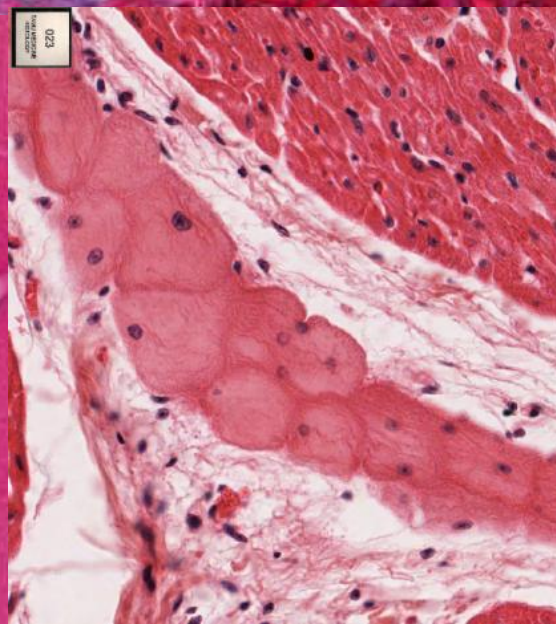
CARDIOVASCULAR SYSTEM PART 1

Dr. Larry Johnson



Objectives

Part 1

- Identify elastic and muscular arteries, arterioles, capillaries, venules and veins.
- Describe the intima, media, and adventitia of all vessels.

Part 2

- Describe the structure of the heart.
- Also regulation of blood flow, lymphatic vessels, and diseases

From: Douglas P. Dohrman and TAMHSC Faculty 2012 Structure and Function of Human Organ Systems, Histology Laboratory Manual

Introduction
Multicellular Organisms Need 3 Mechanisms

1. Distribute oxygen, nutrients, and hormones
2. Collect waste
3. Transport waste
   to excretory organs

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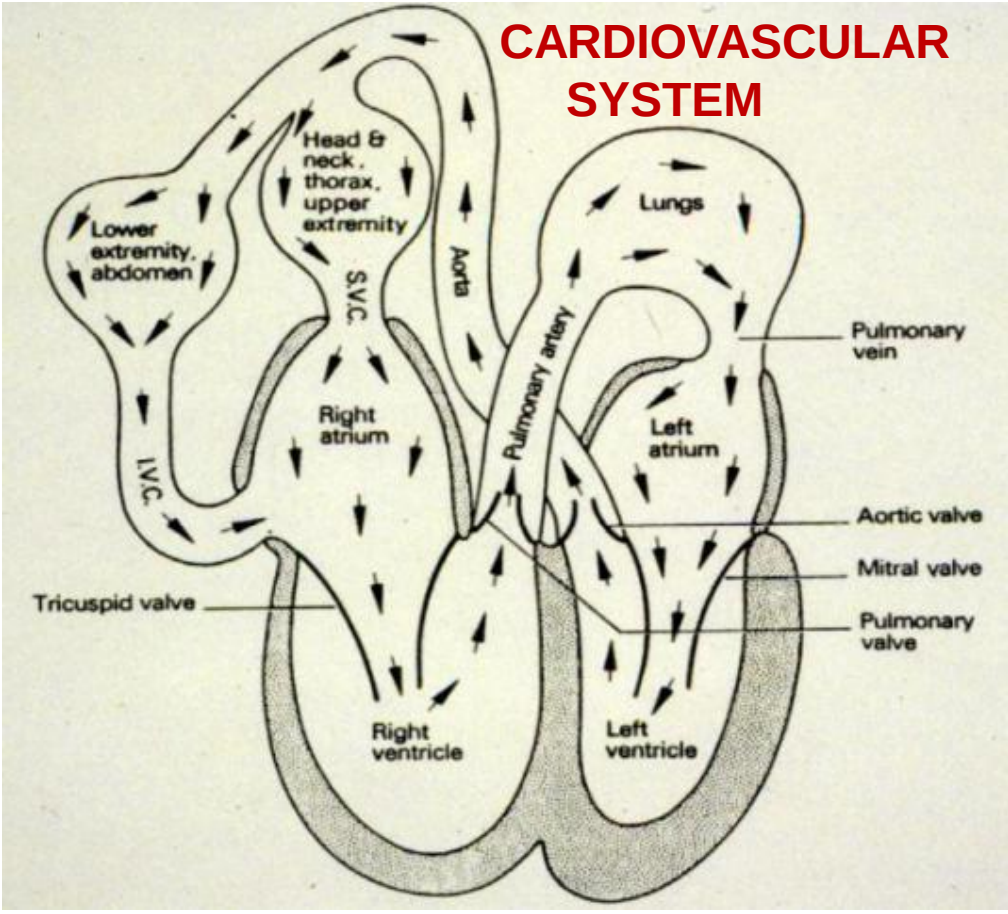
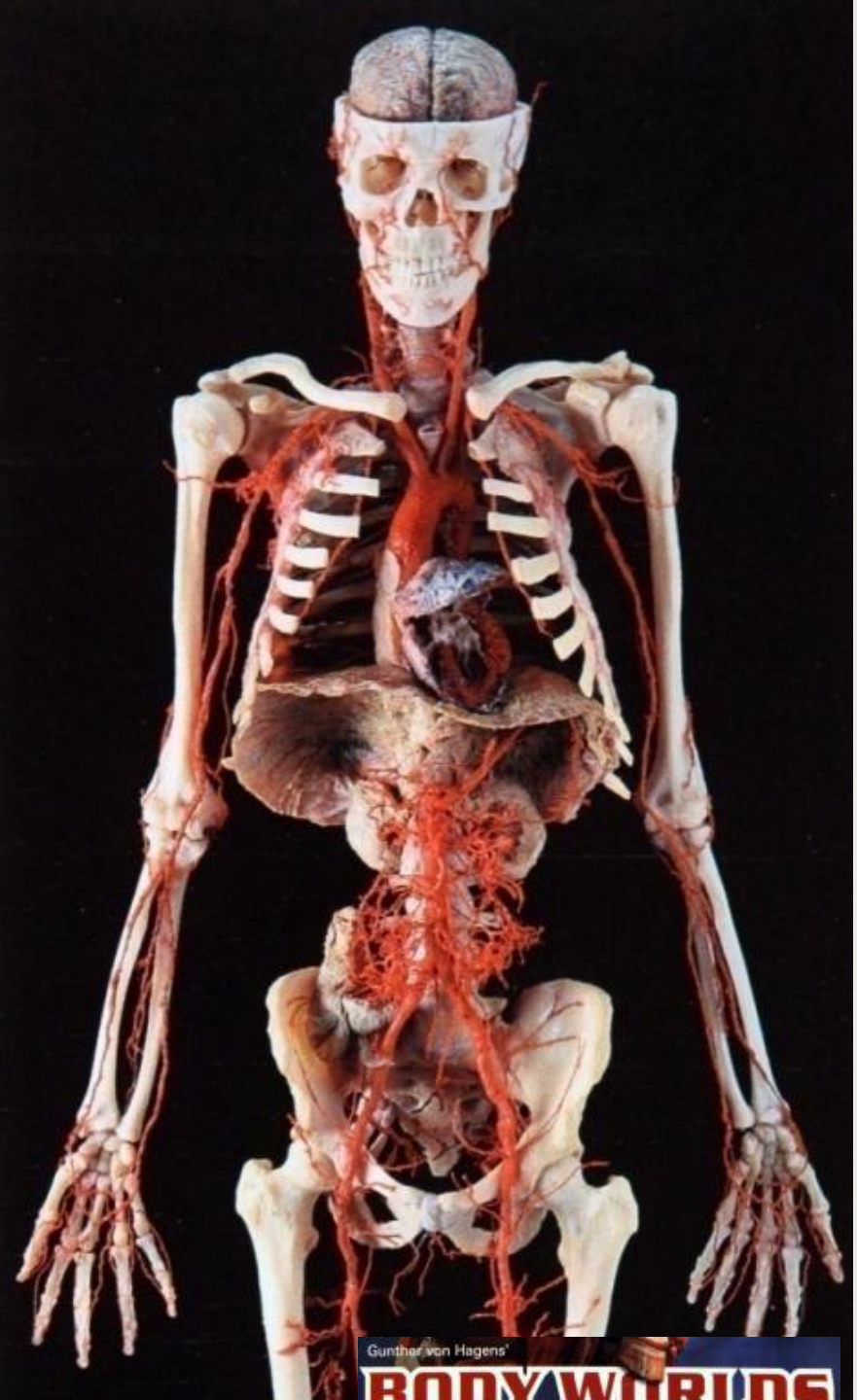
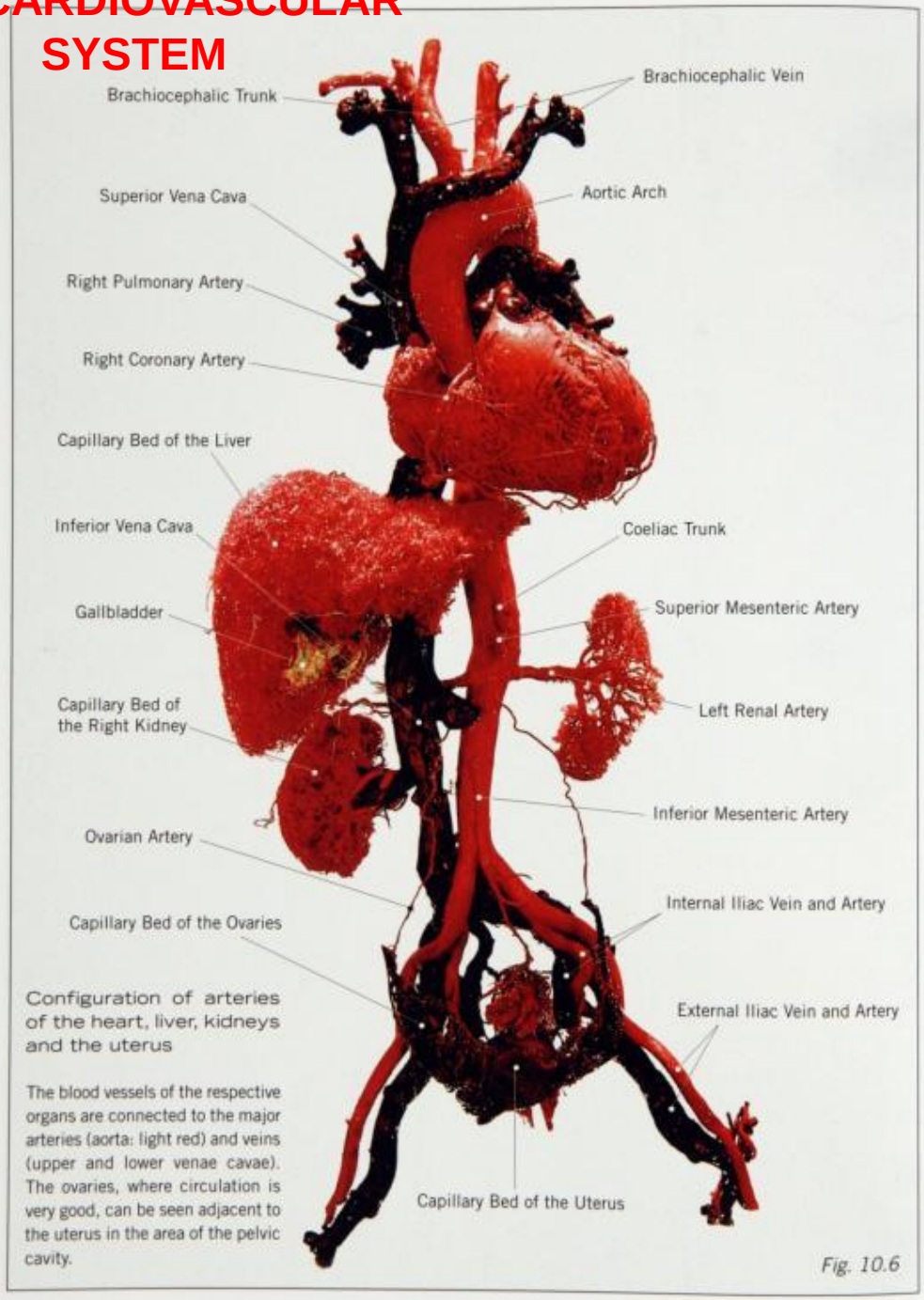
The cardiovascular system is composed of two sets of closed vessels open only to each other. One goes to the lungs and the other to the rest of the body



CARDIOVASCULAR SYSTEM



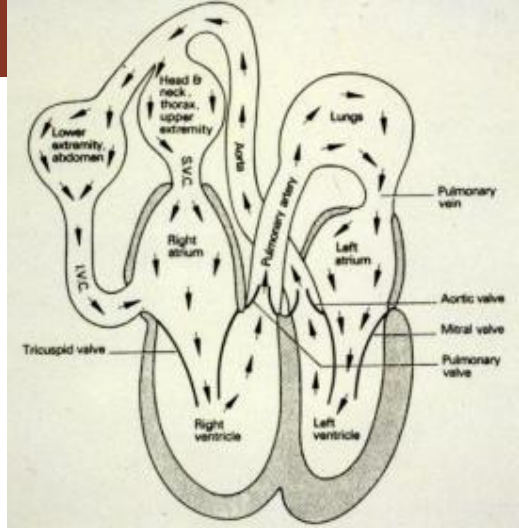


Configuration of arteries of the heart, liver, kidneys and the uterus

The blood vessels of the respective organs are connected to the major arteries (aorta: light red) and veins (upper and lower venae cavae). The ovaries, where circulation is very good, can be seen adjacent to the uterus in the area of the pelvic cavity.

Fig. 10.6

CARDIOVASCULAR SYSTEM

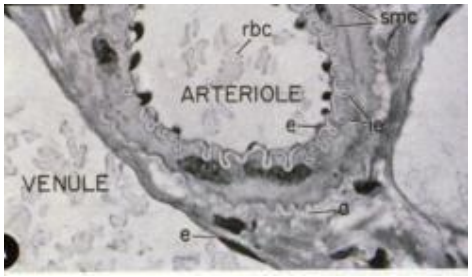


COMPONENT	FUNCTION
HEART	- PRODUCE BLOOD PRESSURE (SYSTOLE)
ELASTIC ARTERIES	- CONDUCT BLOOD AND MAINTAIN PRESSURE DURING DIASTOLE
MUSCULAR ARTERIES	- DISTRIBUTE BLOOD, MAINTAIN PRESSURE
ARTERIOLES	- PERIPHERAL RESISTANCE AND DISTRIBUTE BLOOD
CAPILLARIES	- EXCHANGE NUTRIENTS AND WASTE
VENULES	- COLLECT BLOOD FROM CAPILLARIES (EDEMA)
VEINS	- TRANSMIT BLOOD TO LARGE VEINS, RESERVOIR
LARGER VEINS	- RECEIVE LYMPH AND RETURN BLOOD TO HEART, BLOOD RESERVOIR

CARDIOVASCULAR SYSTEM

MUSCULAR ARTERIES -
DISTRIBUTE BLOOD, MAINTAIN PRESSURE

CARDIOVASCULAR SYSTEM

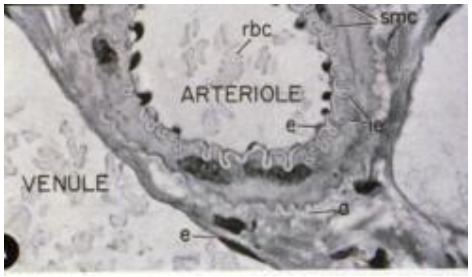


MUSCULAR ARTERIES - DISTRIBUTE BLOOD, MAINTAIN PRESSURE

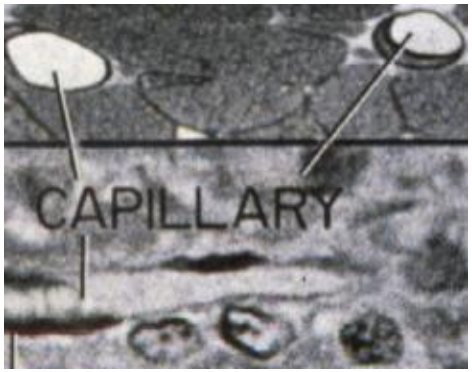
ARTERIOLES - PERIPHERAL RESISTANCE AND DISTRIBUTE BLOOD

CARDIOVASCULAR SYSTEM

MUSCULAR ARTERIES - DISTRIBUTE BLOOD, MAINTAIN PRESSURE



ARTERIOLES - PERIPHERAL RESISTANCE AND DISTRIBUTE BLOOD



CAPILLARIES - EXCHANGE NUTRIENTS AND WASTE

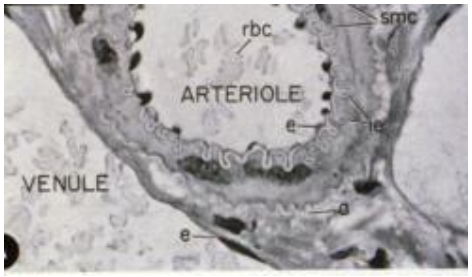
CARDIOVASCULAR SYSTEM

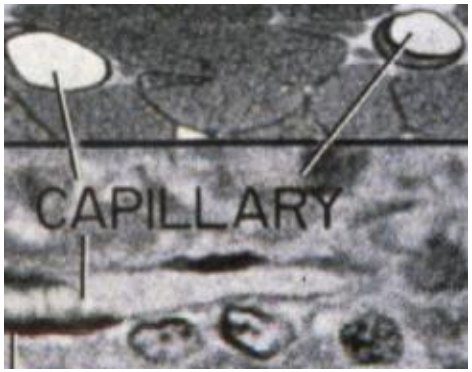
MUSCULAR ARTERIES - DISTRIBUTE BLOOD, MAINTAIN PRESSURE

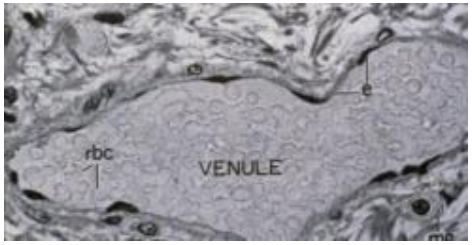
ARTERIOLES - PERIPHERAL RESISTANCE AND DISTRIBUTE BLOOD

CAPILLARIES - EXCHANGE NUTRIENTS AND WASTE

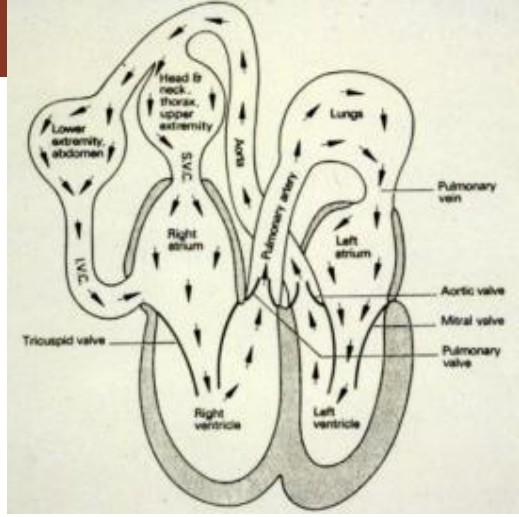
VENULES - COLLECT BLOOD FROM CAPILLARIES (EDEMA)



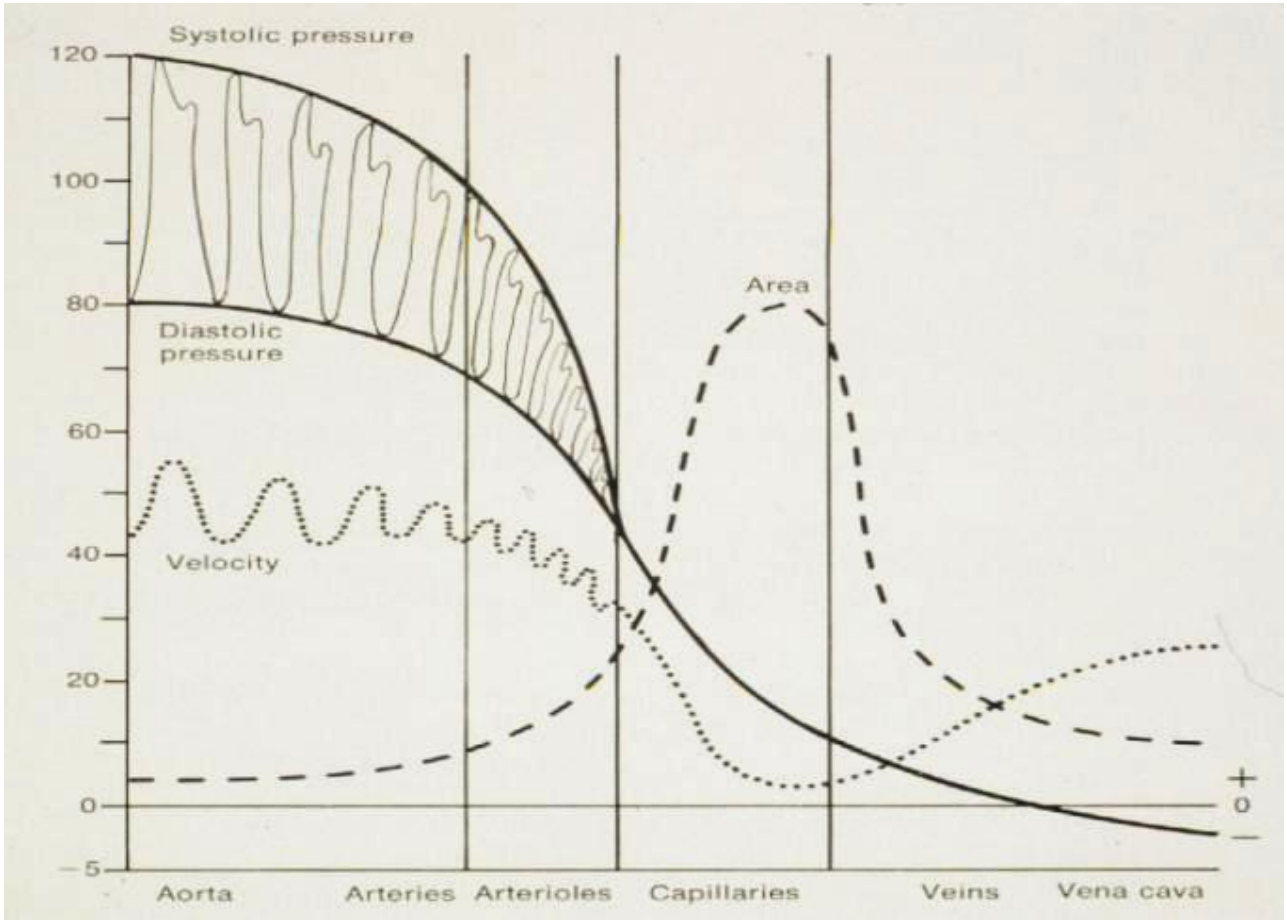




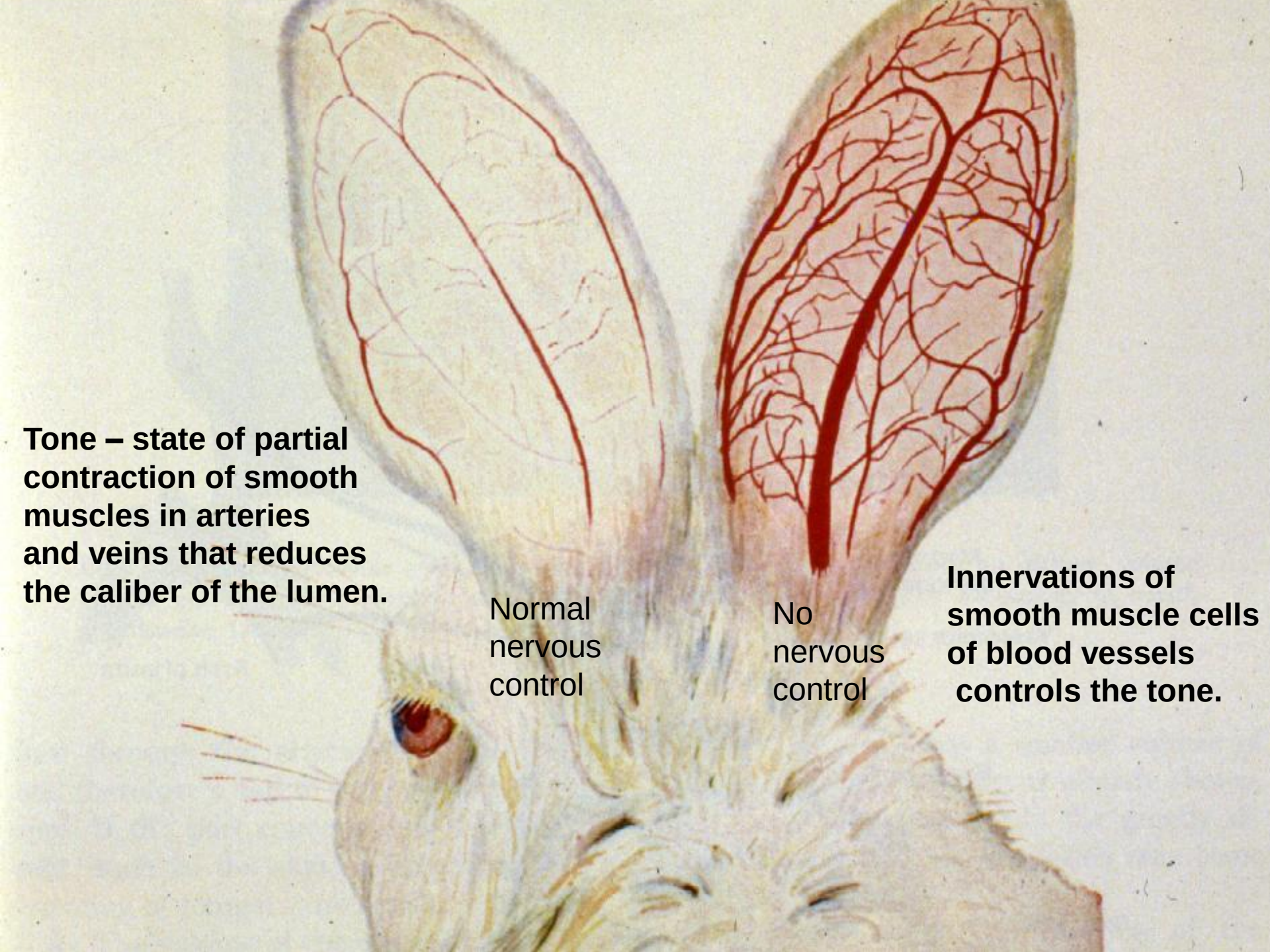
CARDIOVASCULAR SYSTEM



HEART PRODUCES BLOOD PRESSURE (SYSTOLE)



Smooth muscle contraction in blood vessel wall reduces the vessel caliber and restricts blood flow. A state of partial contraction is known as "tone".


Tone – state of partial contraction of smooth muscles in arteries and veins that reduces the caliber of the lumen.
Normal nervous control
No nervous control
Innervations of smooth muscle cells of blood vessels controls the tone.

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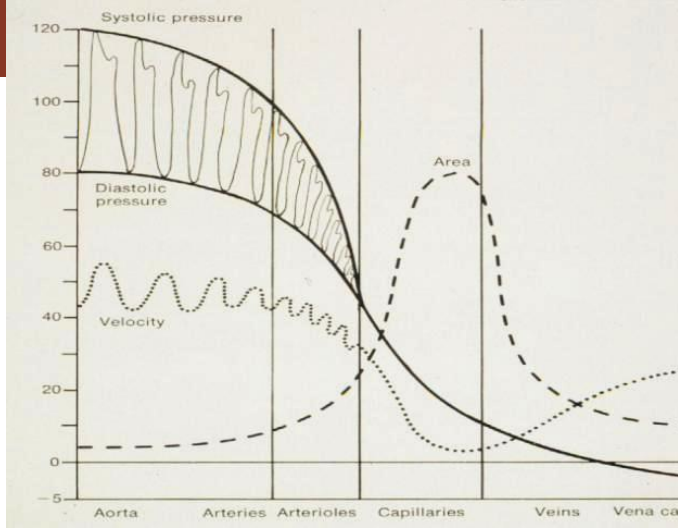
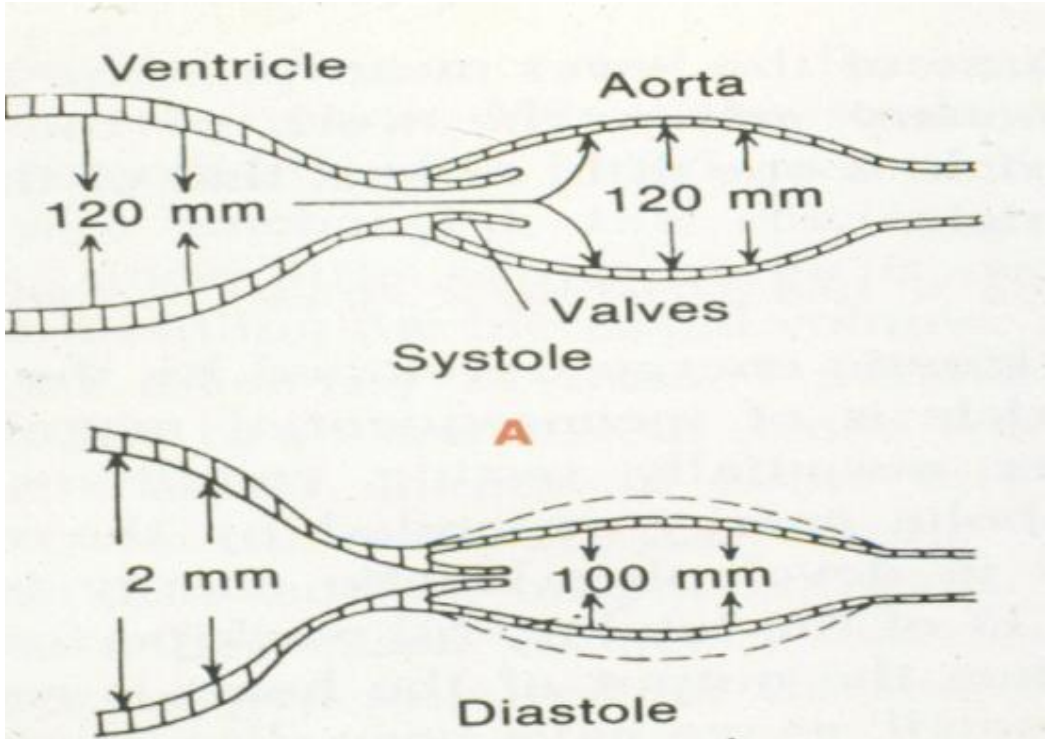
Innervations of smooth muscle cells of blood vessels controls the tone.

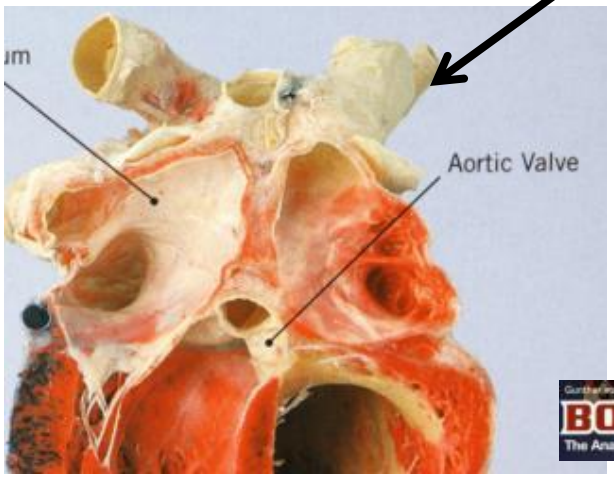
CARDIOVASCULAR SYSTEM

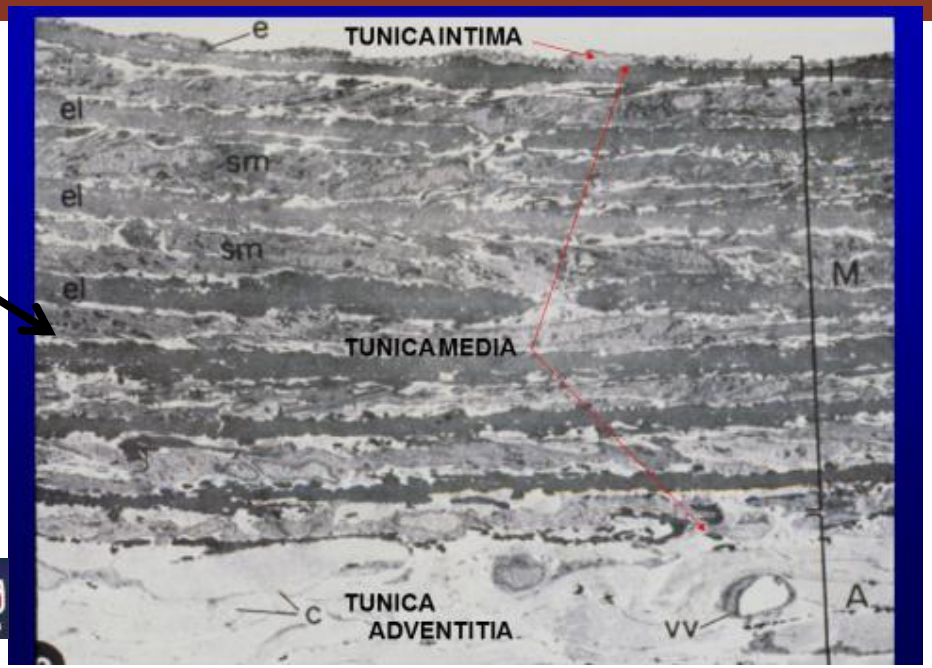


ELASTIC ARTERIES - CONDUCT BLOOD AND MAINTAIN PRESSURE DURING DIASTOLE



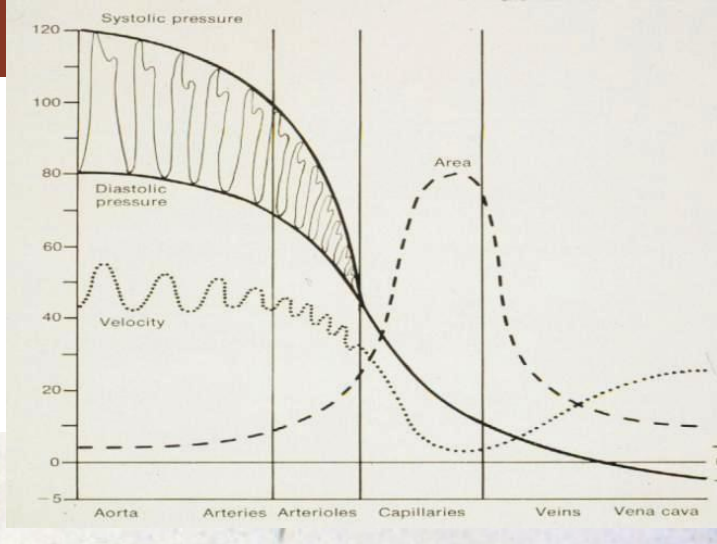
Elastic arteries

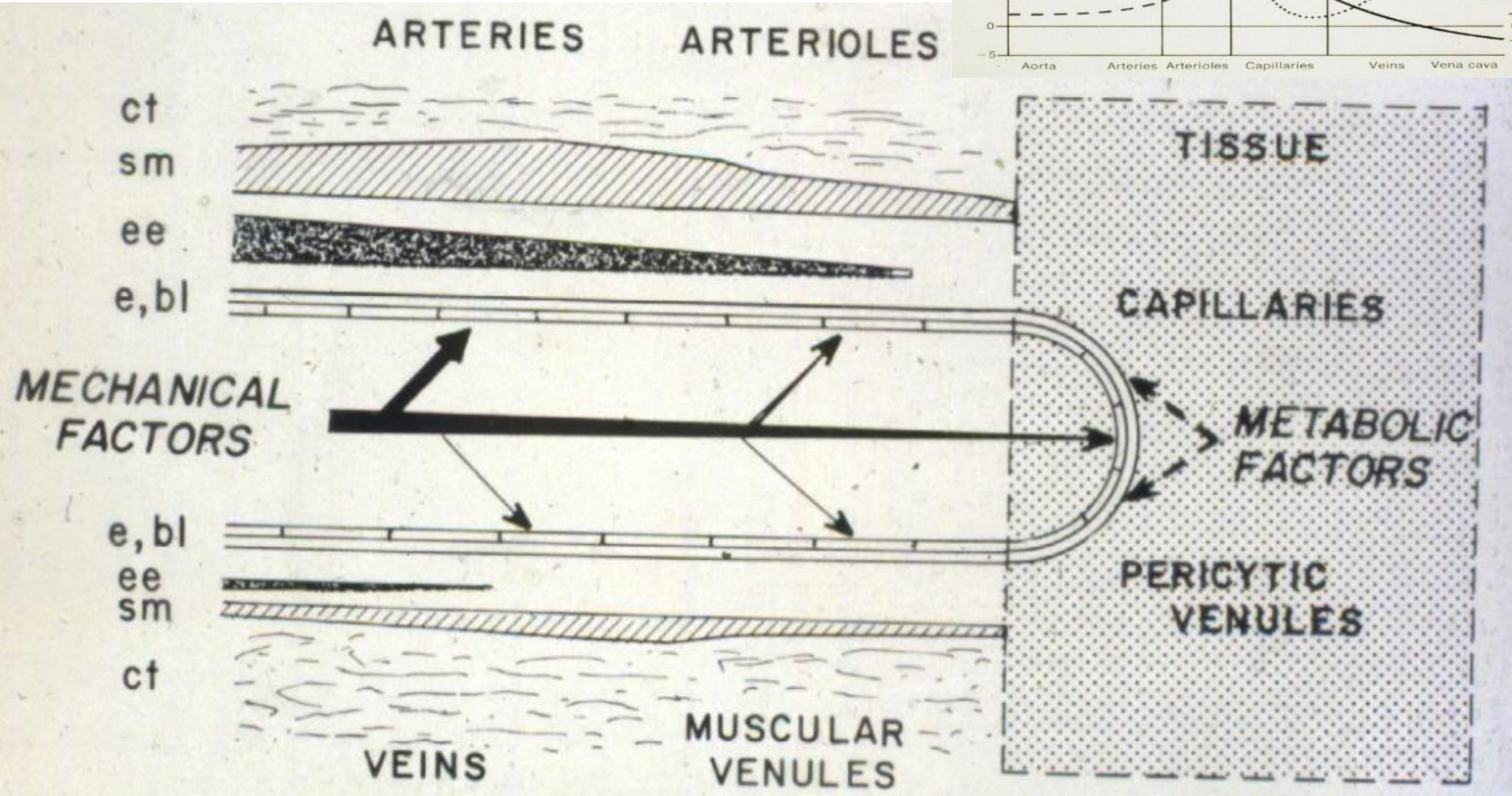




The elasticity of large arteries close to the heart is important as it facilitates a more uniform blood flow. During systole, blood moves forcefully into the large elastic arteries; however, the elastic fibers in the arterial wall stretch to compensate. This expansion of the lumen caliber dampens the rise in pressure. During diastole, both the ventricular pressure and resulting arterial pressure are low, but elastin in the wall of elastic arteries recoils to its original shape and reduces the lumen caliber and, thereby, maintains a relative high arterial pressure. How does this relate to arteriosclerosis?

Vessels are structurally adapted to physical and metabolic requirements.

