Circulatory system

BY

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First stage

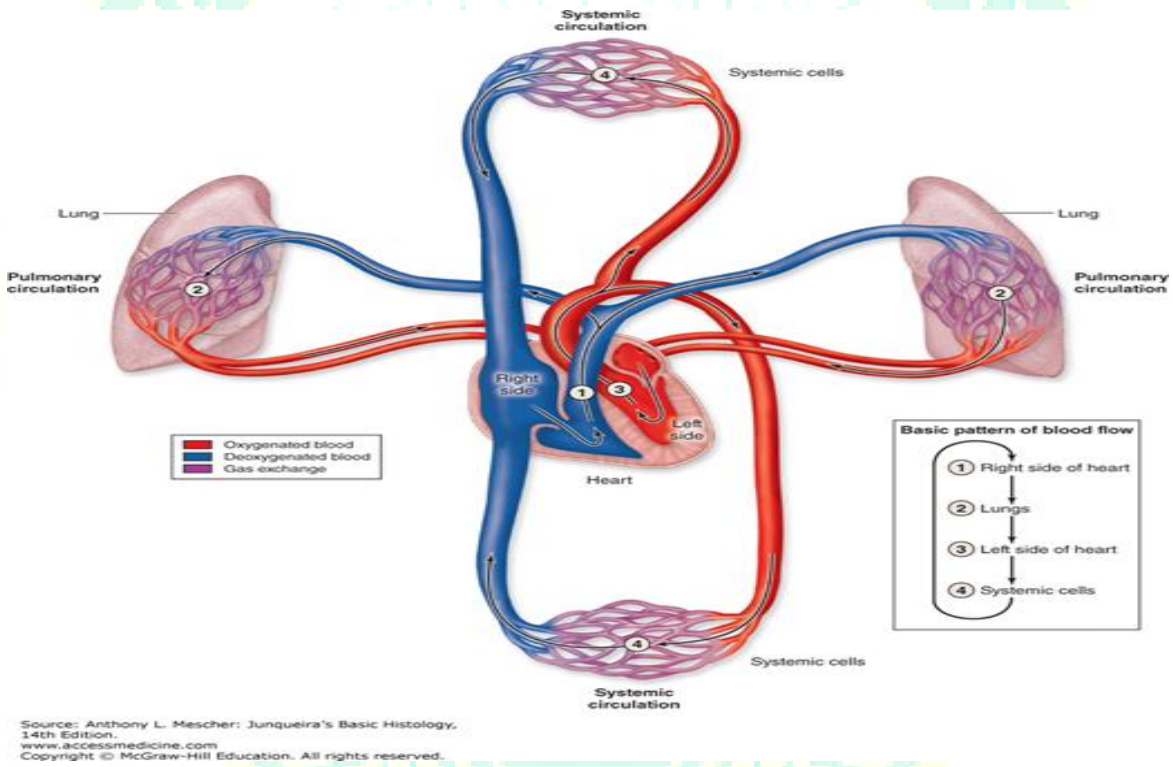
2021-2022

The Circulatory System Consists Of:

1. Blood vascular system or cardiovascular system.
2. Lymphatic system.

Blood Vascular System

The mammalian blood vascular system consists of the arteries, arterioles, veins, venules, capillaries and heart. The main function of this system is to deliver oxygenated blood to cells and tissues and return venous blood to the lung for gaseous exchange.



Consisting of the heart, arteries, veins, and micro-vascular beds are organized as the pulmonary circulation and the systemic circulation. In pulmonary circulation, the right side of the heart pumps blood through pulmonary vessels, through the lungs for oxygenation, and back to the left side of the heart. The larger systemic circulation pumps blood from the left side of the heart through vessels supplying either the head and arms or the lower body, and back to the right side of the heart.

When the body is at rest, approximately 70% of the blood moves through the systemic circulation, about 18% through the pulmonary circulation, and 12% through the heart.

Heart

The heart is a muscular pump that propels blood at high pressure around the body through the blood vessels. The heart contracts **rhythmically**, and **autonomously**. Contractions begin at the **apex** of the heart and spread through to the other chambers.

