CVS HISTOLOGY

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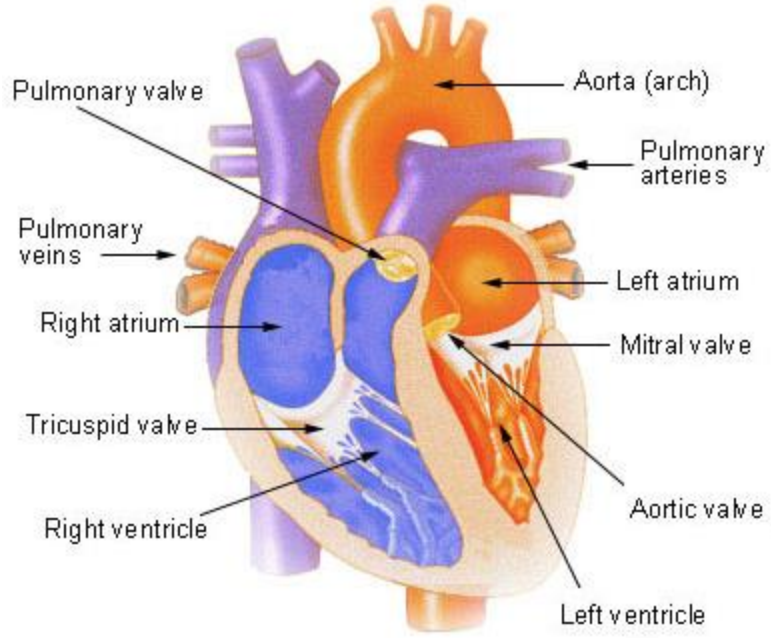
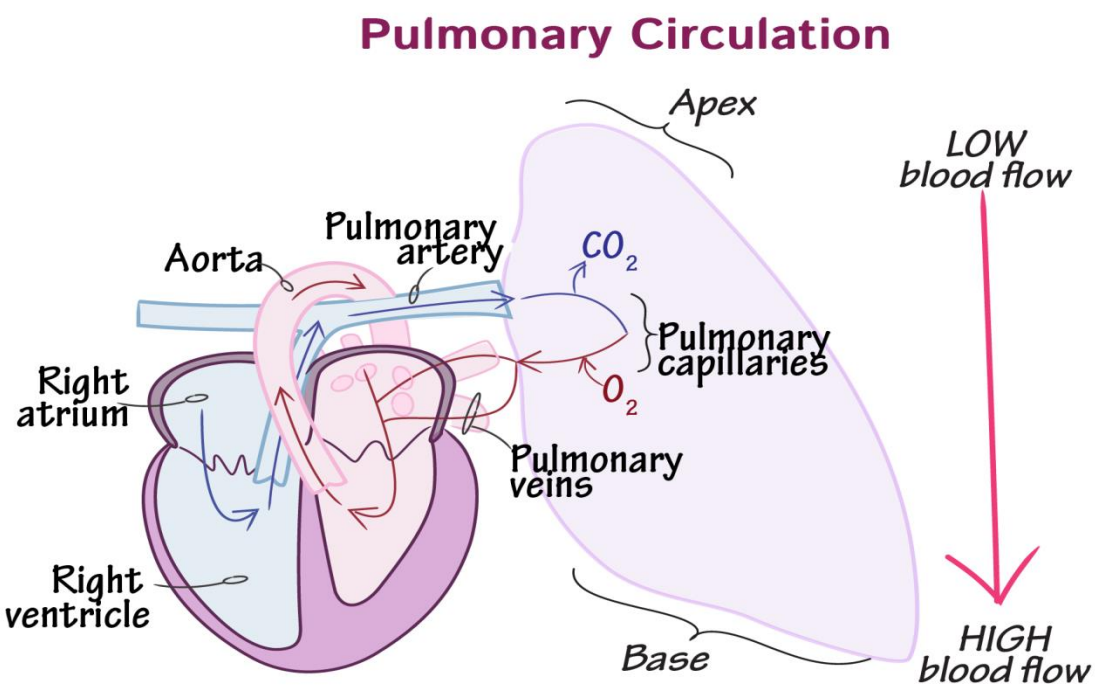
HEART STRUCTURE



