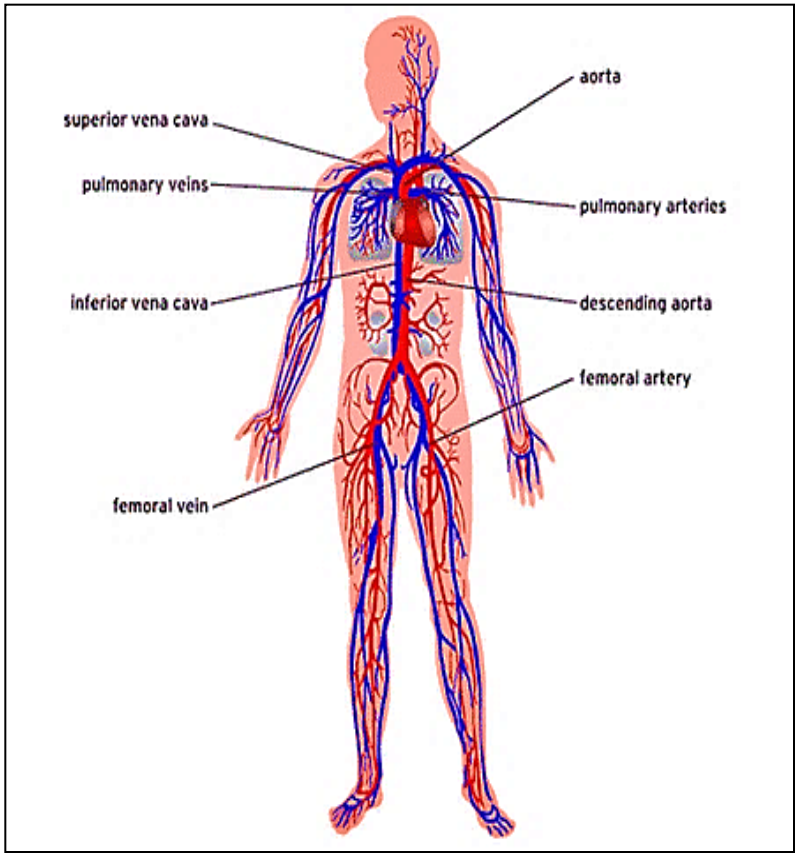
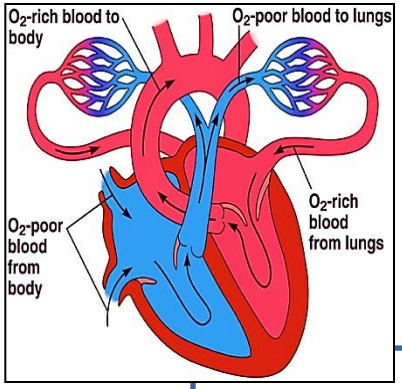
The vascular system

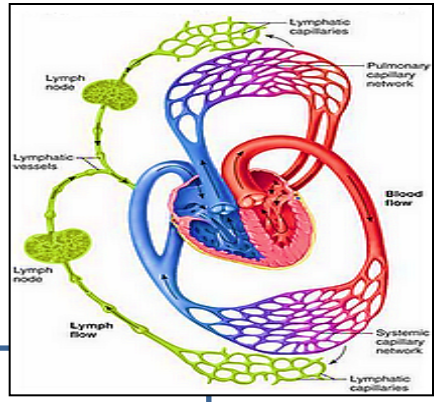
Professor Dr. Hala El-mazar 2022

(Lecture 1)



Circulatory system





I. Blood - vascular

II. Lymphatic vascular

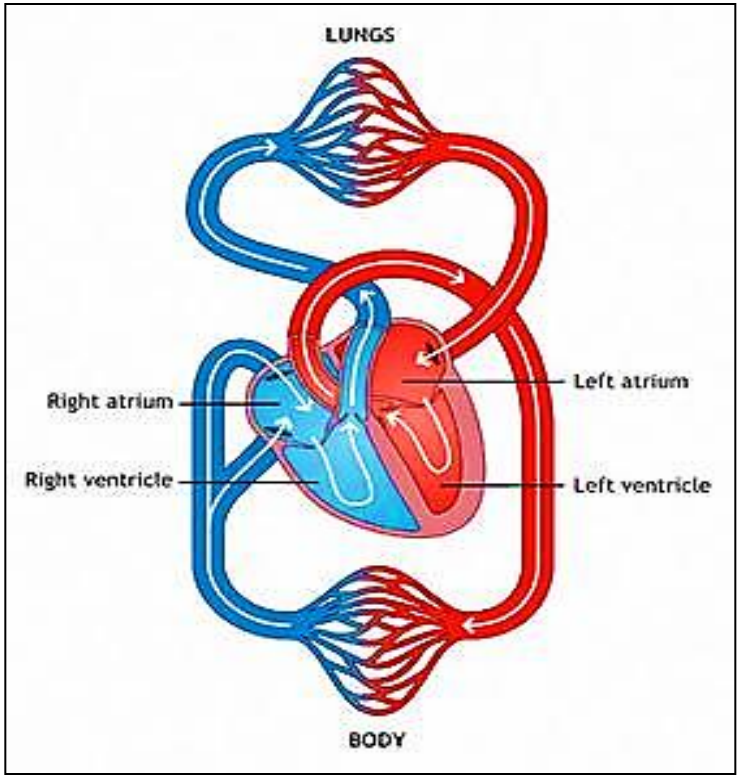
Cardio-vascular system

- Includes: The heart + blood vessels + blood
- Humans have a closed circulatory system

(***blood circulate within vessels & is distinct from interstitial fluid***)

The heart pumps blood into large vessels that branch into smaller ones leading into the organs.

Materials are exchanged by **diffusion** between the blood and the interstitial fluid around the cells.



Main functions of the Vascular system

- Transport of oxygen, carbon dioxide, nutrients, hormones, metabolic products, cells of immune defense system and many other essential products
- Gaseous exchange
- Temperature control

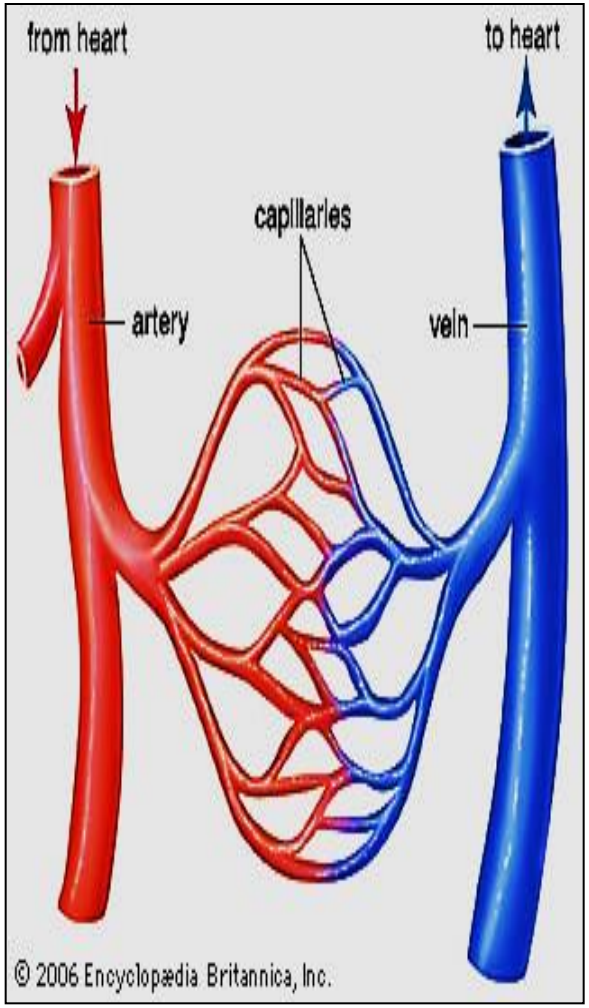
The blood vessels

Include:

