

# Circulatory system

**First year- Histology subject– Laboratory sciences department.**

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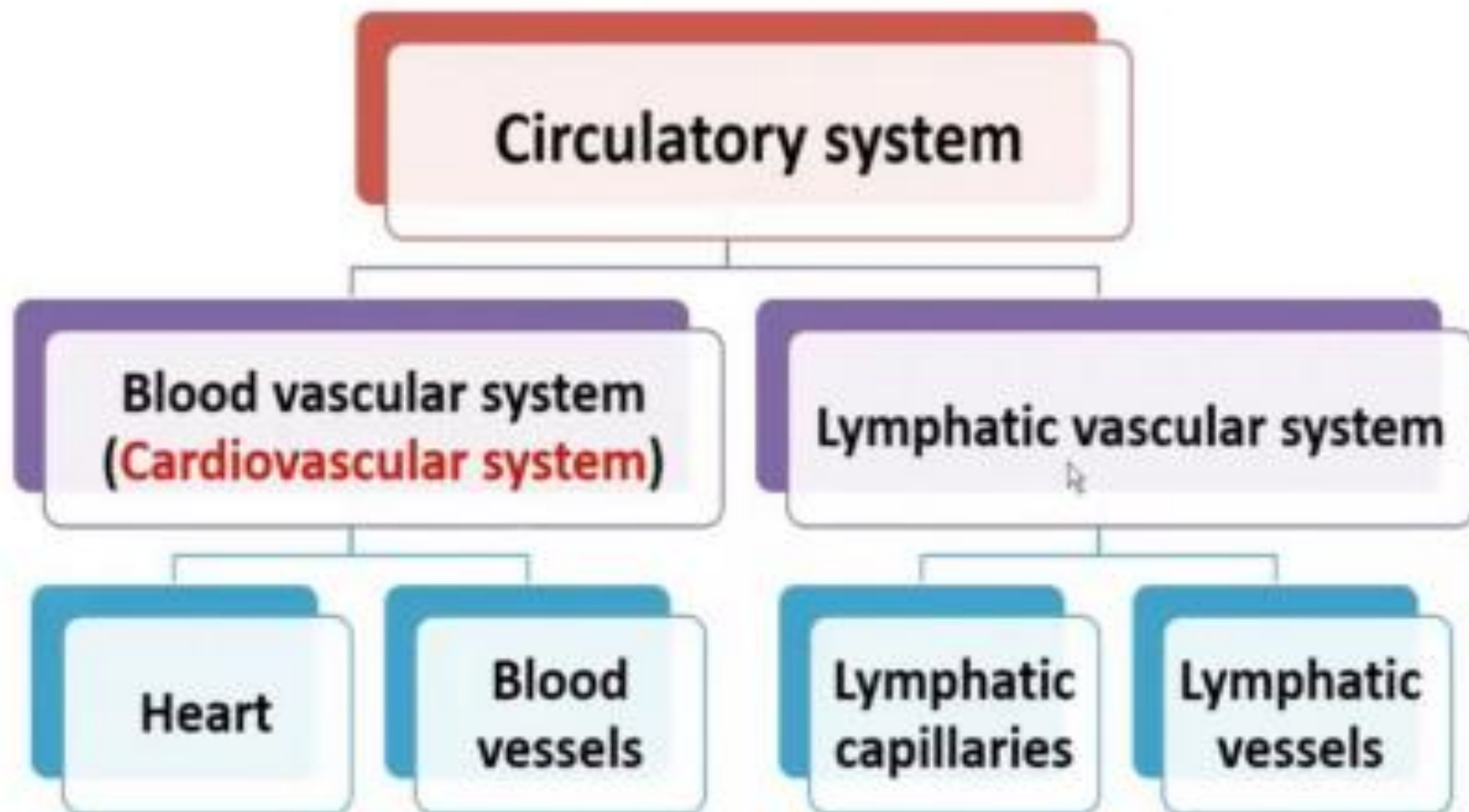
# Learning objectives

**By the end of this lecture, the students should be able to:**

- 1- Describe the circulatory system.
- 2- Recognize the histological structure of the heart wall.
- 3- Identify the fibrous skeleton of the heart.
- 4- Discuss the impulse conducting system of the heart.
- 5- Describe the general microscopic structure of blood vessels wall.

# Contents

- 1- Circulatory system and its contents.
- 2- Major histological features of the heart.
- 3- Heart wall and its layers (endocardium, myocardium, and epicardium).
- 4- Pericardium and its types.
- 5- Impulse conducting system of the heart.
- 6- Blood vessels types.
- 7- Blood vessels structure.

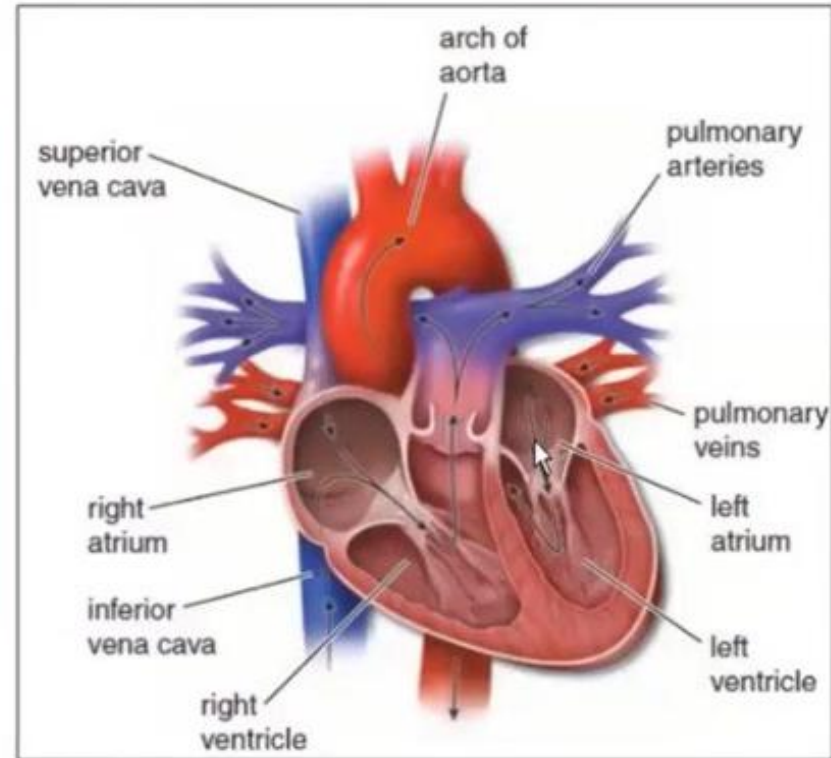


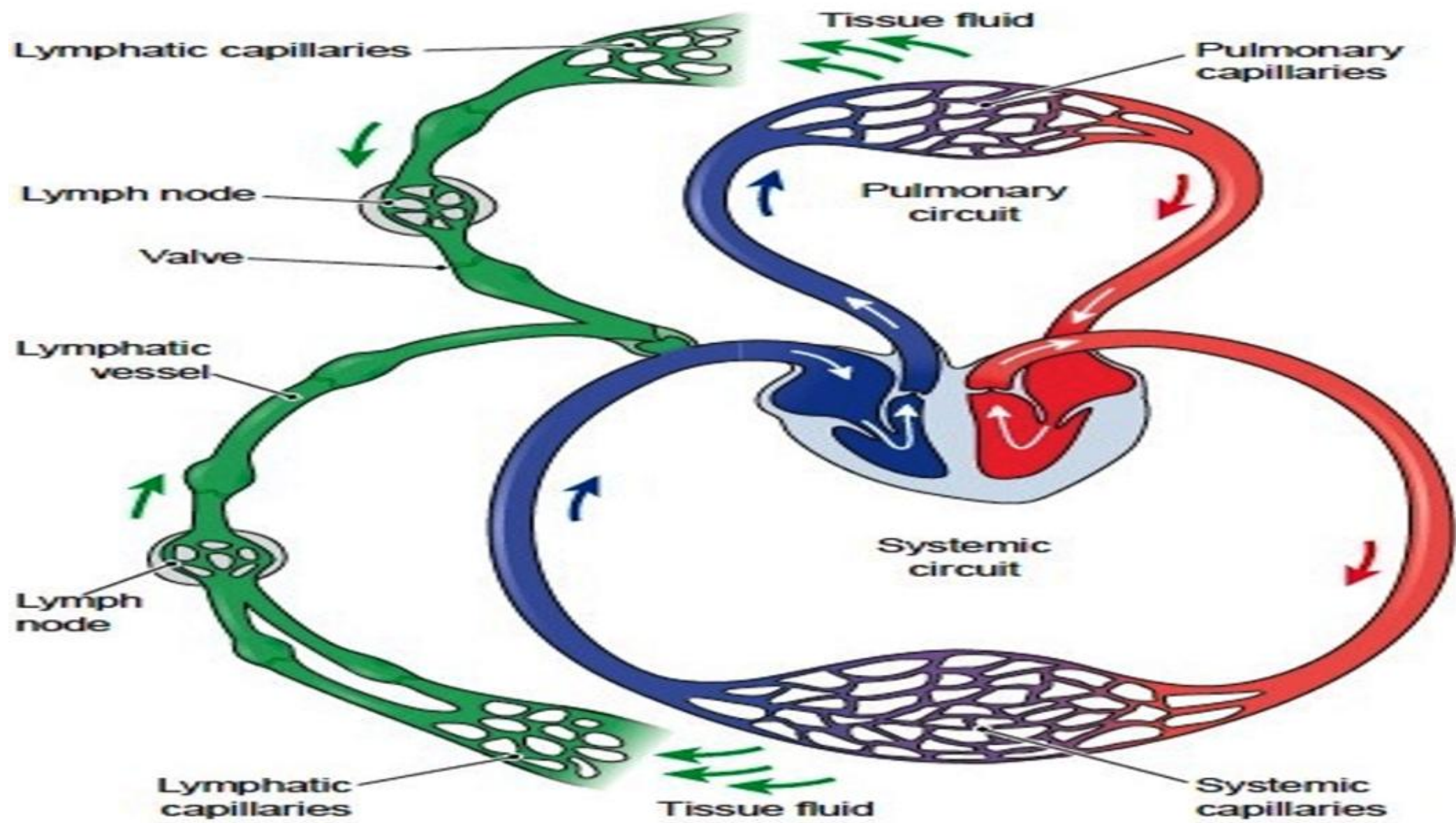
# Circulatory system

- The circulatory system includes both the blood and lymphatic vascular systems. The blood vascular system is composed of the following structures:
- **The heart**, an organ whose function is to pump the blood.
- **The arteries**, a series of efferent vessels that become smaller as they branch, and whose function is to carry the blood, with its nutrients and oxygen, to the tissues.
- **The capillaries**, the smallest blood vessels, constituting a complex network of thin tubules that branch profusely in almost every organ and through whose walls interchange between blood and tissues takes place.
- **The veins**, which result from the convergence of capillaries into a system of larger channels that continue enlarging as they approach the heart, toward which they convey the blood to be pumped again.

