CARDIOVASCULAR SYSTEM

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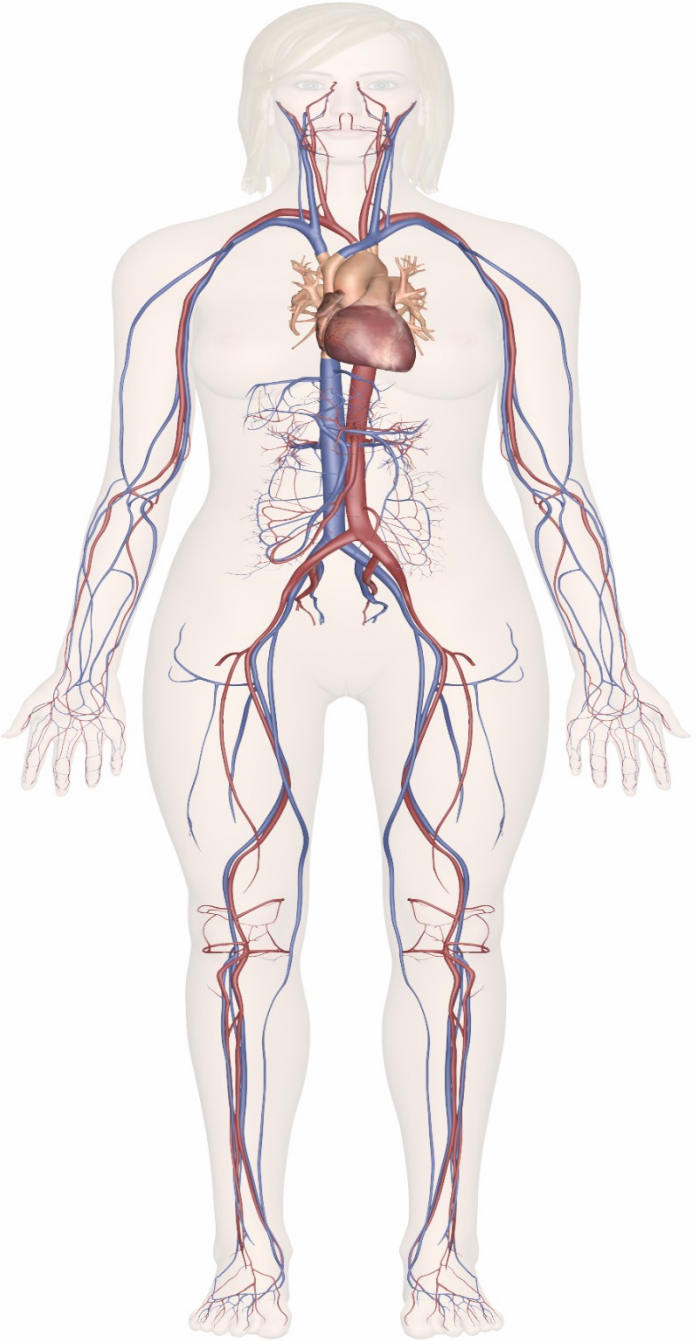
INTRODUCTION TO CARDIOVASCULAR SYSTEM

- Cardiovascular system includes **heart** and **blood vessels.** Heart pumps blood into the blood vessels.
- Blood vessels circulate the blood throughout the body.
- Blood transports nutrients and oxygen to the tissues and removes carbon dioxide and waste products from the tissues.



THE HEART

- Heart is a muscular organ that pumps blood throughout the circulatory system.
- It is situated in between two lungs in the mediastinum.
- It is made up of four chambers, two atria and two ventricles.
- The musculature of ventricles is thicker than that of atria.
- Force of contraction of heart depends upon the muscles.