- Arteries: Large (**elastic)** arteries
  Medium (**muscular**) arteries
  Arterioles

- Veins: Large veins
  Medium sized veins
  Venules

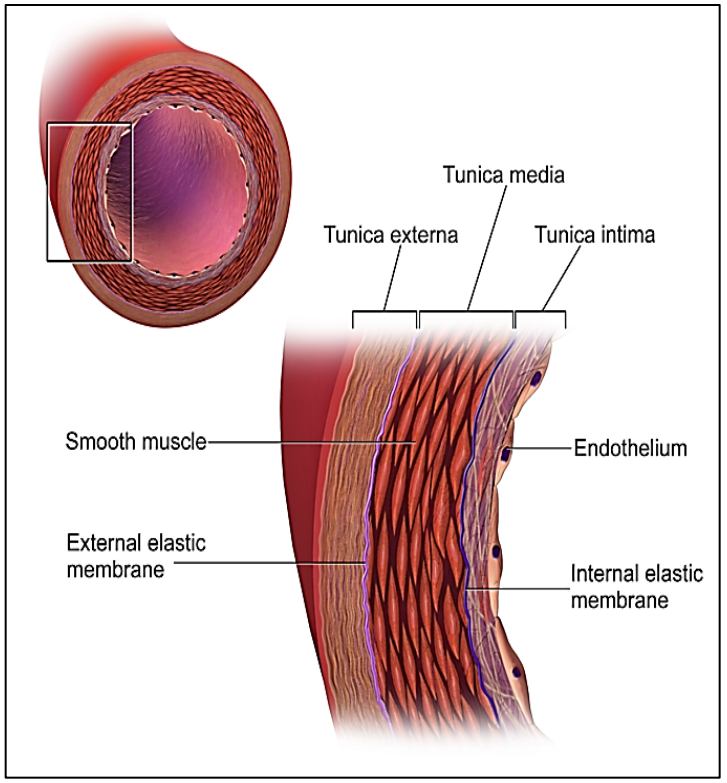
- Microcirulation:
  Capillaries
  Arterio –venous anastomosis



The basic structural components of the vascular wall:

1. Endothelium
2. Connective tissue
3. Collagen fibers run longitudinally
4. Elastic material (fenestrated)
5. Ground substance

   (glycosaminoglycan)

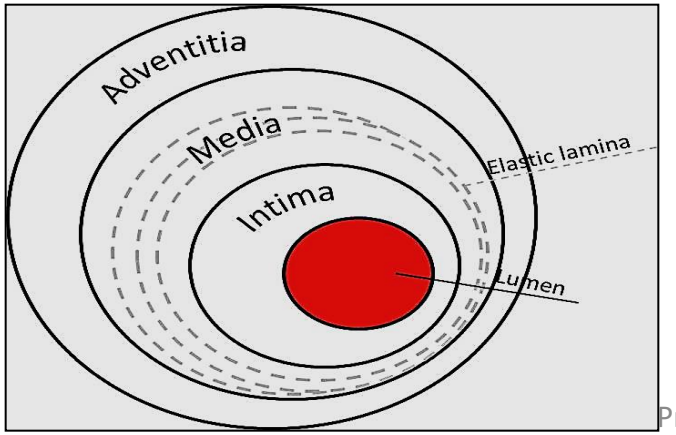


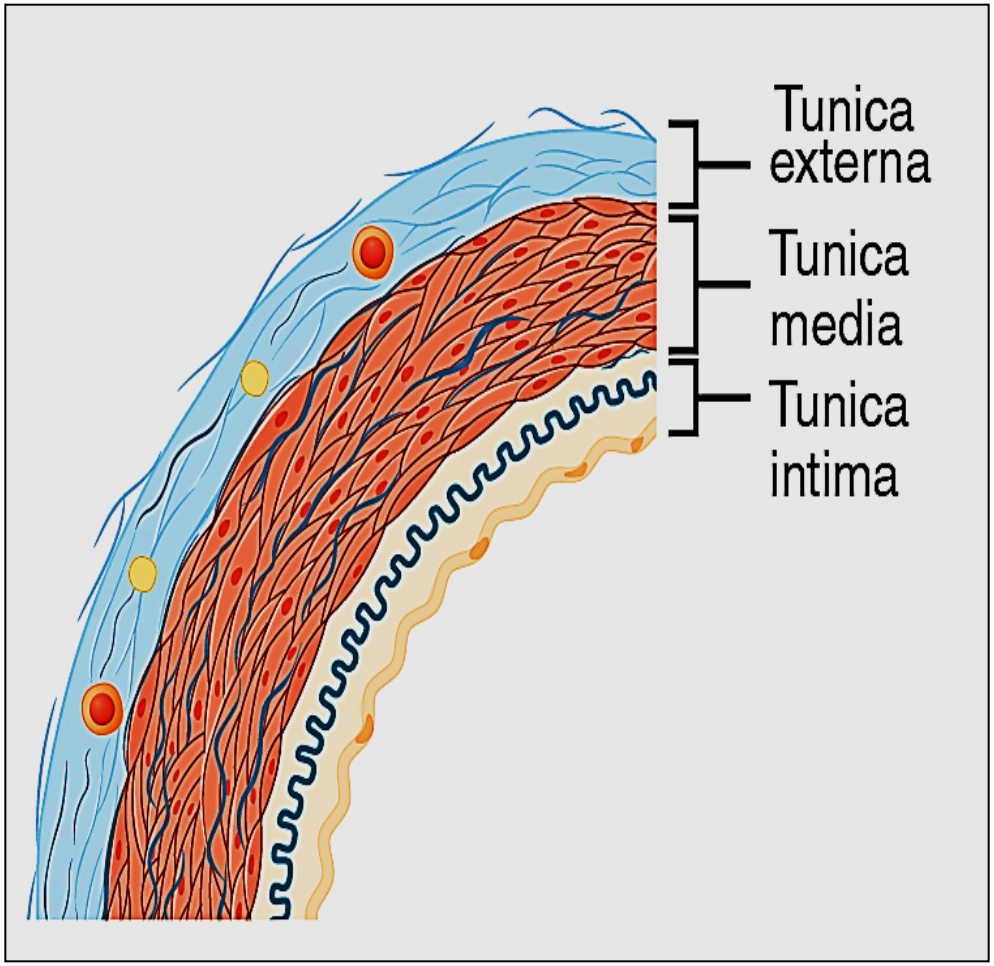
The transition from one type of vessels to another is **gradual**

