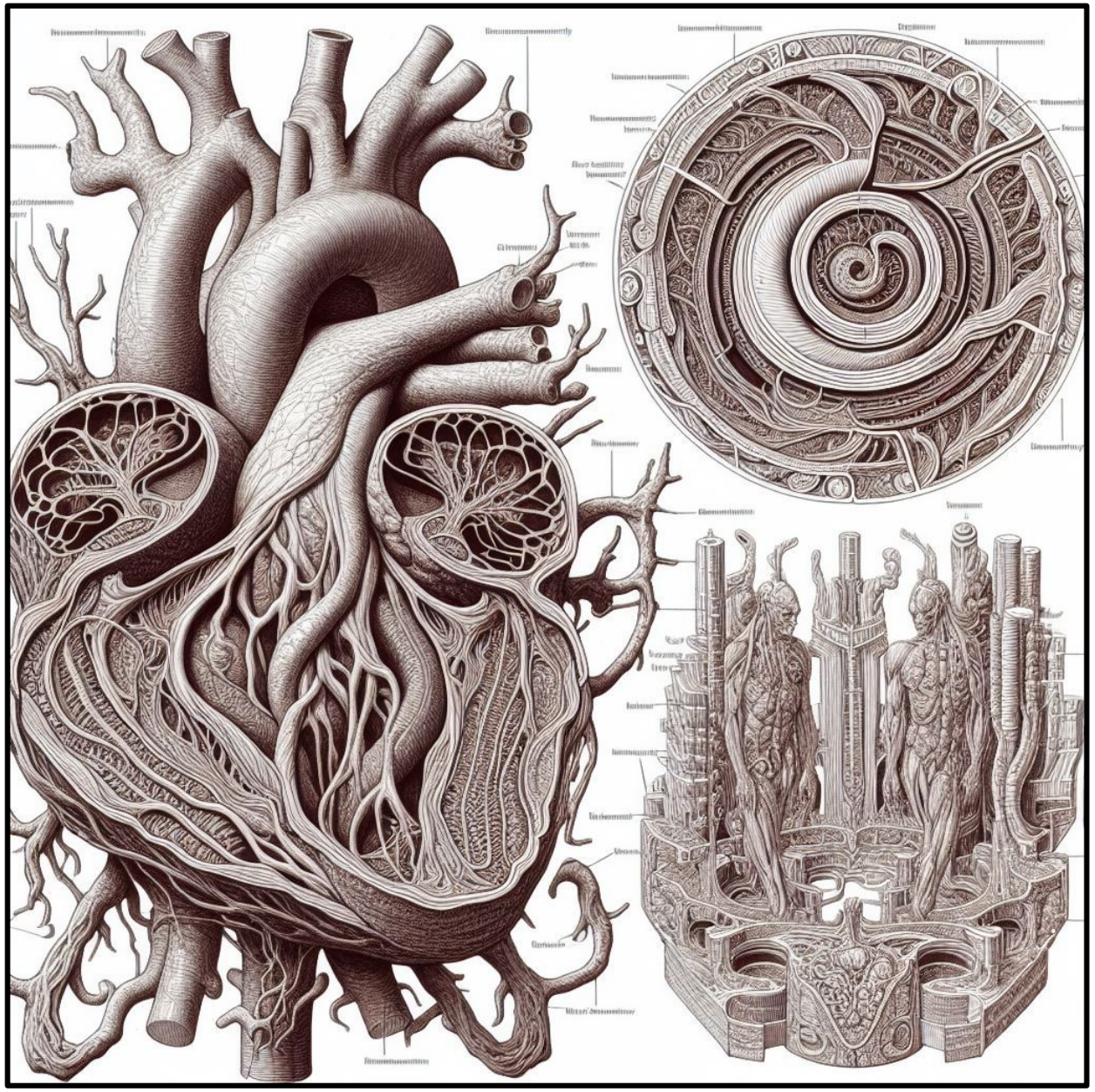

You must not allow
kitchen appliances
to liven up your
solitude

Histology of the Cardiovascular System



Contact me

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Philosophy 1:

What is the least amount of work I can do so I can get out of here.

You vs Future You
There is a cost

Philosophy 2:

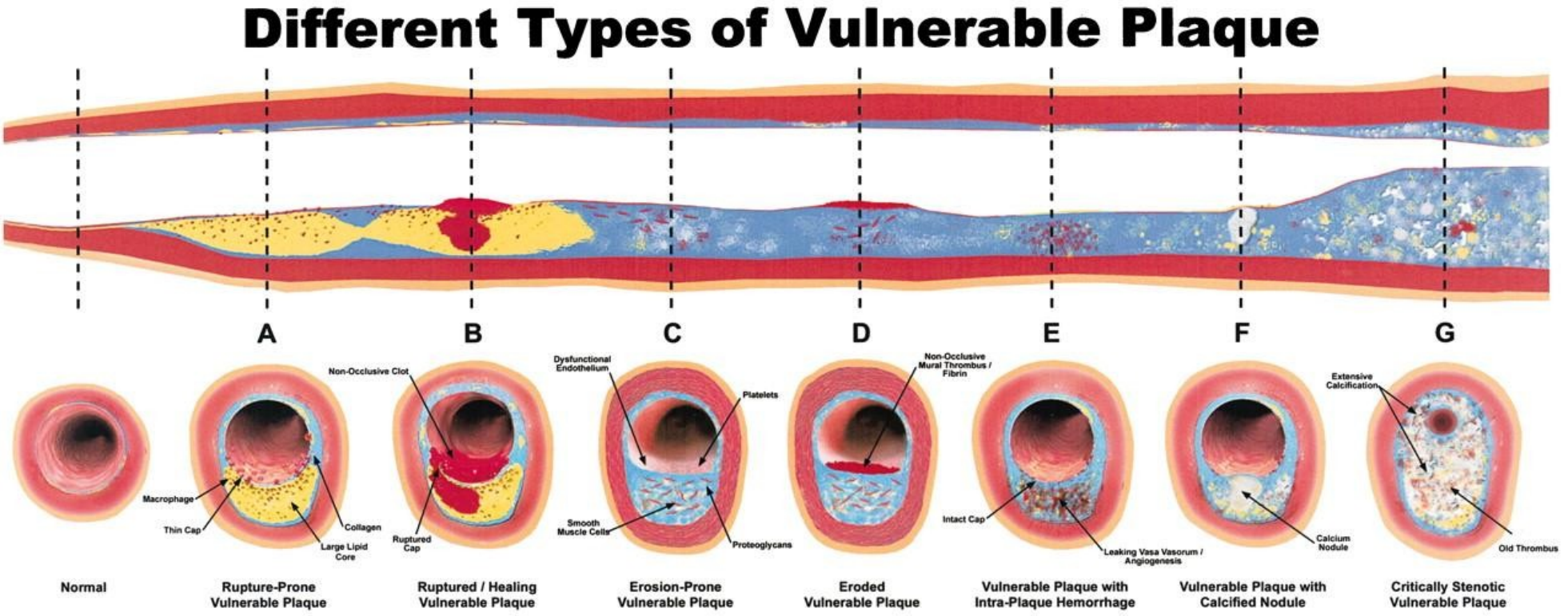
Today and Now
I will do something for my future self.

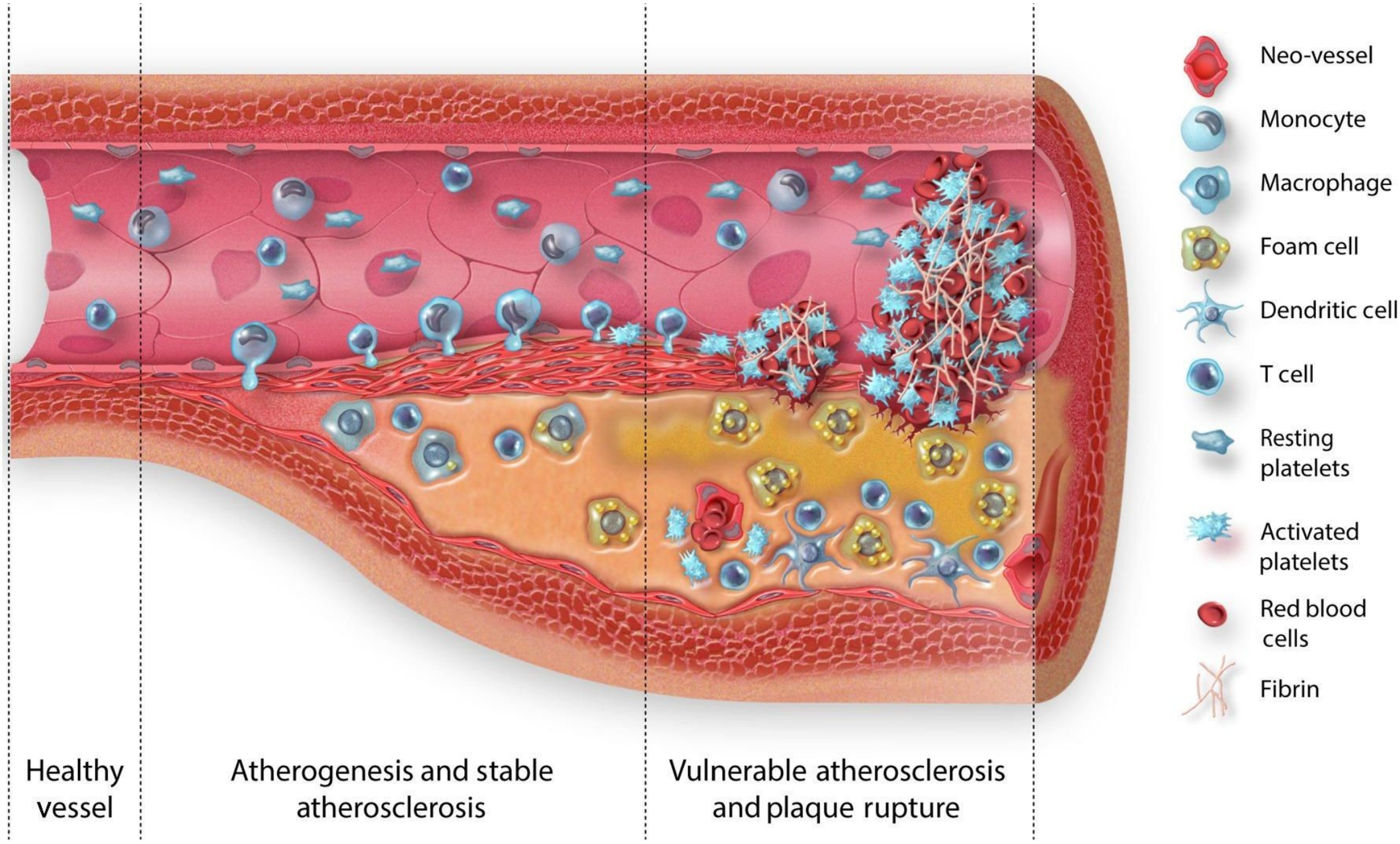
Investment

5 slides	
Tuesday	Muscular artery and vein
Wednesday	Elastic artery
Thursday	Large vein
Friday	Ductus thoracicus & Valve
Weekend	Complete work
Next week	Revision

Point to ponder

Histology of the CVS?




Neo-vessel
Monocyte
Macrophage
Foam cell
Dendritic cell
T cell
Resting platelets
Activated platelets
Red blood cells
Fibrin
Healthy vessel
Atherogenesis and stable atherosclerosis
Vulnerable atherosclerosis and plaque rupture

Words

adipose, adventitia, arteriole, artery, blood, bundle, capillary, capsule, cell, circular, collagen, compact, connective, continuous, cross, distribute, elastic, elastic, endothelium, erythrocyte, fenestrated, fiber, fine, flap, ganglion, hilus, inner, internal, interspersed, intima, laminae, large, layer, longitudinal, loose, lumen, lymph, lymphatic, media, medium, membrane, muscle, muscular, narrow, nerve, node, oblique, pericyte, perineurium, red blood cell, sinusoid, small, smooth, sphincter, sub-endothelium, sympathetic, terminal, thick, thin, tissue, transverse, tunica, unmyelinated, valve, vasa vasorum, vasomotor, vein, venule, vessel, wall

Others?

Cells

erythrocyte
fat cell
nerve cell
pericyte
red blood cell
smooth muscle fiber
squamous cell

Others?

Tissues

adipose tissue
collagen fibres
elastic fibres
loose connective tissue
subendothelial connective tissue

Others?

Structures

arteriole, artery, capillary, capsule, continuous capillary, elastic laminae, endothelium, fenestrated capillary, internal elastic membrane, large vein, lumen, lymph node, lymph vessel, medium vein, muscular artery, nerve, nerve fiber, neurovascular bundle, perineurium, precapillary sphincter, sinusoidal capillary, sympathetic ganglion, tunica adventitia, tunica intima, tunica media, valve, vasa vasorum, vein, venule

Others?

Slides: Vessels

- Muscular artery and vein: Slide 69
- Muscular artery and vein: Slide 70
- Elastic artery: Slide 67
- Elastic artery: Slide 49
- Large vein: Slide 92
- Large vein: Slide 109
- Ductus thoracicus: Slide 75
- Ductus thoracicus: Slide 65
- Valves: Slide 47

Tubes

Round "things"

Objective

- Compare and contrast the three tunics
- Distinguish between:
  - Elastic arteries and muscular arteries
  - Arteries and veins
- Identify capillaries
- Identify lymphatic vessels
- Identify nerves
- Identify small associated features
- Describe the functioning of the capillary bed
- Describe portal systems
- Describe end-arteries

Overview

- Network of organs and vessels
- Transportation of
  - Blood
  - Transport O2 & CO2
  - Nutrients
  - Hormones
  - Metabolic waste products
- Crucial role
  - Maintaining homeostasis
  - Temperature regulation
  - Immune function

Components 1: Heart

- Muscular organ
- Central pump
- Four chambers
  - 2x Atria
  - 2x Ventricles
- Left side – oxygenated to body
- Right side – deoxygenated to lungs

Components 2: Blood vessels

- Arteries
  - Thick walled to the body
- Veins
  - Thinner walls + valves
- Capillaries
  - Tiny connection
  - Facilitate exchange between blood & cells
  - 3 Types
    - Continuous
    - Fenestrated
    - Sinusoidal

Components 3: Lymph vessels

- Parallel system
- Blind start
- Transport lymph back to the heart
  - WBC, proteins, waste products
- Role in immune function & fluid balance

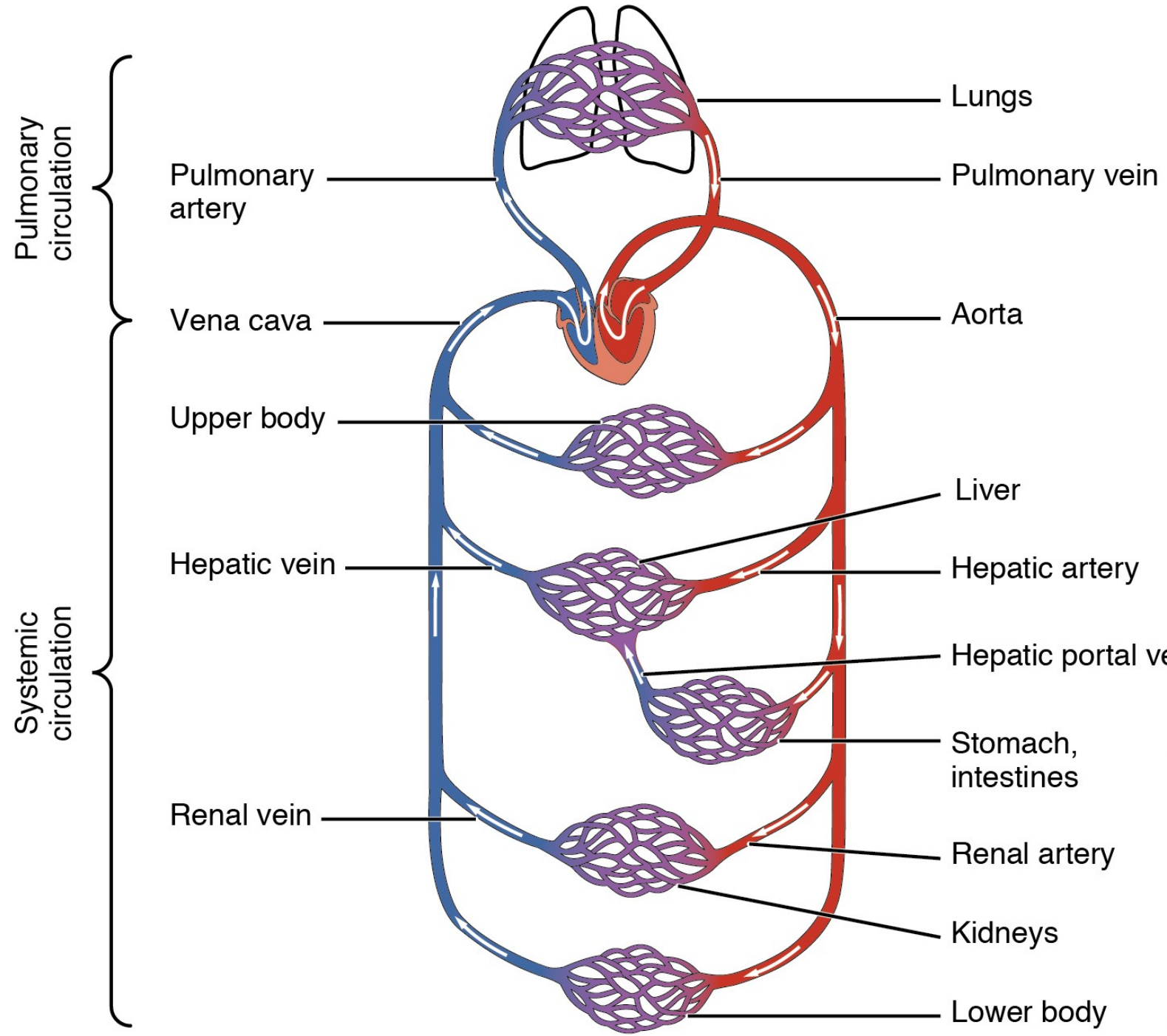


Figure 20.2

Cardiovascular Circulation

Anatomy and Physiology 25 April 2013

OpenStax CC-A 4.0; https://openstax.org/books/anatomy-and-physiology/pages/20-1-structure-and-function-of-blood-vessels

Histology of the heart

- Revision exercise
- You can expect questions on this content
- Review from you workbook and HistoWeb

Slides: Cardiac muscle

- Heart muscle (longitudinal section): Slide 20
- Heart muscle (cross section): Slide 77
- Heart muscle: Slide 86

Blood vessel histology

- Generic structure
  - Tunica intima
    - Endothelial cells
    - Subendothelial layer
  - Tunica media
    - Smooth muscle cells
    - Elastic fibers
    - Collagen fibers
  - Tunica adventitia
    - Collagen
    - Elastic fibers
    - Fibroblasts
    - Vasa vasorum

Tunica intima

- The innermost layer of the blood vessel, in direct contact with the blood.
- Endothelium
  - Single layer simple squamous epithelial cells known as endothelial cells lines the tunica intima. These cells form a smooth surface that minimizes friction and facilitates the movement of blood.
- Subendothelial layer
  - Beneath the endothelium, composed of connective tissue containing elastic fibers. It provides support to the endothelial layer.

Tunica media

- Between the tunica intima and tunica adventitia
- Smooth Muscle Cells
  - Predominant cell type
  - Arranged in circular layers around the vessel.
- Elastic Fibers
  - Interspersed among the smooth muscle cells
  - Provide elasticity to the vessel, allowing it to expand and contract with changes in blood pressure.
- Collagen Fibers
  - Contribute to the structural integrity of the vessel and help maintain its shape.

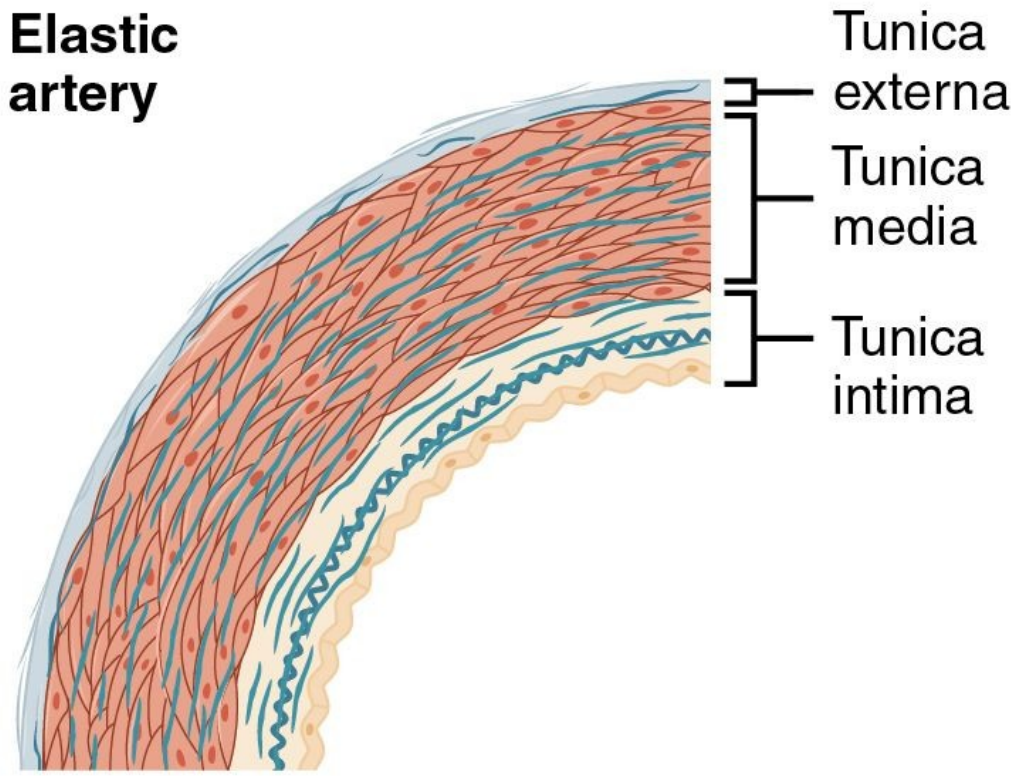
Tunica adventitia

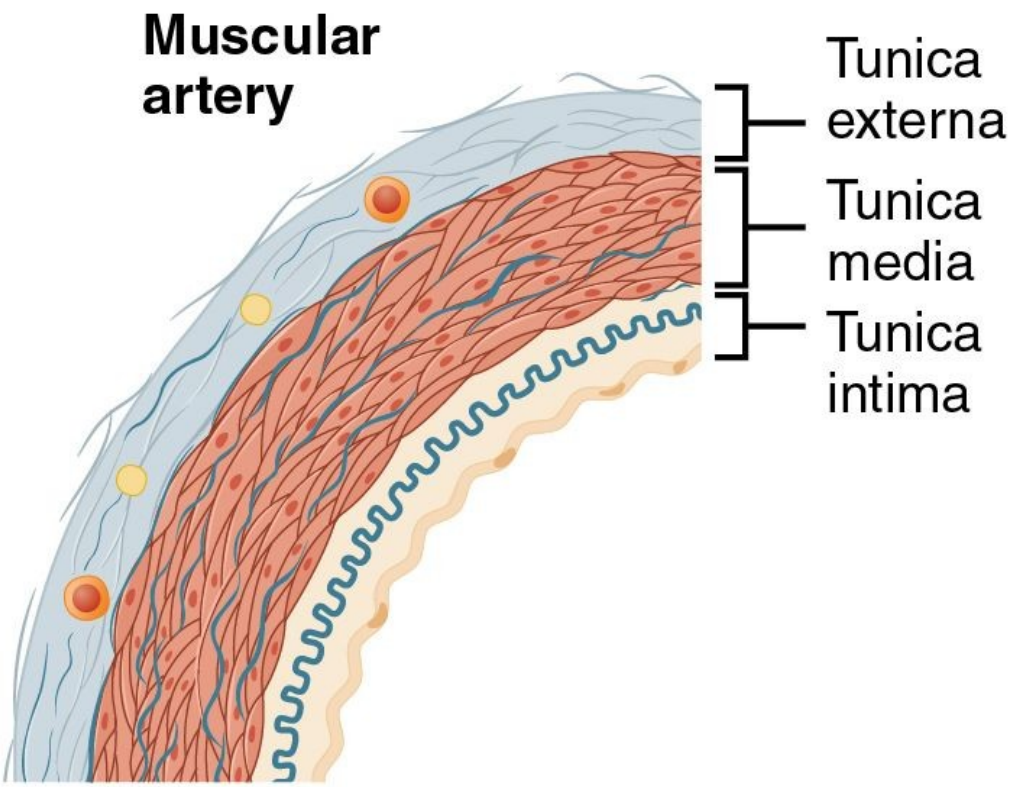
- Outermost layer
- Collagen and Elastic Fibers
  - Rich in collagen and elastic fibers
  - Providing strength, support, and flexibility to the vessel
- Fibroblasts
  - Responsible for synthesizing and maintaining the extracellular matrix.
- Blood Vessel & Nerves (Vasa Vasorum)
  - Small blood vessels and nerves, known as vasa vasorum, are found in the tunica adventitia, supplying oxygen and nutrients to the outer layers of the vessel wall.