PULMONARY CIRCULATION

Pulmonary circulation pathway:

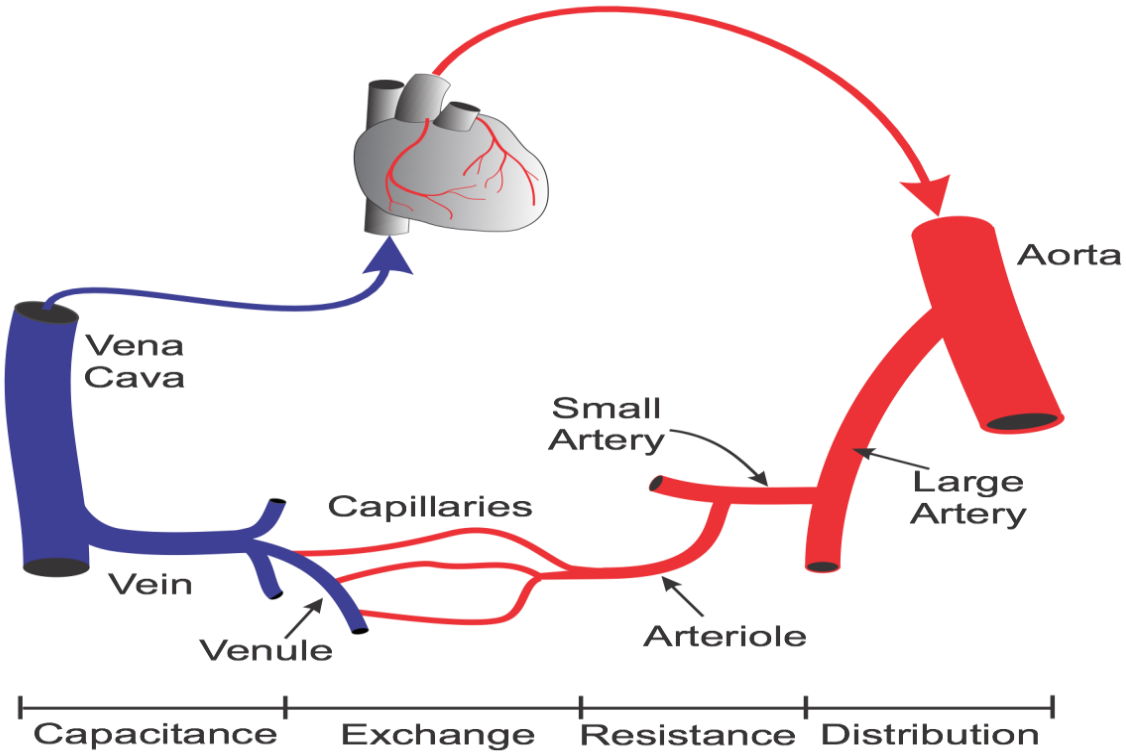
- Right ventricle
- Pulmonary valve
- Pulmonary artery
- Pulmonary capillaries
- Left atrium



SYSTEMIC CIRCULATION

Systemic circulation pathway:

- Aorta and major arteries (elastic arteries)
- Medium sized arteries (2 – 10mm) also called muscular arteries
- Arterioles (0.1 – 2 mm)
- Meta arterioles
- Capillaries
- Venules
- Small veins
- Venae cavae
- Right heart



DIFFERENCE BETWEEN PULMONARY AND SYSTEMIC CIRCULATION

PULMONARY CIRCULATION	SYSTEMIC CIRCULATION
▫ Pulmonary circulation is between right heart and left heart	▫ Systemic circulation is between left heart and right heart
▫ Smaller circulation	▫ Larger circulation
▫ Low pressure circulation	▫ High pressure circulation
▫ Pulmonary arteries carry de-oxygenated blood	▫ Systemic arteries carry oxygenated blood
▫ Pulmonary veins carry oxygenated blood	▫ Systemic veins carry de-oxygenated blood