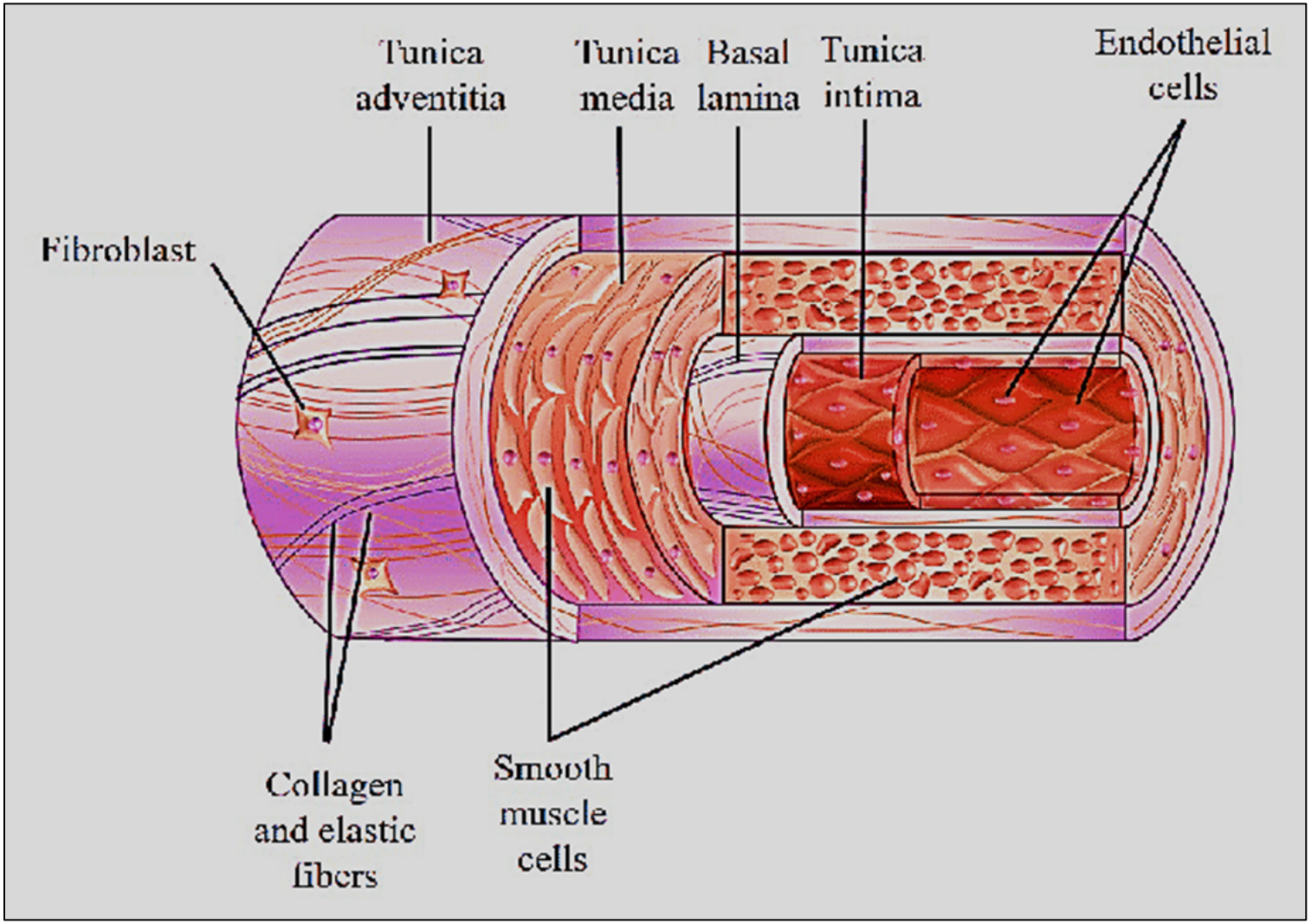
General structure of the wall of a blood vessel

Formed of 3 layers or tunics: inside → outside

- Tunica intima
- Tunica media
- Tunica adventitia







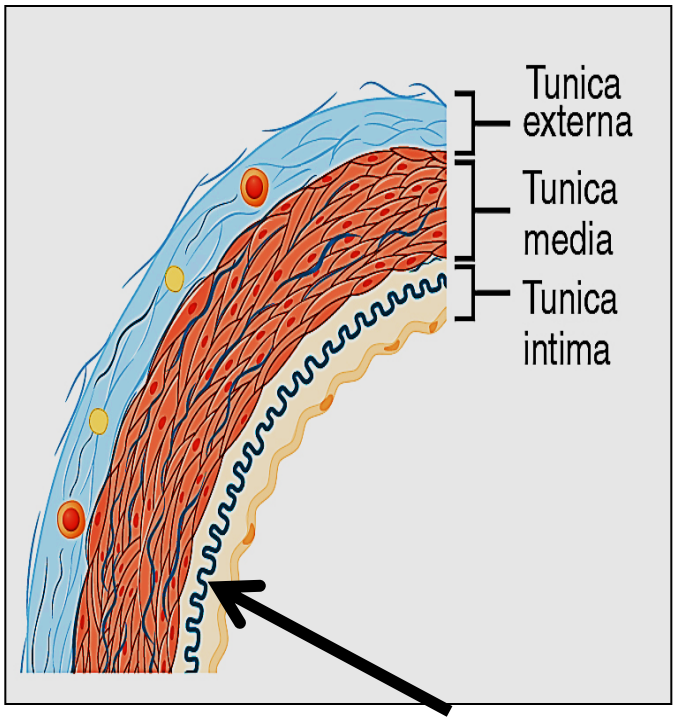
L.S showing the wall, of the Blood Vessel

Tunica intima

1- Endothelium:

simple squamous epith - basal lamina

(smooth surface , easy exchange)



2- Sub-endothelium:

contains fibrocytes**, macrophages** and smooth muscle like-cells called **Myointimal Cells**. The collagen and elastic fibers are longitudinally arranged.

3- Internal elastic lamina (IEL):

Layer of elastic fibers separates intima from media

Present ONLY in arteries , very clear in muscular arteries,

absent in veins & small arterioles

(for elasticity & prevent complete occlusion of arteries)

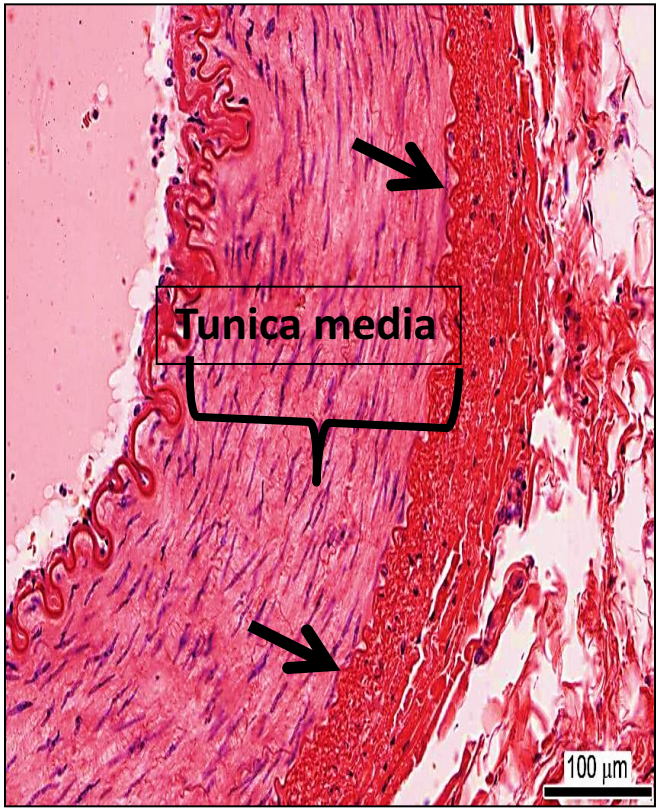
The IEL composed of elastin , has holes that allow the diffusion of substances to nourish cells deep in the vessel wall

Tunica media

- Middle layer of circularly arranged smooth muscle cells

- Contains collagen (III) & elastic fibers

- Some larger muscular arteries shows external **elastic lamina (EEL)** separates The tunica media from adventitia