Arteries vs Veins

	Arteries	Veins
Wall thickness	Thick	Thin
Size lumen	Narrow	Wide
Shape lumen	Rounded	Irregular, often collapsed

- Three layers not always visible
- Elastic arteries
  - Ventricular contraction = systolic blood pressure (BP)
  - Diastolic BP = interim pressure maintained by elastic arteries
- Muscular arteries
  - Distribute blood volume appropriate to requirements at destination
- Layers best seen in muscular arteries





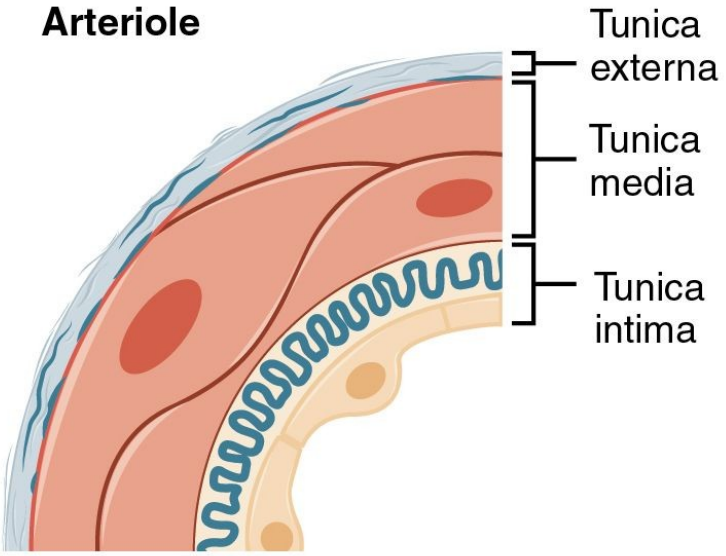


Figure 20.4 Types of Arteries and Arterioles. Comparison of the walls of an elastic artery, a muscular artery, and an arteriole is shown. In terms of scale, the diameter of an arteriole is measured in micrometers compared to millimeters for elastic and muscular arteries.

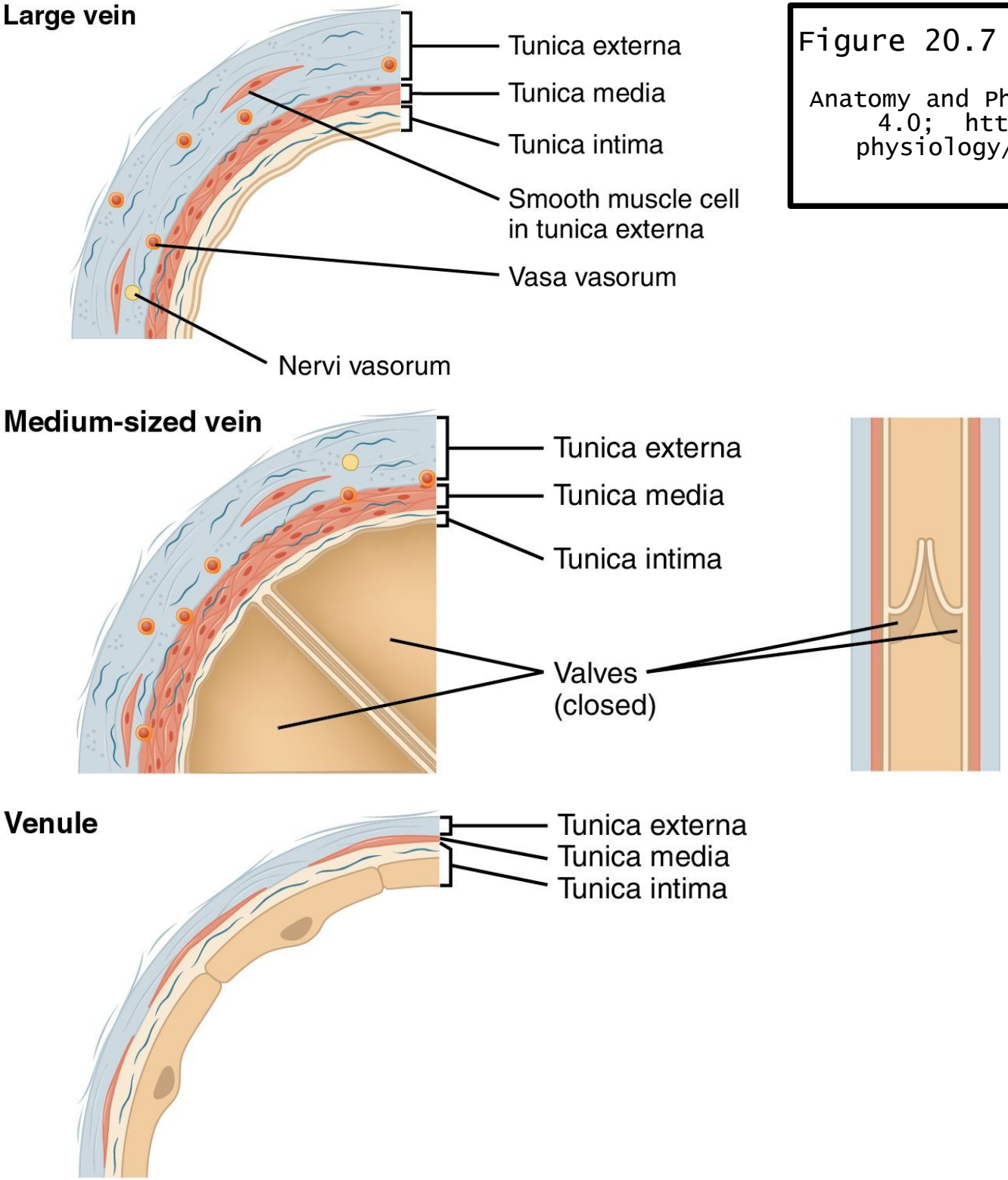


Figure 20.7 Comparison of Veins and Venules

Anatomy and Physiology 25 April 2013; OpenStax; CC-A 4.0; https://openstax.org/books/anatomy-and-physiology/pages/20-1-structure-and-function-of-blood-vessels

Elastic arteries

Elastic arteries, such as the aorta, act as conduits that expand and recoil to accommodate the surge of blood ejected from the heart during systole. They help maintain continuous blood flow and smooth pressure.

Muscular arteries

Muscular arteries, like the femoral artery, distribute blood to specific organs and tissues. They regulate blood flow through vasoconstriction and vasodilation, contributing to overall blood pressure control

Capillaries

- Continuous capillaries
  - Found in muscle and nervous tissue
  - Allow for exchange of small molecules: oxygen & nutrients.
  - Tight junctions limit the passage of larger substances.
- Fenestrated capillaries
  - Present in the kidneys and intestines
  - Pores (fenestrations) that enhance the exchange of larger molecules, including proteins and hormones.
- Sinusoidal capillaries
  - Located in the liver and spleen
  - Large gaps between cells, facilitating the passage of blood cells and larger substances.
  - Role in blood cell filtration and immune responses.

Medium veins

Medium veins, such as the radial vein, collect blood from smaller veins and return it to the heart. They have valves that prevent the backflow of blood, aiding in the venous return to the heart.

Large veins

Large veins, including the superior vena cava and inferior vena cava, serve as the major conduits for returning deoxygenated blood from the body back to the right atrium of the heart. They have a larger diameter and thinner walls compared to arteries.

Lymphatic System

- Collects excess tissue fluid
- Filters through lymph nodes
- Return to blood
- Start as blind-ending vessels

Muscular artery & Vein

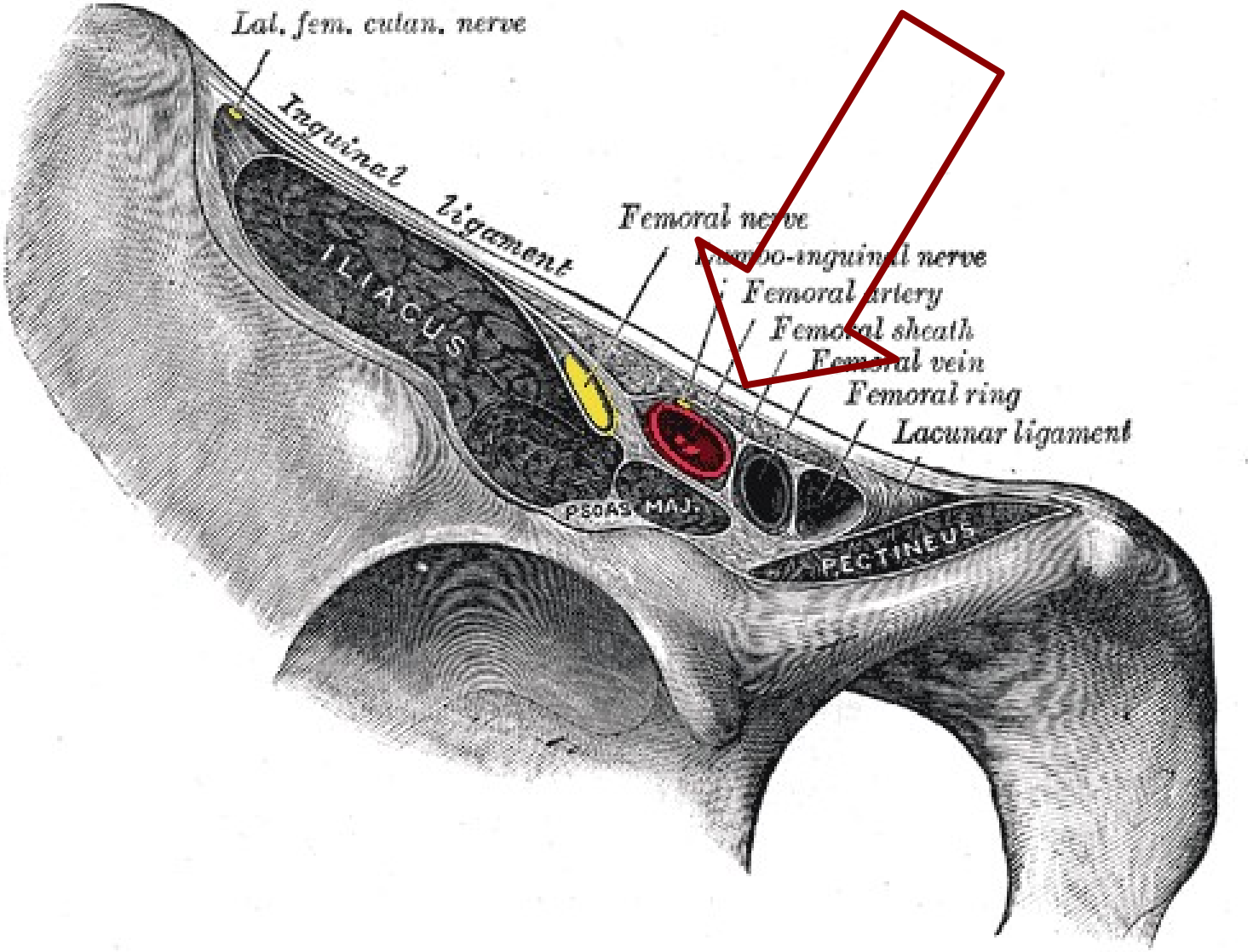
Slides 69 & 70

Majority

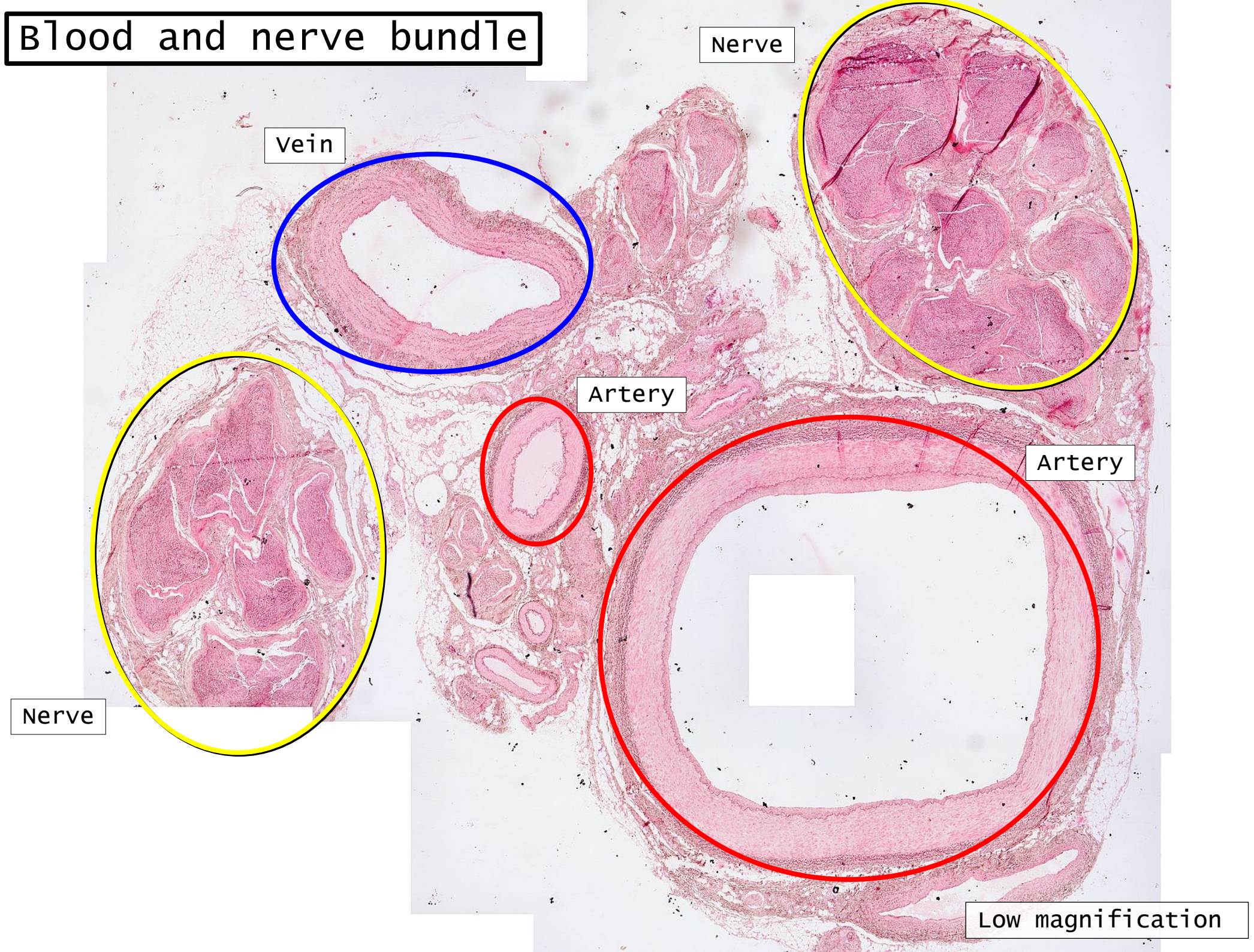
Macroscopic anatomy

- Holds true at the microscopic level
- Blood vessels in sheath
- Artery + Vein + Nerve + Lymphatics
- Example femoral sheath