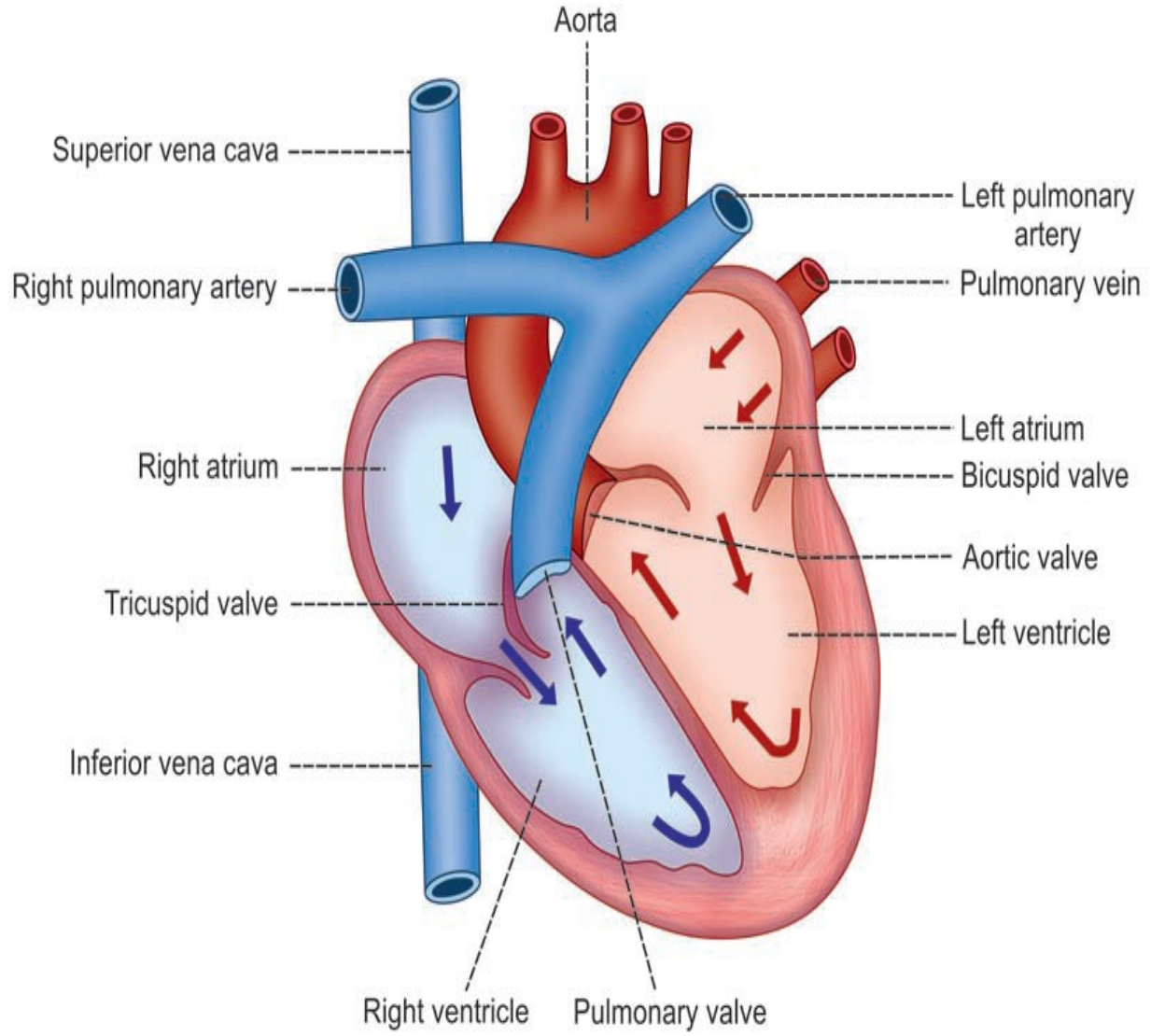


FIGURE : SECTION OF THE HEART

FUNCTIONAL ANATOMY OF HEART

RIGHT SIDE OF THE HEART

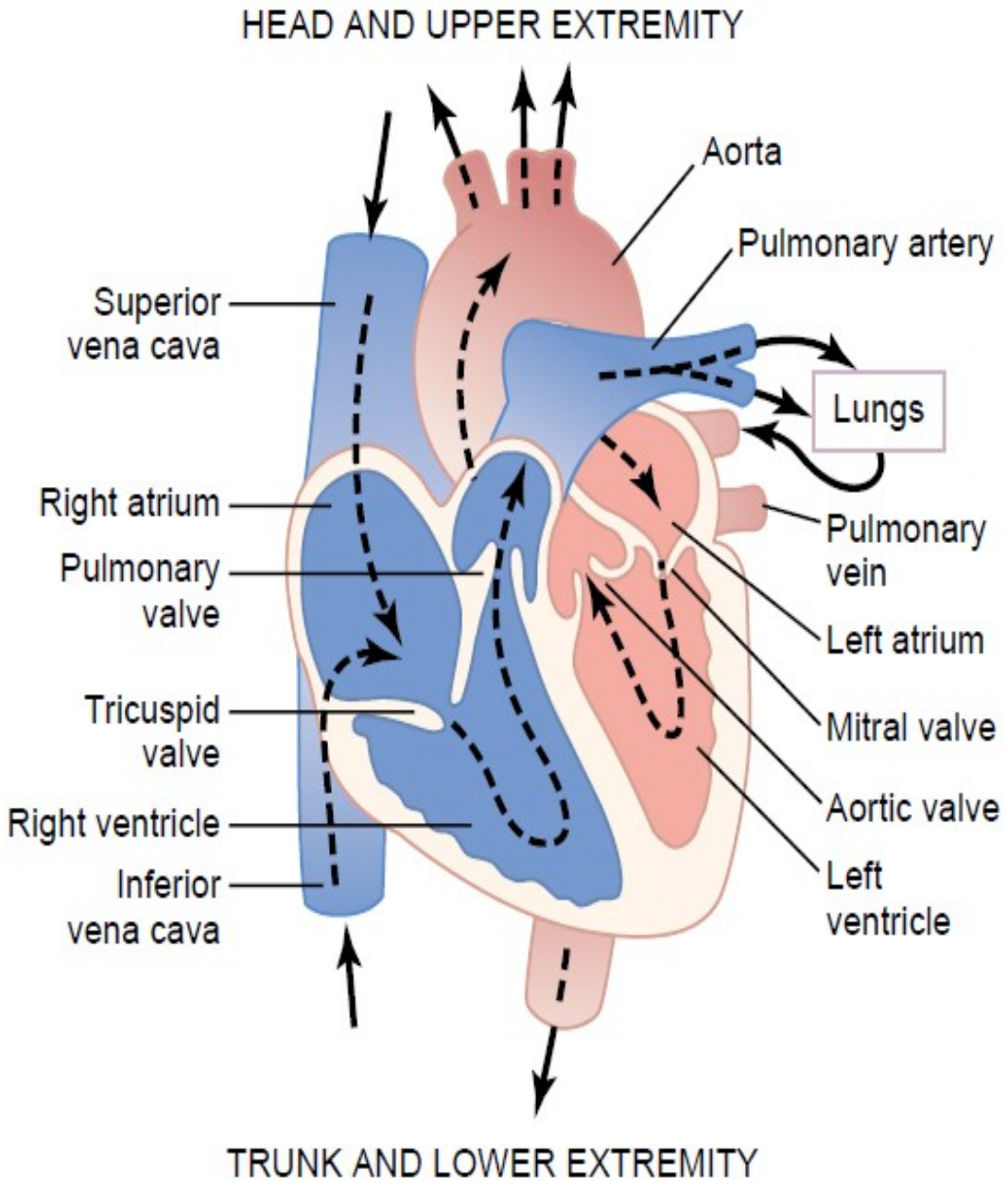
- Right side of the heart has two chambers, **right atrium** and **right ventricle.**
- Right atrium is a thin walled and low pressure chamber.
- It has got the pacemaker known as sinoatrial node (SA node) that produces cardiac impulses and atrioventricular node (AV node) that conducts the impulses to the ventricles.
- Right atrium receives venous (deoxygenated) blood via two large veins:

1. **Superior vena cava :** It returns back venous blood from the head, neck and upper limbs.
2. **Inferior vena cava :** that returns venous blood back to the heart from lower parts of the body

- Right atrium communicates with right ventricle through tricuspid valve.
- Wall of right ventricle is thick.
- Venous blood from the right atrium enters the right ventricle through this valve.
- From the right ventricle, pulmonary artery arises.
- It carries the venous blood from right ventricle to lungs. In the lungs, the deoxygenated blood is oxygenated.

LEFT SIDE OF THE HEART

- Left side of the heart has two chambers, **left atrium** and **left ventricle.**



- Left atrium is a thin walled and low pressure chamber.
- It receives oxygenated blood from the lungs through pulmonary veins.
- This is the only exception in the body, where an artery carries venous blood and vein carries the arterial blood.
- Blood from left atrium enters the left ventricle through mitral valve (bicuspid valve).
- Wall of the left ventricle is very thick.
- Left ventricle pumps the arterial blood to different parts of the body through **systemic aorta.**

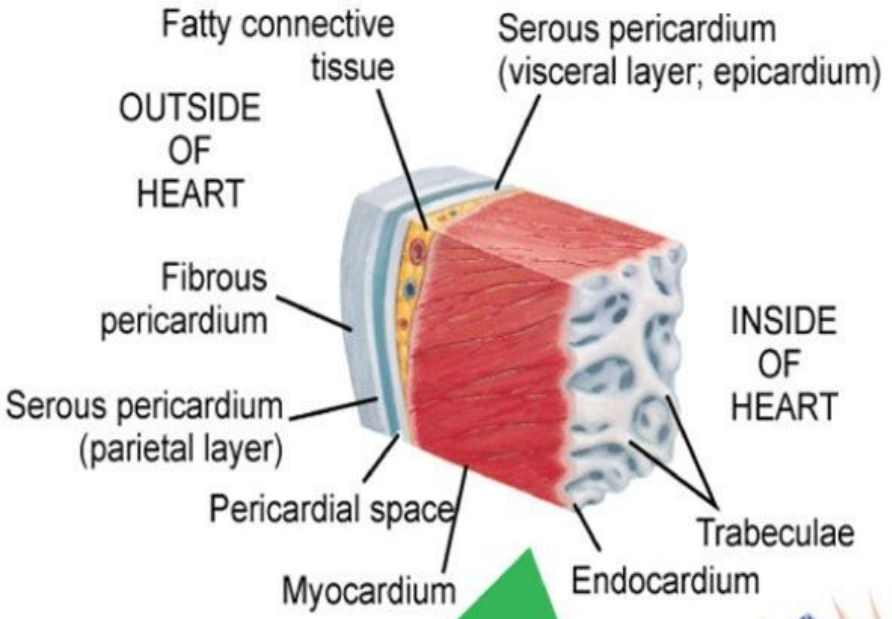
SEPTA OF THE HEART

- Right and left atria are separated from one another by a fibrous septum called **interatrial septum.**
- Right and left ventricles are separated from one another by **interventricular septum.**
- The upper part of this septum is a membranous structure, whereas the lower part of it is muscular in nature.

LAYERS OF WALL OF THE HEART

- Heart is made up of three layers of tissues:

1. Outer pericardium
2. Middle myocardium
3. Inner endocardium.



PERICARDIUM

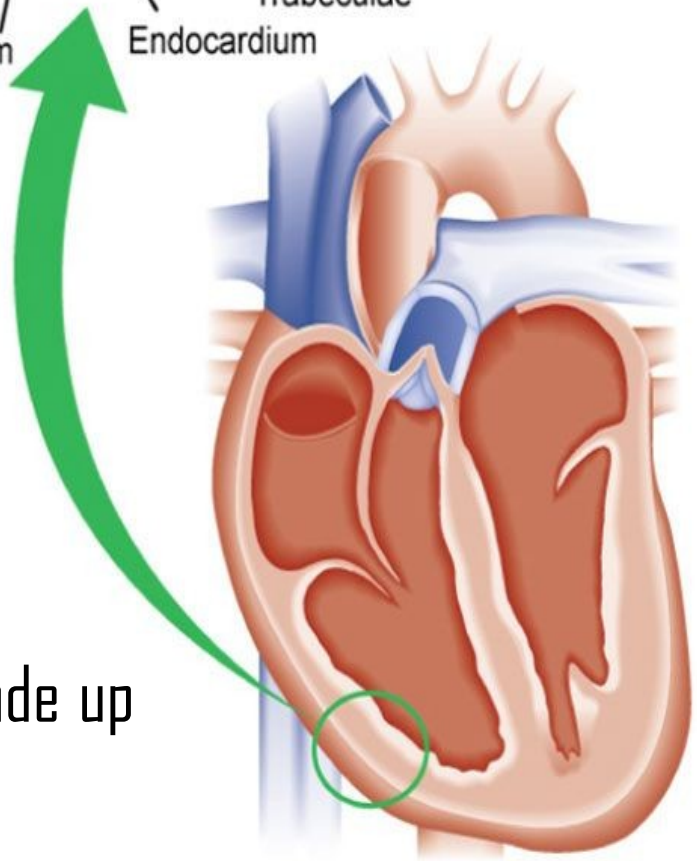
- Pericardium is the outer covering of the heart.
- It is made up of two layers:

i. Outer parietal pericardium

- Parietal pericardium forms a strong protective sac for the heart. It helps also to anchor the heart within the mediastinum.

ii. Inner visceral pericardium

- Inner visceral pericardium lines the surface of myocardium. It is made up of flattened epithelial cells. This layer is also known as **epicardium.**



- The space between the two layers is called **pericardial cavity** or **pericardial space** and it contains a thin film of fluid.