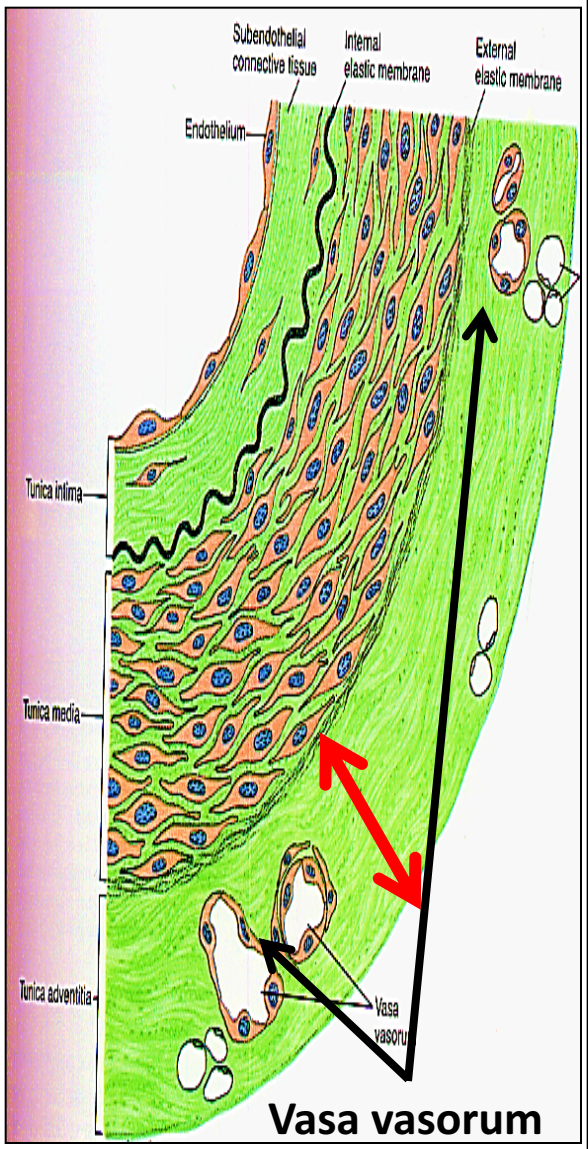


- Elastic fibers help expansion in systole & its recoil helps maintain blood flow in diastole

- The activity of smooth ms. Fibers is regulated by vasomotor autonomic supply

Tunica adventitia

- Outermost C.T. layer, contains collagen fibers (T: I) more than elastic fibers
- Contains nerves, lymphatics & vasa vasorum (common *in large vessels since their wall is too thick to be nourished solely by diffusion from blood in lumen)*
- It prevents over distension of vessel
- Anchor the blood vessel to the surroundings organs and tissues
- Prevents shortening if vessel is cut
- Since veins carry deoxygenated blood they have more vasa vasorum than arteries



- Large vessels are supplied with network of unmyelinated sympathetic nerve fibers (vasomotor) whose neurotransmitter is norepinephrine .

- Discharge of epinephrine produce vasoconstriction . These efferent nerves (out CNS) generally do not enter the media of arteries instead they discharge the neurotransmitters which diffuse through the wall to affect the smooth muscle cells of the media

- the gap junction between the smooth muscle cells propagate the response

- Sympathetic nerve fibers innervate all vessels except capillaries ,precapillary sphincters & metarterioles

- The density of innervation of veins is less than that of arteries
- Innervation of small arteries & arterioles allow the sympathetic nerves to increase the peripheral resistance

- skeletal muscles arteries of certain species receive a sympathetic cholinergic nerve supply. Ach. Is released by these nerves act on endothelium to produce nitric oxide which diffuses into smooth muscle cells→ its relaxation → dilatation of the lumen → hyperemia particularly at exercise

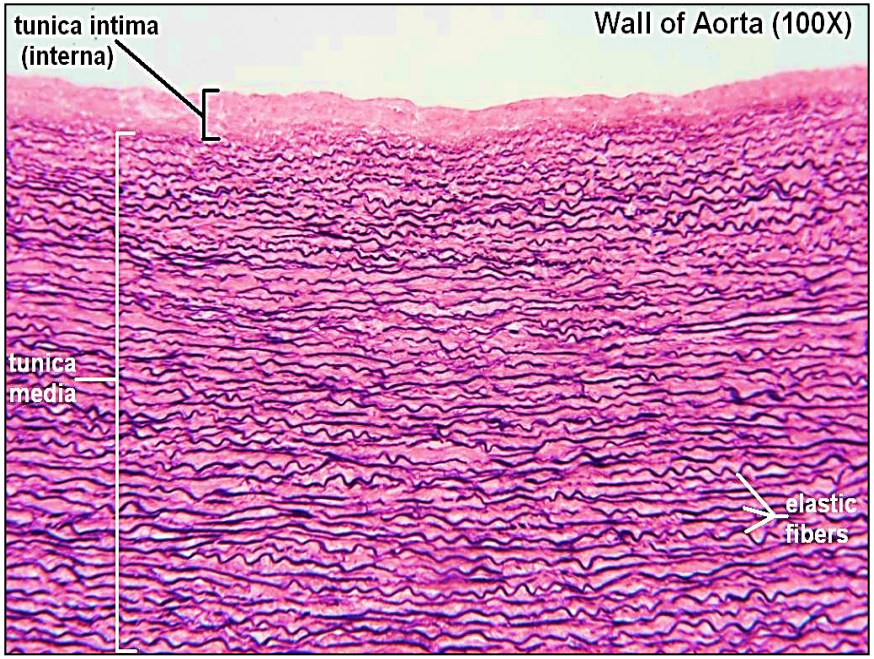
Large (Elastic) arteries/ Aorta

- large branches e.g. pulmonary, subclavian, innominate a.
- **Wide lumen** + **very thick wall** (mainly elastic fibers)
- Tunica intima:

  Thick sub-endothelium rich in elastic fibers, **IEL not clear**
- Tunica media (70%):

- **very thick** mostly fenestrated elastic membranes (elasticity) + smooth muscle cells
- **EEL not clear**
- Tunica adventitia:

  CT contains collagen + elastic fibers +**vasa vasorum**



Medium sized (Muscular) arteries

- They deliver blood to muscles & organs (**renal , coronary**)
- Their wall is formed mainly of **smooth muscles**
- The transition from elastic to muscular arteries is gradual

(Gradual ↓in elastic fibers & ↑in smooth ms cells)

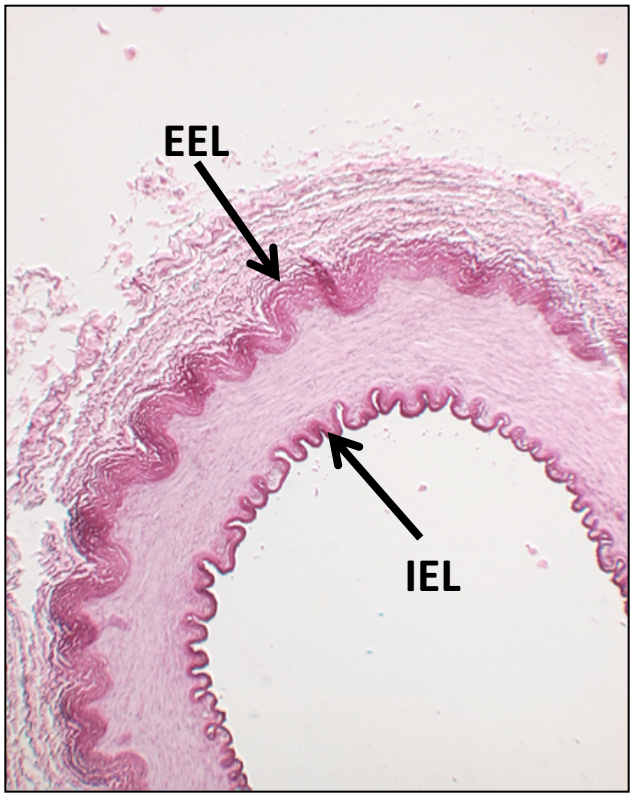
Tunica Intima: thinner, No subendothelial layer + **clear IEL**

Tunica media: mainly smooth muscles (40 layer s) + **EEL is clear**

Tunica adventitia:

Thick CT layer contains collagen & elastic fibers + V.V.

