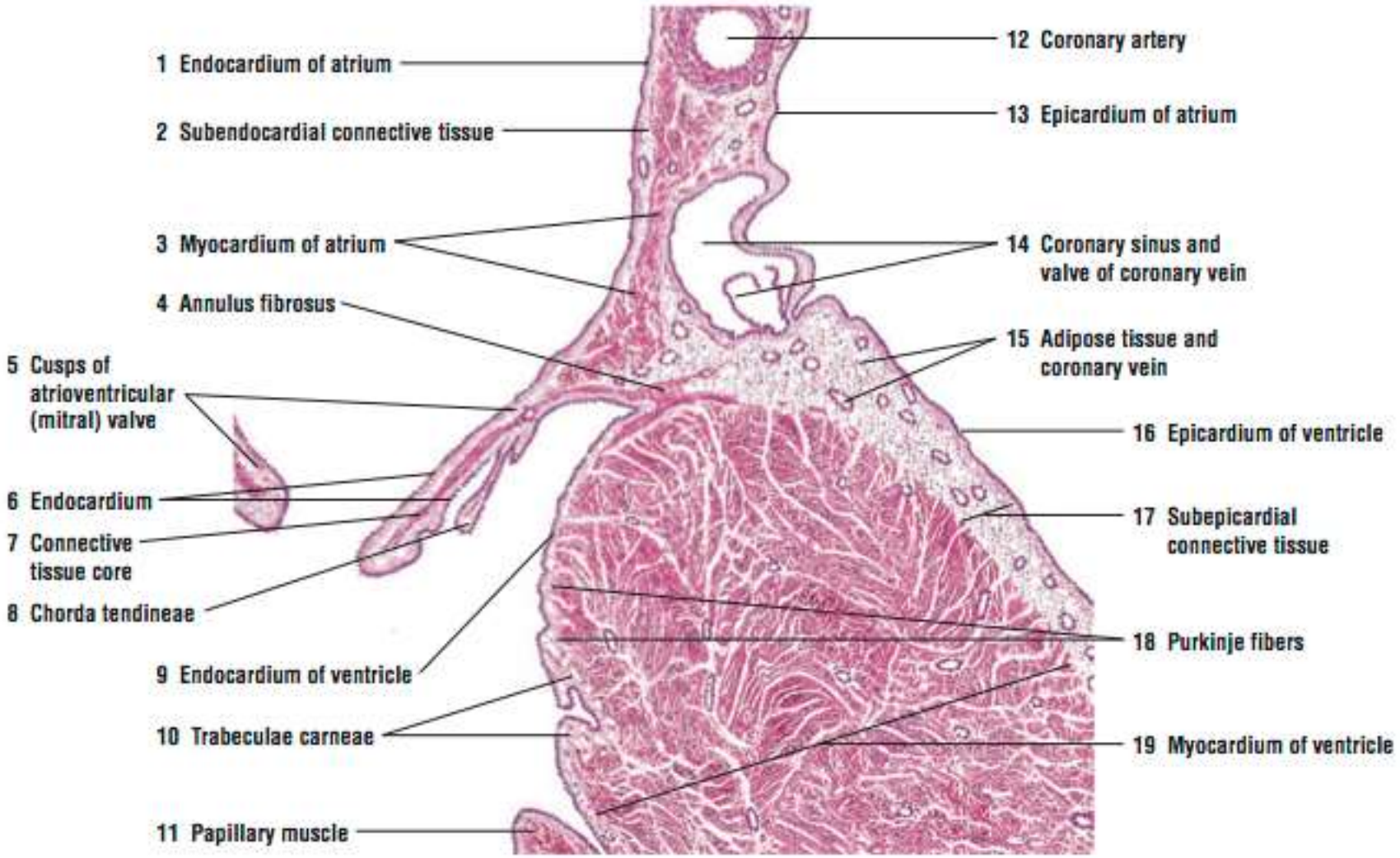
1- nucleus,
2- myofibrils,
3- mitochondria,
4- desmosomes,
5- glycogen,
6- collagen fibrils



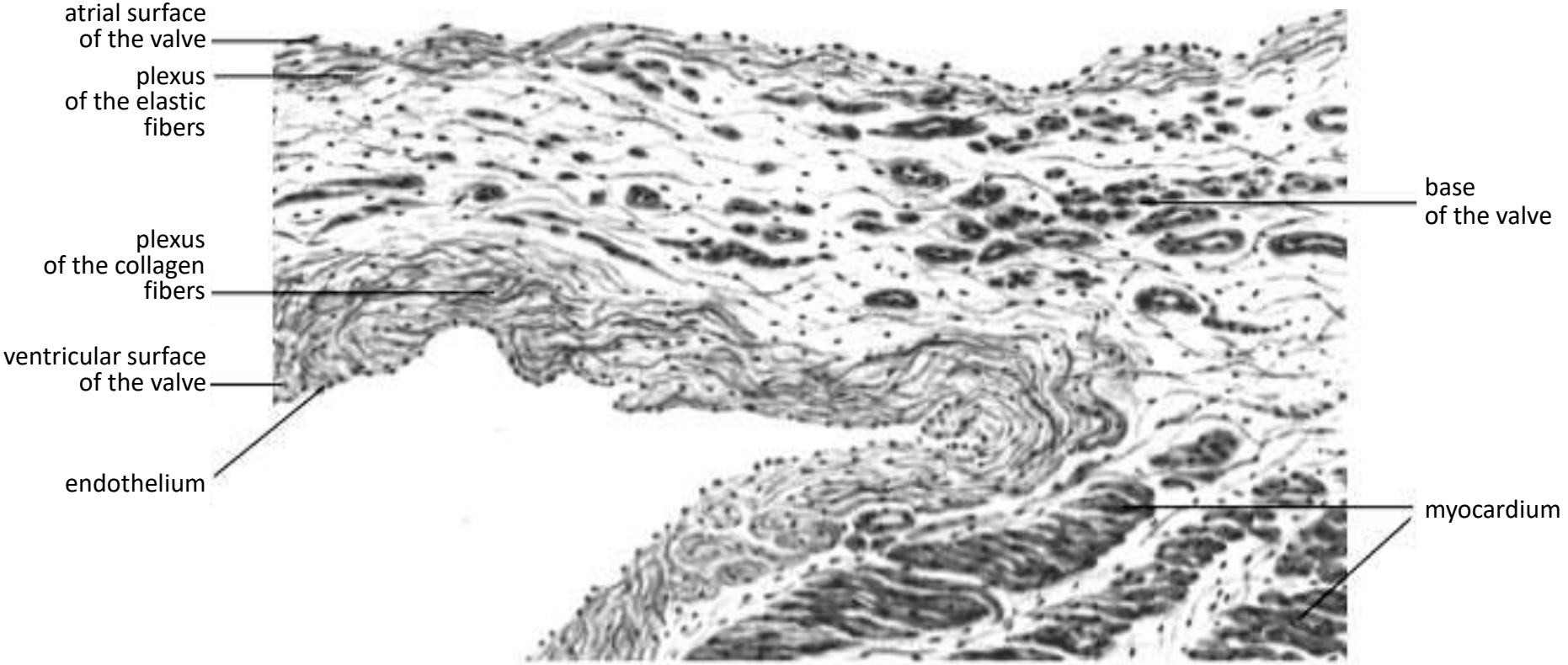