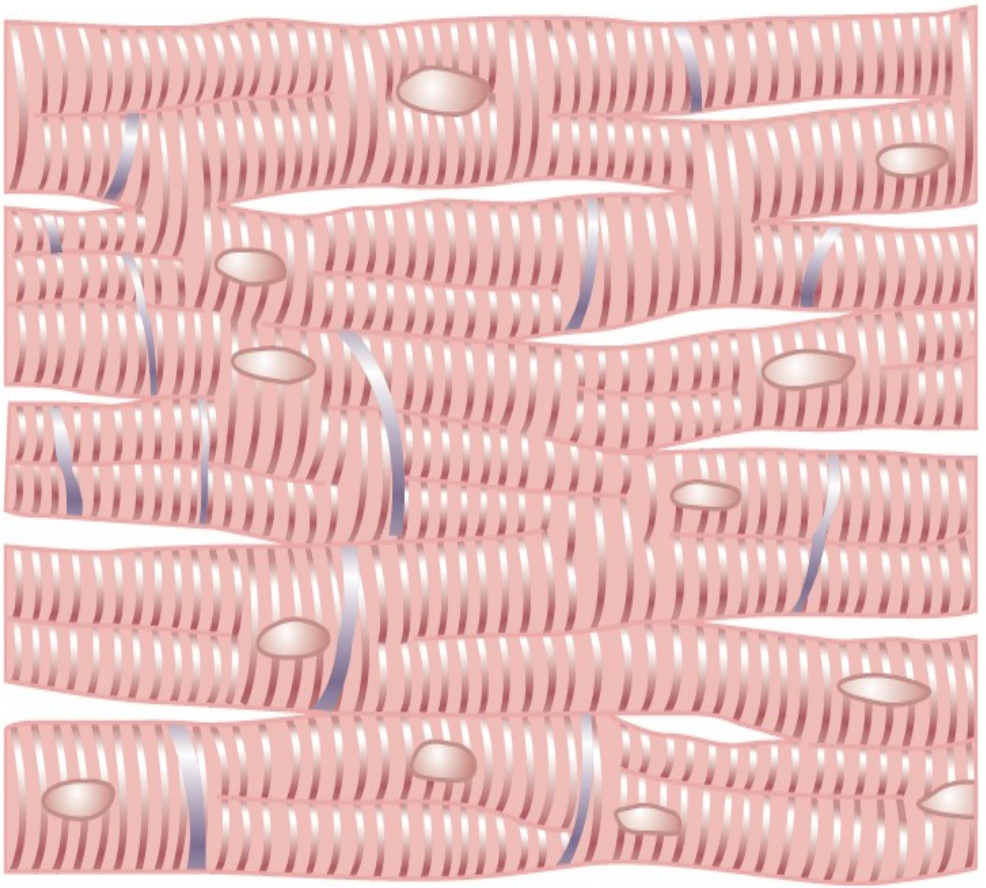
MYOCARDIUM

- Myocardium is the middle layer of wall of the heart and it is formed by cardiac muscle fibers or cardiac myocytes.
- Myocardium forms the bulk of the heart and it is responsible for pumping action of the heart.
- Unlike skeletal muscle fibers, the cardiac muscle fibers are involuntary in nature.
- Myocardium has three types of muscle fibers:

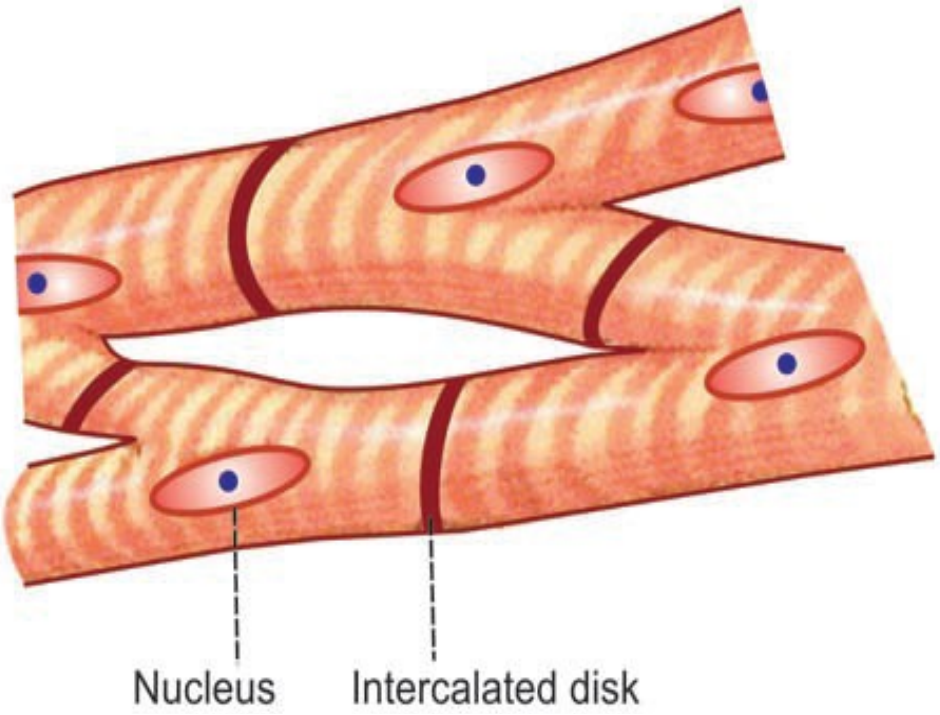
i. Muscle fibers which form contractile unit of heart.
ii. Muscle fibers which form pacemaker.
iii. Muscle fibers which form conductive system.

I. MUSCLE FIBERS WHICH FORM CONTRACTILE UNIT OF HEART

- These cardiac muscle fibers are striated and resemble the skeletal muscle fibers in structure.
- Cardiac muscle fiber is bound by **sarcolemma.**
- It has a centrally placed nucleus.
- **Myofibrils** are embedded in the sarcoplasm.
- **Sarcomere** of the cardiac muscle has all the contractile proteins, namely actin, myosin, troponin and tropomyosin.
- **Sarcotubular system** in cardiac muscle is similar to that of skeletal muscle.



- Important difference between skeletal muscle and cardiac muscle is that the cardiac muscle fiber is branched and the skeletal muscle is not branched.



INTERCALATED DISK

- Intercalated disk is a tough double membranous structure, situated at the junction between the branches of neighboring cardiac muscle fibers.

II. MUSCLE FIBERS WHICH FORM THE PACEMAKER

- Some of the muscle fibers of heart are modified into a specialized structure known as pacemaker.
- These muscle fibers forming the pacemaker have less striation.

PACEMAKER

- Pacemaker is structure in the heart that generates the impulses for heart beat. It is formed by **pacemaker cells** called **P cells.**
- Sinoatrial (SA) node forms the pacemaker in human heart.

III. MUSCLE FIBERS WHICH FORM CONDUCTIVE SYSTEM

- Conductive system of the heart is formed by modified cardiac muscle fibers. Impulses from SA node are transmitted to the atria directly.
- However, the impulses are transmitted to ventricles through various components of conducting system.

ENDOCARDIUM

- Endocardium is the inner most layer of heart wall.
- It is a thin, smooth and glistening membrane.
- It is formed by a single layer of endothelial cells, lining the inner surface of the heart.
- Endocardium continues as endothelium of the blood vessels.