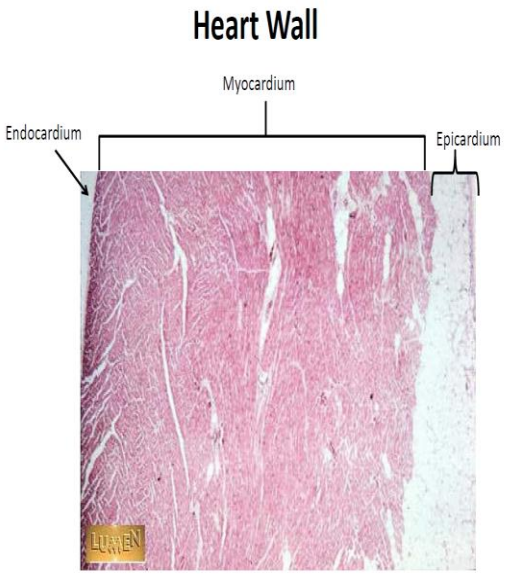
The cardiac muscle in the four chambers of the heart wall contracts rhythmically, pumping the blood through the circulatory system. The right and left **ventricles** propel blood to the pulmonary and systemic circulation, respectively; right and left **atria** receive blood from the body and the pulmonary veins, respectively. The walls of all four heart chambers consist of three major layers: the internal endocardium; the middle myocardium; and the external epicardium.

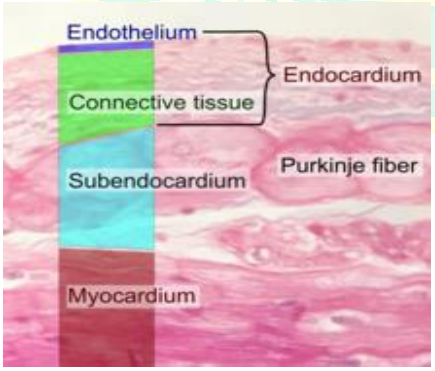
The heart wall can be viewed as a three-layered structure

1. Inner layer = Endocardium.
2. Middle Layer = Myocardium.
3. Outer layer = Epicardium (also called the pericardium).

1- Endocardium

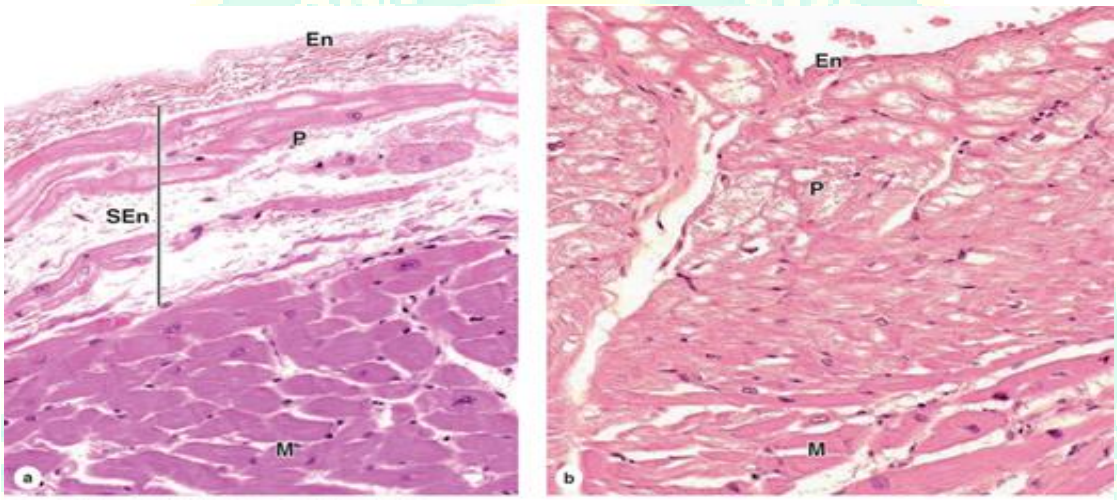
The endocardium consists of a **thin inner layer of endothelium** and **supporting connective tissue**, **a middle myoelastic layer of smooth muscle fibers**, **and a deep layer of connective tissue** called the subendocardial layer that merges with the myocardium.