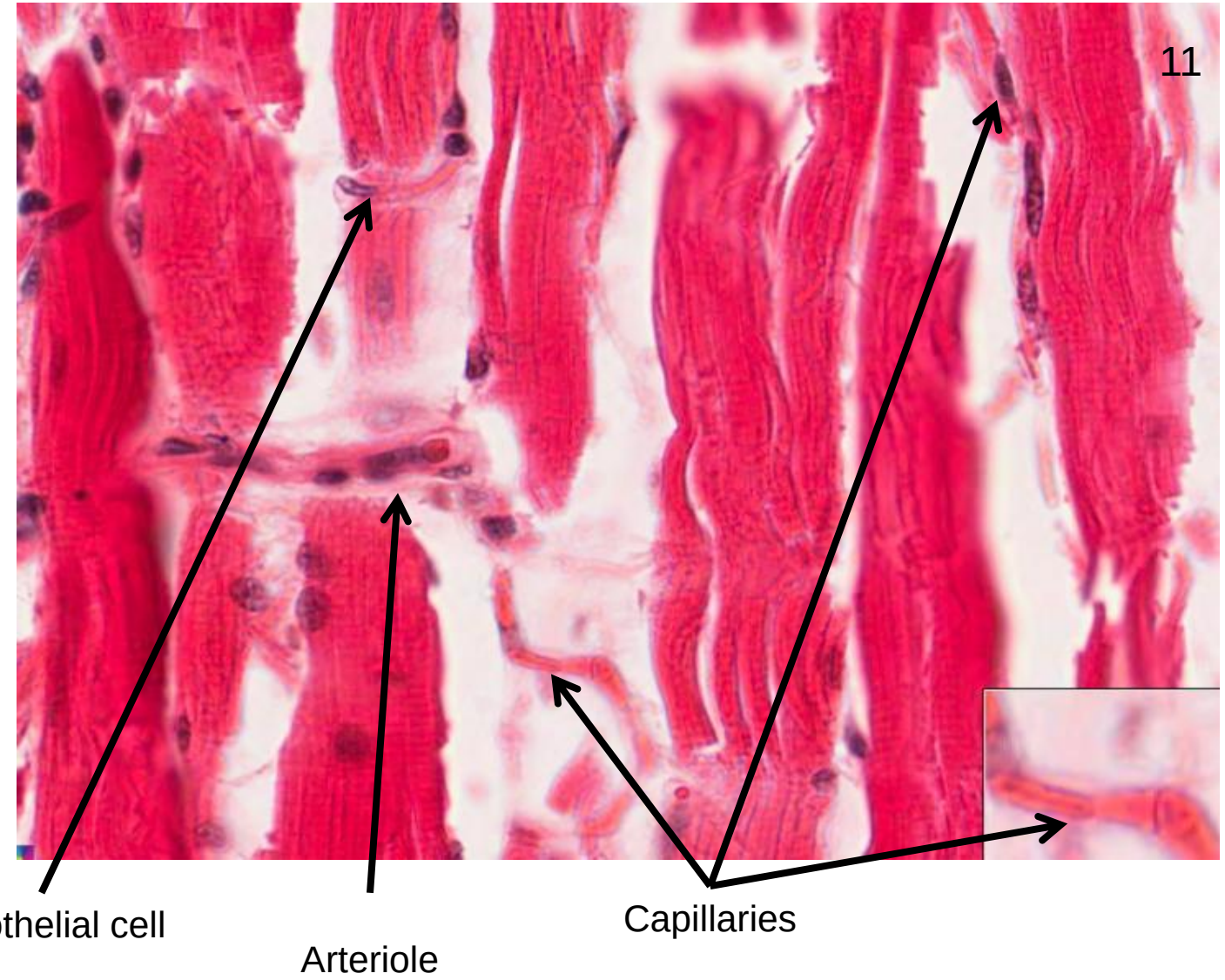




Cardiovascular System Overview

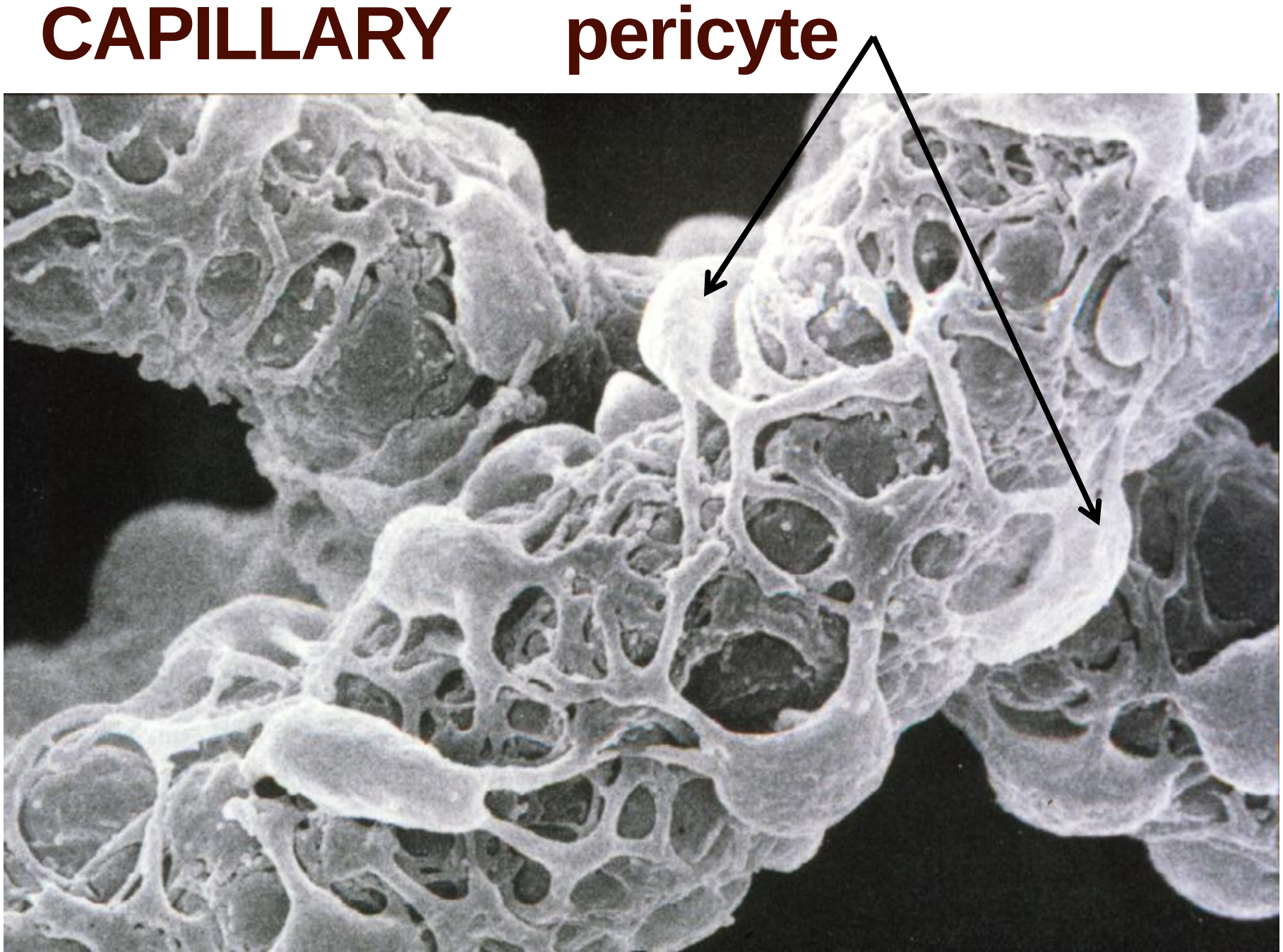
Heart	Modified vessel that pumps the blood through the network
Macrovessels	Arteries and veins that serve as large conduits between organs and body parts
Microvessels	Capillaries and venules carrying metabolites, gases, immune cells and waste products
Vessel layers	• **Tunica intima**: simple squamous endothelium over loose CT (subendothelium); non-thrombogenic • **Tunica media**: smooth muscle layer; accommodate pressure by expanding • **Tunica adventia**: fibroelastic CT and vascular networks; reinforces wall shape, prevents rupture, and brings nutrients to outer layers of tunica media via **vasa vasorum** (*vessels of the vessel*)
Heart layers	• Endocardium – (tunica intima) simple squamous endothelium on loose fibroelastic subendothelial CT, merges with endomysium and perimysium surrounding cardiac myofibers in the media • Myocardium – (tunica media) thicker in the ventricle • Epicardium – (tunica adventia) visceral pericardium and adventitia of heart
Purkinje cells	• No intercalated discs • Bound together by macular adherens • Electrically integrated by gap junctions which conduct depolarization from pacemaker cell sin the sinoatrial nodes • Coordinate ventricular contraction and comprise the bundle of His

Slide 11: Skeletal muscle

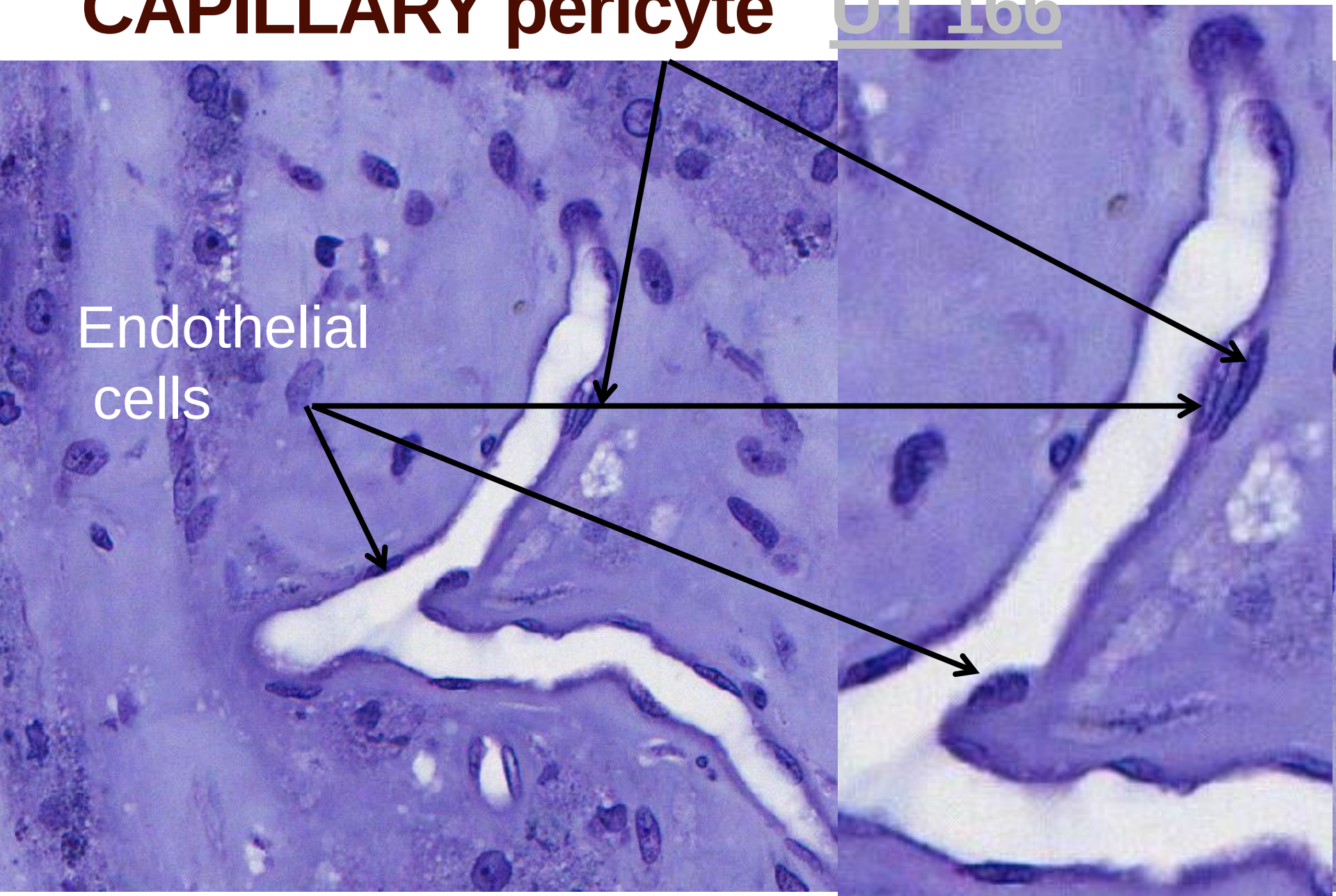


ARTERIOLE - CAPILLARY - VENULE

CAPILLARY



CAPILLARY pericyte UT 166

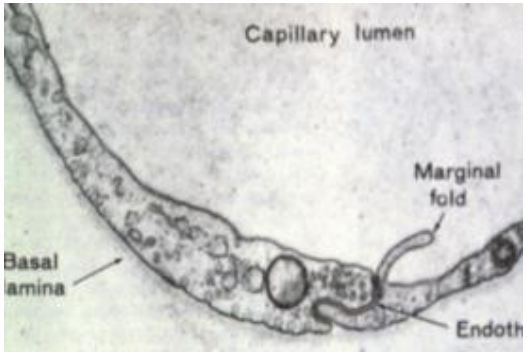


ENDOTHELIUM - ACTIVE CELL

HAS ENZYMES AND RECEPTORS

TRANSPORT WITHOUT MUCH ENERGY

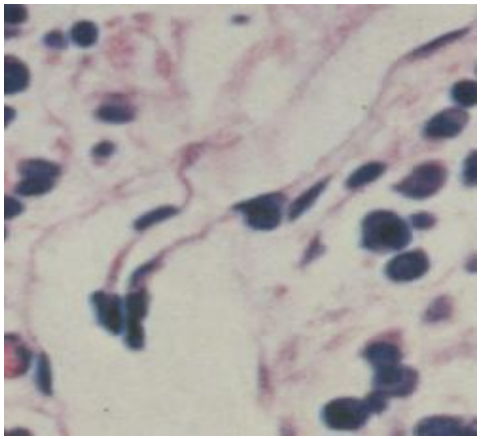
FLAT FOR LESS TURBULANCE



Blood capillary

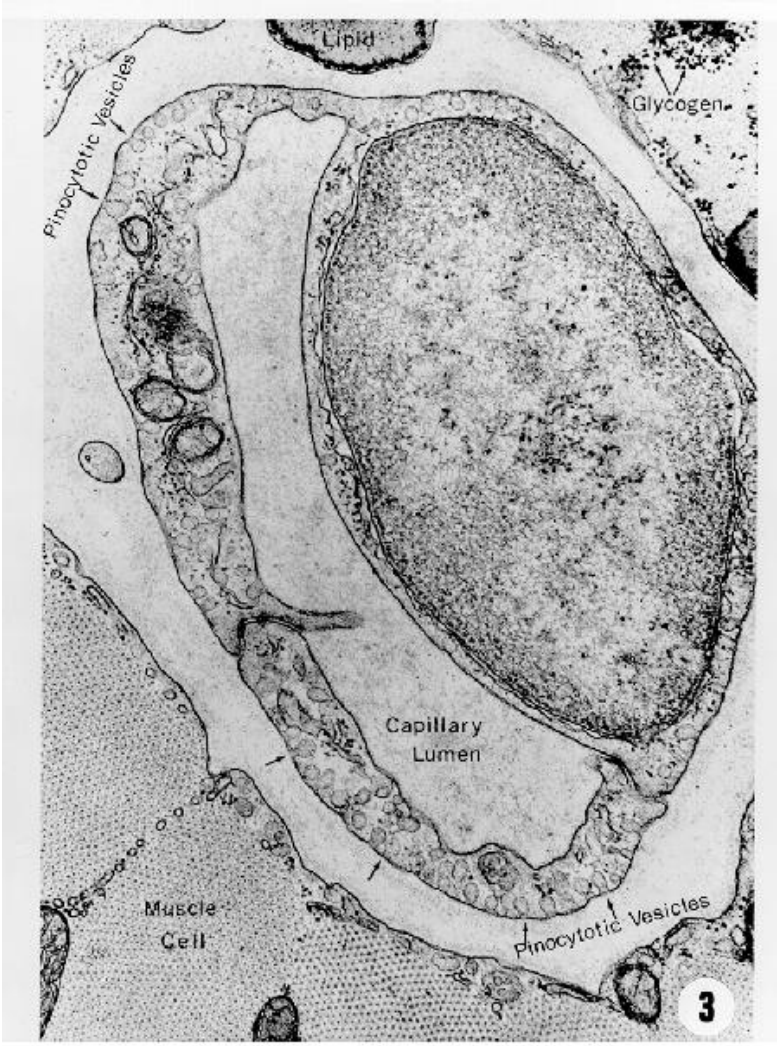
NEGATIVELY CHARGED SURFACE

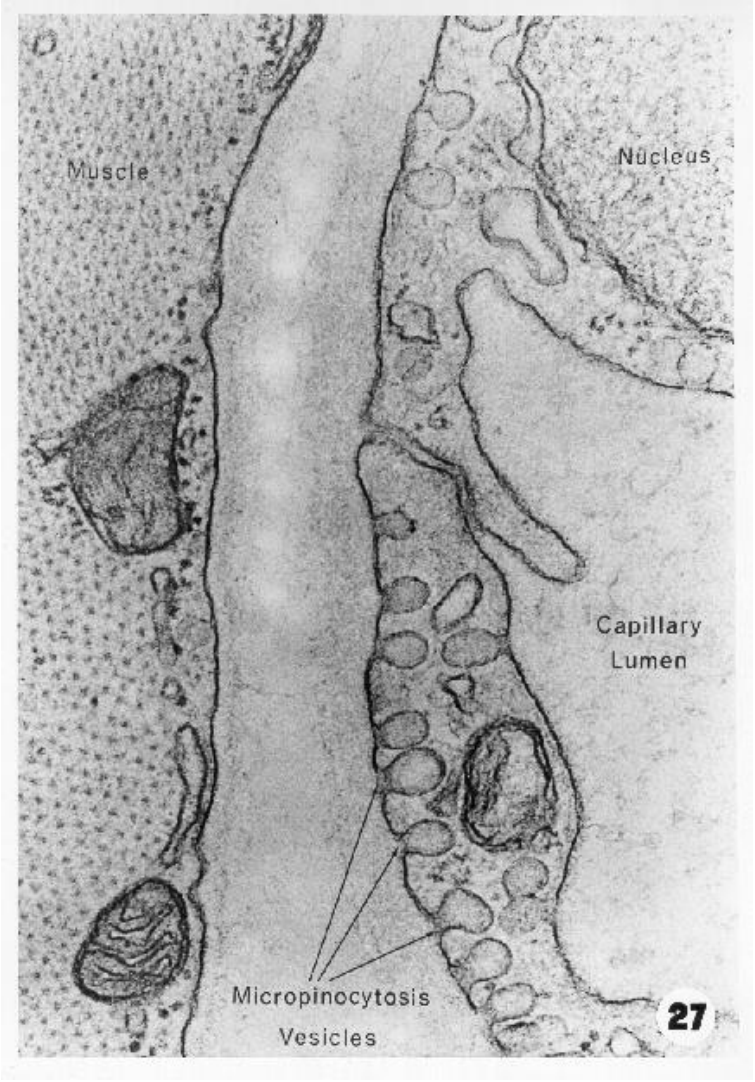
NOT WETABLE SURFACE



Lymphatic vessel with valve

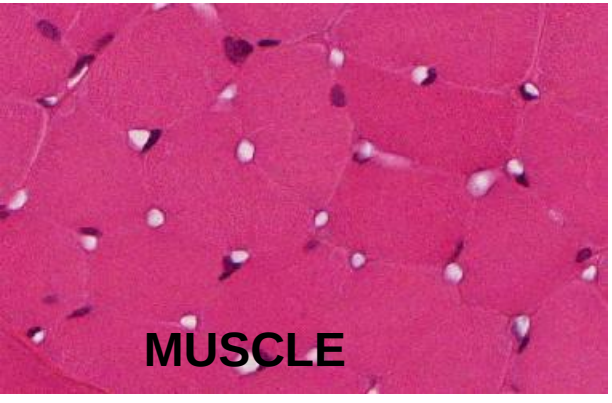
EM 3 & 27: Endothelial cells





TYPES OF CAPILLARIES & BASAL LAMINA CHARACTERISTICS

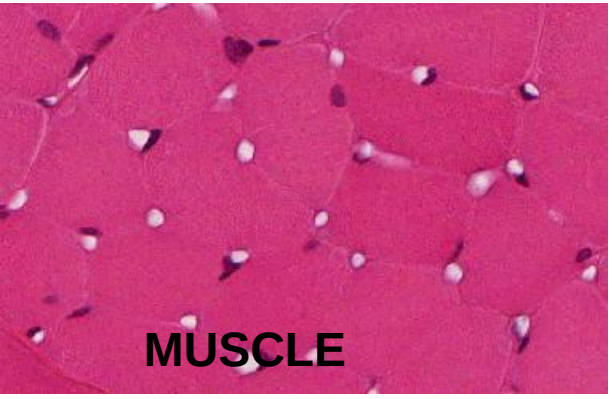
CAPILLARIES LOCATIONS	BASAL LAMINA	EXAMPLES OF
CONTINUOUS	COMPLETE	MUSCLE, TESTIS, BRAIN, THYMUS



MUSCLE

TYPES OF CAPILLARIES & BASAL LAMINA CHARACTERISTICS

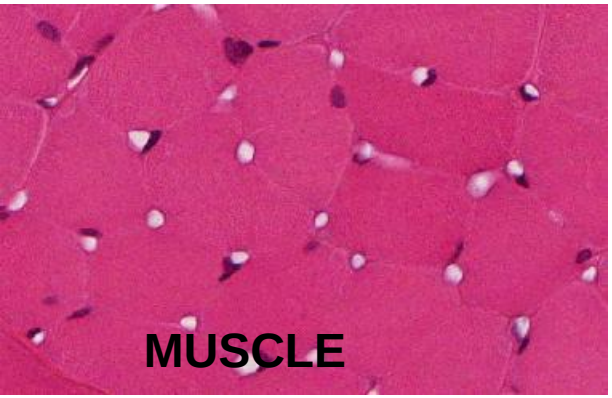
CAPILLARIES LOCATIONS	BASAL LAMINA	EXAMPLES OF
CONTINUOUS	COMPLETE	MUSCLE, TESTIS, BRAIN, THYMUS
FENESTRATED	COMPLETE	GLOMERULUS, ADRENAL


MUSCLE

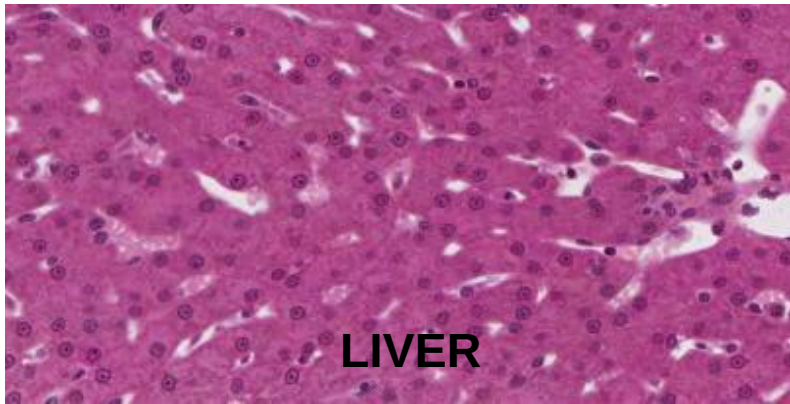

GLOMERULUS

TYPES OF CAPILLARIES & BASAL LAMINA CHARACTERISTICS

CAPILLARIES LOCATIONS	BASAL LAMINA	EXAMPLES OF
CONTINUOUS	COMPLETE	MUSCLE, TESTIS, BRAIN, THYMUS
FENESTRATED	COMPLETE	GLOMERULUS, ADRENAL
DISCONTINUOUS OR SINUSOIDAL	INCOMPLETE OR LACKING	LIVER, SPLEEN, BONE MARROW


MUSCLE

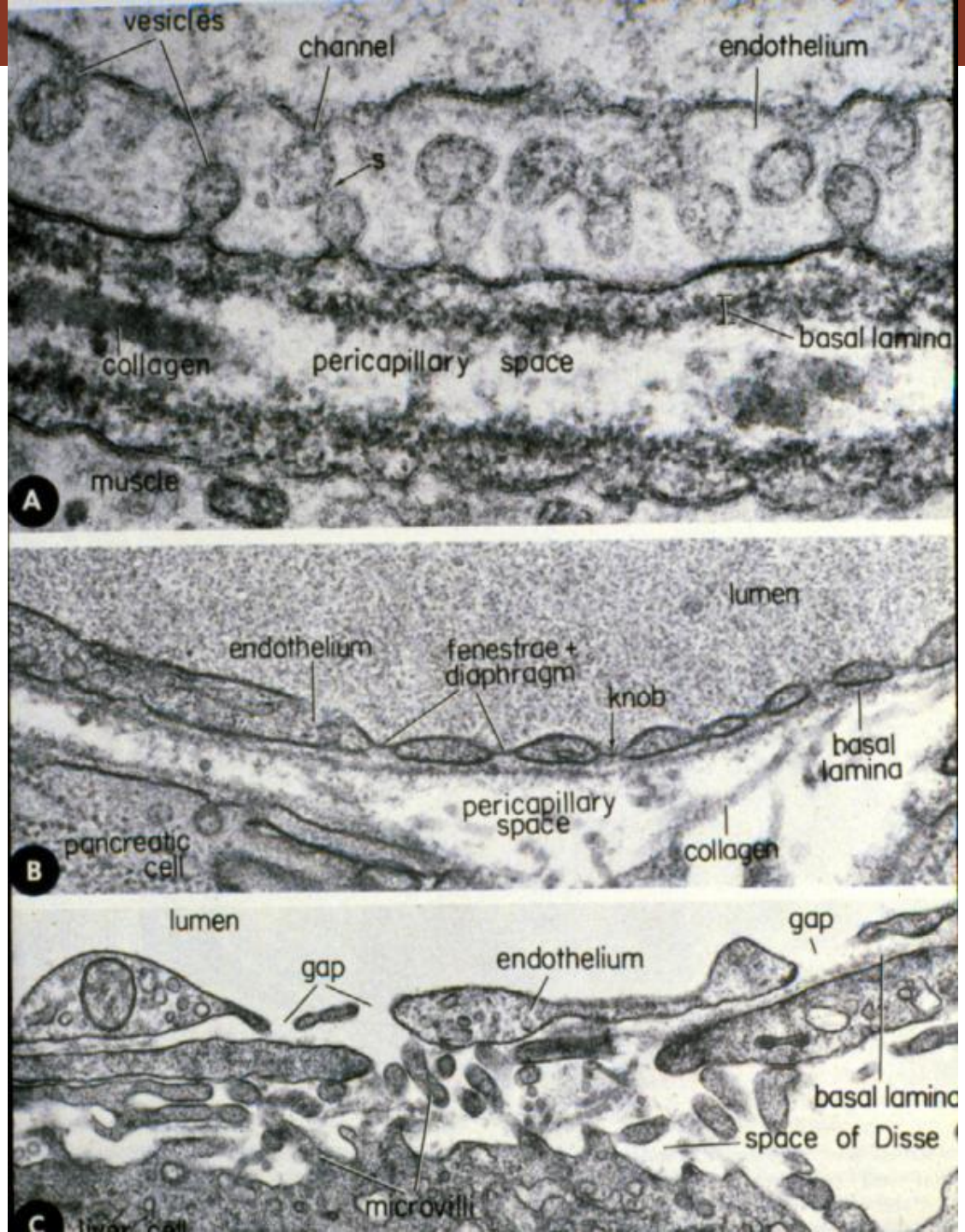

GLOMERULUS


LIVER

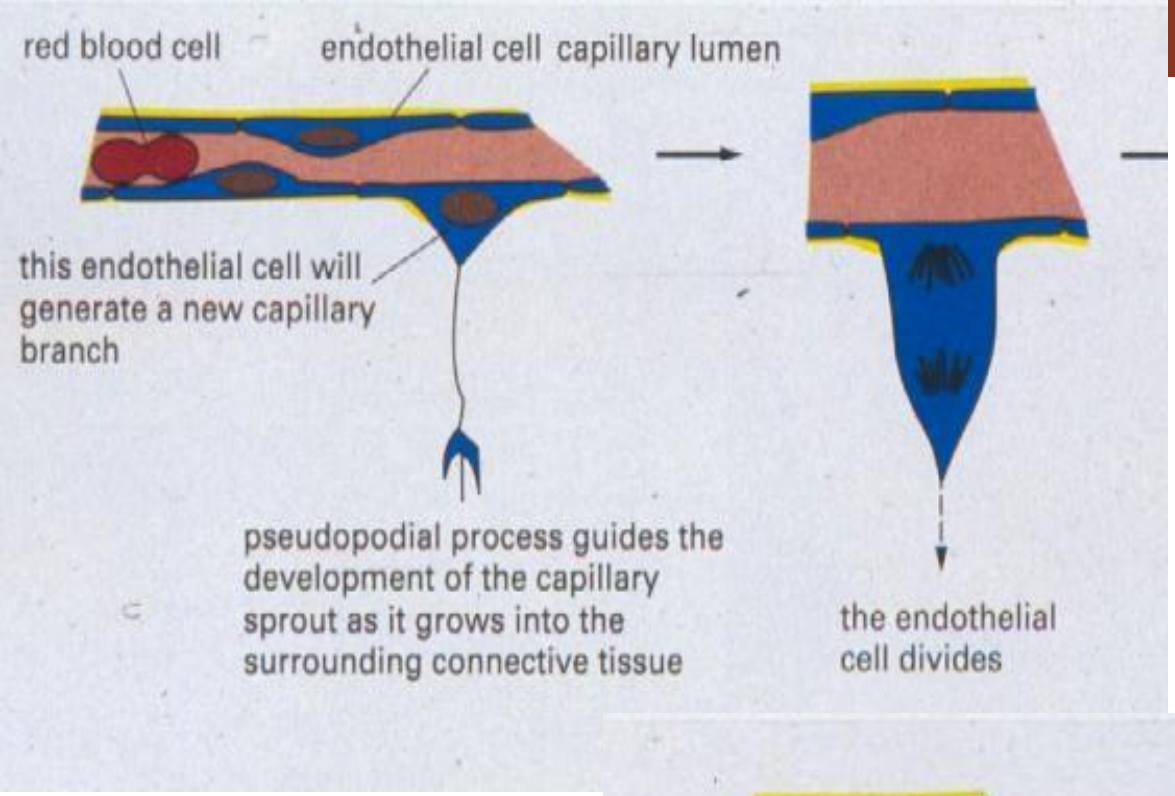
CONTINUOUS

FENESTRATED

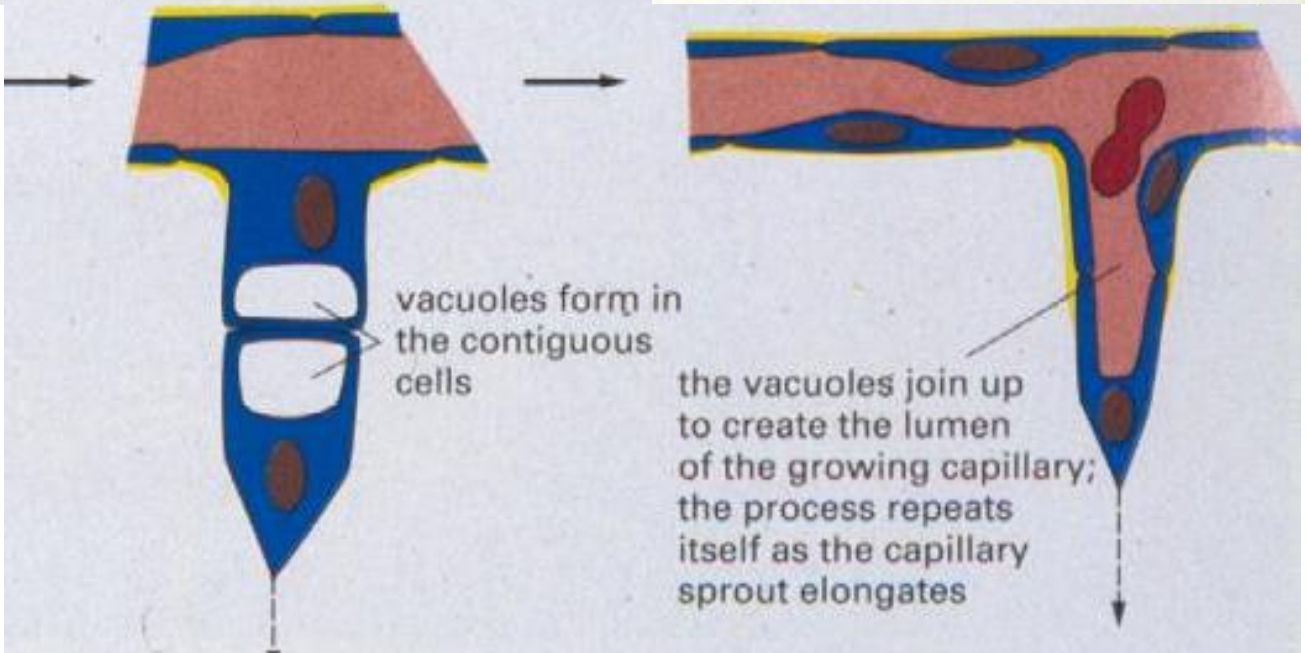
SINUSOIDAL



ANGIOGENESIS – growth of blood vessels



60 hours after wounding

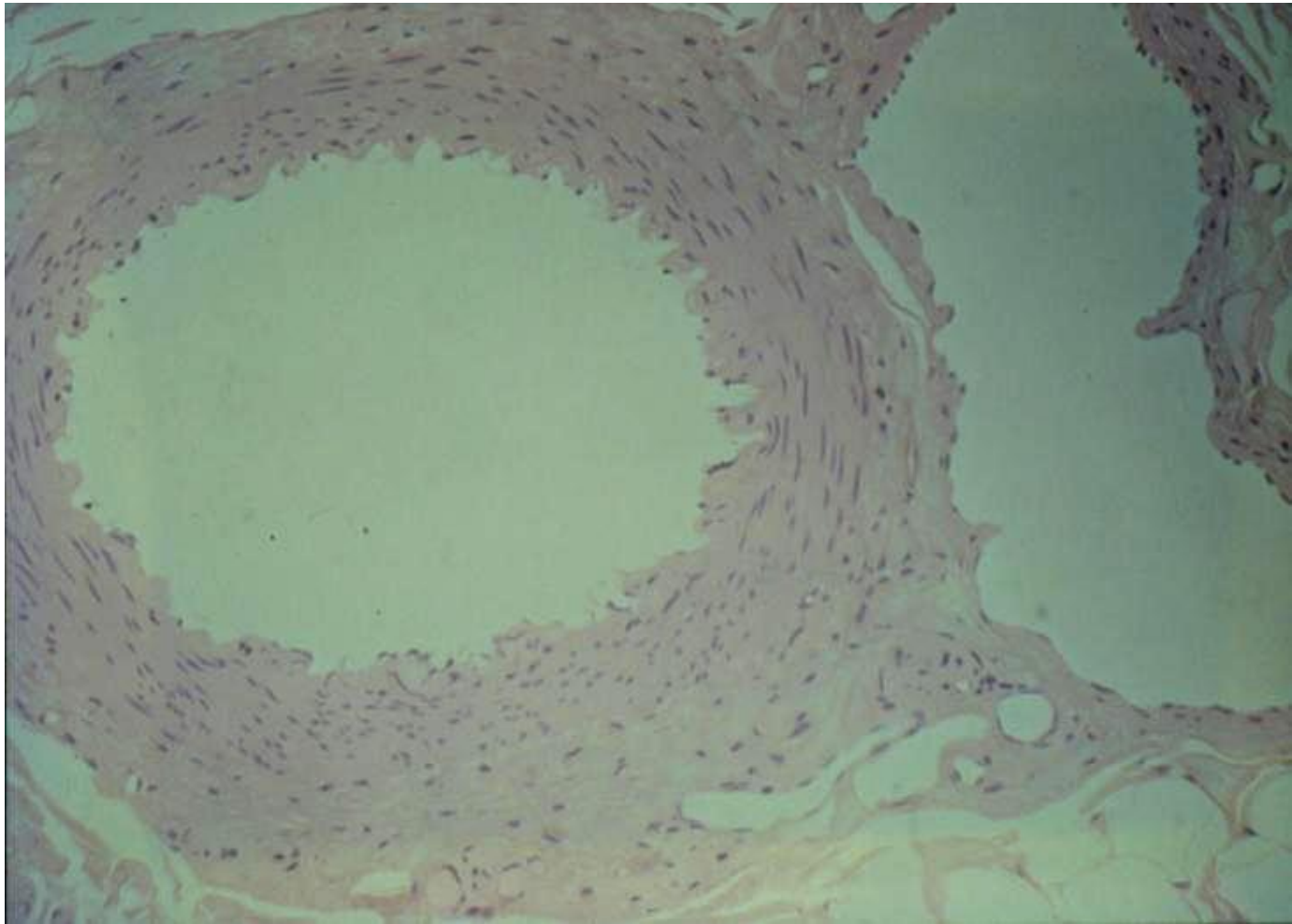


CLASSIFICATION OF VESSEL

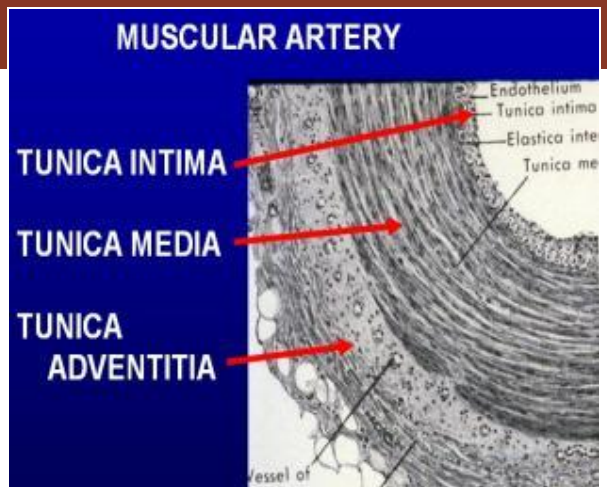
SIZE (CALIBER)

PROMINENT STRUCTURES IN WALL

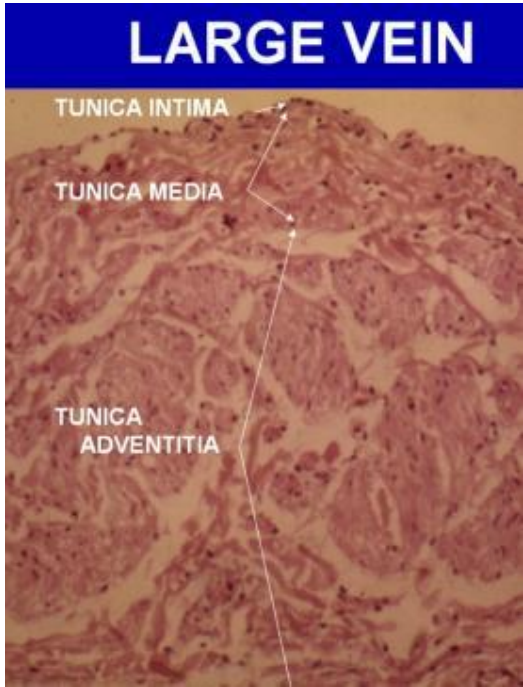
FUNCTION



LAYERS IN VASCULAR WALL



LAYER	COMPOSITION
TUNICA INTIMA	ENDOTHELIUM (SUBENDOTHELIA CT. INTERNAL ELASTIC LAMINA)
TUNICA MEDIA	SMOOTH MUSCLE (ELASTIC LAMELLAE, EXTERNAL ELASTIC LAMINA)
TUNICA ADVENTITIA	CONNECTIVE TISSUE (LONGITUDINAL SMOOTH MUSCLE, VASA VASORUM)

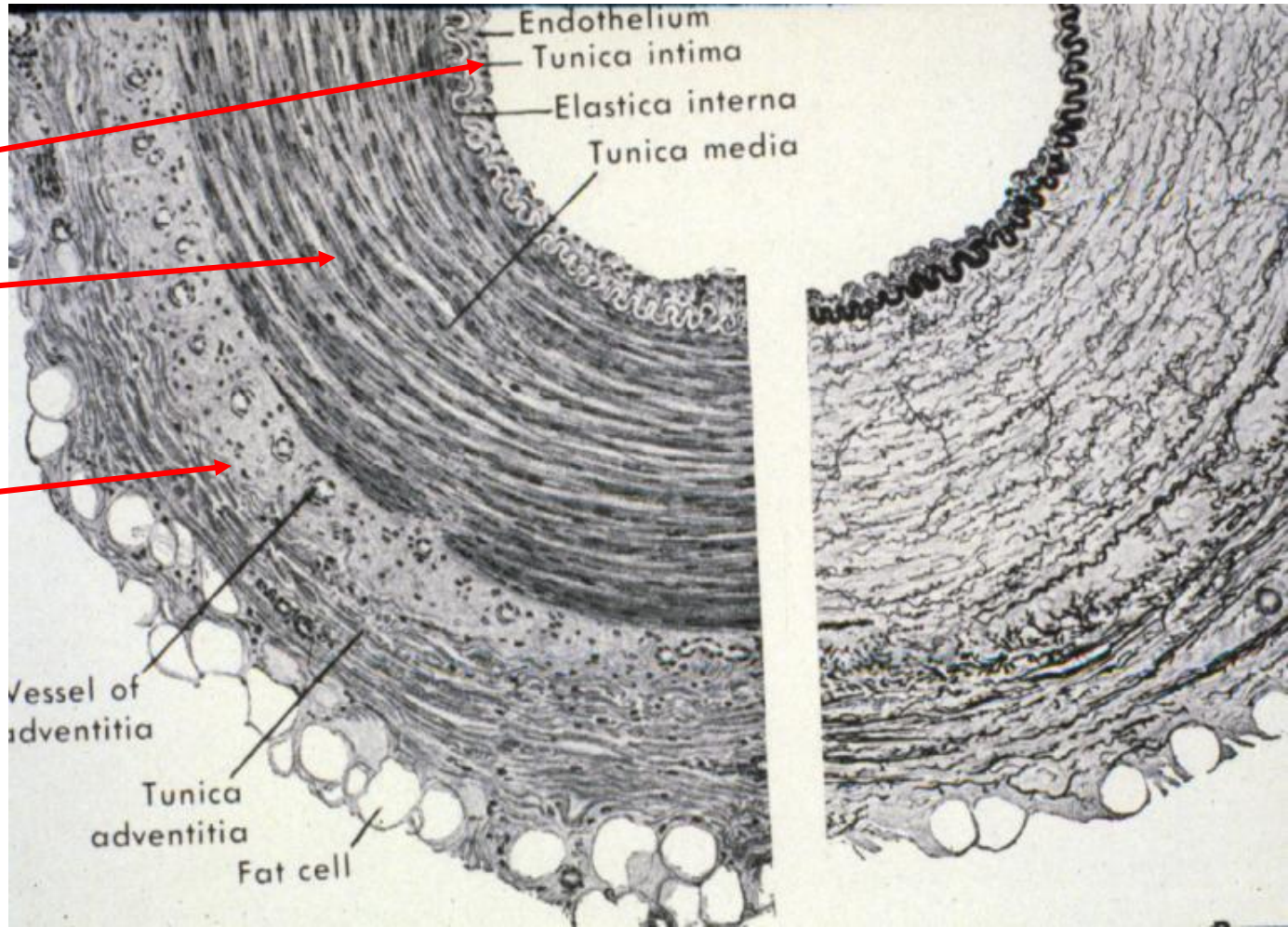


LAYERS IN VASCULAR WALL

TUNICA INTIMA

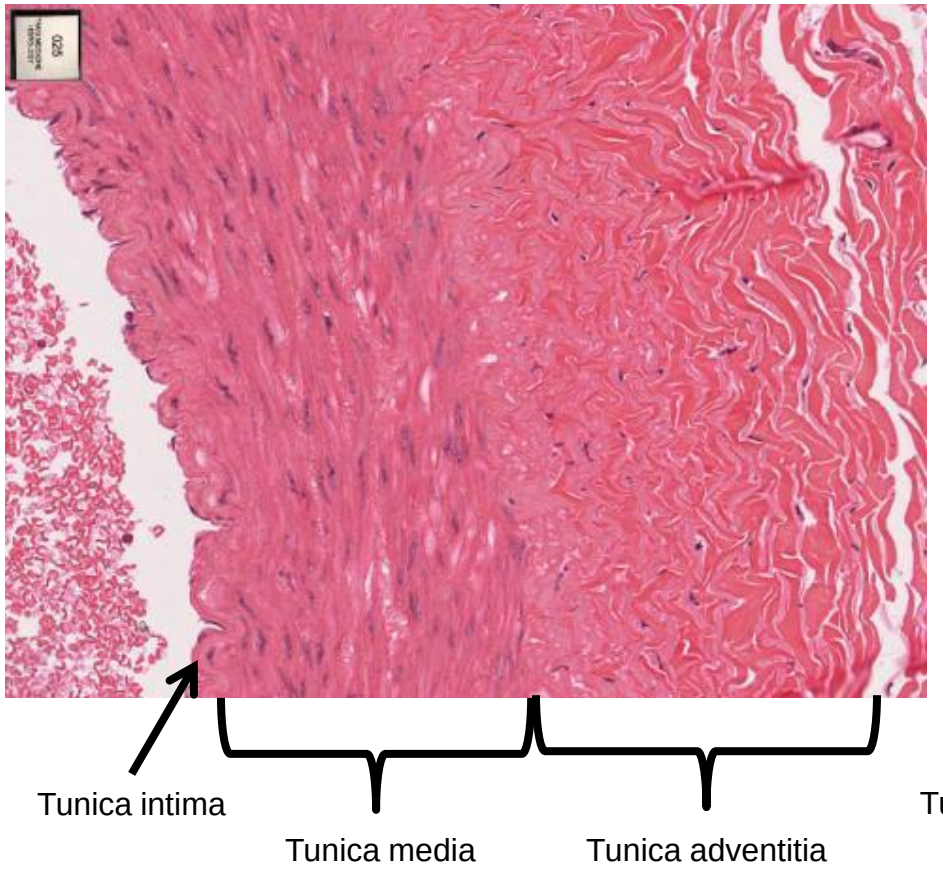
TUNICA MEDIA

TUNICA ADVENTITIA

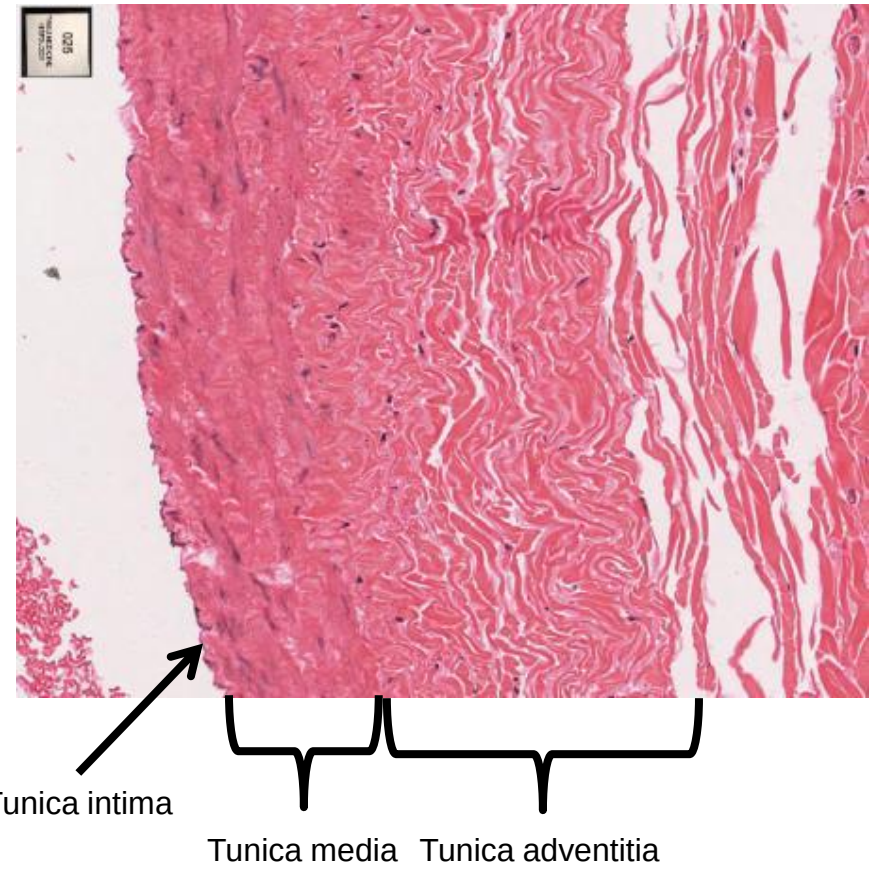


Slide 25: Muscular artery/vein/nerve (H&E)

