**THE CIRCULATORY SYSTEM:**

The circulatory system includes both the blood and lymphatic vascular systems. **I-**The **blood vascular system**  is composed of the following structures:

***i)***The **heart,** an organ whose function is to pump the blood.

***ii)***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.

***iii)***The **capillaries,** the smallest blood vessels, constituting a complex network of thin tubules that branch profusely in almost every organ and through whose walls the interchange between blood and tissues takes place.

***iv)***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:**

1-The heart is a muscular organ that contracts rhythmically, pumping the blood through the circulatory system. The right and left **ventricles** pump

blood to the lungs and the rest of the body respectively; right and left **atria** receive blood from the body and the pulmonary veins respectively. 2-The walls of all four heart chambers consist of three major layers or tunics: the internal endocardium; the middle myocardium; and the external epicardium. ***I)The endocardium* : *a)***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. ***b)***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. ***II)The myocardium*** : ***a)***It is the thickest of the tunics and consists of cardiac muscle cells arranged in layers that surround the heart chambers in a complex spiral. ***b)***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.

***III)the pericardium:***

***a)***The heart is covered externally by simple squamous epithelium (mesothelium) supported by a thin layer of connective tissue that constitutes the **epicardium.**

***b)***A subepicardial layer of loose connective tissue contains veins, nerves, and many adipocytes.The epicardium corresponds to the visceral layer of the **pericardium,** the serous membrane in which the heart lies. ***c)***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.

**STRUCTURAL OF BLOOD VESSELS:**

Blood vessels are usually composed of the following layers, or tunics .

***I-The tunica intima*** : ***a)***Its has one layer of endothelial cells supported by a thin subendothelial layer of loose connective tissue with occasional smooth muscle cells. ***b)*** 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. ***c)***As a result of the loss of blood pressure and contraction of the vessel at death, the tunica intima of arteries may have a slightly folded appearance in tissue sections.

***II-The tunica media***: **a)** The middle layer, consists chiefly of concentric layers of helically arranged smooth muscle cells***. b)***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. ***c)***In arteries, the media has a thinner **external elastic lamina,** which separates it from the tunica adventitia.

***III)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.

**The circulatory system divided into**

**1-The macrovasculare vessels that** are more than (0.1 mm)in diameter (large arterioles ,muscular and elastic arteries and muscular veins ) . **2**-**The microvasculare** ( arterioles, capillaries, and post capillaries venules ) it is important as the site of interchange between the blood and surrounding tissues in both the normal and inflammatory processes .

**Classification of the macrovasculature:**

The vessels of the macrovasculature are classified as the types indicated in the following discussion.

**I-Large Elastic Arteries:**

1-Large elastic arteries help to stabilize the blood flow. The elastic arteries include the aorta and its large branches. They have a yellowish color from the elastin in the media. 2-The intima is thicker than the corresponding tunic of a muscular artery. 3-The media consists of elastic fibers and a series of concentrically arranged, perforated elastic laminae whose number increases with age . Between the elastic laminae are smooth muscle cells, reticular fibers, and glycoproteins. 4-The tunica adventitia is relatively underdeveloped.

**II-Muscular Arteries:**

1-The muscular arteries can control blood flow to organs by contracting or relaxing the smooth muscle cells of the tunica media. The intima has a very thin subendothelial layer and the internal elastic lamina, the most external component of the intima, is prominent . 2- The tunica media may contain up to 40 layers of more prominent smooth muscle cells which are intermingled with a variable number of elastic lamellae (depending on the size of the vessel) as well as reticular fibers and proteoglycans. 3- An external elastic lamina, the last component of the media, is present only in the larger muscular arteries. 4-The adventitia consists of connective tissue. Lymphatic capillaries, vasa vasorum, and nerves are also found in the adventitia and these structures may penetrate to the outer part of the media.

**III-Large Arterioles:**

Muscular arteries branch repeatedly into smaller and smaller arteries, until reaching a size with only two or three medial layers of muscle.

**IV-Muscular veins:**

1-The big venous trunks, paired with elastic arteries close to the heart, are **large veins** . Large veins have a well-developed tunica intima, but the

tunica media is relatively thin, with few layers of smooth muscle and abundant connective tissue. 2-The adventitial layer is thick in large veins and frequently contains longitudinal bundles of smooth muscle. Both the media and adventitia contain elastic fibers, but elastic laminae like those of arteries are not present.

3-Most veins have valves, but these are most prominent in large veins. Valves consist of paired semilunar folds of the tunica intima projecting across part of the lumen .

**Classification of the microvasculature:**

**I-Small** **arterioles**:

1-The smallest arteries branch as **arterioles**, which have one or two smooth muscle layers and indicate the beginning of an organ's **microvasculature** exchanges between blood and tissue fluid occur . 2-Arterioles are generally less than 0.5 mm in diameter, with lumens approximately as wide as the wall is thick

**II-Capillaries** : 1-They composed of a single layer of endothelial cells of mesenchymal origin . The a verage diameter of capillaries is small . When cut transversely their walls are observed to consist of portion of one to three cells , the external surfaces of these cells usually rest on a basal lamina, a product of endothelial origin . 2-In general, endothelial cell are polygonal and elongated in the direction of blood flow , nucleus causes the cell to bulge into the capillary lumen . 3-Junction between endothelial cell of venules are the loosest . At these locations there is a characteristic loss of fluid from circulatory system occur during the inflammatory response leading to edema. 4-At various location along capillaries and postcapillary venule are cells of mesenchymal origin with long cytoplasmic processes that partly surround the endothelial cells . 5-These cells are called pericytes , which are present at various location along the capillaries and post capillary (small venules ). 6- After tissue injuries , pericytes proliferate and differentiate to form new blood vessels and connective tissue cell, thus participating in the repair process .

**Types of capillaries :**

Capillaries have structural variations to permit different levels of metabolic exchange between blood and surrounding tissues ( depending on the structure of endothelial cell and present or absent of basal lamina ), capillaries can be grouped into three major categories :

1-Continuous or somatic capillaries. 2- Fenestrated or visceral capillaries. 3-Discontinuous sinusoidal capillaries. **Function** **of** **capillaries** :

**A**-Selective permeability barrier capillaries and post capillaries venules exchange vessels . at these sites the O2 and CO2 substrates and metabolites are transferred from blood to the tissues and the tissues to the blood. The permeability of capillaries wall vary in size and charge of permeating molecules and with structure of endothelial cells .

**B-Metabolic** **function** : 1- Activation : like conversion of angiotensin Ι (in active) to angiotens II (active) . 2- In activation conversion of Bradykinin , serotonin , prostaglandins , nor epinephrine , thrombin to biologically inert compounds . 3-Lipolysis : break down of lipoprotein by enzyme to triglyceride and cholesterol these are substance for steroid hormone synthesis in membrane structure . 4-Production of vasoconstriction factors. 5-Non thrombogenic action .

A**rteriovenous anastomoses :** they are direct communication between arterioles and venules circulation . these arteriovenous anastomoses are highly distributed through the body in are generally occur in small blood vessels

**III-Venules:**

1-The transition from capillaries to venules occurs gradually. The immediate **postcapillary venules** are similar structurally to capillaries, with pericytes . 2-Postcapillary venules participate in the exchanges between the blood and the tissues and are the primary site at which white blood cells leave the circulation at sites of infection or tissue damage . 3-These venules converge into larger **collecting venules** which have more contractile cells. With greater size the venules become surrounded by recognizable tunica media with two or three smooth muscle layers and

are called **muscular venules** . 4-A characteristic feature of all venules is the large diameter of the lumen compared to the overall thinness of the wall