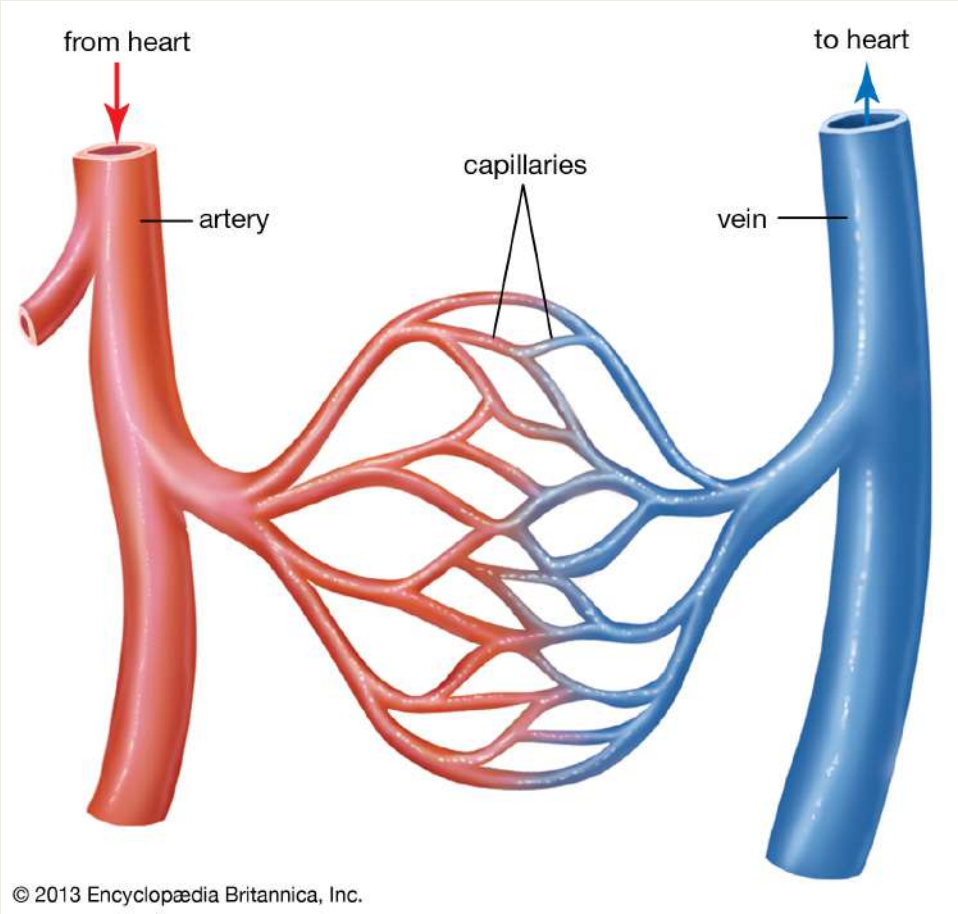
CARDIOVASCULAR SYSTEM

Ms. Martel

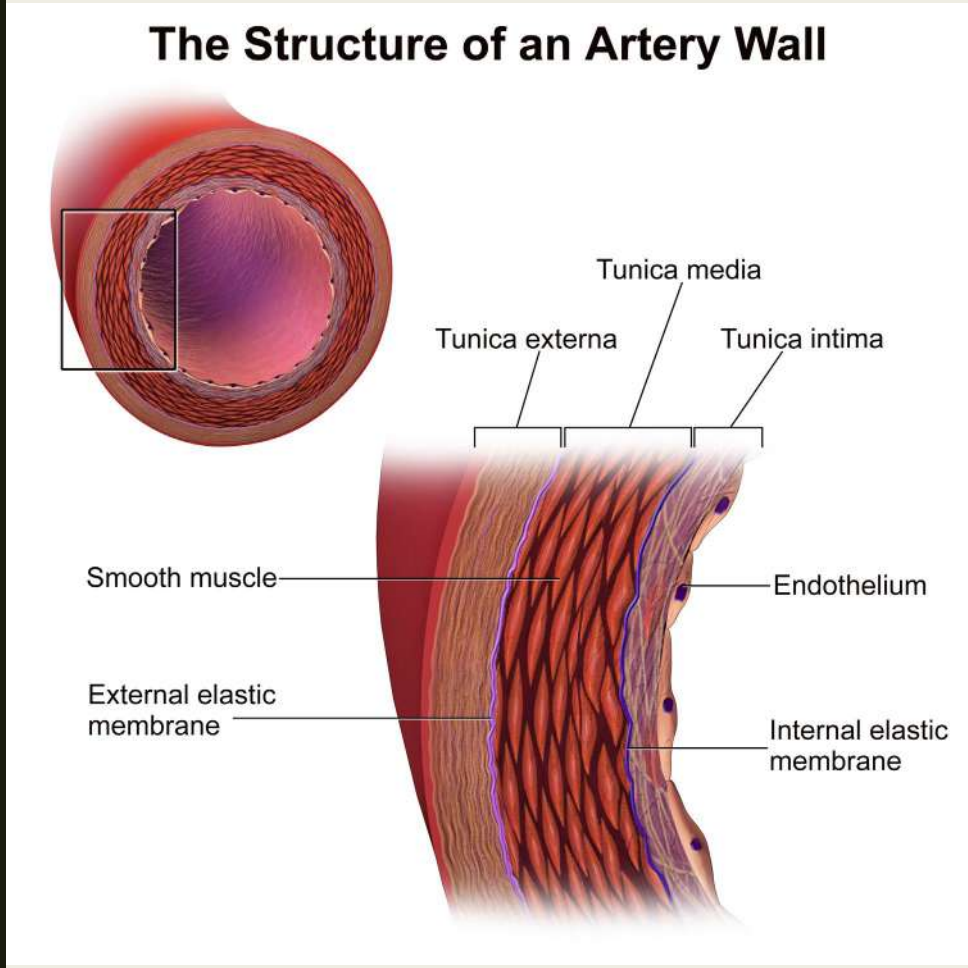
10.1 – THE BLOOD VESSELS

- The circulatory system has 3 types of blood vessels:
  - Arteries, **which carry blood away from the heart to the capillaries.**
  - Capillaries, **which allow exchange of material with the tissues.**
  - Veins, **which return blood from the capillaries to the heart.**



The Arteries

- An arterial wall has 3 layers:
  - **Inner endothelium**
  - **Middle smooth muscle** – controls blood flow and pressure
  - **Outer fibrous connective tissue**
- The largest artery in the body is the aorta.
- Smaller arteries branch off from the aorta, **eventually forming arterioles.**

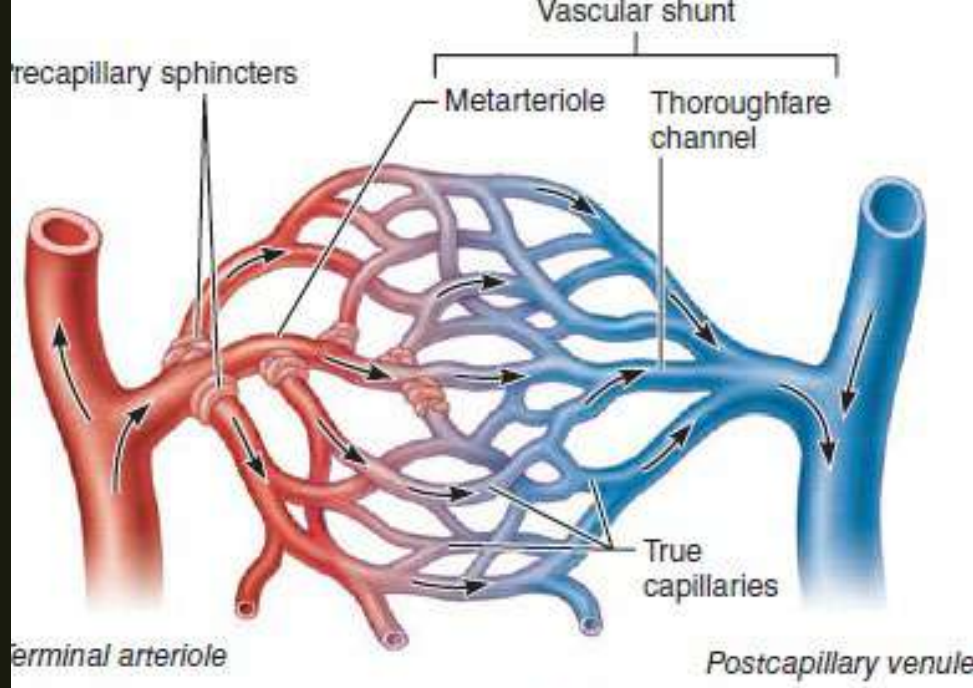


- Arterioles are **small arteries.**
- When the muscle fibers in arteries and arterioles are contracted (constricted), the **vessel is smaller in diameter.**
  - When they are relaxed (dilated), **the vessel has a larger diameter.**
  - Whether they are constricted or dilated, this **affects blood pressure.**