Muscular Artery

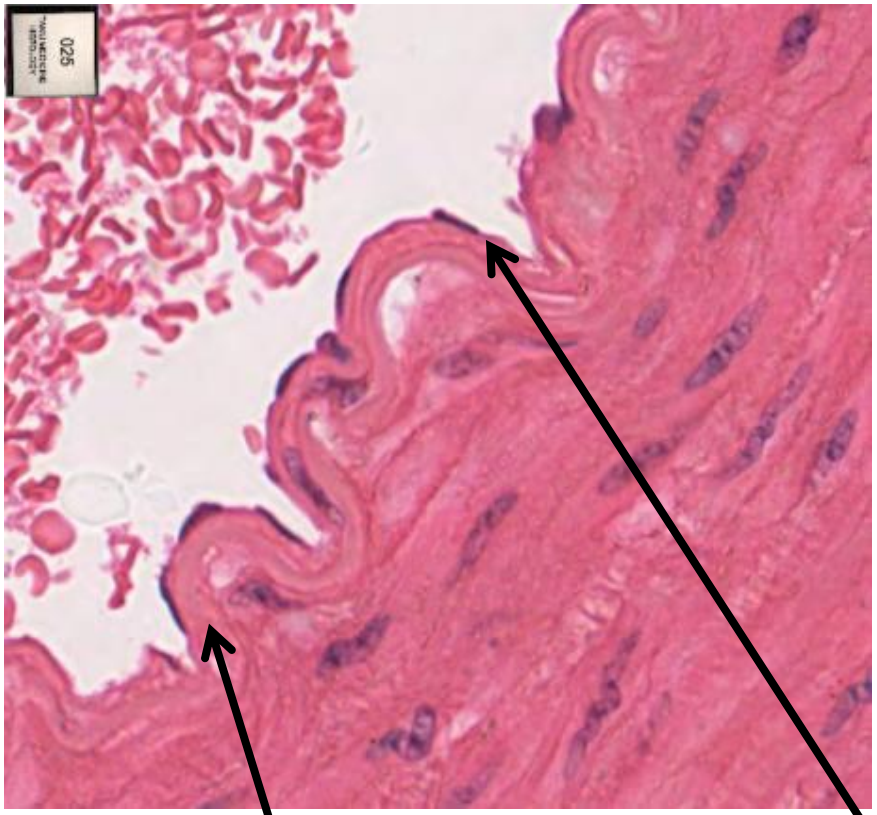


Large Vein



Slide 25: Muscular artery/vein/nerve (H&E)

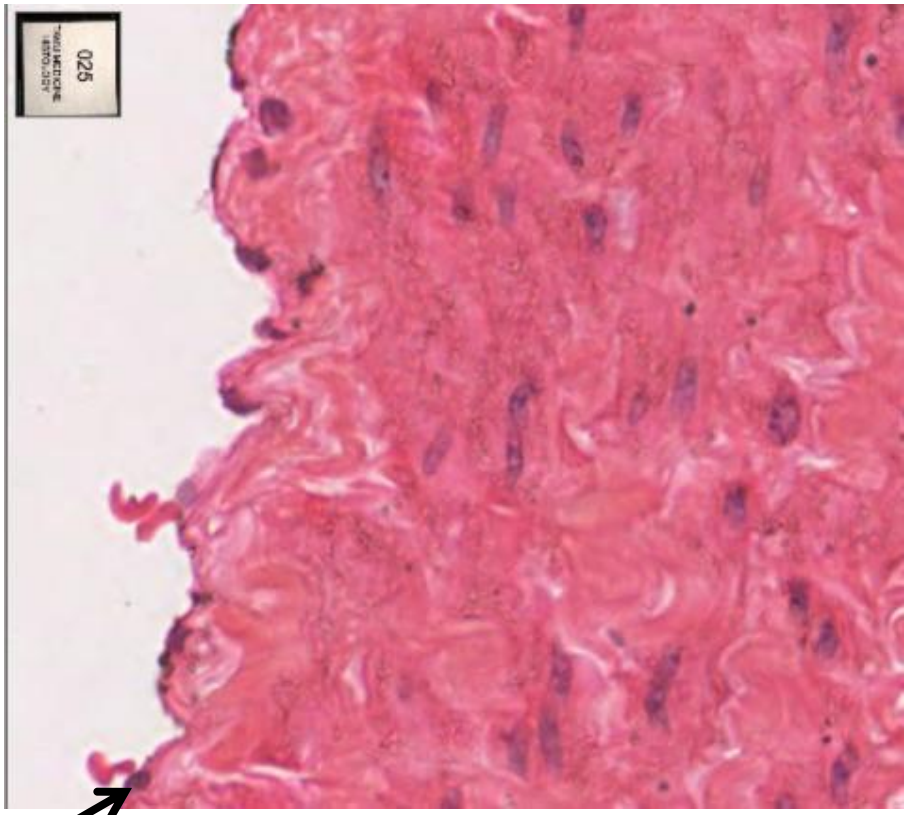
Muscular Artery



Internal elastic lamina (IEL)

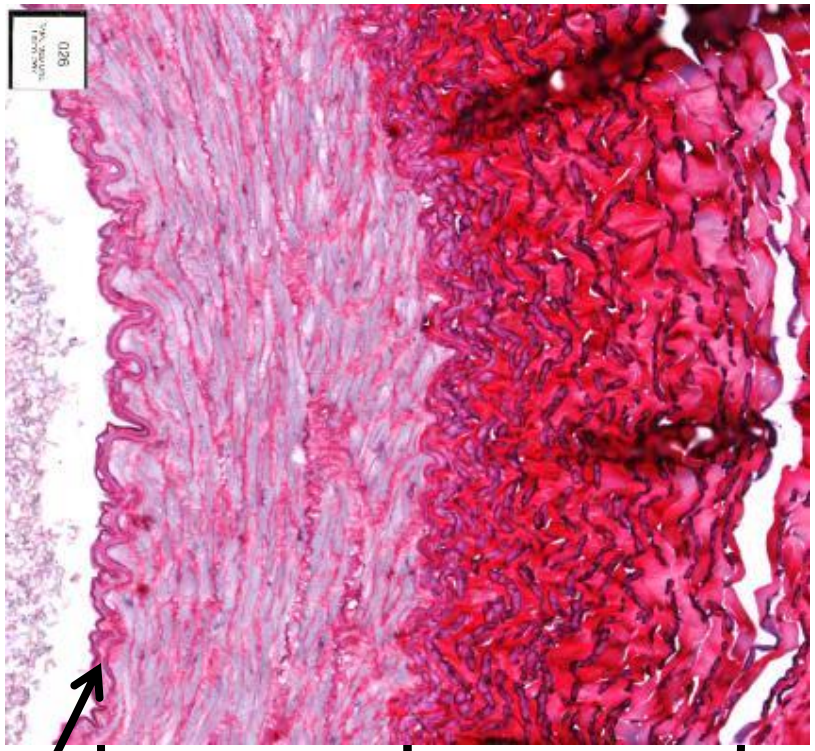
Tunica intima with endothelium and subendothelium

Large Vein



Slide 26: Muscular artery/vein/nerve (elastic-collagen stain)

Muscular Artery

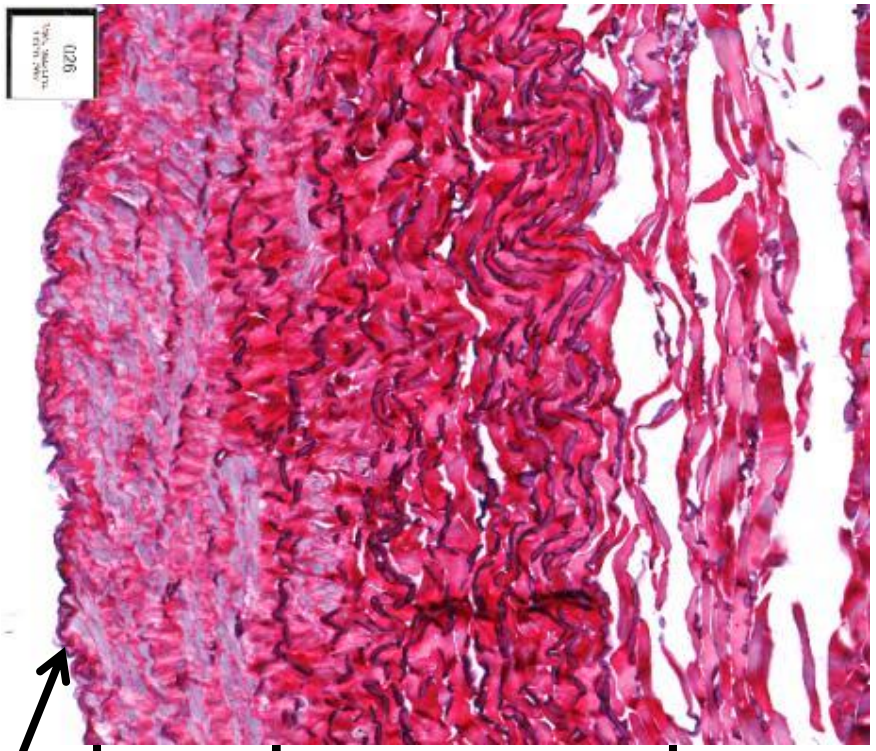


Tunica intima

Tunica media

Tunica adventitia

Large Vein



Tunica intima

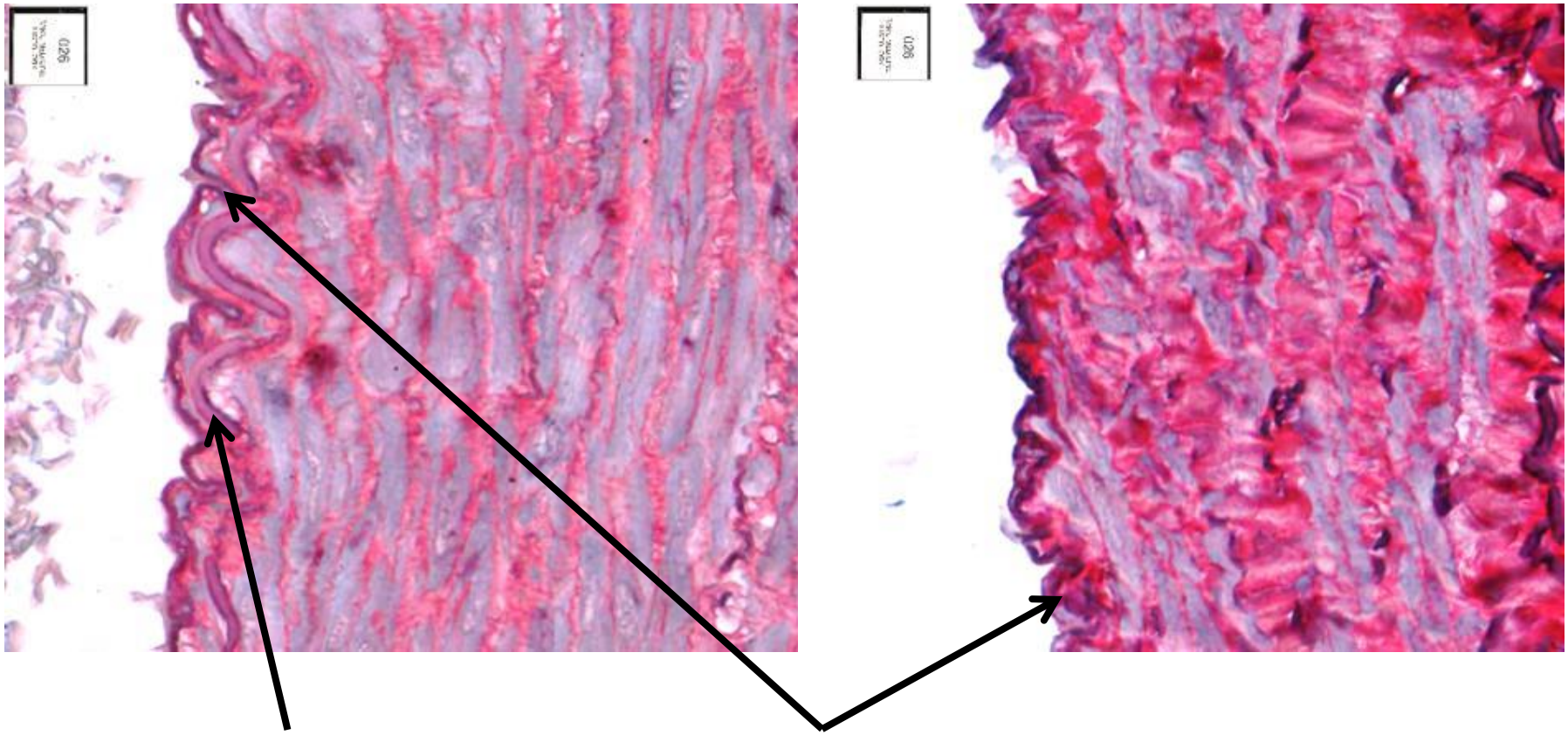
Tunica media

Tunica adventitia

Slide 26: Muscular artery/vein/nerve (elastic-collagen stain)

Muscular Artery

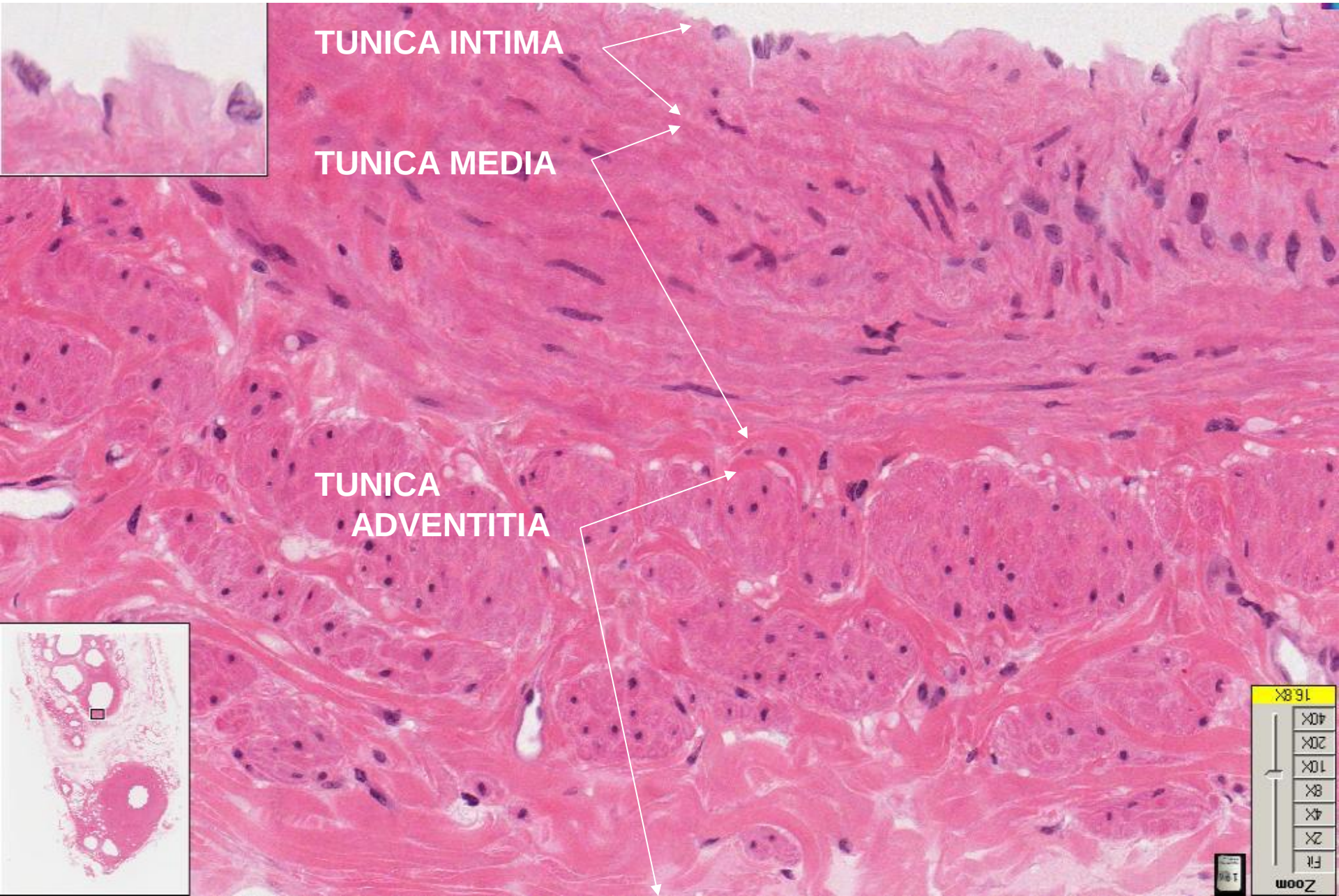
Large Vein



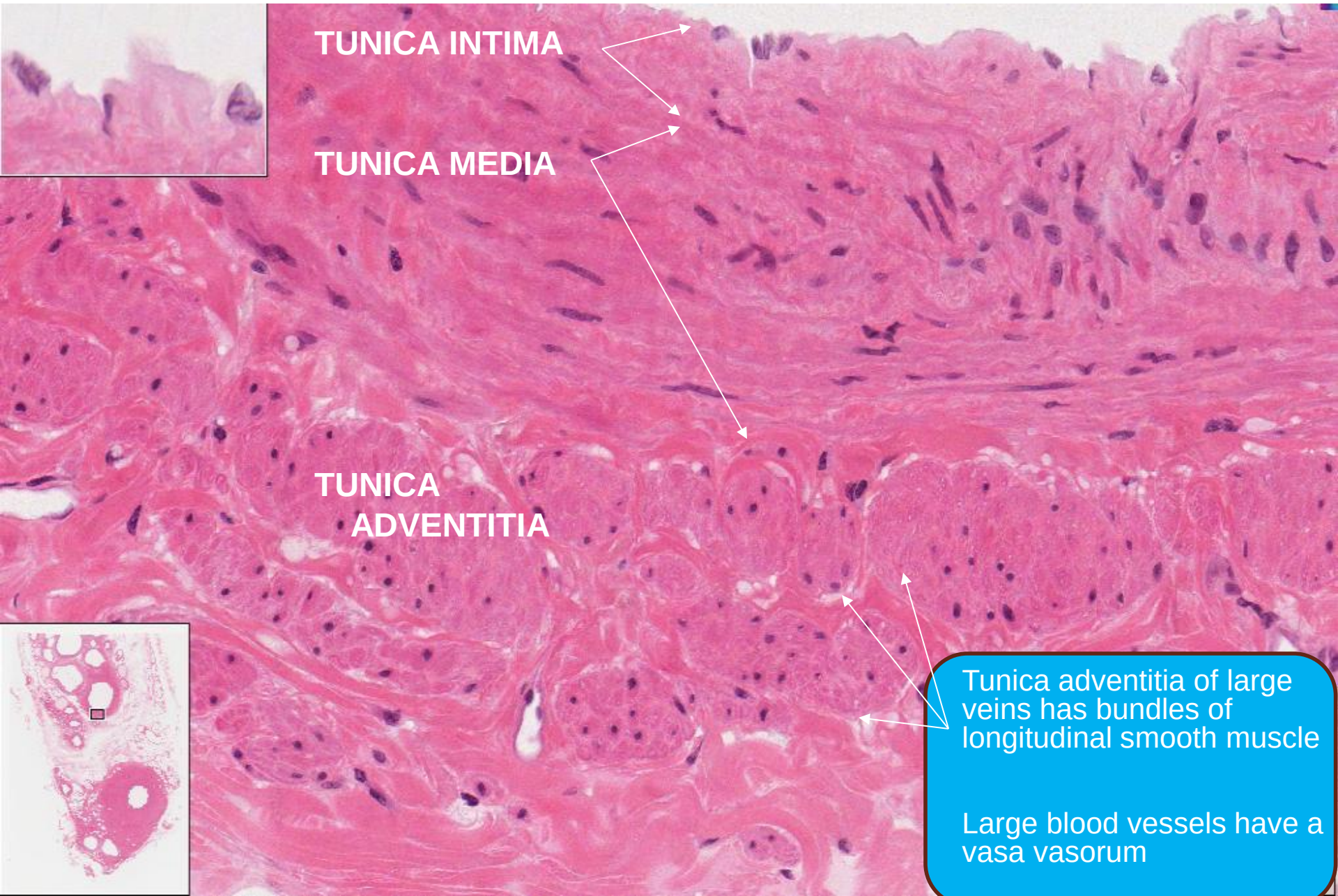
Internal elastic lamina (IEL)

Tunica intima with endothelium and subendothelium

LARGE VEIN


TUNICA INTIMA
TUNICA MEDIA
TUNICA
ADVENTITIA
Zoom
16.8X
40X
20X
10X
8X
4X
2X
Fit

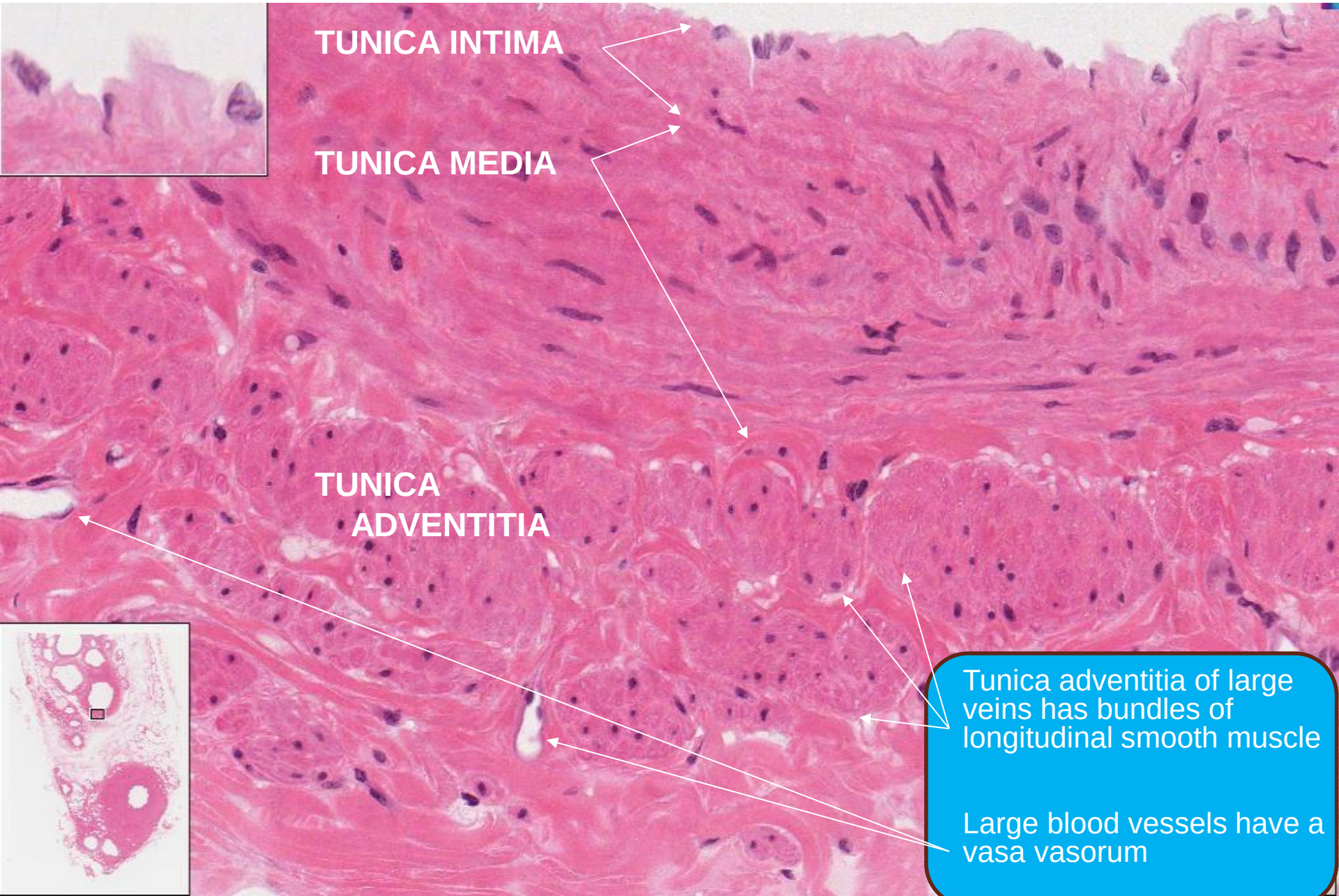
LARGE VEIN



Tunica adventitia of large veins has bundles of longitudinal smooth muscle

Large blood vessels have a vasa vasorum

LARGE VEIN



Tunica adventitia of large veins has bundles of longitudinal smooth muscle

Large blood vessels have a vasa vasorum

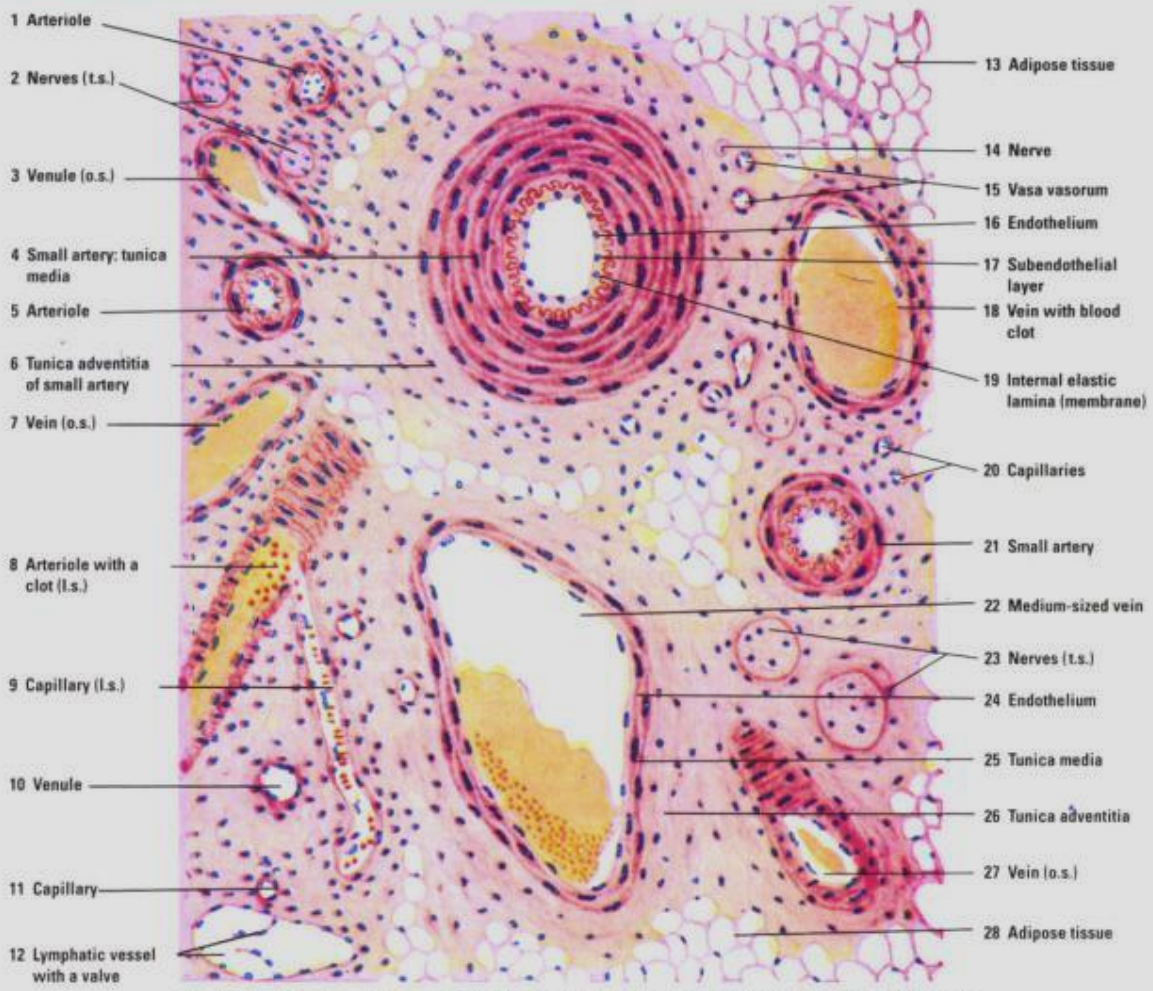
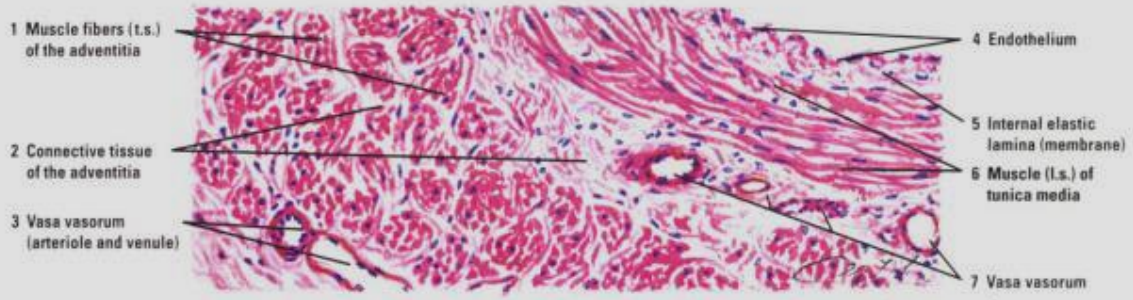
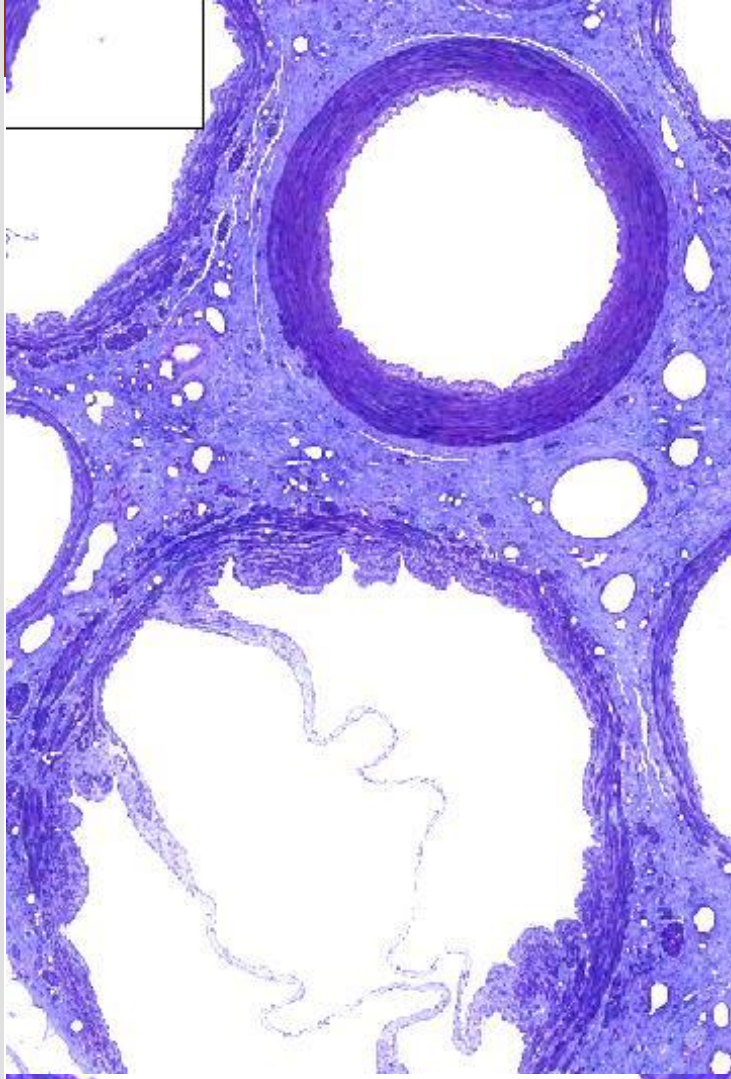
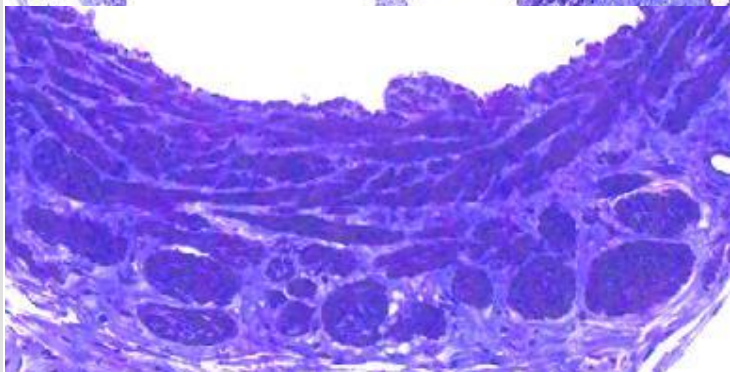


Fig. 7-1 Blood and Lymphatic Vessels. Stain: hematoxylin. Medium magnification.

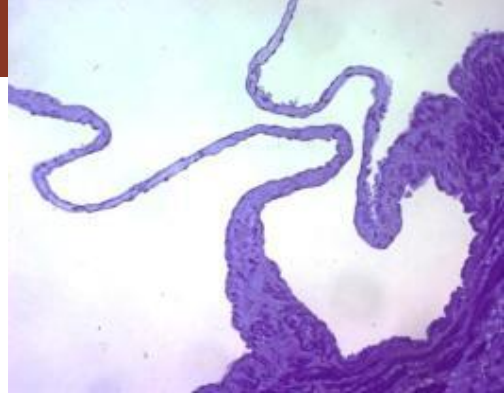


atoxylin-eosin. Medium magnification.