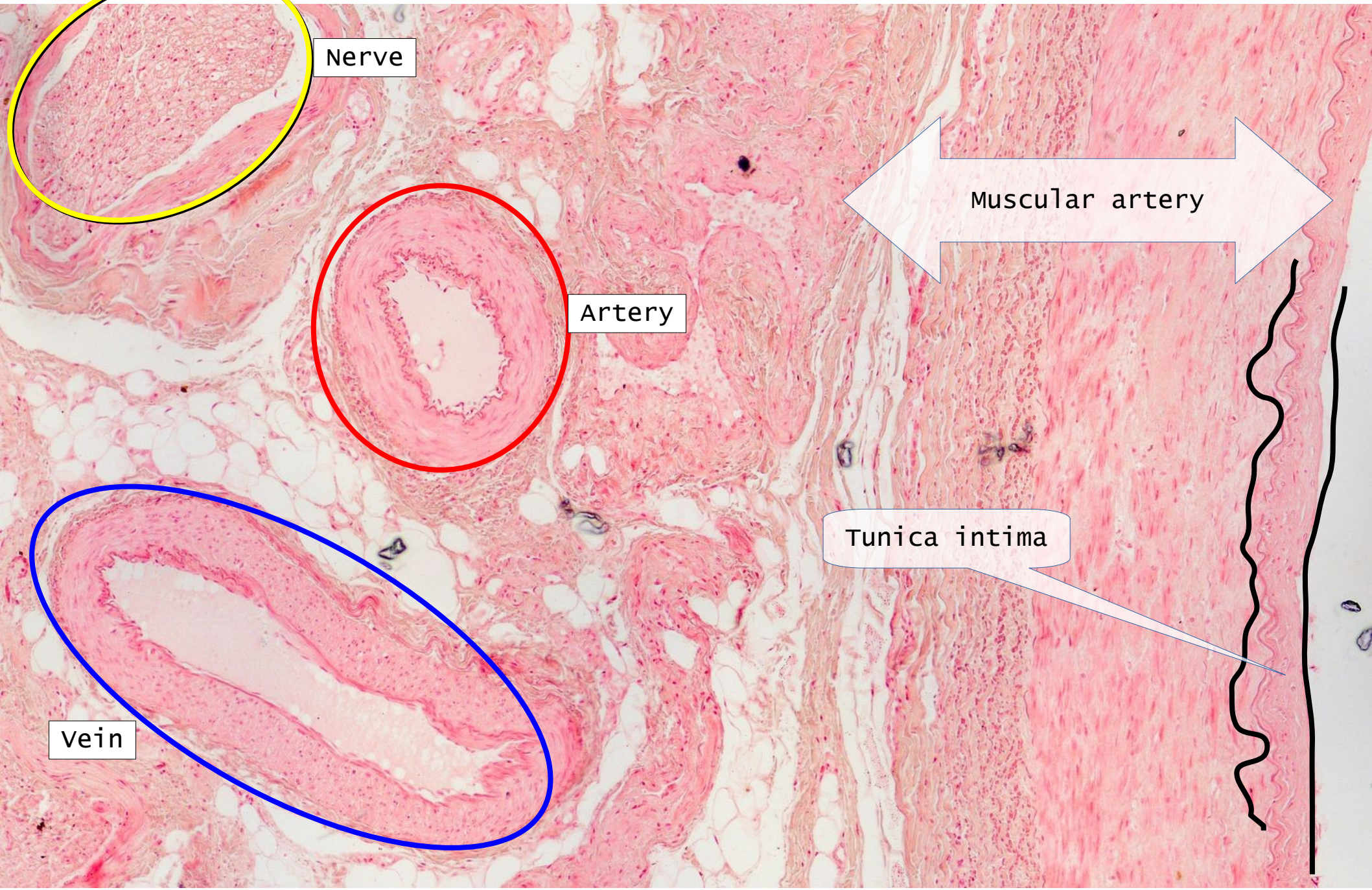
Femoral sheath



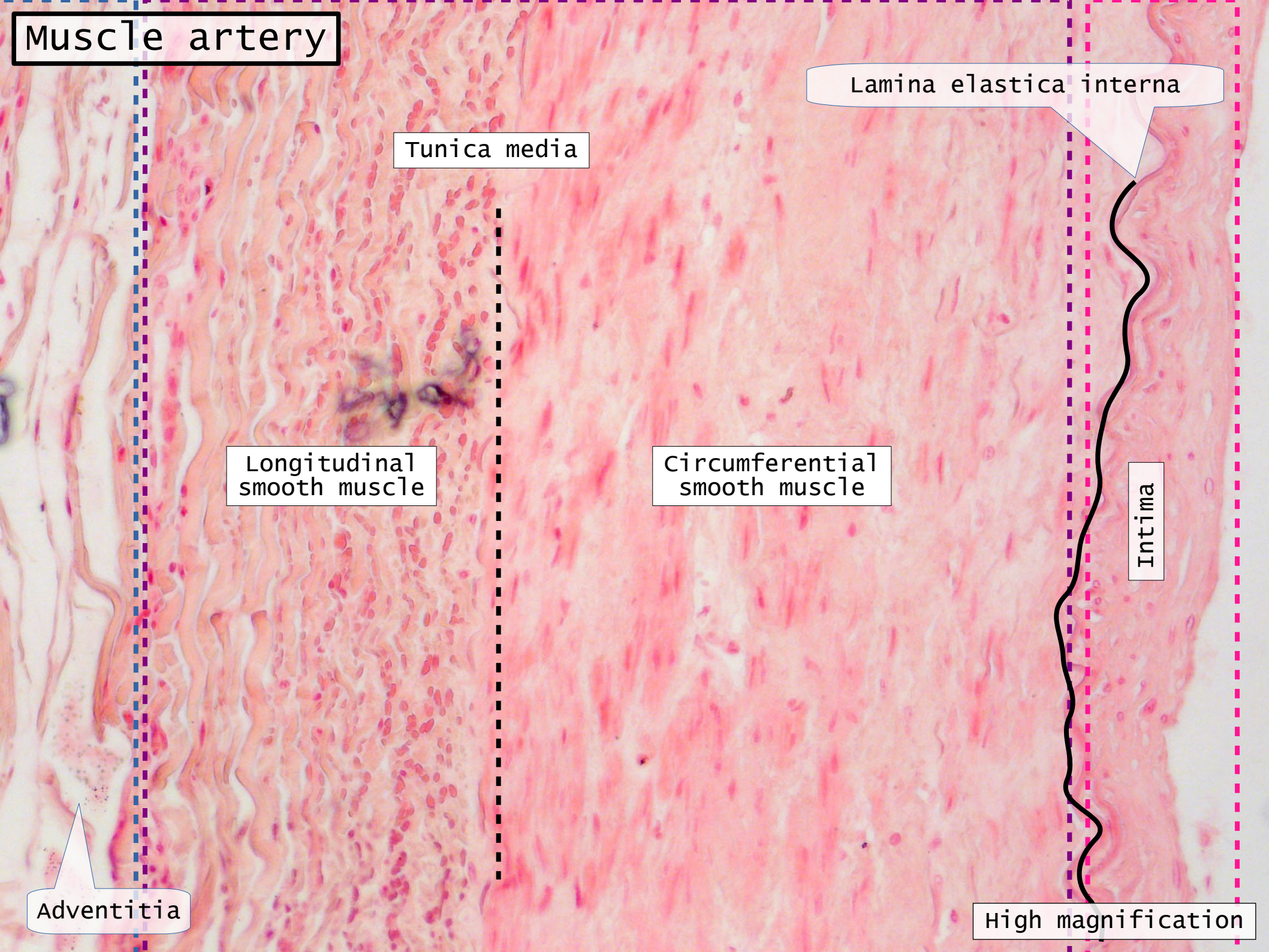
Blood and nerve bundle

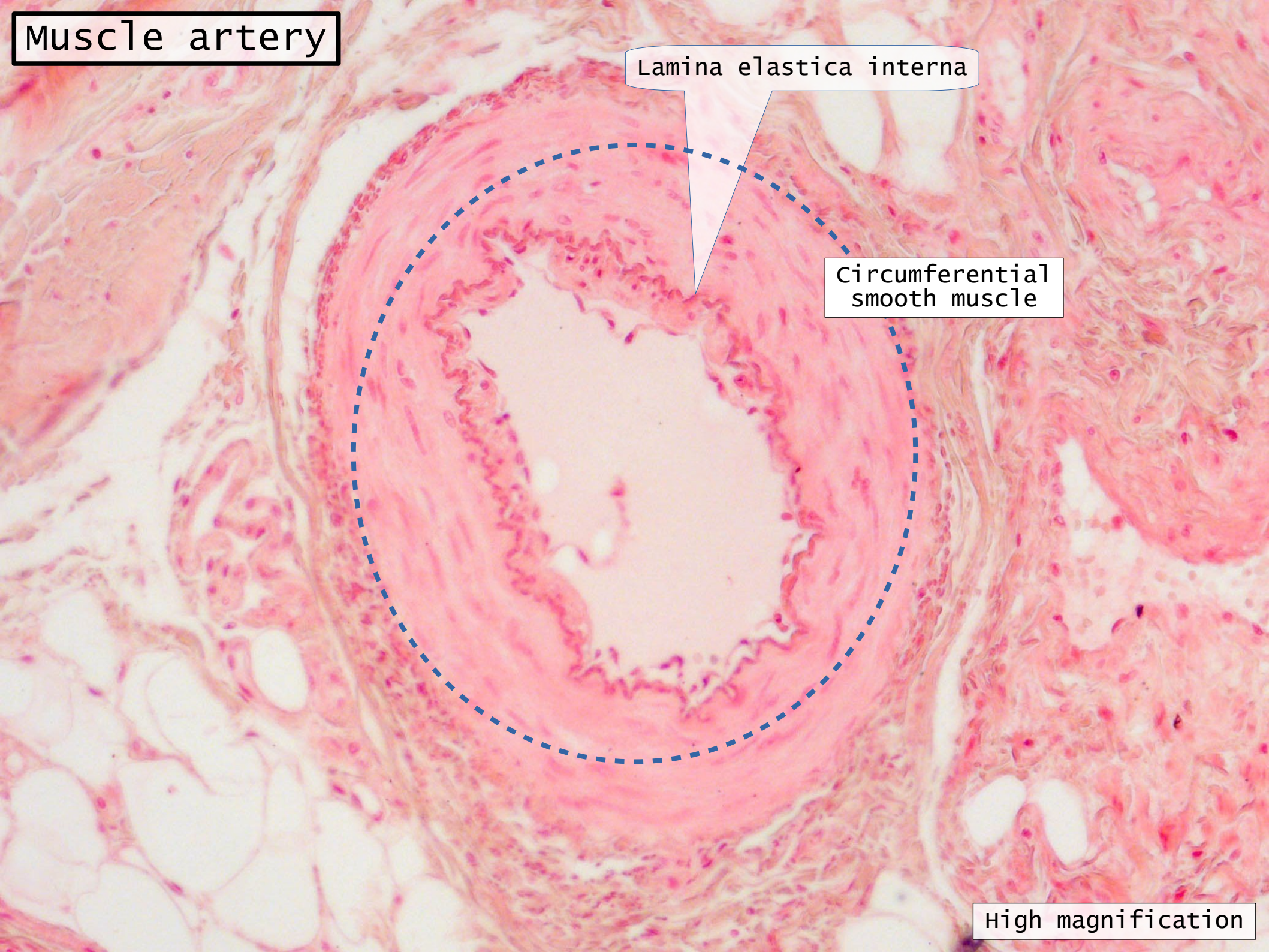


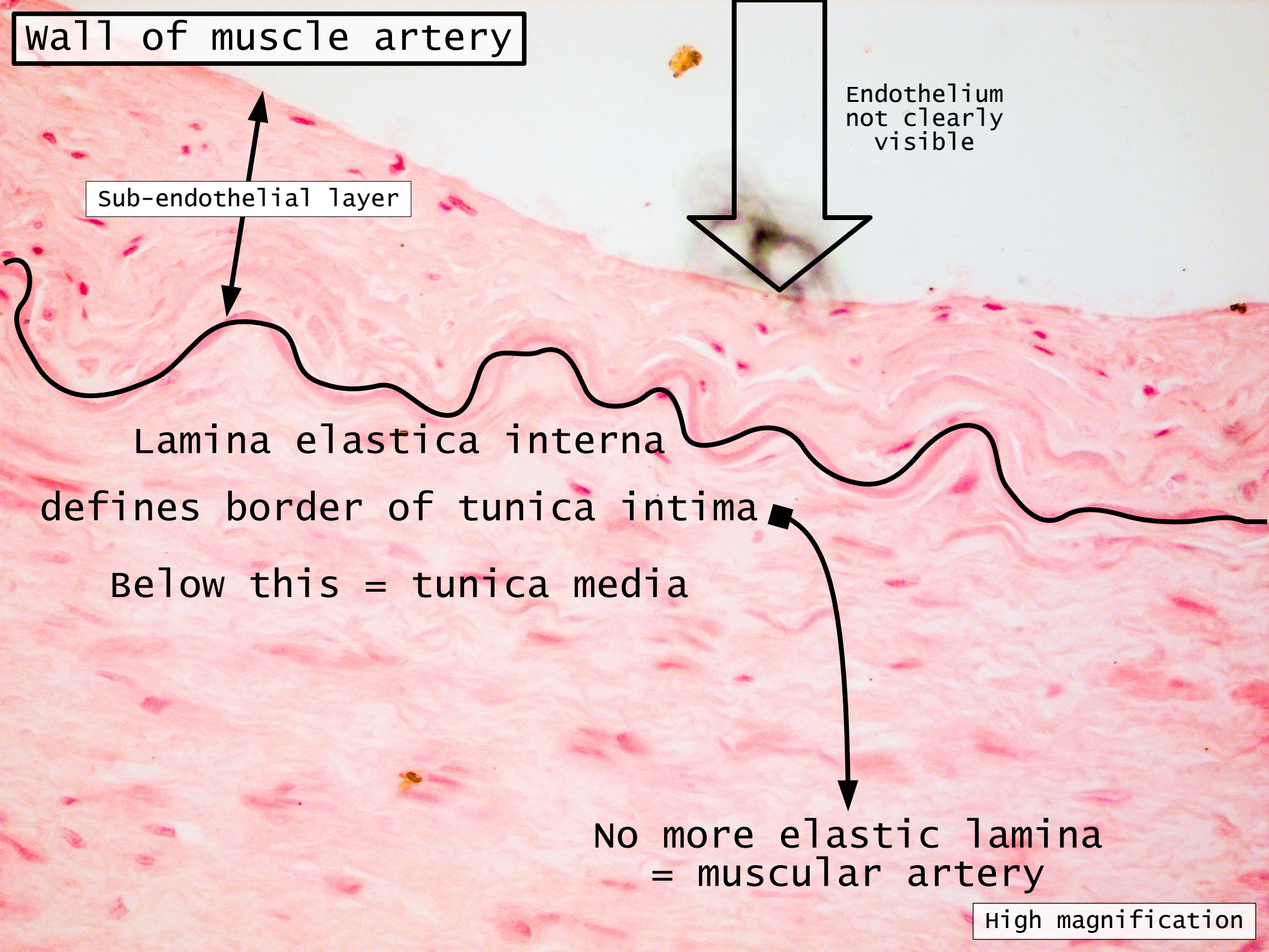
Blood and nerve bundle

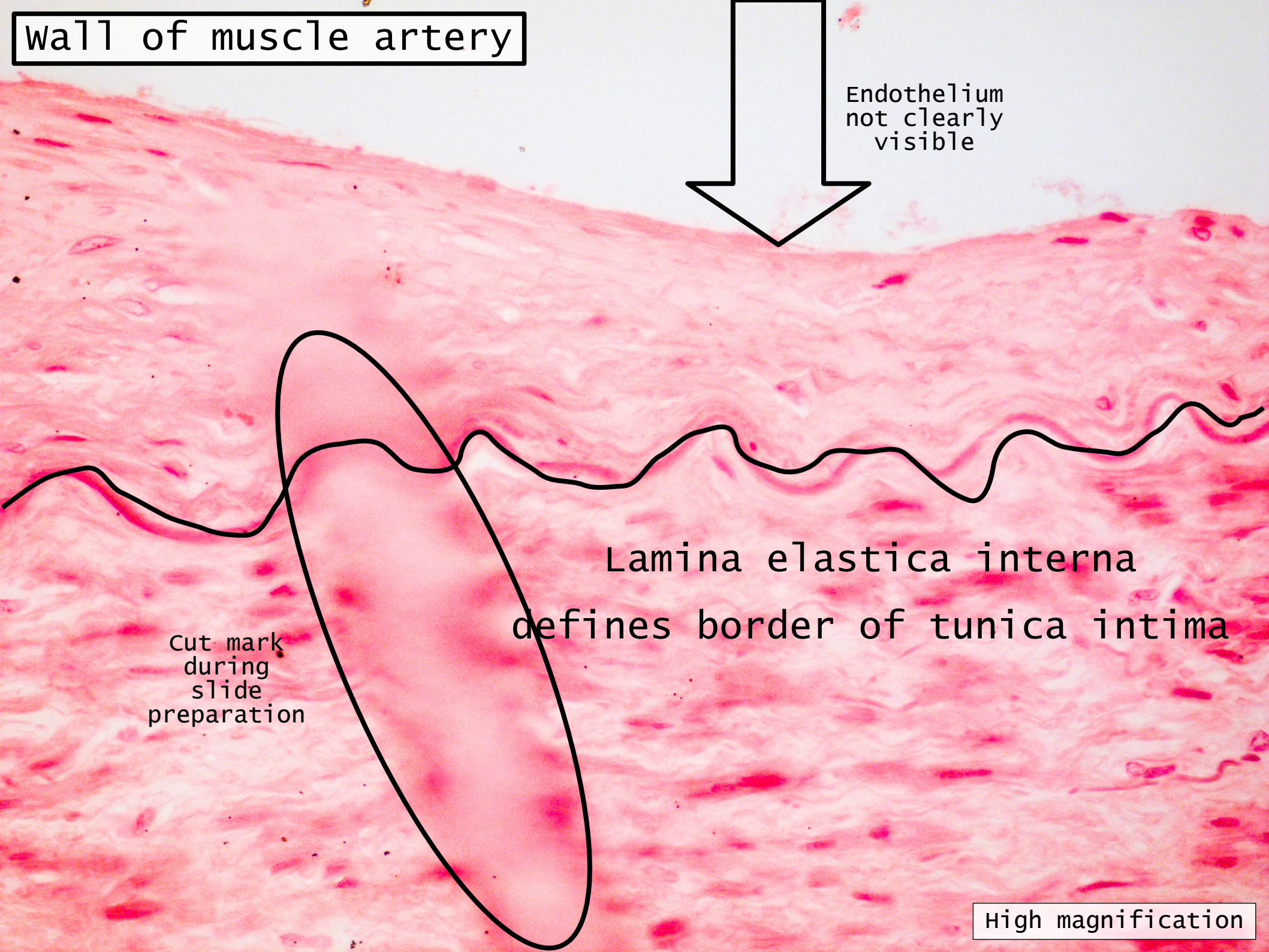


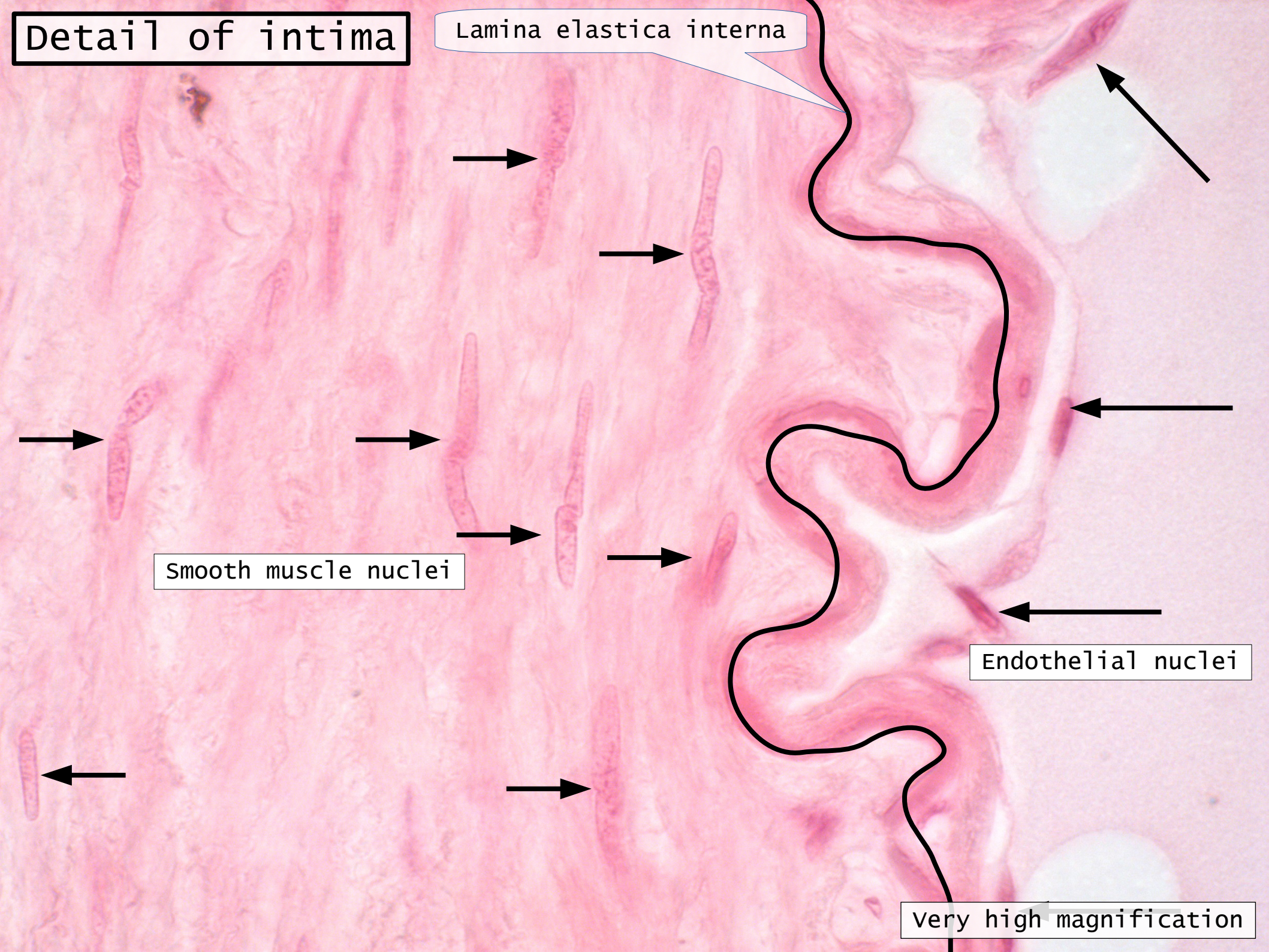
Medium magnification

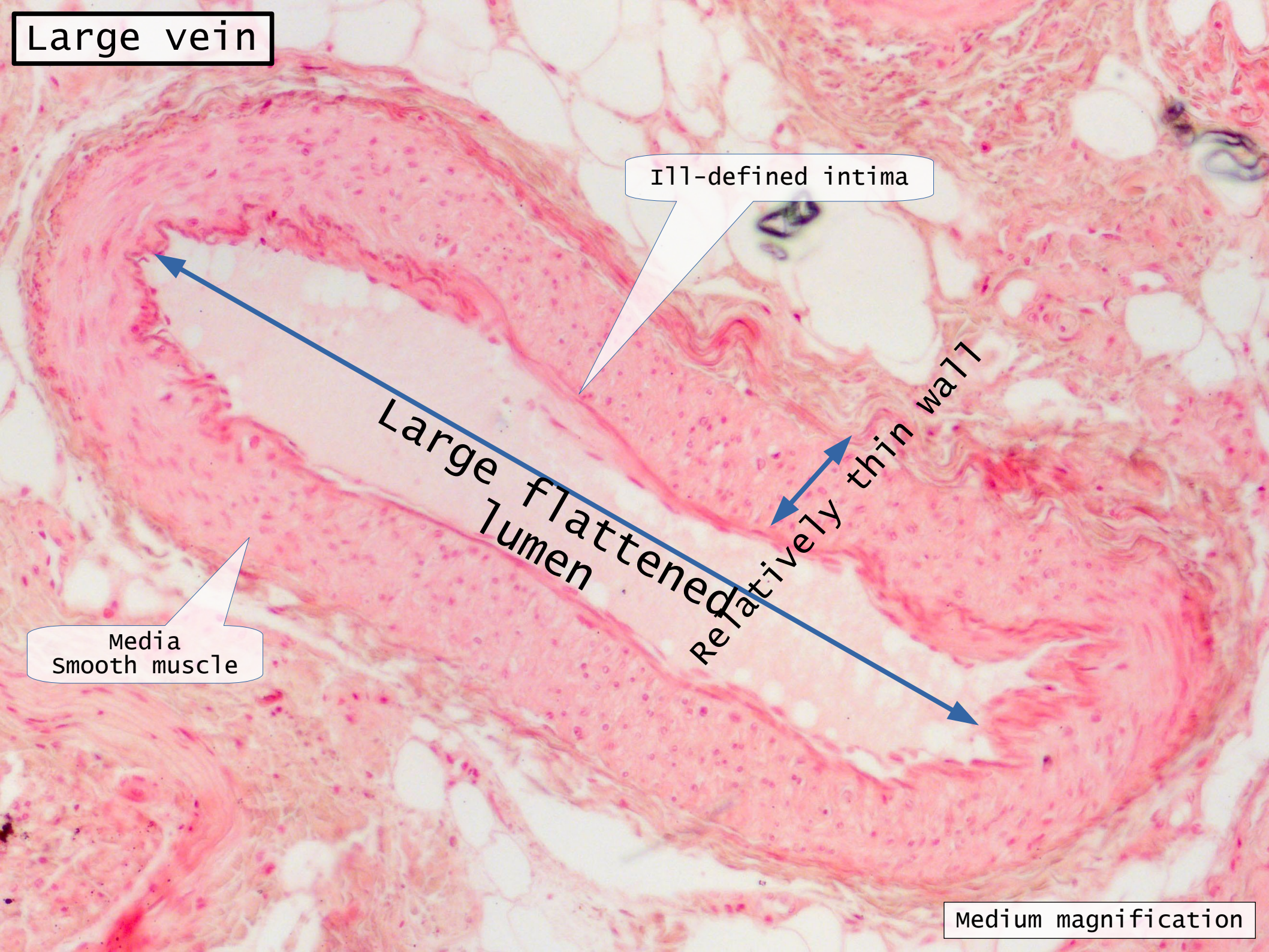

Muscle artery
Lamina elastica interna
Tunica media
Longitudinal smooth muscle
Circumferential smooth muscle
Intima
Adventitia
High magnification

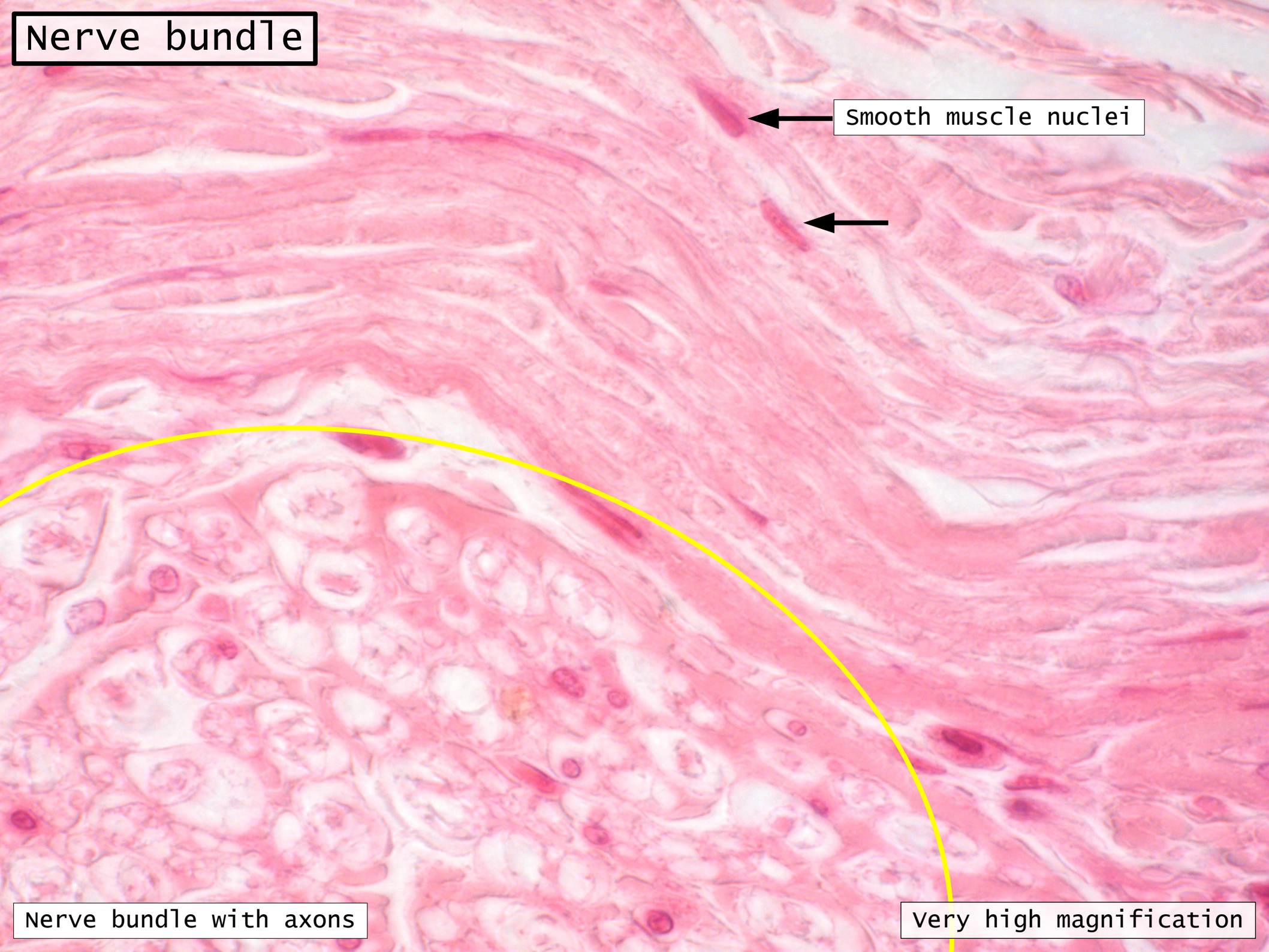

Muscle artery
Lamina elastica interna
Circumferential smooth muscle
High magnification


Wall of muscle artery
Endothelium not clearly visible
Sub-endothelial layer
Lamina elastica interna
defines border of tunica intima
Below this = tunica media
No more elastic lamina
= muscular artery
High magnification