PORTAL CIRCULATION

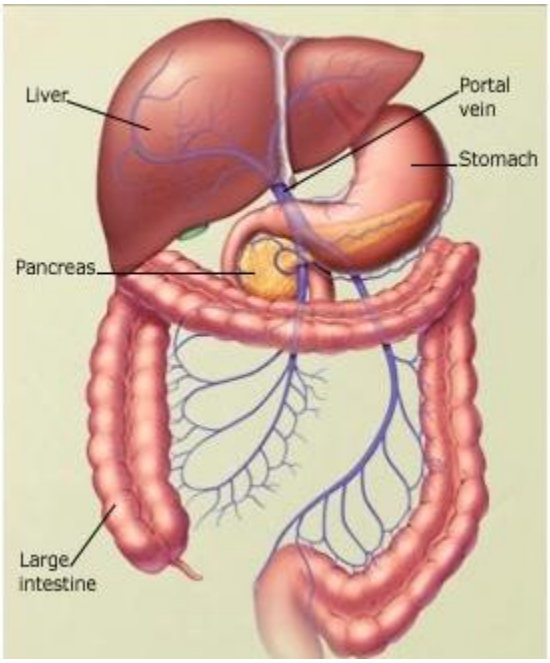
Any circulation which does not follow the normal pathway is called portal circulation.

In normal pathway there is an input artery followed by capillary exchange and an output vein

PORTAL CIRCULATION IN GUT

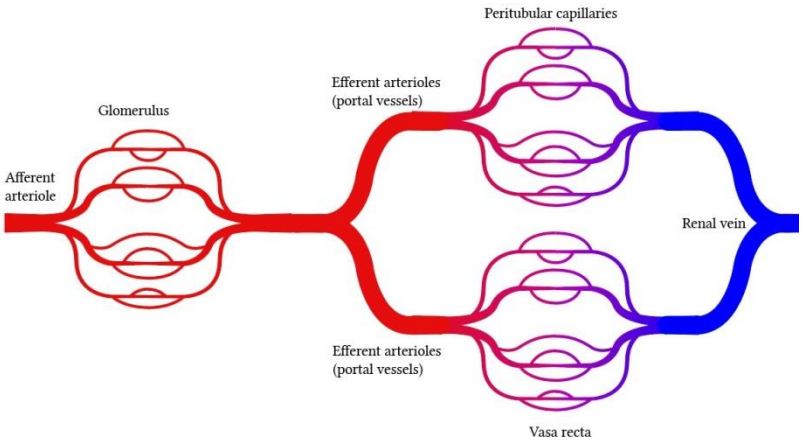
- Artery
- Capillary

- Vein to liver
- Capillaries in liver
- Vein to inferior vena cava



PORTAL CIRCULATION IN KIDNEY

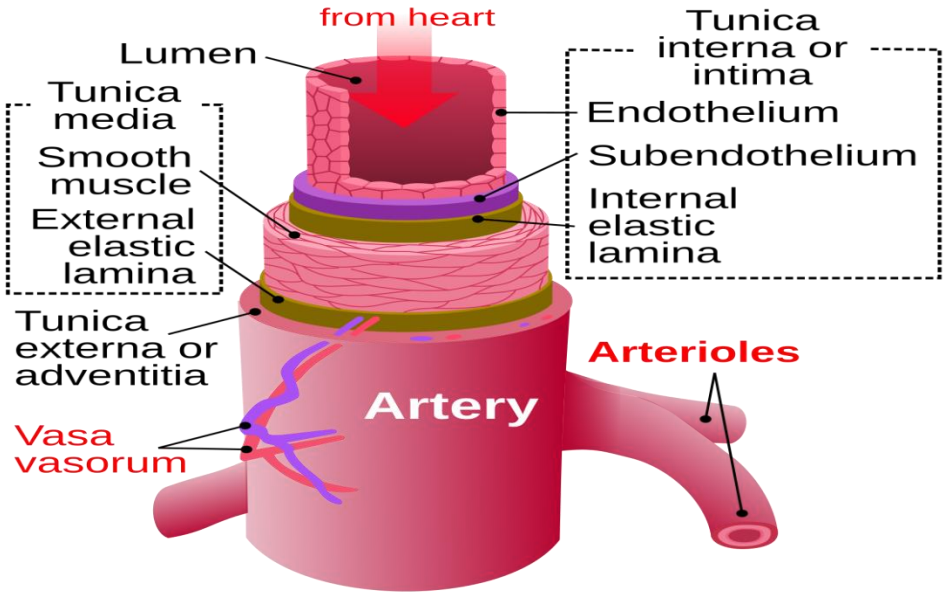
- Afferent arteriole
- Capillaries
- Efferent arterioles
- Peritubular capillaries
- Veins