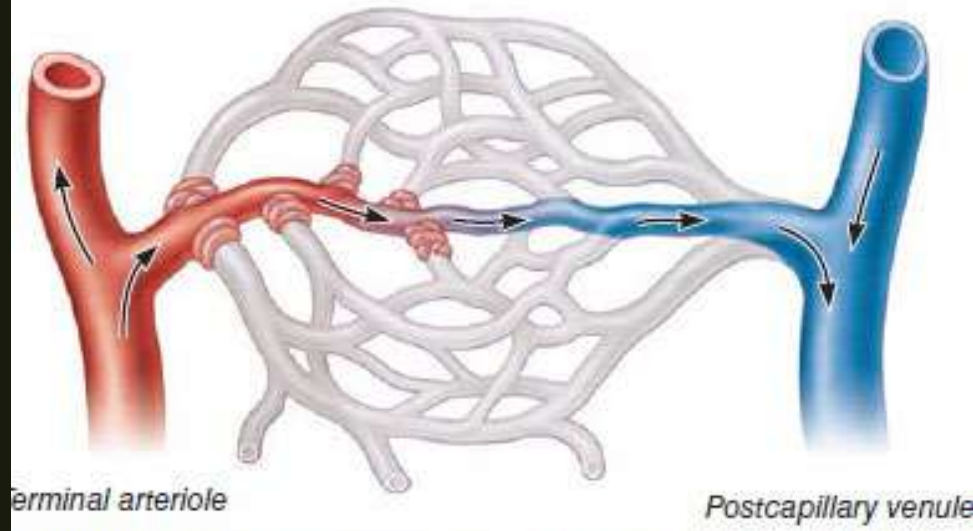
The Capillaries

- Capillaries join **arterioles to venules.**
  - They are extremely narrow, and have thin walls made of only **one cell layer.**
  - Although they are small they form vast networks called **capillary beds.**
  - Capillaries play a very important role in homeostasis, because they facilitate **exchange of substances.**
  - **O2 and nutrients diffuse out of the capillary** into the fluid that surrounds cells. Some water leaves as well and is picked up by lymphatic vessels.
  - **Wastes such as CO2 diffuse into the capillary.**

- Only certain capillary beds are open all the time.
- Most are **opened and closed depending on the bodies needs.**
  - For example, after eating, the capillary beds that serve the digestive system are mostly open, and those that **serves the muscles are mostly closed.**
  - Each bed has anastomoses, shunts, that allow blood to go through, or **bypass a capillary bed depending on the bodies needs.**



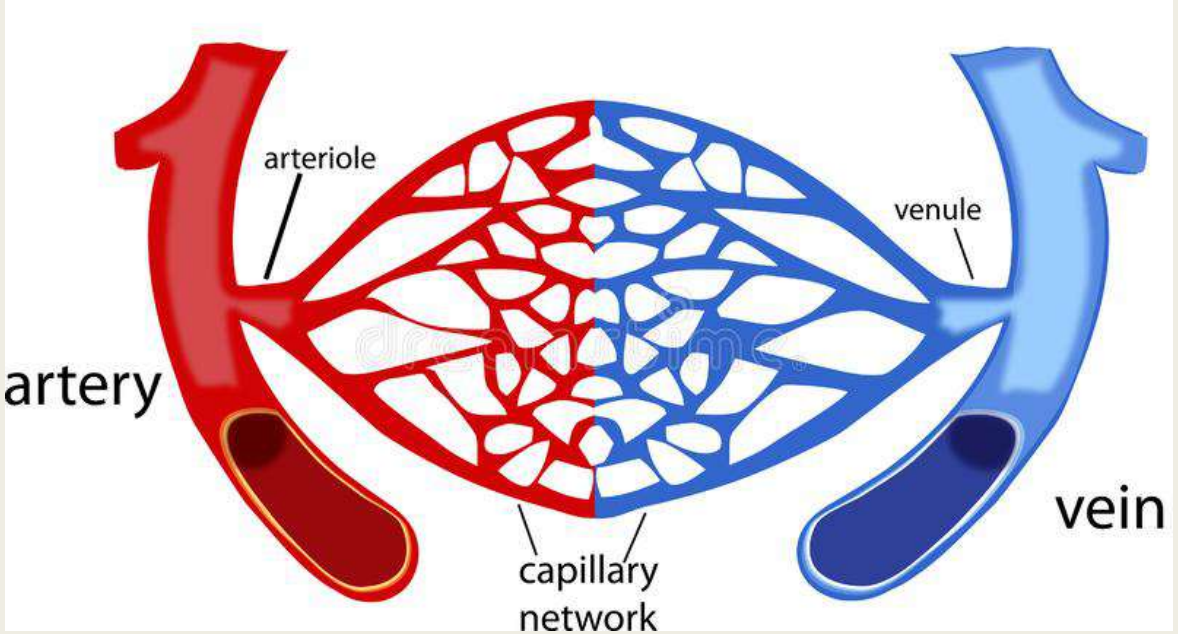
a) **Sphincters open**—blood flows through true capillaries.



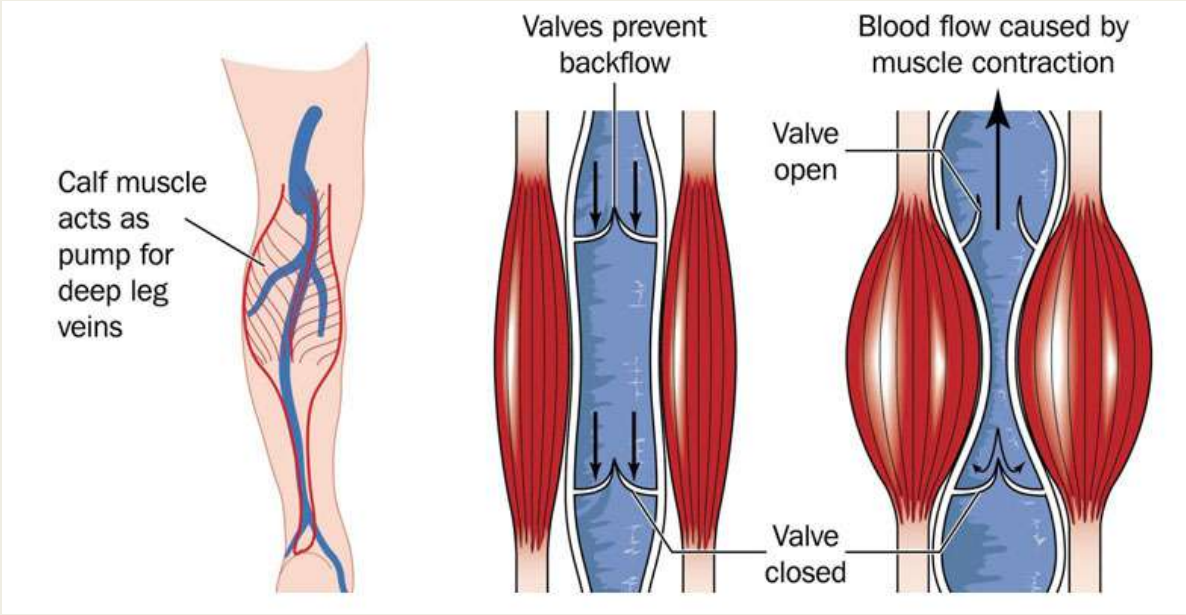
o) **Sphincters closed**—blood flows through metarteriole–thoroughfare hannel and bypasses true capillaries.