(Equal in thickness to T . Media)



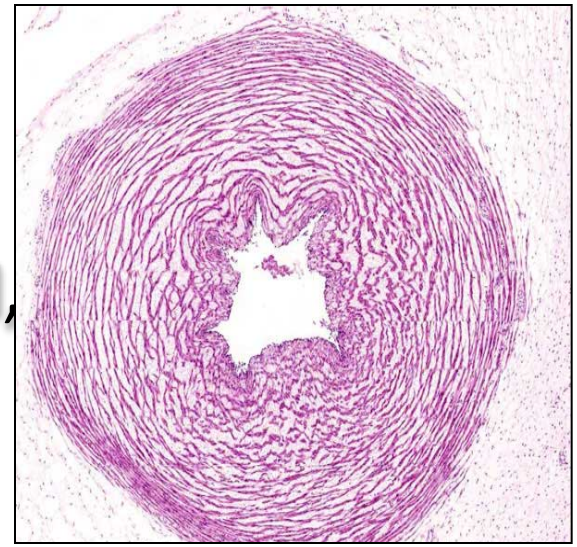
Special types of medium sized arteries

1- Basilar artery: protected by the skull.

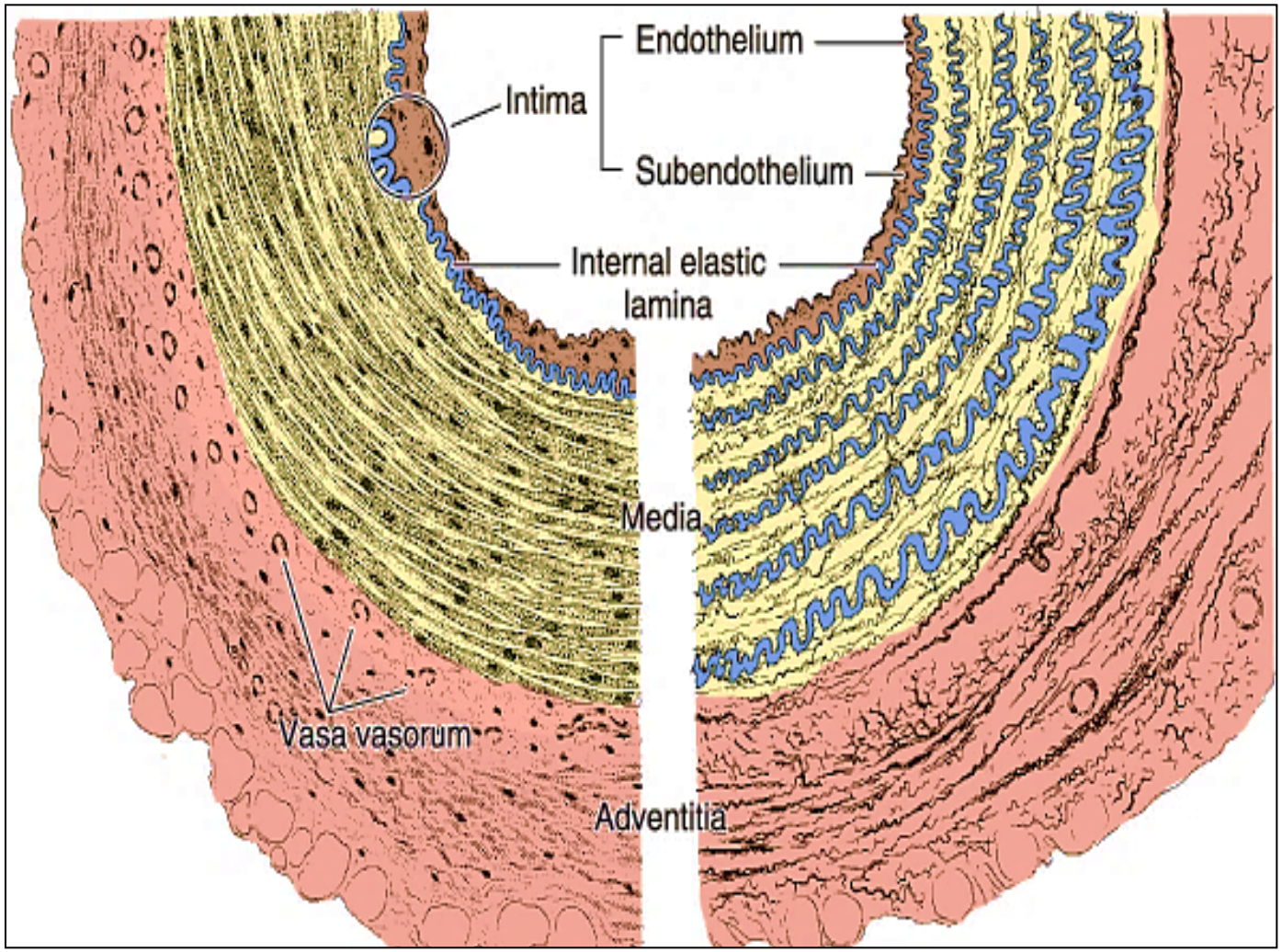
Tunica intima : has **prominent thick IEL**

2- Umbilical artery: in the umbilical Cord,

Tunica adventitia: made by Mucoid CT



Umbilical artery



Muscular arteries

Distributing arteries

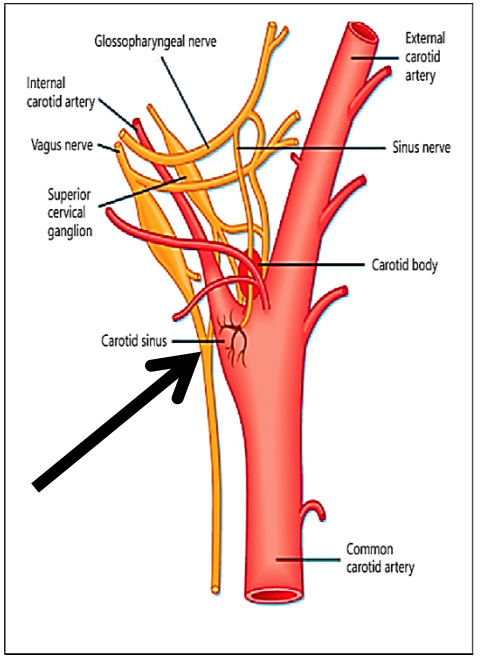
Elastic arteries

Conducting arteries

Arterial sensory structures

1- Carotid sinuses:

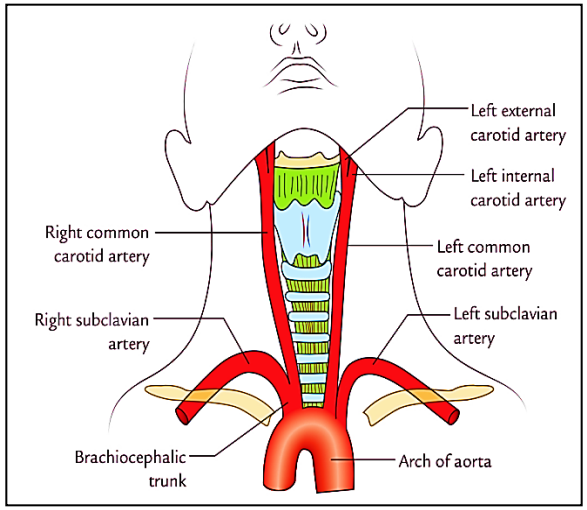
- Dilatation in the wall internal carotid arteries and in Aortic arch
- Contains baroreceptors which monitor Changes in blood pressure.
- The tunica media of each carotid sinus is thinner allowing greater distension when bl. pressure rises