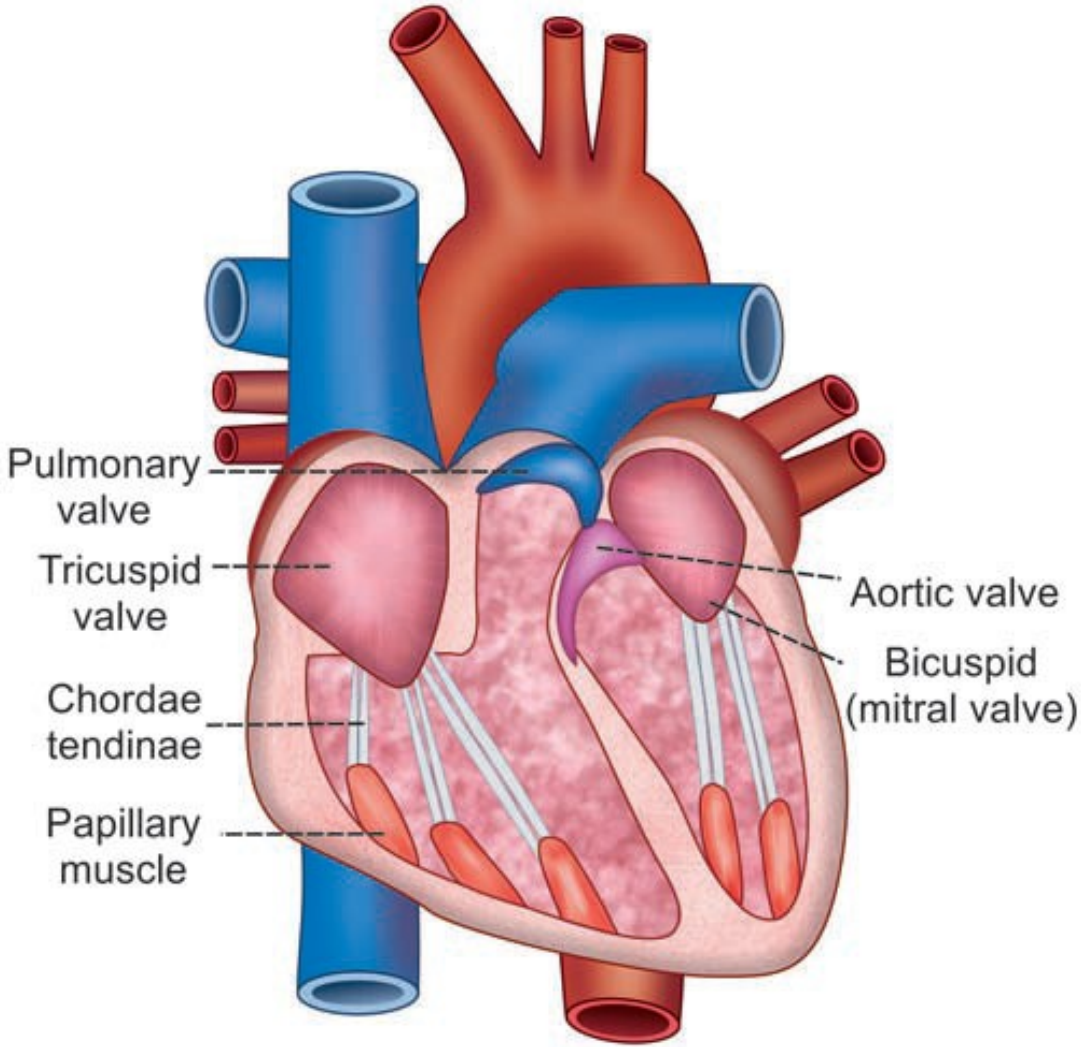
VALVES OF THE HEART

There are four valves in human heart.

Two valves are in between atria and the ventricles called atrioventricular valves.

Other two are the semilunar valves, placed at the opening of blood vessels arising from ventricles, namely systemic aorta and pulmonary artery.

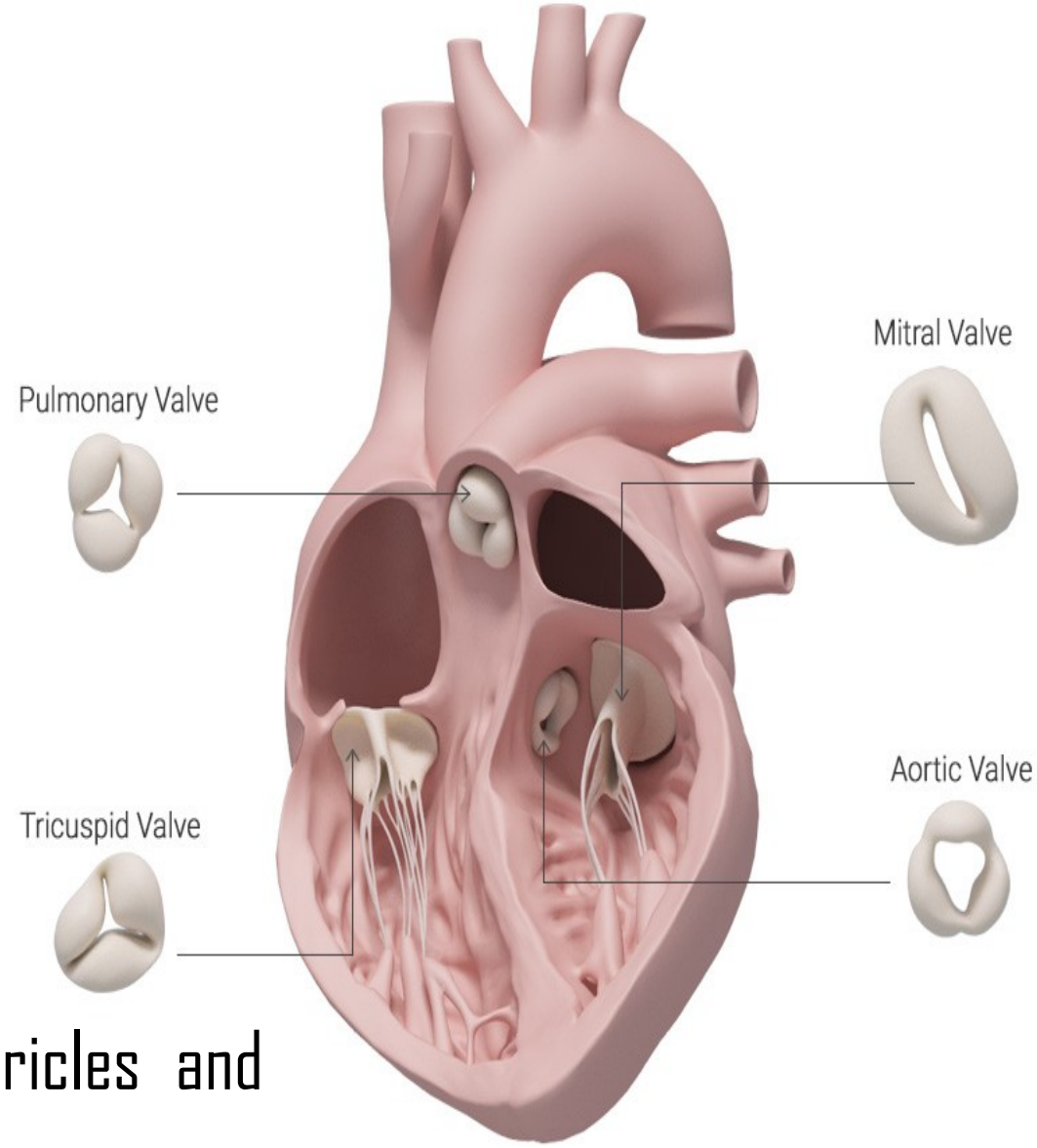
Valves of the heart permit the flow of blood through heart in only one direction.



ATRIOVENTRICULAR VALVES

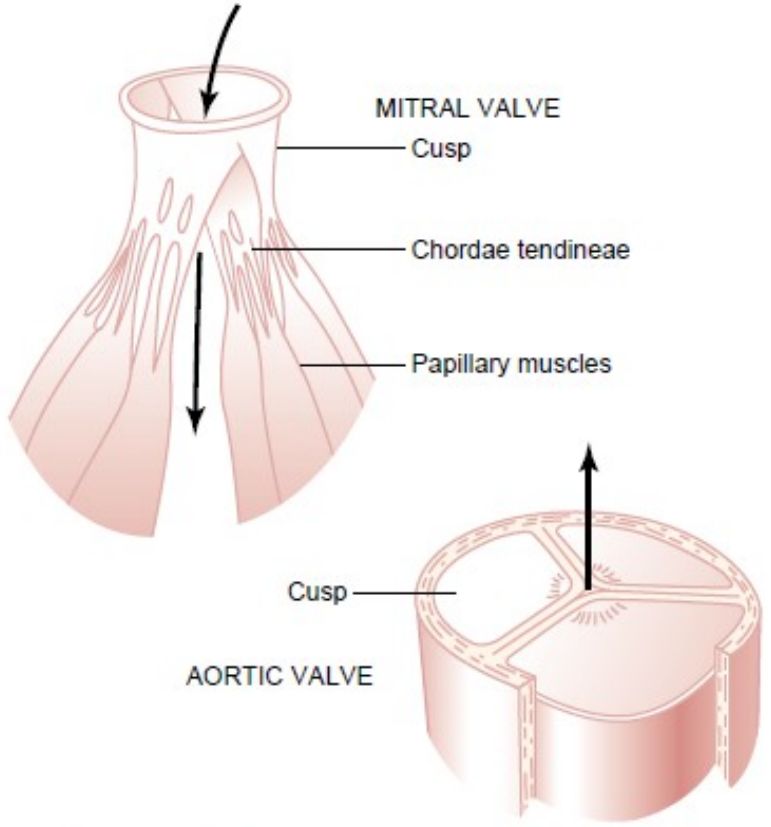
- Left atrioventricular valve is otherwise known as **mitral valve** or **bicuspid valve.**
- It is formed by two valvular **cusps** or flaps

- Right atrioventricular valve is known as **tricuspid valve** and it is formed by three cusps.
- Cusps of the valves are attached to **papillary muscles** by means of **chordae tendineae.**
- Papillary muscles arise from inner surface of the ventricles.
- Papillary muscles play an important role in closure of the cusps and in preventing the back flow of blood from ventricle to atria during ventricular contraction.
- Atrioventricular valves open only towards ventricles and prevent the backflow of blood into atria.