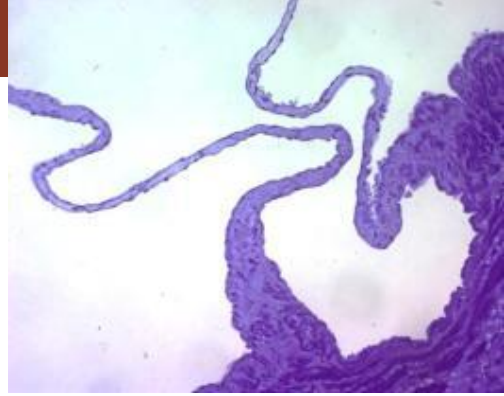


VASCULAR VALVES



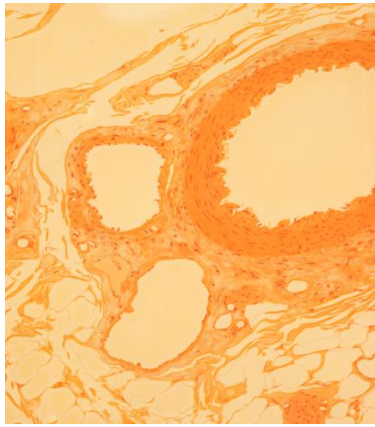
LOCATION - MEDIUM CALIBER VEINS (ESPECIALLY EXTREMITIES)

VASCULAR VALVES

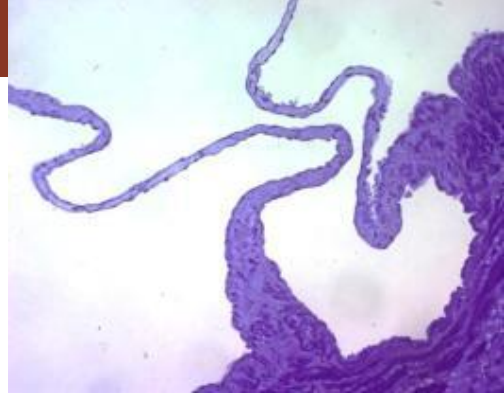


LOCATION - MEDIUM CALIBER

- **VEINS (ESPECIALLY EXTREMITIES)**
- **COLLECTING AND LYMPHATIC DUCTS**

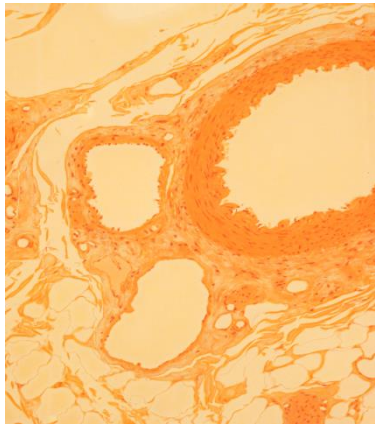


VASCULAR VALVES



LOCATION - MEDIUM CALIBER

- **VEINS (ESPECIALLY EXTREMITIES)**
- **COLLECTING AND LYMPHATIC DUCTS**



FUNCTION - INSURE

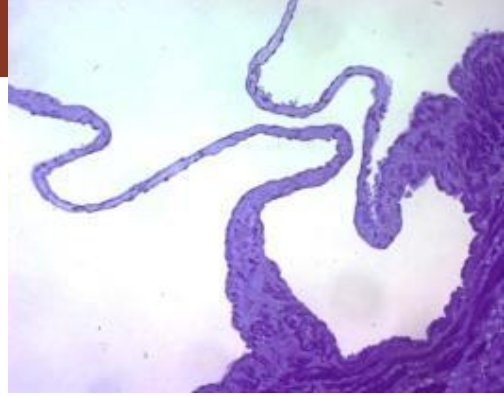
- **UNIDIRECTIONAL FLOW**

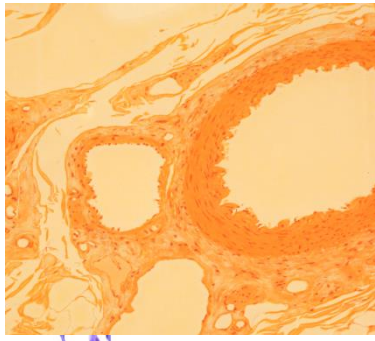
VASCULAR VALVES

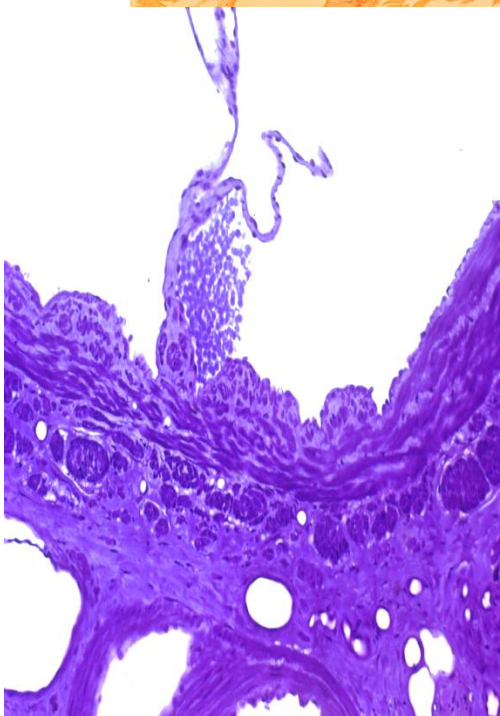
LOCATION - MEDIUM CALIBER
VEINS (ESPECIALLY EXTREMITIES)
COLLECTING AND
LYMPHATIC DUCTS

FUNCTION - INSURE
UNIDIRECTIONAL FLOW

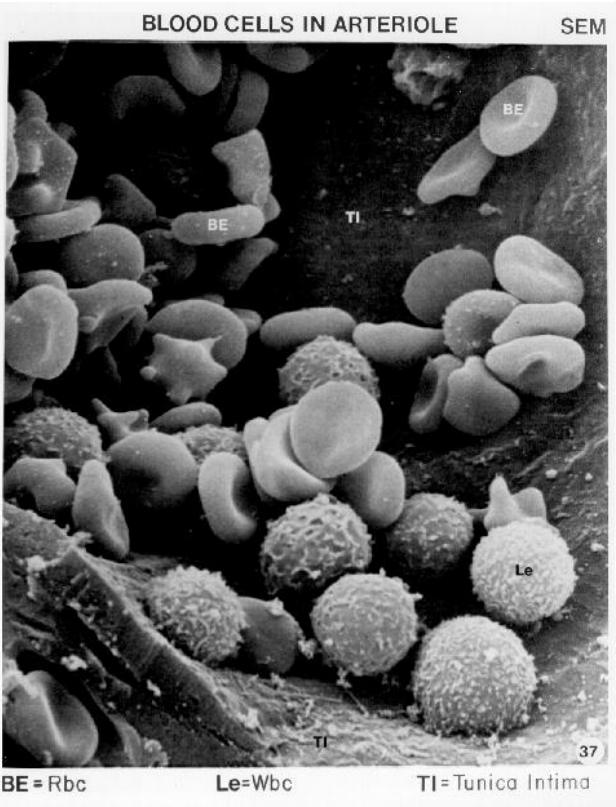
COMPOSITION FLAP OR LEAFLET
WHICH ARE FOLDINGS OF
THE INTIMA WITH
REINFORCEMENTS OF
CONNECTIVE TISSUE

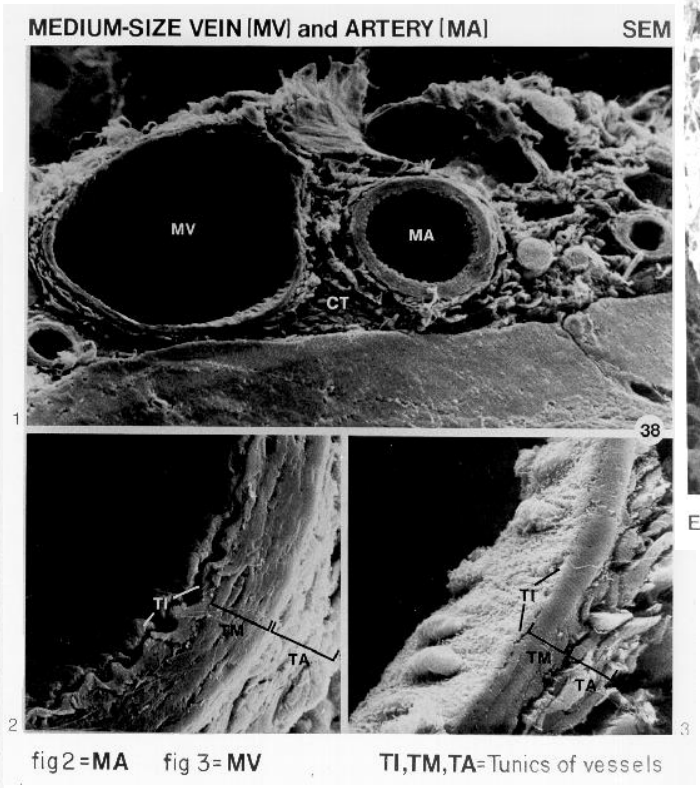


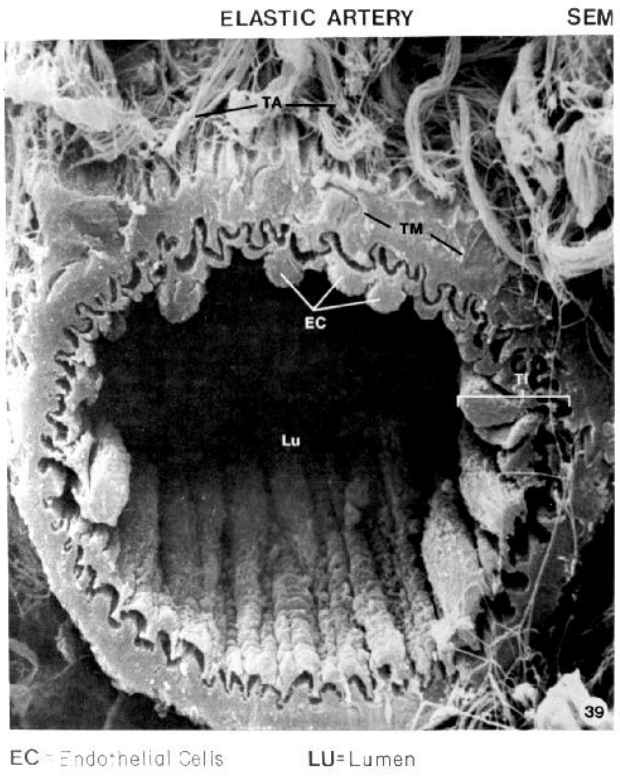




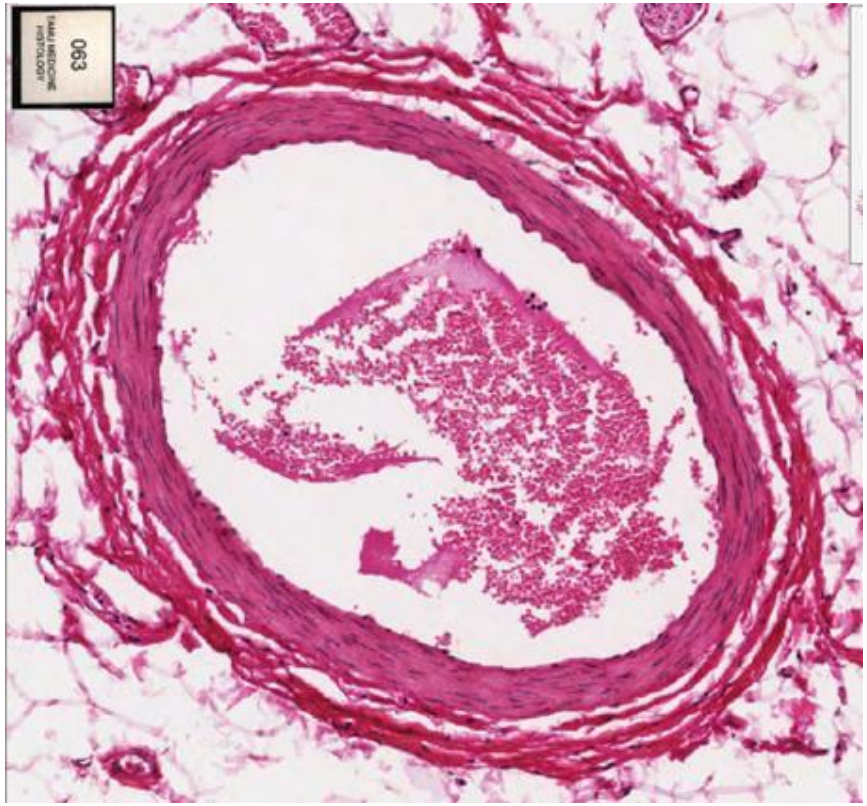
EM 37, 38, & 39

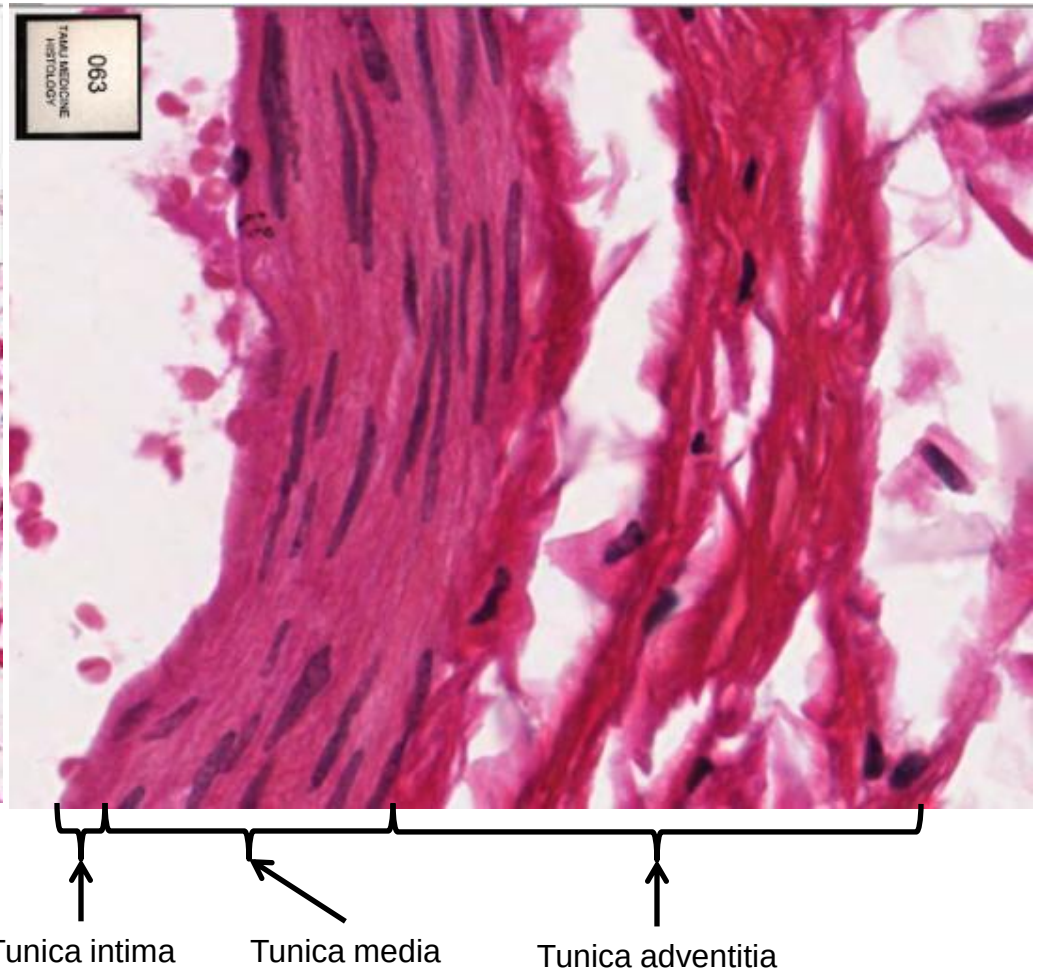

BLOOD CELLS IN ARTERIOLE
SEM
BE
BE
TI
Le
TI
37
BE = Rbc
Le=Wbc
TI = Tunica Intima


MEDIUM-SIZE VEIN [MV] and ARTERY [MA]
SEM
MV
MA
CT
1
38
TI
TM
TA
2
TI
TM
TA
3
fig 2 = MA
fig 3 = MV
TI,TM,TA = Tunics of vessels


ELASTIC ARTERY
SEM
TA
TM
EC
TI
Lu
39
EC = Endothelial Cells
LU = Lumen

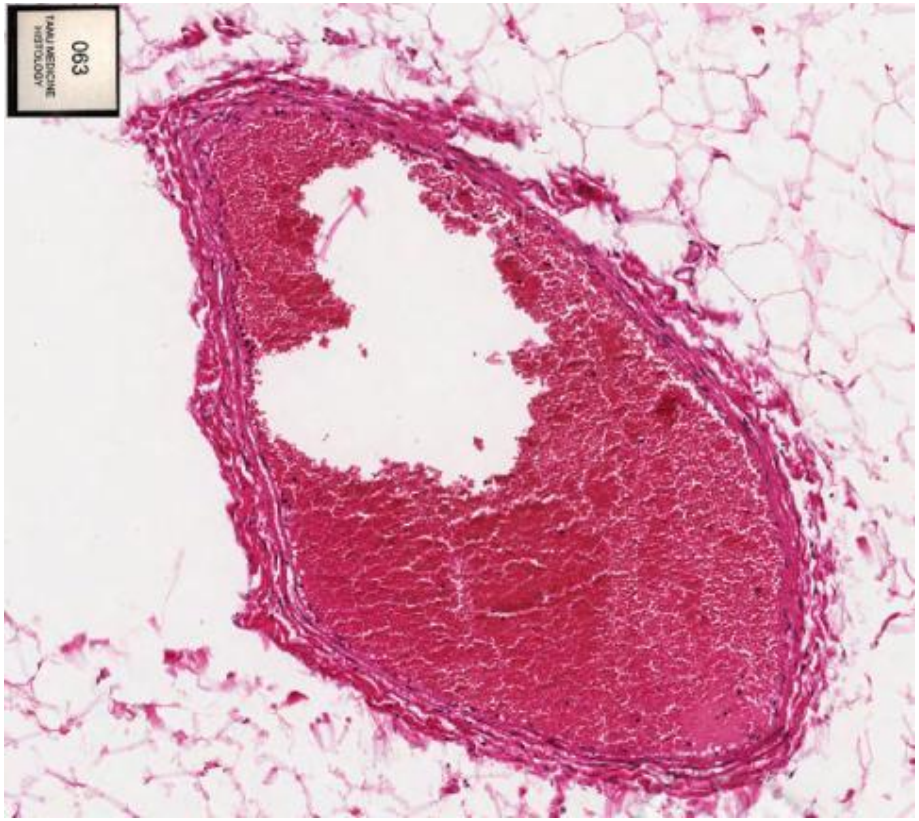
Slide 63: Appendix (H&E)



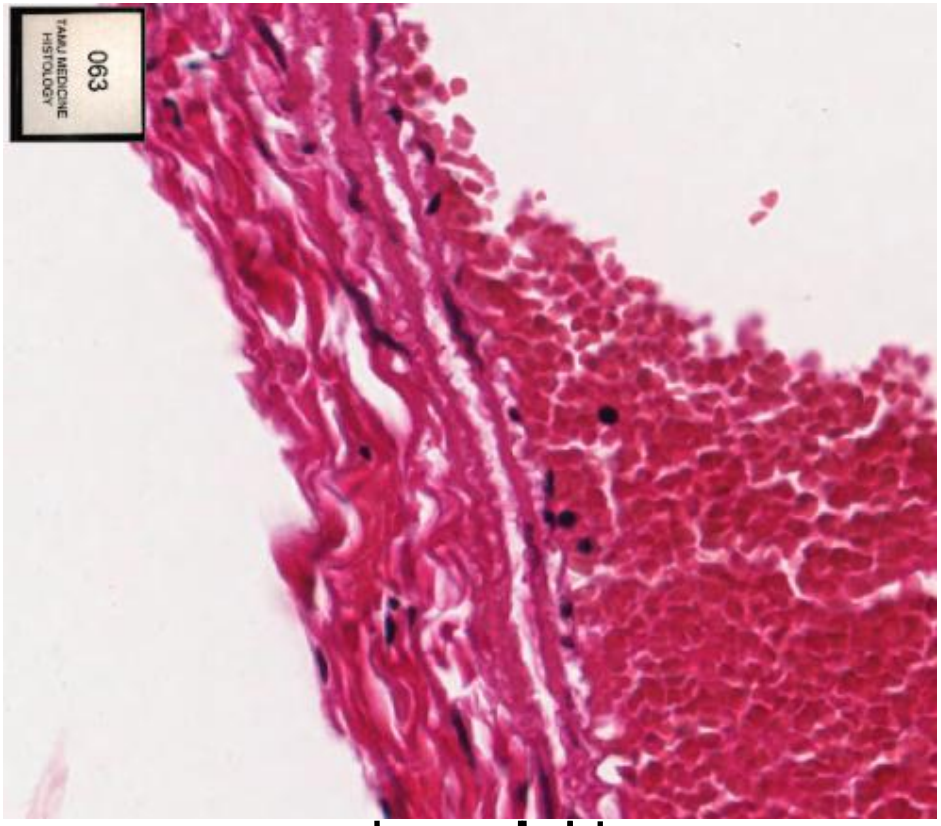


Large Artery

Slide 63: Appendix (H&E)



Large Vein

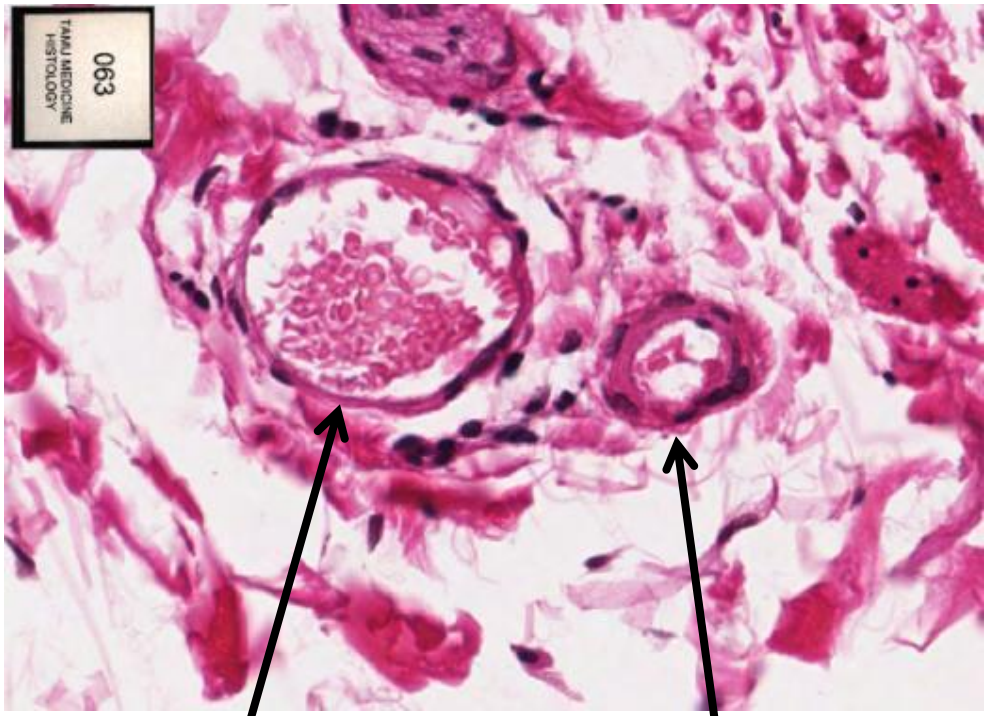


Tunica adventitia

Tunica media

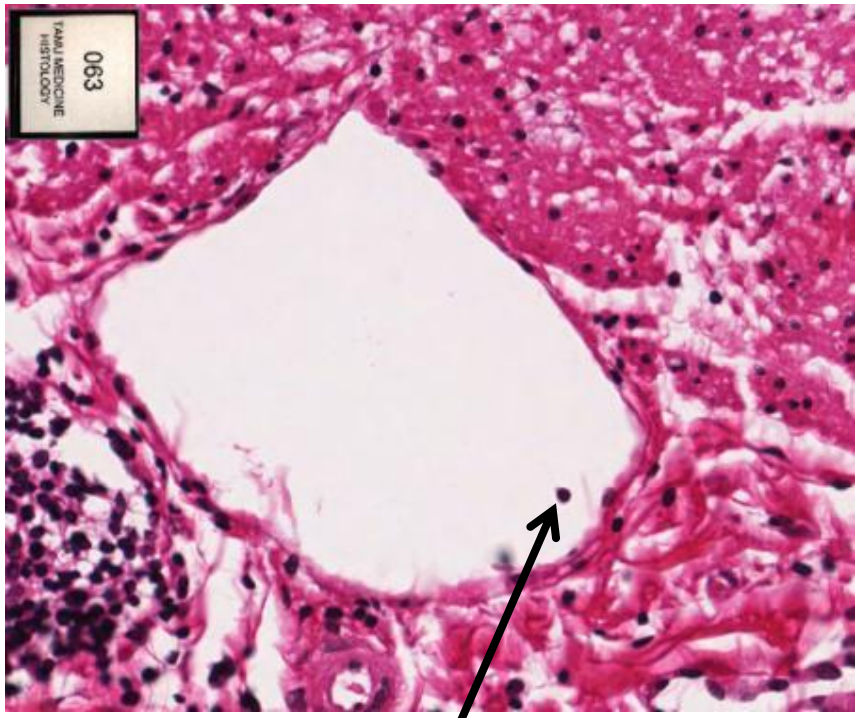
Tunica intima

Slide 63: Appendix (H&E)



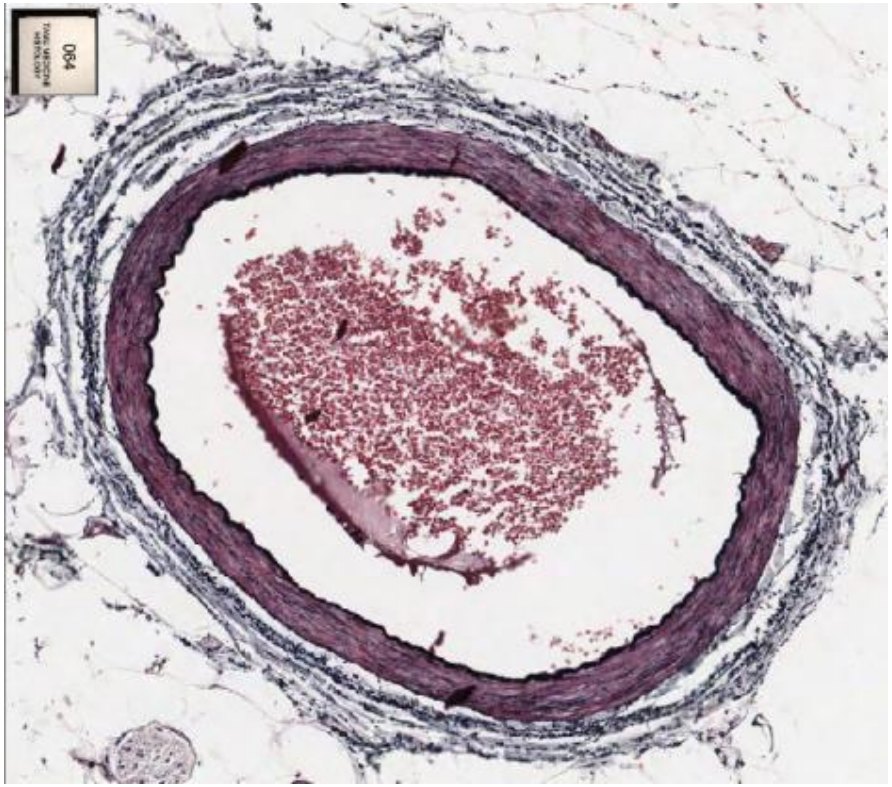
Venule

Arteriole

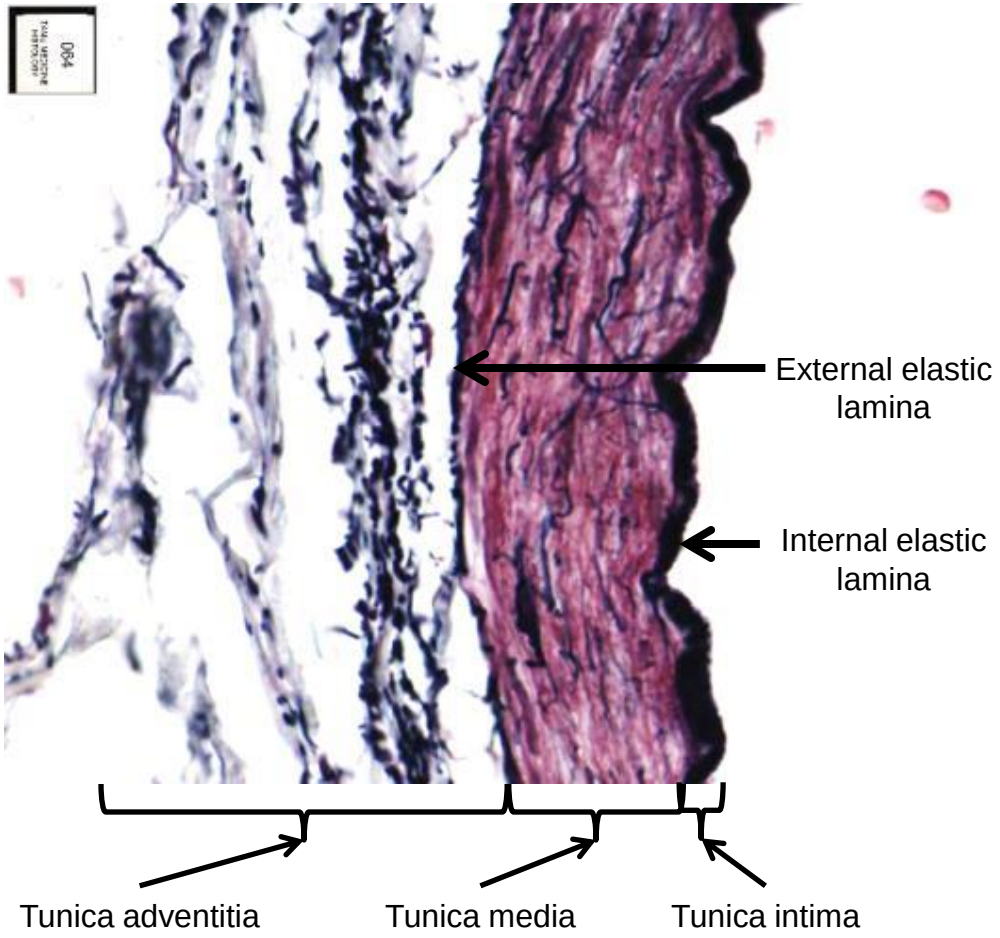


Lymphatic vessel with lymphocyte

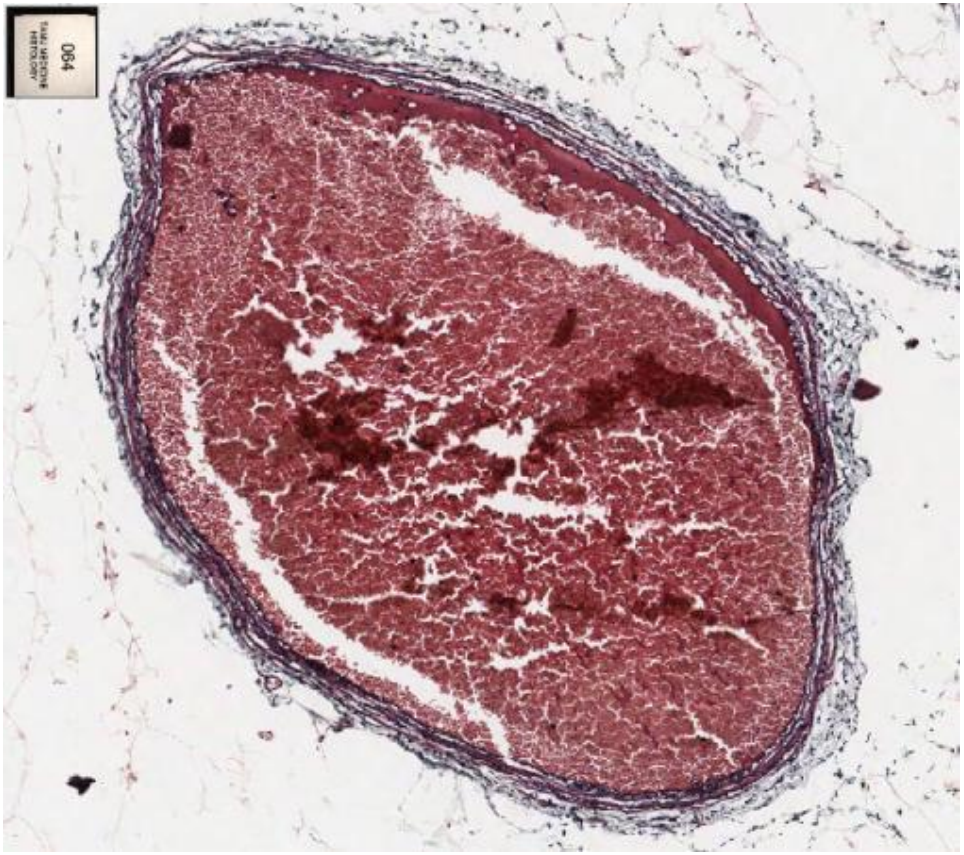
Slide 64: Appendix (Verhoff's and trichrome stain)



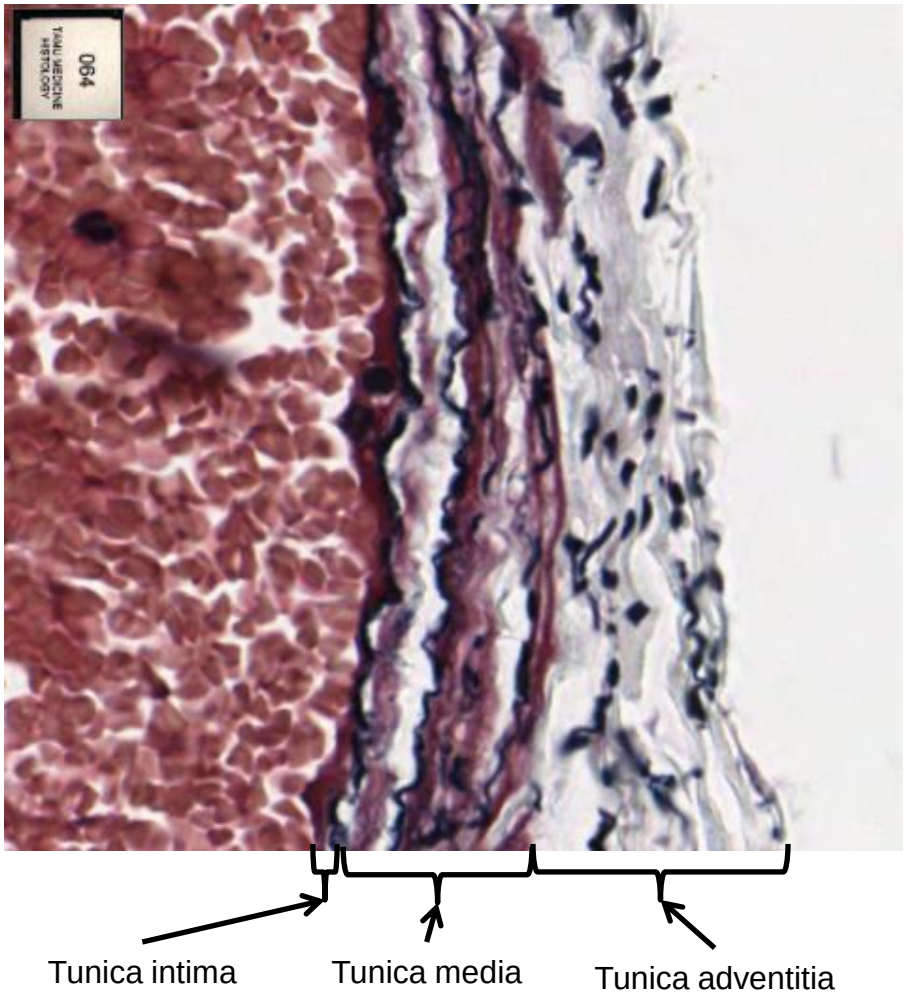
Large Artery



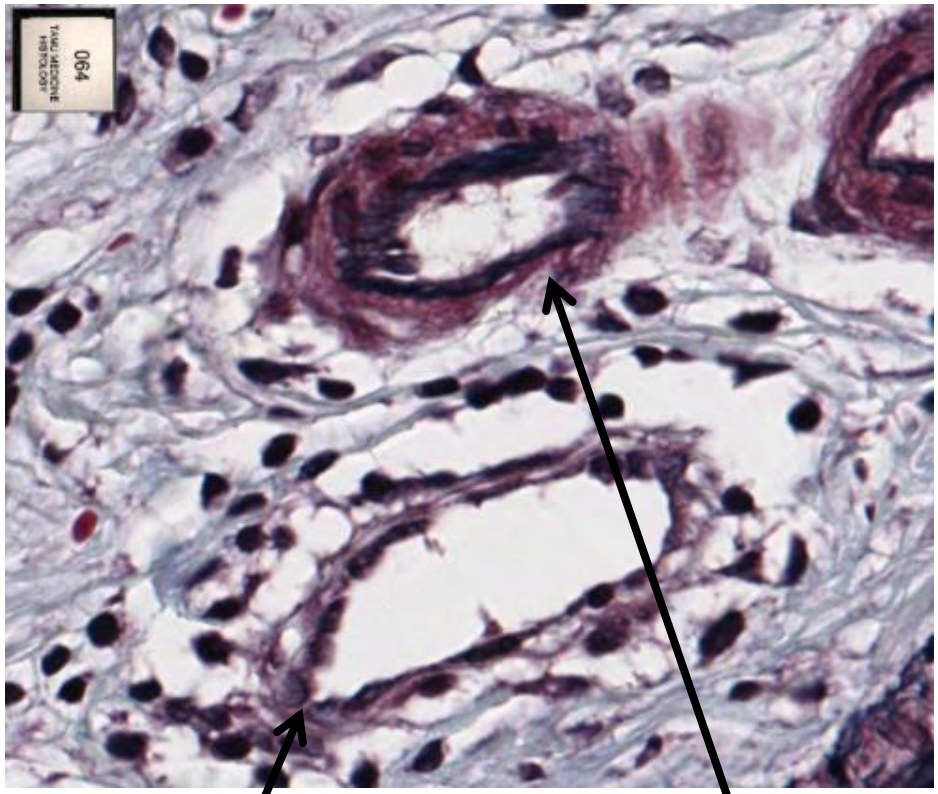
Slide 64: Appendix (Verhoff's and trichrome stain)



Large Vein

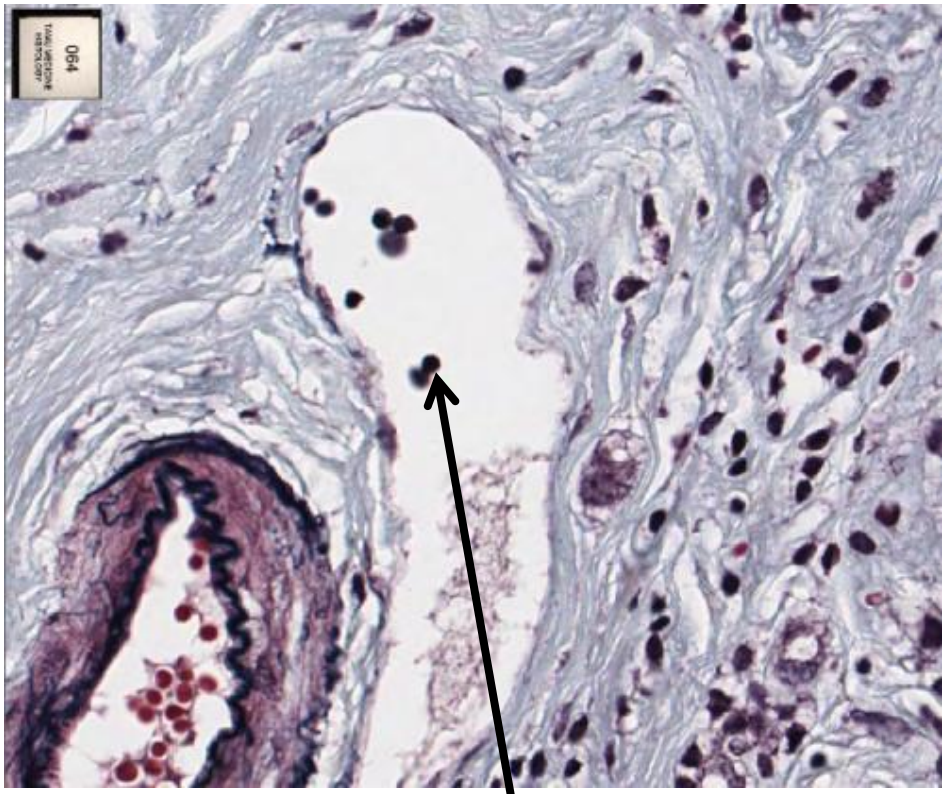


Slide 64: Appendix (Verhoff's and trichrome stain)



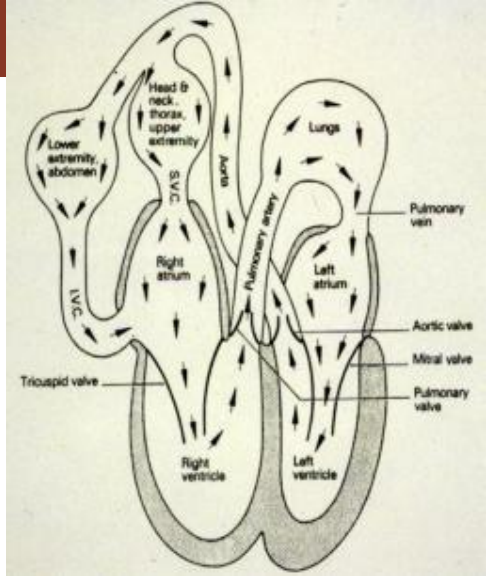
Venule

Arteriole



Lymphatic vessel with lymphocytes

CARDIOVASCULAR SYSTEM

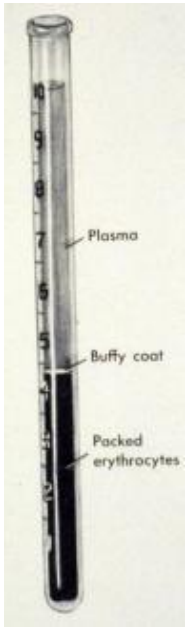


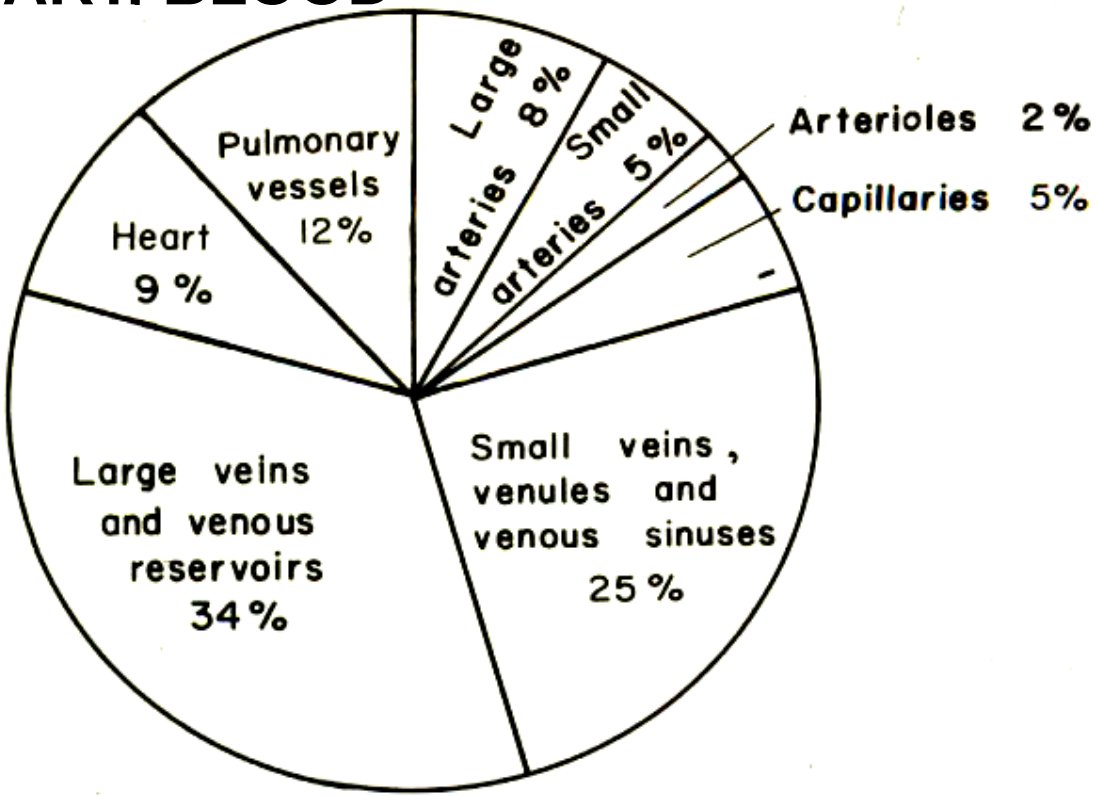
VEINS - TRANSMIT BLOOD TO LARGE VEINS RESERVOIR

LARGER VEINS - RECEIVE LYMPH AND RETURN BLOOD TO HEART. BLOOD RESERVOIR

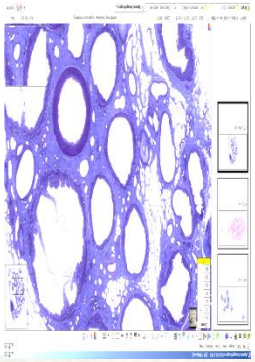
VOLUME:
5-6 L = 12-13 PINTS/PERSON

59% of the blood volume is stored in veins

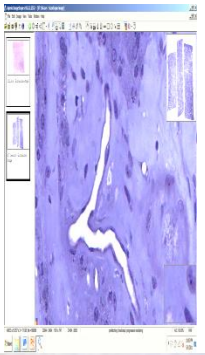


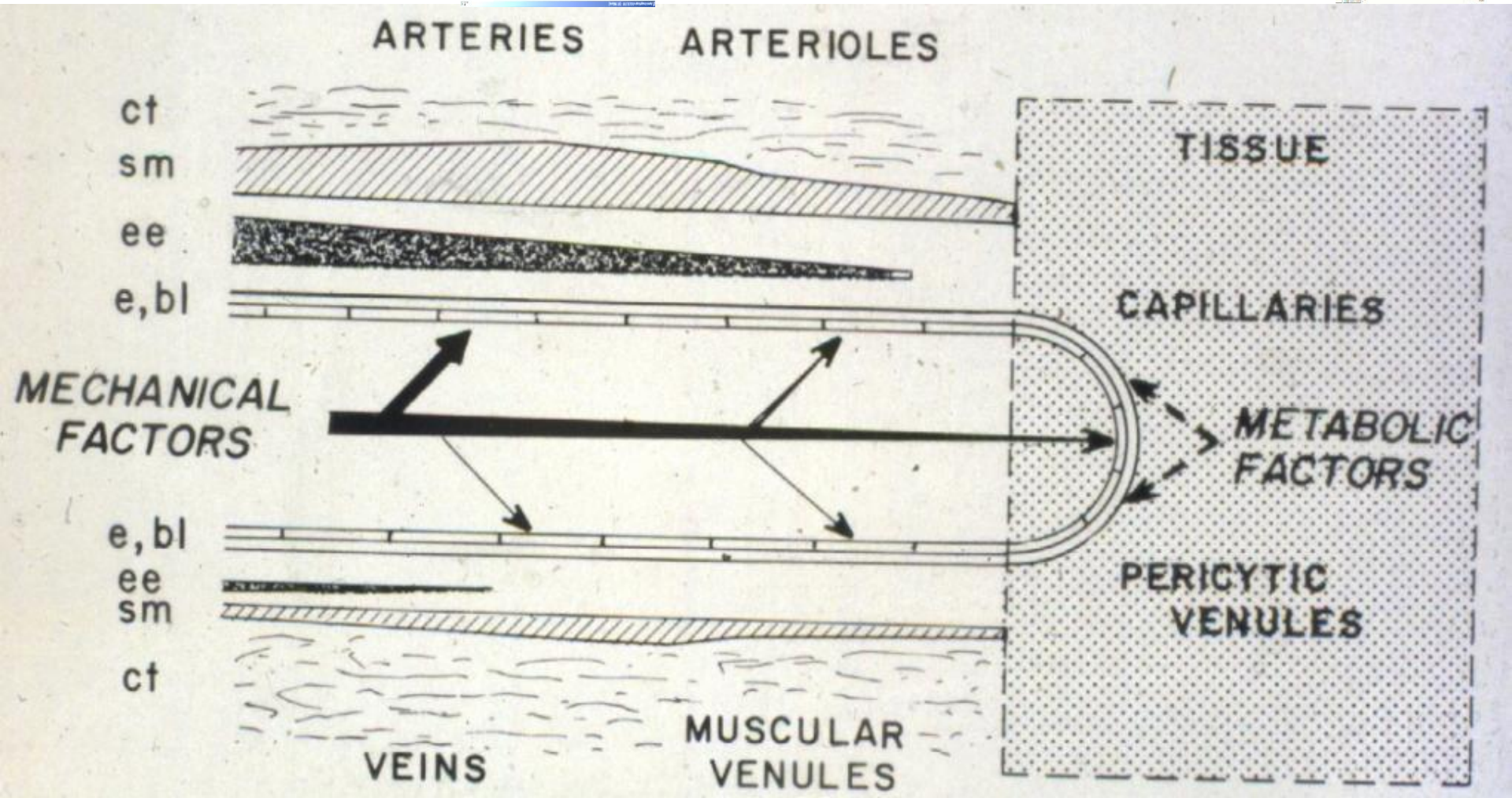


SUMMARY



Vessels are structurally adapted to physical and metabolic requirements.