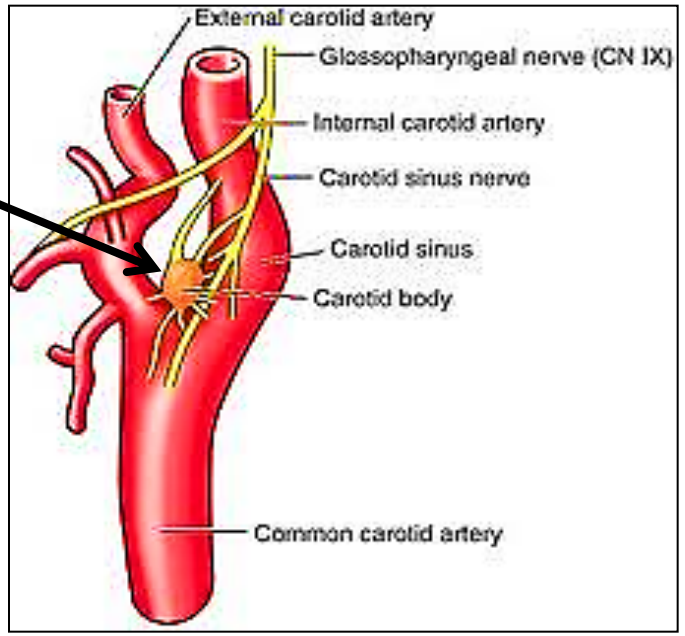


- Sensory nerve endings from cranial n. IX glossopharyngeal nerve are embedded in the wall of the artery
- Afferent n impulse → brain → trigger adjustment in vasoconstriction → blood pressure return to normal

2- Carotid bodies:

- Small , ganglion like structures
- Found in the adventitia near the bifurcation of common Carotid arteries

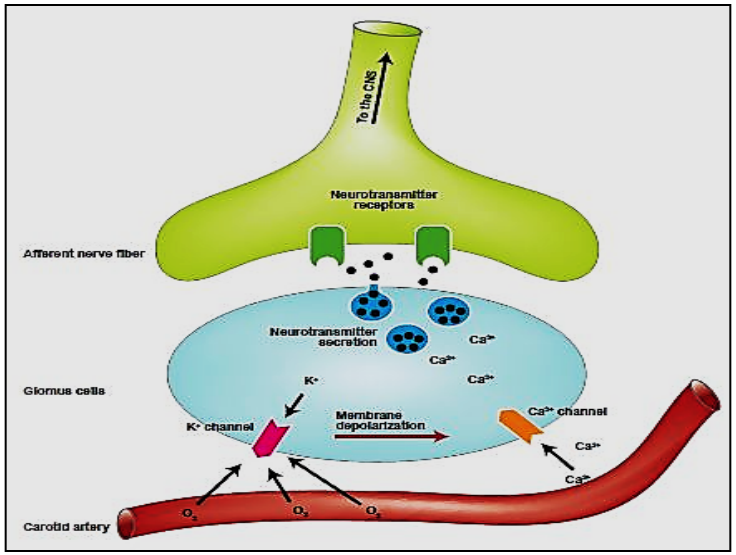


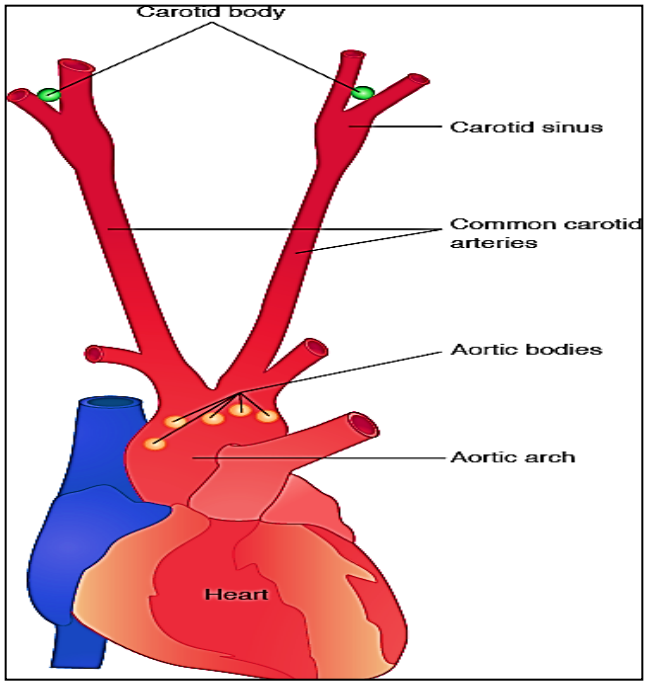


- Contain **chemoreceptors** sensitive to blood Co_2 & O_2 & H^+ concentrations
- These structures contains **sinusoidal capillaries** that - intermingled with clusters of cells called **Glomus cells**

- Glomus cells cytoplasm contain neurotransmitters e.g. dopamine, serotonin , adrenaline,

- Glomus cells form synaptic connection with dendritic fibers of glossopharyngeal nerve. the sensory nerve is activated by neurotransmitters released from glomus cells in response to changes in the composition of the sinusoidal blood





3- Aortic bodies

Located on the arch of aorta similar to carotid bodies

Arterioles (10- 100 µm)

Responsible for **peripheral resistance** of blood vessels

Control blood flow into capillaries

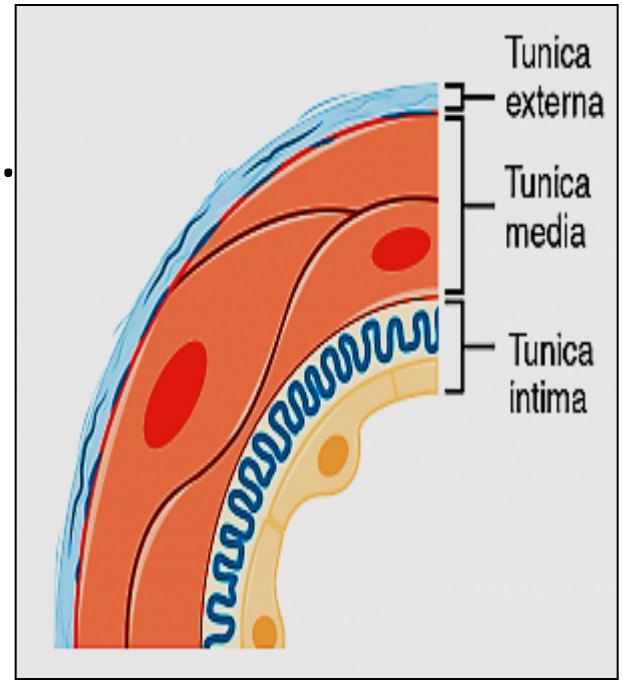
Tunica intima: thin with thin IEL

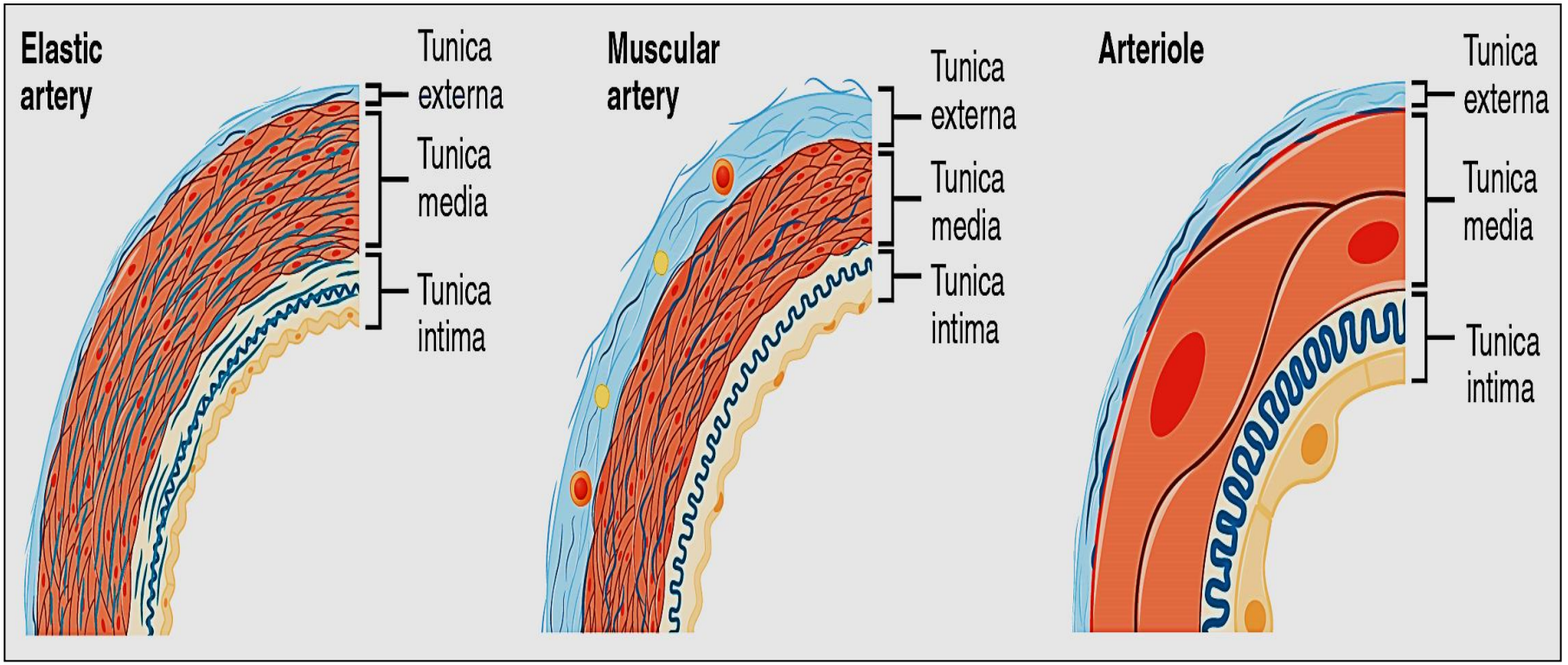
(IEL gradually disappear in small arterioles)