# HEART

- It is a muscular organ.
- It has 4 chambers (2 atria and 2 ventricles).
- Pumps and distributes blood through a series of closed vessels in the body.





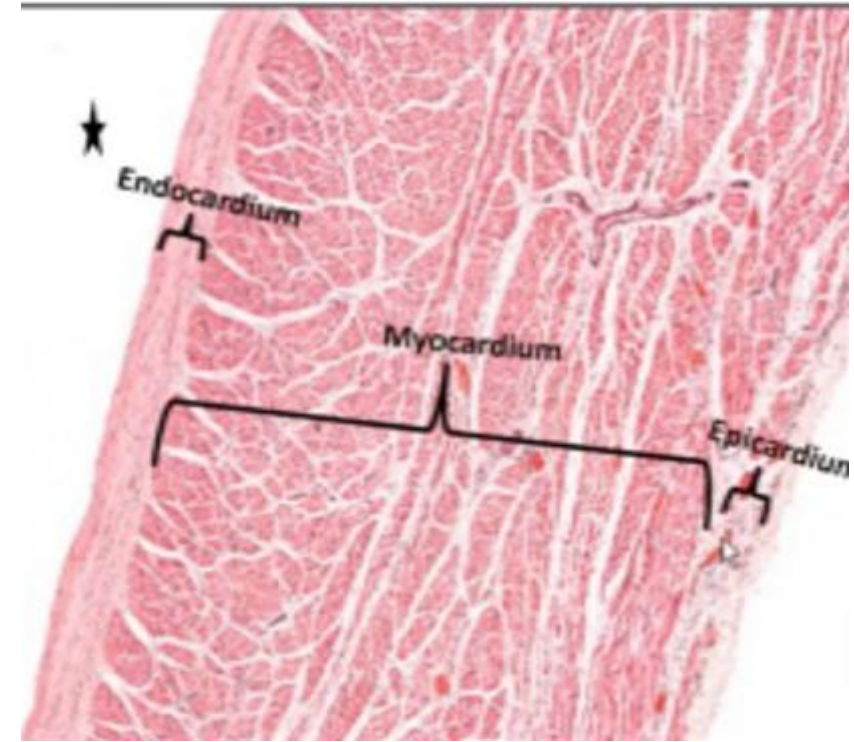
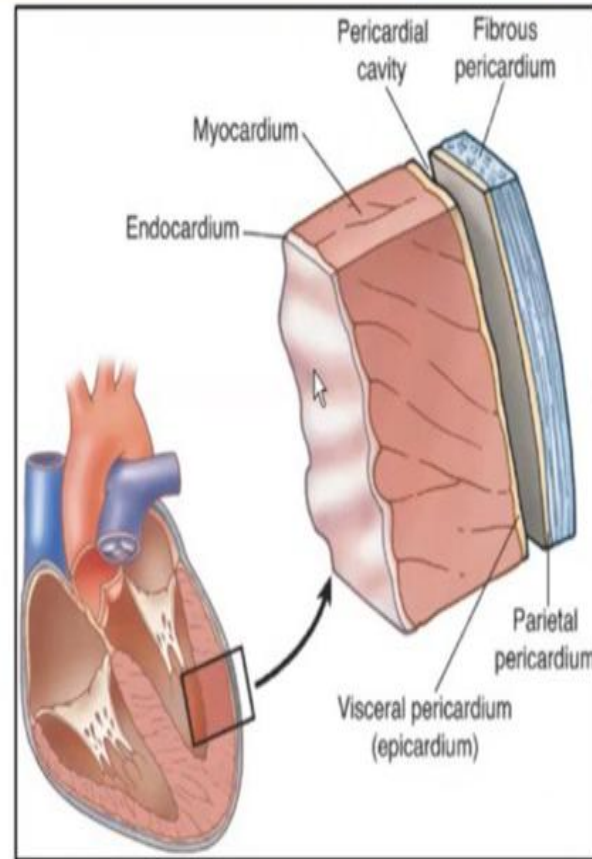