ARTERIAL WALLS

Arterial wall consist of:

1. Tunica interna or intima
2. Tunica media
3. Tunica externa or adventitia



TUNICA INTERNA OR INTIMA

- Innermost lining is **endothelial cells** which is single layer of flat cells
- **Basement membrane or basal lamina** is a special layer of collagen around endothelial cells on which these endothelial cells are resting
- Outside basal lamina is another layer of loose connective tissue called **subendothelial connective tissue**
- **Internal elastic lamina** made of elastin fibers

TUNICA MEDIA

- Tunica media consist of multiple concentric layers of **smooth muscles**
- Thickness of smooth muscles depend on type of artery
  In medium sized artery, 30 – 40 smooth muscle layers are present
- In between muscular tissues, there are elastic and collagen fibers which are secreted by smooth muscles
- Outside smooth muscles, **external elastic lamina** is present

TUNICA EXTERNA OR ADVENTITIA

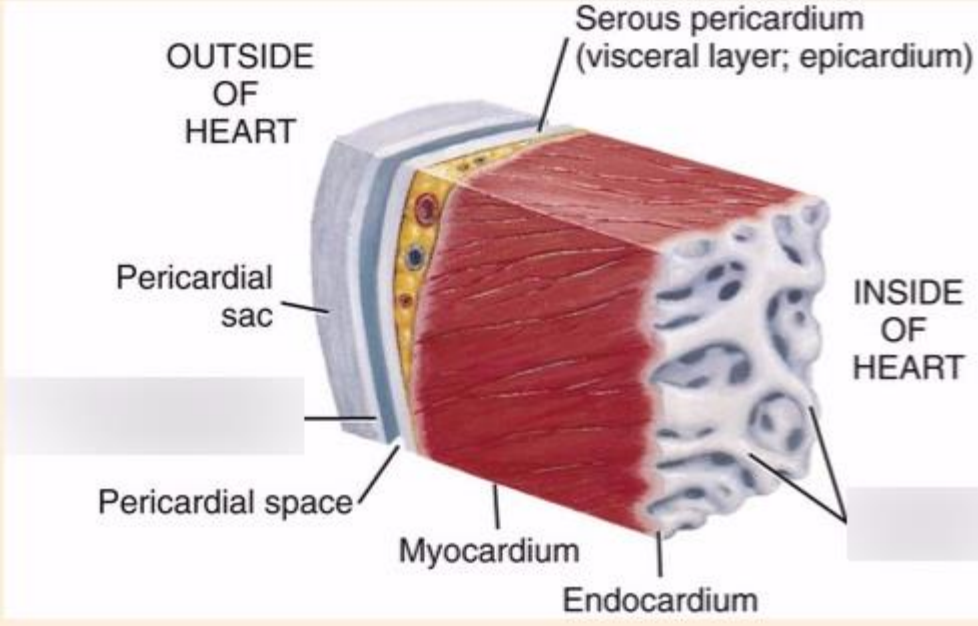
- Layer of connective tissue having collagen, elastic fibers and fibroblast

- Sympathetic nerves
- Small arterioles which supply outer part of artery and are called vasa vasorum
  Vasa vasorum seen only in large arteries and medium sized arteries
- Lymphatics

HEART WALL

The heart wall is composed of three layes

1. Innermost endocardium
2. Middle myocardium
3. Outermost pericardium



FIBROUS SKELETON OF HEART

The fibrous skeleton of heart anchors the valves of the heart and gives attachment to the myocardium above and below.