Tunica media: 1 or 2 layers of smooth m.

(gradually disappear & replaced by pericytes in capillaries

Tunica adventitia : very thin





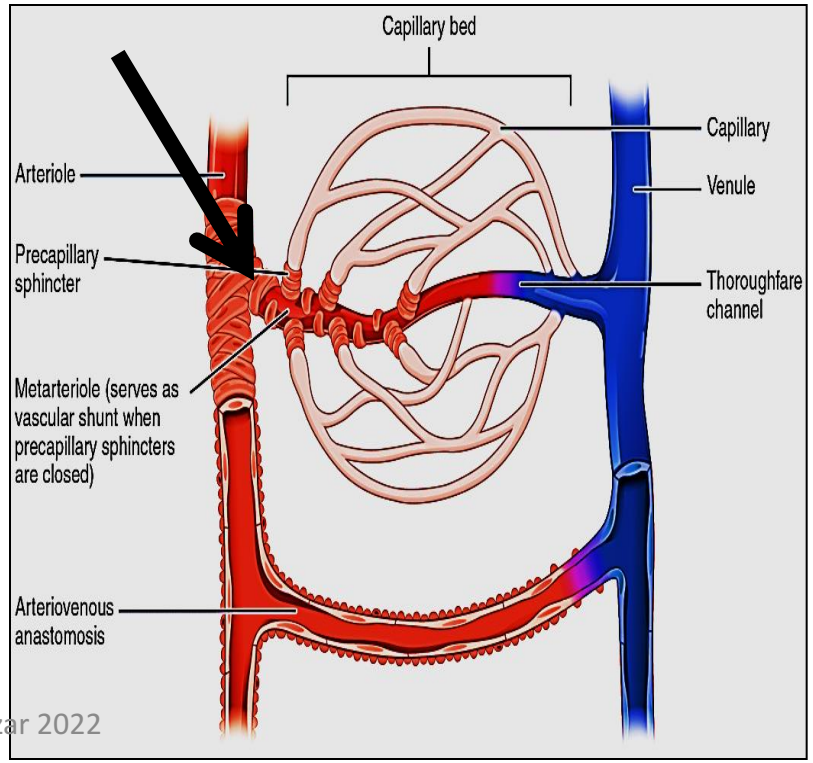
Arterioles have muscular walls only 1 or 2 layers of smooth muscle

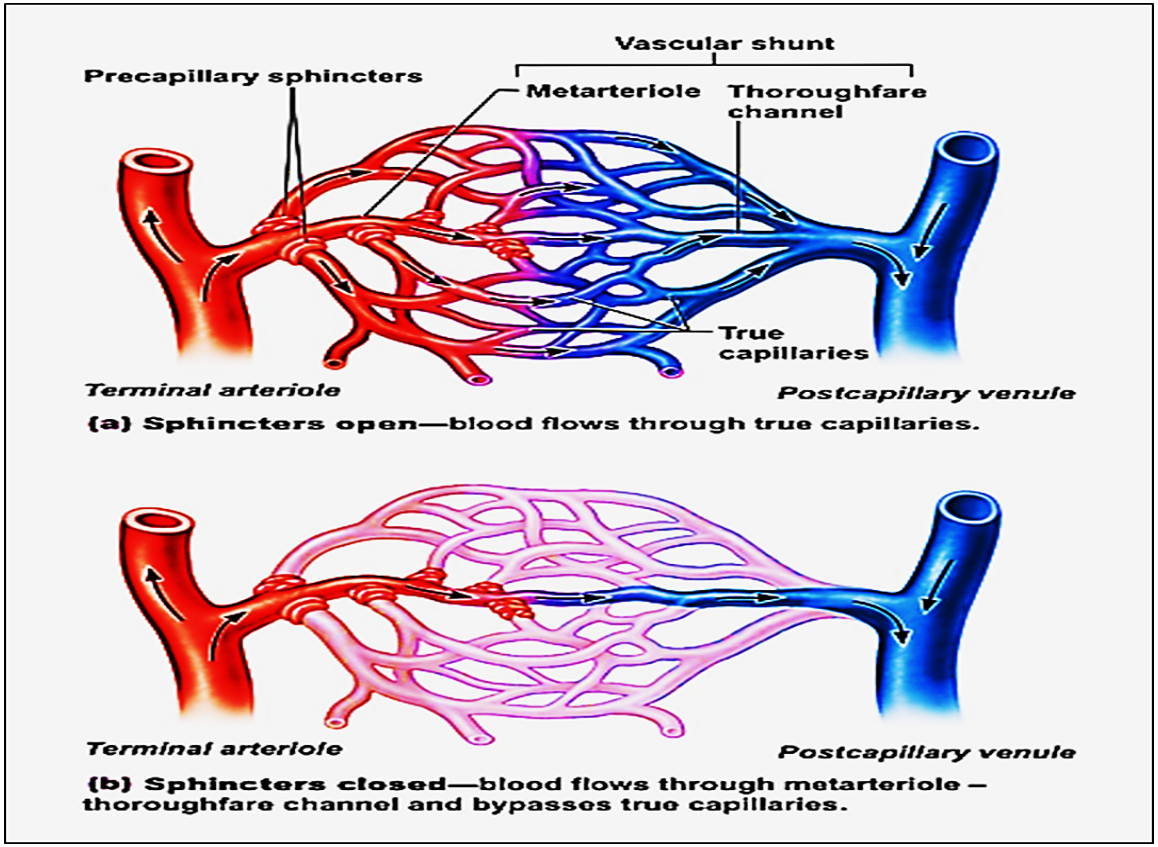
Metarterioles (arterial capillaries)

- short micro vessels (8- 10 µm) that links terminal arterioles to capillaries

- Instead of continues tunica media they have individual muscle cells placed short distance apart.