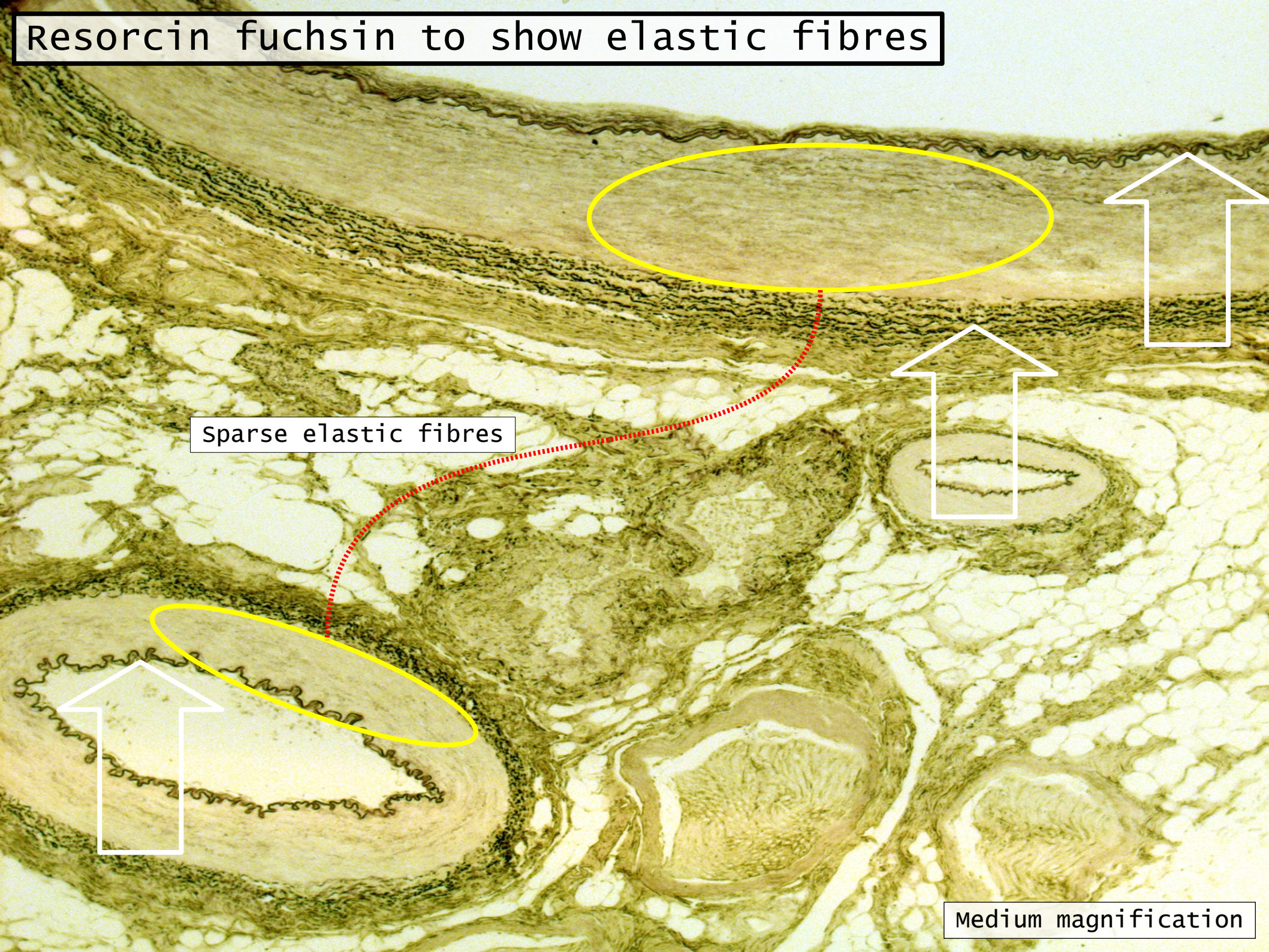

Wall of muscle artery
Endothelium not clearly visible
Lamina elastica interna
defines border of tunica intima
Cut mark during slide preparation
High magnification

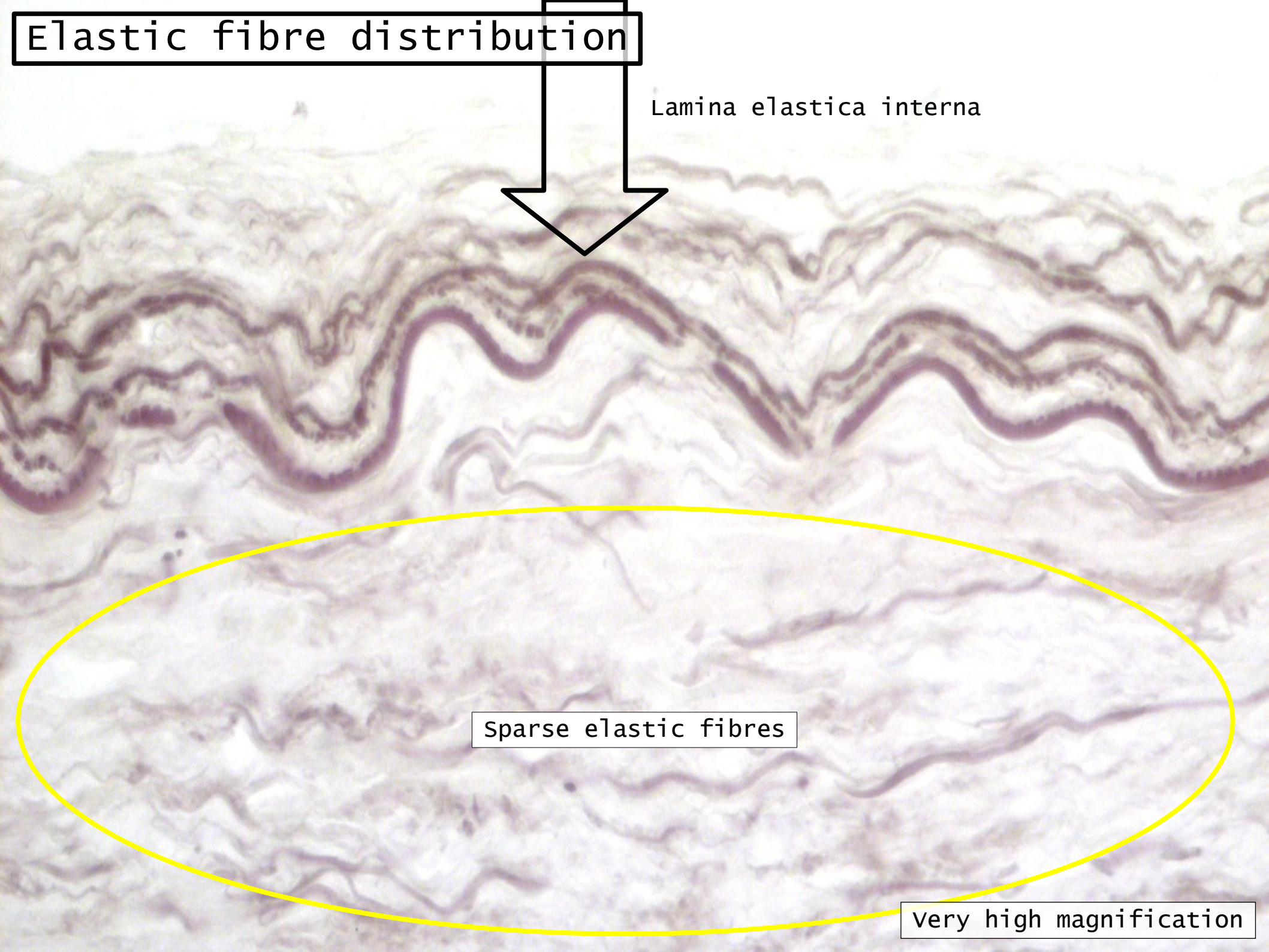

Detail of intima
Lamina elastica interna
Smooth muscle nuclei
Endothelial nuclei
Very high magnification


Large vein
Ill-defined intima
Large flattened lumen
Relatively thin wall
Media
Smooth muscle
Medium magnification

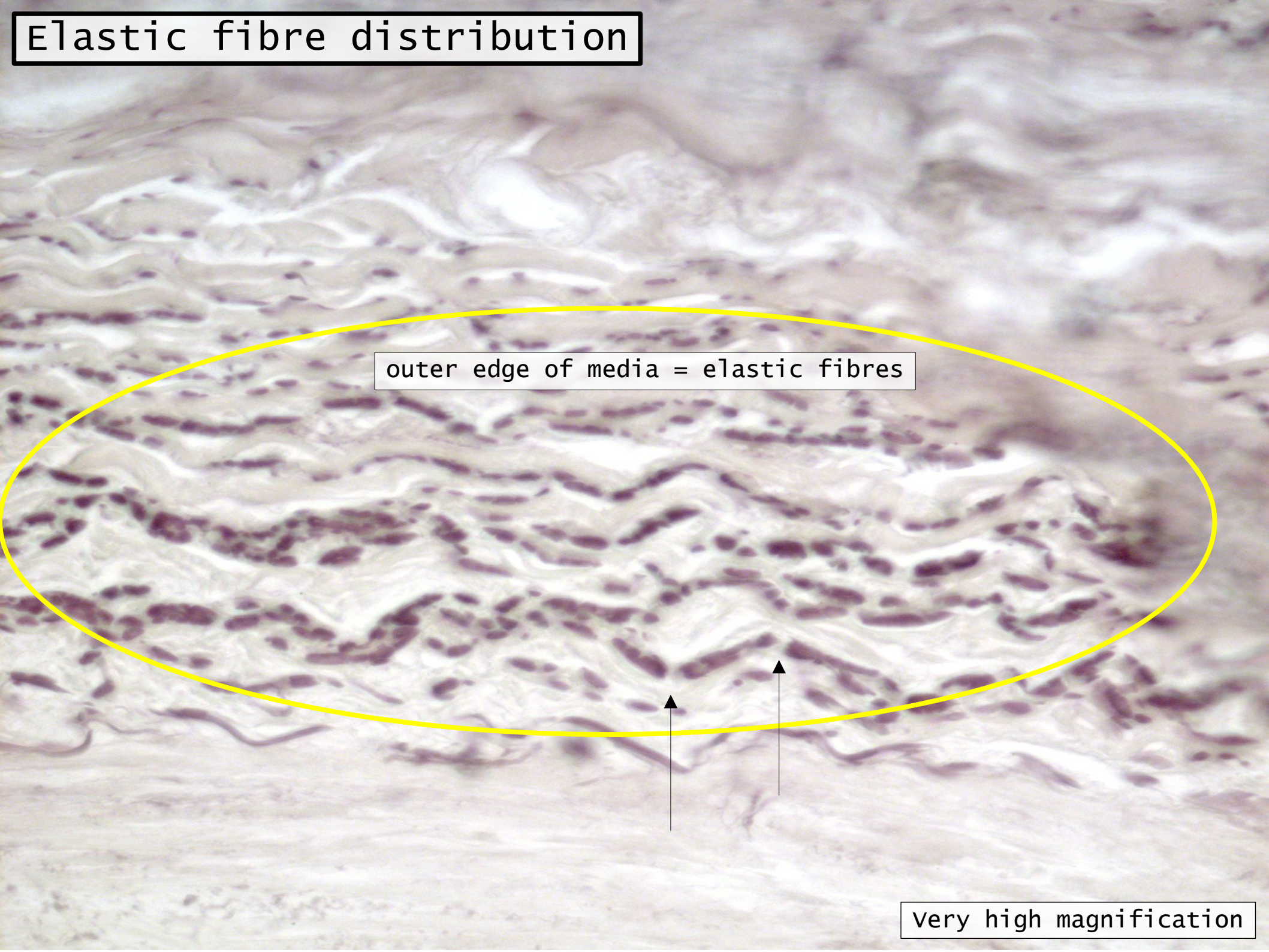

Nerve bundle
Smooth muscle nuclei
Nerve bundle with axons
Very high magnification

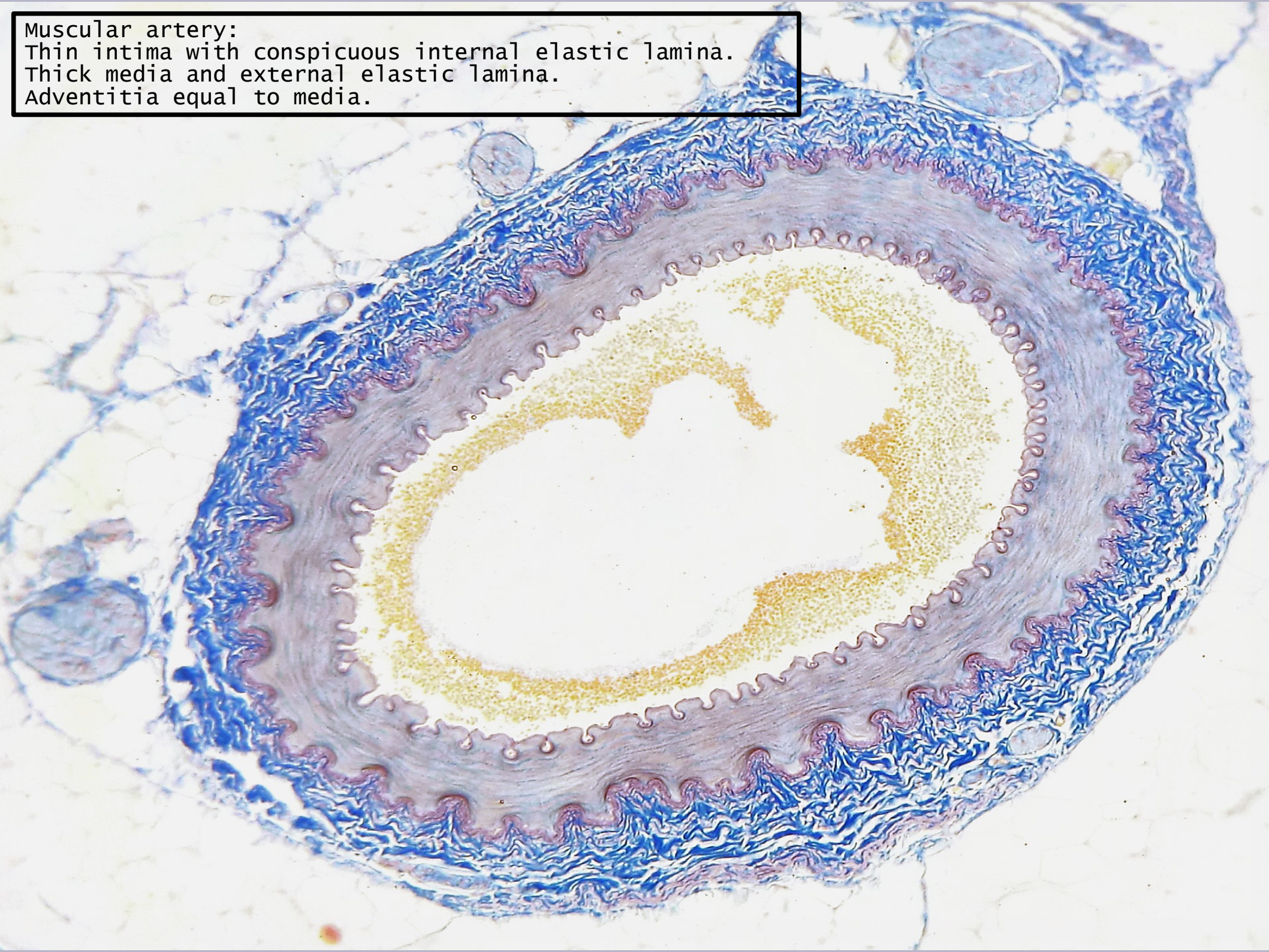

Axons
Axons
Nuclei of support cells
Schwann cells in peripheral nerves
Very high magnification

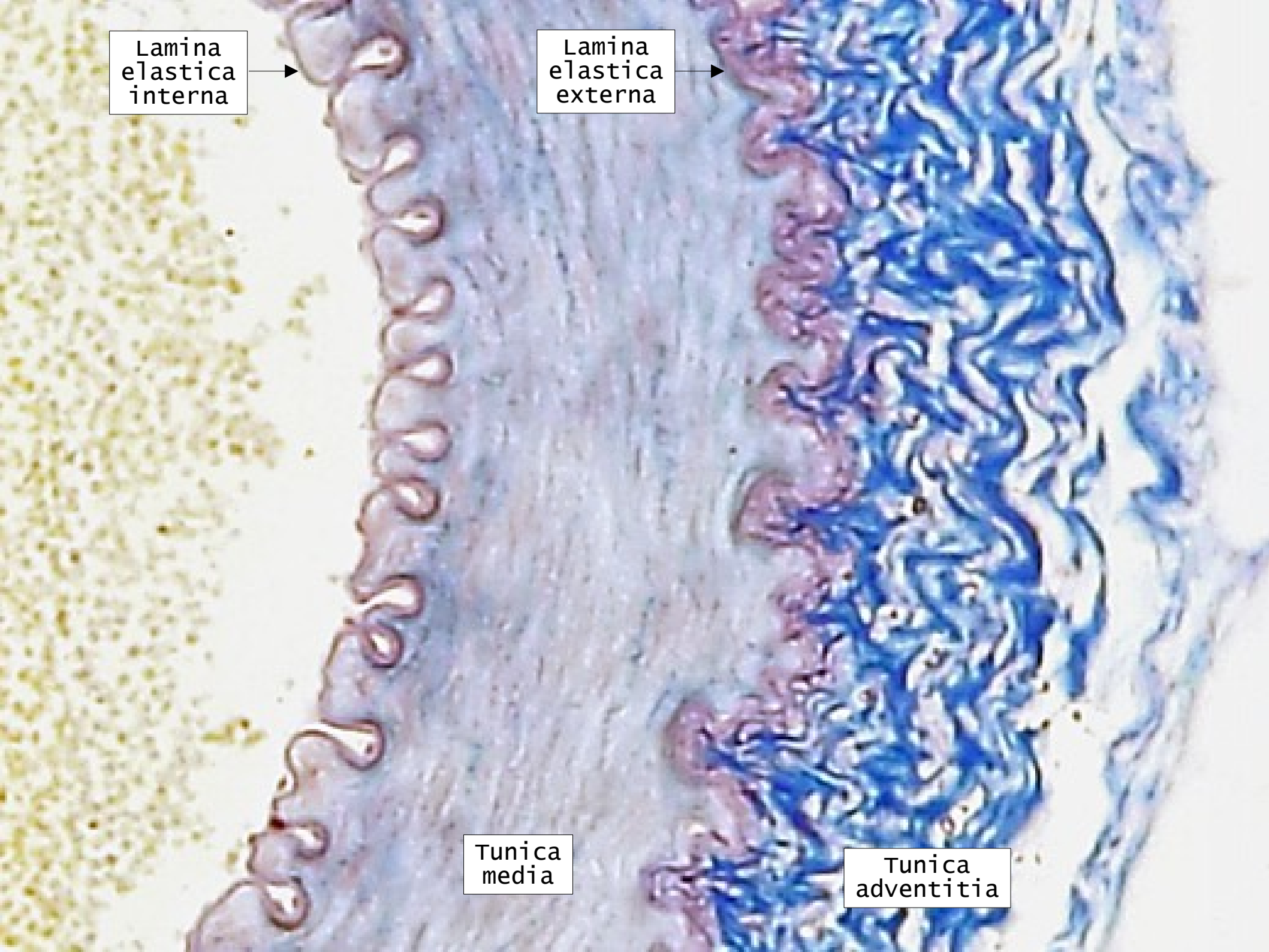

Resorcin fuchsin to show elastic fibres
Sparse elastic fibres
Medium magnification


Elastic fibre distribution
Lamina elastica interna
Sparse elastic fibres
Very high magnification

Elastic fibre distribution



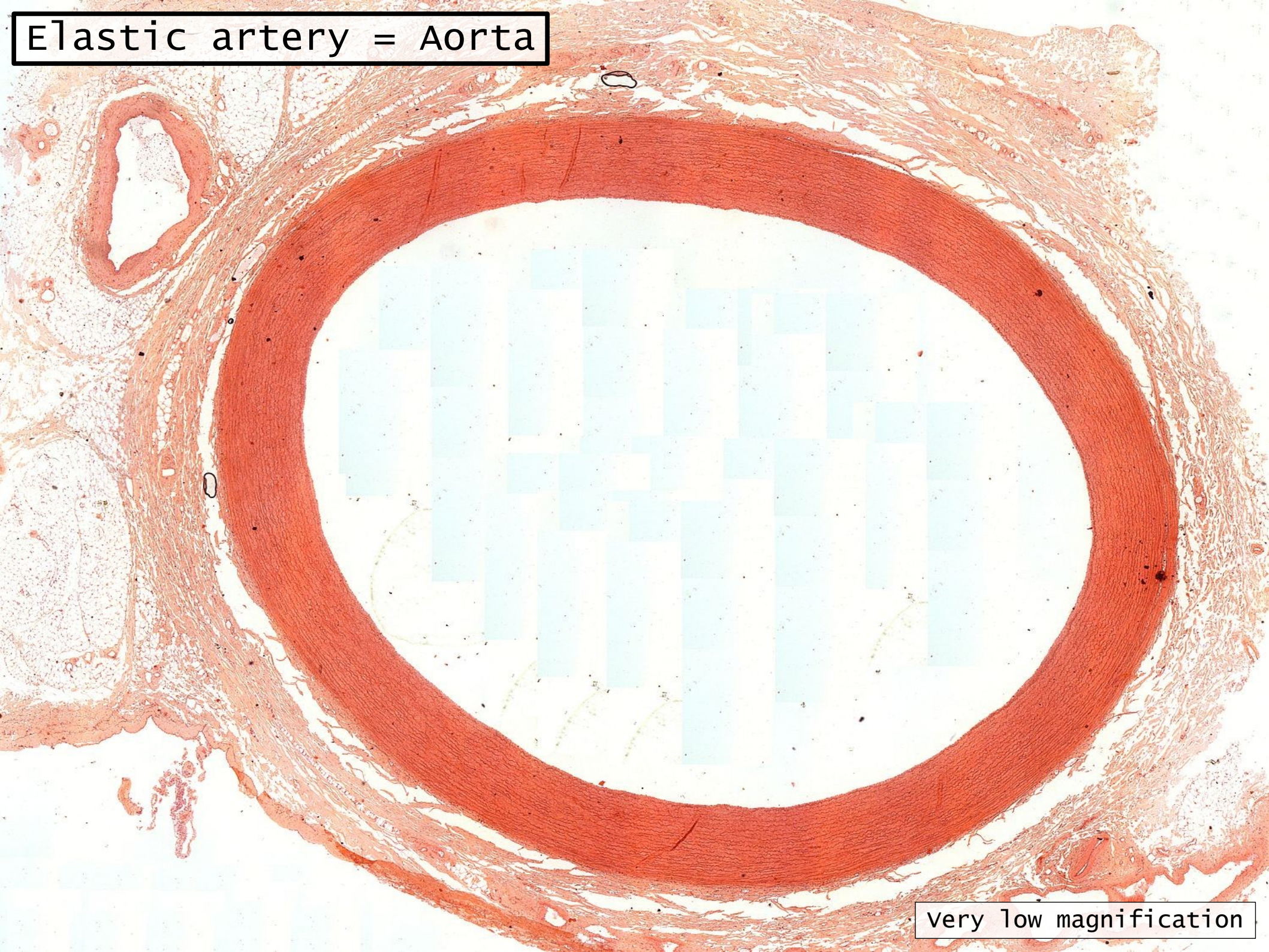

Muscular artery:
Thin intima with conspicuous internal elastic lamina.
Thick media and external elastic lamina.
Adventitia equal to media.