The wall of heart consists of three layers

Inner layer: **Endocardium**

Middle layer: **Myocardium**

Outer layer: **Epicardium**





# The Heart Wall

- There are three layers of the heart wall

- **Epicardium**

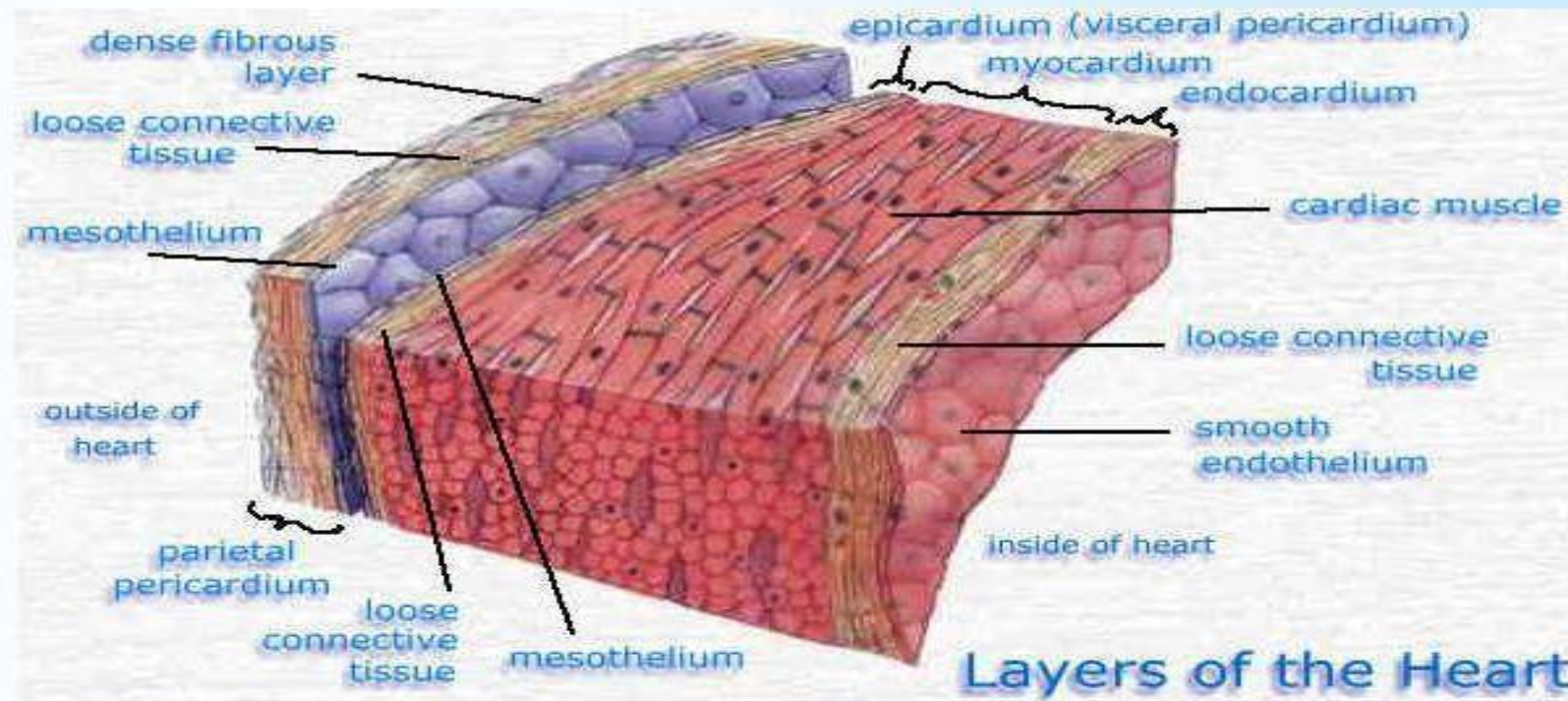
- Outer layer
- Visceral pericardium

- **Myocardium**

- Middle layer
- Makes up the majority of the heart's mass

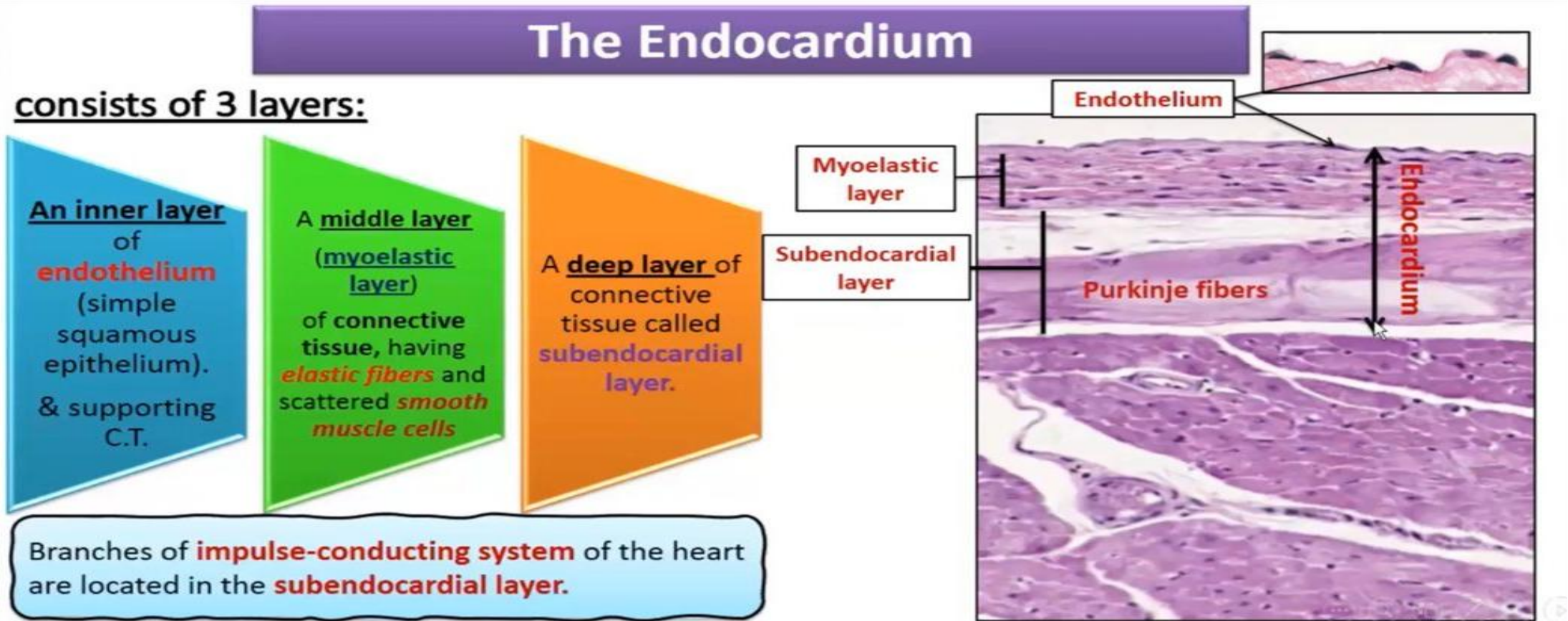
- **Endocardium**

- Inner layer
- Lines the chambers, valves, vessels



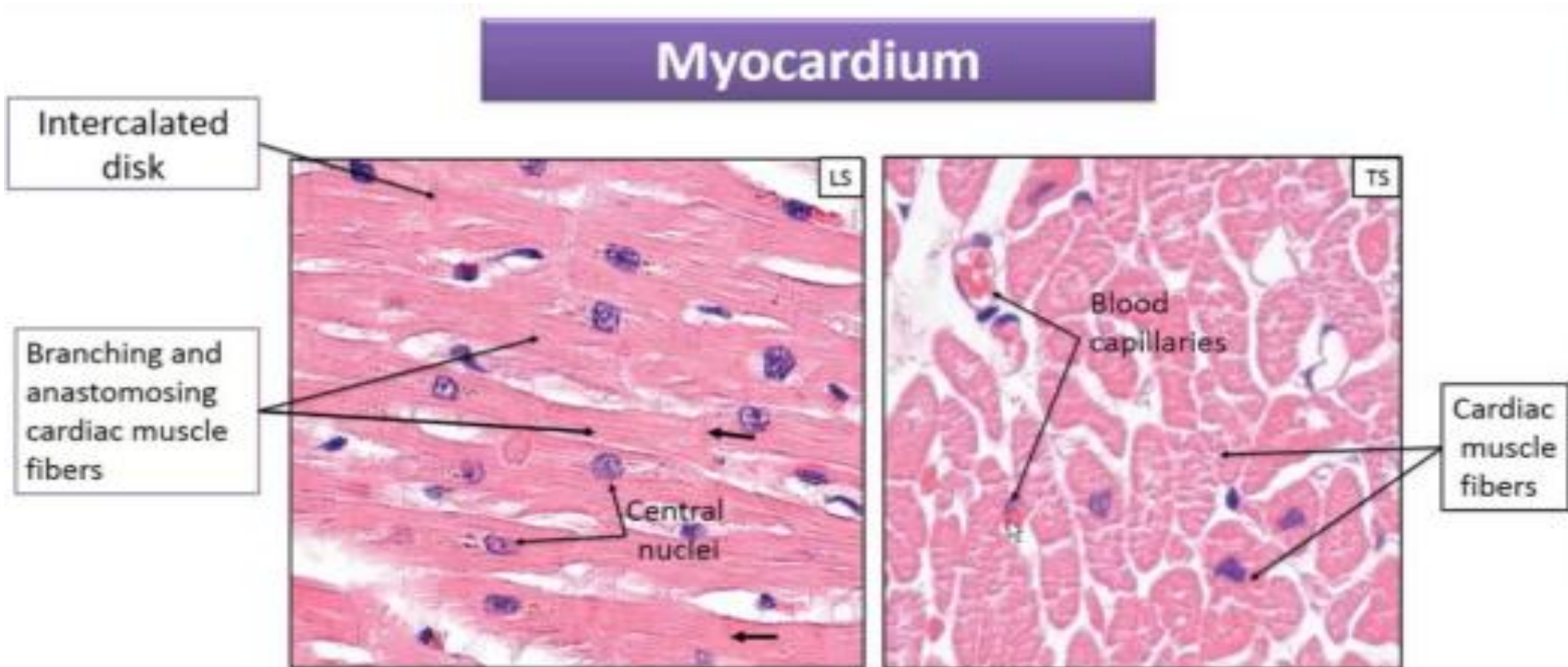
## The endocardium

- consists of a single layer of squamous endothelial cells on a thin layer of loose connective tissue containing elastic and collagen fibers as well as some smooth muscle cells. Connecting this subendothelial layer to the myocardium is additional connective tissue (often called the subendocardial layer) containing veins, nerves, and branches of the impulse-conducting system of the heart.





- **The myocardium** is the thickest layer , consists of cardiac muscle cells arranged in layers that surround the heart chambers in a complex spiral. The myocardium is much thicker in the ventricles than in the atria. The arrangement of these muscle cells is extremely varied, so that in sections , cells are seen to be oriented in many directions.



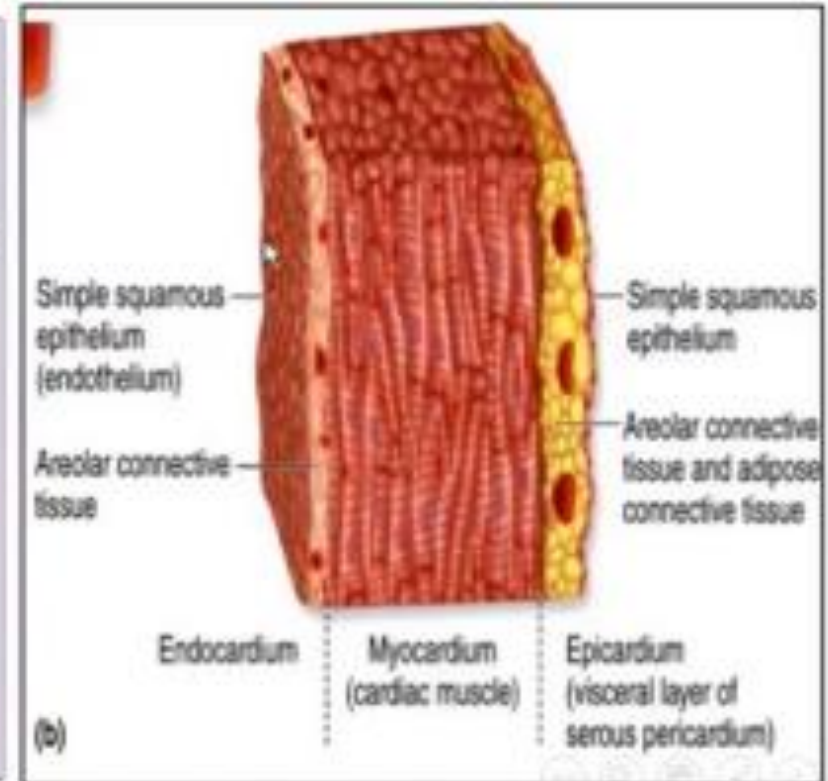
- **The epicardium** corresponds to the visceral layer of the pericardium, the serous membrane in which the heart lies. In the space between the pericardium's visceral layer (epicardium) and its parietal layer is a small amount of lubricant fluid that facilitates the heart's movements.

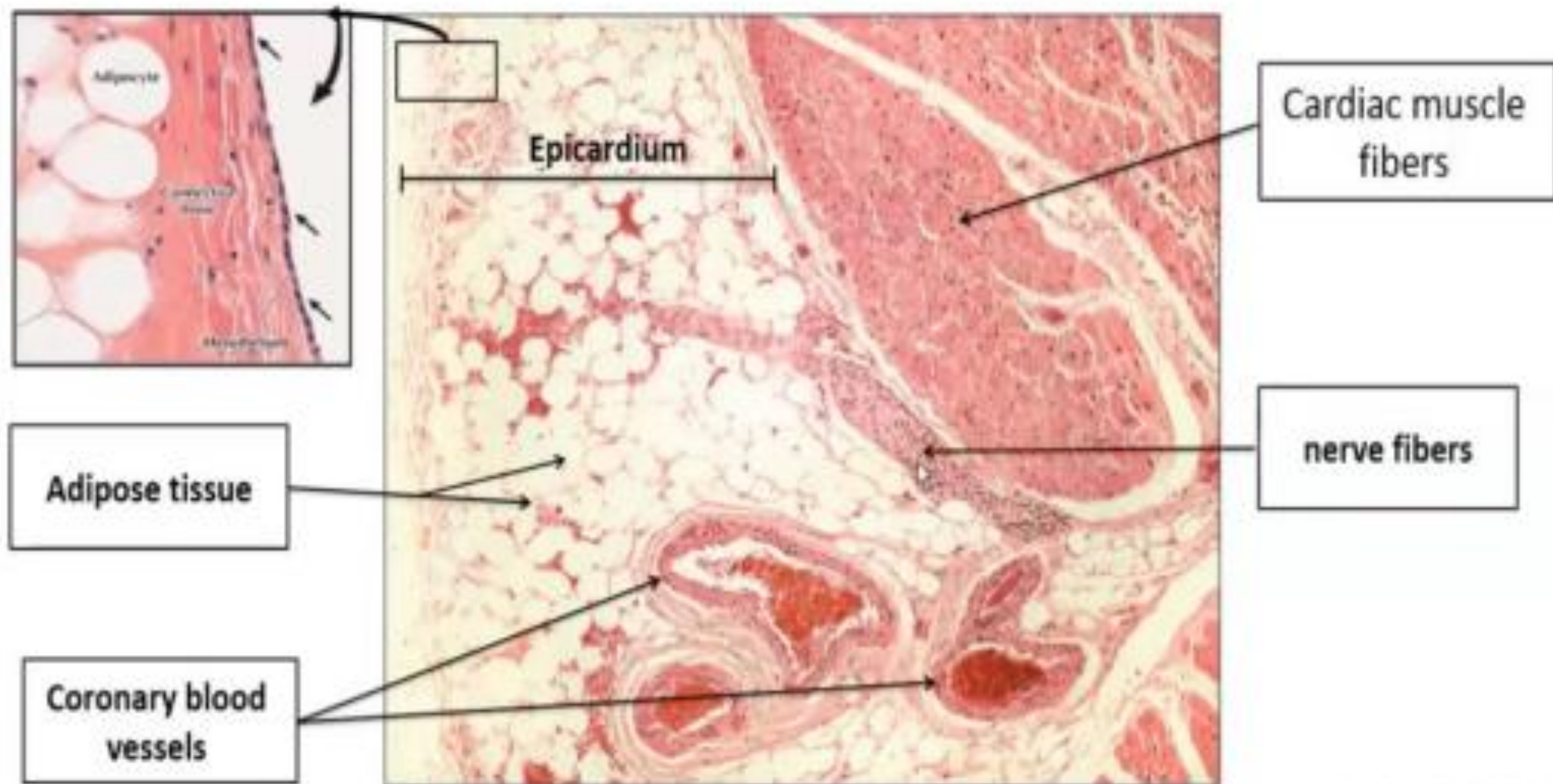
## The Epicardium

❖ It is the **visceral layer of serous pericardium**.