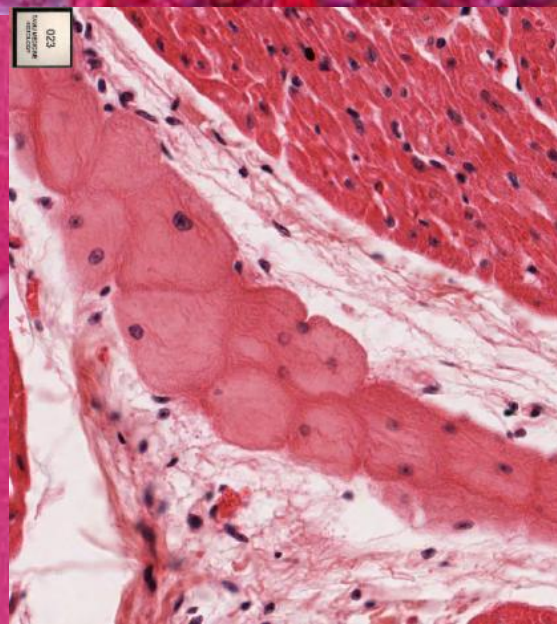




This concludes Part 1.

CARDIOVASCULAR SYSTEM PART 2

Dr. Larry Johnson



Objectives

Part 1

- Identify elastic and muscular arteries, arterioles, capillaries, venules and veins.
- Describe the intima, media, and adventitia of all vessels.

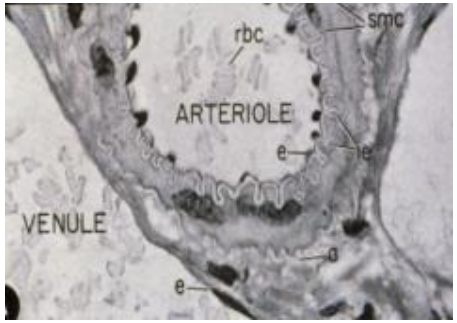
Part 2

- Describe the structure of the heart.
- Also regulation of blood flow, lymphatic vessels, and diseases

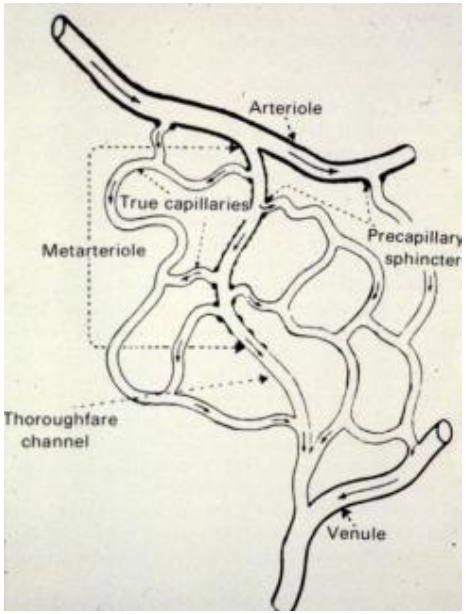
From: Douglas P. Dohrman and TAMHSC Faculty 2012 Structure and Function of Human Organ Systems, Histology Laboratory Manual

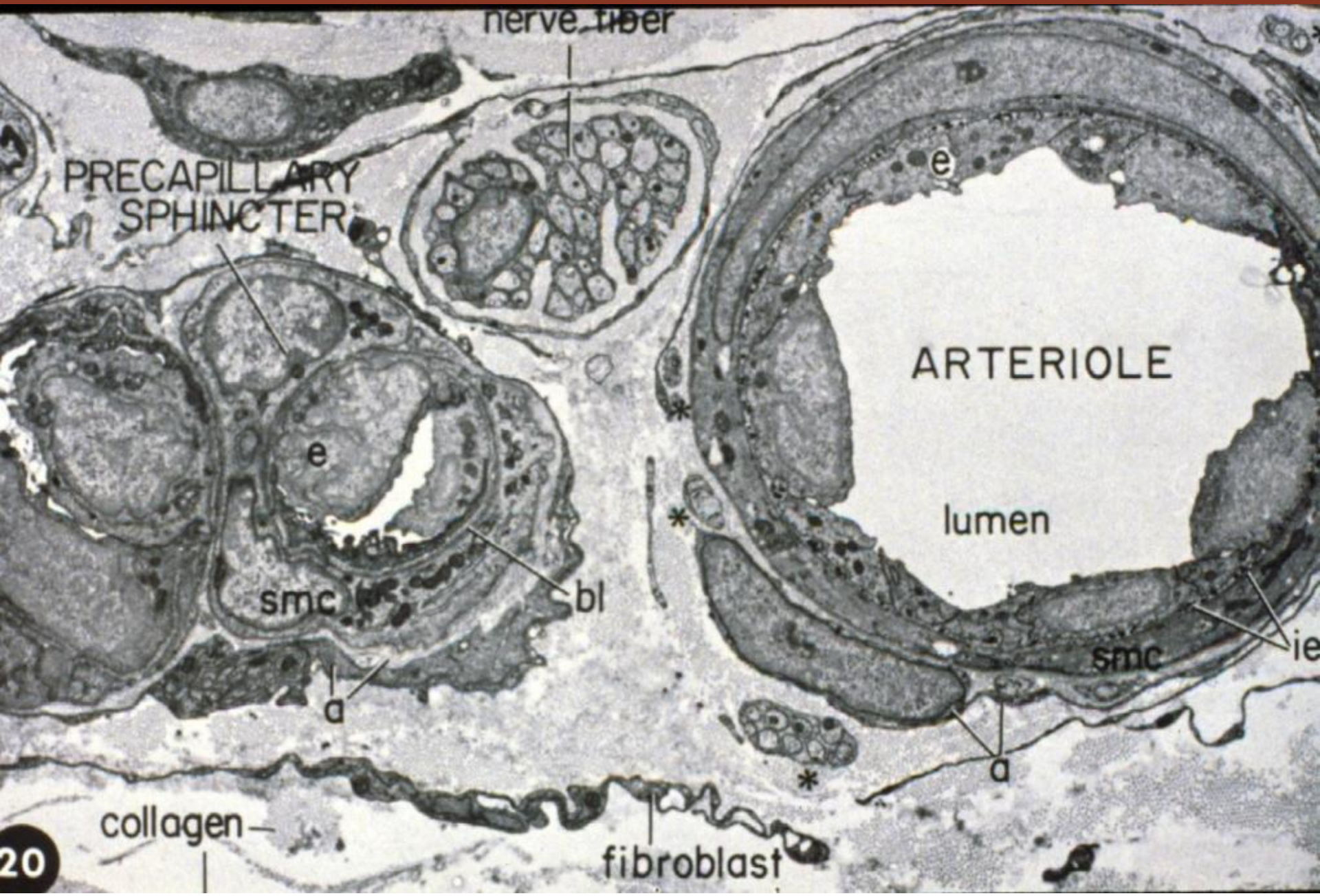
ARTERIOLAR FUNCTIONS

- ALLOW SUFFICIENT PRESSURE FOR FLOW THROUGH CAPILLARIES
- LOW ENOUGH PRESSURE TO PREVENT DAMAGE
- CONSTANT INTERMITTANCE OF BLOOD FLOW TO CAPILLARY BEDS



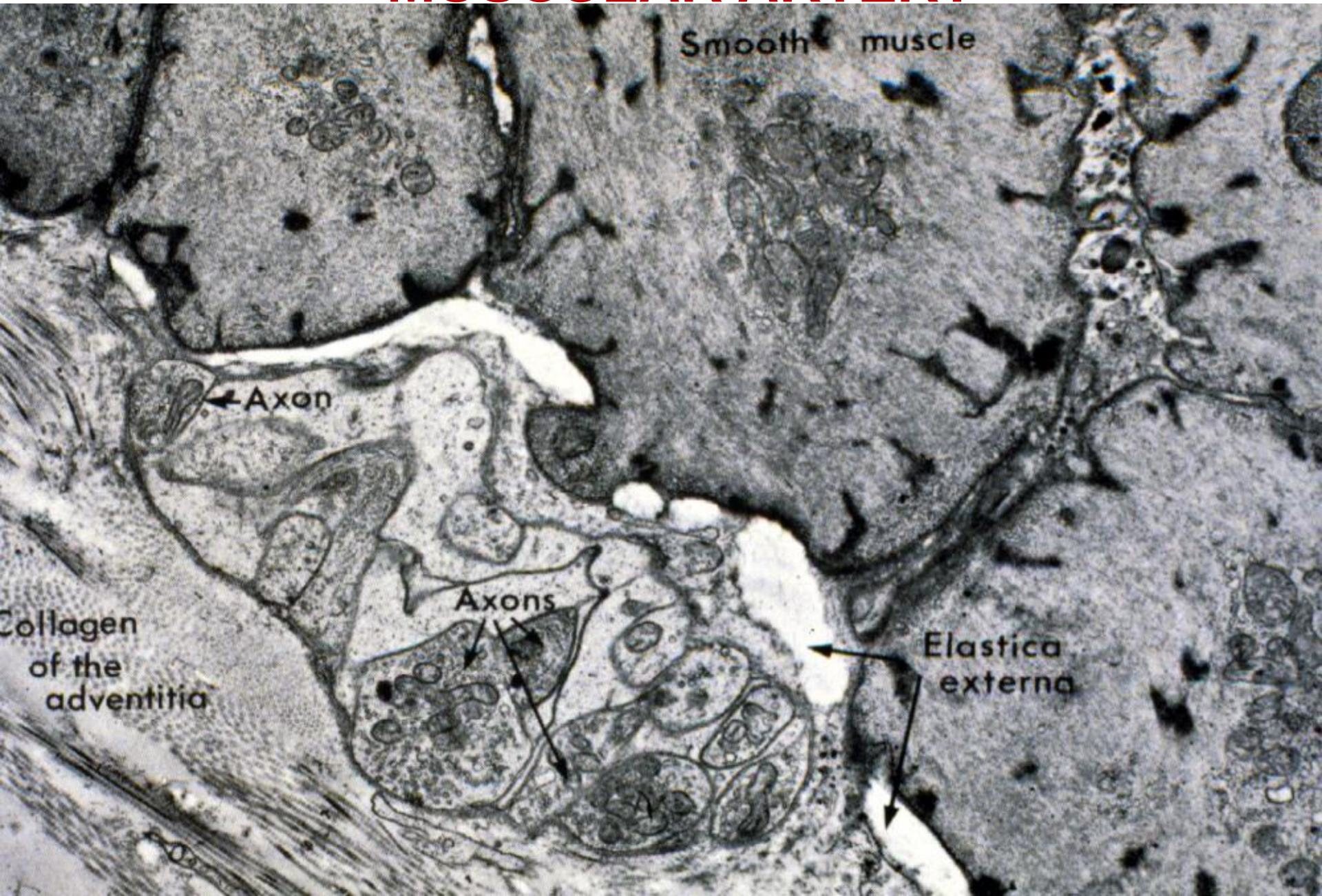
AUTOREGULATION - SMOOTH MUSCLE CELLS IN ARTERIOLES AND IN PRE-CAPILLARY SPHINCTERS RESPOND TO METABOLIC NEEDS, LOW O2 TENSION, THEN RELAX ⇨ INCREASED BLOOD FLOW (INDEPENDENT OF NERVOUS SYSTEM)

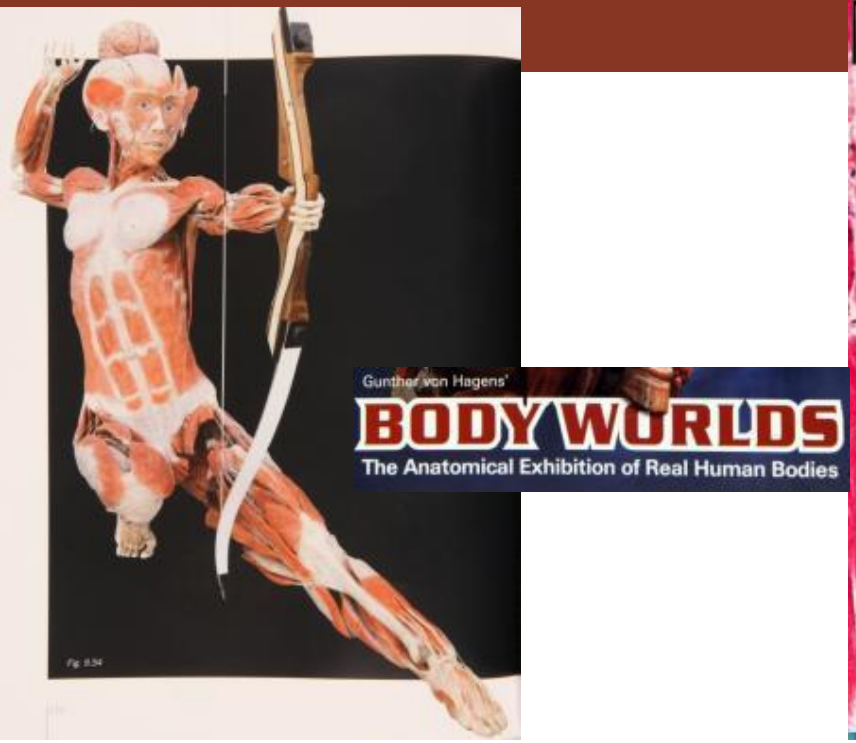


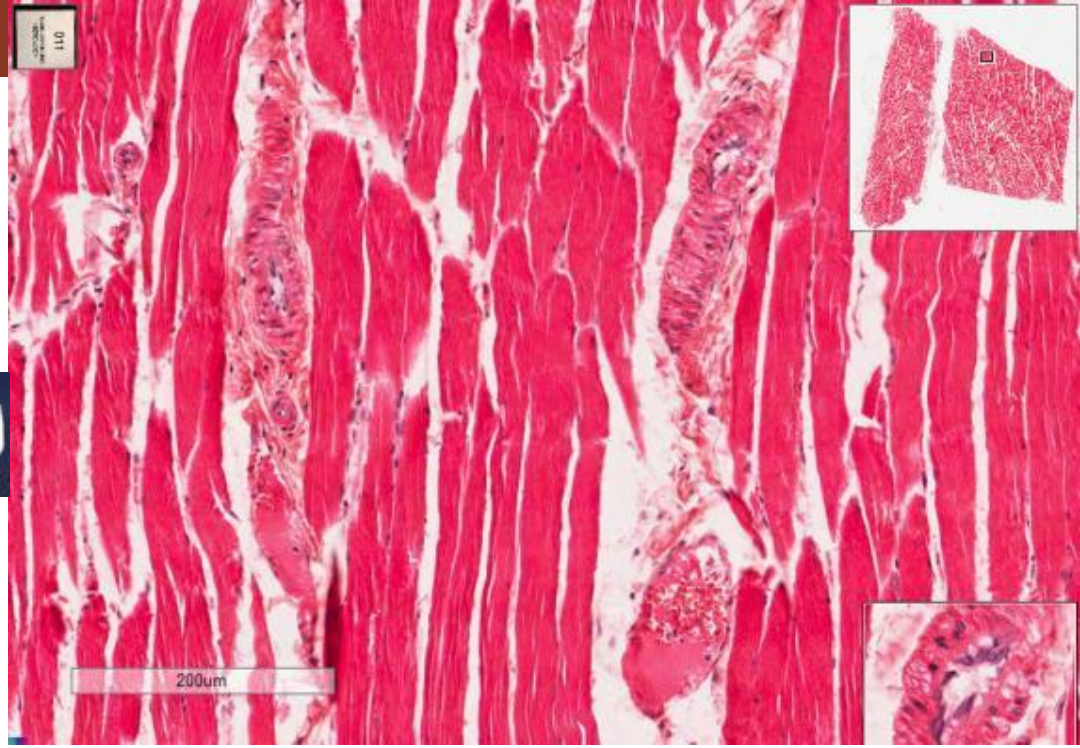

nerve fiber
PRECAPILLARY SPHINCTER
e
ARTERIOLE
lumen
smc
bl
a
collagen
fibroblast
ie

20

MUSCULAR ARTERY

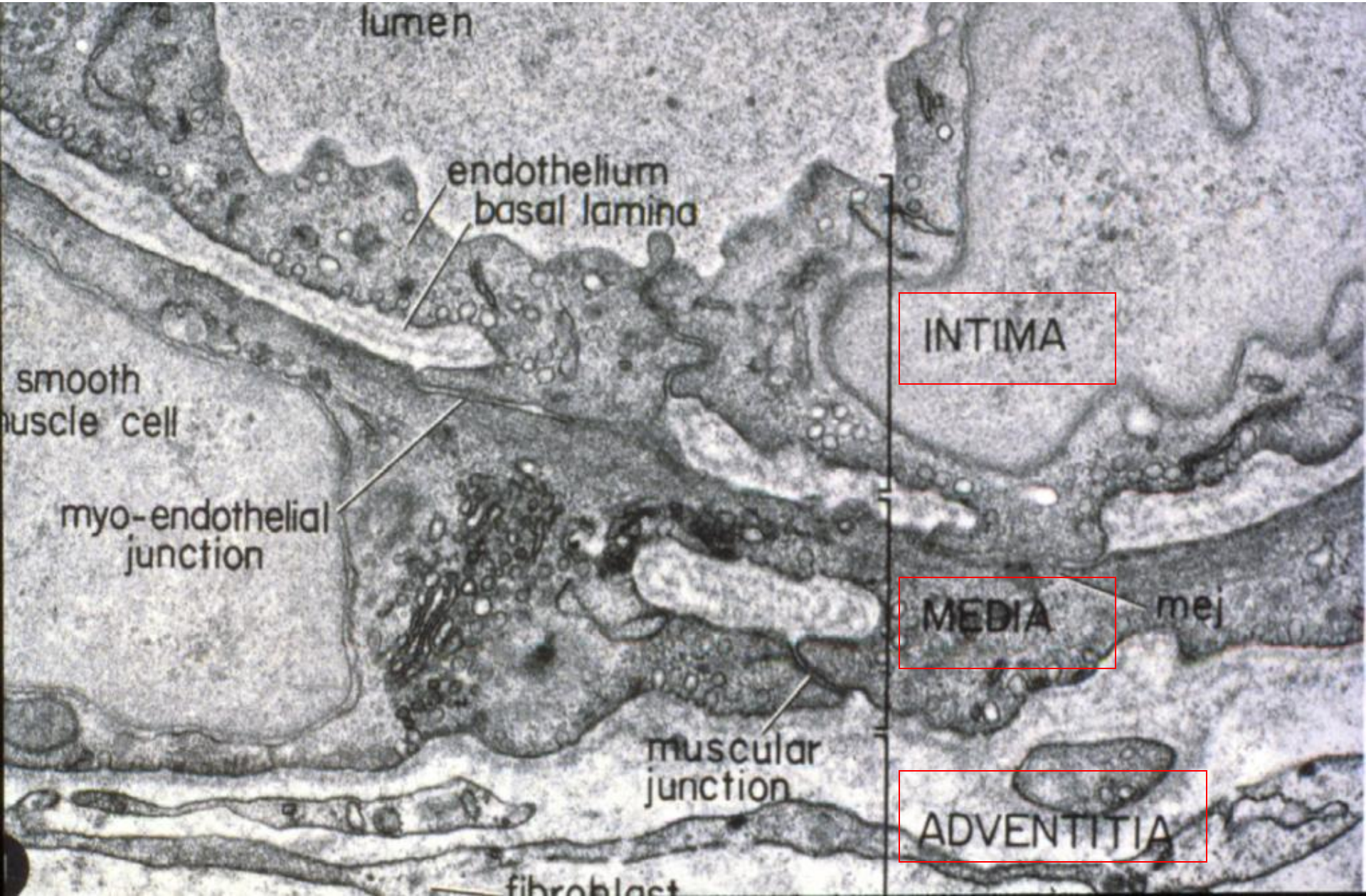




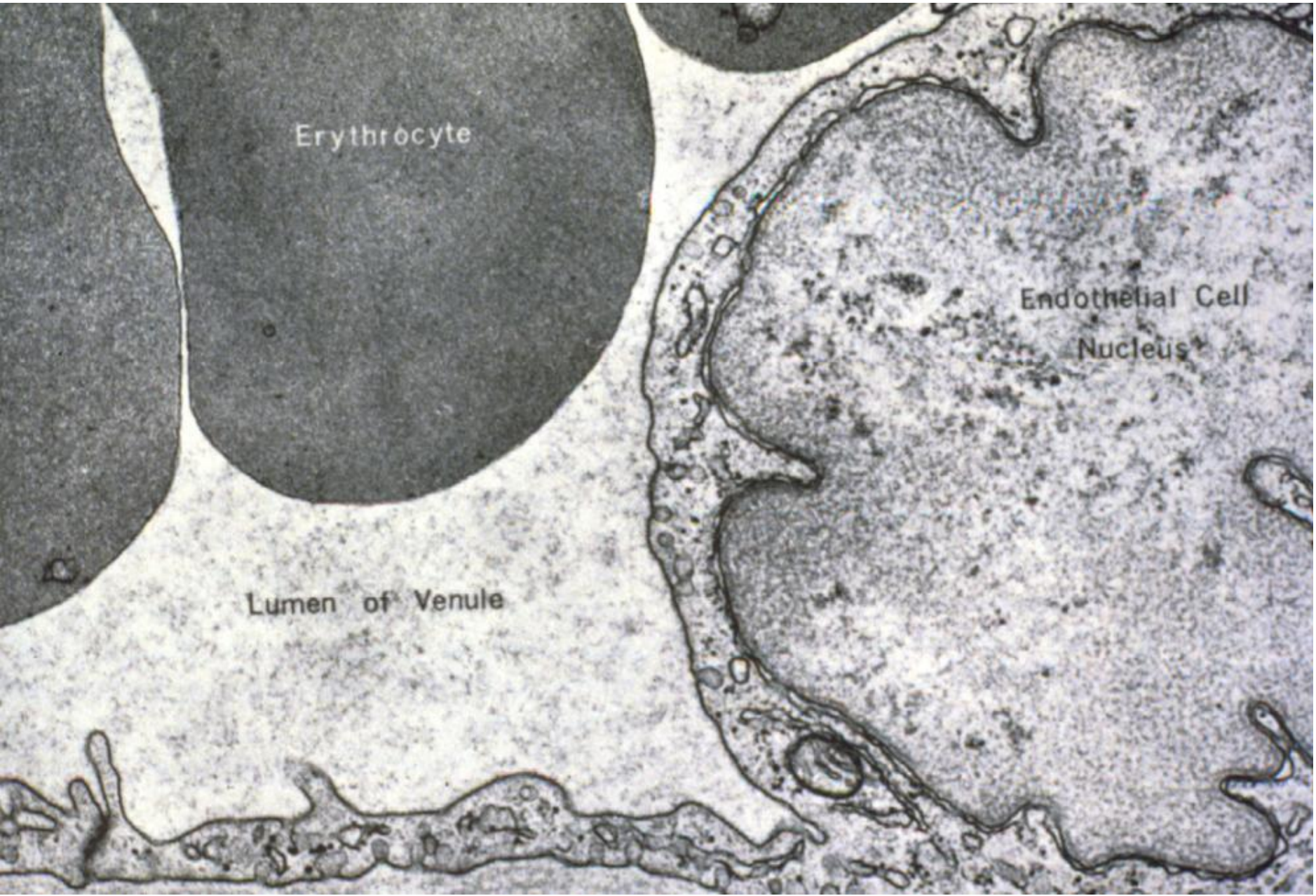


During exercise, the increase of blood flow to skeletal muscle is primarily the result meeting the metabolic needs (e.g., low O2 levels reduces the contraction of smooth muscle and their constriction of arteriolar blood flow) of the tissue due to local, nervous, and hormonal regulatory mechanisms. Also, there will be an increased heart rate.

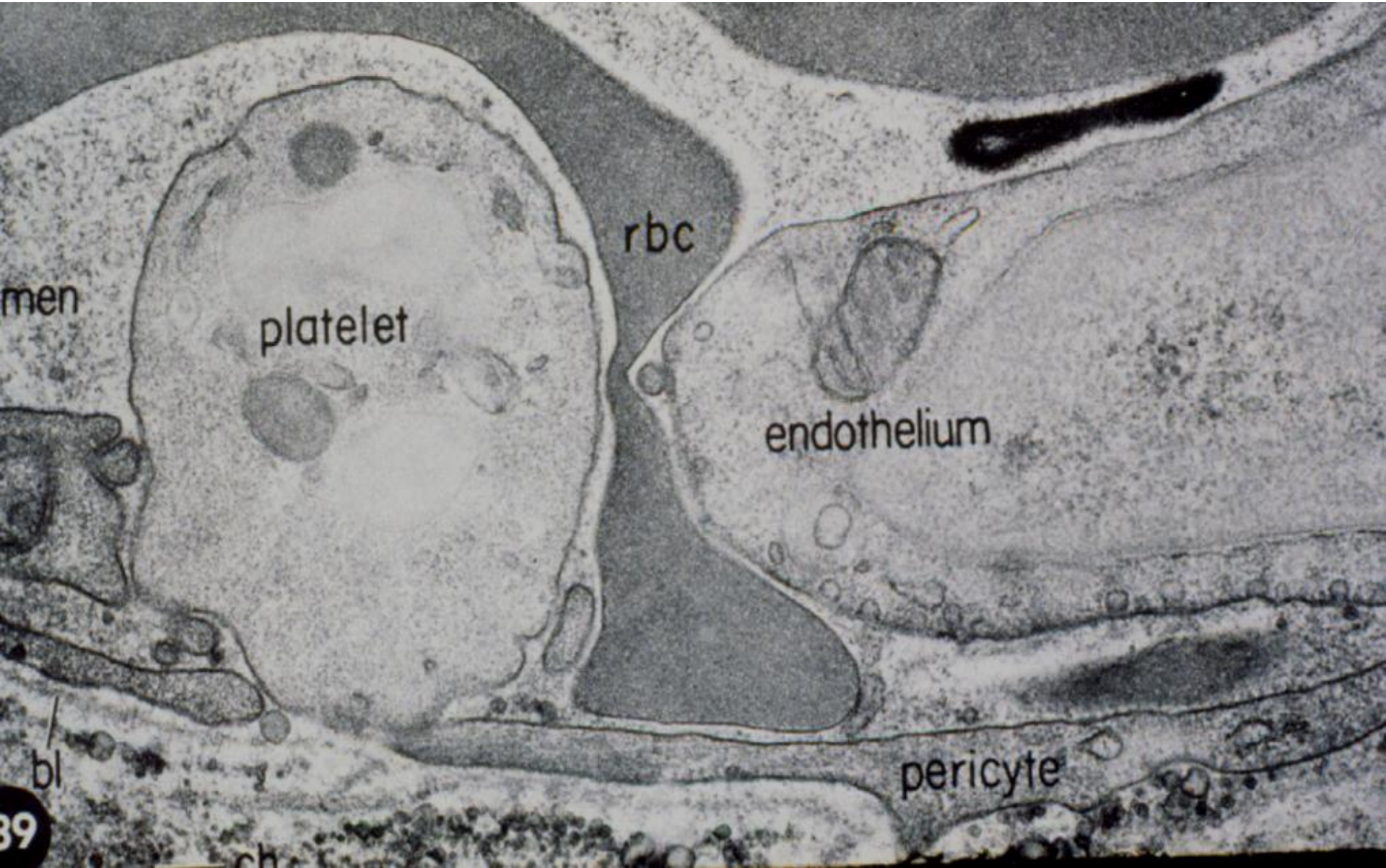
ARTERIOLE


lumen
endothelium
basal lamina
INTIMA
smooth
uscle cell
myo-endothelial
junction
MEDIA
mej
muscular
junction
ADVENTITIA
fibroblast

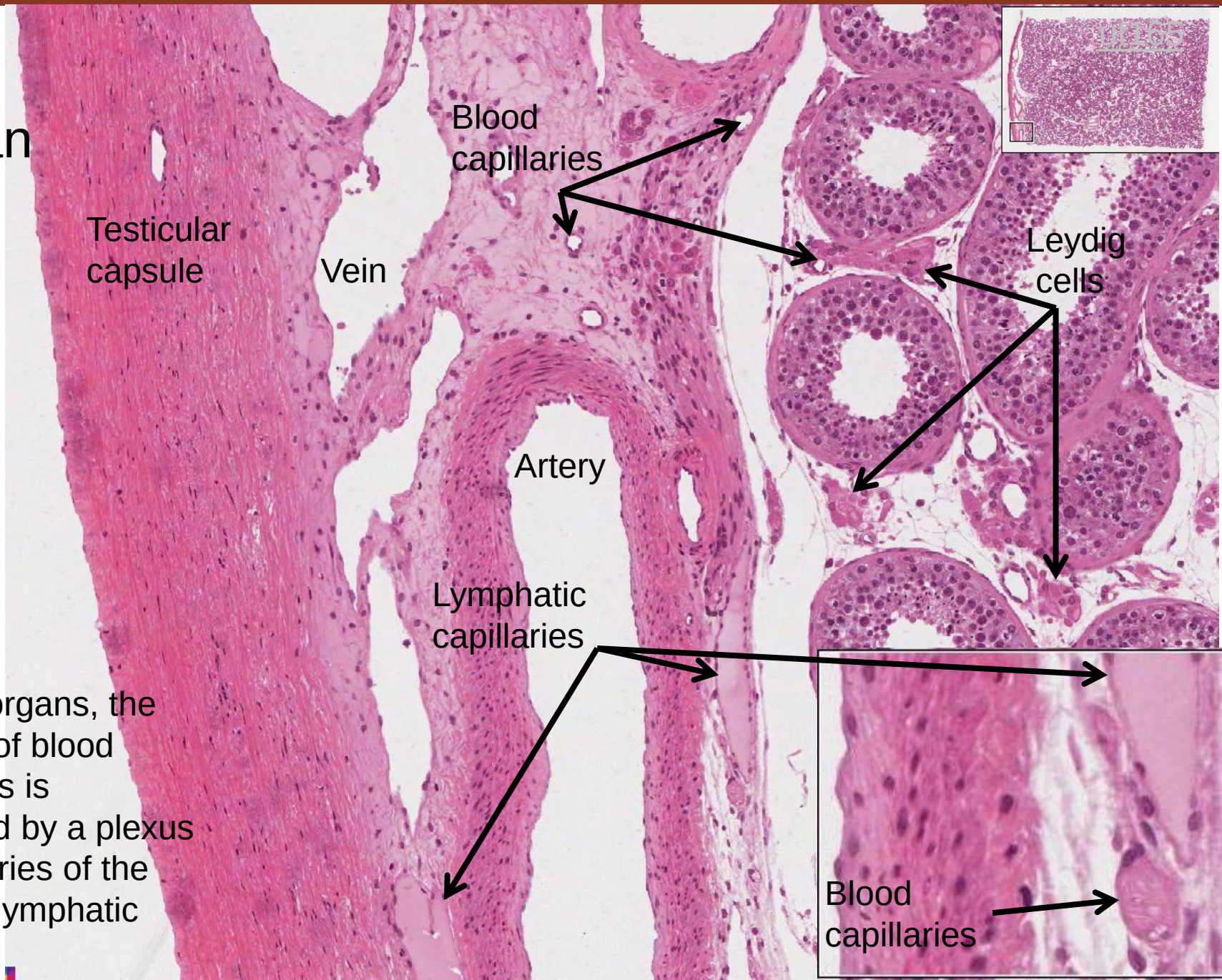
VENULE



VENULE COLLECT BLOOD FROM CAPILLARIES (EDEMA)



Human testis

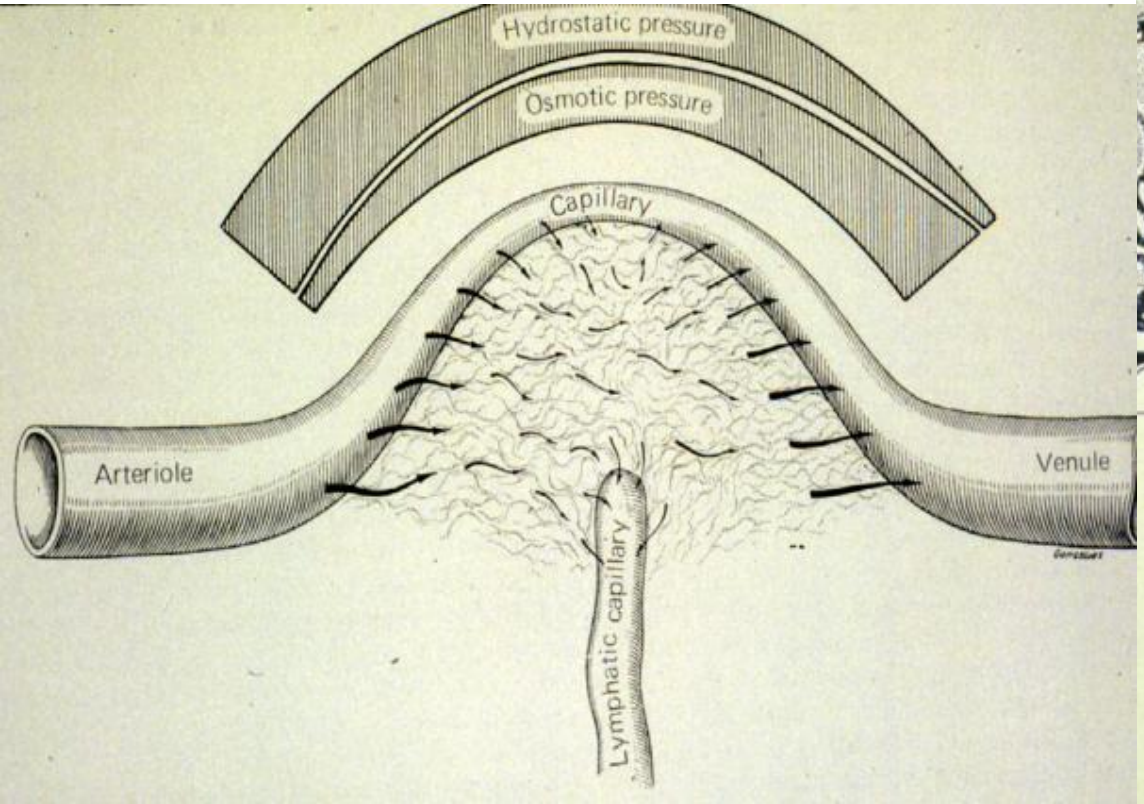


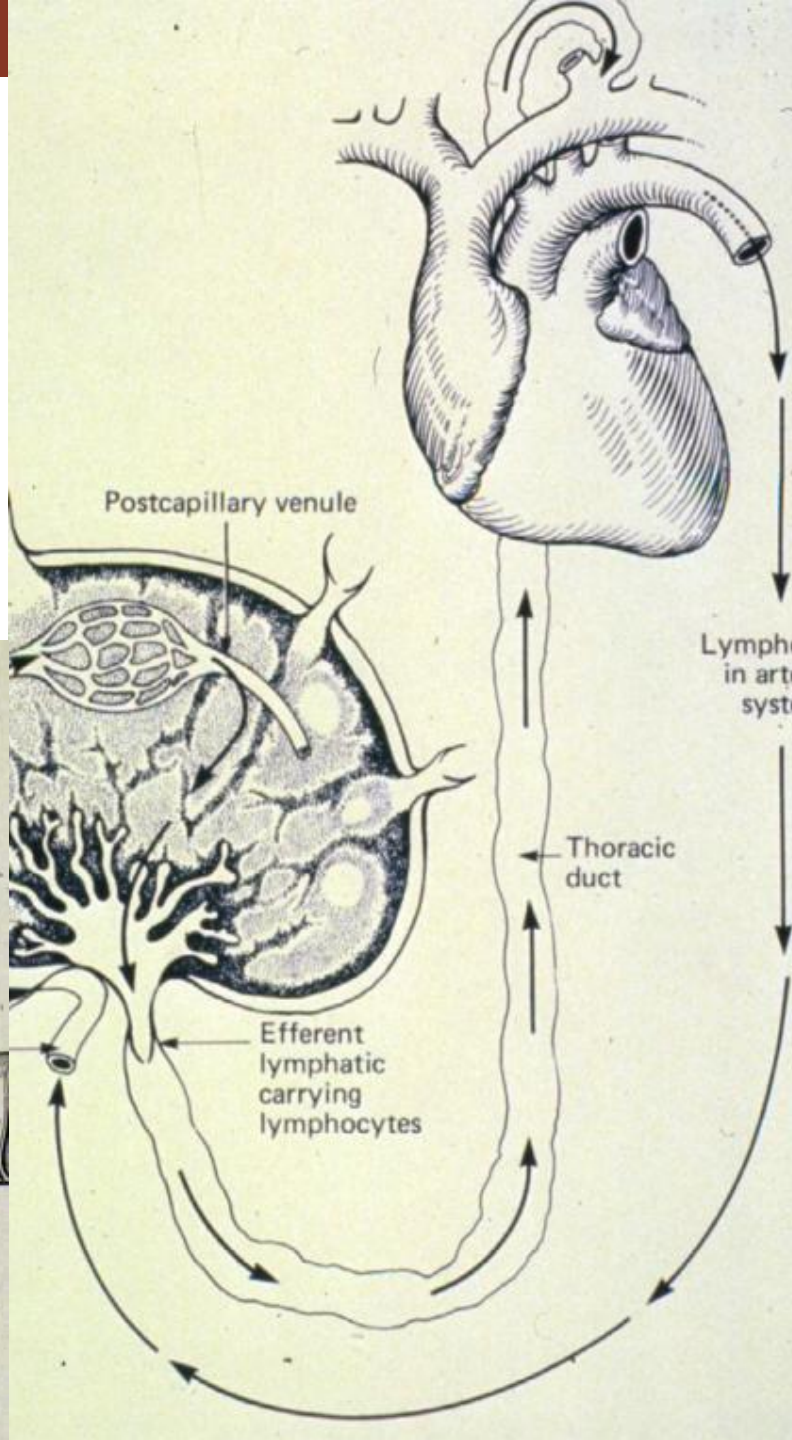
In most organs, the network of blood capillaries is paralleled by a plexus of capillaries of the draining lymphatic system.