It consist of four fibrous rings, each surrounding one of the valves (aortic, pulmonary, bicuspid and tricuspid) plus the membranous part of interventricular septum.

Fibrous skeleton is made of dense irregular connective tissue.

Functions of fibrous skeleton of heart:

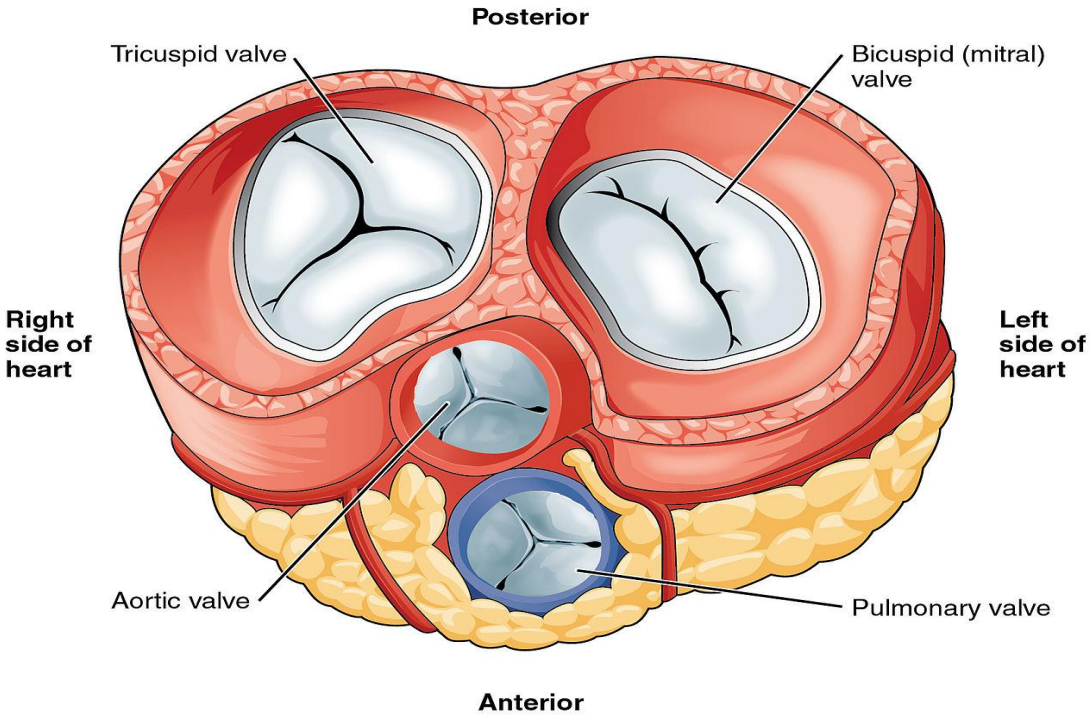
1. Provide attachment for valve leaflets
2. Provide attachment for atrial and ventricular myocardium
3. Provide base for attachment of major arteries i.e. aorta and pulmonary artery

4. Acts as electrical insulator between atrial and ventricular myocardium.

Atrial myocardium cells are electrically connected with each other through gap junctions so right and left atrium are electrically connected.

Similarly ventricular myocardial cells are electrically connected.

However atria and ventricles are not connected with each other due to presence of fibrous skeleton. The only electrical connection between atria and ventricles is AV node.



ENDOCARDIUM OF HEART

- Endothelial cells (innermost)
- Basement membrane (subendothelial connective tissue)
- Subendocardial connective tissue

HEART VALVES

Heart valves do not have myocardium.

Valve leaflets consist of:

- Fibrosa of valve which is made of dense connective tissue i.e. collagen
- Spongiosa of valve which is loose connective tissue
- Endothelial lining

Fibrosa of the valve provide strength to the valve.