❖ It consists of a simple squamous **mesothelium** (simple squamous epithelium) supported by a layer of loose connective tissue and **adipose tissue** that cushions the heart.

❖ Containing **coronary blood vessels** and autonomic **nerves**.







# The pericardium

## Fibrous Pericardium

Dense Fibrous C.T.

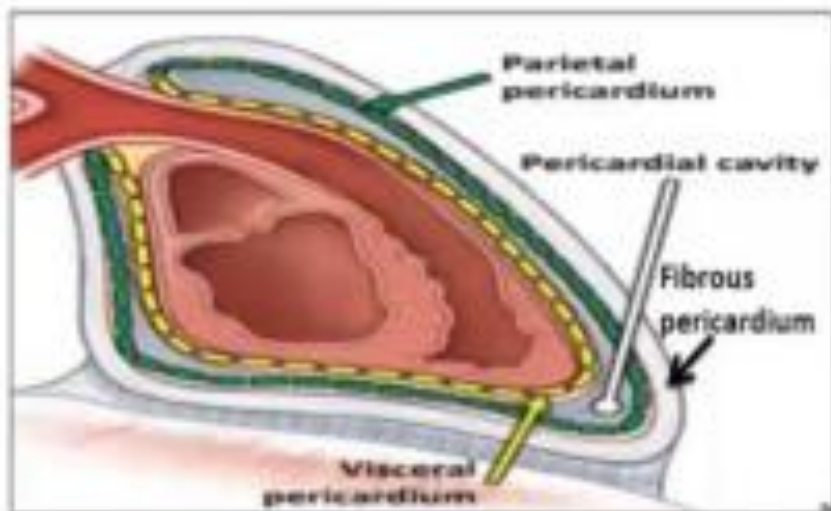
## Serous pericardium

Visceral Layer

= **Epicardium**

Parietal layer

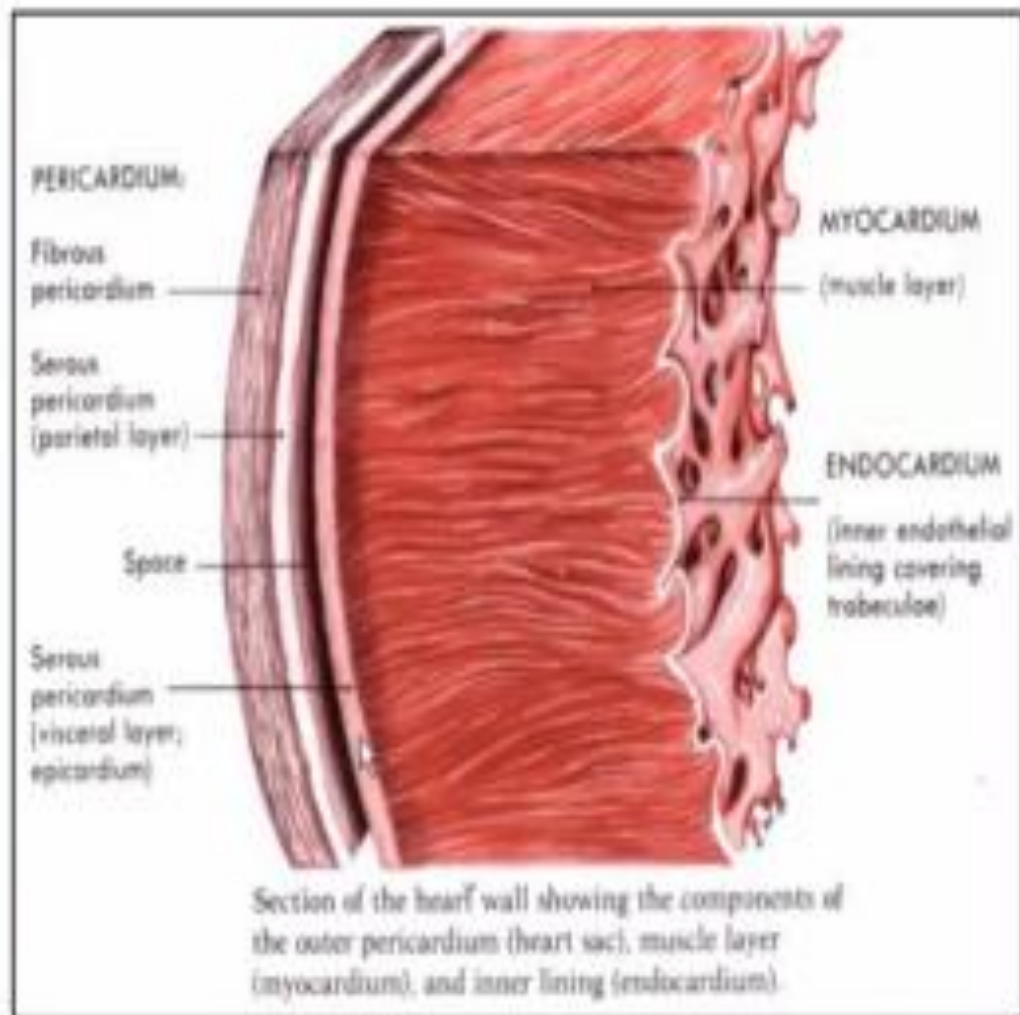
Formed by **reflection** of the **epicardium** back at the great vessels entering and leaving the heart.





## Pericardial cavity

- ❖ between visceral and parietal layers.
- ❖ contains lubricant fluid produced by **both layers of serous mesothelial cells.**
- ❖ This fluid prevents friction within serous pericardium.



# Fibrous skeleton of the heart

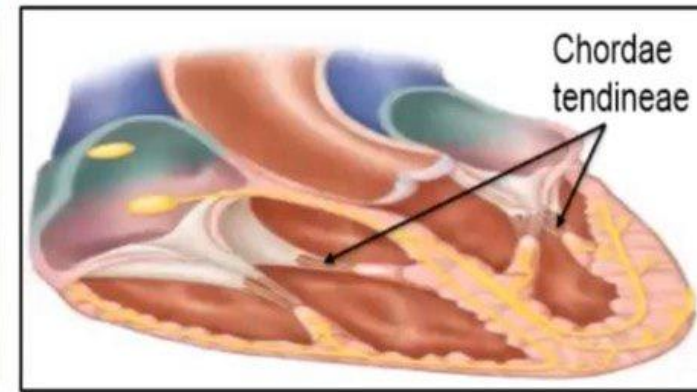
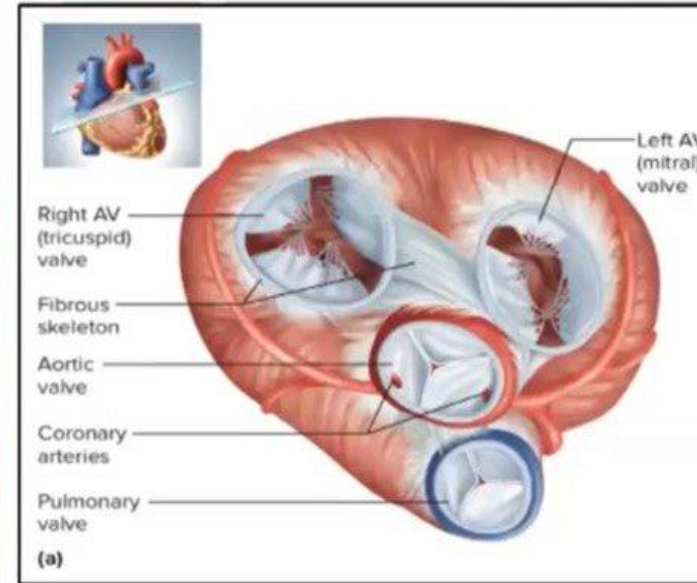
**Definition:** Regions of dense irregular connective tissue covered by endothelium.

## Sites:

- ☐ Valve rings (surrounds valves orifices).
- ☐ Valve cusps.
- ☐ Chordae tendineae.
- ☐ Membranous part of the interventricular and interatrial septa.

## Functions:

- ✓ **Anchoring** and **supporting** the heart valves.
- ✓ Providing firm points of **insertion** for cardiac muscle.
- ✓ Helping **coordinate the heartbeat** by acting as **electrical insulation** between atria and ventricles.



## Heart valves

Folds of endocardium that prevent backflow of the blood

- Consists of fibroelastic C.T. core
- Covered by a thin layer of endothelium continuous with that lining the heart chambers and great vessels.