The Veins

- Veins and venules take blood from the **capillary beds to the heart.**
  - First, the venules drain blood from the capillaries and **then join to form a vein.**
  - The walls of veins and venules have the same three layers of arteries, but **less smooth muscle, making them thinner.**



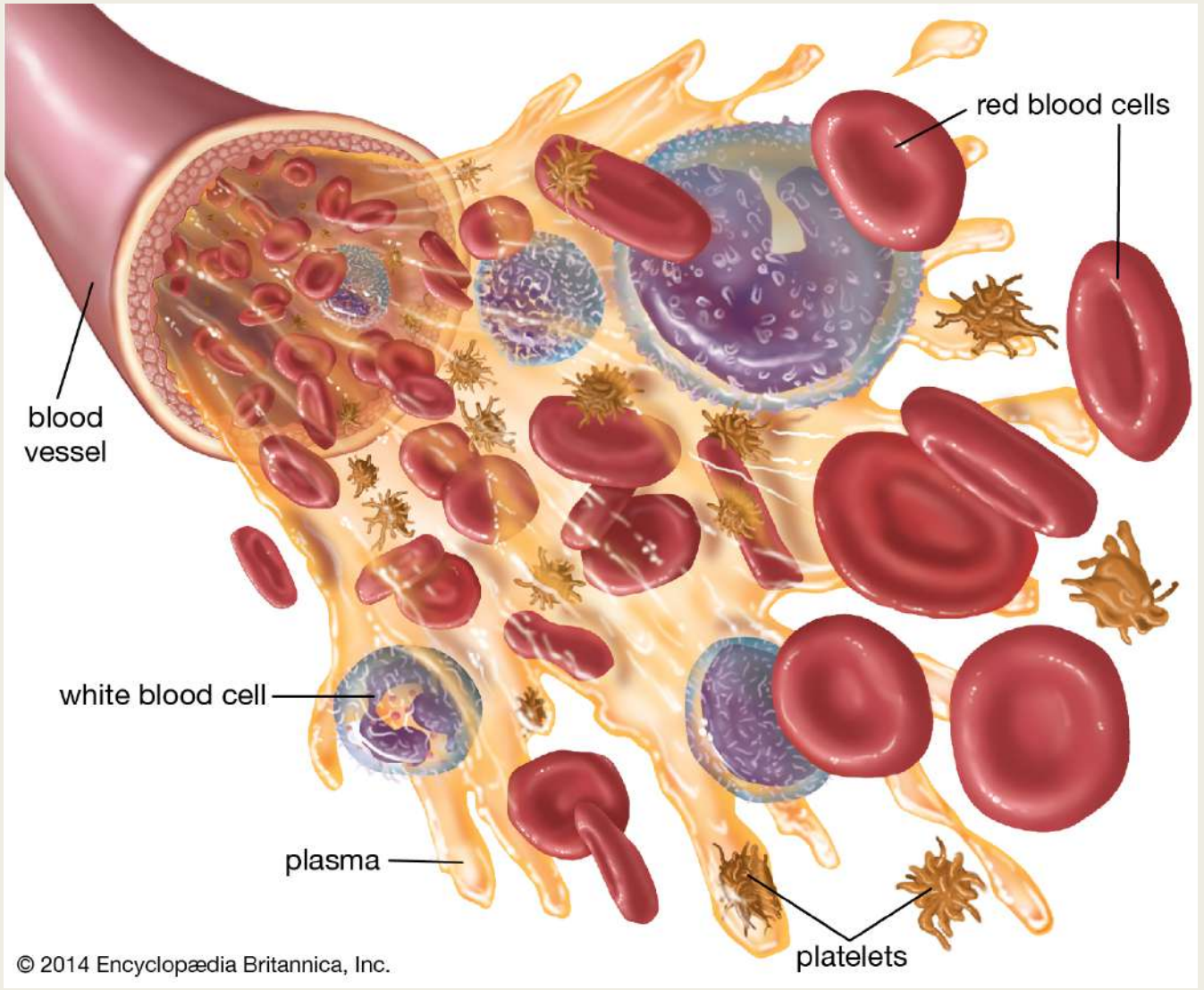
- Veins often have valves, which **allow blood to flow only towards the heart.**
- Valves are found in the veins that carry blood **against the force of gravity.**
  - Blood flow in the veins is primarily due to **skeletal muscle contraction.**
  - If the valves become damaged by disease or through normal wear and tear of aging, **blood may begin to pool in veins**, causing them to enlarge (varicose veins).
- The largest veins are the **superior and inferior vena cava.**



10.2 - BLOOD

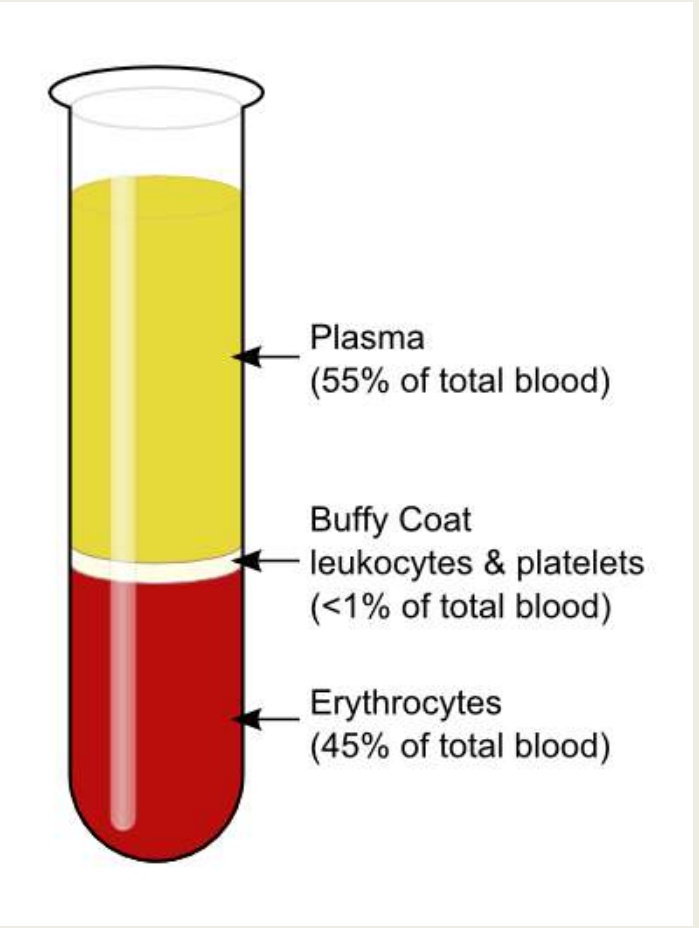
- Blood is considered to be a **liquid connective tissue.**
- It has **transport and protective functions.**
  - Blood transports **nutrients, waste, and hormones.**
- Blood helps regulate temperature by dispersing body heat, and regulate **blood pressure due to plasma proteins contributing to osmotic pressure.**
  - It also helps protect the body against **disease causing pathogens.**
  - Clotting mechanisms protect the body against **blood loss.**

- Blood is separated into three components:
  - **Plasma** – the liquid portion of blood
  - **White blood cells and platelets**–formed elements
  - **Red blood cells** – formed elements