SEMILUNAR VALVES

- Semilunar valves are present at the openings of systemic aorta and pulmonary artery and are known as **aortic valve** and **pulmonary valve** respectively.
- Because of the half moon shape, these two valves are called semilunar valves.
- Semilunar valves are made up of three flaps.
- Semilular valves open only towards the aorta and pulmonary artery and prevent the backflow of blood into the ventricles.



BLOOD VESSELS

- Vessels of circulatory system are the aorta, arteries, arterioles, capillaries, venules, veins and vena cava.
- Structural differences between different blood vessels are given in Table.

Blood vessel	Diameter	Thickness of the wall
Aorta	25 mm	2 mm
Artery	4 mm	1 mm
Arteriole	30 μ	6 μ
Terminal arteriole	10 μ	2 μ
Capillary	8 μ	0.5 μ
Venule	20 μ	1 μ
Vein	5 mm	0.5 mm
Vena cava	30 mm	1.5 mm

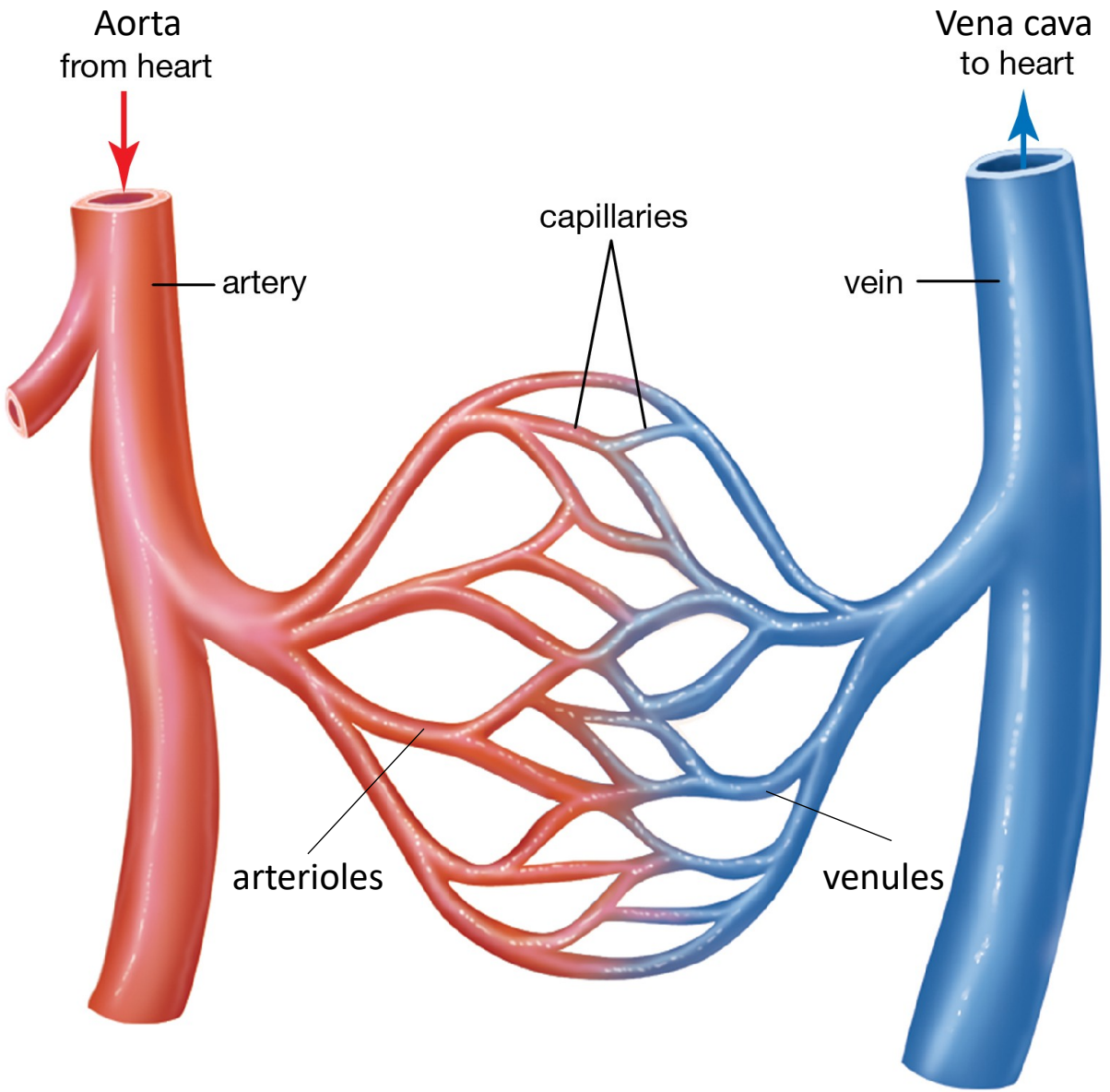


FIGURE : TYPES OF BLOOD VESSELS

ARTERIAL SYSTEM

- Arterial system comprises the aorta, arteries and arterioles.
- Walls of the aorta and arteries are formed by three layers:

1. OUTER TUNICA ADVENTITIA

- It is made up of connective tissue layer.
- It is the continuation of fibrous layer of parietal pericardium.

2. MIDDLE TUNICA MEDIA

- This layer is formed by smooth muscles

3. INNER TUNICA INTIMA

- This layer is made up of endothelium.
- It is the continuation of endocardium.

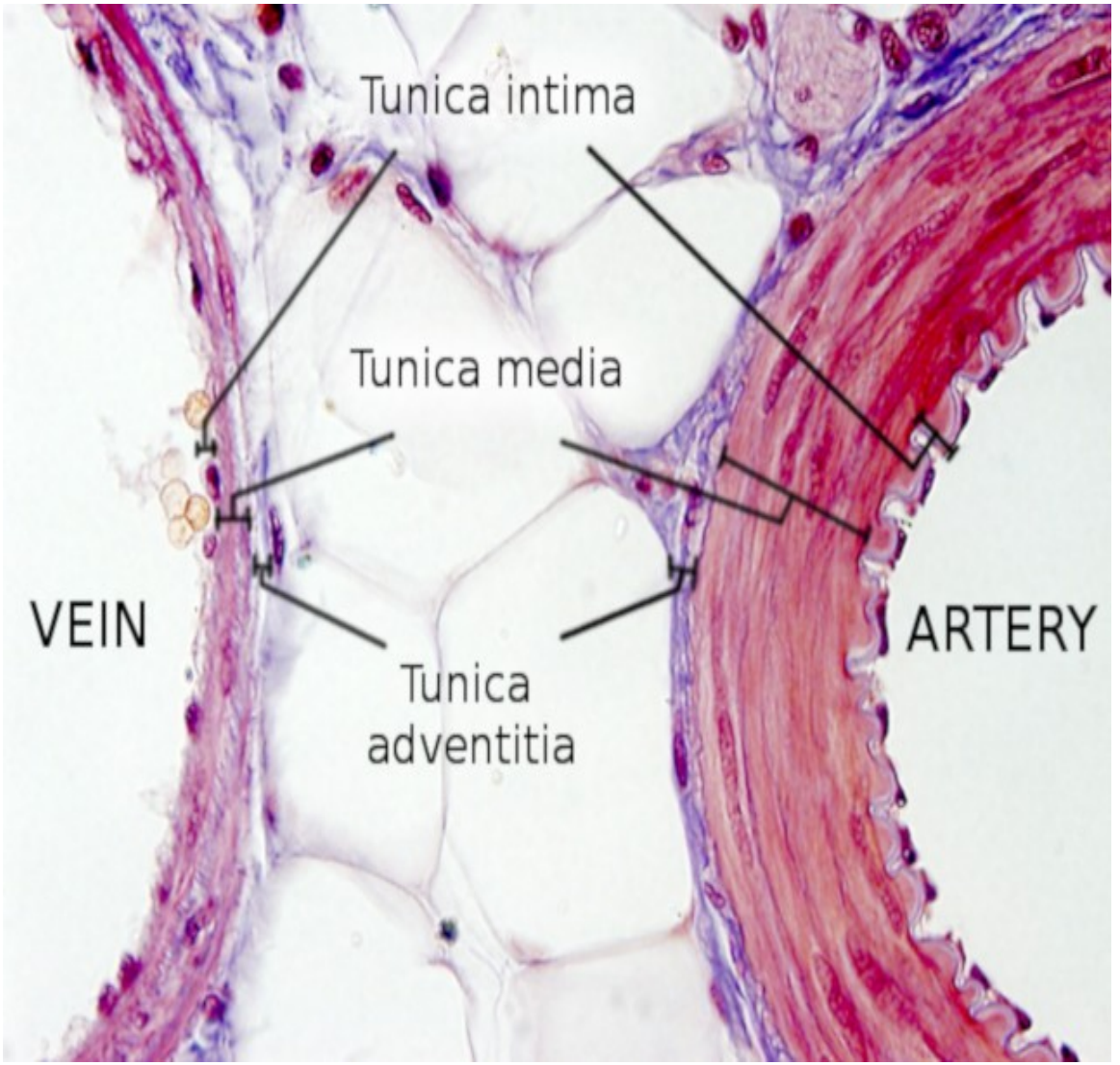


FIGURE : HISTOLOGY OF BLOOD VESSELS

Aorta, arteries and arterioles have two laminae of elastic tissues:

i. **External elastic lamina** between tunica adventitia and tunica media
ii. **Internal elastic lamina** between tunica media and tunica intima.