2- Myocardium

The thickest layer, the myocardium, consists mainly of **cardiac muscle** with its fibers arranged spirally around each heart chamber. Because strong force is required to pump blood through the systemic and pulmonary circulations, the myocardium is much thicker in the walls of the ventricles.

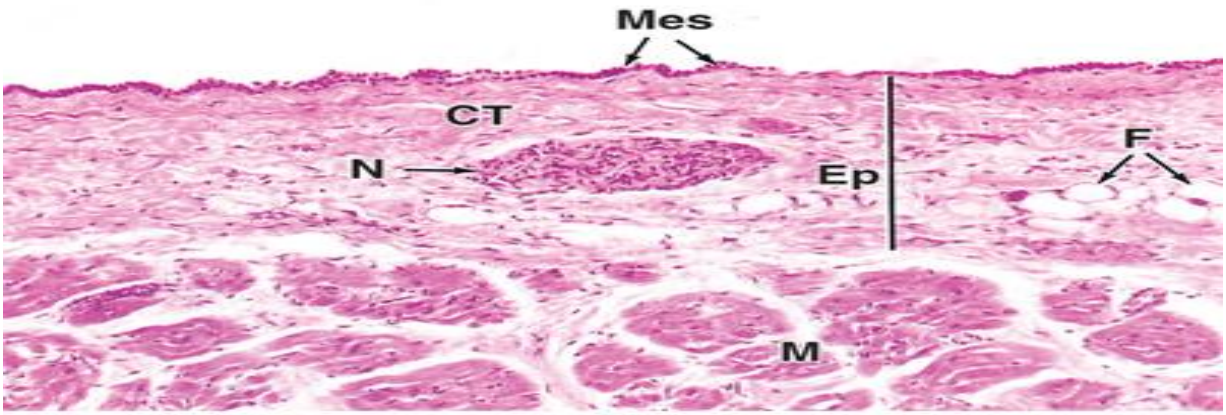


(a) Located below the endothelium **(En)** and myoelastic layer, the subendocardial layer **(SEn)** in the ventricles contains the conducting (Purkinje) fibers **(P)** of the heart's impulse conducting network. These fibers are modified cardiac muscle cells joined by intercalated disks but specialized for impulse conduction rather than contraction. Purkinje fibers typically are paler staining than contractile cardiac muscle fibers **(M)**.

(b) In the atria Purkinje fibers **(P)** are often closer to the endothelium **(En)** and intermingle with the contractile fibers within the myocardium **(M)**. (Both X200; H&E).

3- Epicardium

The epicardium is a simple squamous mesothelium supported by a layer of loose connective tissue containing **blood vessels** and **nerves.** Is the site of the coronary vessels and contains considerable adipose tissue.



The external tunic of the heart, the epicardium, is the site of the coronary vessels and contains considerable adipose tissue. This section of atrium shows part of the myocardium **(M)** and epicardium **(Ep)**. The epicardium consists of loose connective tissue **(CT)** containing autonomic nerves **(N)** and variable amounts of fat **(F)**. The epicardium is the visceral layer of the pericardium and is covered by the simple mesothelium **(Mes)** that also lines the pericardial space. The mesothelial cells secrete a lubricant fluid that prevents friction as the beating heart contacts the parietal pericardium on the other side of the pericardial cavity (X100; H&E).