LYMPH VESSELS

FUNCTIONS

RETURN PROTEIN, FLUID, AND BLOOD CELLS





LYMPH VESSELS

LYMPH FLOW

- COMPRESSION OF LYMPHATIC VESICLES (MUSCLES, PULSATING BLOOD VESSELS)

UNIDIRECTIONAL FLOW

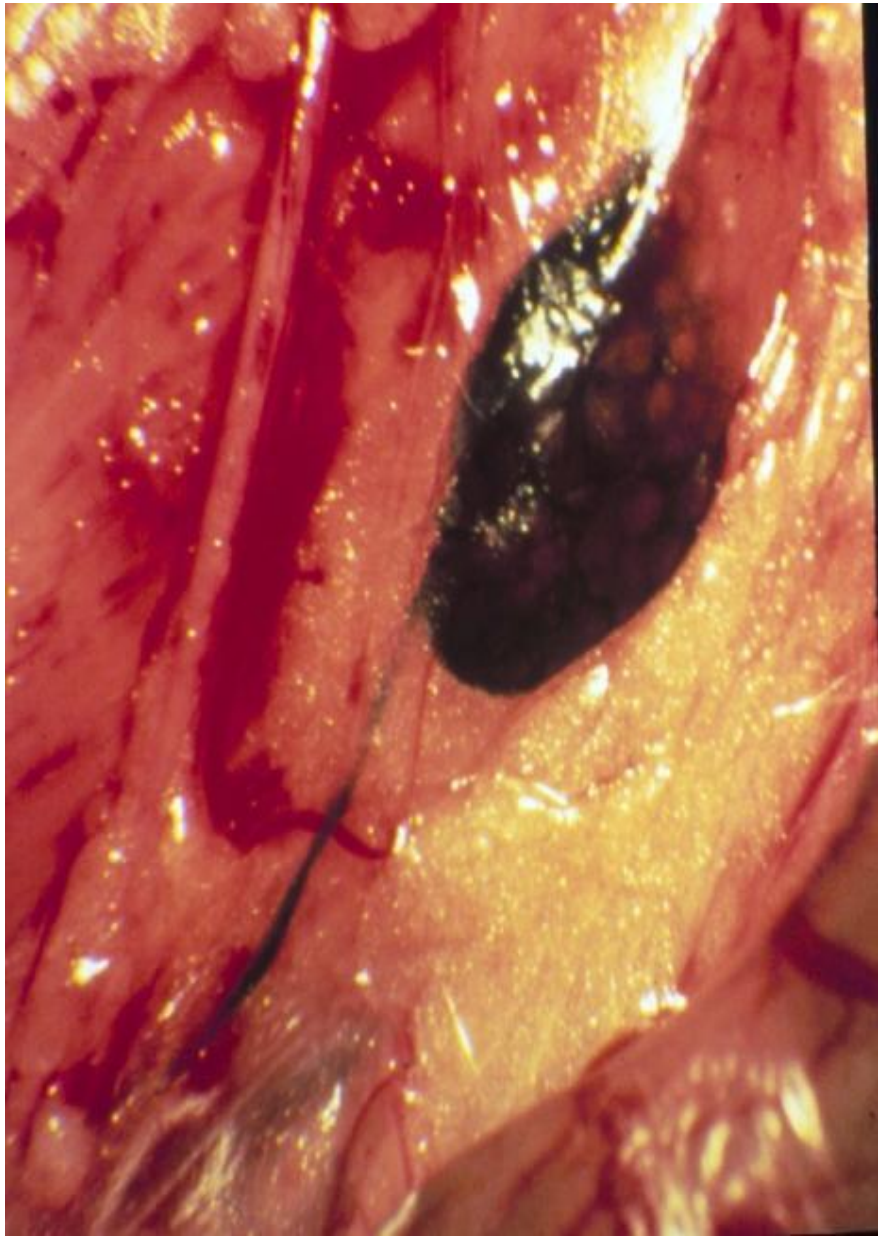
- CONTROLLED BY VALVES

FLOW RATE

- REMARKABLY RAPID

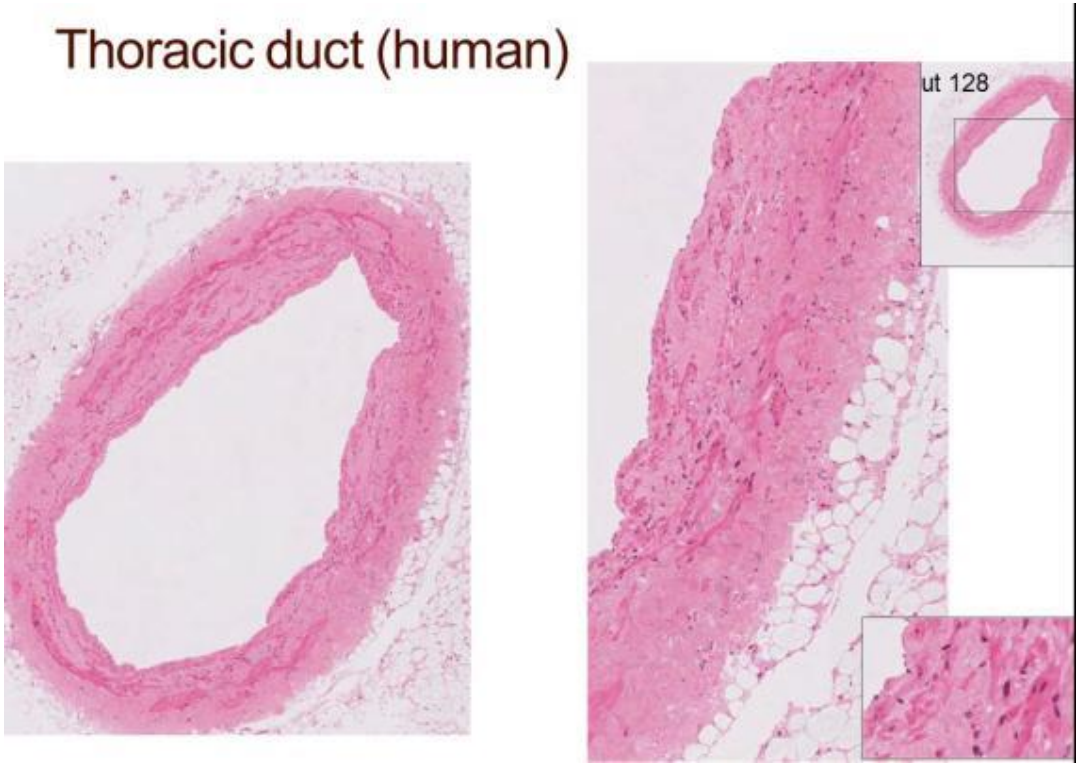
ANCHORING DEVICE

- VESSELS OPEN



Drainage and the function of lymph vessels

- Function: collect excess interstitial fluid “lymph” from tissue and return it to the blood
- Drain: starts as lymph capillaries to lymph vessels to lymph nodes for filtration then to lymph ducts (thoracic, tracheal duct, and right lymphatic) that empty into the blood stream.



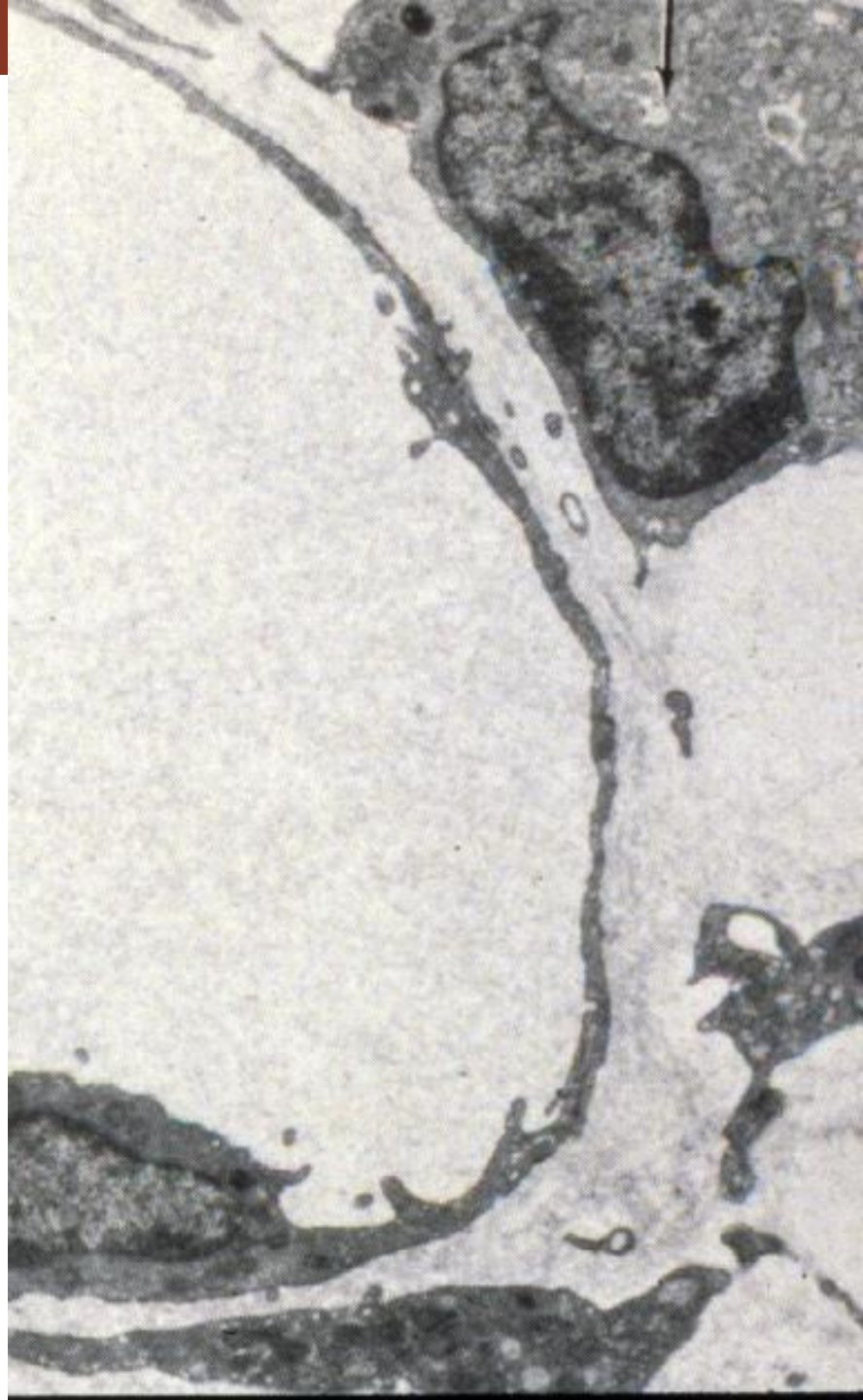
LYMPH VESSELS

TRANSPORT ACROSS
TRANSIT VESICLES

CAPILLARIES

INTERCELLULAR

JUNCTIONS



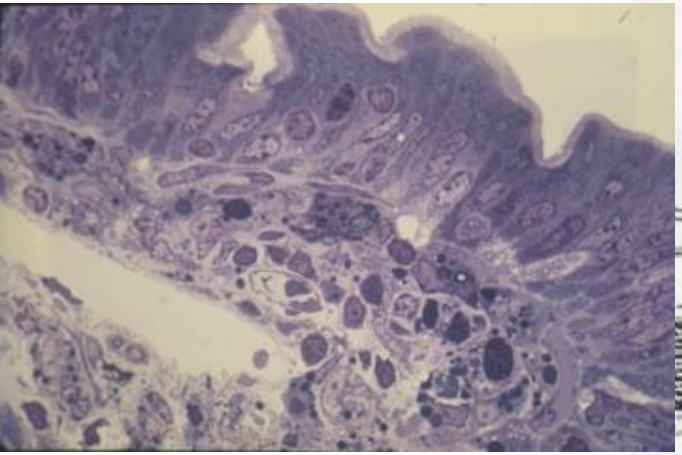
LYMPH VESSELS

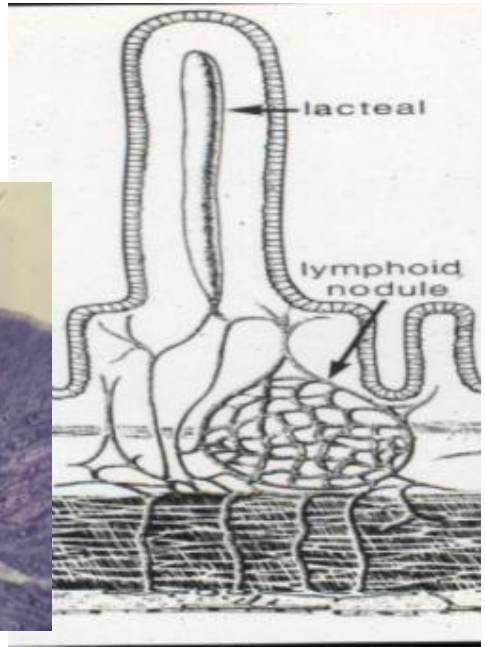
FUNCTIONS

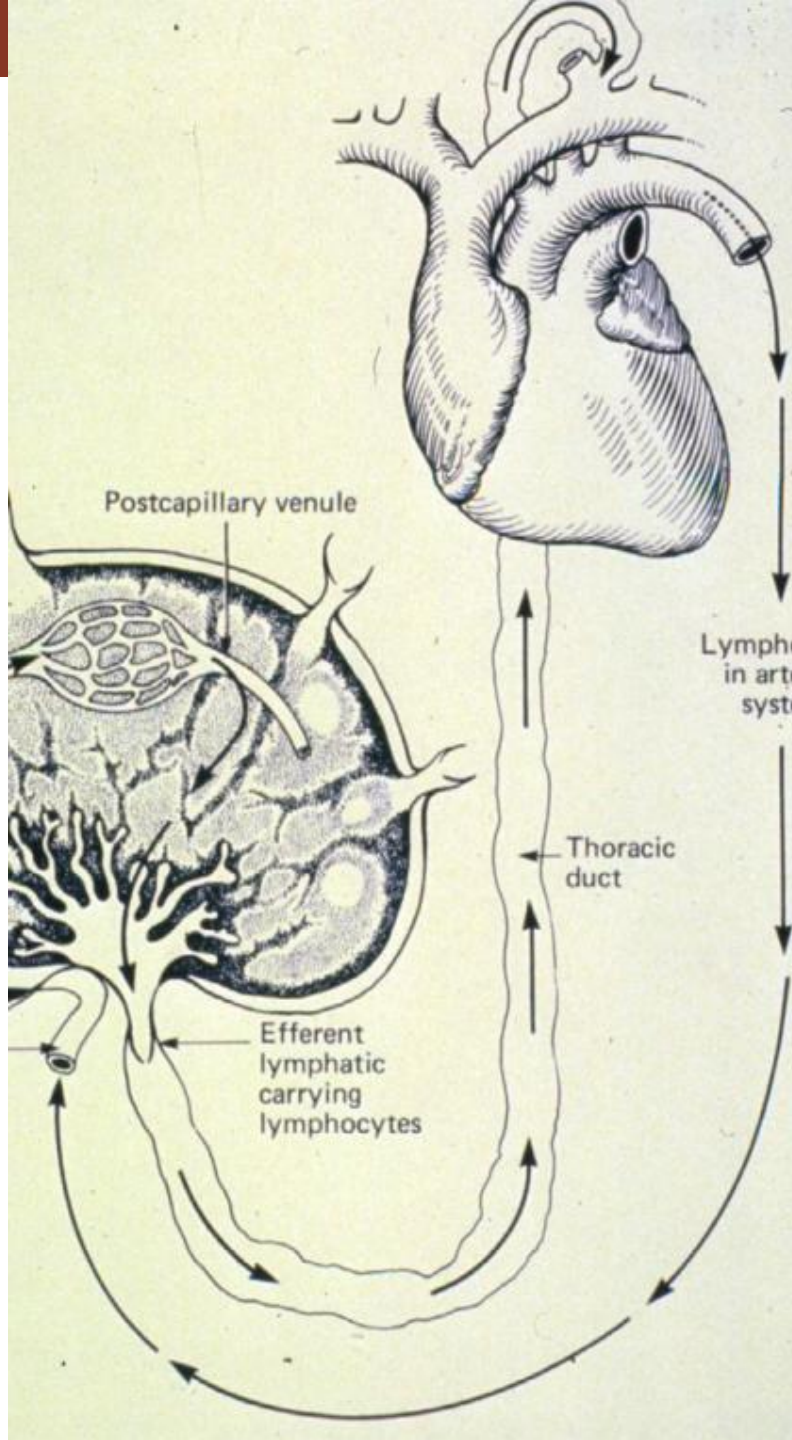
RETURN PROTEIN, FLUID, AND BLOOD CELLS

TRANSPORT SECRETIONS (HORMONES, ANTIBODIES)

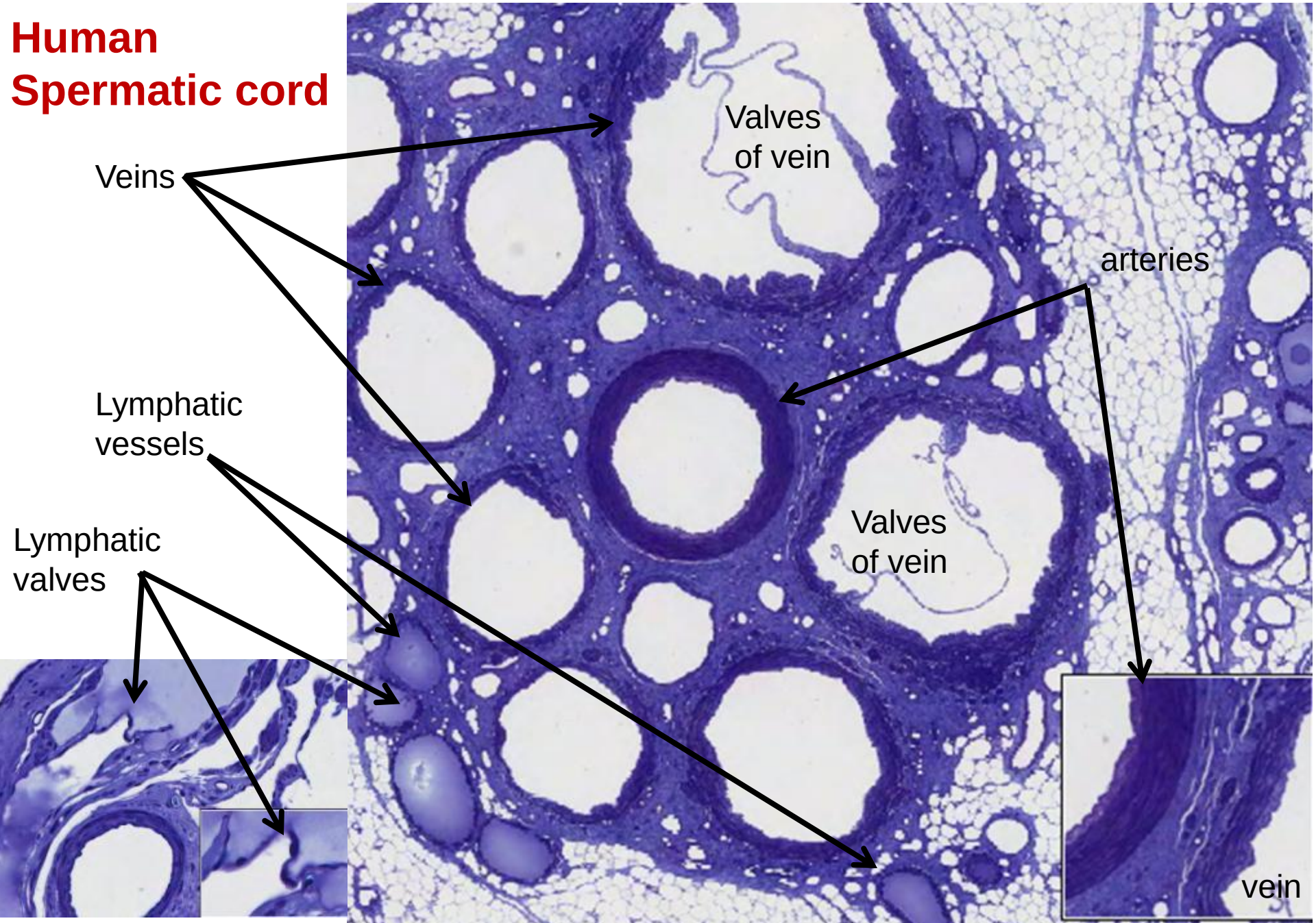
TRANSPORT FAT (NEUTRAL FAT)



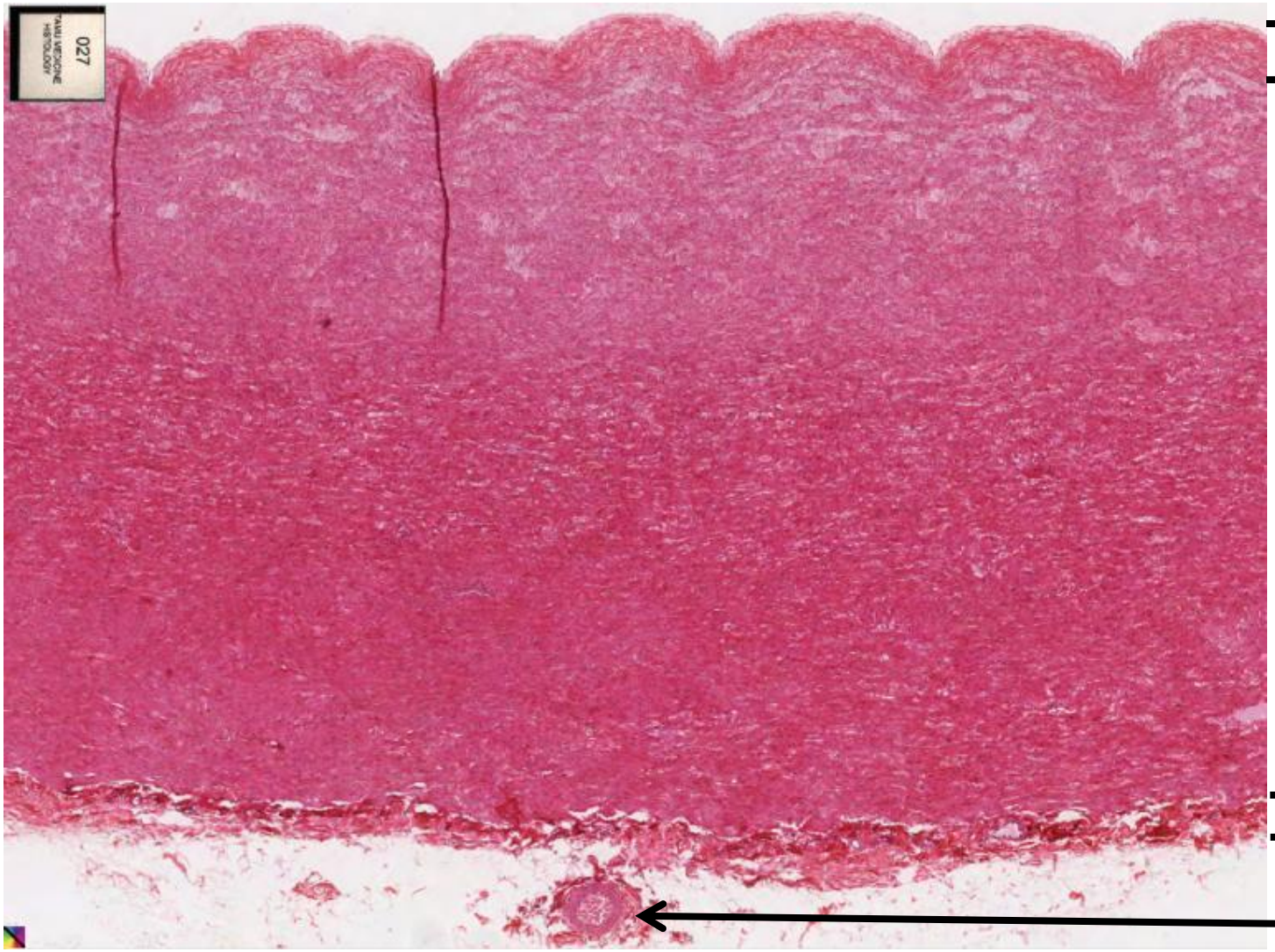




Human Spermatic cord



Slide 27: Aorta (elastic/conducting artery)



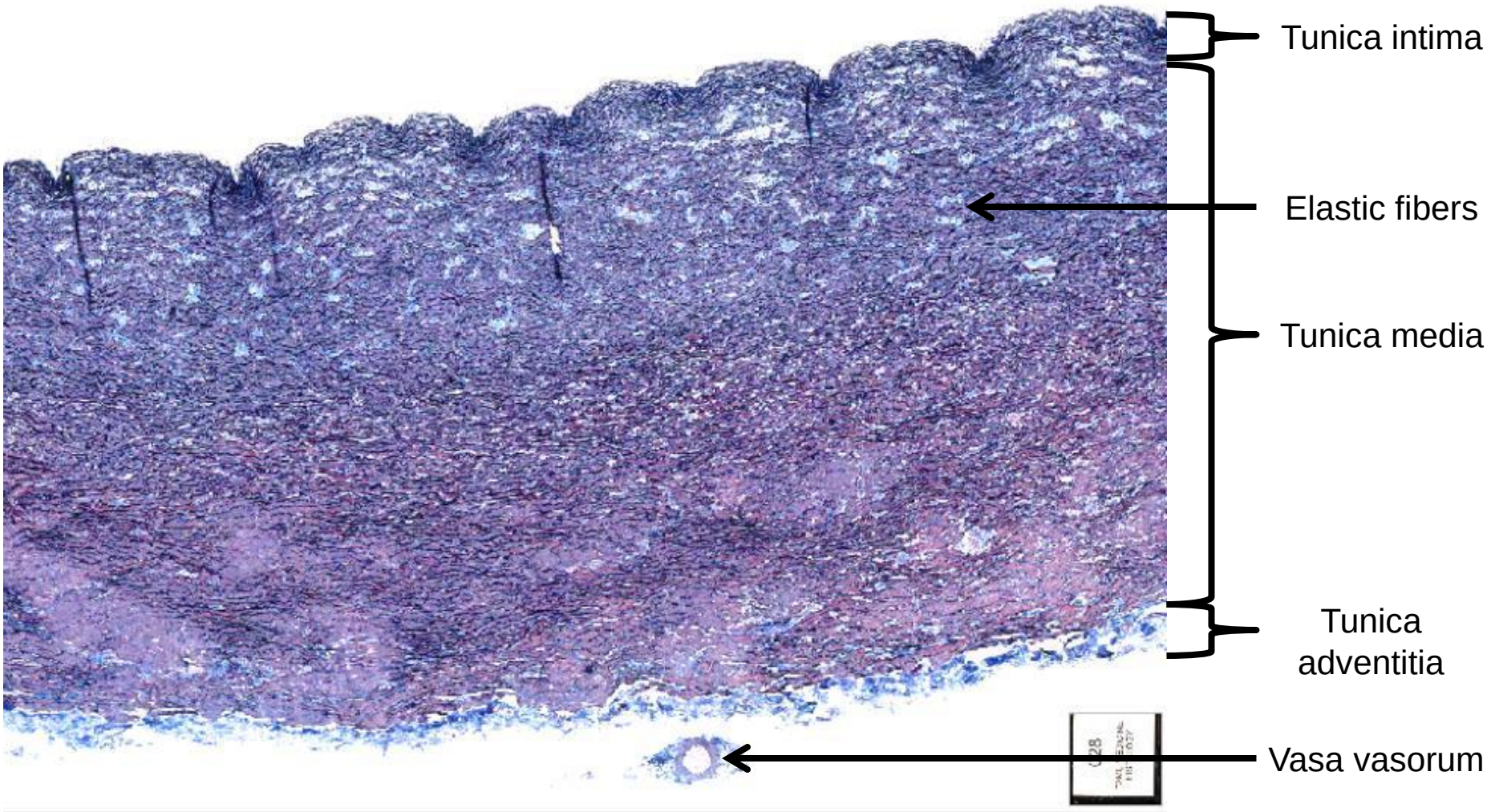
Tunica intima

Tunica media

Tunica adventitia

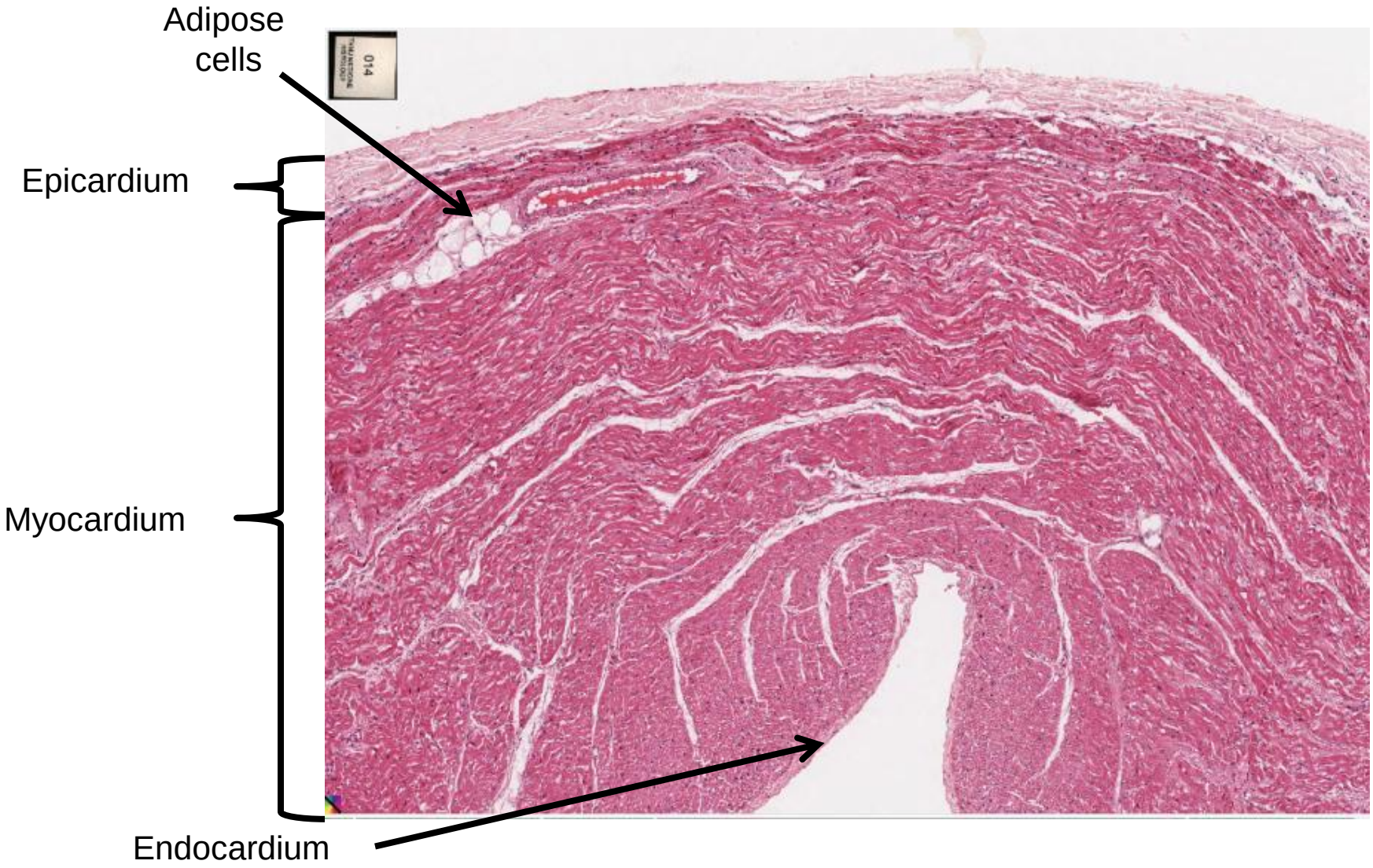
Vaso vasorum

Slide 28: Aorta (Verhoeff's and trichrome stains)

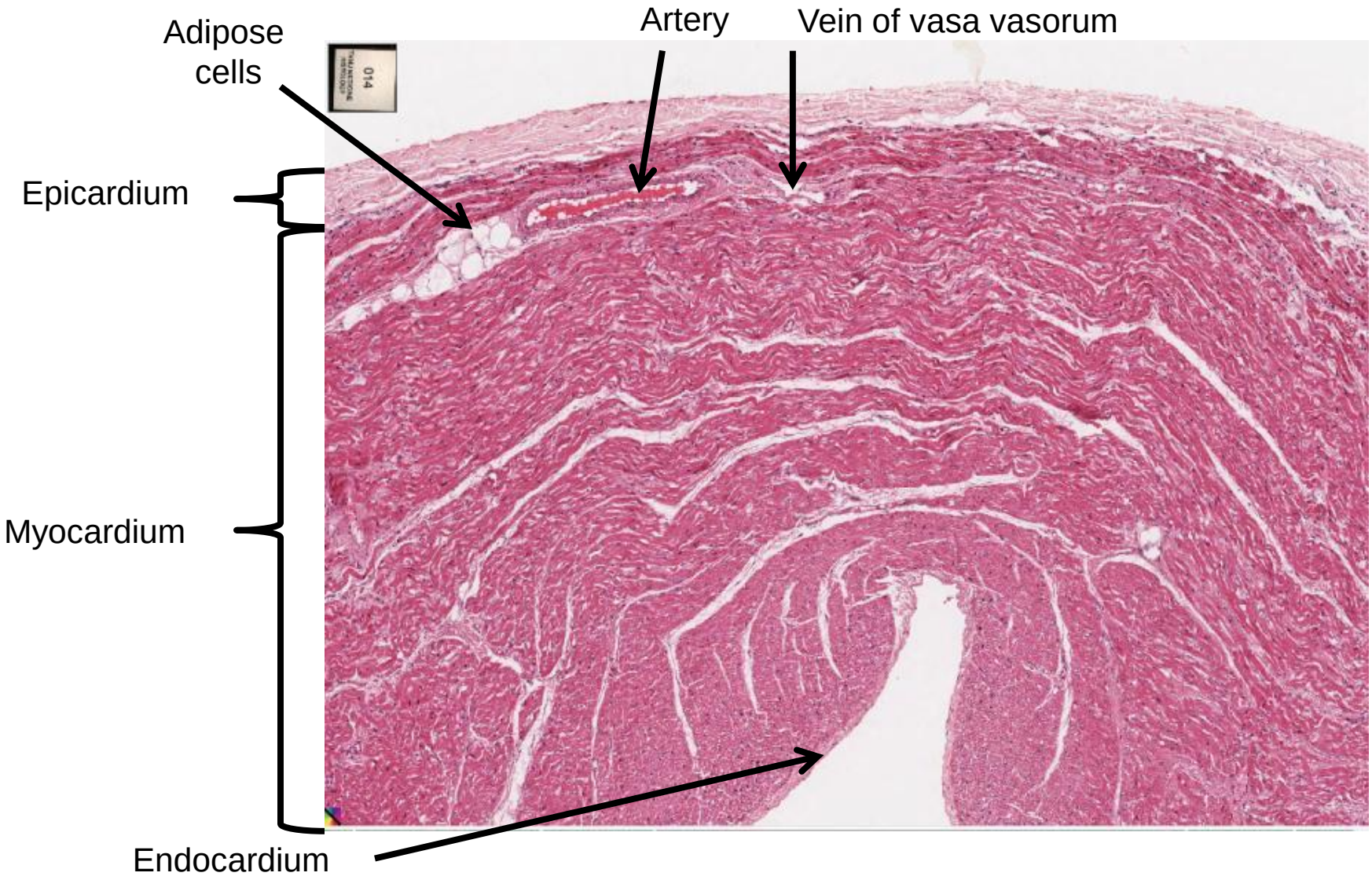


Slide 14: Heart (right ventricle)

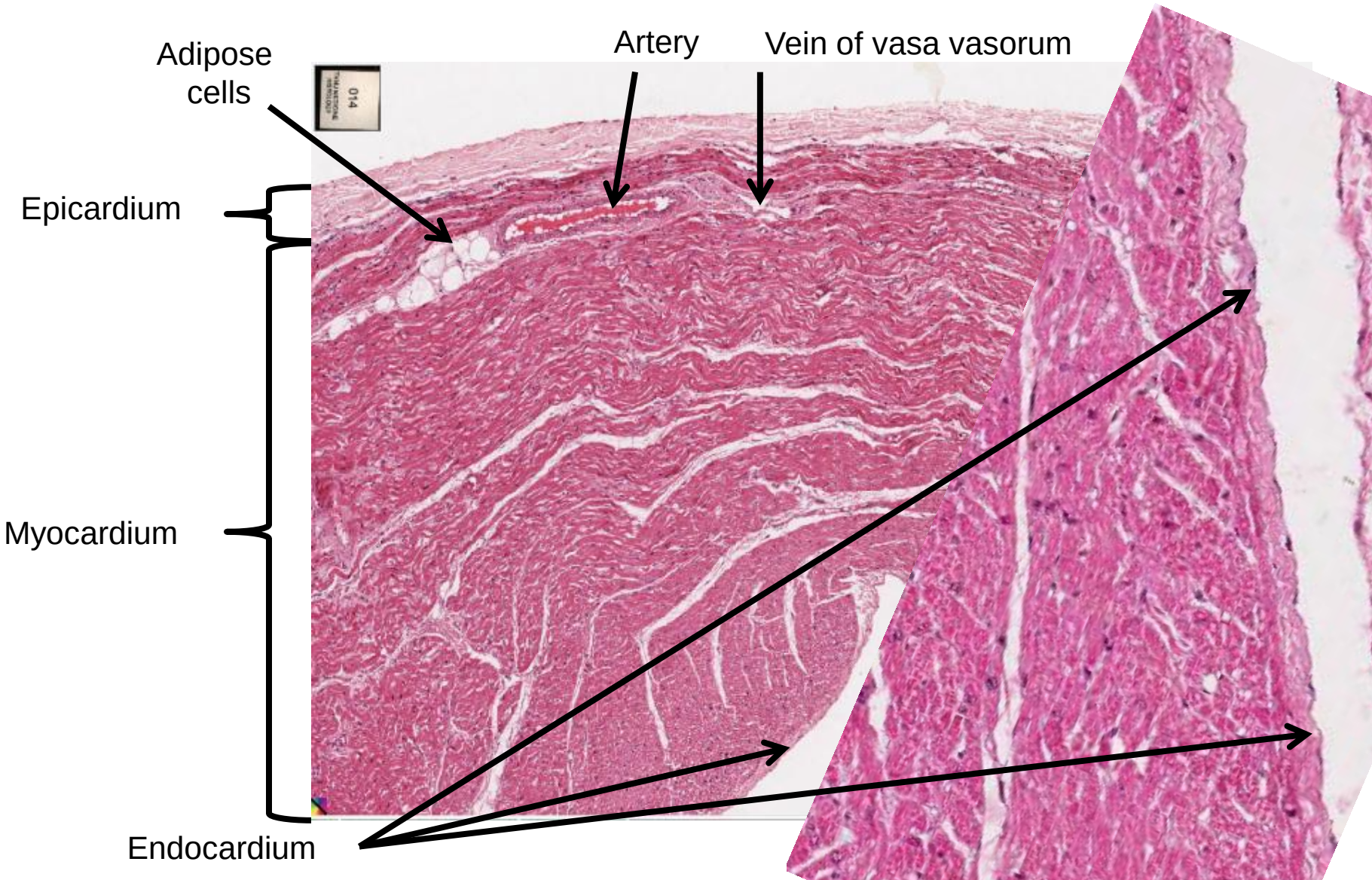
Slide 14: Heart (right ventricle)

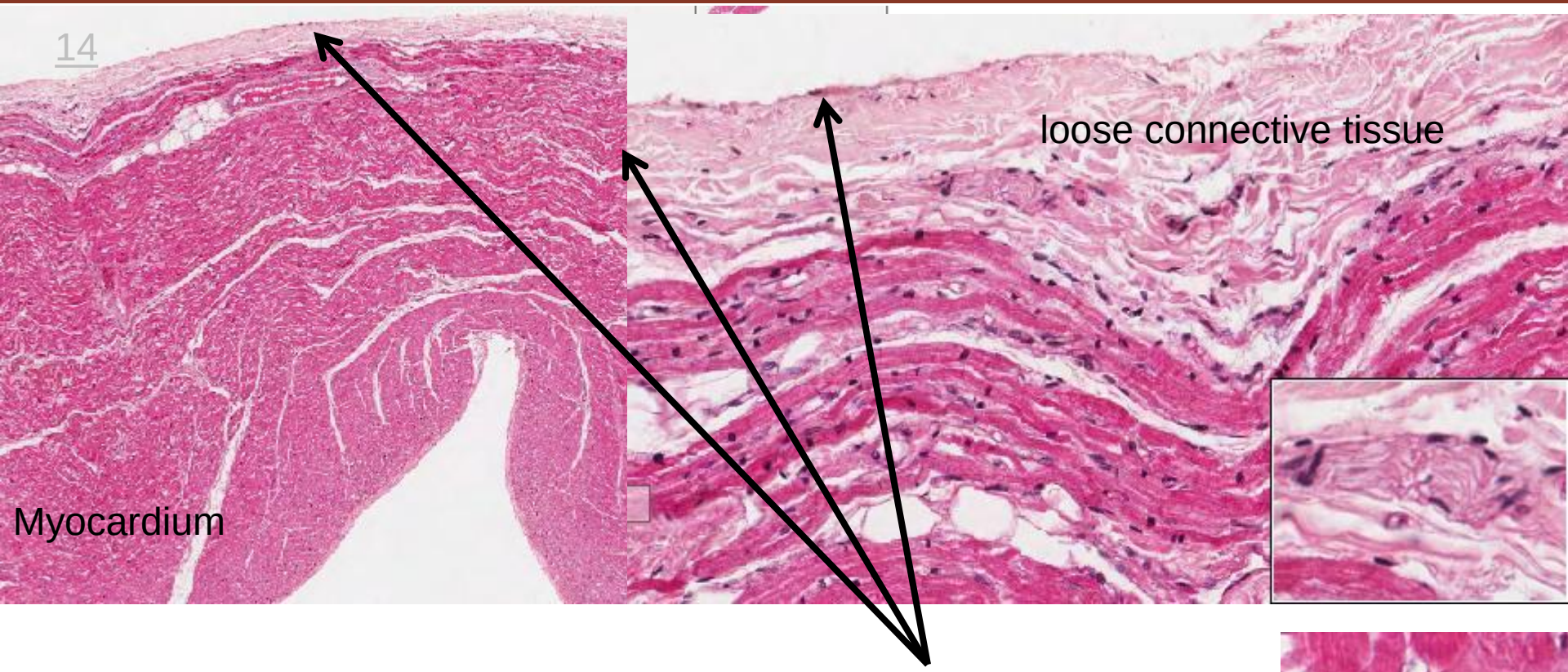


Slide 14: Heart (right ventricle)

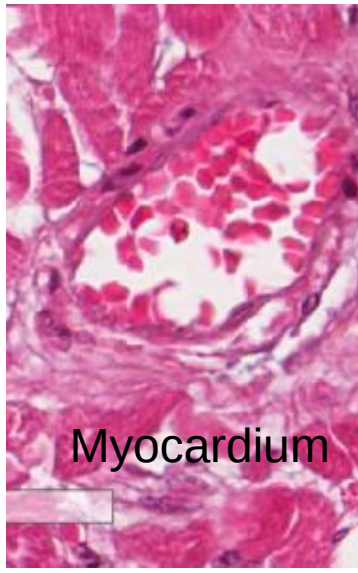


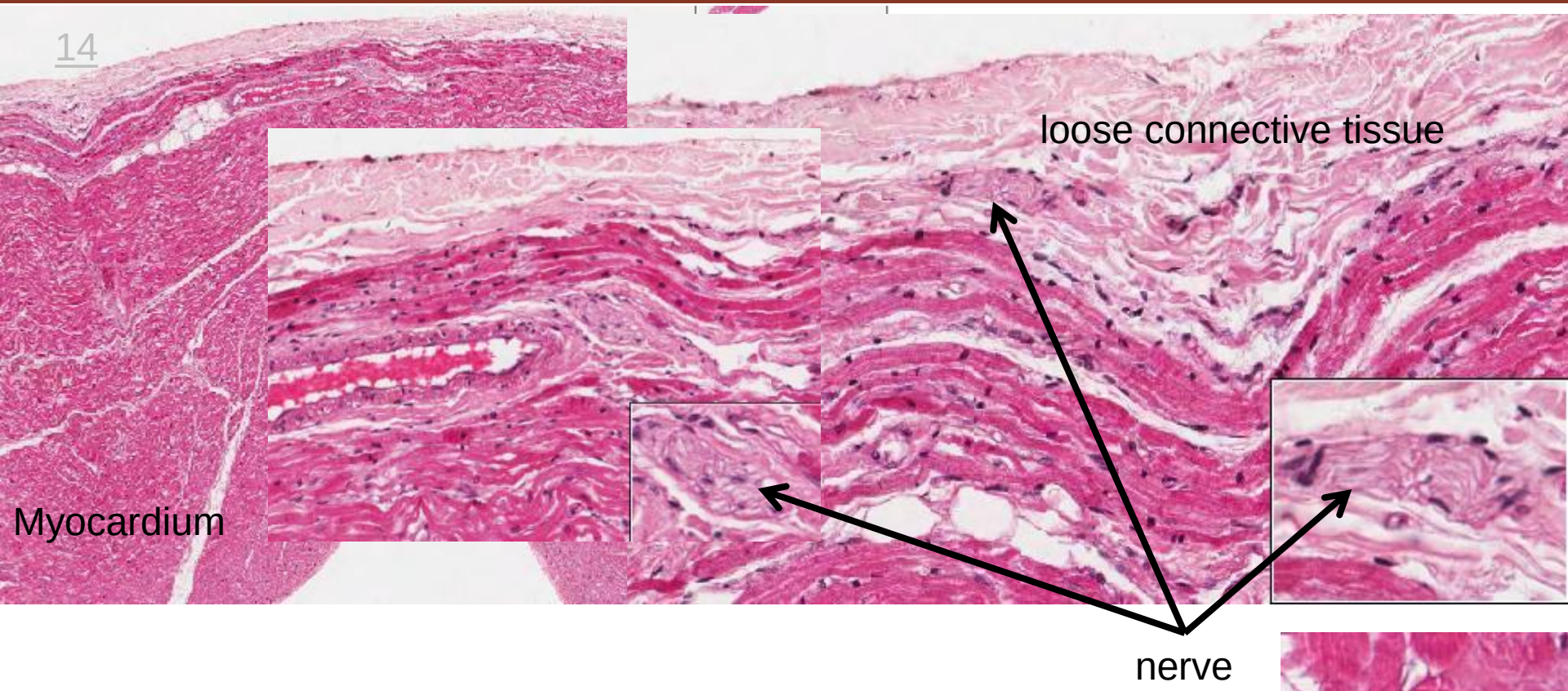
Slide 14: Heart (right ventricle)





The epicardium is a simple squamous mesothelium supported by a layer of loose connective tissue containing blood vessels and nerves. Also there are blood vessels in the myocardium too.