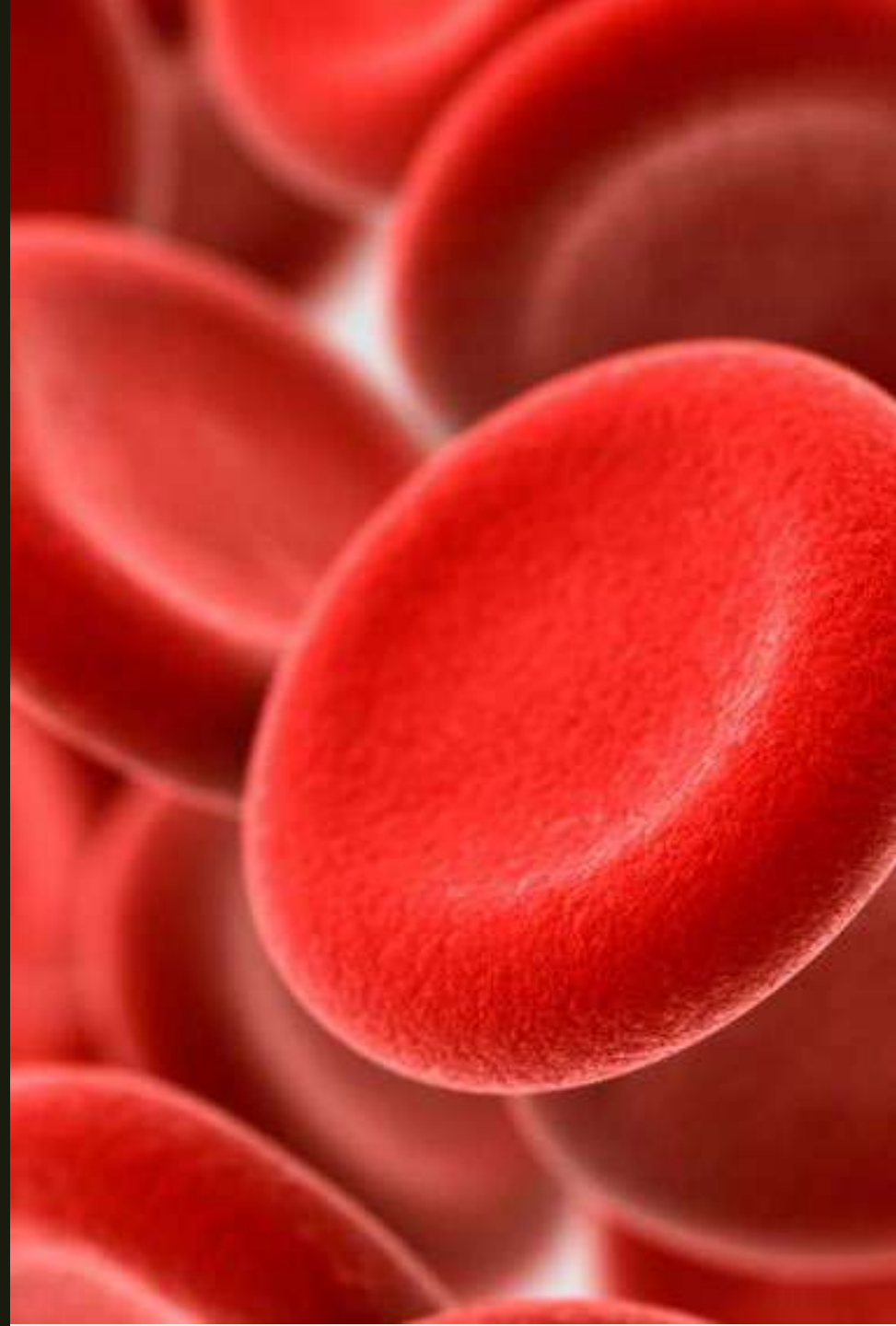
Plasma

- Plasma contains a variety of **inorganic and organic substances** dissolved or suspended in H2O.
- Plasma proteins assist in transporting **large inorganic molecules in blood.**
  - For example: lipoproteins transport cholesterol.
- Other plasma proteins such as **fibrinogen, are necessary for blood clotting.**
  - Some even have immune functions such as **immunoglobulins, which are antibodies.**

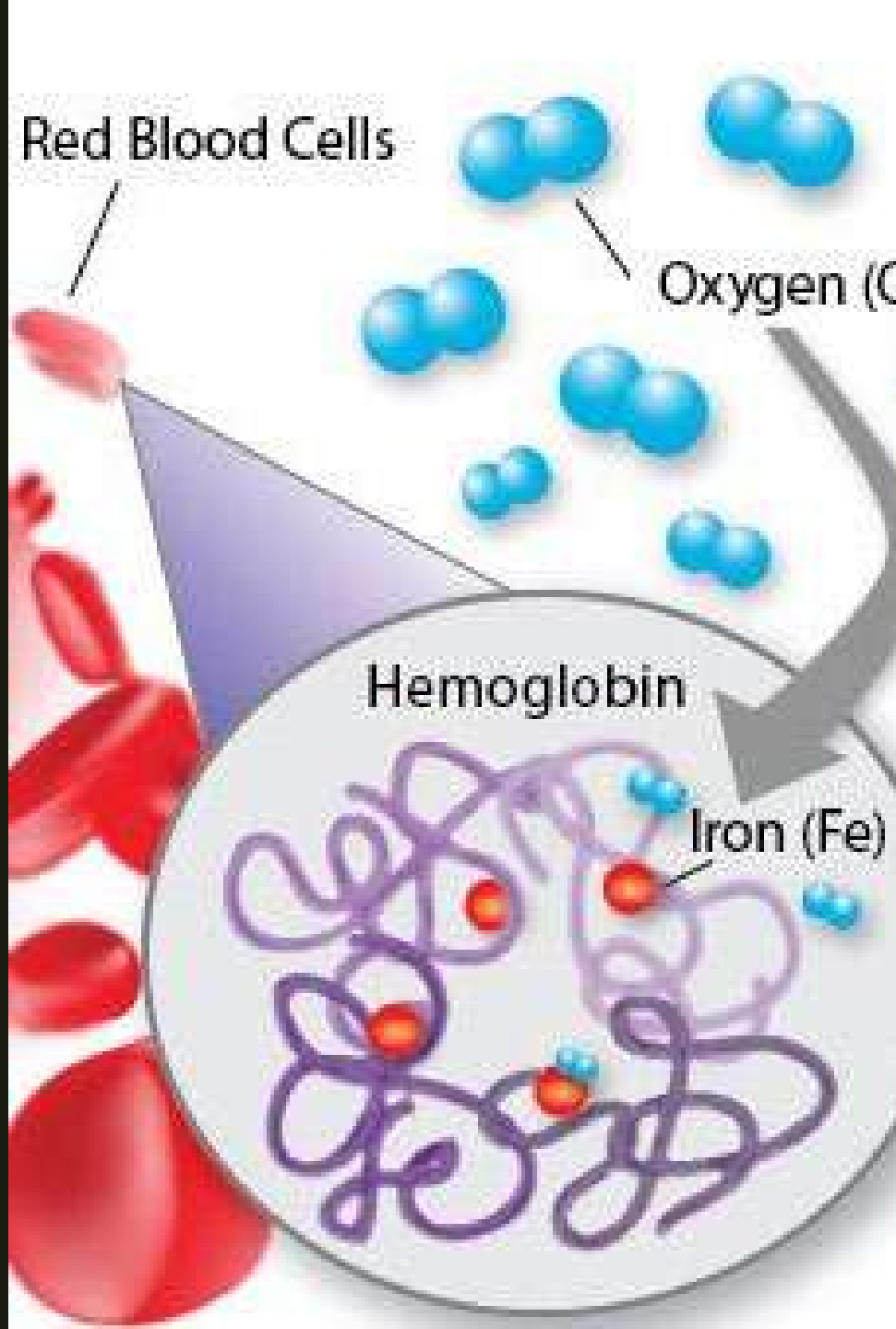


Red Blood Cells

- Red blood cells (erythrocytes), are **continuously manufactured in the red bone marrow** of the skull, ribs, vertebrae, and ends of the long bones.
  - Mature red blood cells do not have a nucleus, this shape helps them to move more easily through capillaries, as well as **increase surface area for gas diffusion.**
  - RBC's carry **oxygen because of hemoglobin.**
  - A hemoglobin molecule contains a heme group which contains the **iron complex that binds to oxygen.**

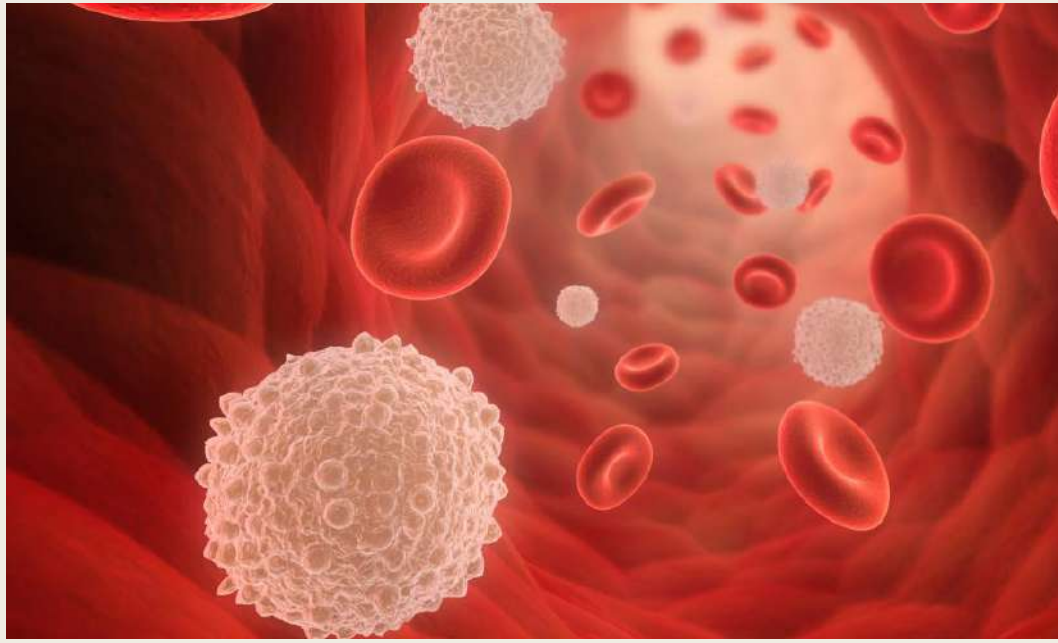


- RBC's only live for 120 days, they are **destroyed in the liver**, and the iron is mostly salvaged.
- When the body does not contain enough hemoglobin, and individual suffers from anemia. There are 3 basic causes of anemia:
  - **Decreased production of RBC's**
  - **Loss of RBC's from the body**
  - **Destruction of RBC's within the body**
- Whenever arterial blood carries a reduced amount of oxygen, the **kidneys increase their production of the hormone erythropoietin**, which speeds the maturation of RBC's.