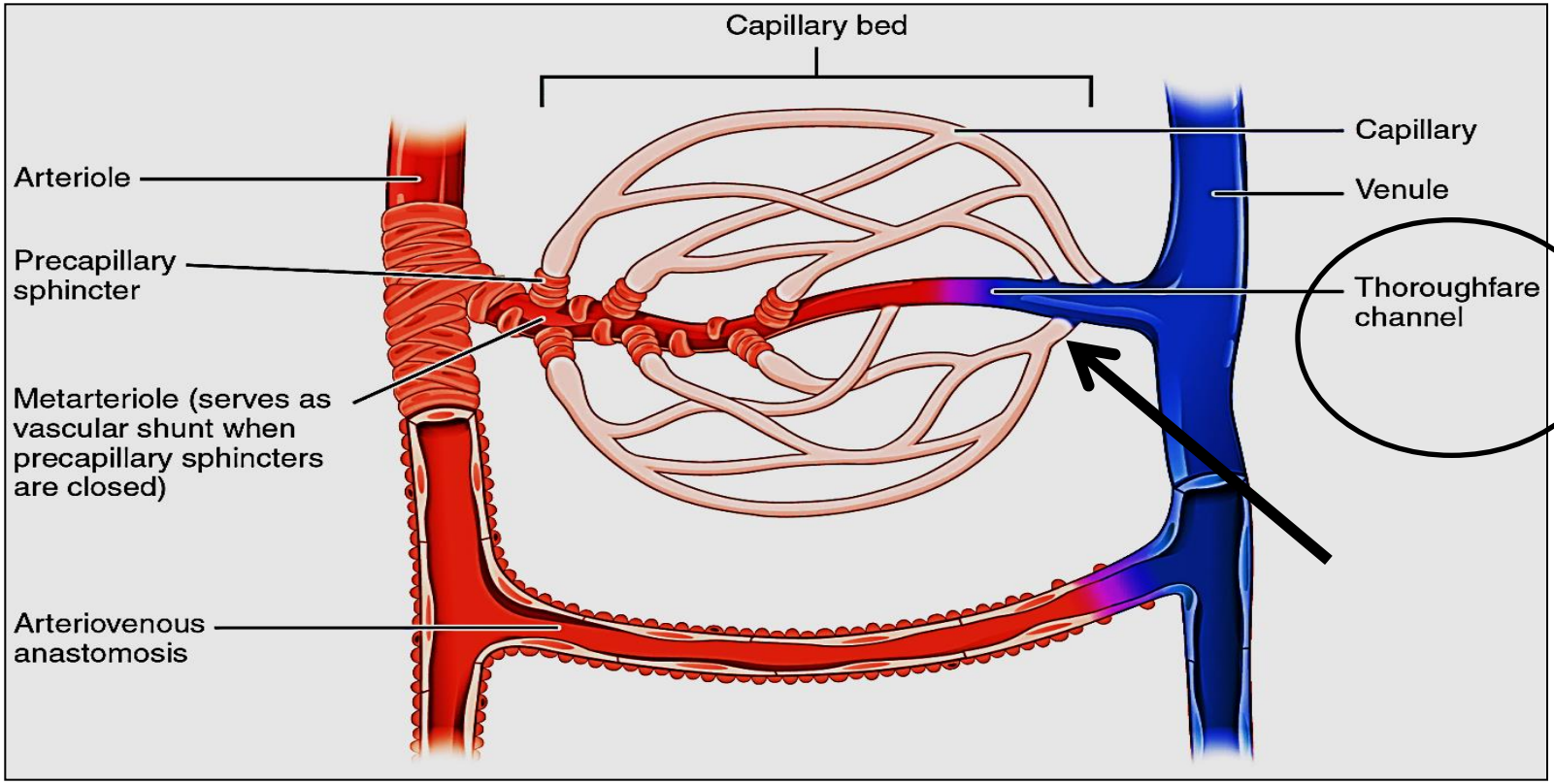
- Form **pre-capillary sphincters**
  rings of smooth ms fibers
  at the entrance to capillaries,
  act as a valve to regulate
  blood flow into capillary





- When pre- capillary sphincter **relaxed** →blood flow through true capillaries, takes parts in exchange with tissue

- When pre- capillary sphincter **contracted** blood flows through shunts and bypasses tissue cells



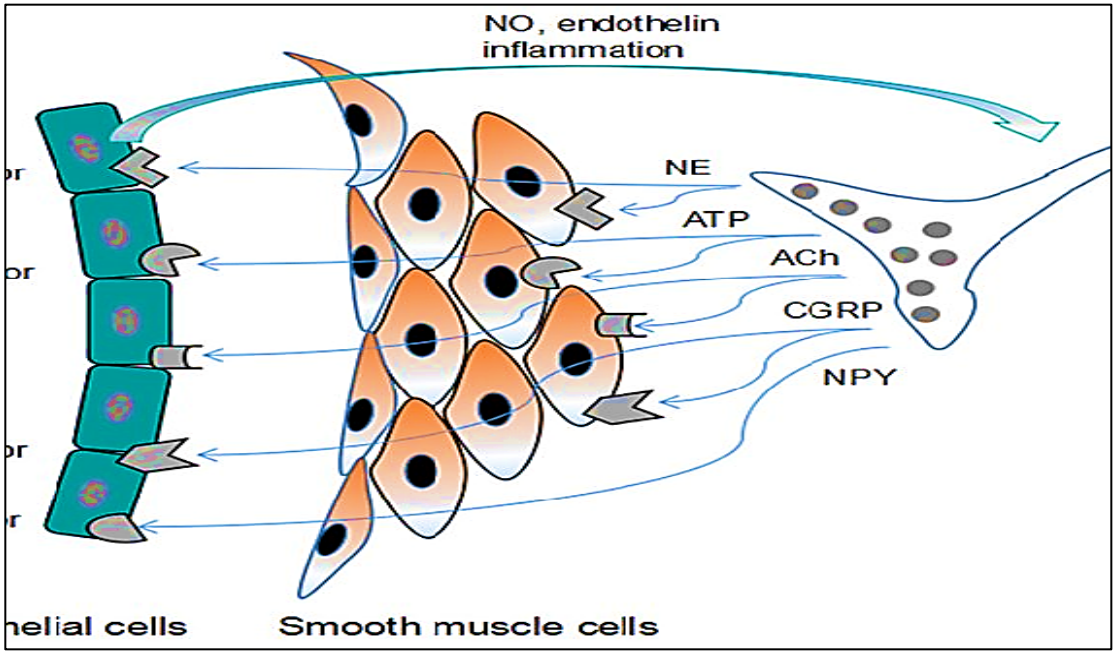
The smooth muscle of metarterioles and the precapillary sphincters contract and relax causing intermittent flow of blood in capillaries this is known as vasomotion. The osmotic pressure (OP) of plasma proteins plays a role in that process

Thoroughfare channel = the distal half of the metarteriole is called thoroughfare Channel which has no sphincters (No smooth muscles) and receives blood from the capillary bed , becoming more like a venule

Vasoconstriction: primarily involves arterioles

Vasoconstriction is stimulated by sympathetic nerve fibers

These fibers don't synapse on the muscle cells of tunica media rather than that they discharge the neurotransmitter that diffuse throughout the muscle layer and induce contraction of cells via gap junctions



- Vascular smooth muscles is **not innervated** by parasympathetic nervous system (except salivary glands, gastrointestinal glands, genital erectile tissue in male penis)
- **Vasodilation**: is caused through muscarinic receptors on endothelial cells → release endothelium derived relaxing factor nitric oxide → diffuse to muscle cells in media → activates cGMP→ relaxation
- However smooth muscles in tunica media posses muscarinic receptors, which when activated cause vasodilation… (medications can work on them)
- Endothelial dysfunction and inflammation are associated with disturbed sympathetic nerve activity in many pathological conditions, such as hypertension, heart failure, and diabetes mellitus.

- The arterioles including terminal are well innervated because they contain smooth muscle cells

- The capillaries are not innervated cuz they don't have smooth muscles

- **Hormones** circulate in the blood (catecholamine, renin-angiotensin, vasopressin, atrial natriuretic peptide can affect the microcirculation causing vasodilation or vasoconstriction
- **Altogether capillaries** compromise approximately over 70% of all blood vessels in the body. The exchange of substances through capillaries occur through 3 different mechanisms: Diffusion, bulk flow, transcytosis

Thank you