Lamina elastica interna
Lamina elastica externa
Tunica media
Tunica adventitia

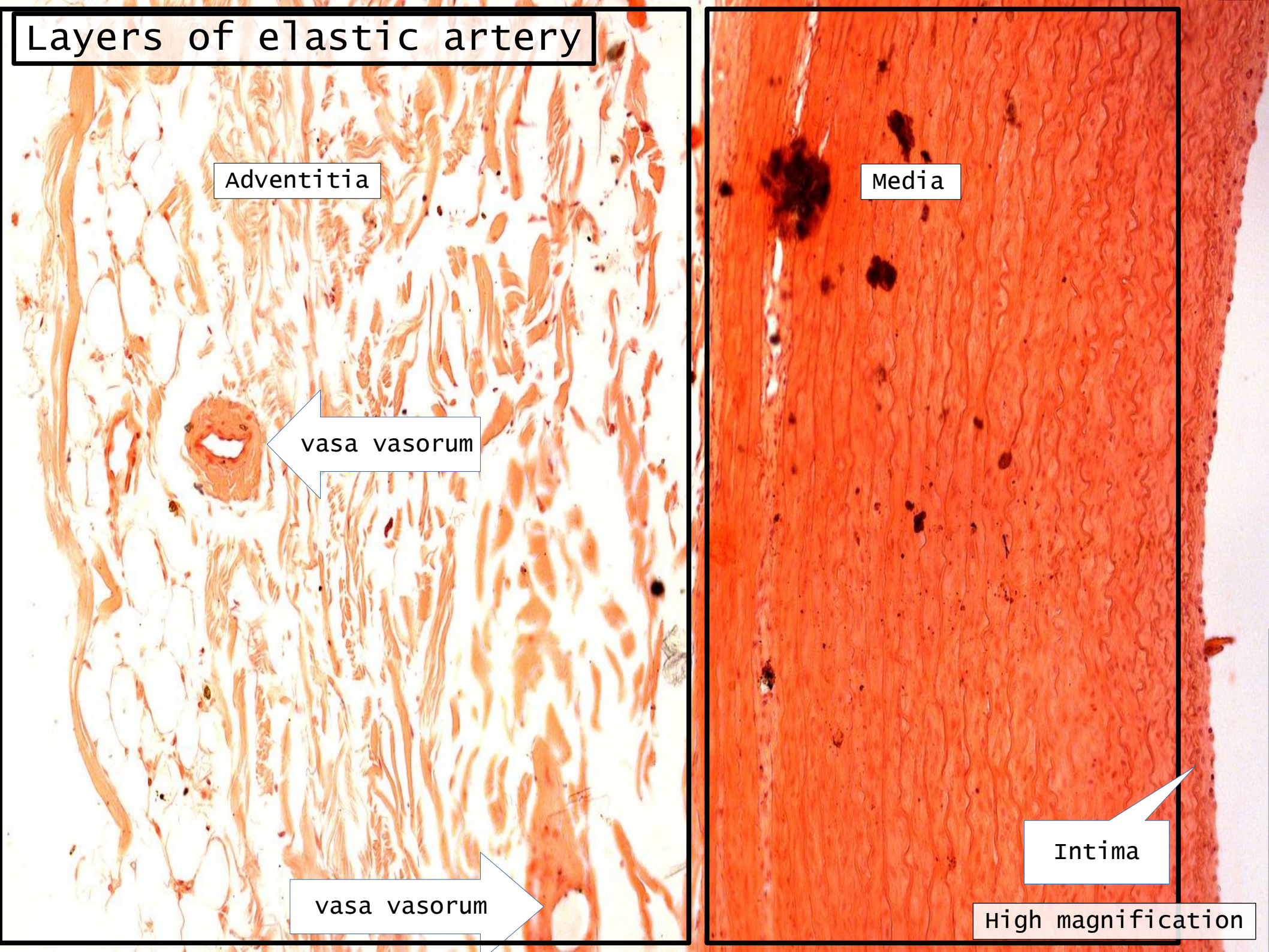
Elastic artery

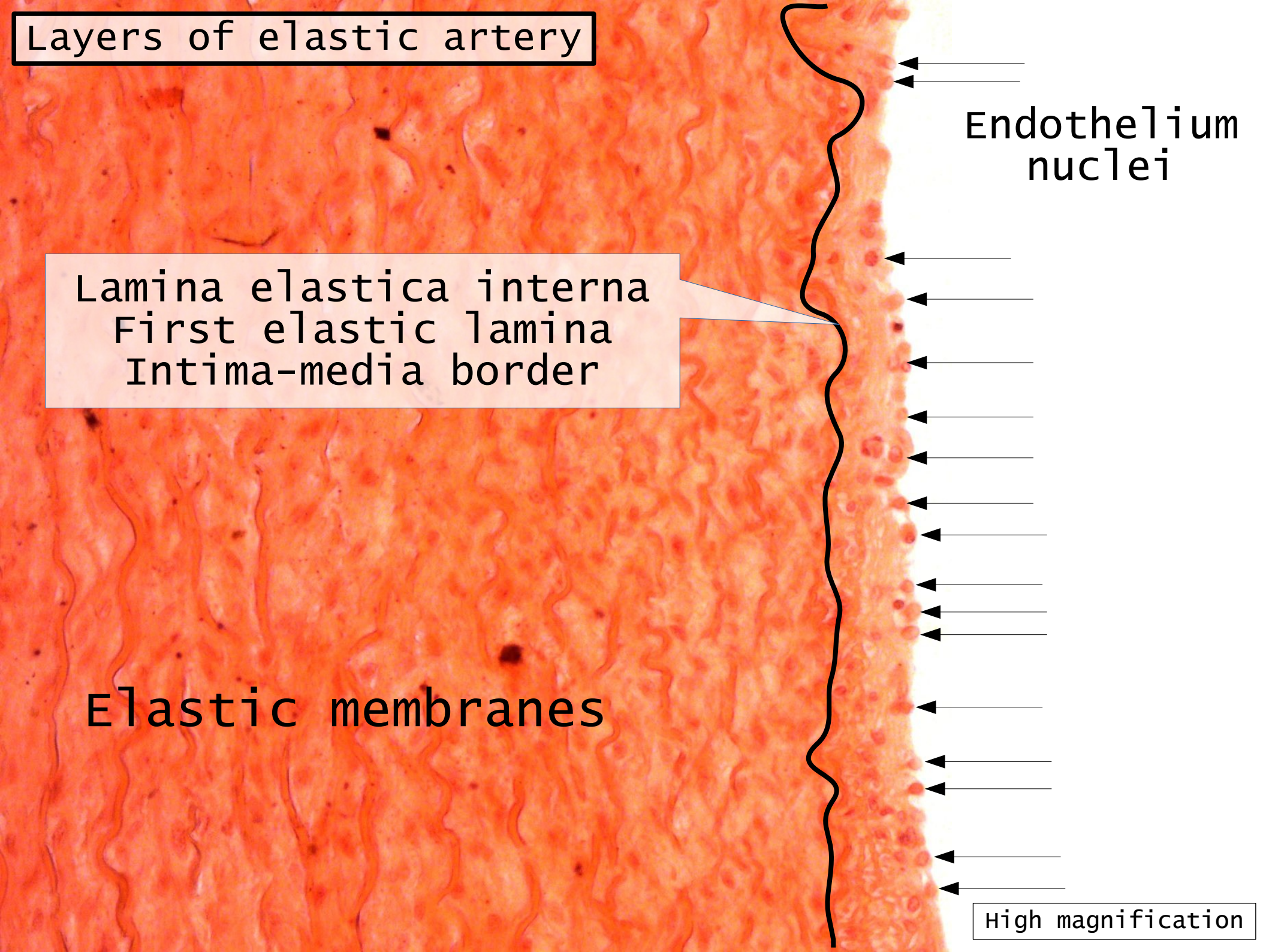
Slides 67 & 49

Aorta

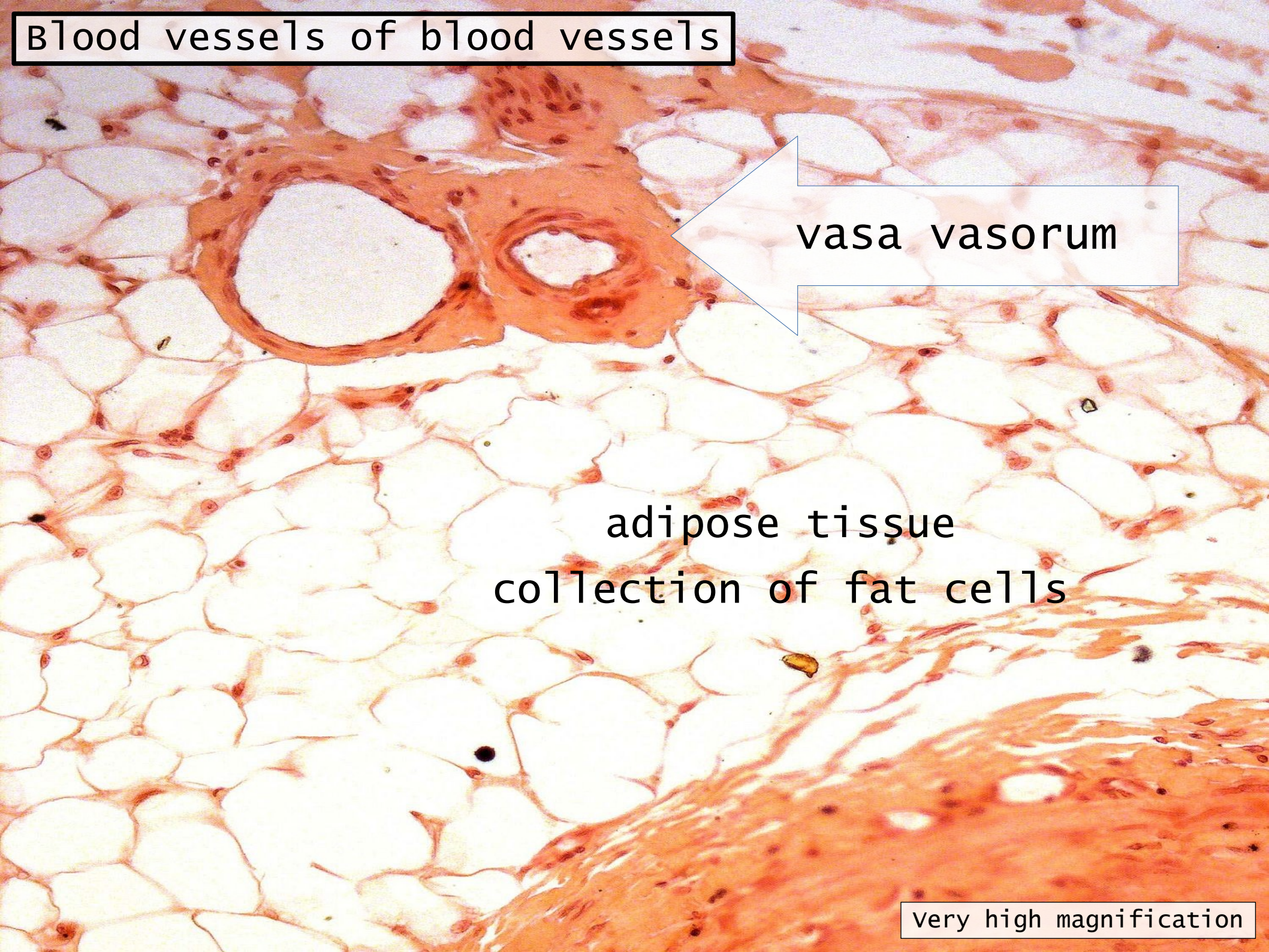

Elastic artery = Aorta
Very low magnification

Layers of elastic artery

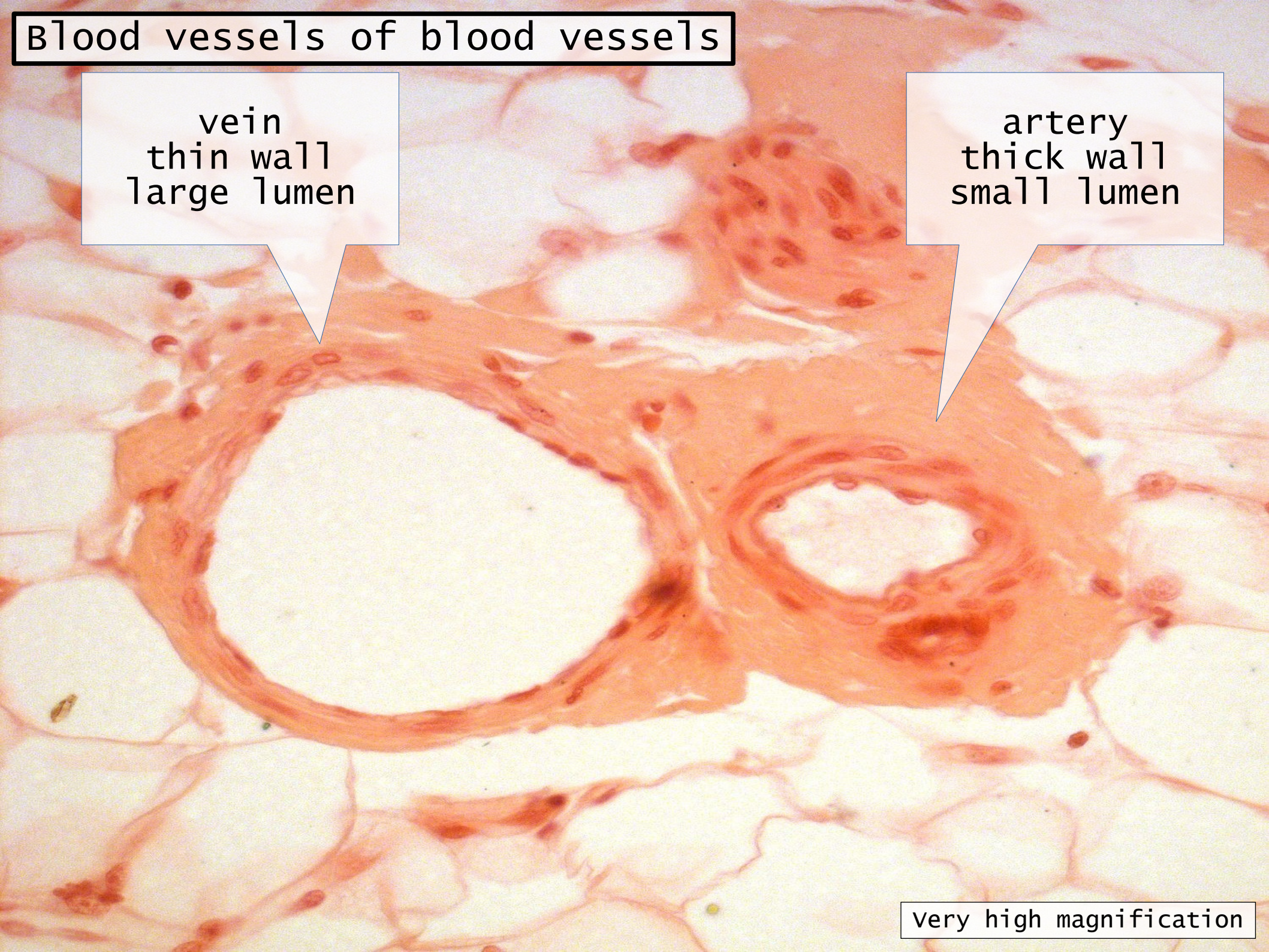



Layers of elastic artery
Endothelium nuclei
Lamina elastica interna
First elastic lamina
Intima-media border
Elastic membranes
High magnification