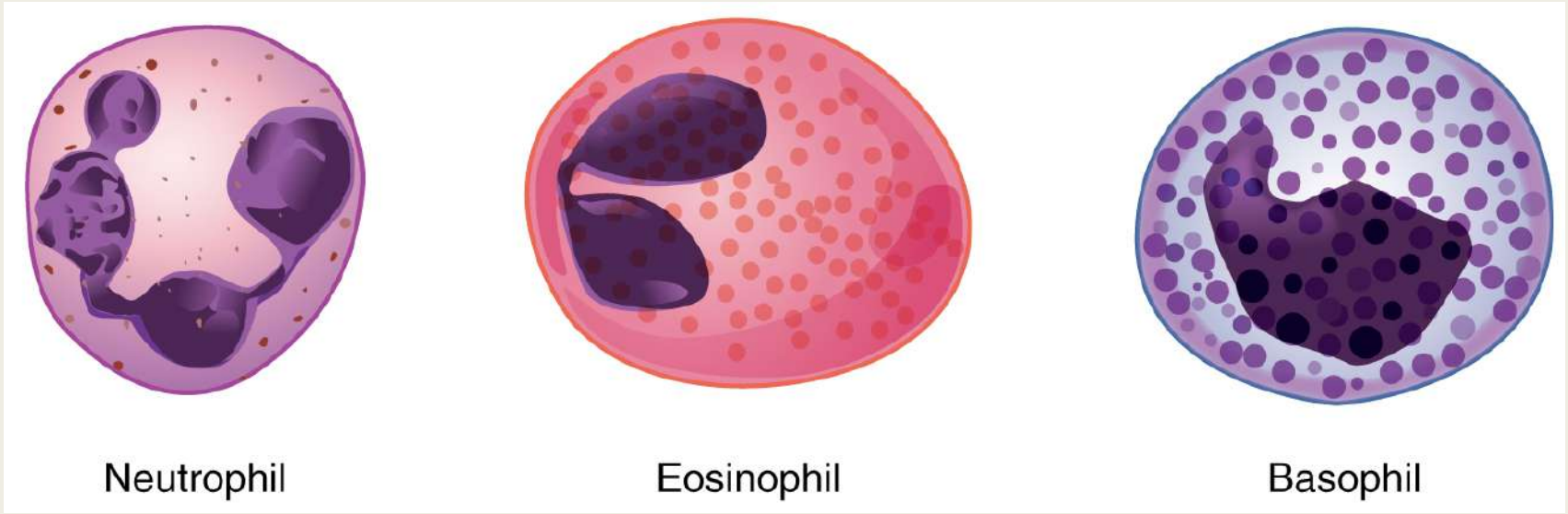


White Blood Cells

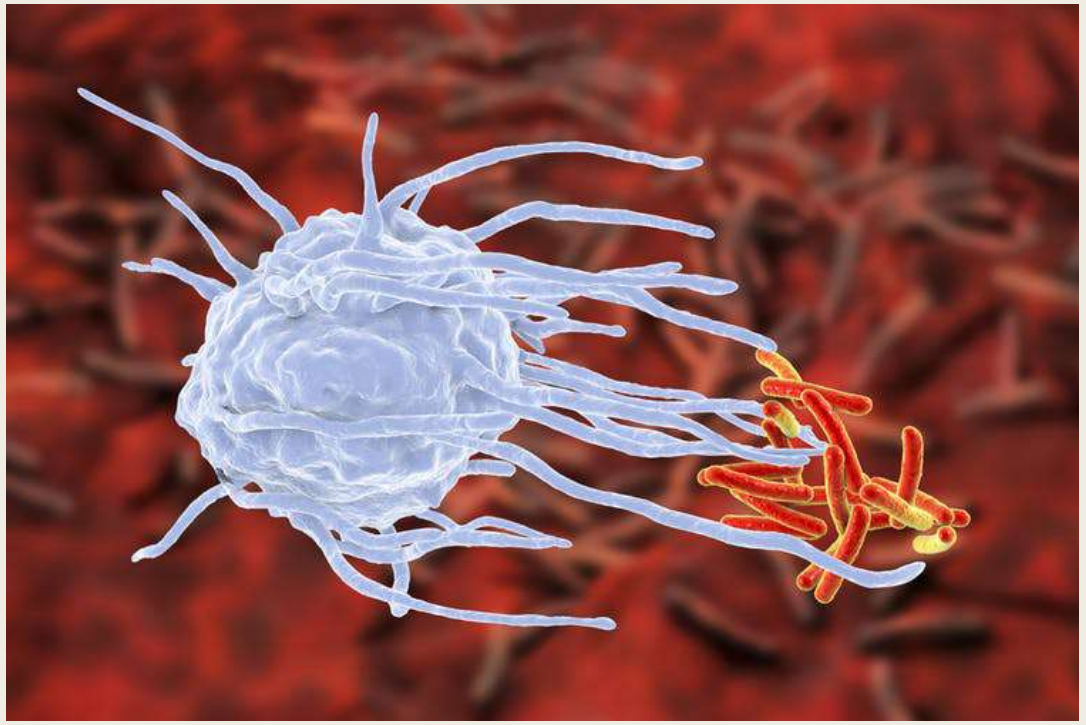
- White blood cells (leukocytes) fight infection and play a role in the **development of immunity.**
  - They are larger than RBC's and **have a nucleus.**
- Based on structure: it is possible to divide WBC's into **granular leukocytes and agranular leukocytes.**
  - Granular leukocytes (**neutrophils, basophils, and eosinophils**) are filled with **spheres that contain enzymes and proteins**, which help WBC's defend the body against microbes.



- Neutrophils are the most **abundant of the WBC's and can phagocytize and digest bacteria.**
- Basophils **release histamine**, which can cause inflammation
- Eosinophils are thought to fight parasitic worms, although they are also **involved in some allergies.**



- Agranular leukocytes (monocytes and lymphocytes) typically have a **kidney-shaped or spherical nucleus.**
  - Monocytes are the largest of the WBC, and they differentiate into **dendritic cells and macrophages.**
    - Dendritic cells are **present in tissue in contact with the environment**: skin, nose, lungs, and intestines. Once they catch a microbe, they stimulate other WBC's to defend the body.
    - Macrophages play a similar role in the **liver kidney and spleen.**



- Lymphocytes are of two major types: **B lymphocytes and T lymphocytes.**
  - B cells produced **antibodies**
  - T cells branch into another two types: helper T cells that **regulate the responses of other cells**, and cytotoxic T cells **that are able to kill other cells**

- If the number of WBC's increases or decreases beyond normal, **disease may be present.**
  - If neutrophil numbers decrease, this indicates a **bacterial infection.**
  - An HIV infected person will have a very **low number of T cells.**
  - Leukemia is characterized by **uncontrolled production of abnormal WBC's.**

Platelets and Blood Clotting

- Platelets (thrombocytes) are fragments of certain large cells called **megakaryocytes.**
  - These formed elements are involved in the process of **blood clotting or coagulation.**