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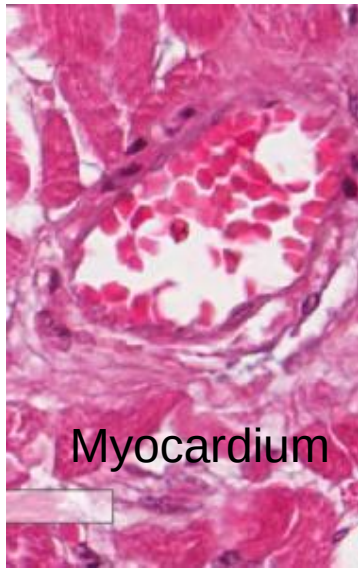

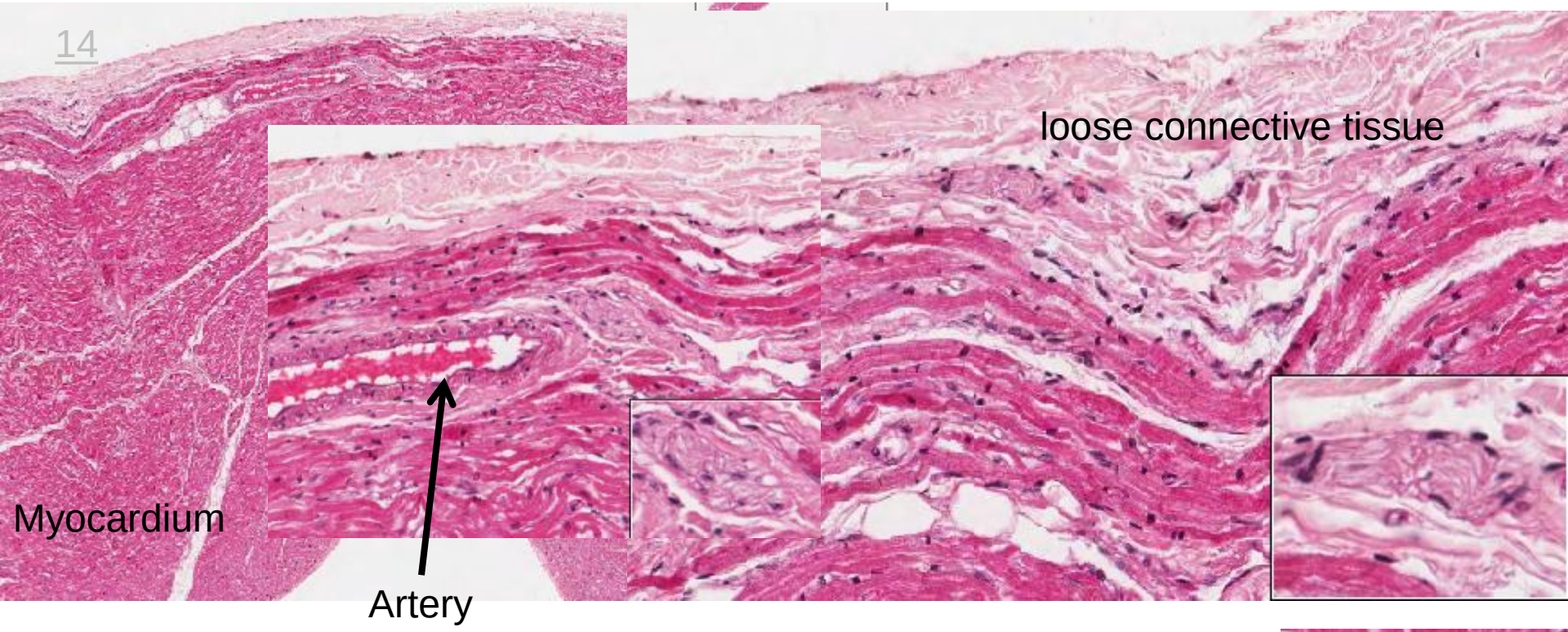

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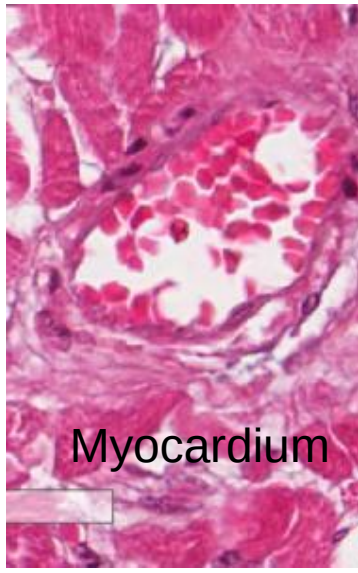

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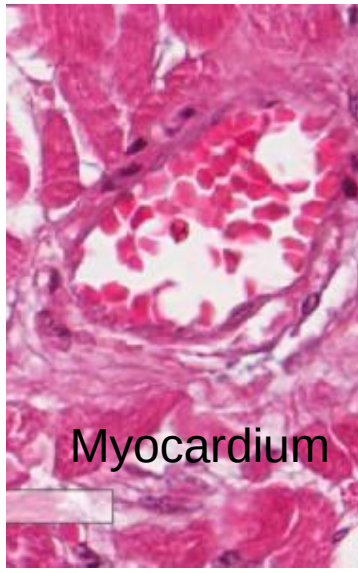
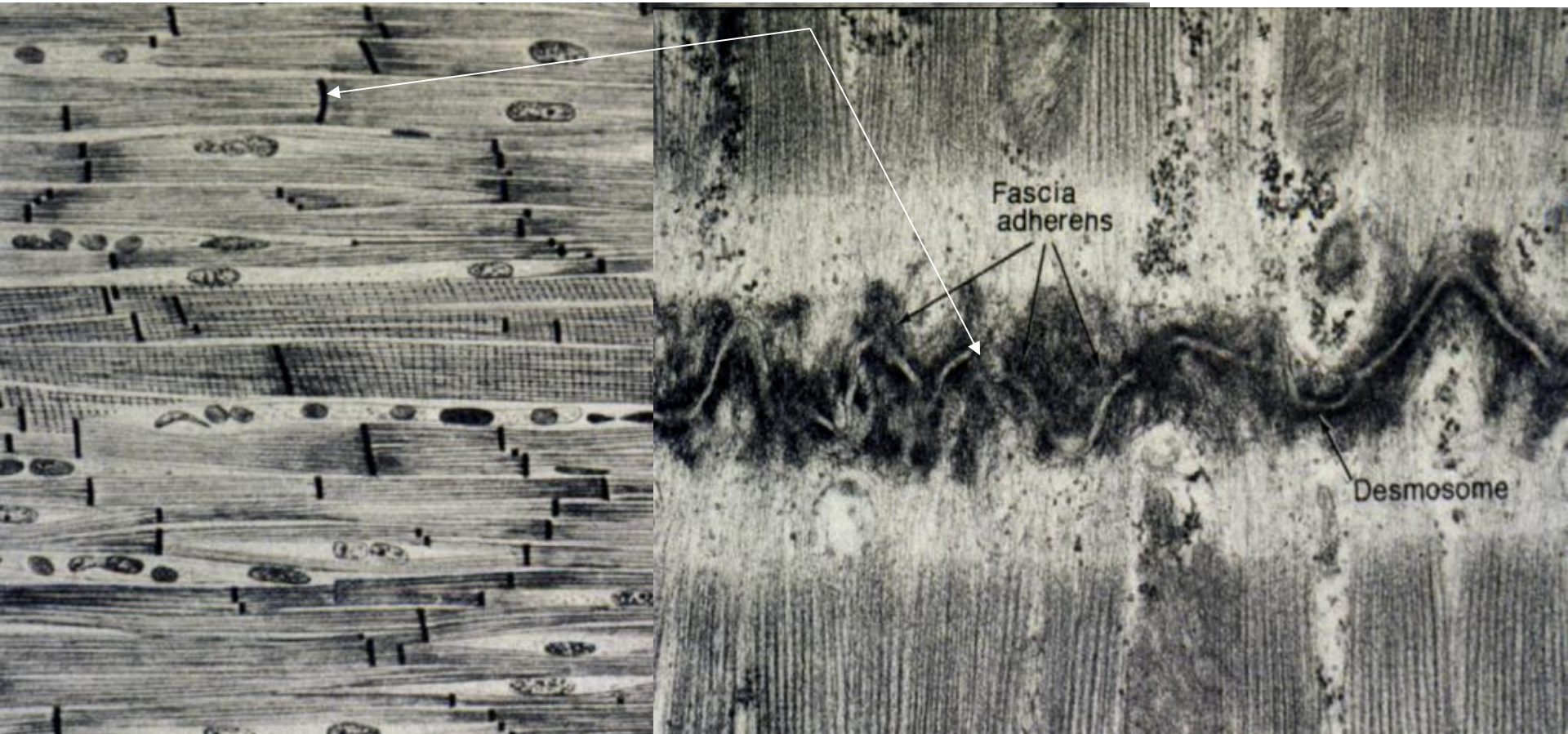


CARDIAC MUSCLE

INTERCALATED DISC



CARDIAC MUSCLE

INTERCALATED DISC

FASCIA ADHERENS

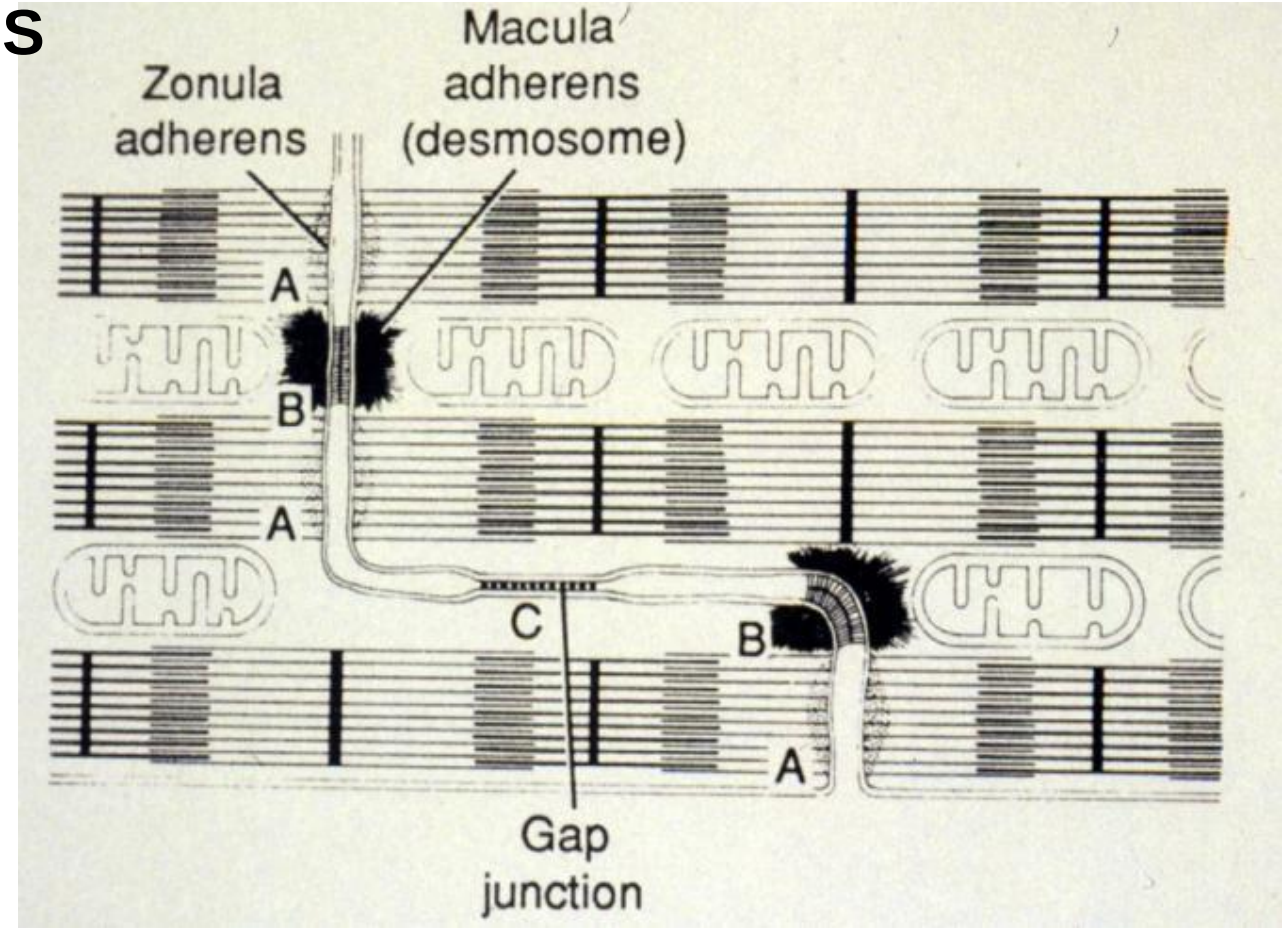
MACULAE

ADHERENS

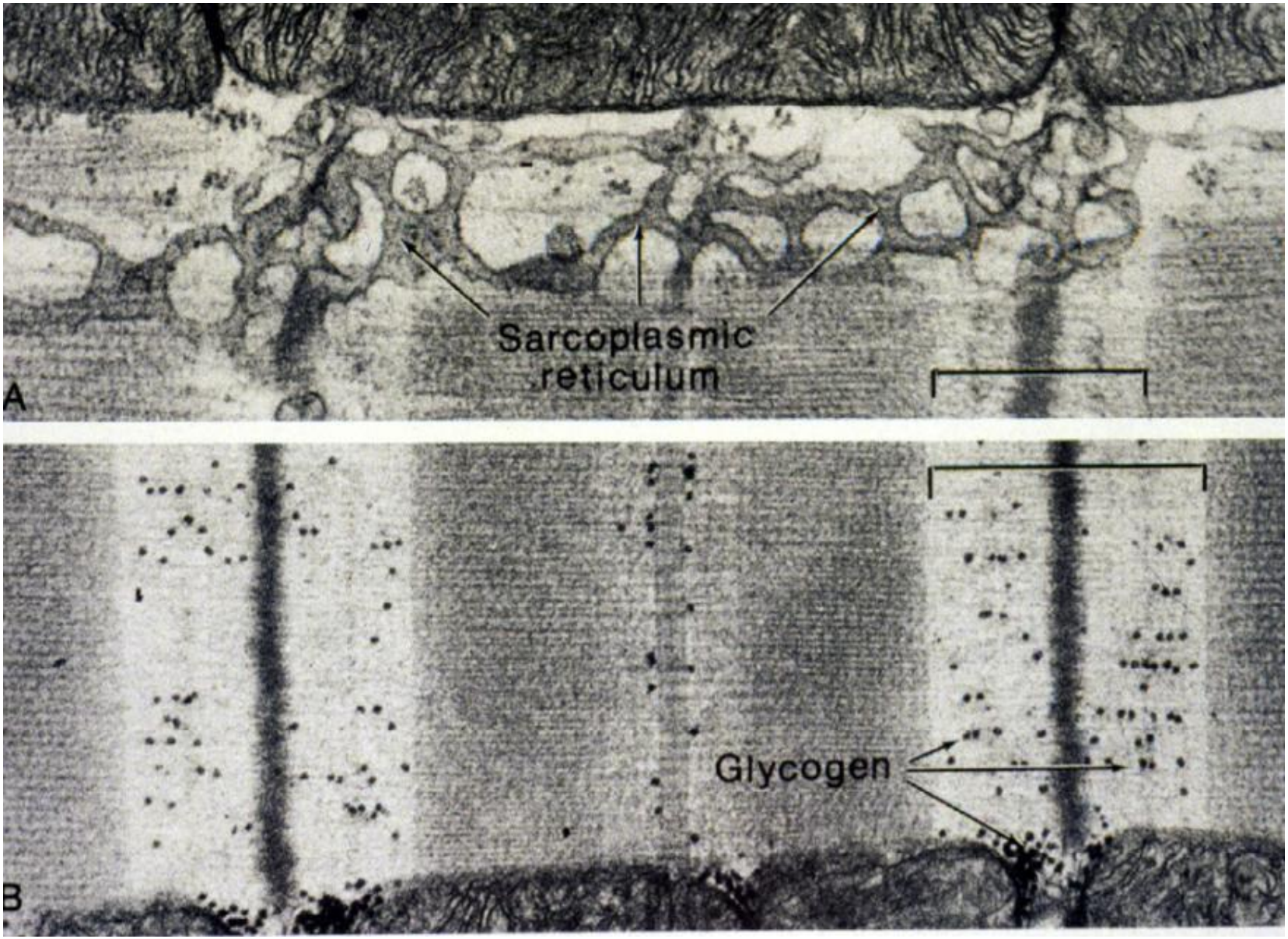
GAP JUNCTIONS

LATERAL

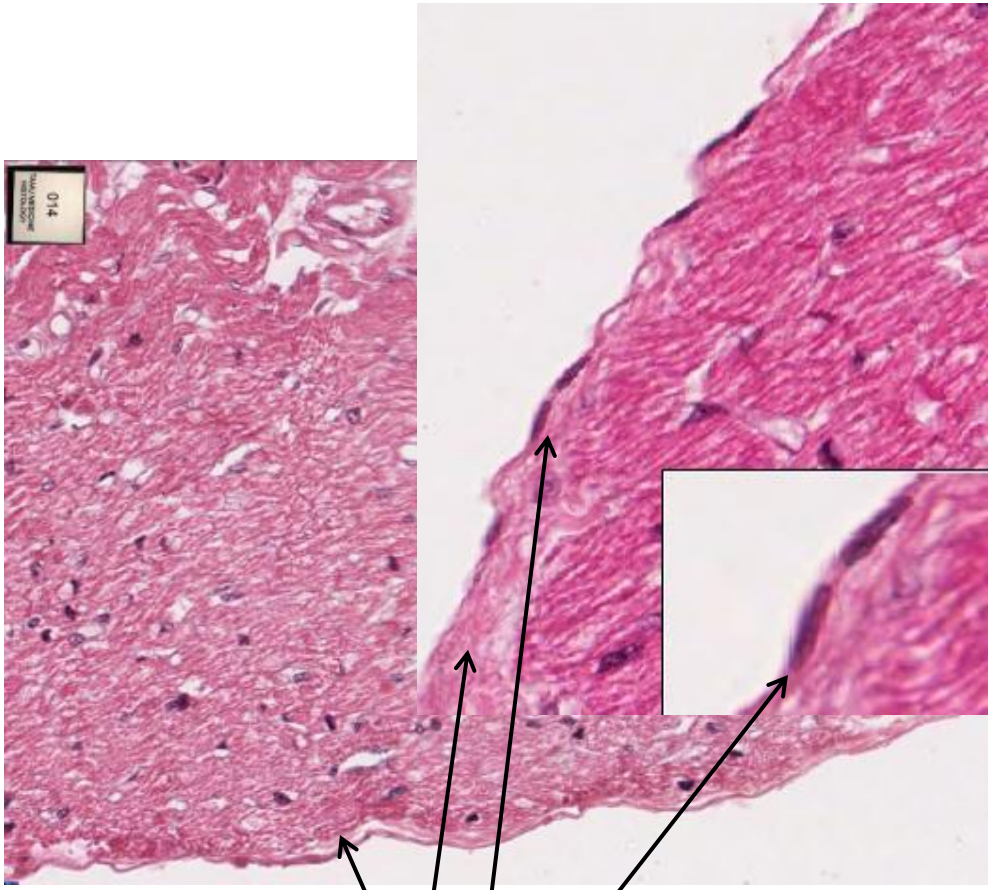
PORTION

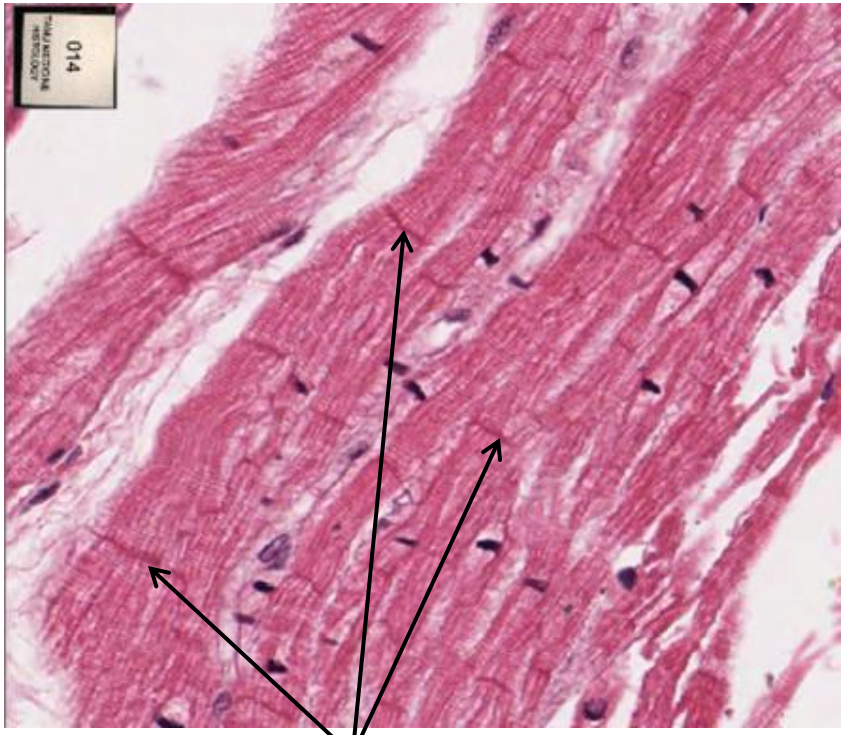


CARDIAC MUSCLE



Slide 14: Heart (right ventricle)





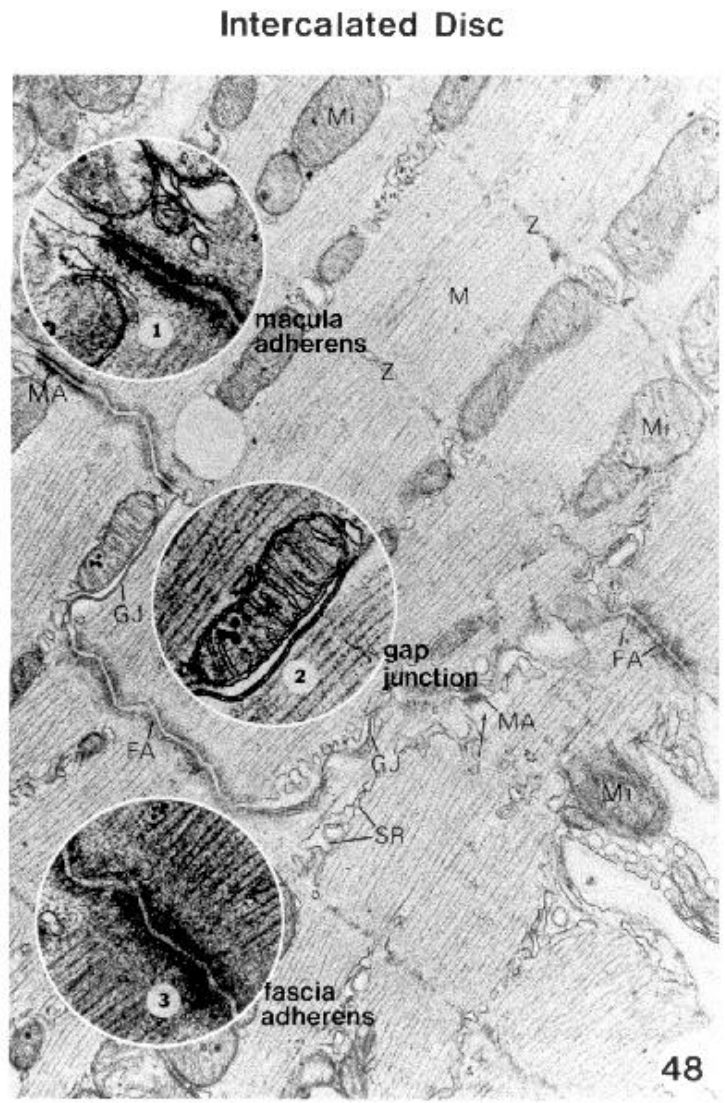
Intercalated discs

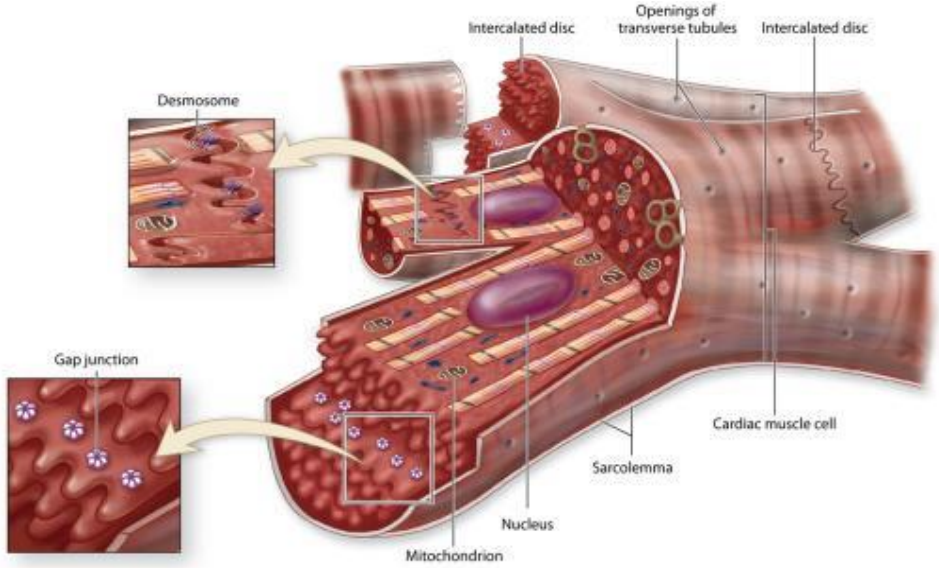
Subendothelium

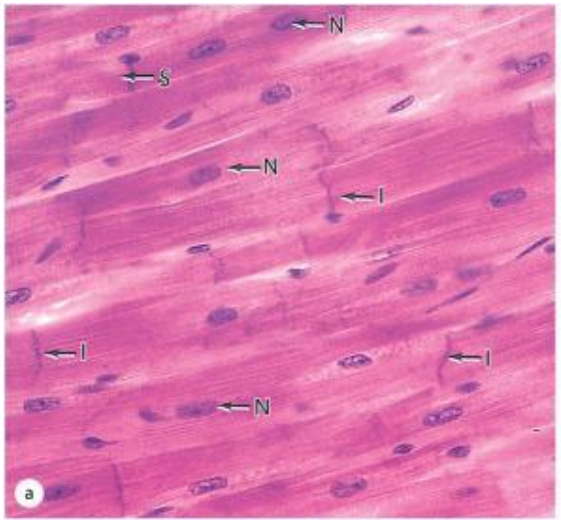
Endothelium

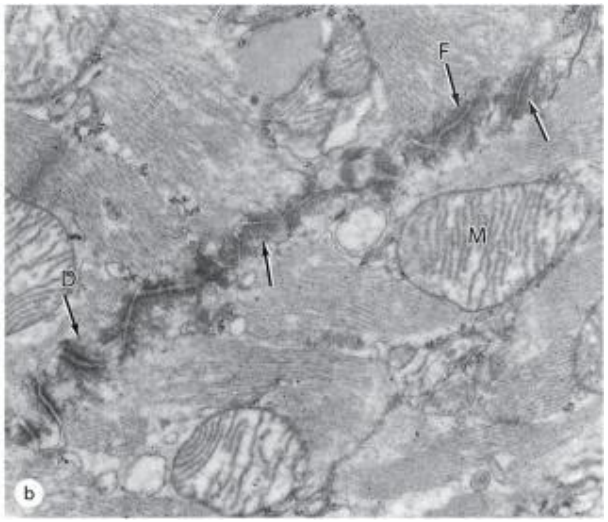
You will likely not find PURKINJE FIBERS in this image, but you can in image 23.

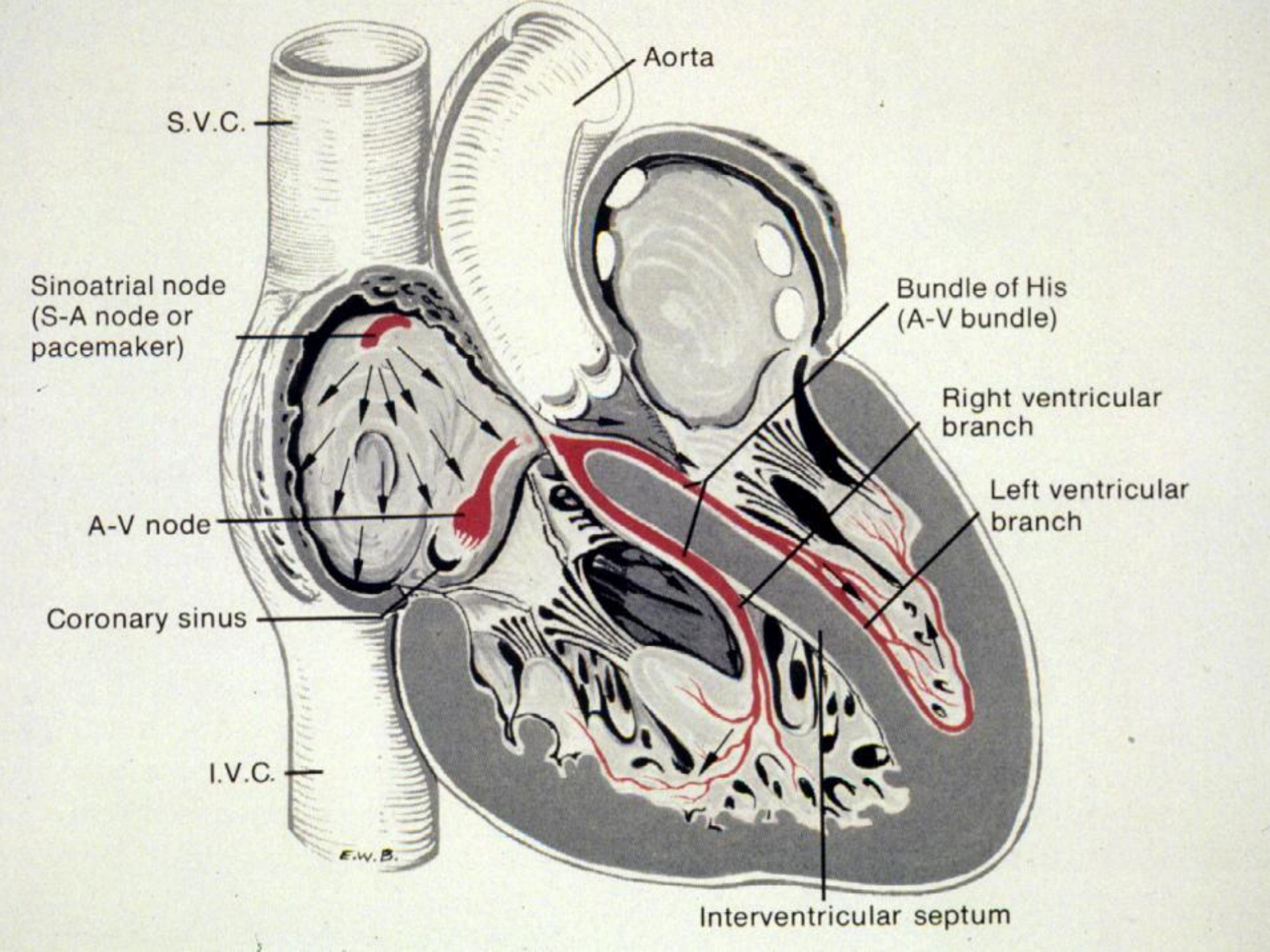
EM 48: Heart

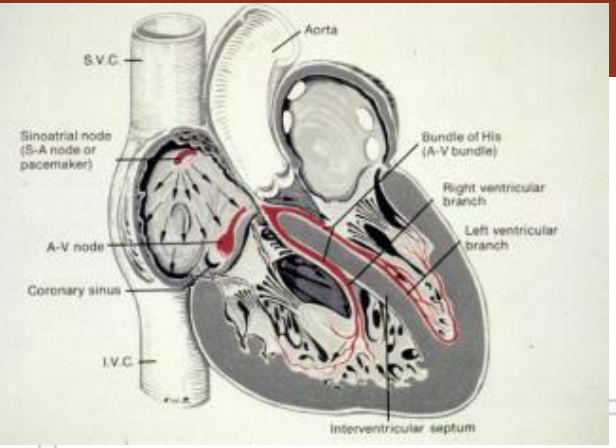


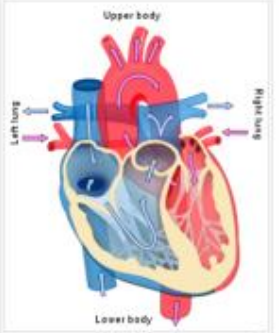







Aorta
S.V.C.
Sinoatrial node
(S-A node or
pacemaker)
Bundle of His
(A-V bundle)
Right ventricular
branch
Left ventricular
branch
A-V node
Coronary sinus
I.V.C.
E.W.B.
Interventricular septum





Blood flow diagram of the human heart. Blue components indicate de-oxygenated blood pathways and red components indicate oxygenated pathways.