- Aorta and arteries have more elastic tissues and the arterioles have more smooth muscles.

VENOUS SYSTEM

- From the capillaries, venous system starts and it includes venules, veins and venae cavae.
- Capillaries end in venules, which are the smaller vessels with thin muscular wall than the arterioles.

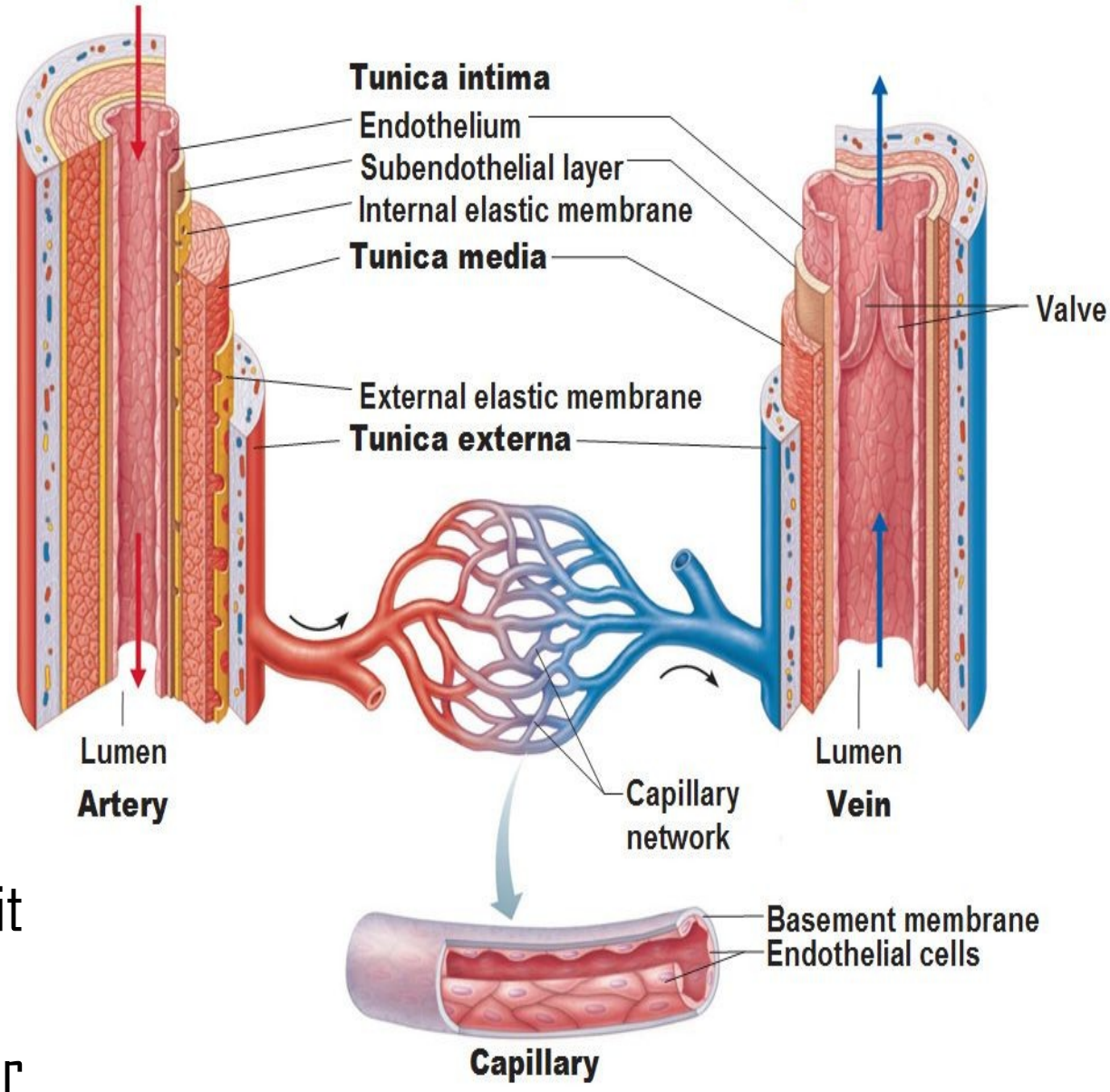


FIGURE : LAYARS OF BLOOD VESSELS

- Diameter of the venules is about 20 μ.
- At a time, a large quantity of blood is held in venules and hence the venules are called **capacitance vessels.**
- Venules are continued as veins, which have the diameter of 5 mm.
- Veins form superior and inferior venae cavae, which have a diameter of about 30 mm.
- Walls of the veins and venae cavae are made up of inner endothelium, elastic tissues, smooth muscles and outer connective tissue layer.
- In the veins and venae cavae, the elastic tissue is less but the smooth muscle fibers are more.

DIVISIONS OF CIRCULATION

- Blood flows through two divisions of circulatory system:

1. Systemic circulation
2. Pulmonary circulation.

SYSTEMIC CIRCULATION

- Systemic circulation is otherwise known as **greater circulation**.
- Blood pumped from left ventricle passes through a series of blood vessels, arterial system and reaches the tissues.
- Exchange of various substances between blood and the tissues occurs at the capillaries.
- After exchange of materials, blood enters the venous system and returns to right atrium of the heart.
- From right atrium, blood enters the right ventricle.
- Thus, through systemic circulation, oxygenated blood is supplied from heart to the tissues and venous blood returns to the heart from tissues.