Blood Clotting

- Platelets clump at the site of puncture and **partially seal the leak.**
  - Platelets then release prothrombin activator, which **converts prothrombin into thrombin**, Ca^{2+} is required for this.
  - Thrombin acts as an enzyme that **converts fibrinogen into fibrin.**
  - Fibrin threads wind around platelets and **plug the damaged area of the blood vessel**
  - A fibrin clot is temporary, as soon as the blood vessel begins to repair, an enzyme called **plasmin destroys the fibrin network.**

Blood clotting diagram

Hemophilia

- Hemophilia is a group of inherited clotting disorders caused by a **deficiency in a clotting factor.**
  - Hemophilia A accounts for 90% of clotting disorders and is primarily seen in men because the **gene is found on the X-chromosome.**
  - The slightest bump can cause **bleeding in the joints.**
  - Bleeding into muscles can lead to **nerve damage and muscle atrophy.**
  - Death can result from **bleeding into the brain.**
  - People with hemophilia require **frequent blood transfusions.**

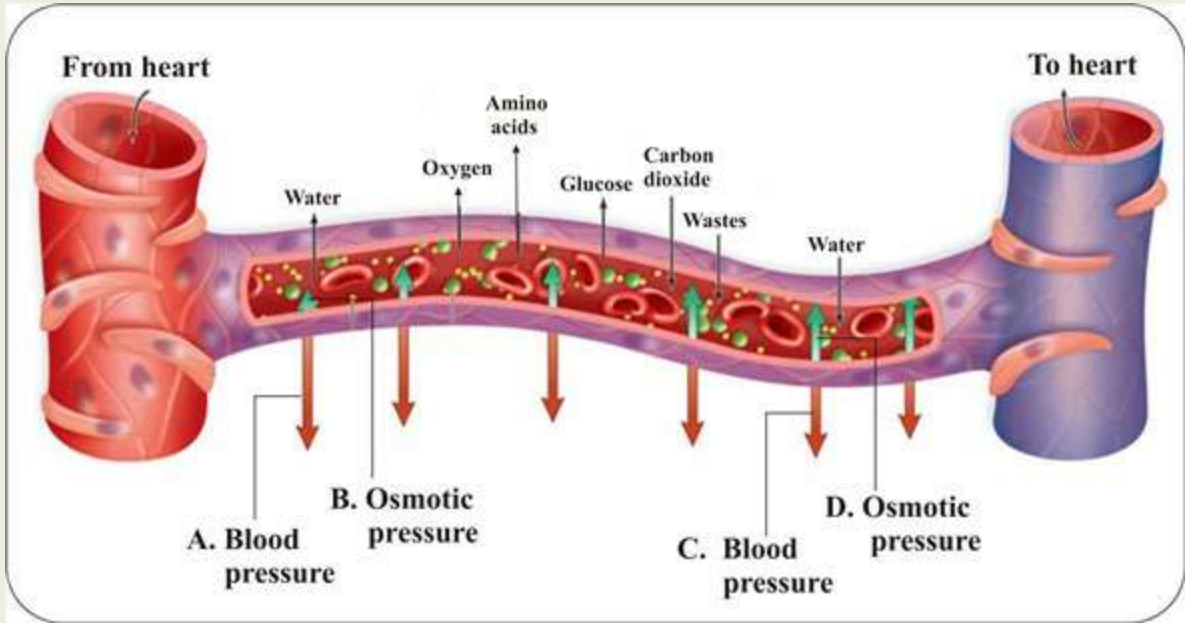
Bone Marrow Stem Cells

- A stem cell is a cell is a cell that is capable of dividing and producing new cells that go on to **differentiate into particular types of cells.**
- Bone marrow stem cells have the ability to differentiate into:
  - **Formed elements of blood**
  - **Liver cells**
  - **Bone cells**
  - **Fat**
  - **Cartilage cells**
  - **Heart cells**

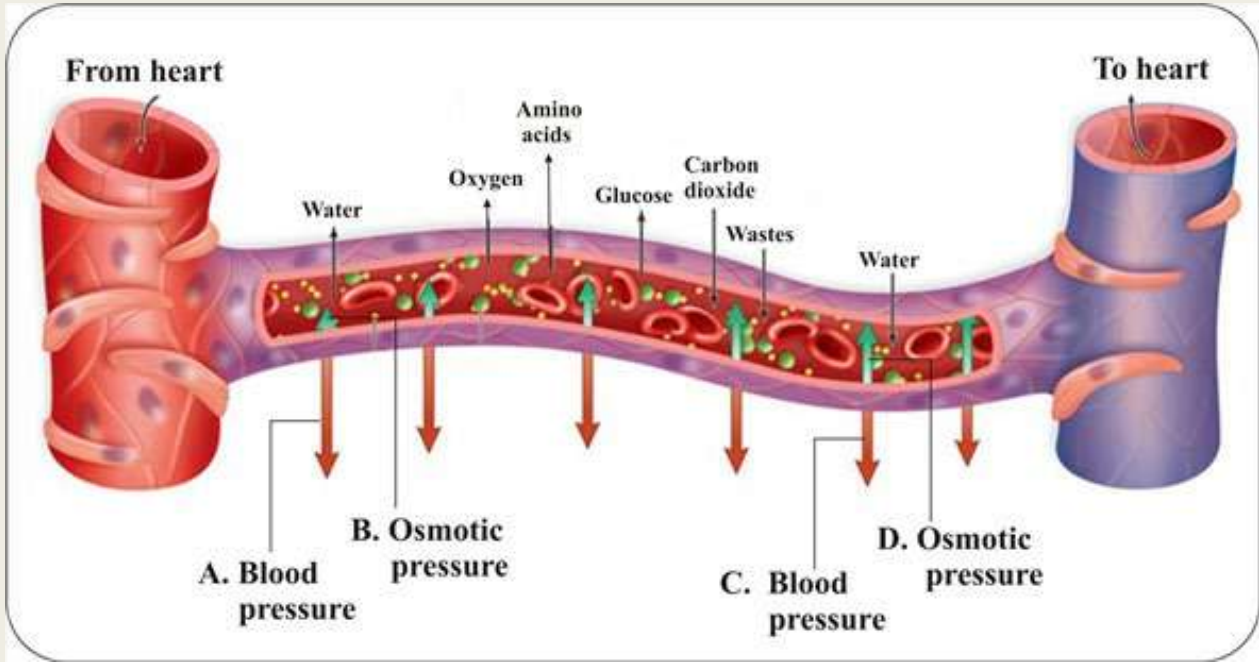
- **The use of a patients own bone marrow** could be used to treat conditions such as diabetes, heart disease and liver disease.
- The use of a persons own stem cells is ideal because they **won’t reject the transplant.**
- Some researchers also work with embryonic stem cells which can be collected from **umbilical cord blood for possible future treatments.**

Capillary Exchange

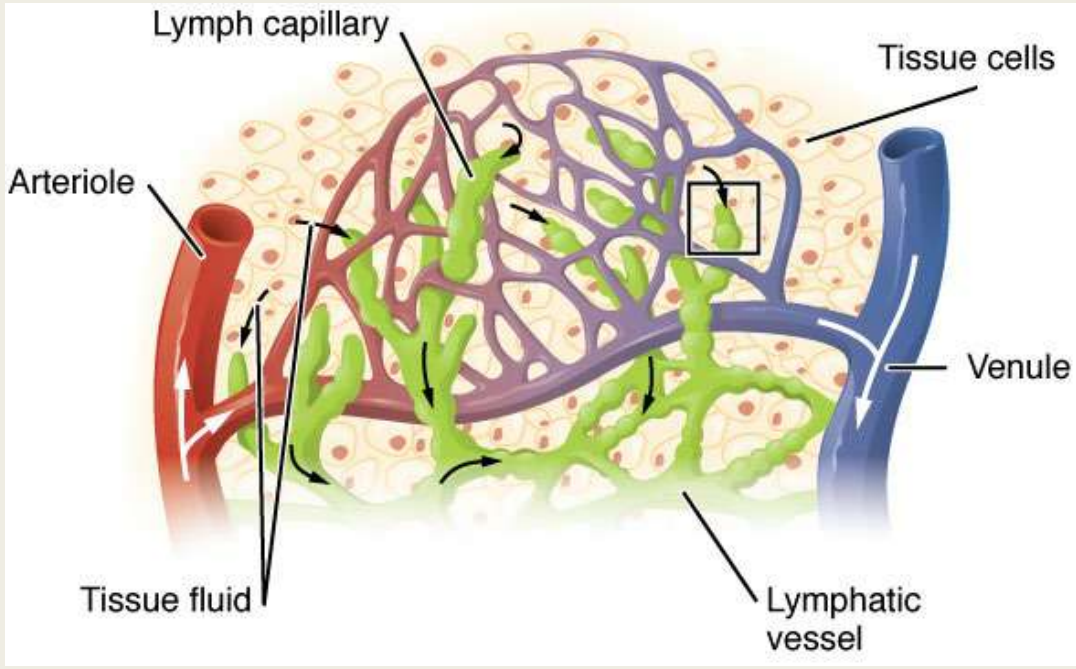
- Two forces primarily control movement of fluid through the capillary wall:
  - **Osmotic pressure, created by salts and plasma proteins.** Here waster moves from the tissue into the blood
  - **Blood pressure** tends to cause water to move in the opposite direction.