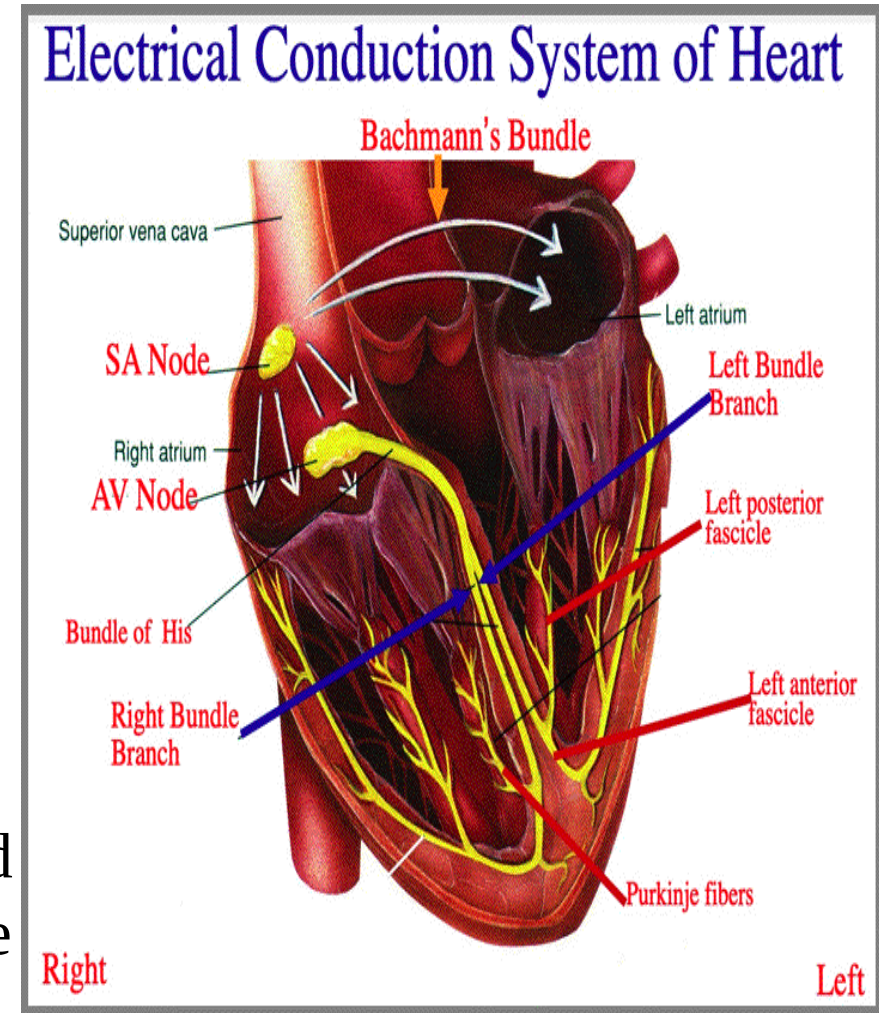




# Impulse conducting system of the heart

The heart has a specialized system to generate a rhythmic stimulus for contraction that is spread to the entire myocardium.

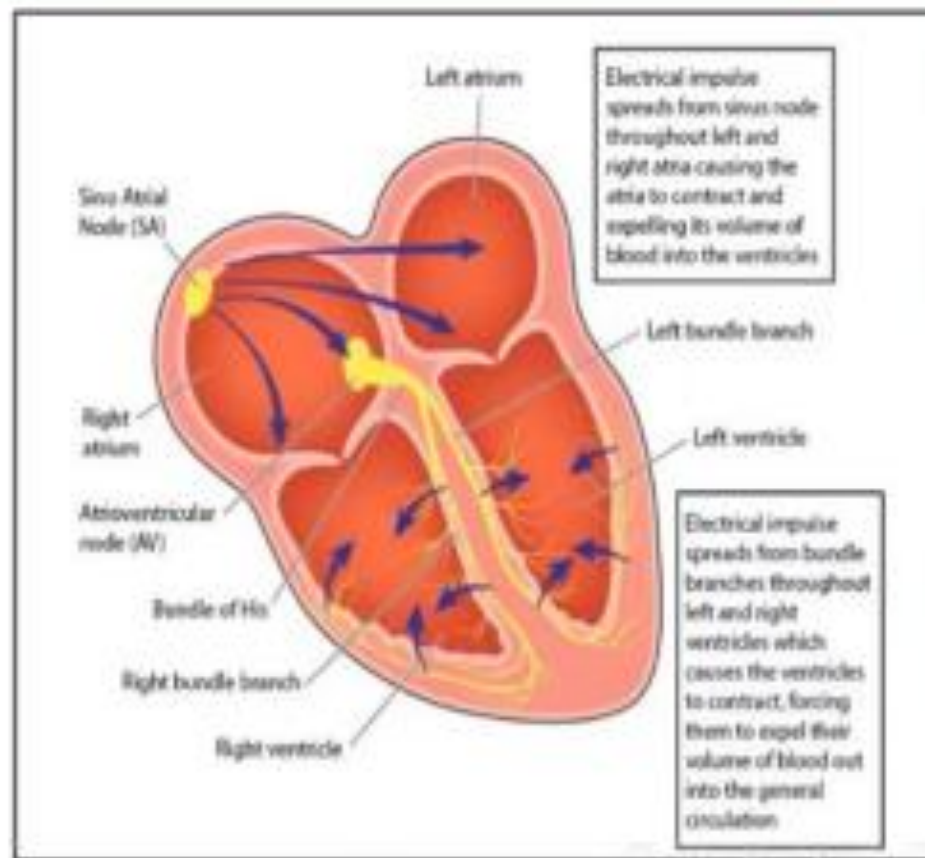
This system consists of two nodes located in the right atrium—the sinoatrial (SA) node (pacemaker) and the atrioventricular (AV) node—and the atrioventricular bundle (of His). **The SA node** is a small mass of modified cardiac muscle cells that are fusiform, smaller and with fewer myofibrils than neighboring muscle cells. **The cells of the AV node** are similar to those of the SA node but their cytoplasmic projections branch in various directions, forming a network. **The AV bundle** originates from the node of the same name, passes along the interventricular septum and splits into left and right bundles, and then branches further to both ventricles. The cells/fibers of the impulse-conducting system are modified cardiac muscle cells functionally integrated by gap junctions.





# Impulse conducting system of the heart

- Consists of modified cardiac muscle cells.
- **Site:** within the subendocardial layer.
- **Function:** generation and propagation of waves of depolarization that spread through the myocardium to stimulate rhythmic contractions.



# Impulse conducting system of the heart

## ❖ includes:

- ✓ Sinoatrial (SA) node (**pacemaker**).
- ✓ Atrioventricular (AV) node.
- ✓ AV bundle (**Bundle of His**).
- ✓ Rt & Lt bundle branches.
- ✓ **Purkinje fibers**

Smaller  
than  
atrial  
cardiac  
ms cells

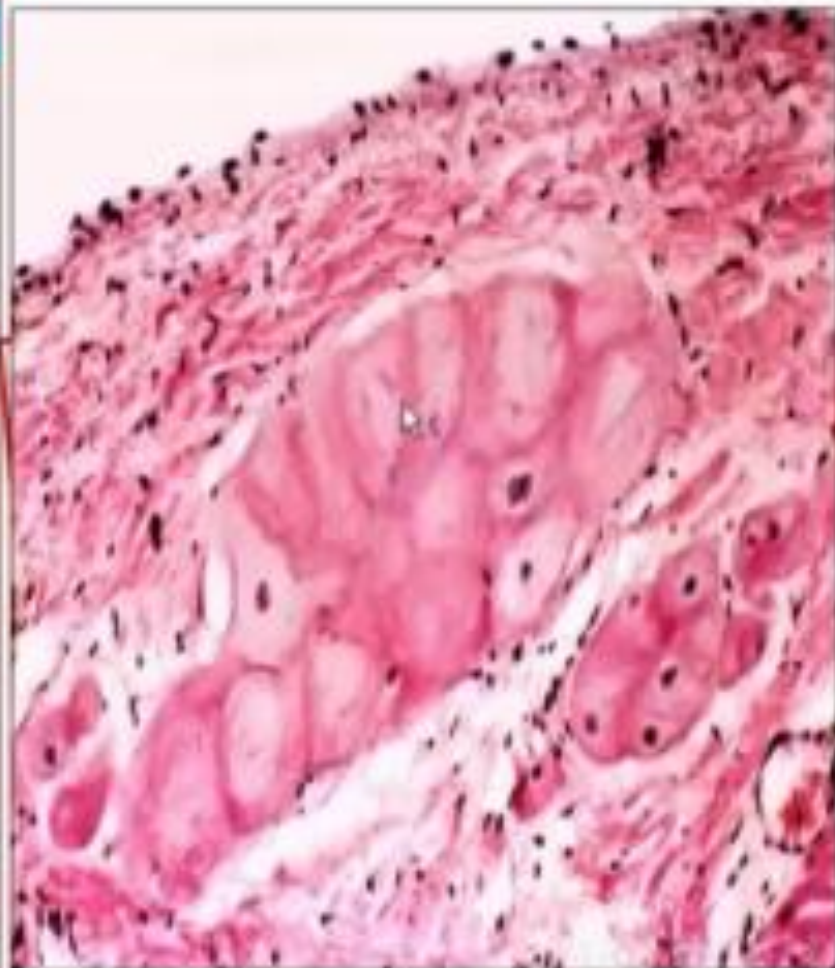
Larger than  
ventricular  
cardiac ms  
cells

(Subendocardial conducting network)  
arise at the **apex** of the heart as final  
divisions of Rt and Lt bundle branches.



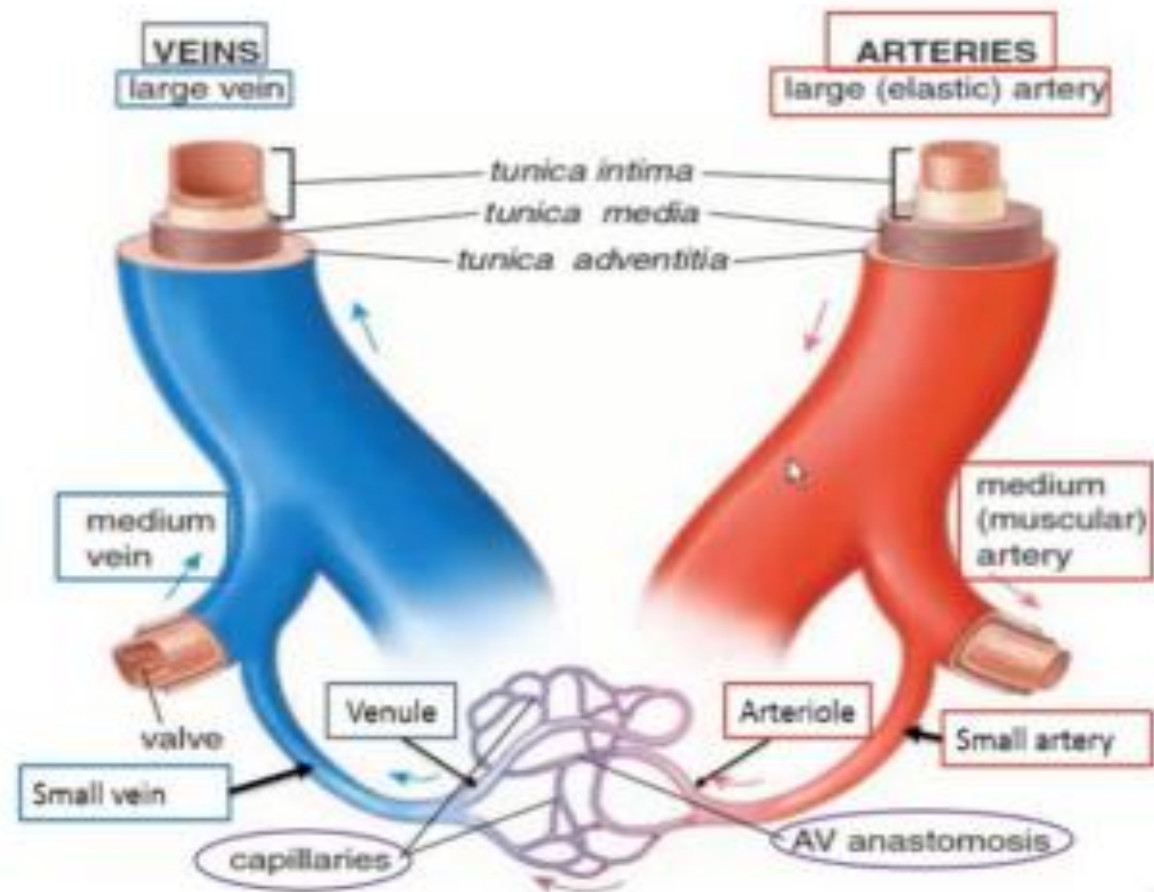
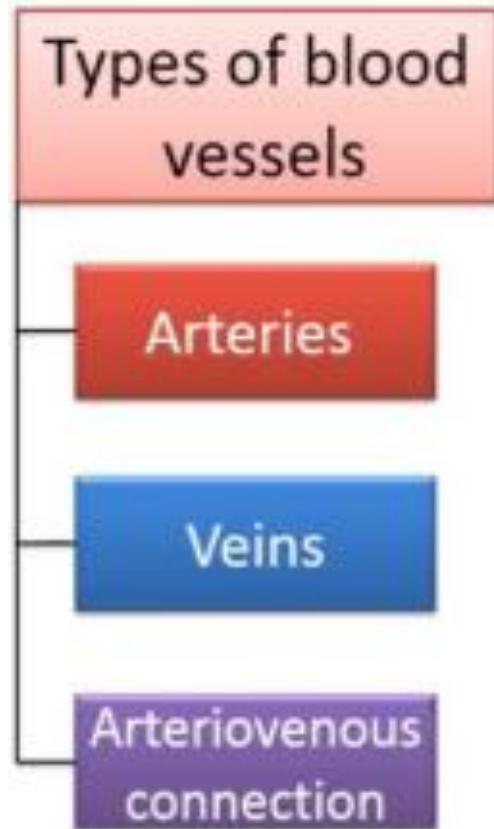
## Purkinje fibers