Histology of blood vessels

The wall of blood vessels contains three layers or tunics:

1. **The innermost layer is the tunica intima:**

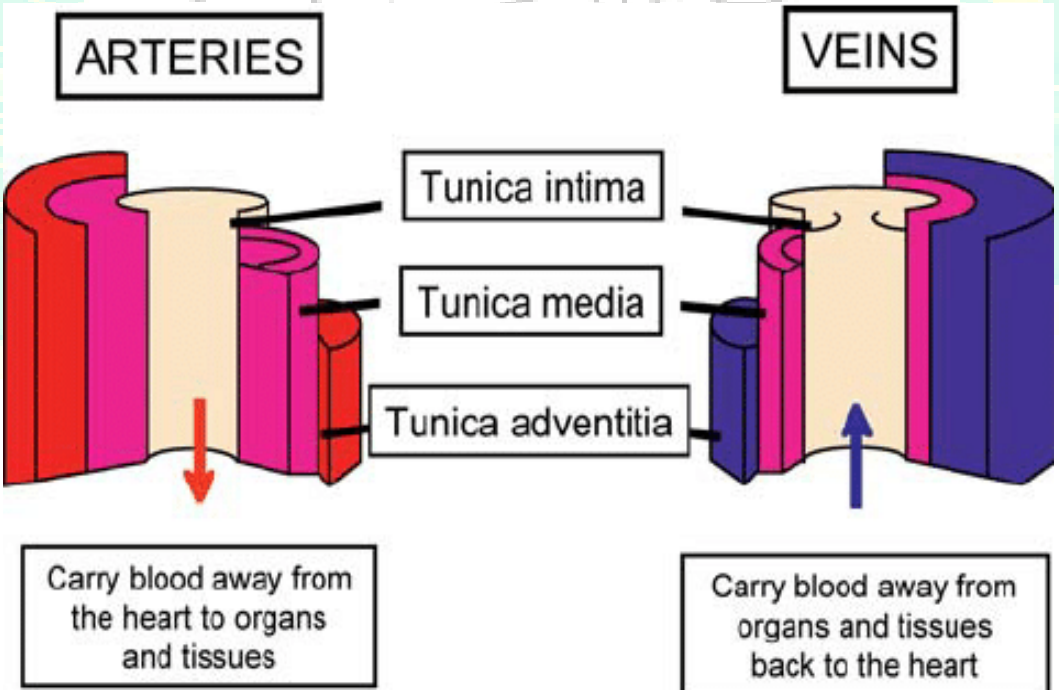
   This layer consists of a simple squamous epithelium, called endothelium.

2. **The middle layer is the tunica media:**

   Composed primarily of smooth muscle fibers. Interspersed among the smooth cells are variable amounts of elastic and reticular fibers.

3. **The outermost layer is the tunica adventitia**

   Composed primarily of collagen and elastic connective tissue fibers.



Arteries

The blood vessels take blood from the heart to organs and tissues. Arteries leave the heart to distribute the oxygenated blood. With each branching, the luminal diameters of the arteries gradually decrease, until the smallest vessel, the capillary is formed.

There are three types of arteries:

1. **Large-sized elastic arteries**

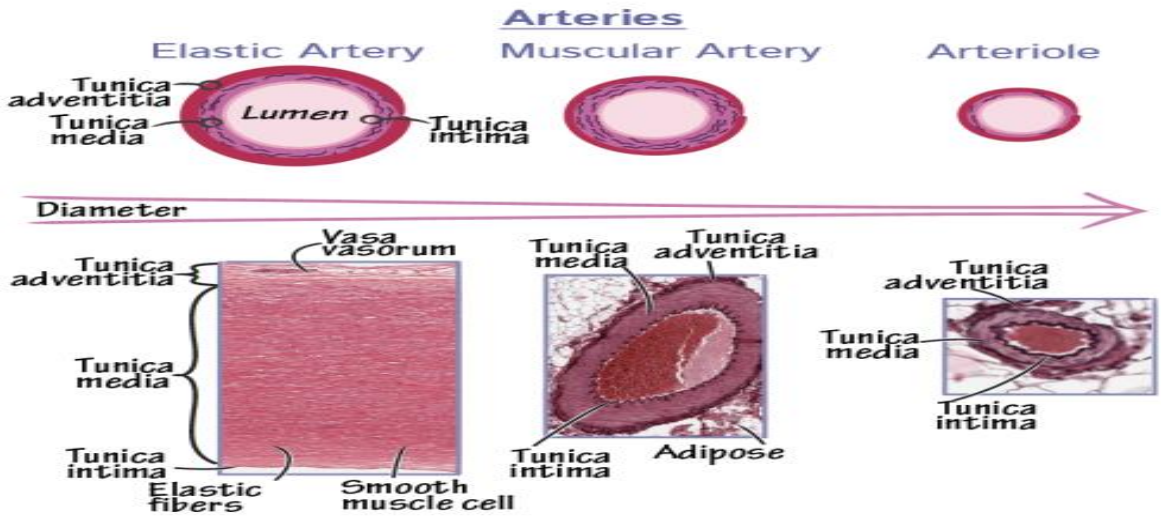
   The largest blood vessels in the body such as the pulmonary trunk and aorta. The walls of these vessels are primarily composed of elastic connective tissue fibers.