- At the arterial end of a capillary, blood pressure is higher than osmotic pressure, so **water leaves the capillary at this end.**
- Midway along the capillary, blood and osmotic pressure are essentially equal, **no net movement of H20.**
  - Solutes can diffuse **with their concentration gradient.**
  - **Nutrients and O2 diffuse out, and wastes and CO2 diffuse in.**
  - In the lungs, the movement of O2 and CO2 is reversed.

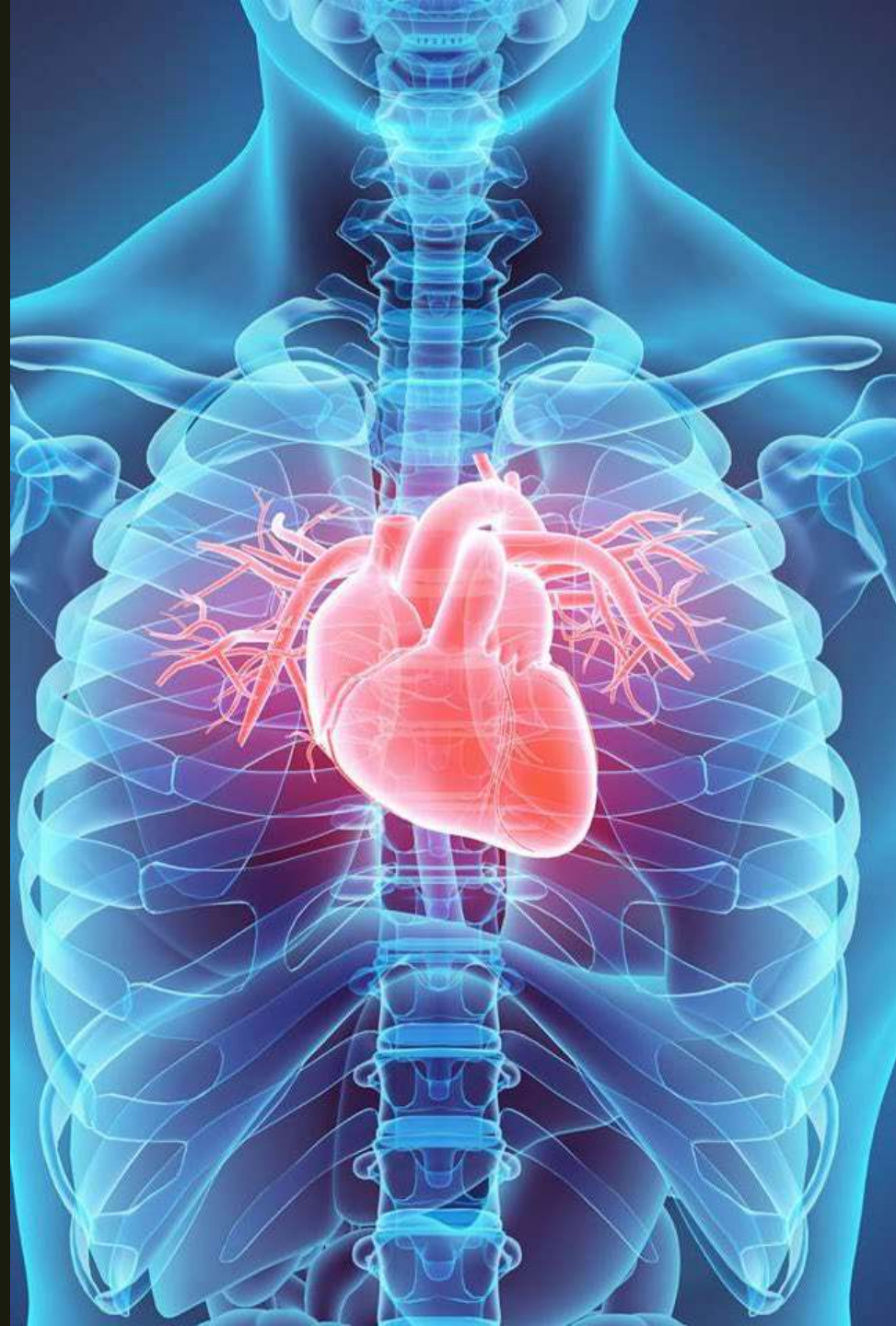


- Red blood cells and almost all plasma proteins **remain in the capillaries.**
- At the venous end of the capillary, blood pressure is less than osmotic pressure, so **H2O tends to move in.**
  - Excess fluid is collected by the **lymphatic capillaries.**
  - Tissue fluid contained within lymphatic vessels is called **lymph.**
  - Lymph is returned to venous blood when **lymphatic vessels enter the subclavian vein in the shoulder.**