- **Modified** cardiac muscle fibers specialized for **impulse conduction**.
- **Structure:**
  - ✓ **Size:** **larger** than the adjacent contractile muscle fibers.
  - ✓ **Nuclei:** one or two large, rounded & centrally located.
  - ✓ **Sarcoplasm:**
    - **Its center is pale-stained**, as it is filled with **glycogen** that dissolve during H&E staining.
    - **Sparse myofibrils** displaced **peripherally** by abundant glycogen.
  - ✓ Joined by **intercalated discs** specialized for **impulse conduction** not contraction (**desmosomes** and **gap junctions**).





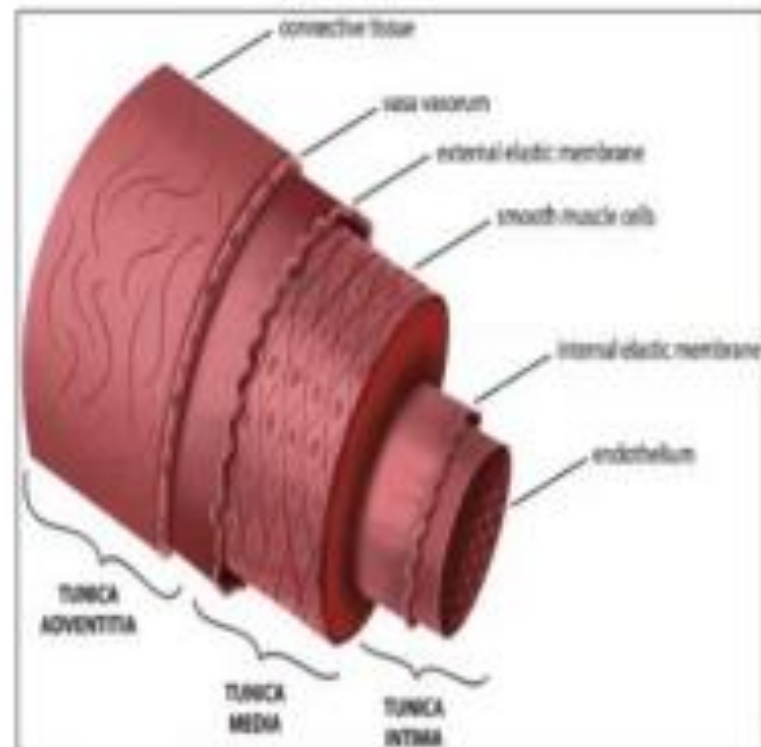
# Blood vessels



## General structure of blood vessels wall **Except capillaries**

The walls of arteries and veins are composed of three layers called *tunics*

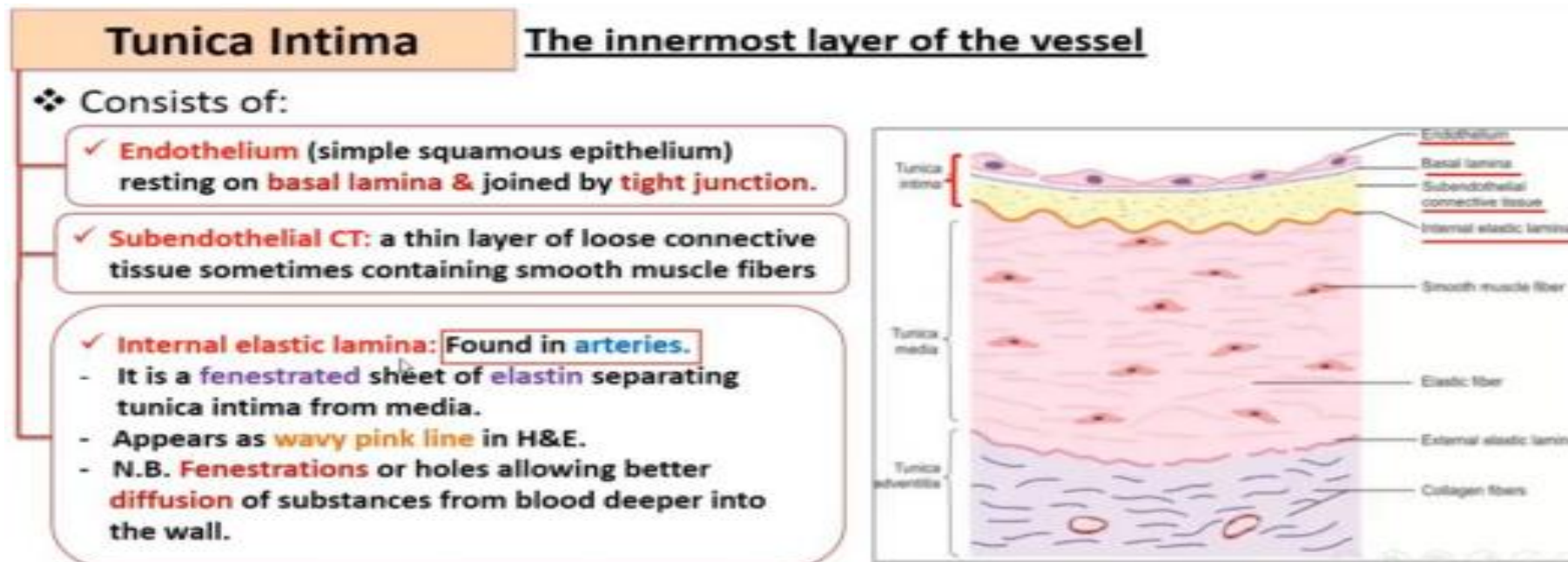
- **Tunica intima:** the innermost layer in contact with blood.
- **Tunica media:** the middle layer.
- **Tunica adventitia:** the outermost layer.



# Structure of blood vessels

## The tunica intima

- has one layer of endothelial cells supported by a thin subendothelial layer of loose connective tissue with occasional smooth muscle cells. In arteries, the intima is separated from the media by an internal elastic lamina, the most external component of the intima. This lamina, composed of elastin, has holes (fenestrae) that allow the diffusion of substances to nourish cells deep in the vessel wall.





- **The tunica media**, the middle layer, consists chiefly of concentric layers of helically arranged smooth muscle cells. Interposed among the smooth muscle cells are variable amounts of elastic fibers and lamellae, reticular fibers of collagen type III, proteoglycans, and glycoproteins, all of which is produced by these cells. In arteries, the media has a thinner external elastic lamina, which separates it from the tunica adventitia.

### **Tunica Media** ❖ The middle layer of the vessel wall

❖ Consists of

Concentric layers of **smooth muscle cells**

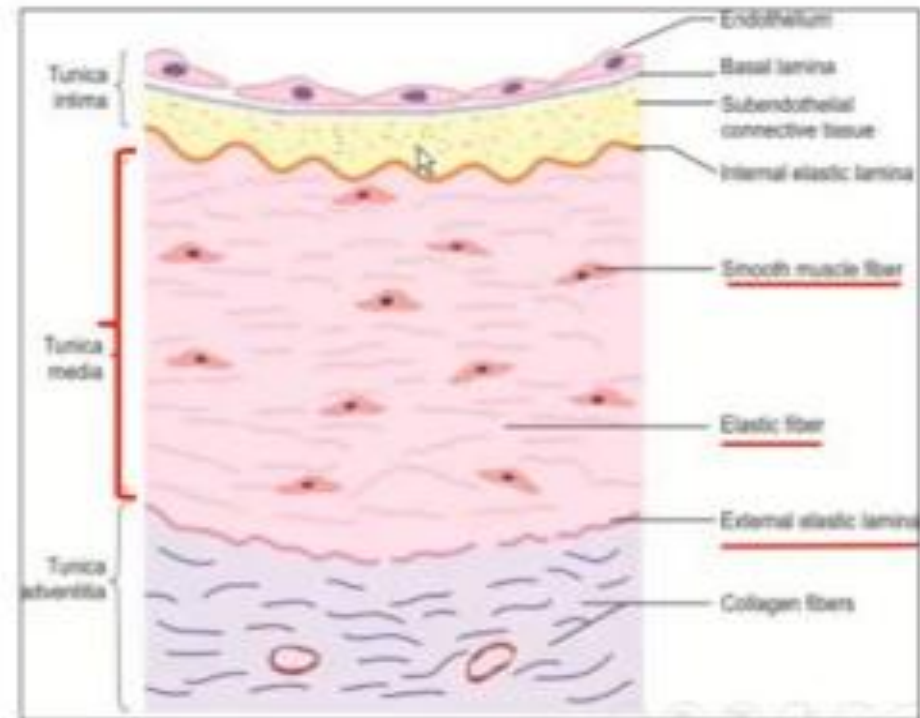
**Elastic fibers**  
(**Fenestrated** elastic lamellae)

**Reticular fibers**

**Proteoglycans**

Produced  
by  
vascular  
smooth  
muscle  
cells

**External elastic lamina:** found in **arteries**  
It is a layer of elastin that separates tunica media from adventitia.