ATRIOVENTRICULAR VALVES OF THE HEART

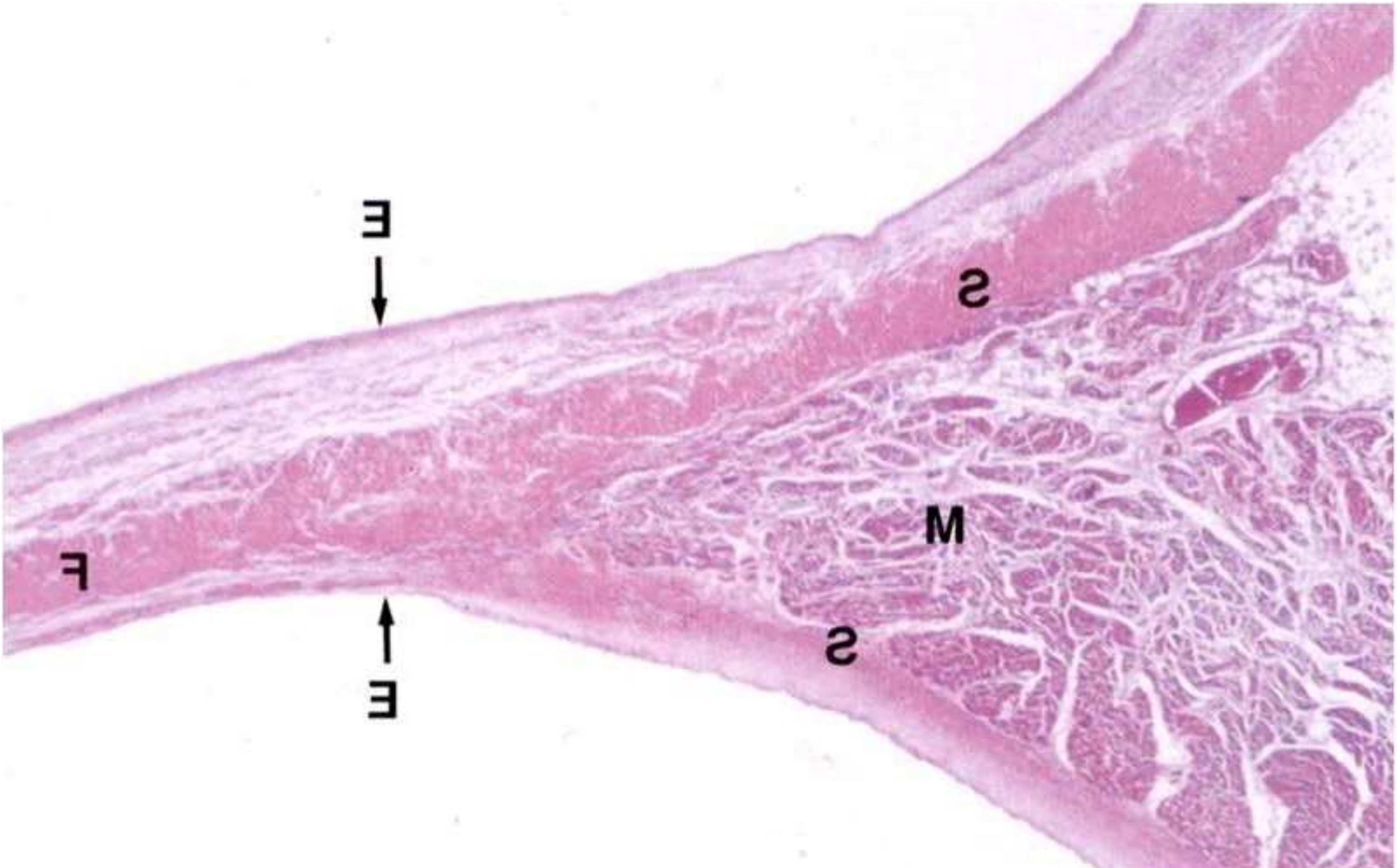


STRUCTURE OF ATRIOVENTRICULAR VALVES OF THE HEART