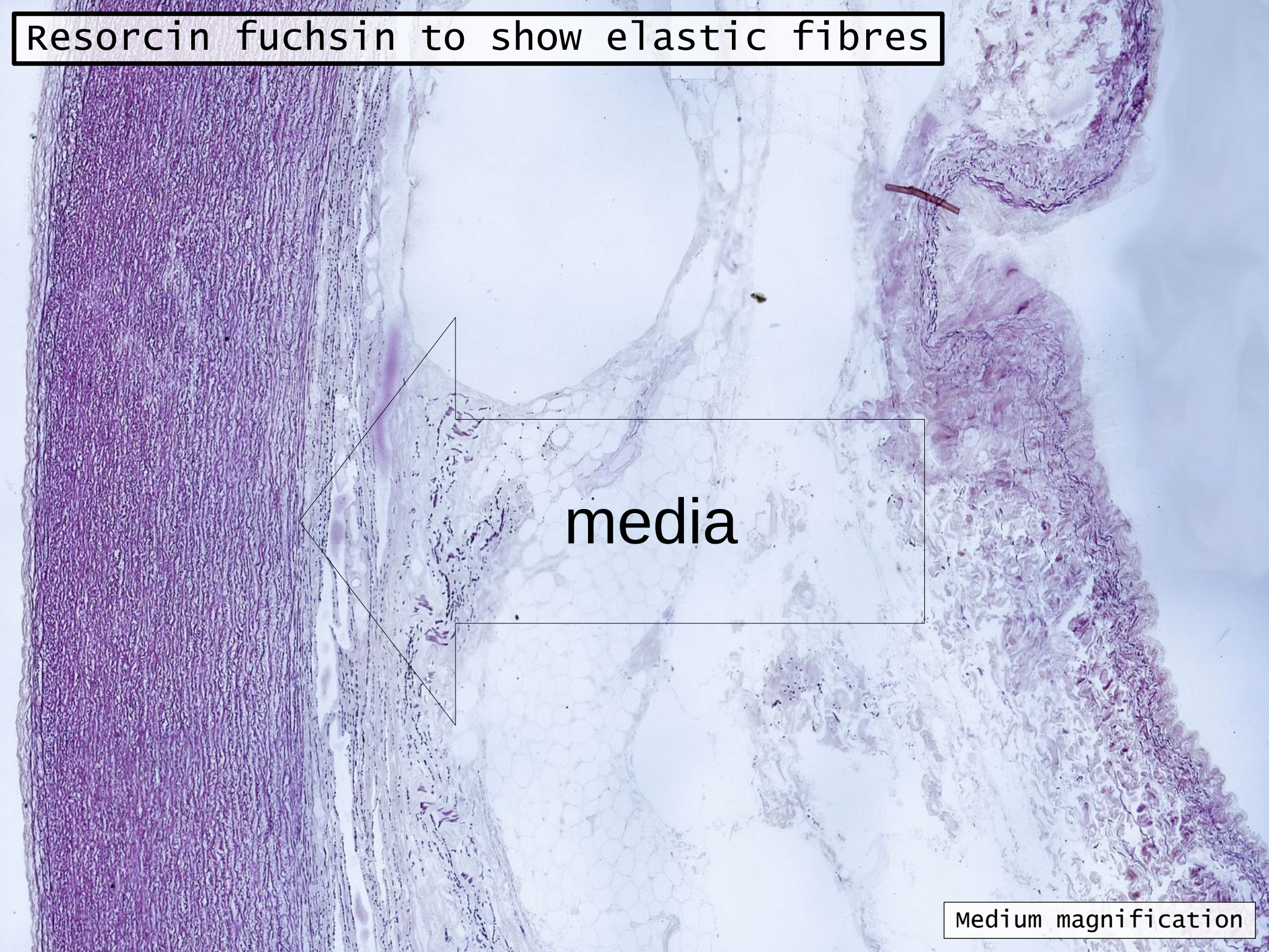
Blood vessels of blood vessels



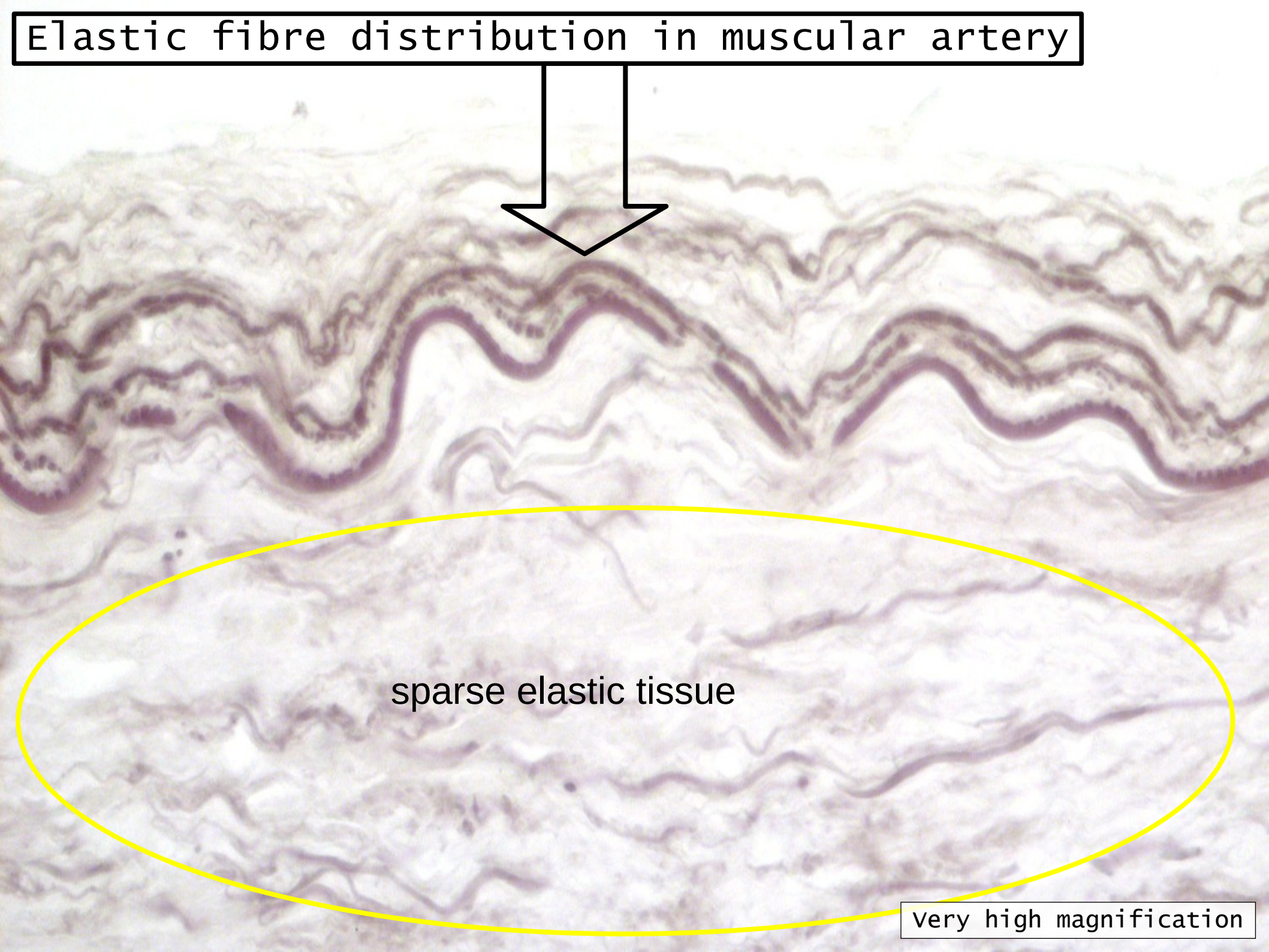
Blood vessels of blood vessels

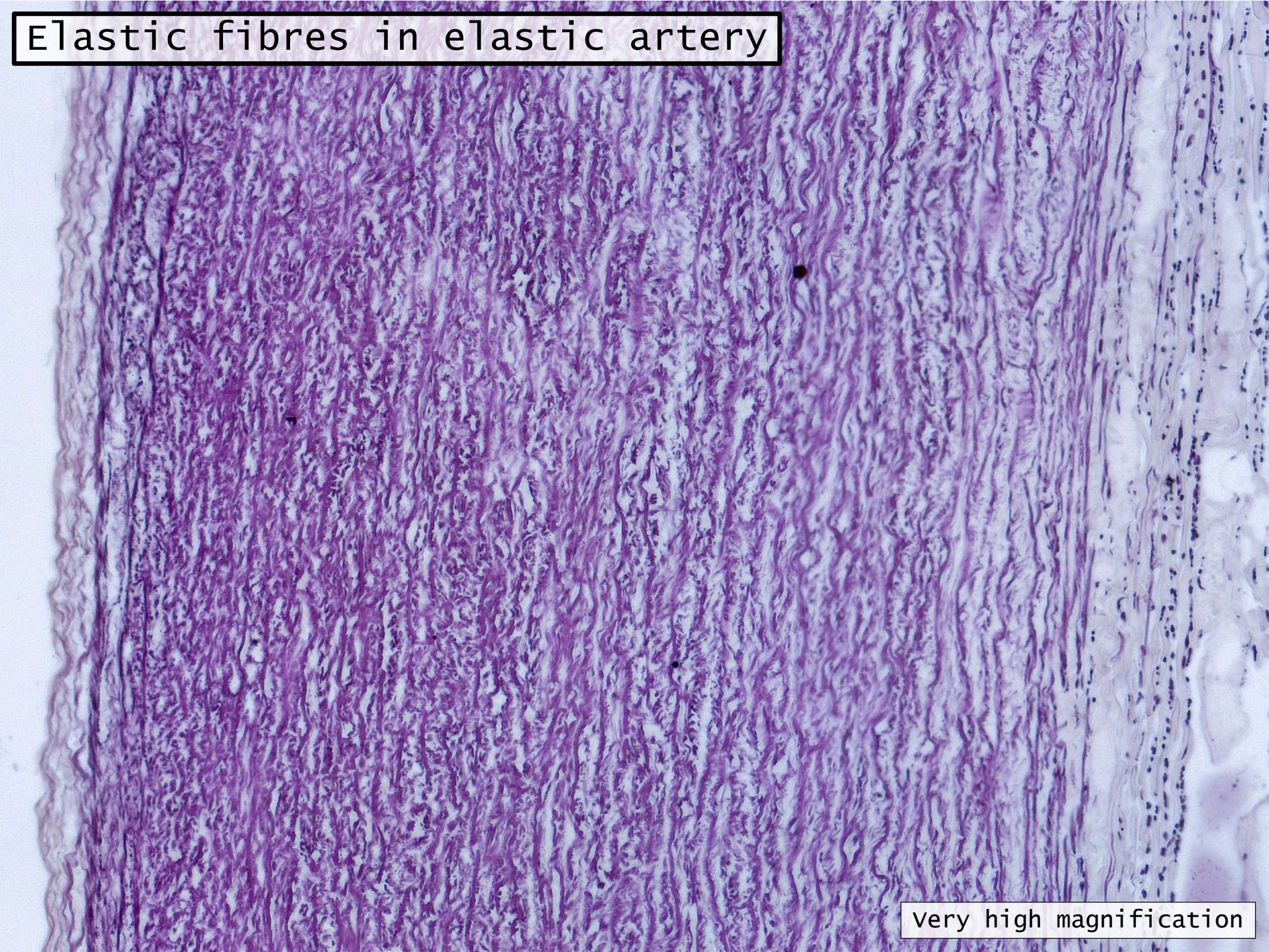


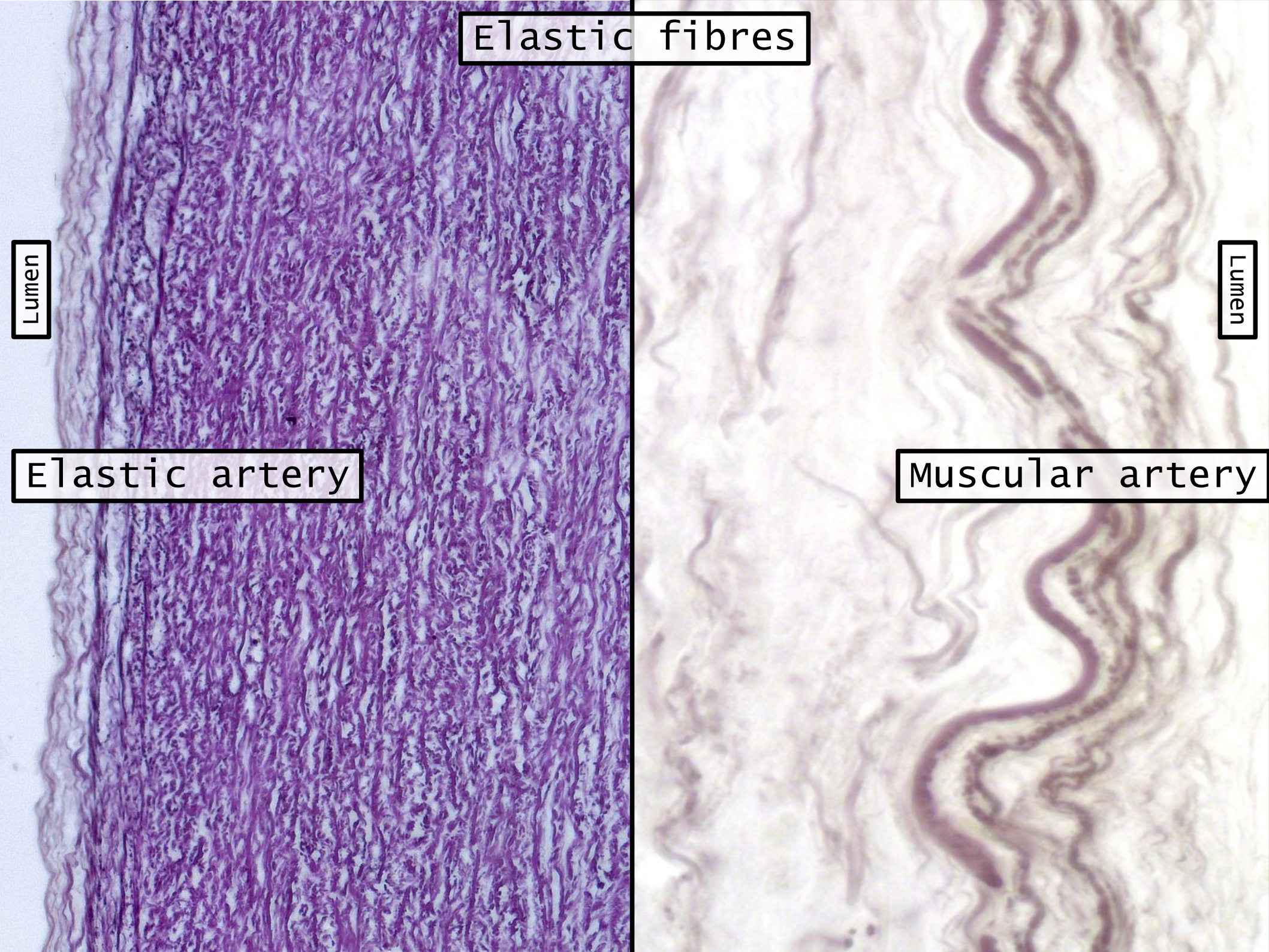
Resorcin fuchsin to show elastic fibres




Resorcin fuchsin to show elastic fibres
DENSE ELASTIC TISSUE
Very high magnification


Elastic fibre distribution in muscular artery
sparse elastic tissue
Very high magnification


Elastic fibres in elastic artery
Very high magnification


Elastic fibres
Lumen
Elastic artery
Lumen
Muscular artery

Capillaries

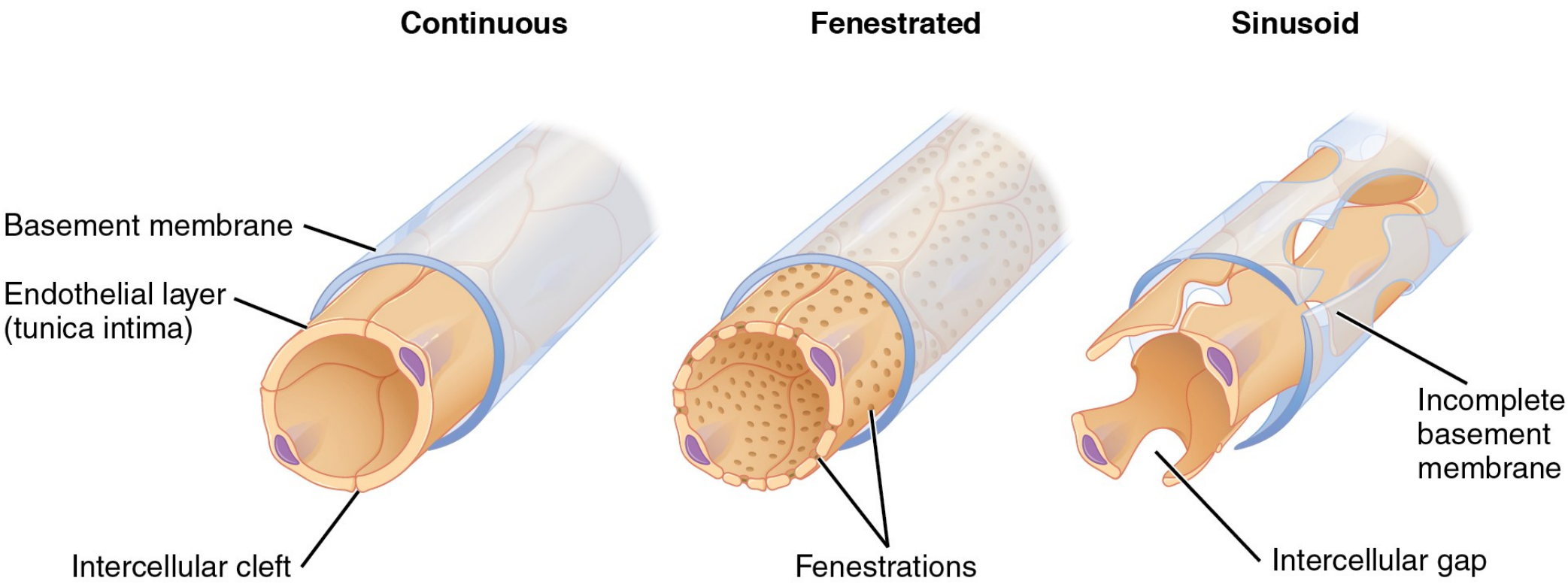
In context

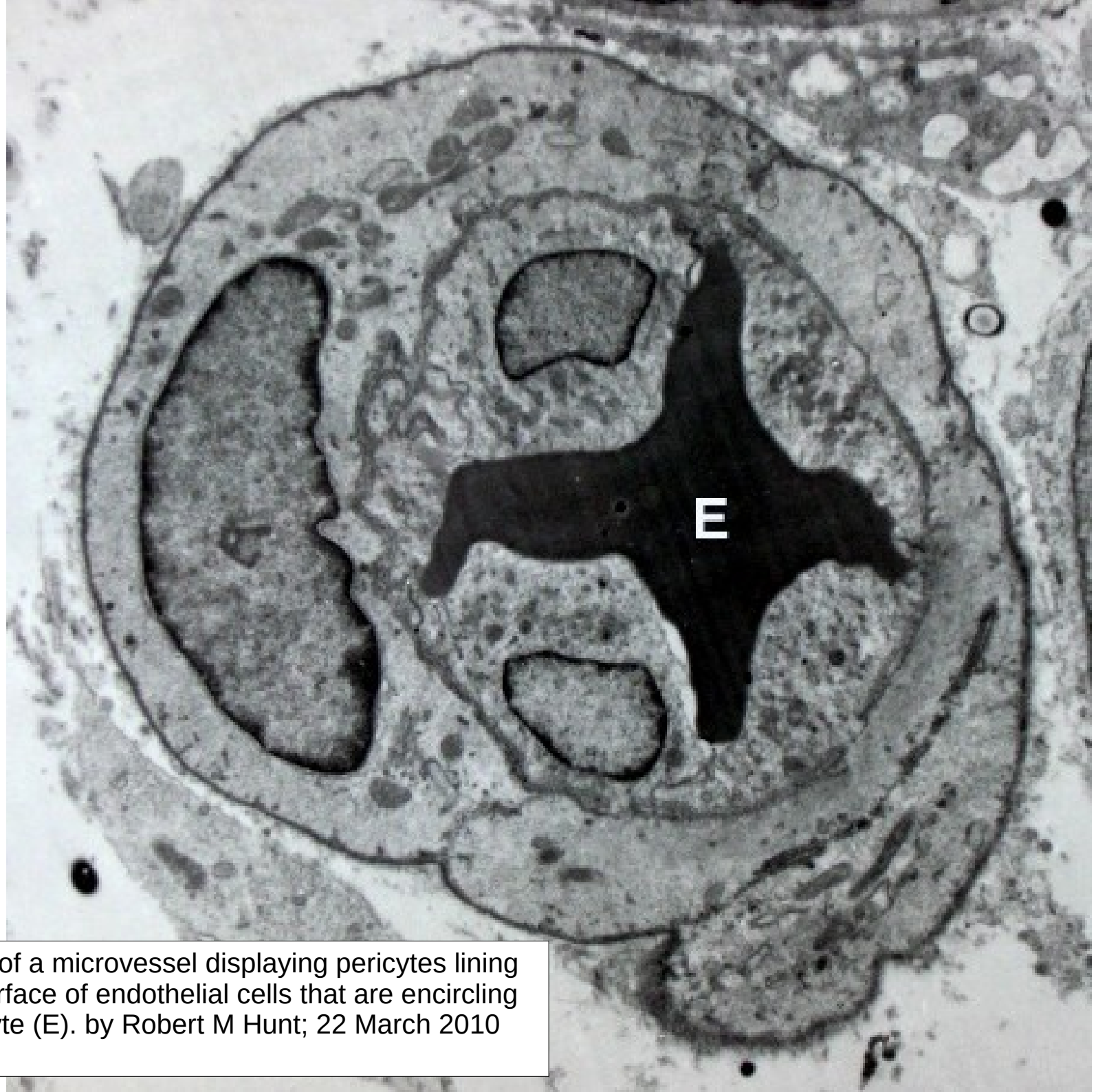
Capillaries

- Small thin walled diameter 8 – 10µm
- Slightly wider than red blood cells
- Intima
  - Lined with endothelium
  - Resting on BM
  - Lateral margins connected with tight junctions
  - Do not extend around entire perimeter
  - Slit-like intercellular clefts
  - Tissue fluid and small molecules can pass through
  - Brain: entire perimeter = blood-brain barrier with astrocytes
  - Scattered pericytes
  - Involved with blood-vessel growth
  - Endo+BM+Pericytes = tunica intima
- No Media
- Adventitia with little CT

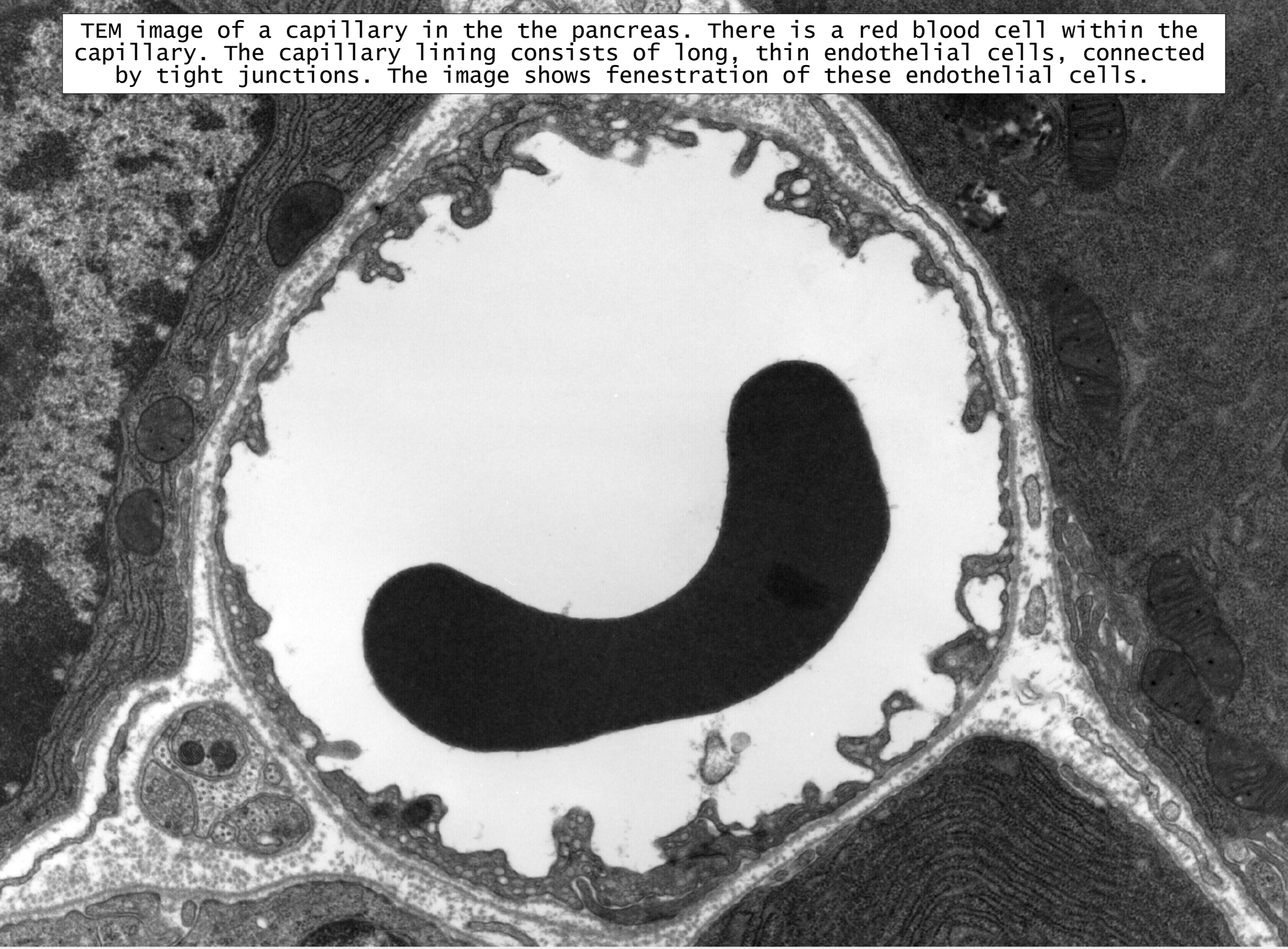
Capillaries

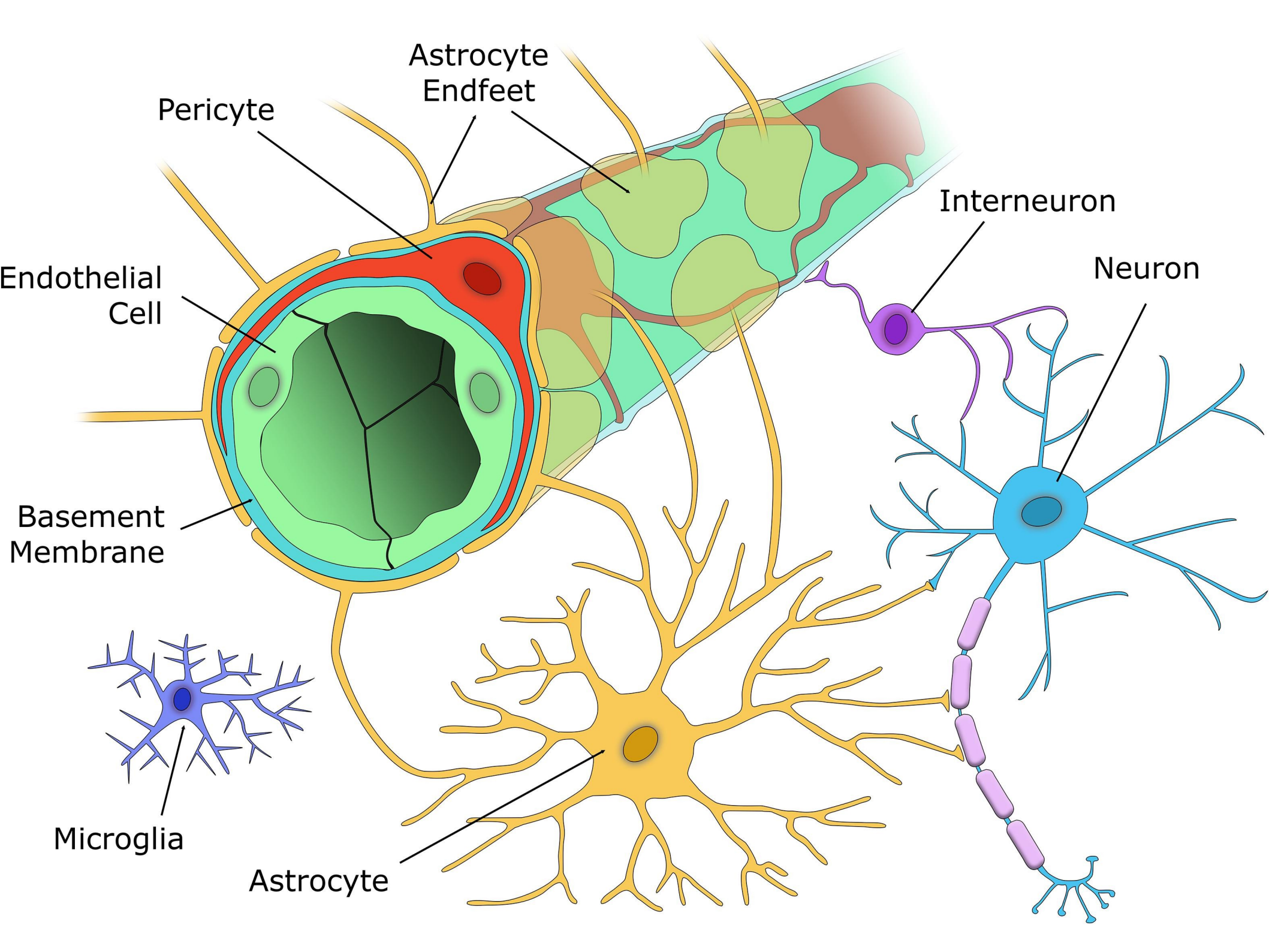
- Three types
- Continuous
  - Most parts
  - Endothelium uninterrupted
  - Allow passage water and ions and small molecules
- Fenestrated
  - Circular fenestrations (windows) in cytoplasm
  - More permeable varies according to location
  - Larger molecules
  - Small intestine, kidneys, endocrine organs
- Sinusoids
  - Thin-walled with wide lumen
  - Associated population of macrophages
  - Extensive intercellular gaps
  - Incomplete BM
  - Large molecules can pass
  - Plasma proteins and cells
  - Bone marrow, liver, spleen, lymph nodes, endocrine organs