## Tunica Media ❖ The middle layer of the vessel wall

❖ Consists of

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**Elastic fibers**  
(**Fenestrated** elastic lamellae)

**Reticular fibers**

**Proteoglycans**

Produced  
by  
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**External elastic lamina:** found in **arteries**  
It is a layer of elastin that separates tunica media from adventitia.



- **The tunica adventitia** or tunica externa consists principally of type I collagen and elastic fibers . This adventitial layer is gradually continuous with the stromal connective tissue of the organ through which the blood vessel runs.

## **Tunica Adventitia (tunica externa)** ❖ the outermost connective tissue layer

❖ Consists of

**longitudinally arranged  
collagen fibers (type I)**

**Elastic fibers**

**Fibroblasts**

**Vasa vasorum  
(vessels of the vessel)**

**Nervi vasorum  
(vasomotor nerves)**

**In adventitia of  
large vessels**

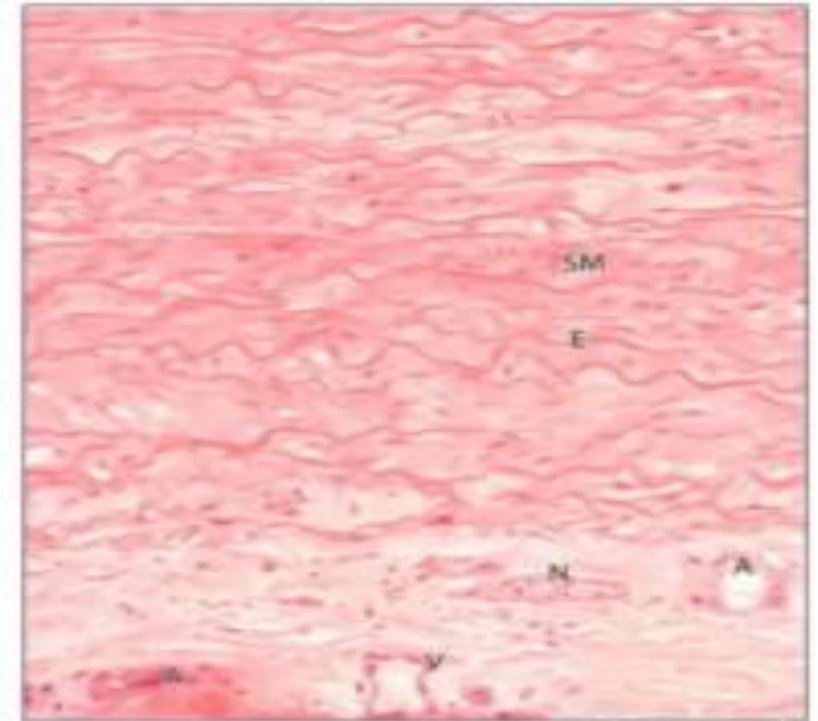




- Large vessels usually have **vasa vasorum ("vessels of the vessel")**, which consist of arterioles, capillaries, and venules in the tunica adventitia and the outer part of the media. The vasa vasorum provide metabolites to cells of those layers, since in larger vessels the wall is too thick to be nourished solely by diffusion from the blood in the lumen. Luminal blood alone does provide nutrients and oxygen for cells of the tunica intima. Since they carry deoxygenated blood, large veins typically have more vasa.

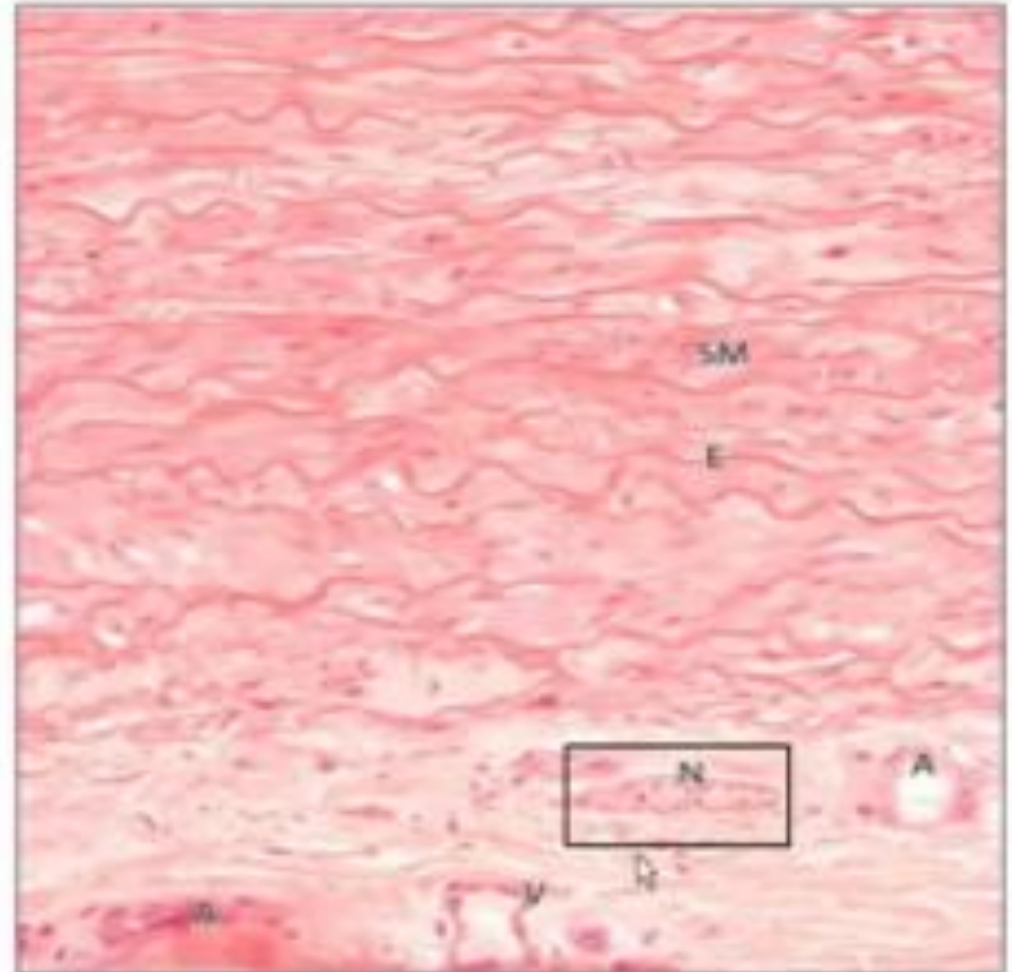
**Vasa vasorum**  
**(vessels of the vessel)**

- ☐ They are arterioles, capillaries, and venules in the tunica adventitia and outer part of tunica media of large vessels.
- ☐ Provide these tunics with nutrients and oxygen and remove waste products.
- ☐ **Vasa vasorum are more numerous in large veins than arteries (why??)**



## Nervi vasorum (**vasomotor nerves**)

- Network of autonomic nerve fibers.
- control **contraction of the smooth muscle** in the vessel walls.
- Their density is greater in arteries than veins.



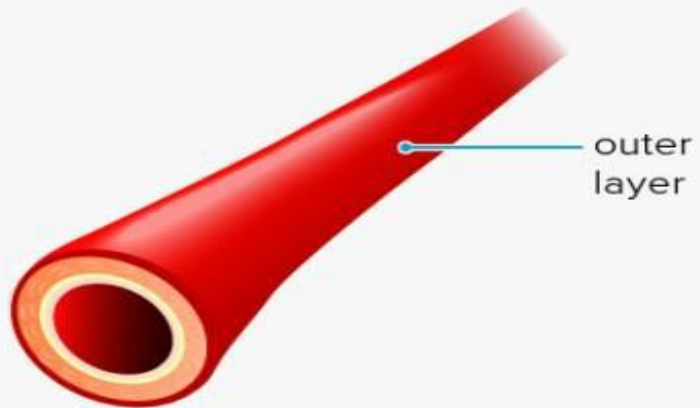
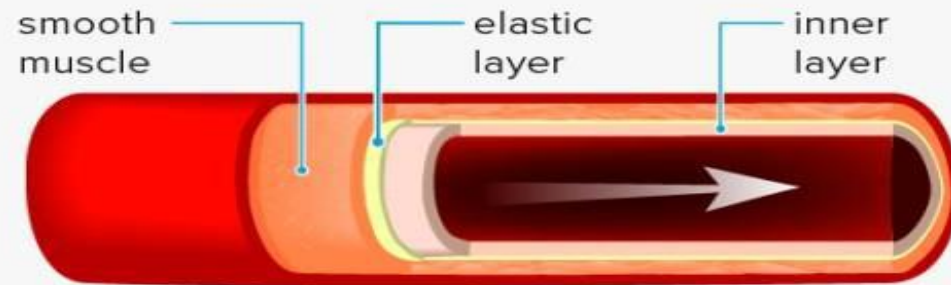
# Vessel Wall Structure



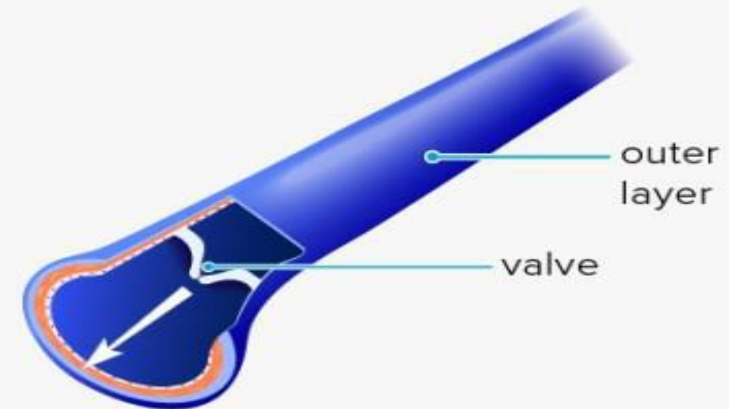
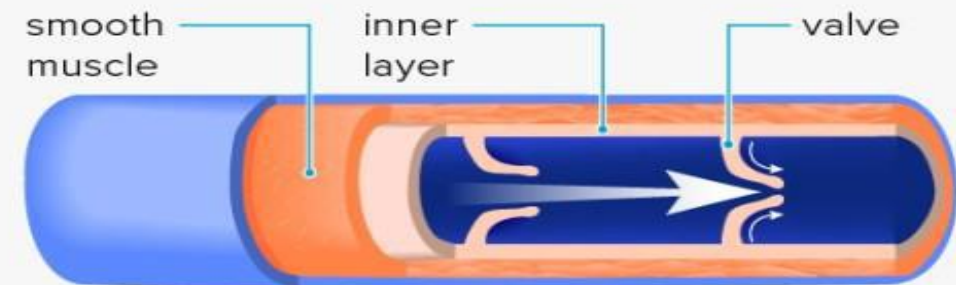