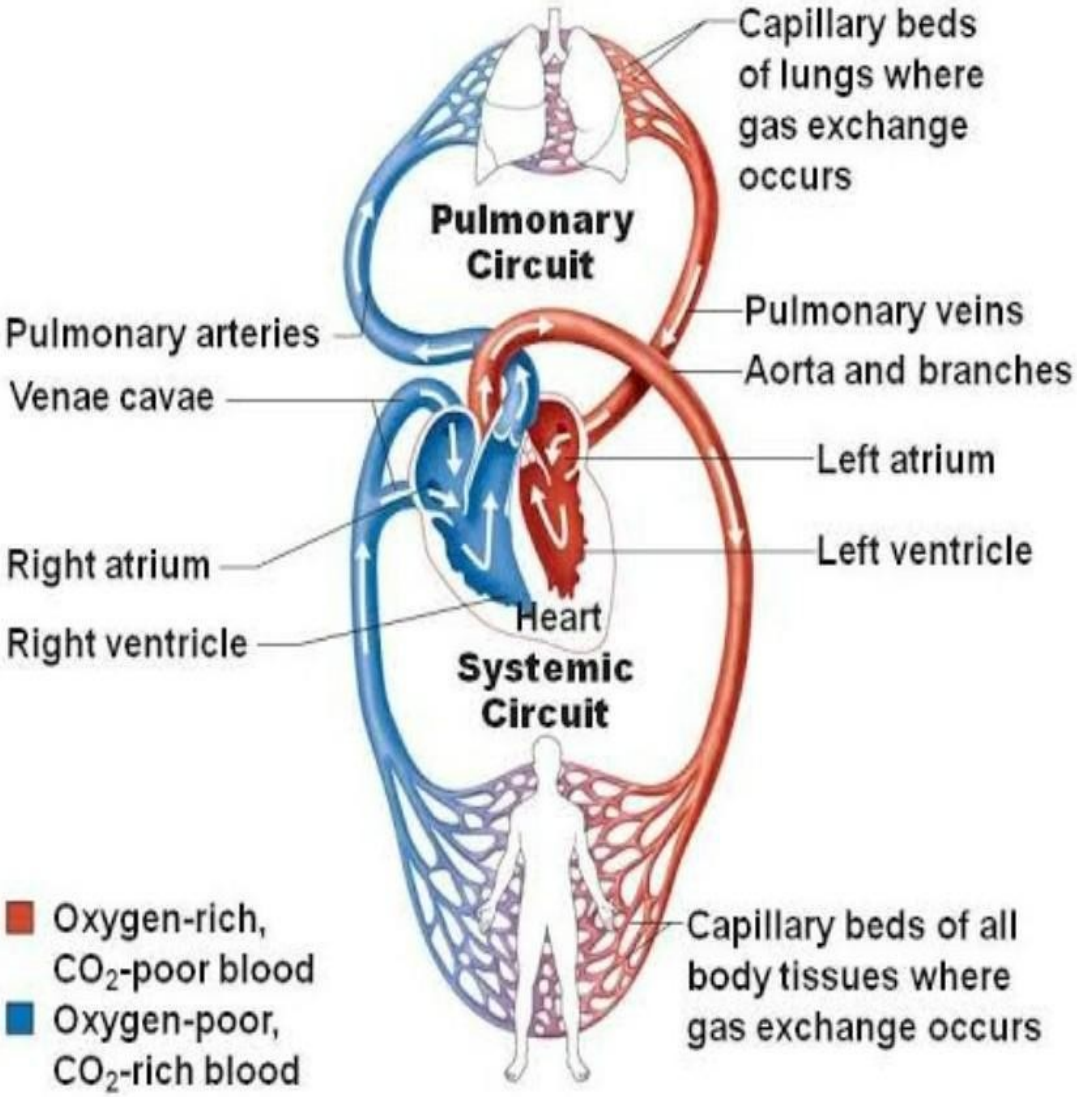
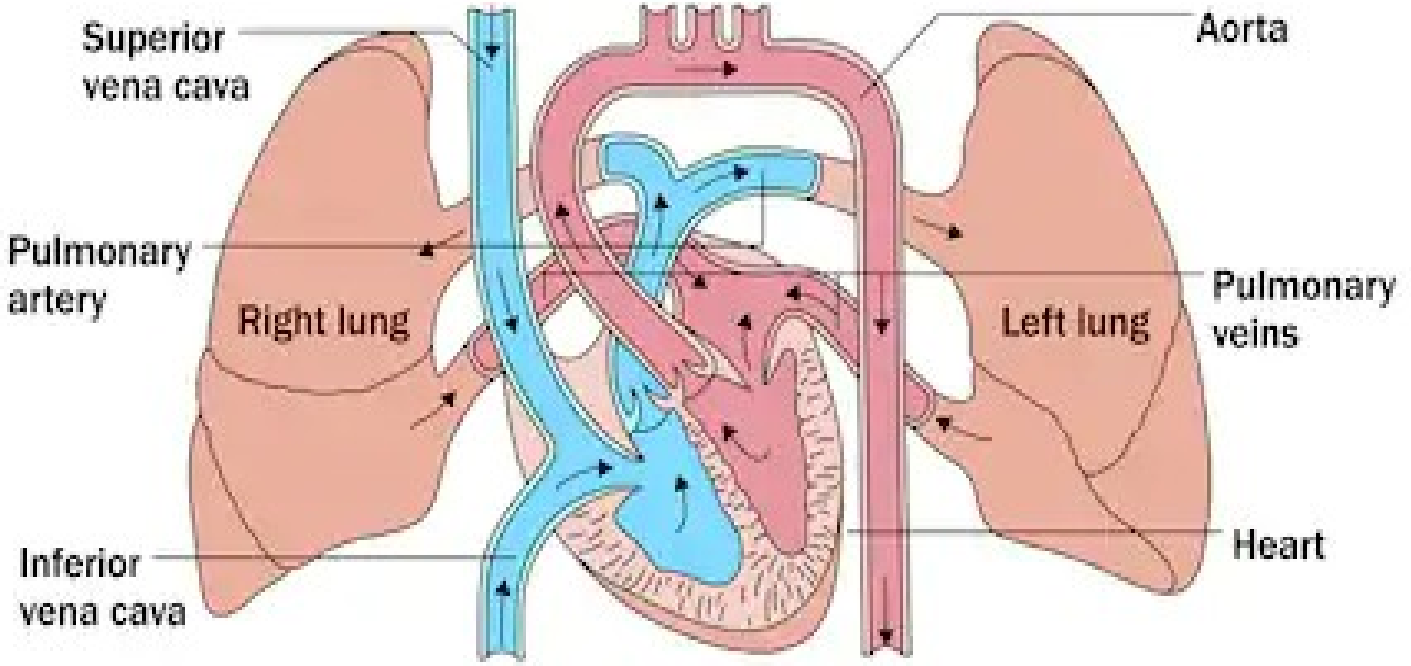


FIGURE : DIVISIONS OF CIRCULATION

PULMONARY CIRCULATION

- Pulmonary circulation is otherwise called **lesser circulation.**
- Blood is pumped from right ventricle to lungs through pulmonary artery.
- Exchange of gases occurs between blood and alveoli of the lungs at pulmonary capillaries.
- Oxygenated blood returns to left atrium through the pulmonary veins.
- Thus, left side of the heart contains oxygenated or arterial blood and the right side of the heart contains deoxygenated or venous blood.



RHYTHMICAL EXCITATION OF THE HEART

- The heart is endowed with a special system for generating rhythmical electrical impulses to cause rhythmical contraction of the heart muscle and conducting these impulses rapidly through theheart

1. EXCITATORY SYSTEM OF THE HEART

- The heart has a specialized excitatory structure, from which the discharge of impulses is rapid.
- This specialized structure is called pacemaker.
- From here, the impulses spread to other parts through the specialized conductive system.