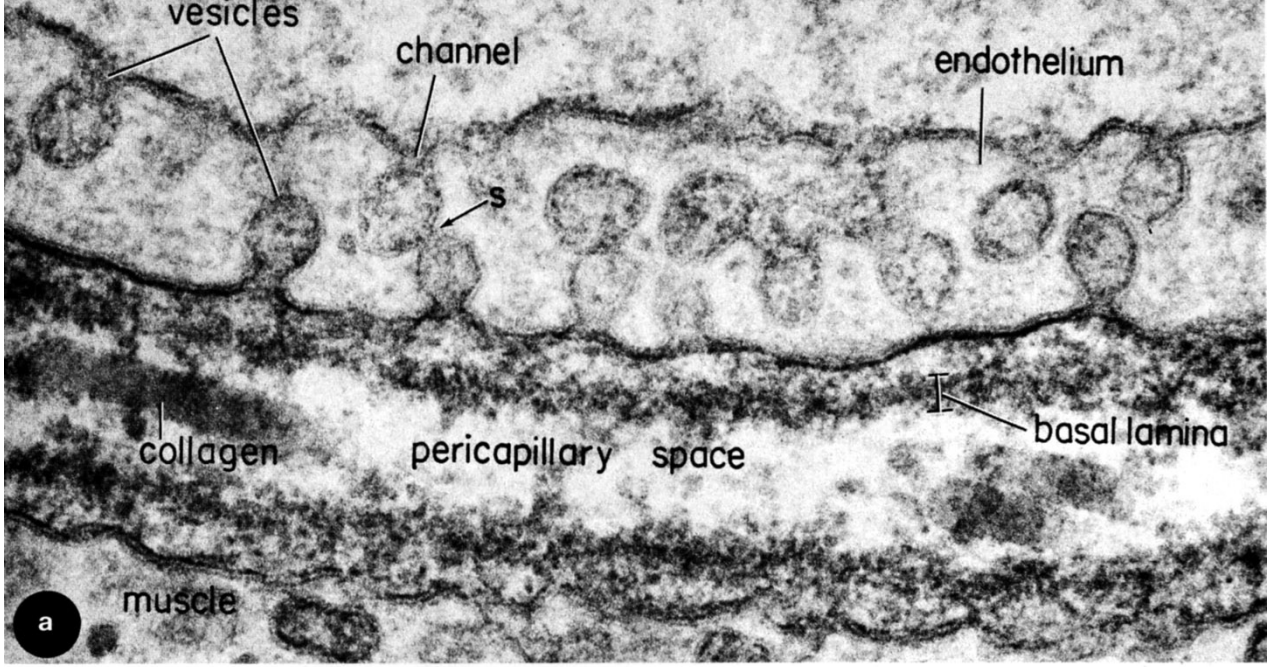

Continuous
Fenestrated
Sinusoid
Basement membrane
Endothelial layer
(tunica intima)
Intercellular cleft
Fenestrations
Incomplete
basement
membrane
Intercellular gap

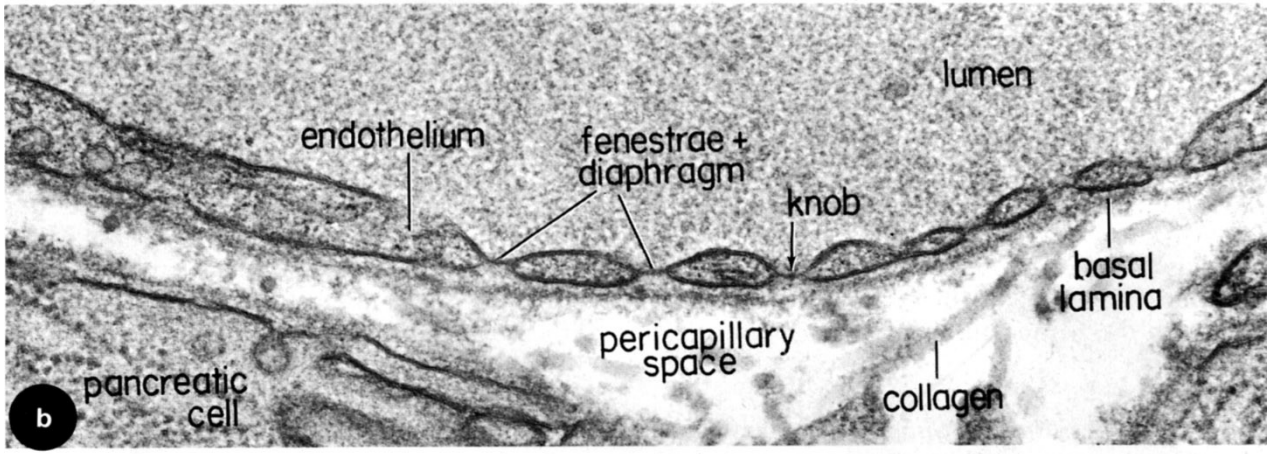


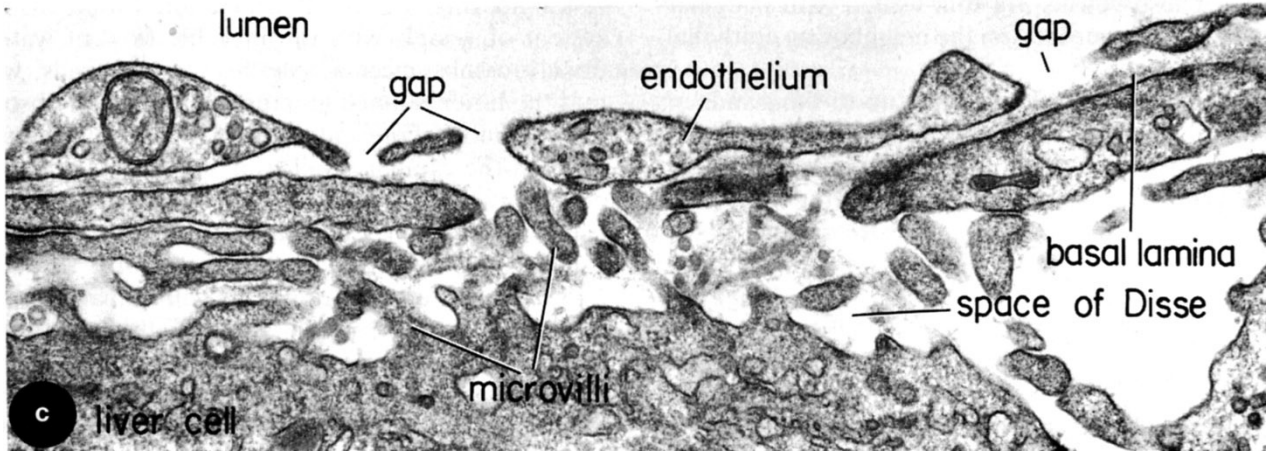
TEM image of a microvessel displaying pericytes lining the outer surface of endothelial cells that are encircling an erythrocyte (E). by Robert M Hunt; 22 March 2010


TEM image of a capillary in the the pancreas. There is a red blood cell within the capillary. The capillary lining consists of long, thin endothelial cells, connected by tight junctions. The image shows fenestration of these endothelial cells.
1 µm
Pancreas/cap./axon#80308-6.6
1/7/0 REMF


Astrocyte
Endfeet
Pericyte
Interneuron
Endothelial
Cell
Neuron
Basement
Membrane
Microglia
Astrocyte

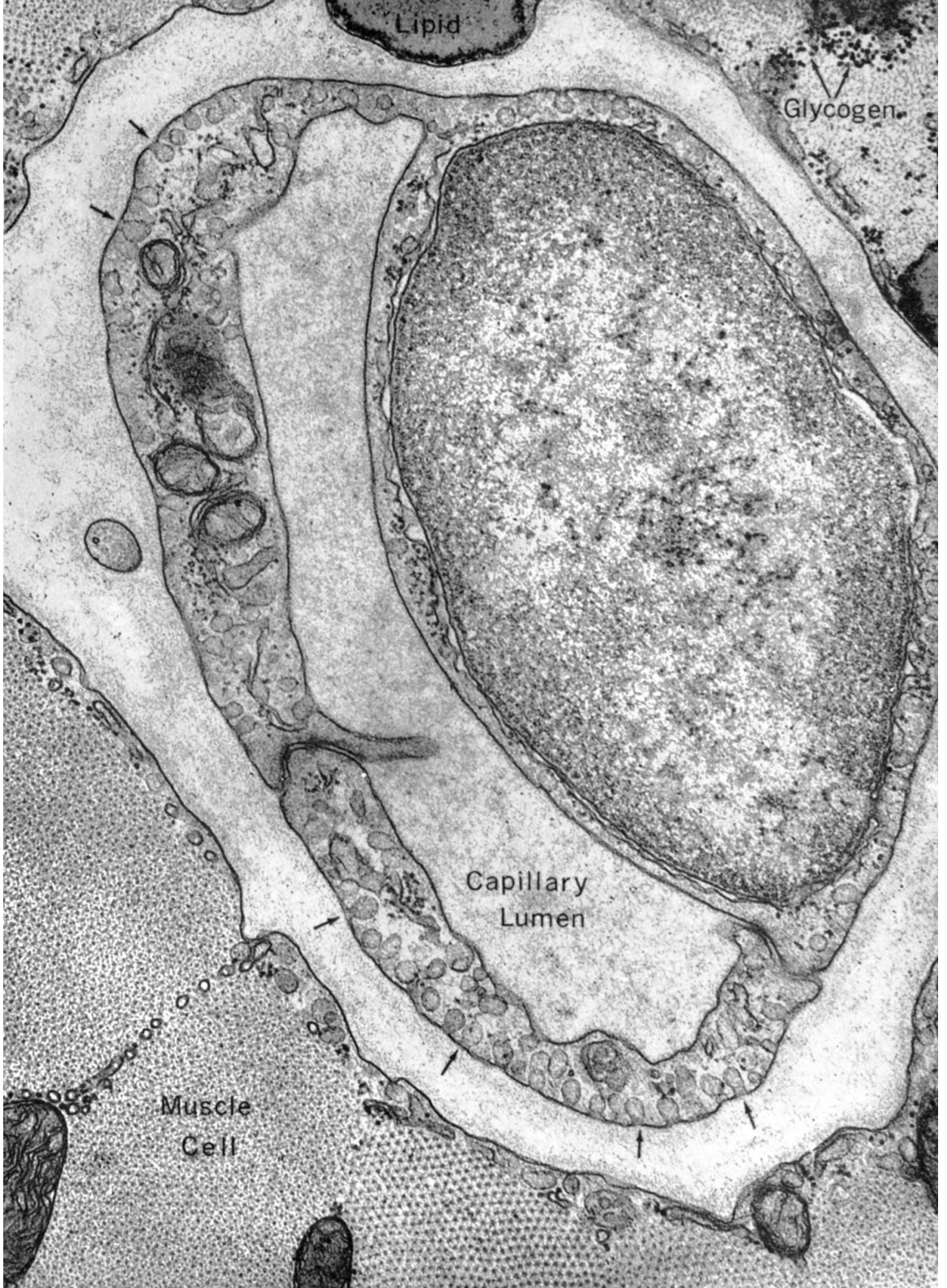


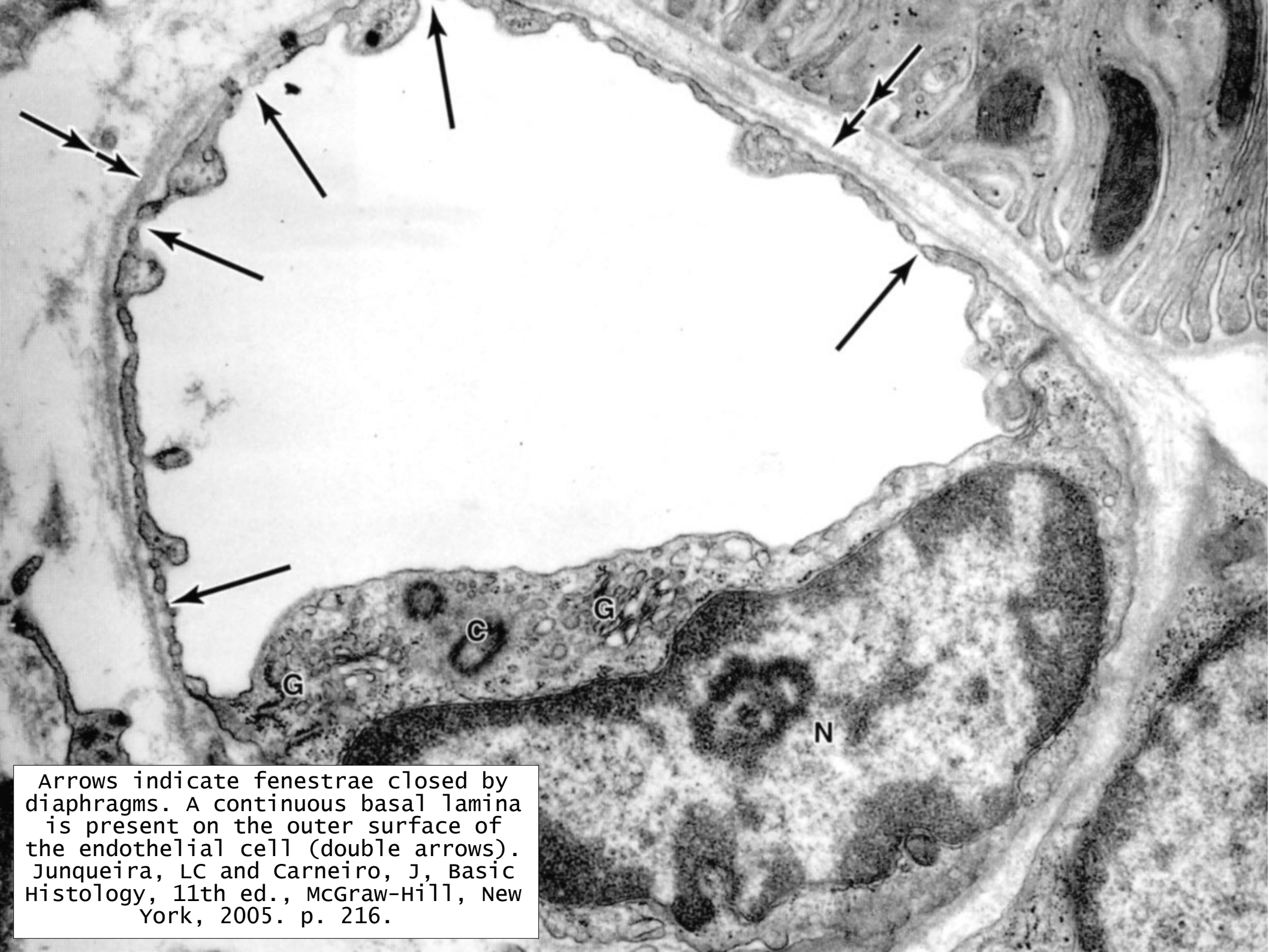




Three types of blood capillaries are differentiated by the continuity of the endothelial cell and the basal lamina. A, continuous capillary; b, fenestrated capillary; c, discontinuous capillary (sinusoid). Rat diaphragm, pancreas and liver, respectively.
Weiss, L. ed., Cell and Tissue Biology, 6th ed., Urban & Schwarzenberg, Baltimore, 1988, p. 381.

Endothelial cells of continuous capillaries are joined by tight junctions and a continuous basal lamina.
Fawcett DW, The Cell: An Atlas of Fine Structure, WB Saunders, Philadelphia, 1966, p. 403.

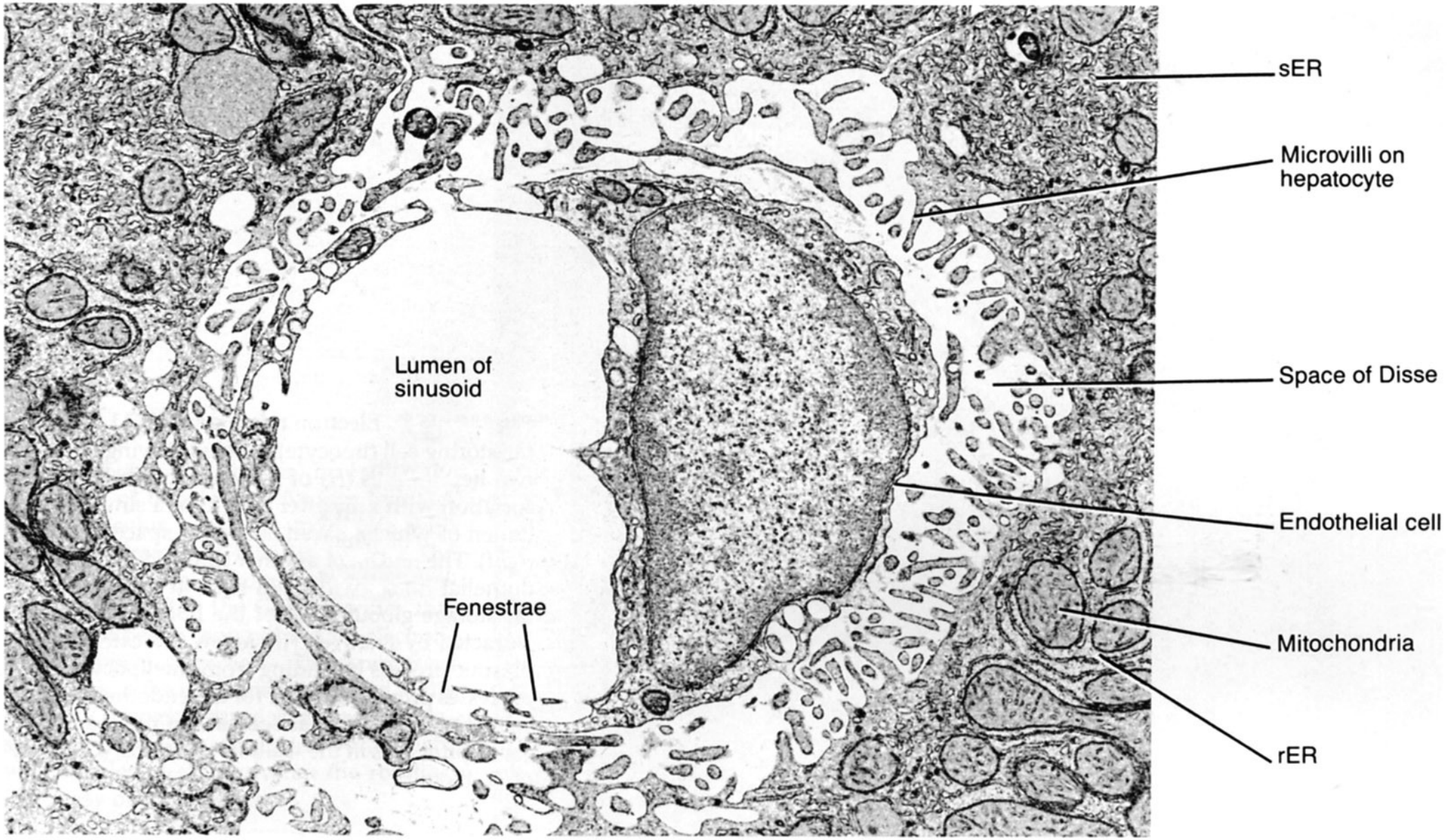




Arrows indicate fenestrae closed by diaphragms. A continuous basal lamina is present on the outer surface of the endothelial cell (double arrows). Junqueira, LC and Carneiro, J, Basic Histology, 11th ed., McGraw-Hill, New York, 2005. p. 216.

Open fenestrae are visible in the endothelial cell cytoplasm of the liver sinusoid.

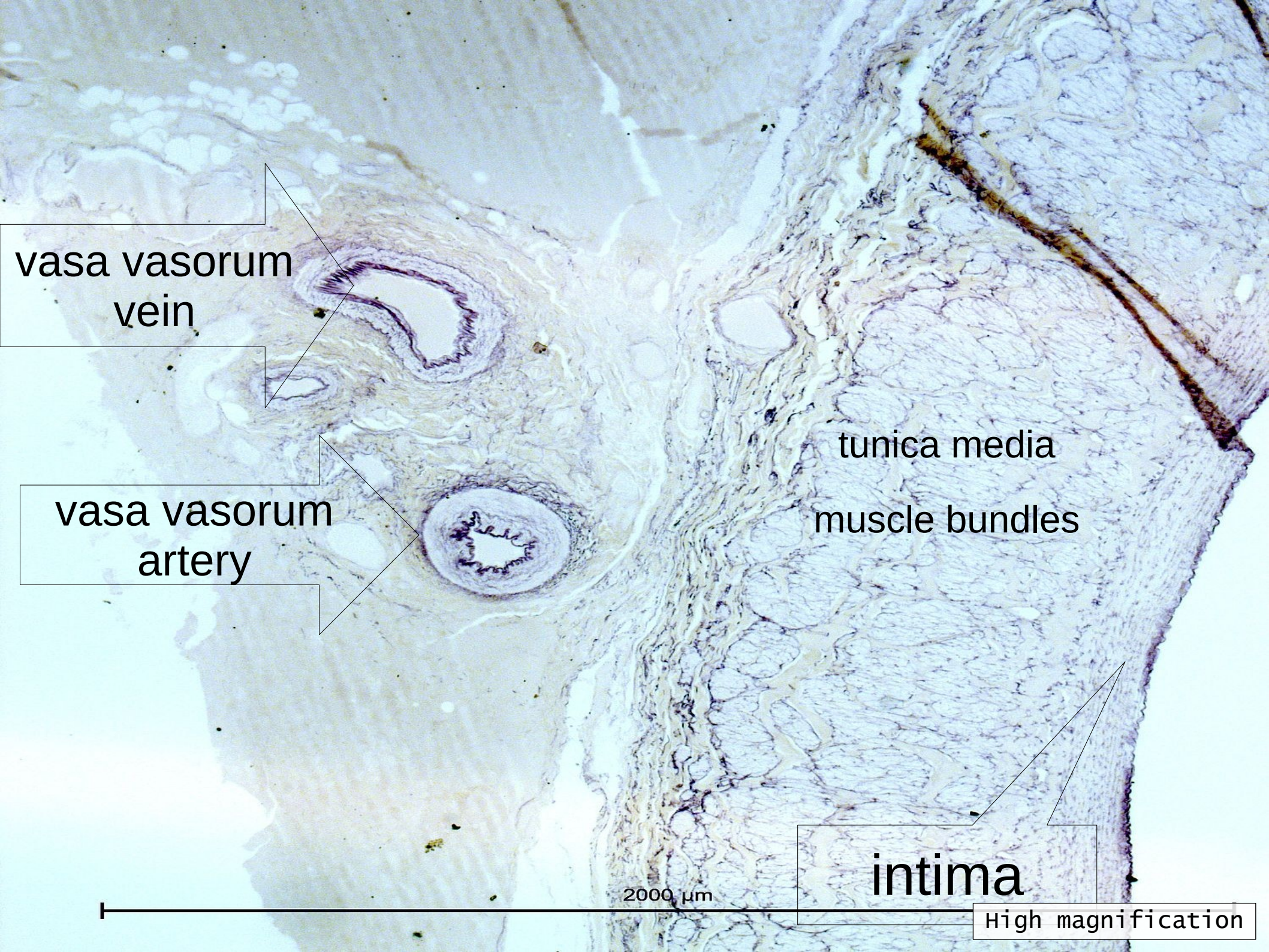
Cormack, D.H. Ham's Histology, 9th ed., Lippincott, Philadelphia, 1987, p. 531.