2. **Medium-sized muscular arteries**

   The most numerous vessels in the body. In contrast to the walls of elastic arteries, those of muscular arteries contain greater amounts of smooth muscle fibers.

3. **Arteriole**

   The smallest branches of the arterial system. Their walls consist of one to five layers of smooth muscle fibers.



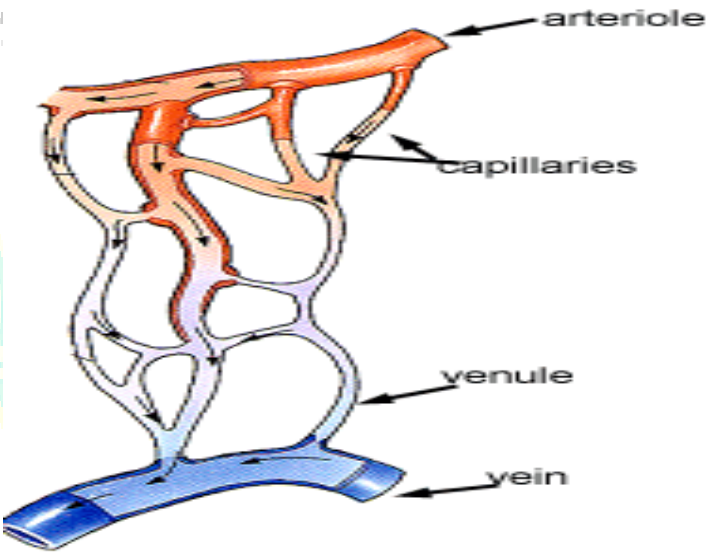
Veins

The blood vessel that backs to the heart from organs and tissues. The walls of the veins, like the arteries, also exhibit three layers or tunics. However, the muscular layer is much less prominent. The veins are classified according to their size small, medium, and large.

They have valves. The presence of valves in veins assists venous blood flow by preventing the backflow of blood. Venous blood between the valves in the extremities flows toward the heart as a result of the contraction of muscles that surround the veins. Compared with arteries, veins typically are more numerous and have thinner walls, larger diameters, and greater structural variation.

Venules

These have a clear tunica intima layer, without any elastic fibers, and a tunica media with one or two layers of muscle fibers. The tunica adventitia fuses with the surrounding tissue.



Capillaries

Capillaries connect arterioles with the smallest veins or venules. Capillaries are the smallest blood vessels.