LONGITUDINAL SECTION OF THE ATRIOVENTRICULAR VALVE OF THE HEART

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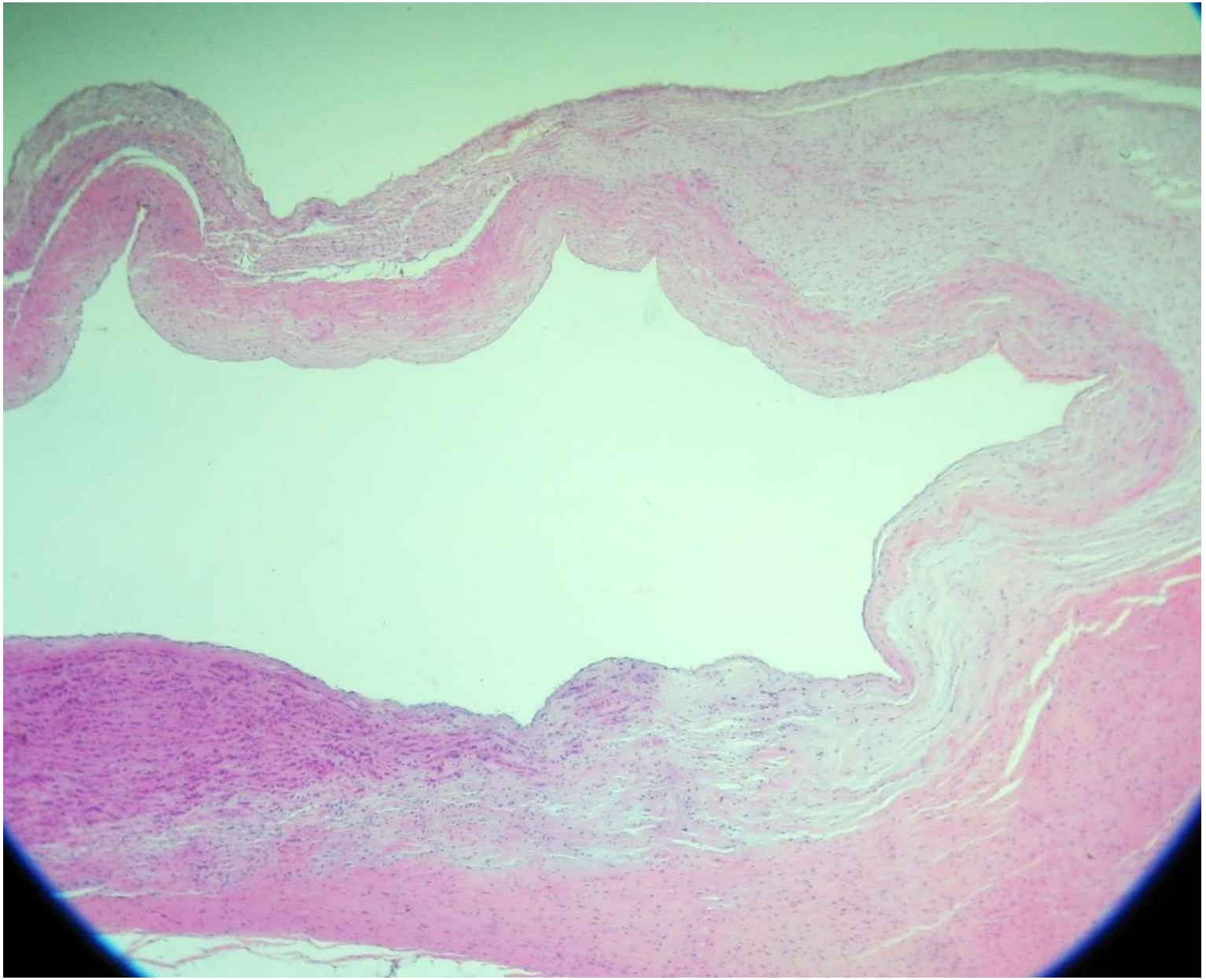
Slide 108 «Valve of the heart. Section of the atrioventricular valve»
Hematoxylin-eosin staining



Slide 108 «Valve of the heart. Section of the atrioventricular valve»
Hematoxylin-eosin staining