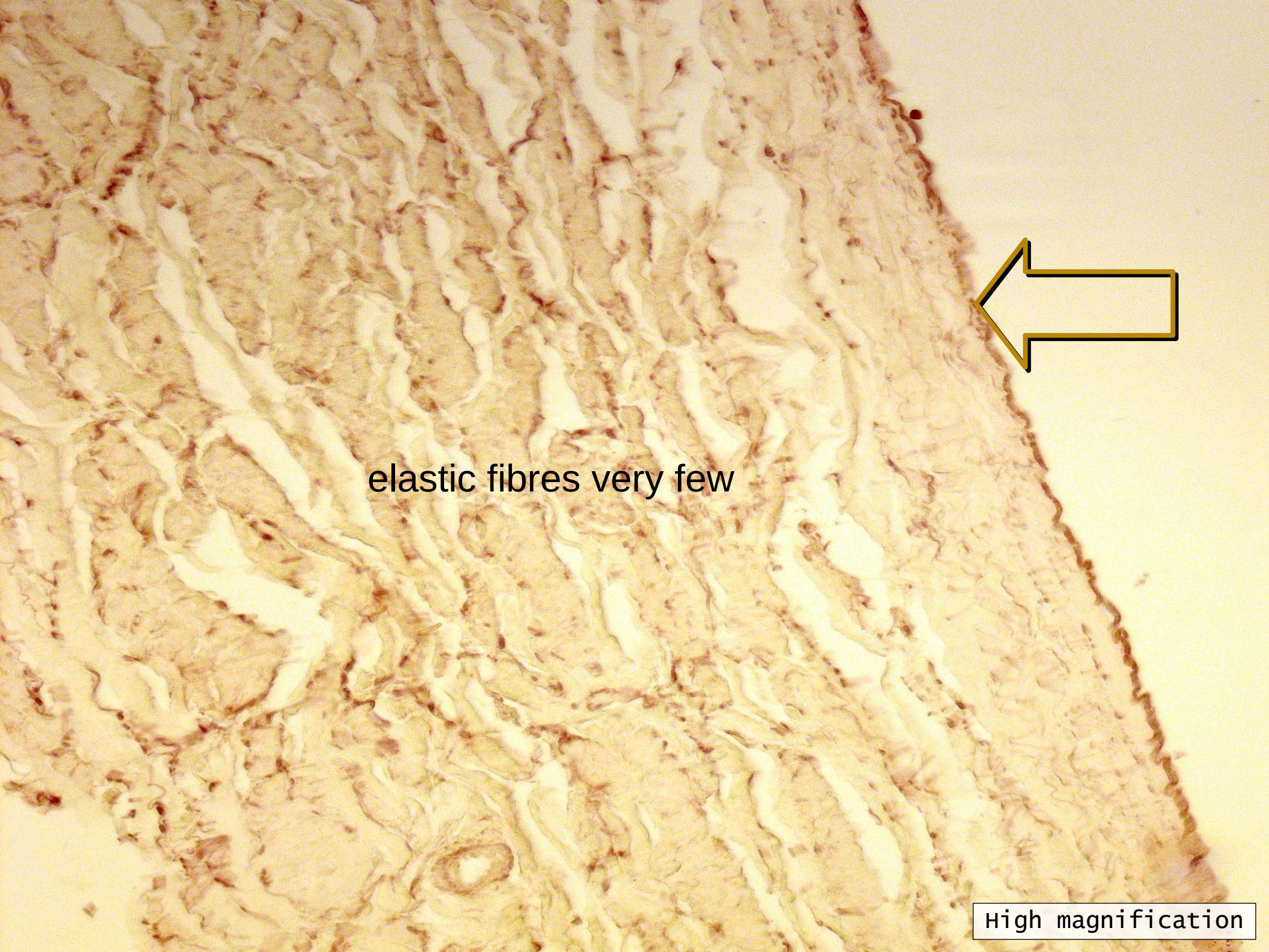


Large Vein

Slides 92 & 109


Very low magnification


vasa vasorum
vein
vasa vasorum
artery
tunica media
muscle bundles
intima
2000 µm
High magnification


elastic fibres very few
High magnification

Ductus thoracicus

Slide 65 & 75

Lymphatic Capillaries

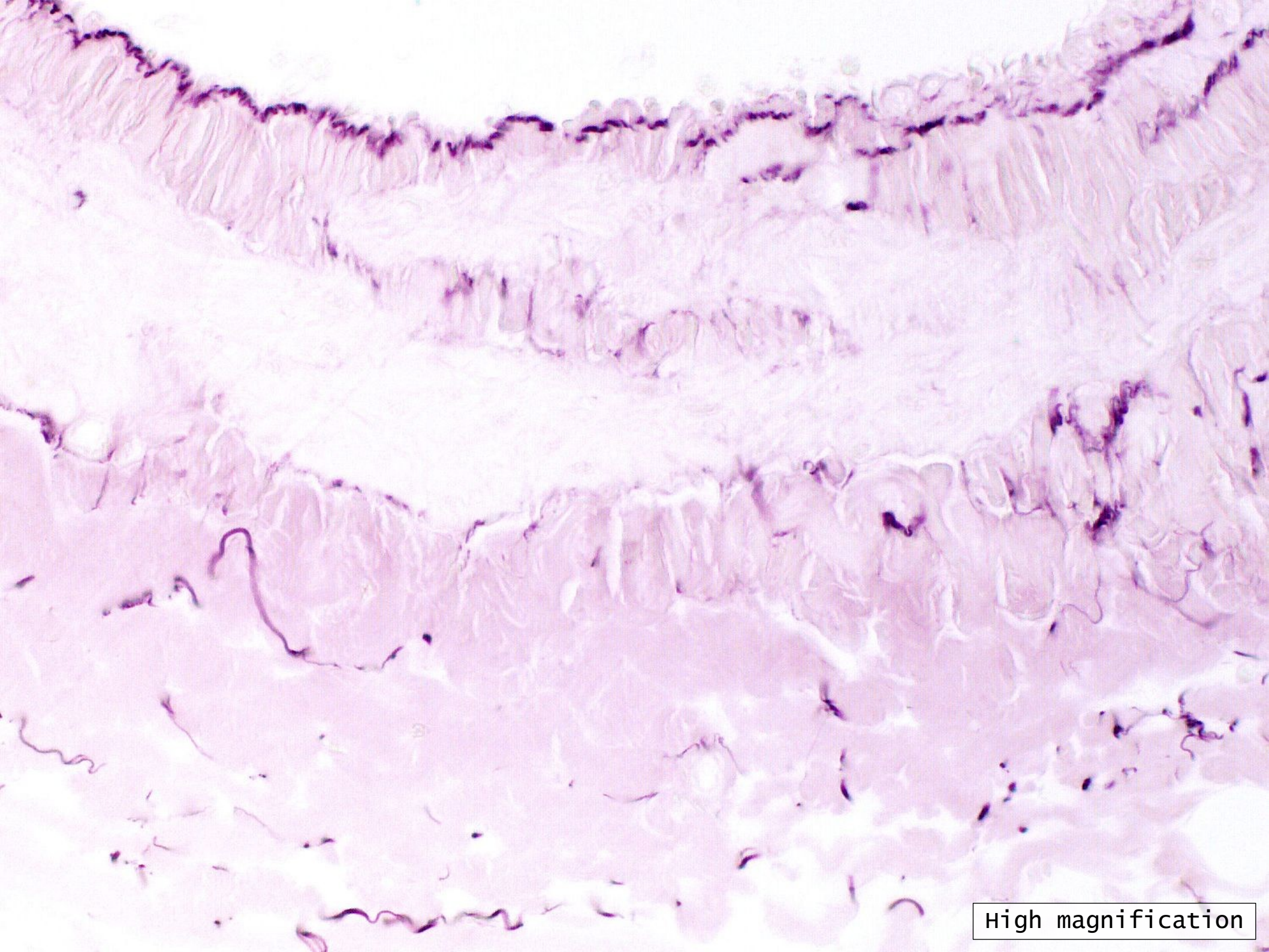
- Lined with endothelium
- BM incomplete or absent
- Allows macromolecules to enter
- No associated pericytes
- Wider than blood capillaries
  - Collagen anchors in surrounding tissue
  - Keep vessels open with oedema

Lymphatic Vessels

- No blood cells in lumen
- Similar to small and medium veins
- Endothelium
- Thin external coat of loose CT
- Medium and large lymphatics 3 coats
- Difficult to distinguish layers
- Intima
  - Endothelium and elastic fibres
- Media and Adventitia
  - Smooth muscle cells and CT fibres


Very low magnification


Smooth muscle fibres – irregular arrangement
High magnification

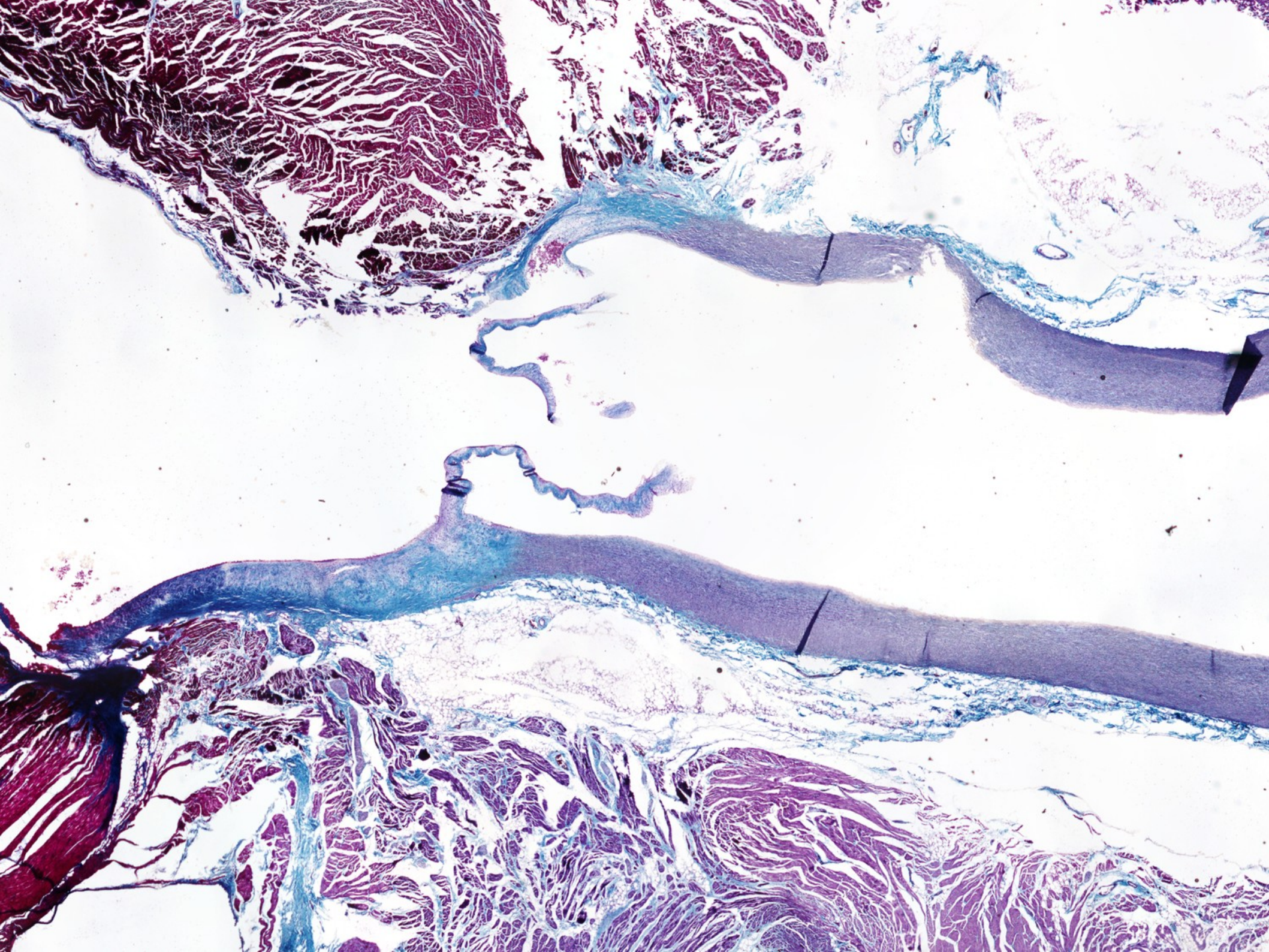

High magnification

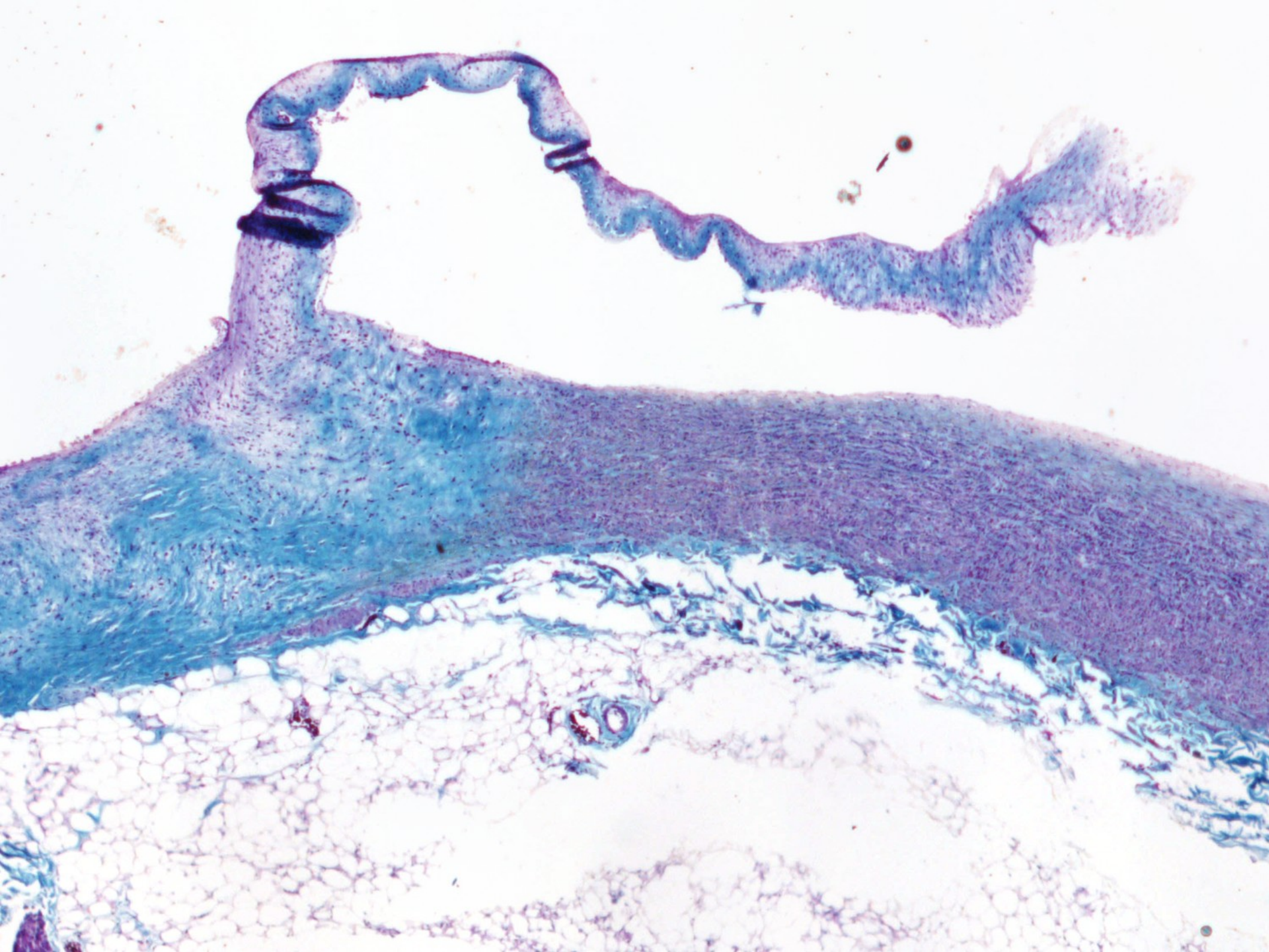
Valve

Slide 47

Valves

- Flap of intima
- Core
- Irregular dense CT
- Without blood vessels
- Some elastic fibers
- Covered with endothelium





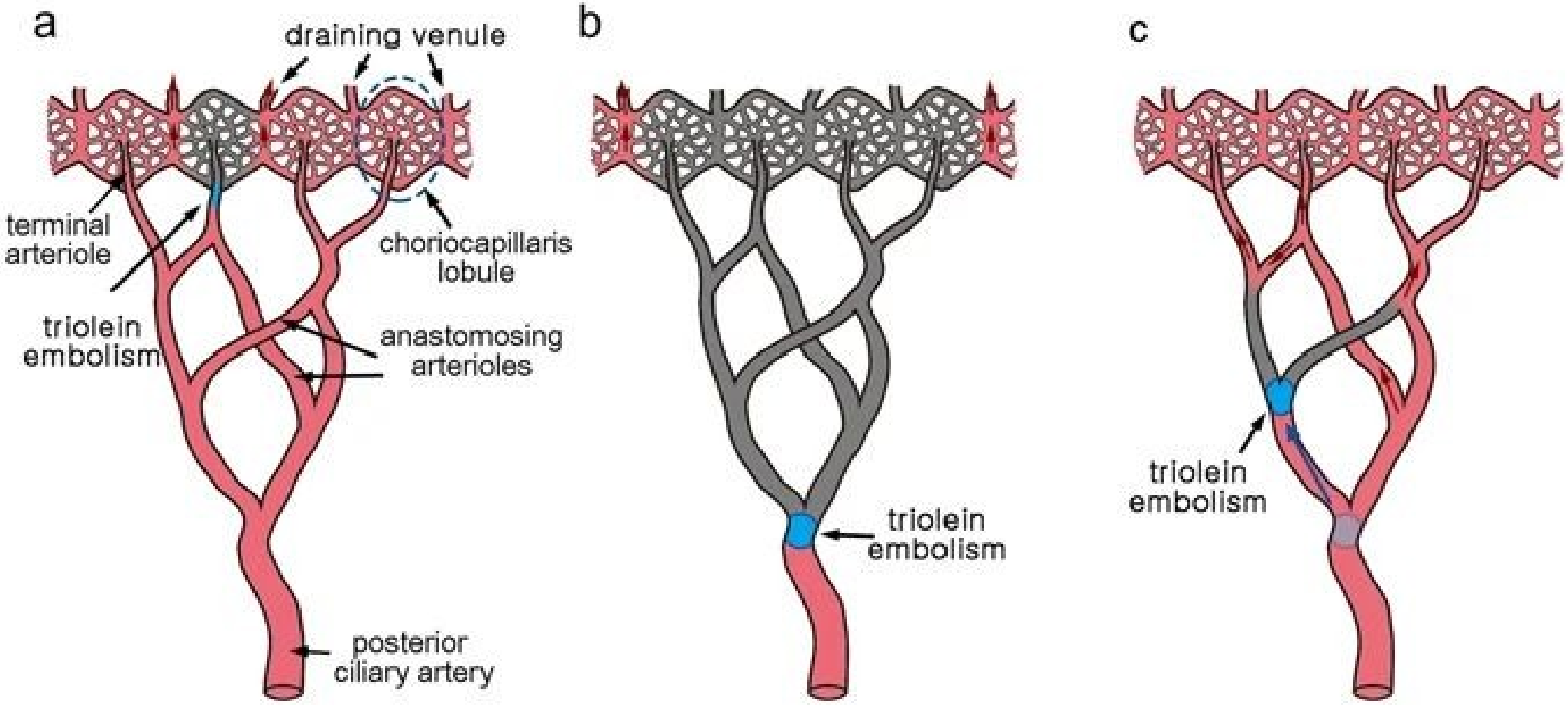
What are end arteries?

End-arteries

- Single small artery
- Sole source of blood supply
- To a specific tissue or organ
- Do not anastomose
- Exclusive supplier of blood to a defined vascular area
- Obstruction compromise blood supply
- Damage – ischaemia

A functional end-arterial model of the choroidal circulation.

From Lee, J.E., Ahn, K.S., Park, K.H. et al. Functional end-arterial circulation of the choroid assessed by using fat embolism and electric circuit simulation. Sci Rep 7, 2490 (2017). https://doi.org/10.1038/s41598-017-02695-z CC-A 4.0



End arteries

- Heart
- Brain
- Eye
- Kidney

End artery

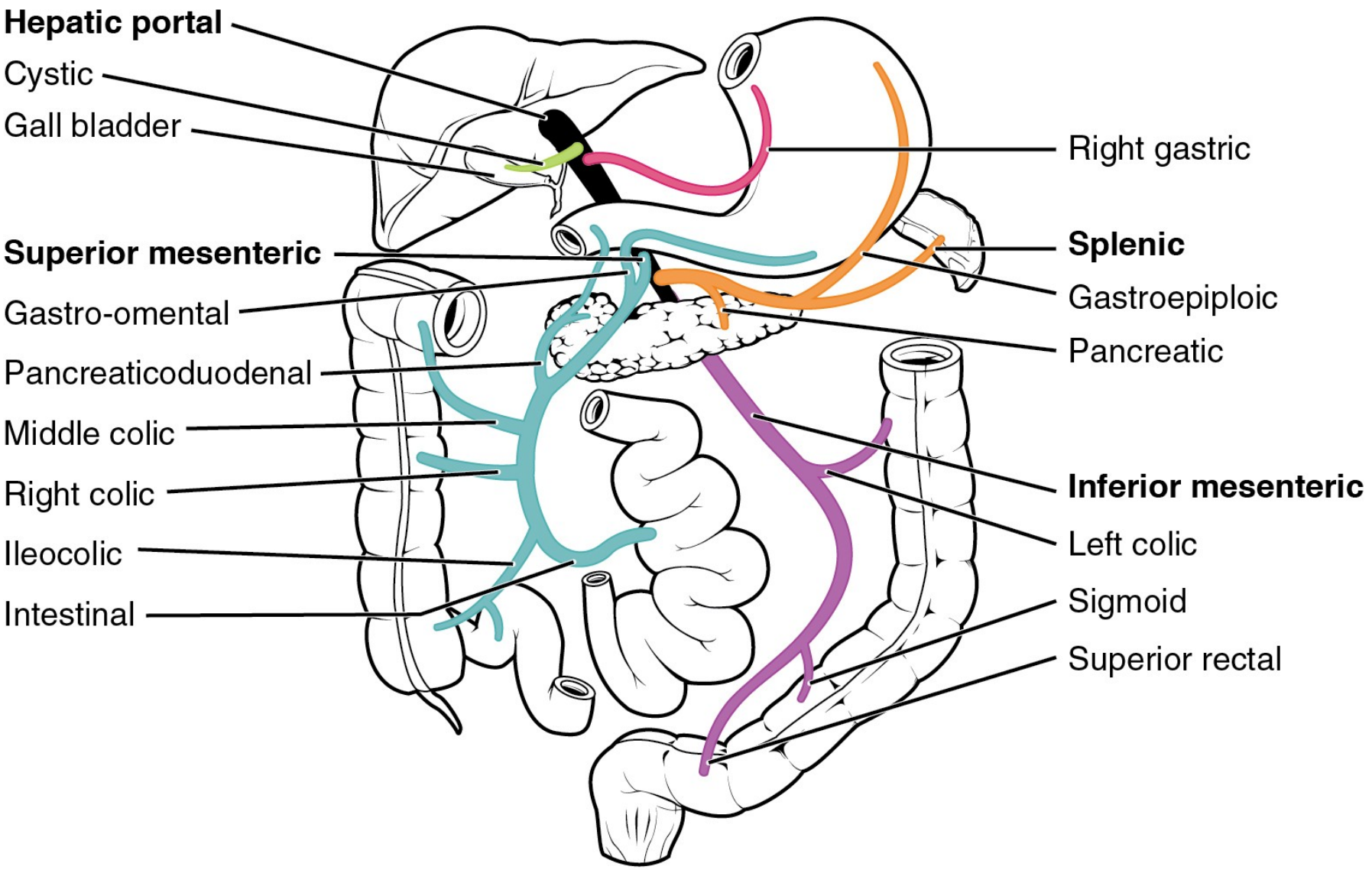
- Heart - Heart attack
- Brain - Stroke
- Eye - Blindness
- Kidney - Kidney ~~attack~~ failure

Portal System

Begin and Ends

In capillaries

Figure 20.43 Hepatic Portal System. The liver receives blood from the normal systemic circulation via the hepatic artery. It also receives and processes blood from other organs, delivered via the veins of the hepatic portal system.



Portal system

- Hepatic portal system
- Hypophyseal portal system

Cardiovascular System

Complete the Tasks

Tasks are in Red Blocks

Arteries + Veins + Lymph vessels

Cardiac muscle - revision

Workbook

- You
  - Complete the tasks for each slide
  - Upload as PDF to clickUP
  - Attend next session

- Me
  - Review your submissions
  - Clarify and expand in next session
  - Compulsory

Contact Sessions

- 15 January 2024
  - Lecture – Prof N Oberholzer

- 17 & 17 January 2024
- OR
- 23 & 24 January 2024
  - Slides review Room 6-30 BMS Building

Respiratory System