1. **Continuous capillaries**

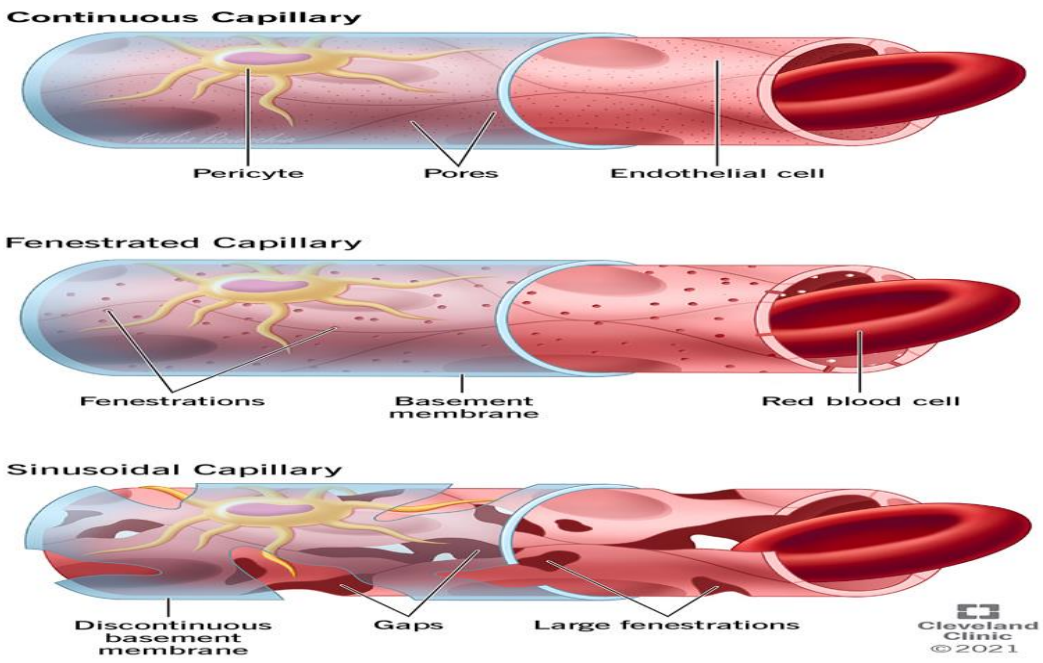
   The most common, in these capillaries the epithelial cells are joined and form a full layer.

2. **Fenestrated capillaries**

   Characterized by large opening or fenestration (pores) in the cytoplasm of epithelial cells designed for a rapid exchange of molecules between blood and tissues.

3. **Sinusoidal (discontinuous) capillaries**

   Endothelial cell junctions are rare in sinusoidal capillaries, and wide gaps exist between individual endothelial cells. Also, because a basement membrane underlying the endothelium is either incomplete or absent, a direct exchange of molecules occurs between blood contents and cells.



Arteries, Veins, and Capillaries Differences

Arteries	Veins	Capillaries
1. Responsible for the transportation of blood from the heart to all parts of the body.	1. Collect blood through capillaries and transport it towards the heart.	1. Connect arteries and veins
2. All arteries carry oxygenated blood except pulmonary arteries which carry deoxygenated blood.	2. All veins carry deoxygenated blood except pulmonary veins which carry oxygenated blood.	2. These carry mixed oxygenated and deoxygenated blood.
3. No valves in them except at the base of the pulmonary trunk and aorta.	3. Valves are present in veins. These valves prevent the backflow of blood.	3. There are no valves in them.
4. Arteries have high blood pressure.	4. Veins have low blood pressure.	4. There is falling pressure on them.
5. In arteries, waves of blood pressure or pulse due to heartbeat can be detected.	5. There is no pulse.	5. There is no pulse.
6. Blood flows rapidly between 400-500mm per second in the aorta and decreases in arteries and arterioles.	6. The rate of blood flow increases from smaller to larger veins.	6. Blood flow is slowest which is less than 1mm per second.
7. Arteries have smaller bore and thick walls.	7. Veins have a larger bore and thin walls.	7. Capillaries have a larger bore and the wall is of one cell in thickness.
8. There are thick muscle layers and elastic fibers present. The elasticity helps to change the pulsating flow of blood.	8. There are thin muscle layers and fewer elastic fibers present in veins. So, they are less elastic.	8. No muscles or elastic fibers are present.
9. There is no exchange of materials.	9. There is no exchange of materials.	9. These are responsible for the exchange of gases and nutrients.

The four major functions of the cardiovascular system are:

1. To transport nutrients, gases, and waste products around the body.
2. To protect the body from infection and blood loss.
3. To help the body maintain a constant body temperature (‘thermoregulation’).
4. To help maintain fluid balance within the body.