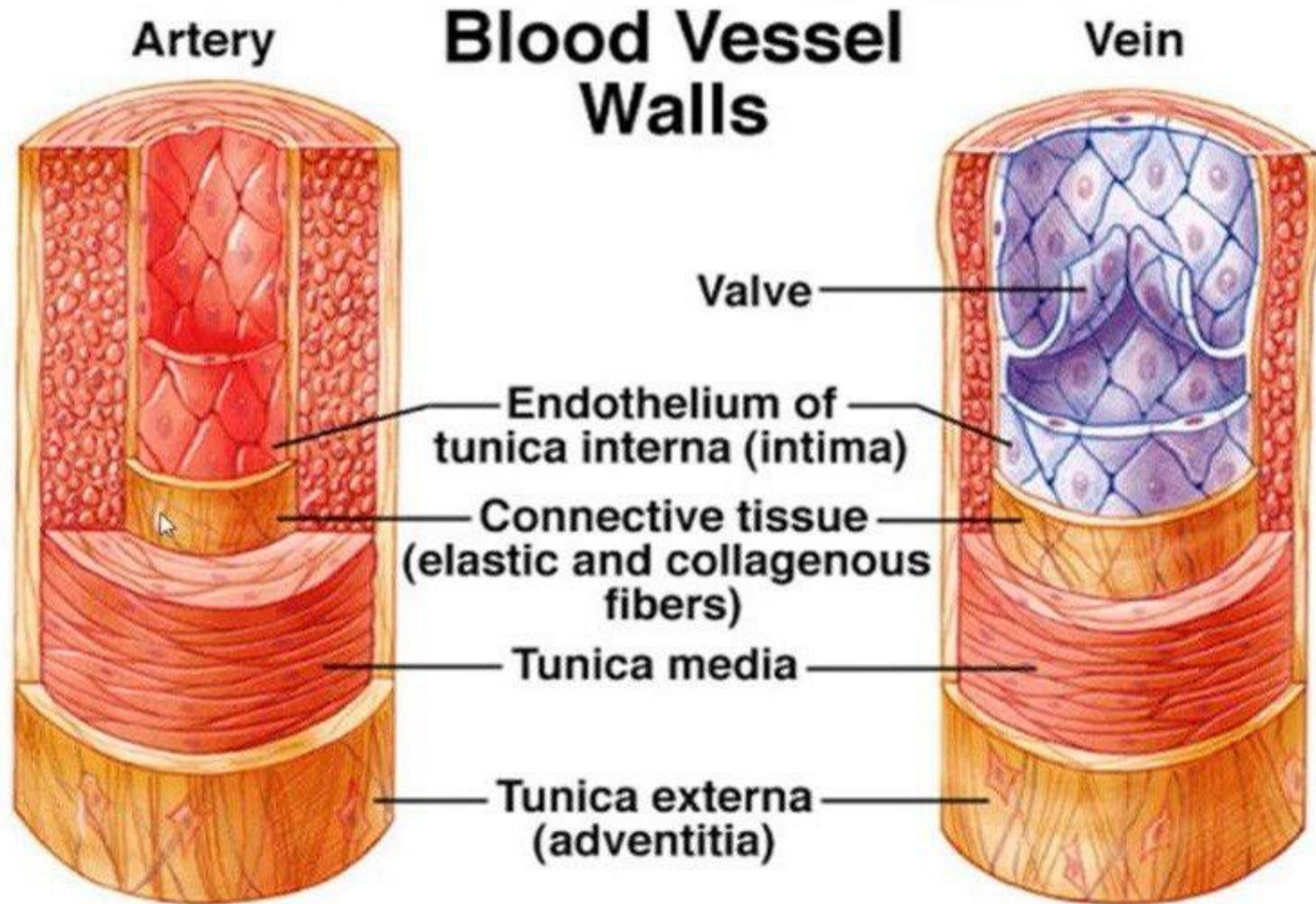
# Artery vs. Vein

## Artery



## Vein





## Tissues found in vascular wall & their Functions

Walls of arteries and veins contain: **smooth muscle**, **connective tissue** & **endothelial lining** (epithelial tissue).

### Smooth muscle fibers

Permit **vasoconstriction** and **vasodilation** → regulating the **blood pressure**.

**Extracellular matrix production** (mainly of tunica media).

### Elastic fibers

**Expansion** of the vascular wall under pressure.

### Collagen fibers

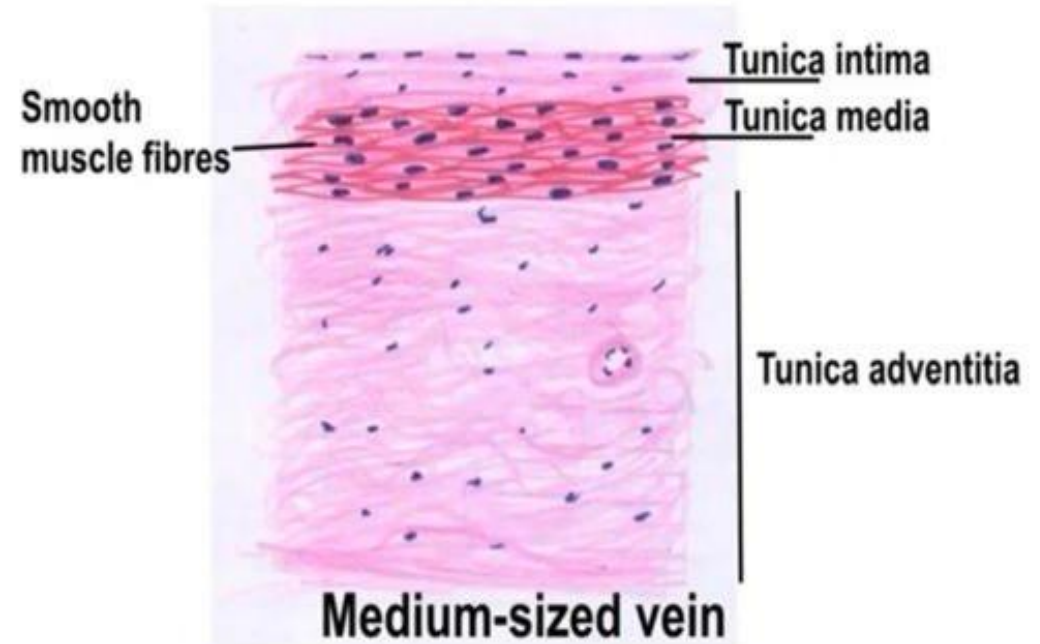
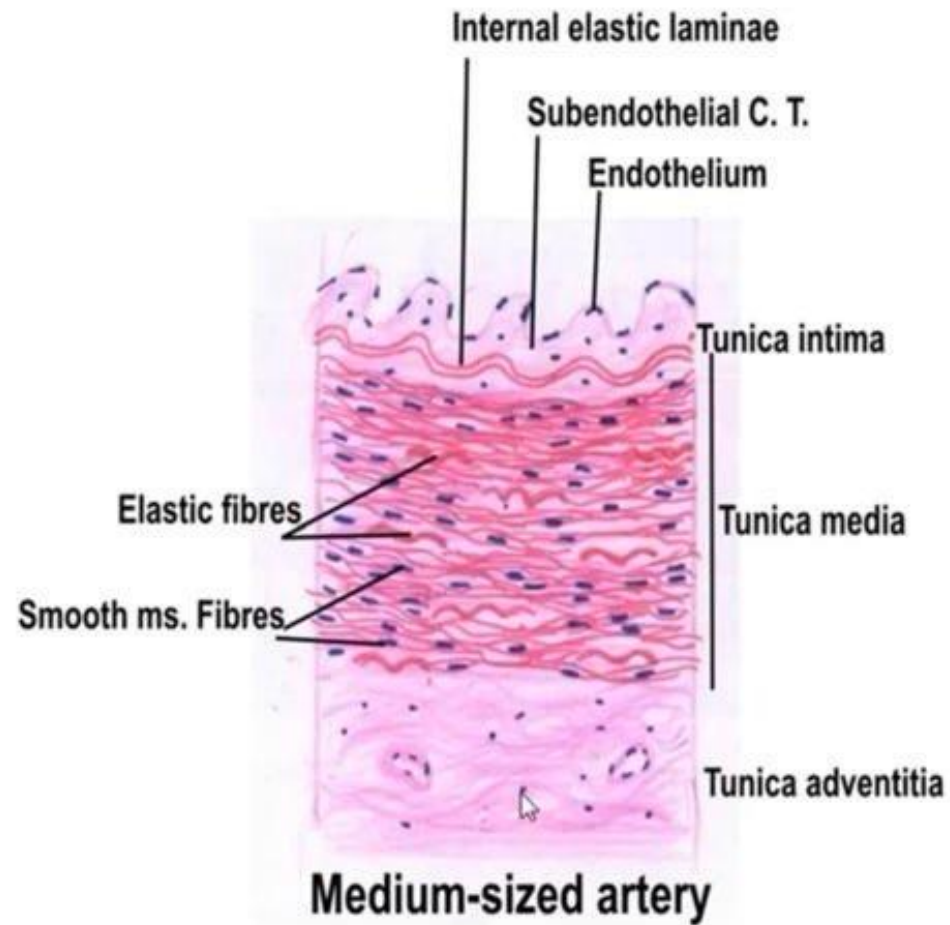
**prevent over expansion** of the arterial wall beyond physiologic limits during systole of the cardiac cycle.

Subendothelial C.T.

T. media

T. **adventitia**





# References

- JUNQUEIRA'S BASIC HISTOLOGY TEXT AND ATLAS, fifteenth edition, 2018.
- Wheater's Functional Histology: A Text and Colour Atlas, sixth edition.



**THANK YOU**