Spongiosa of the valve cushions the valves when they close and helps the valves to dampen or reduce the vibrations at closure.

The valve cusps are not vascularized. However if repeatedly during diseases they get inflamed, they may develop neo-vascularization e.g. in rheumatic fever.

Infective endocarditis is infection caused by bacteria that enter the blood stream and settle in heart valve. Sometimes infective endocarditis can be so severe that valve may rupture and lead to severe cardiac failure.

The AV valves i.e. mitral and tricuspid valves are larger and thinner valves while the aortic and pulmonary valves are small valves.

As AV valves are large and thin, they have a greater tendency to regurgitate. The regurgitation is prevented by the presence of chordae tendinae, which are in turn attached to papillary muscles.

If chordae tendinae are loose, the mitral valve cusps will move a little upward and is called **mitral valve prolapse.** Mitral valve prolapse is the is the bulging of one or both of the mitral valve flaps (leaflets) into the left atrium during the contraction of the heart.

If chordae tendinae are very loose, it may result into **mitral valve regurgitation.**

Mitral valve regurgitation is seen in:

1. Infective endocarditis
2. Myocardial infarction

MYOCARDIUM OF HEART

Myocardium is the main muscular layer. The myocardium of atria and ventricles is not continuous but is separated by fibrous tissue.

Myocardium of left ventricle is thicker than right ventricle.

Myocardium is classified into:

1. **General myocardium** i.e. atrial and ventricular myocardium which are mainly specialized in contractility
2. **Specialized myocardial cells** which may be of two types:
   a) Having electrical properties such as SA node, AV node and purkinje fibers.
   b) Having endocrine properties. The most important hormone produced by myocardial cells is atrial natriuretic peptide.

SA NODE

SA node cells are specialized in myocardial cells. SA node displays the property of automaticity.

The tissue which has a tendency to produce action potentials on its own is said to display properties of automaticity.

SA node produce 60 to 100 action potentials per minute and acts as pacemaker of the heart.

Bachmann's Bundle – the pathway which takes impulses from SA node to left atrium

Internodal pathways – specialized fibers from SA node called internodal pathways (anterior and posterior) takes impulses from SA node to AV node.

AV NODE

AV node is specialized in slow conduction due to following reasons:

1. Cells in AV node are very small
2. Cells are arranged perpendicular to current flow
3. Few gap junctions are present between cells of AV node
4. Resting membrane potential of these cell is -60 mV so positive ions move slowly into these cells and hence depolarization occurs slowly

ISCHEMIC HEART DISEASE

In myocardium, there should be perfect balance between oxygen demand and oxygen supply.

In ischemic heart disease, there is imbalance between oxygen demand and supply.

Ischemia may lead to critical conditions such as:

1. Angina pectoris
2. Myocardial infarction
3. Sudden cardiac death
4. Chronic ischemic heart disease

HISTOLOGY OF LARGE ARTERIES (ELASTIC ARTERIES)

Large arteries such as aorta has 3 wall layers:

1. Intima (innermost)
2. Media
3. Adventitia (outermost)

INTIMA OF ELASTIC ARTERIES

The intima of elastic arteries have:

a) Endothelial cells (innermost)
b) Basal lamina
c) Subendothelial connective tissue

Arterial endothelial cells produce special substance called Von Willebrand factor.

MEDIA OF ELASTIC ARTEIES

The media of elastic arteries have characteristic intermediate patterns of elastic lamina surrounded by smooth muscle layer again surrounded by elastic lamina and smooth muscle layer. This pattern is repeated 40 to 70 times. Special thing about elastic arteries is they have multiple elastic laminas. These elastic laminas are fenestrated i.e. they have multiple holes.

ADVENTITIA OF ELASTIC ARTERIES

Within the adventitia, there are arteries which gives off branches not only to adventitia but also to outer part of media. These are the nutrient arteries to the walls of the major arteries called **vasa vasorum.** Lymphatics and nerve supply also present in adventitia and outer part of media.