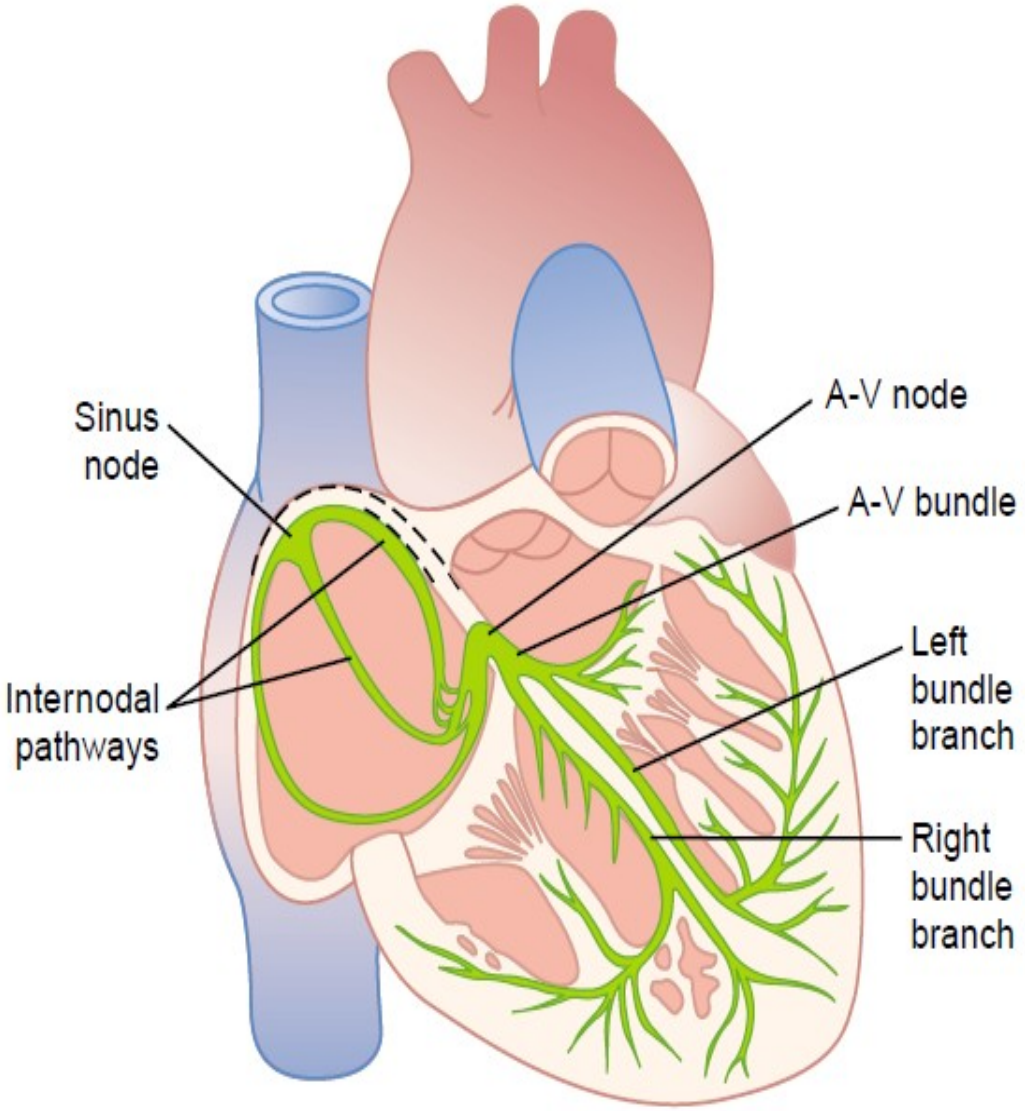


FIGURE : EXCITATORY AND CONDUCTIVE SYSTEM OF THE HEART

PACEMAKER OR S-A NODE

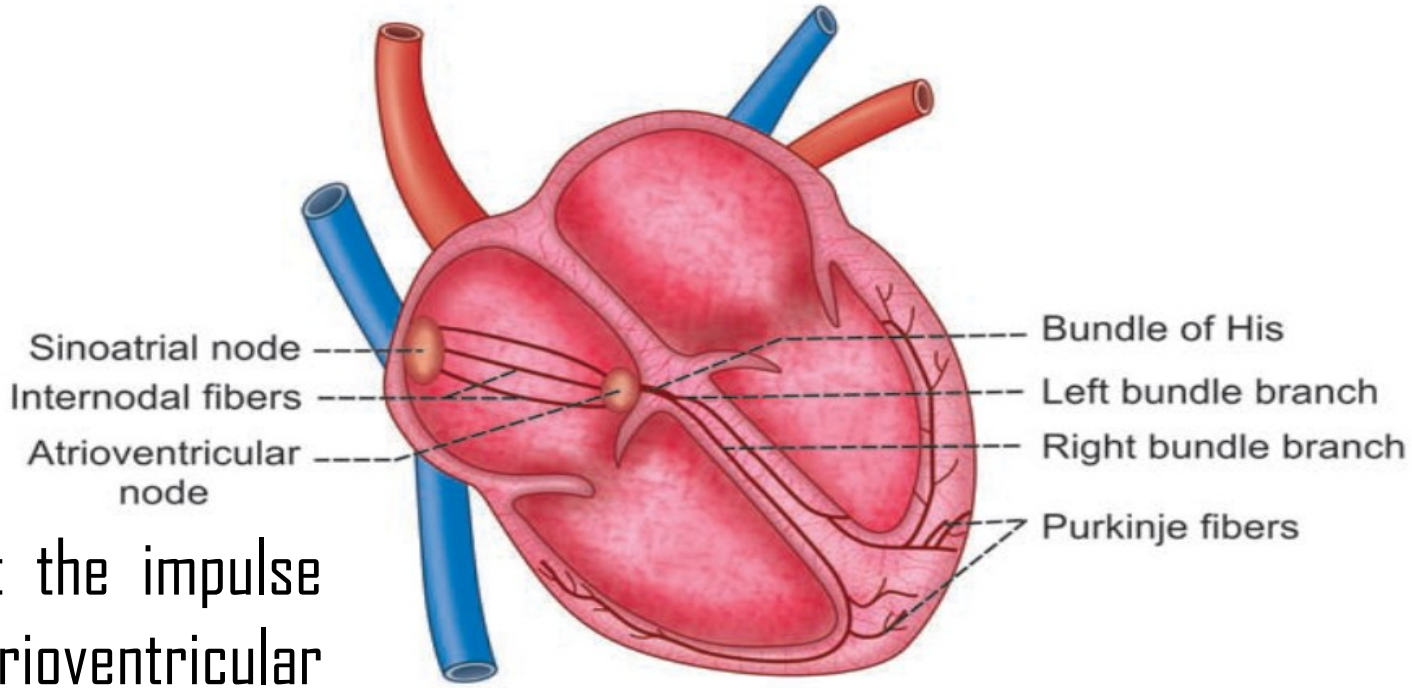
- Pacemaker is the structure of heart from which the impulses for heartbeat are produced.
- It is formed by the **pacemaker cells** called **P cells.**
- In mammalian heart, the pacemaker is sinoatrial node (SA node).
- It was Lewis Sir Thomas, who named SA node as pacemaker of heart, in 1918.
- Sinoatrial (SA) node is a small strip of modified cardiac muscle, situated in the superior part of lateral wall of right Atrium that controls cardiac contractions.
- In which the normal rhythmical impulse is generated; However, the sinus nodal fibers connect directly with the atrial muscle fibers, so that any action potential that begins in the sinus node spreads immediately into the atrial muscle wall.

2. CONDUCTIVE SYSTEM IN HUMAN HEART

- Conductive system of the heart is formed by the modified cardiac muscle fibers.
- These fibers are the specialized cells, which conduct the impulses rapidly from SA node to the ventricles.

COMPONENTS OF CONDUCTIVE SYSTEM IN HUMAN HEART

1. AV node
2. Bundle of His
3. Right and left bundle branches
4. Purkinje fibers.



- The internodal pathways that conduct the impulse from the Sinoatrial (S-A) node to the atrioventricular (A-V) node.
- The A-V node, in which the impulse from the atria is delayed before passing into the ventricles.
- The A-V bundle or Bundle of His, which conducts the impulse from the atria into the ventricles.
- The left and right bundle branches of Purkinje fibers, which conduct the cardiac impulse to all parts of the ventricles.

VELOCITY OF IMPULSES AT DIFFERENT PARTS OF CONDUCTIVE SYSTEM

1. Atrial muscle fibers : 0.3 meter/second
2. Internodal fibers : 1.0 meter/second
3. AV node : 0.05 meter/second
4. Bundle of His : 0.12 meter/second
5. Purkinje fibers : 4.0 meter/second
6. Ventricular muscle fibers : 0.5 meter/second

- Thus, the velocity of impulses is maximum in Purkinje fibers and minimum at AV node.

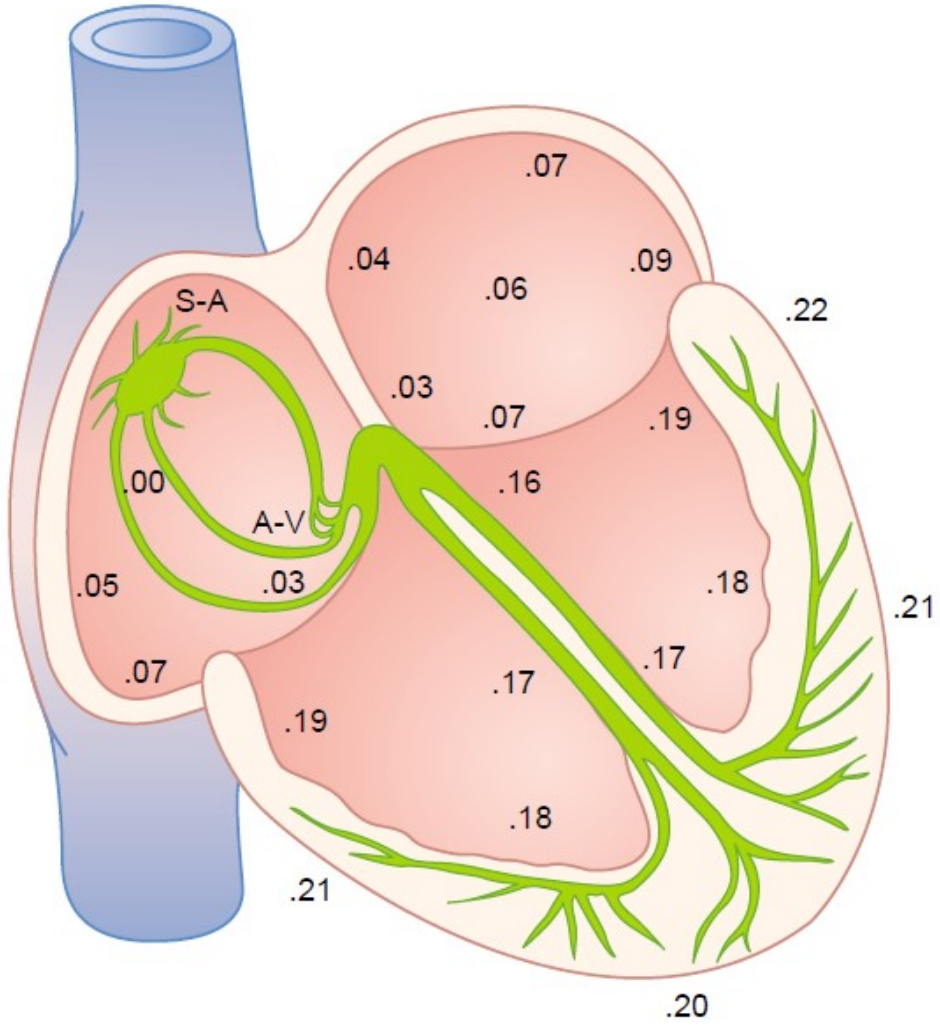


FIGURE : VELOCITY OF IMPULSES AT DIFFERENT PARTS OF CONDUCTIVE SYSTEM

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