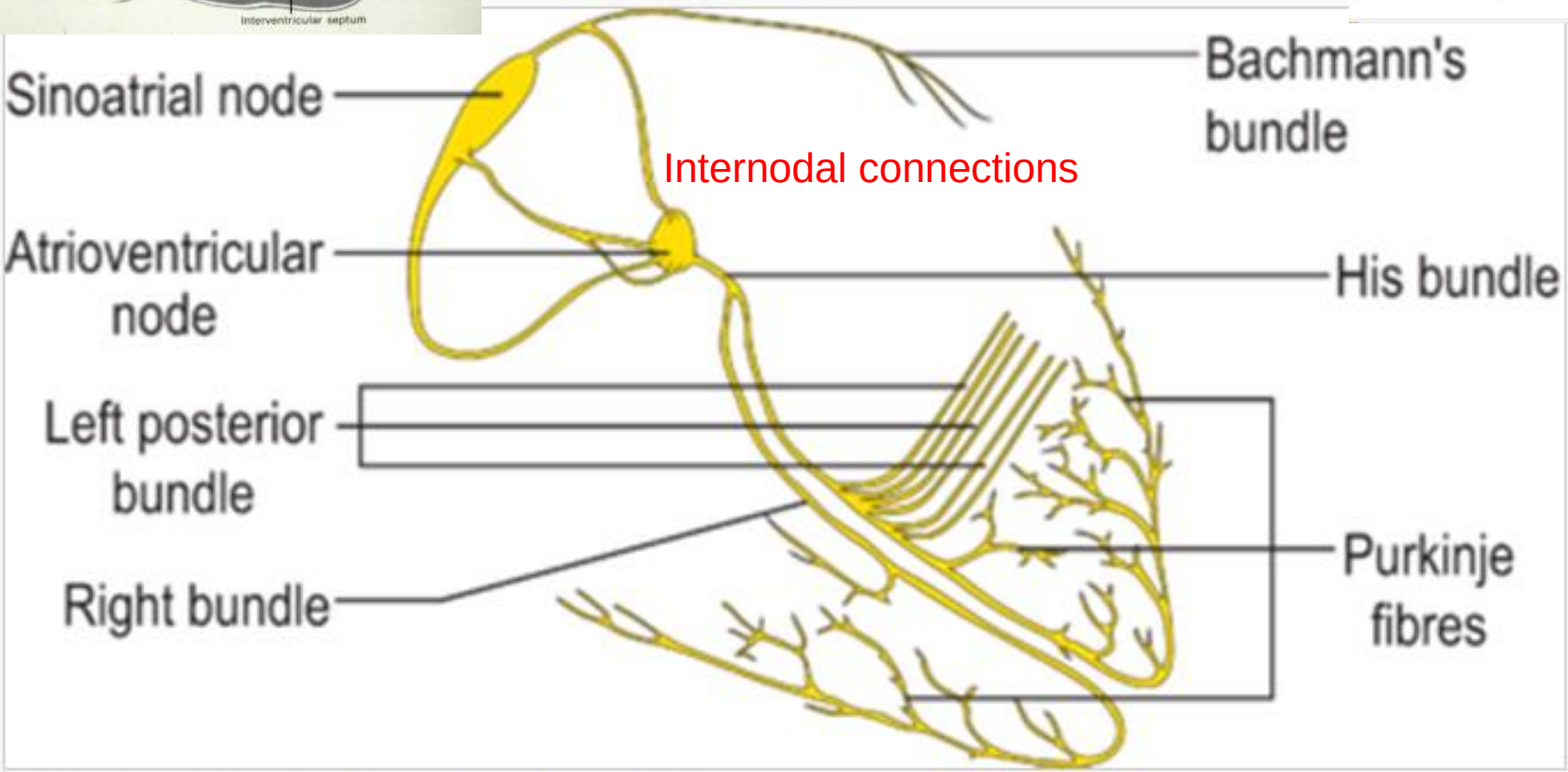
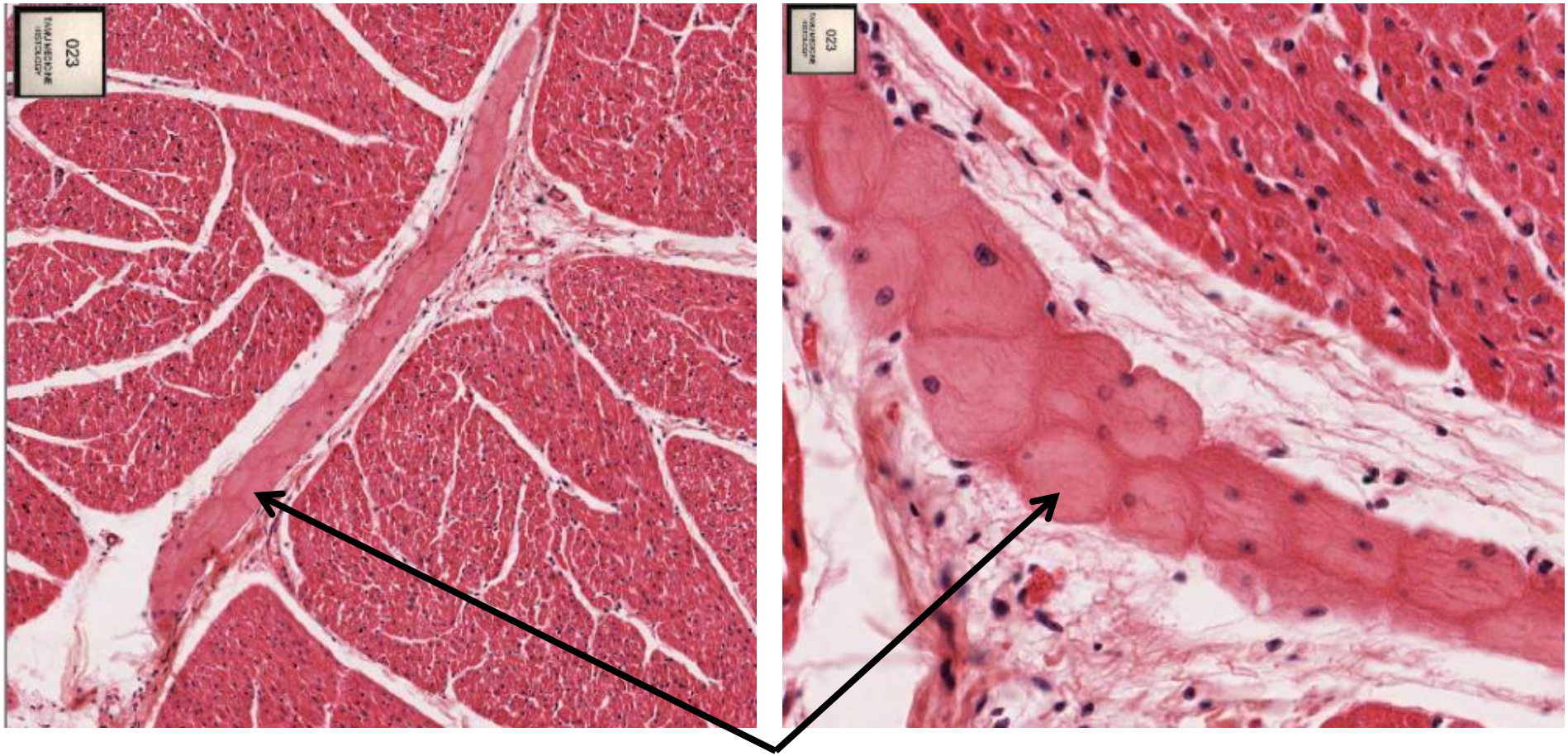
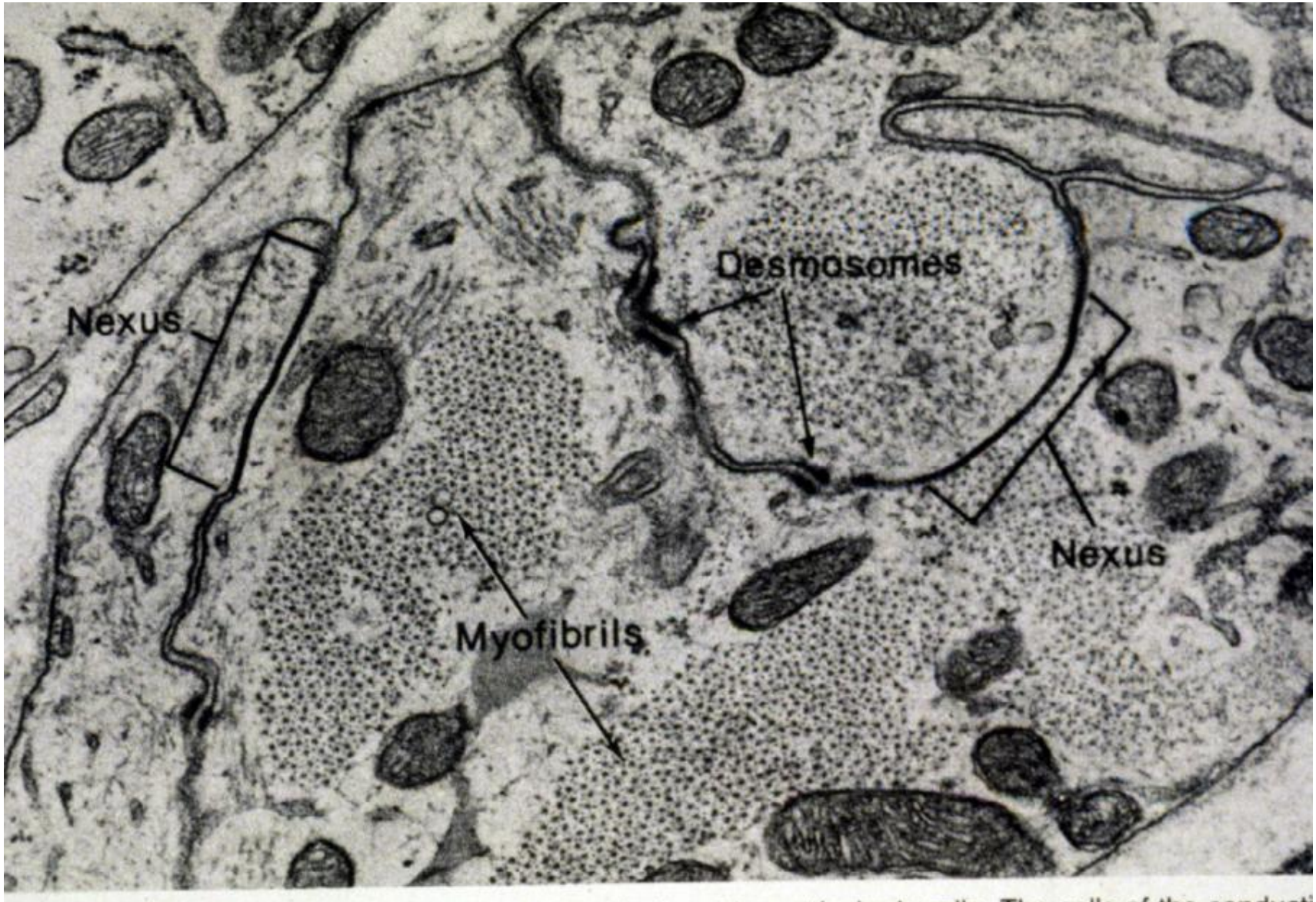


Image showing the conduction system of the heart

Slide 23: Heart (ventricle – bovine)

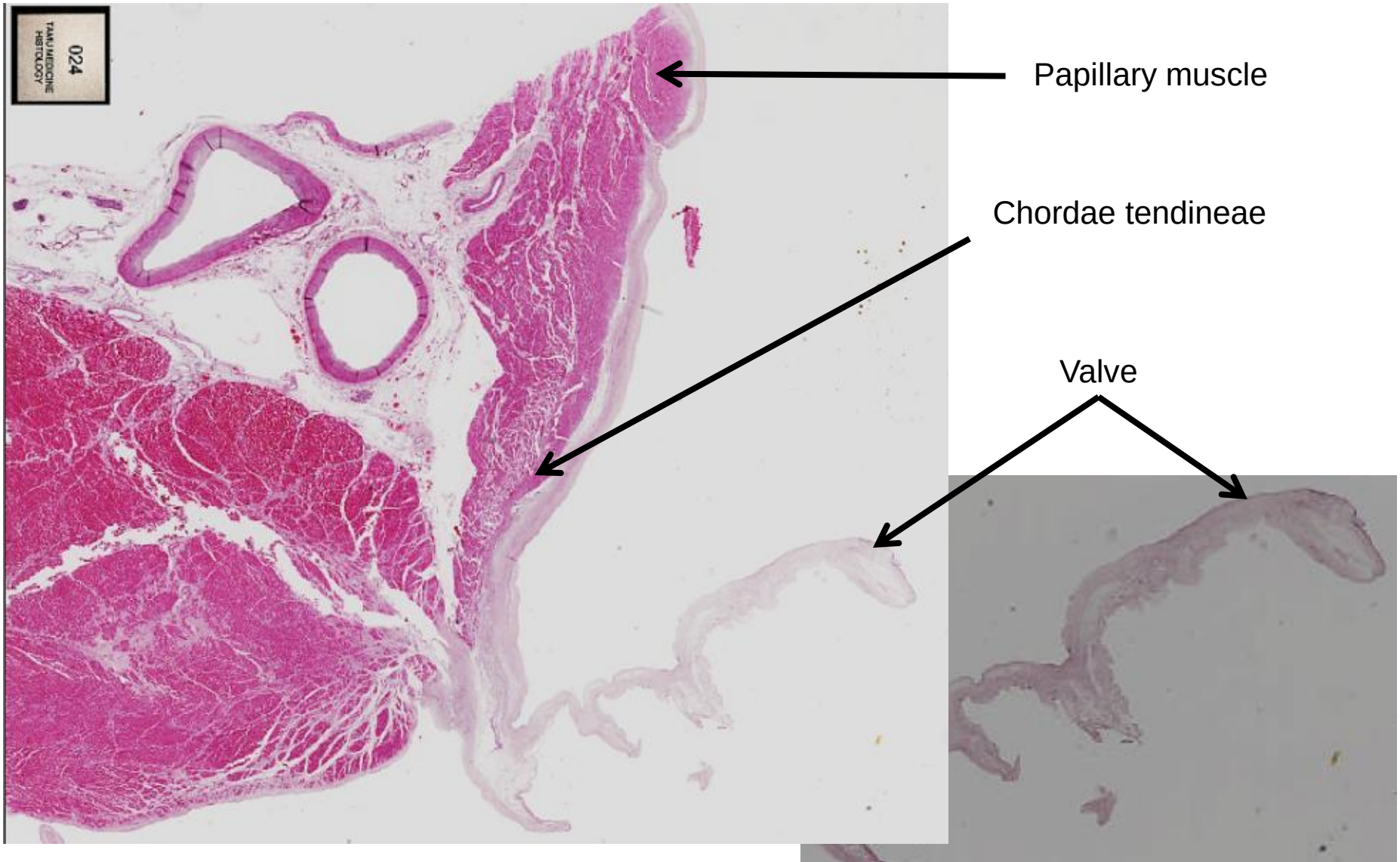


PURKINJE FIBERS (modified cardiac muscle cells)



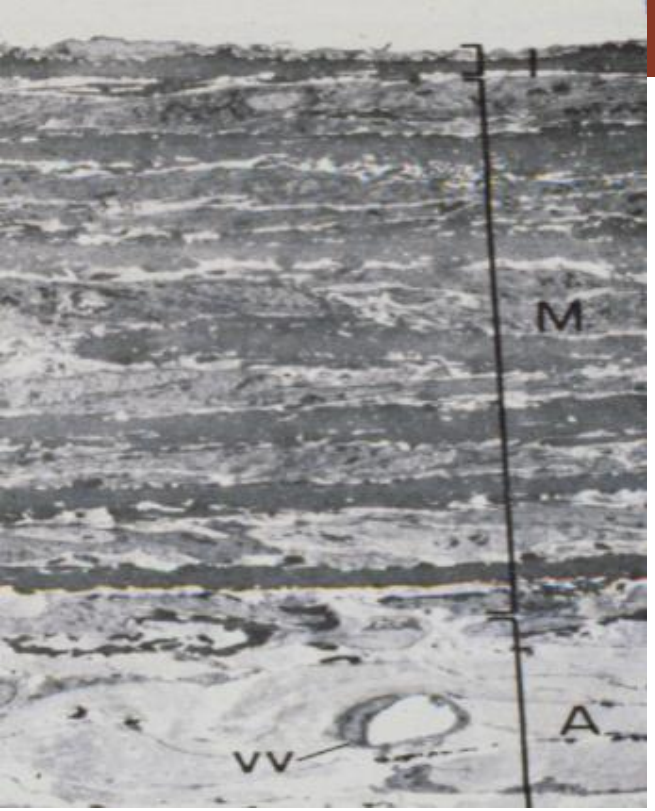
10-49. Electron micrograph of the cell junctions in the atrioventricular bundle. The cells of the conducti

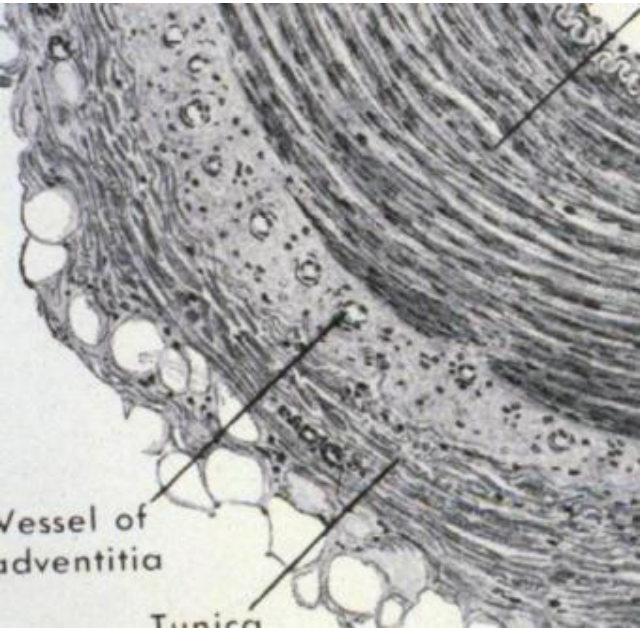
Slide 24: Heart valve

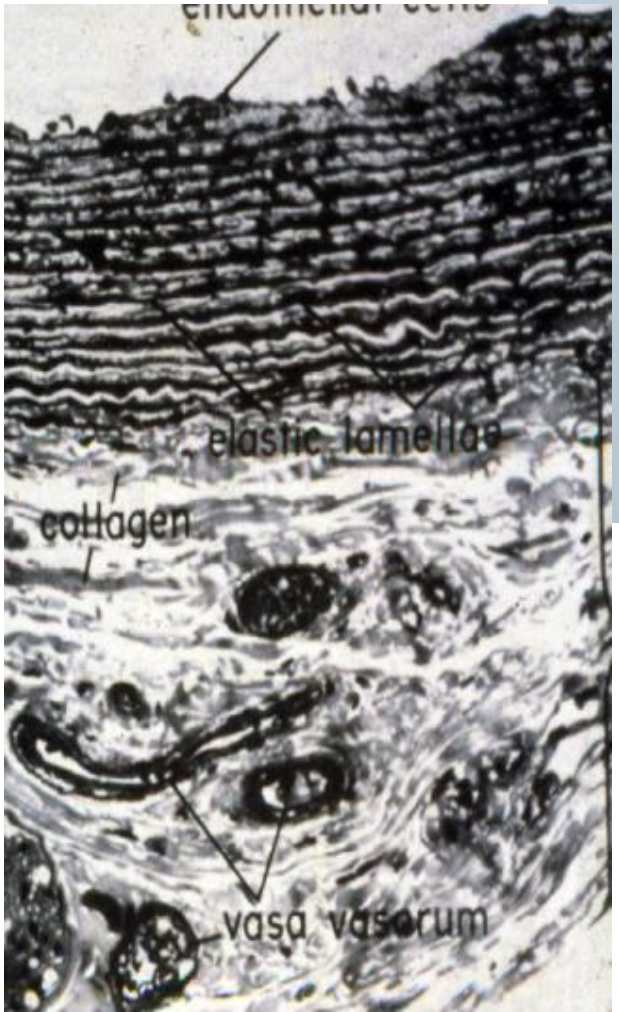


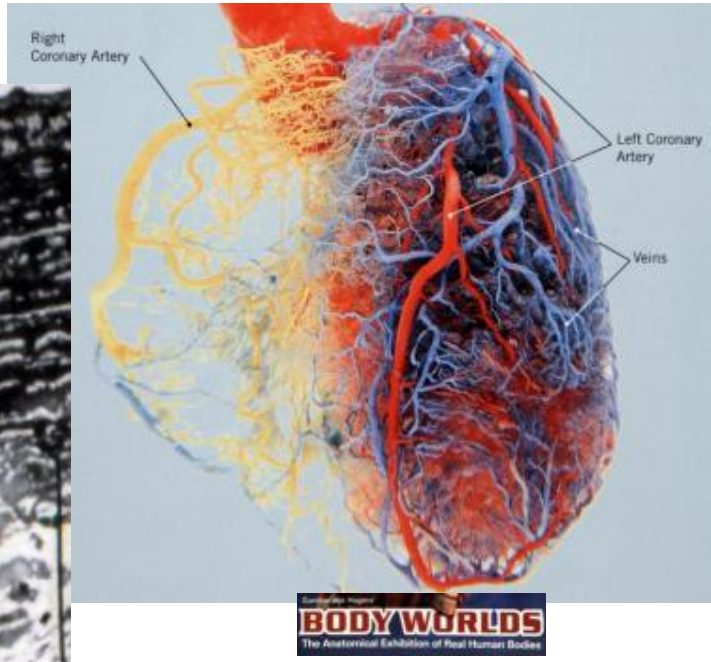
VASA VASORUM

VESSEL OF VESSELS



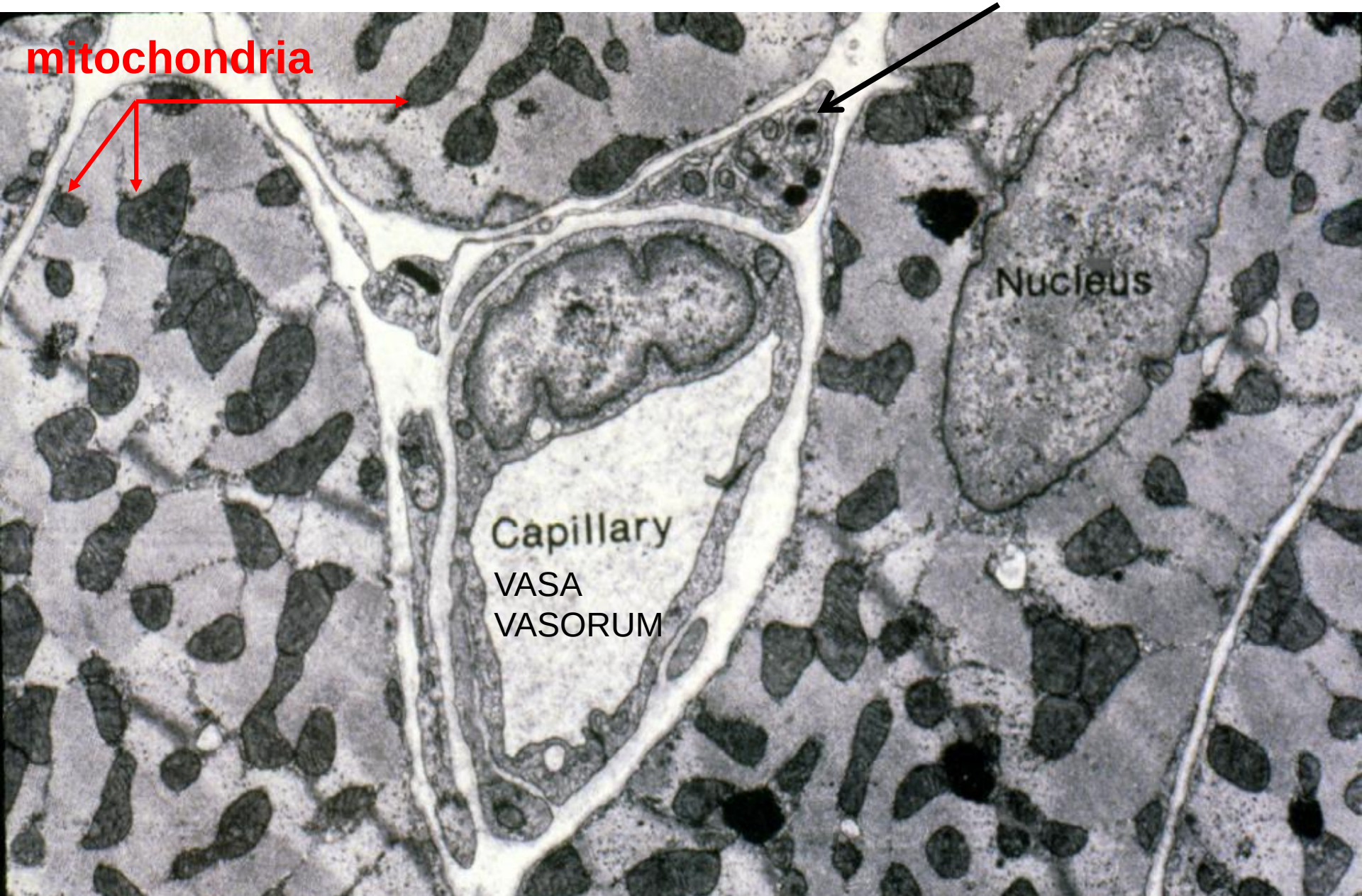




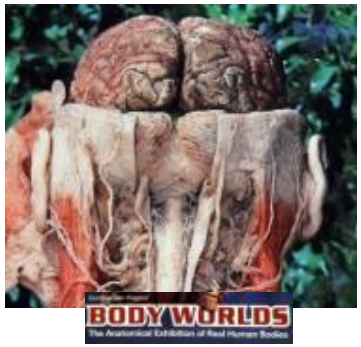


THE CORONARY ARTERY IS A VASA VASORUM

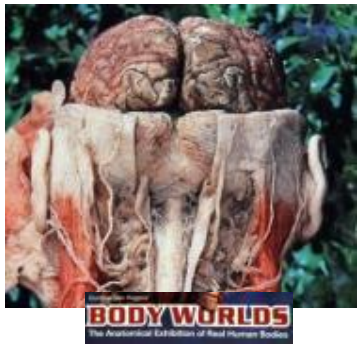
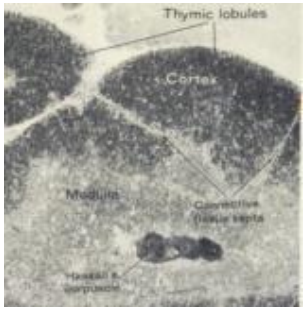
CARDIAC MUSCLE



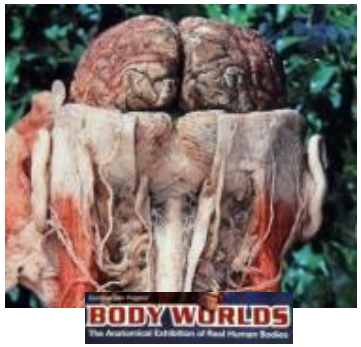
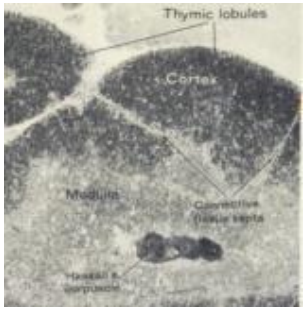
BLOOD BARRIERS

TYPE		SOURCE OF BARRIER
BLOOD-BRAIN		ZONULA OCCLUDENS OF ENDOTHELIUM

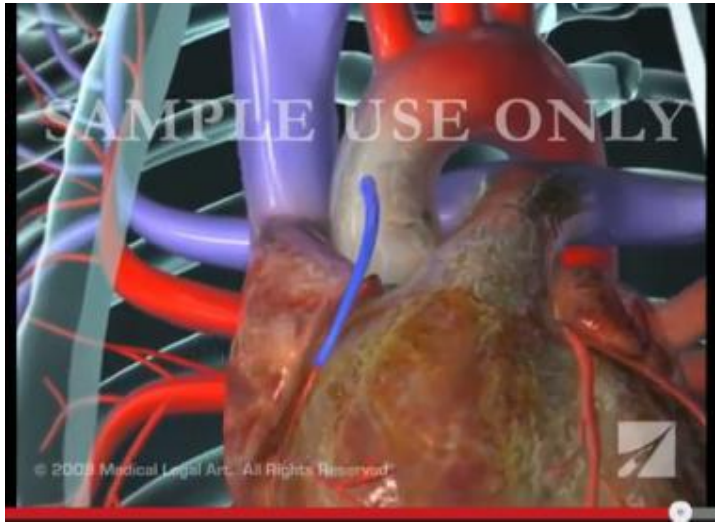
BLOOD BARRIERS

TYPE		SOURCE OF BARRIER
BLOOD-BRAIN		ZONULA OCCLUDENS OF ENDOTHELIUM
BLOOD-THYMUS		ZONULA OCCLUDENS OF ENDOTHELIUM AND SHEATH OF EPITHELIAL RETICULUM

BLOOD BARRIERS

TYPE		SOURCE OF BARRIER
BLOOD-BRAIN		ZONULA OCCLUDENS OF ENDOTHELIUM
BLOOD-THYMUS		ZONULA OCCLUDENS OF ENDOTHELIUM AND SHEATH OF EPITHELIAL RETICULUM
BLOOD-TESTIS		OCCLUDING JUNCTIONS BETWEEN SERTOLI CELLS IN SEMINIFEROUS TUBULES

Clinical Correlation



During coronary bypass surgery, the great saphenous vein of the leg can be used to bypass blocked coronary arteries.

http://www.youtube.com/watch?v=bwJCHYeGcU4

The proper distal / proximal orientation of the vein is important during bypass surgery to prevent engaging the valves of the vein and preventing blood flow.

Images from Wikipedia: Atherosclerosis

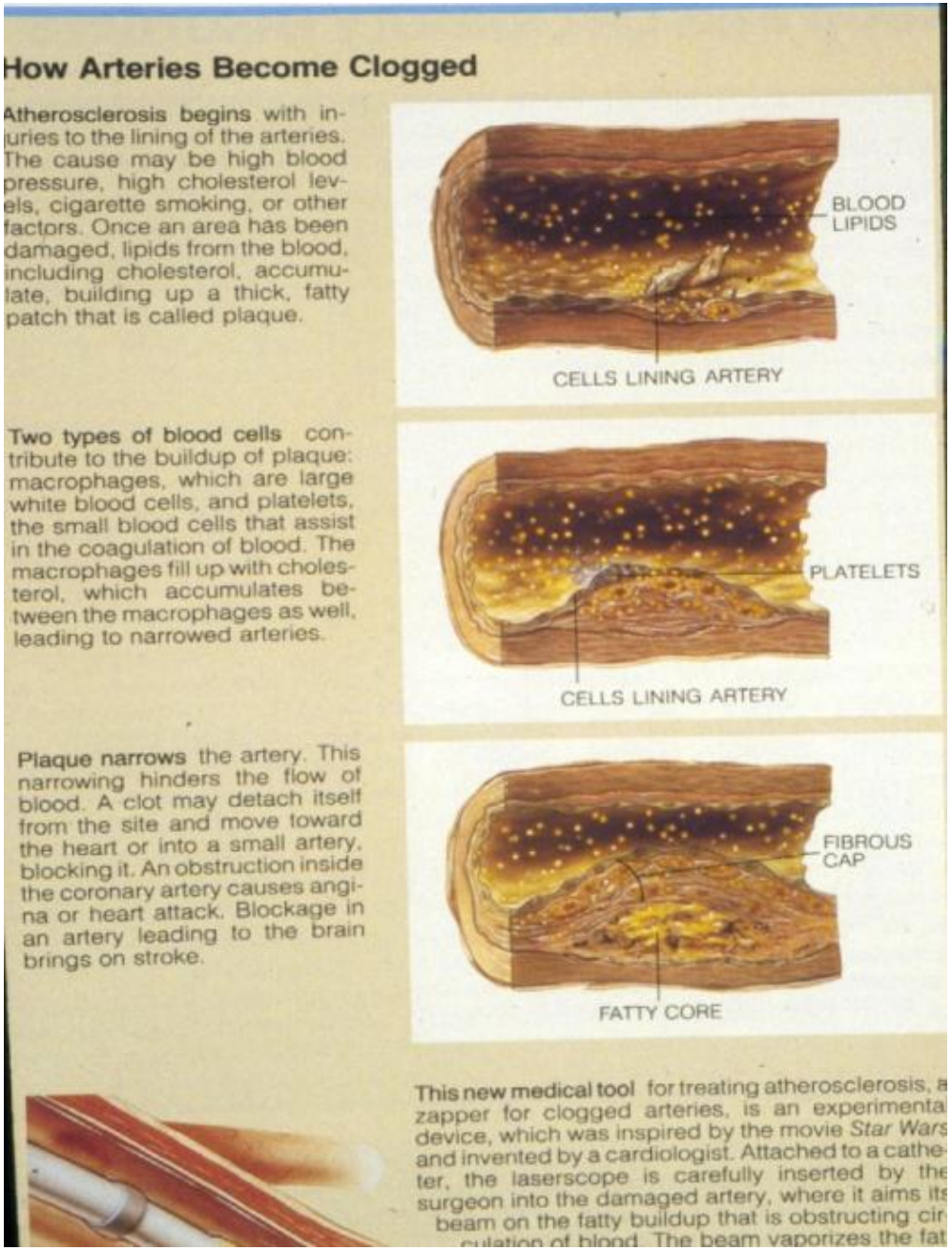
AGE-RELATED AND/OR DISEASE-RELATED CHANGES IN BLOOD VESSELS

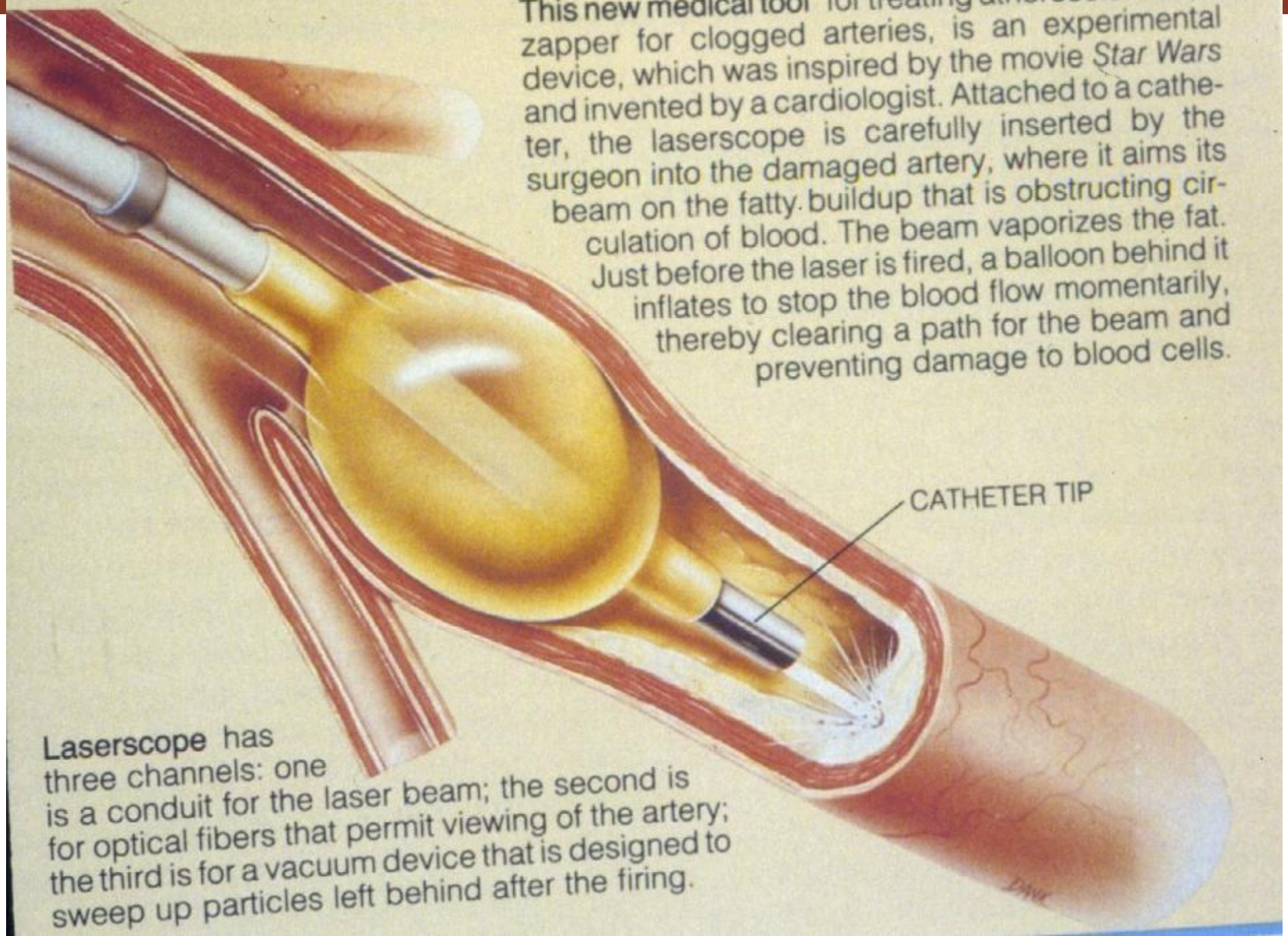
DEFECT	CAUSE
ARTERIOSCLEROSIS (HARDENING OF ARTERIES)	ELASTIC LAMELLAE REPLACED BY OTHER CONNECTIVE TISSUE ELEMENTS
ATHEROSCLEROSIS (HEART ATTACK AND STROKE)	PATCHY, IRREGULAR THICKENING OF INTIMA

Atherosclerosis

is the most common disease of blood vessels.

Tunica intima is either damaged or dysfunctional. Changes seen include the presence of foam cells, accumulation of free LDL, and entry of monocytes and macrophages as well as narrowed lumen due to fibro-fatty plaques (atheromas).





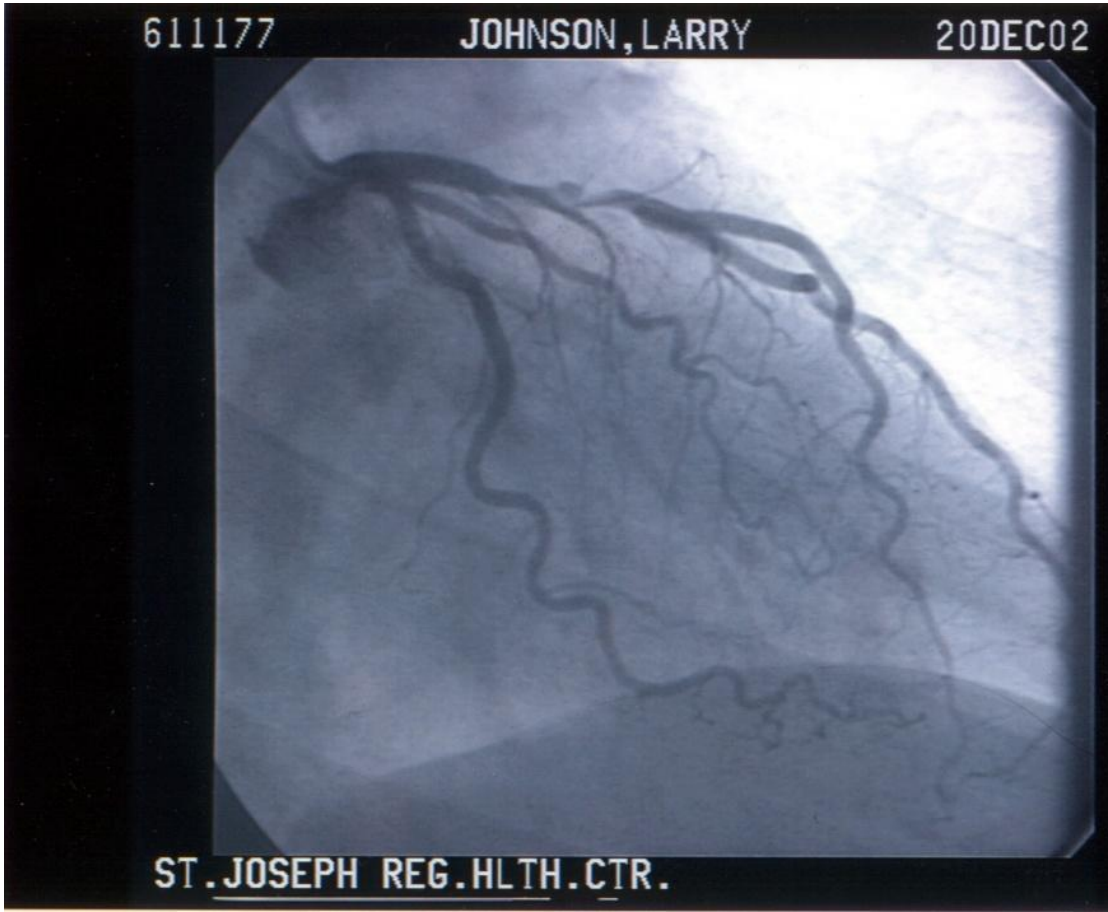
This new medical tool for treating atherosclerosis, a zapper for clogged arteries, is an experimental device, which was inspired by the movie *Star Wars* and invented by a cardiologist. Attached to a catheter, the laserscope is carefully inserted by the surgeon into the damaged artery, where it aims its beam on the fatty buildup that is obstructing circulation of blood. The beam vaporizes the fat. Just before the laser is fired, a balloon behind it inflates to stop the blood flow momentarily, thereby clearing a path for the beam and preventing damage to blood cells.

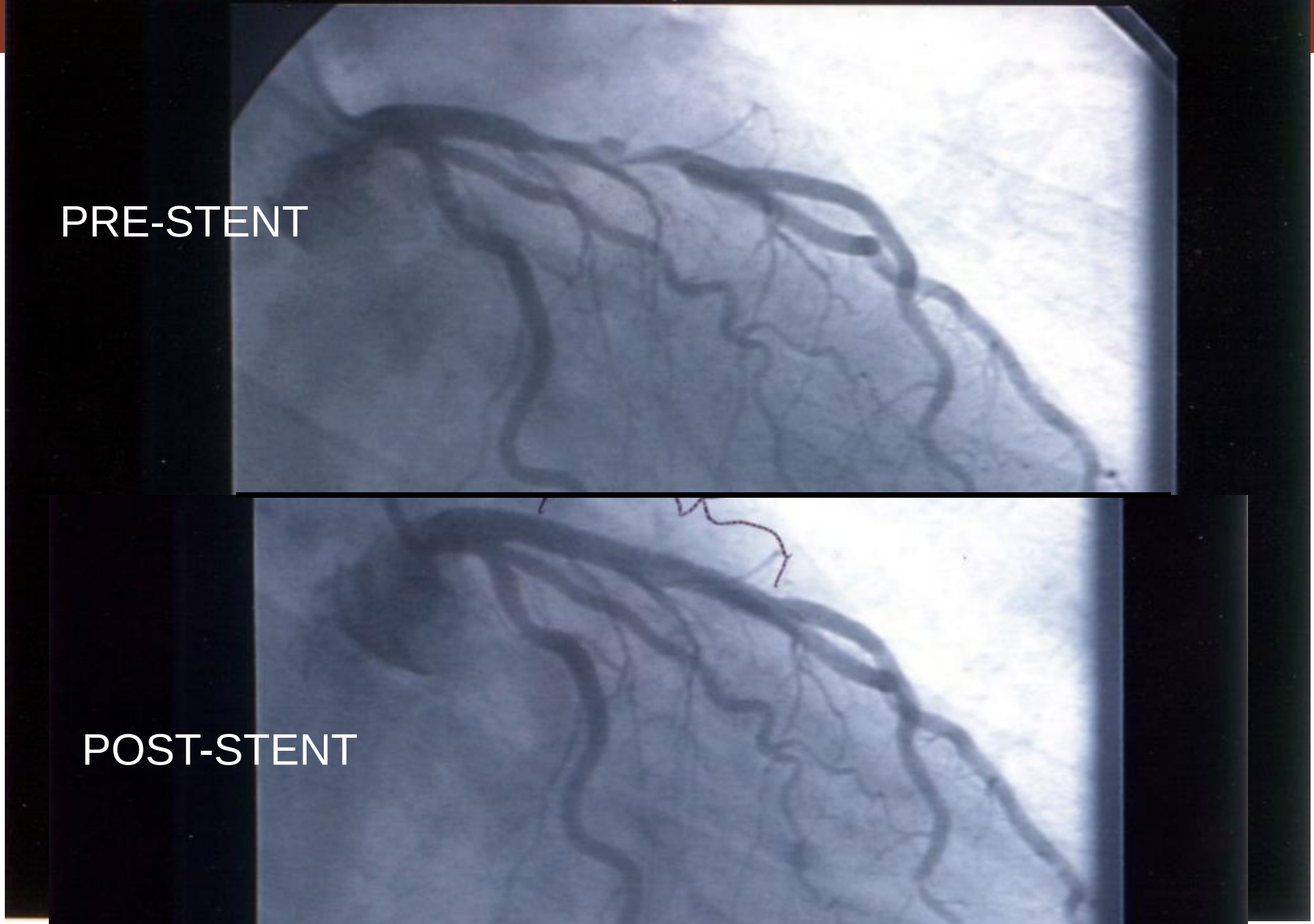
Laserscope has three channels: one is a conduit for the laser beam; the second is for optical fibers that permit viewing of the artery; the third is for a vacuum device that is designed to sweep up particles left behind after the firing.

FUNCTION / ACTIONS OF LYSOSOMES

UNPROGRAMMED CELL DEATH

- DAMAGE/DEATH TO CARDIAC CELLS IN ISCHEMIA ASSOCIATED WITH MYOCARDIAL INFARCTIONS




PRE-STENT
POST-STENT

Many illustrations in these VIBS Histology YouTube videos were modified from the following books and sources: Many thanks to original sources!

- Bruce Alberts, et al. 1983. Molecular Biology of the Cell. Garland Publishing, Inc., New York, NY.
- Bruce Alberts, et al. 1994. Molecular Biology of the Cell. Garland Publishing, Inc., New York, NY.
- William J. Banks, 1981. Applied Veterinary Histology. Williams and Wilkins, Los Angeles, CA.
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