EFFECT OF SYPHILIS ON AORTA

Syphilis is sexually transmitted disease caused by bacterium Treponema pallidum. Tertiary stage of syphilis occurs after many years of infection.

One of the complication of tertiary syphilis is that aorta develop aneurysm i.e. abnormal dilataion. In these patients, over many years lymphocytes and plasma cells react against vasa vasorum. These lymphocytes and plasma cells accumulate around vasa vasorum. These aggregates produce growth factors. Endothelial cells within vasa vasorum also proliferate and block these vessels plus the accumulated lymphocytes compress the vasa vasorum.

Due to this reason, adventitia and outer media are under-supplied with nutrition and eventually this part of artery becomes very weak.

Repeatedly blood is coming into aorta during every cardiac contraction. Due to weak walls, when blood comes into lumen of aorta it stretches the aorta and due to this stretch, abnormal irreversible dilatation of aorta is produced.

HISTOLOGY OF MUSCULAR ARTERIES

The histology of muscular arteries is same as that of large arteries, except that these arteries are smaller in size and in media the intermediate arrangement of elastic lamina is absent. In media of muscular arteries, elastic lamina is present only as innermost and outermost layer and in between these layers, smooth muscle is present.

CAPILLARIES

- Capillaries are the exchange vessels
- Lumen of capillary is 8 – 10 μm
- Length of capillary less than 1 mm
- In the capillary bed, there is a special channel called **thoroughfare channel.** A thoroughfare channel connects the metaarteriole to a venule.

HISTOLOGY OF CAPILLARIES

- Endothelial cells (innermost)
- Basal lamina
- Occasionally pericytes are found
- Special types of intermediate filaments called desmin and vimentin are present in endothelial cells of capillaries

TYPES OF CAPILLARIES

1. **CONTINUOUS CAPILLARIES**
   - Endothelial cells held through tight junctions called zona occludence
   - Basal lamina is continuous
   - Many pinocytic vesicle in endothelial cells
   - Classically present in CNS, muscles, exocrine glands, lungs
     In CNS, continuous capillaries do not have pinocytic vesicles thus contributing to blood-brain barrier

2. **FENESTRATED OR POROUS CAPILLARIES**
   - Fenestrations i.e. small apertures or holes (about 70 nm in size) present in endothelial cells
   - Do not have pinocytic vesicles
   - The fenestrations usually have a diaphragm
   - Found in kidneys (glomerular capillaries), GIT, endocrine glands, pancreas

3. **SINUSOIDAL CAPILLARIES**
   - Basal lamina is discontinuous
   - Endothelial cells not held together tightly
   - Present in liver, spleen, bone marrow and lymph nodes

SUBSTANCES PASS THROUGH CAPILLARIES THROUGH:

1. Diffusion
2. Active transport
3. Fenestrations

4. Endothelial gaps
5. Pinocytic vesicles

FUNCTIONS OF CAPILLARIES

1. Capillaries present in lungs express a special type of enzyme in the lungs. This enzyme can convert Angiotensin I to Angiotensin II.
2. Endothelial cells can catabolize or destroy bradykinin, norepinephrine and prostaglandins.
3. Endothelial cells can catabolize lipids
4. Endothelial cells can produce prostacyclins
5. Endothelial cells can release nitric oxide
6. Endothelial cells can produce endothelin
7. Healthy endothelium normally provide an anti-coagulant and anti-thrombotic surface

VEINS

- Three layers: intima, media and adventitia
- Veins hold 70% of blood at any given time hence called capacitance vessels
- Venoconstriction increase venous return to heart
  Venodilation decrease venous return to heart
- Veins characteristically do not have elastic lamina
- Veins have valves
- Adventitia of large veins have longitudinal smooth muscles while medium sized veins lack these smooth muscles
- In venules, there is no well defined media
- In veins, if pressure is high or valves of the vein become very weak or these valves fail, then part of the vein may abnormally dilate and these abnormal irreversible dilatation of veins is called varicose veins

Arteries and Veins