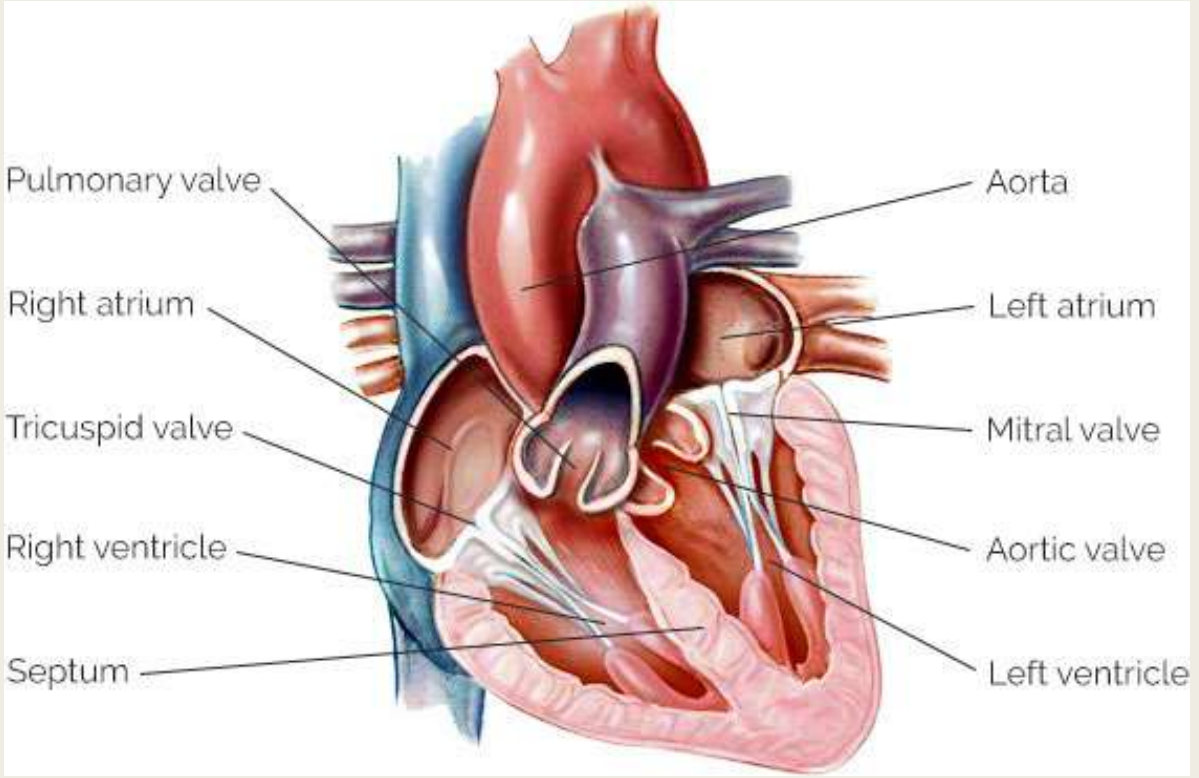


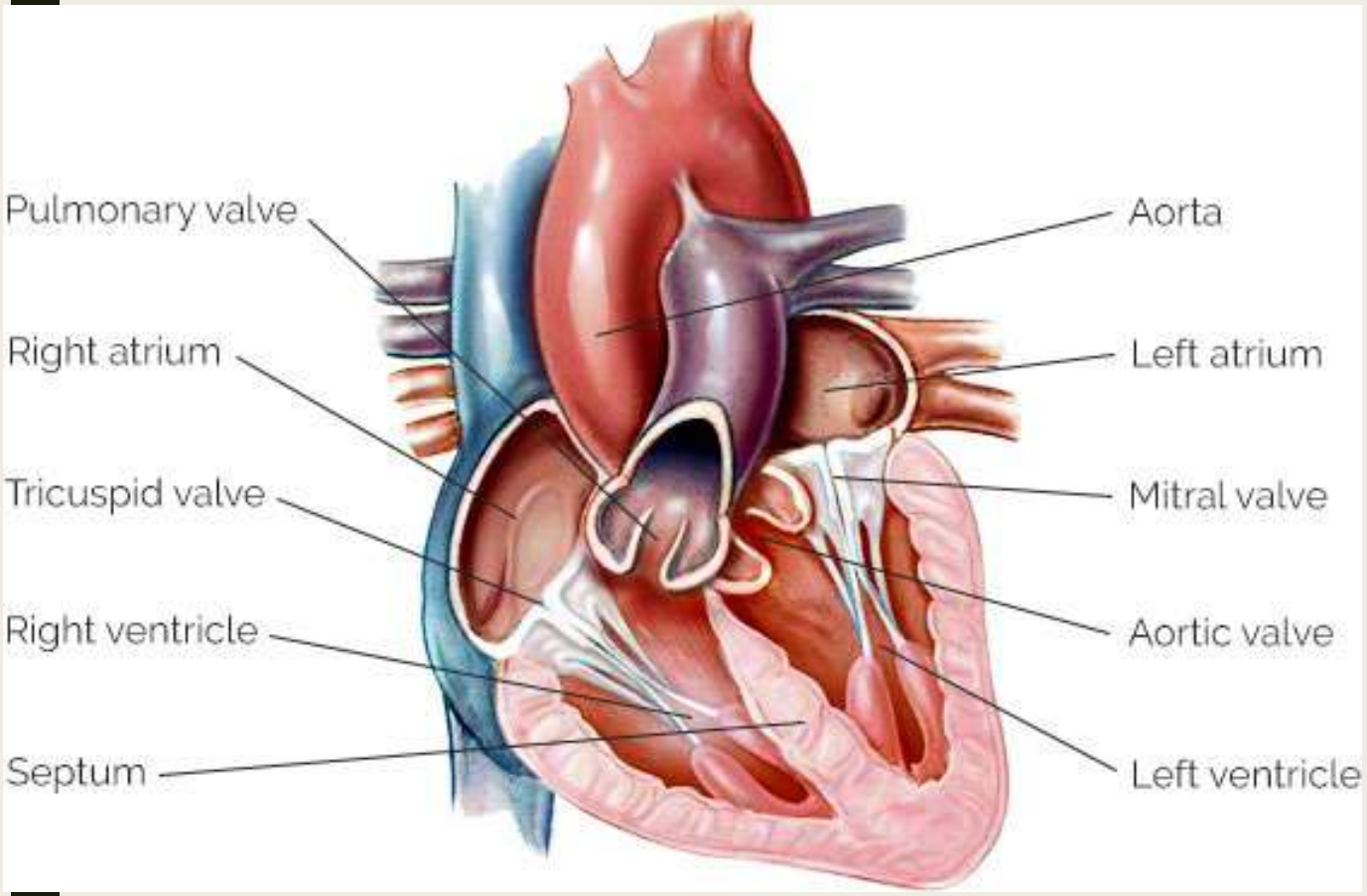
10.3 – THE HUMAN HEART

- The heart is a muscular organ about the size of a fist.
- It is located **between the lungs behind the sternum**, and is tilted so the apex it to the body's left.
  - The major portion of the heart, myocardium, **is made largely of cardiac muscle tissue.**
  - The heart lies in the pericardium, **a thick membrane that secretes small quantities of lubricating liquid.**



- Internally, the septum **separates the heart into a right side and a left side.**
- The heart has four chambers:
  - **The two upper atria sit above the two lower ventricles.**
  - **The ventricles pump the blood to the lungs and the body.**

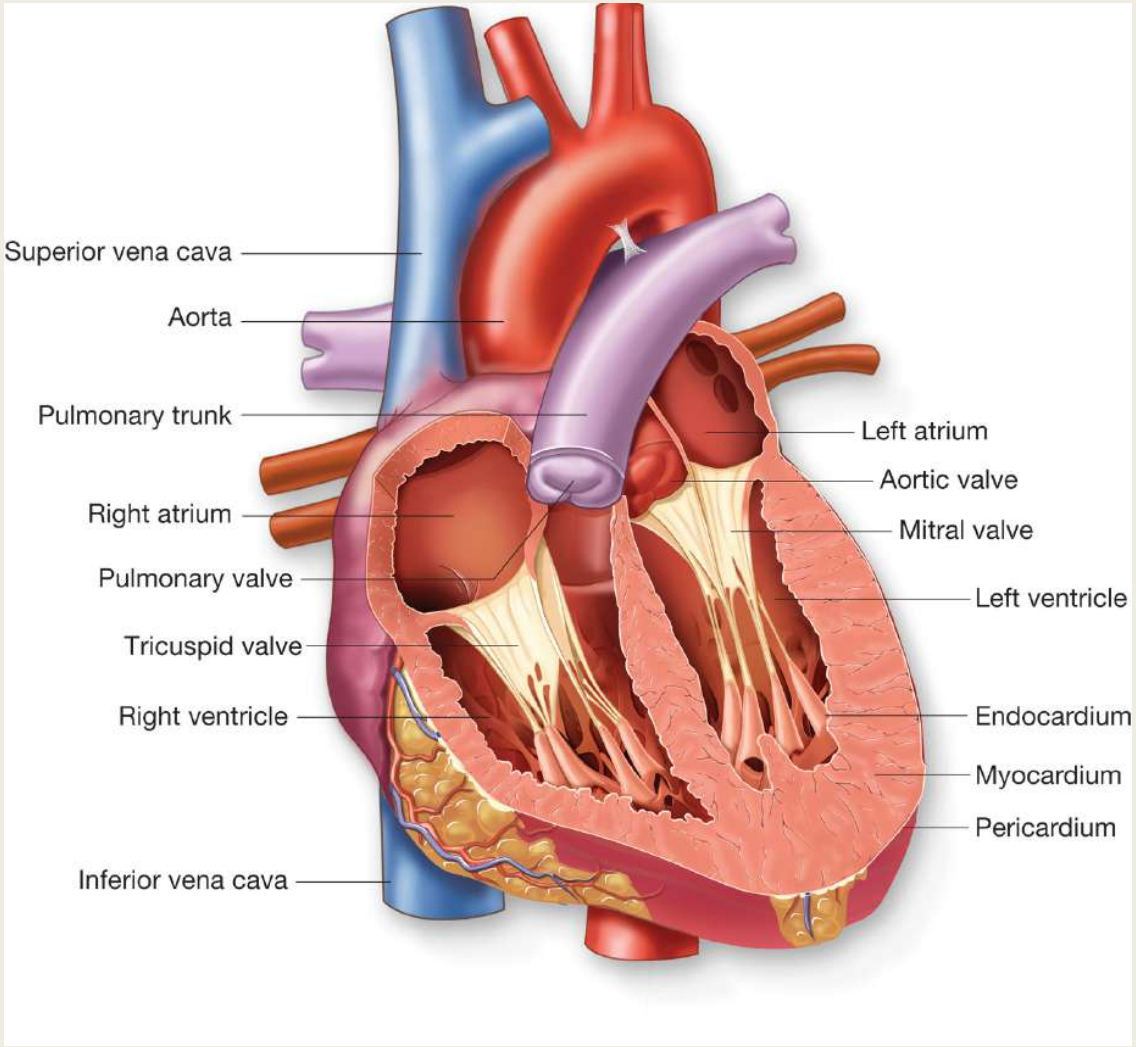


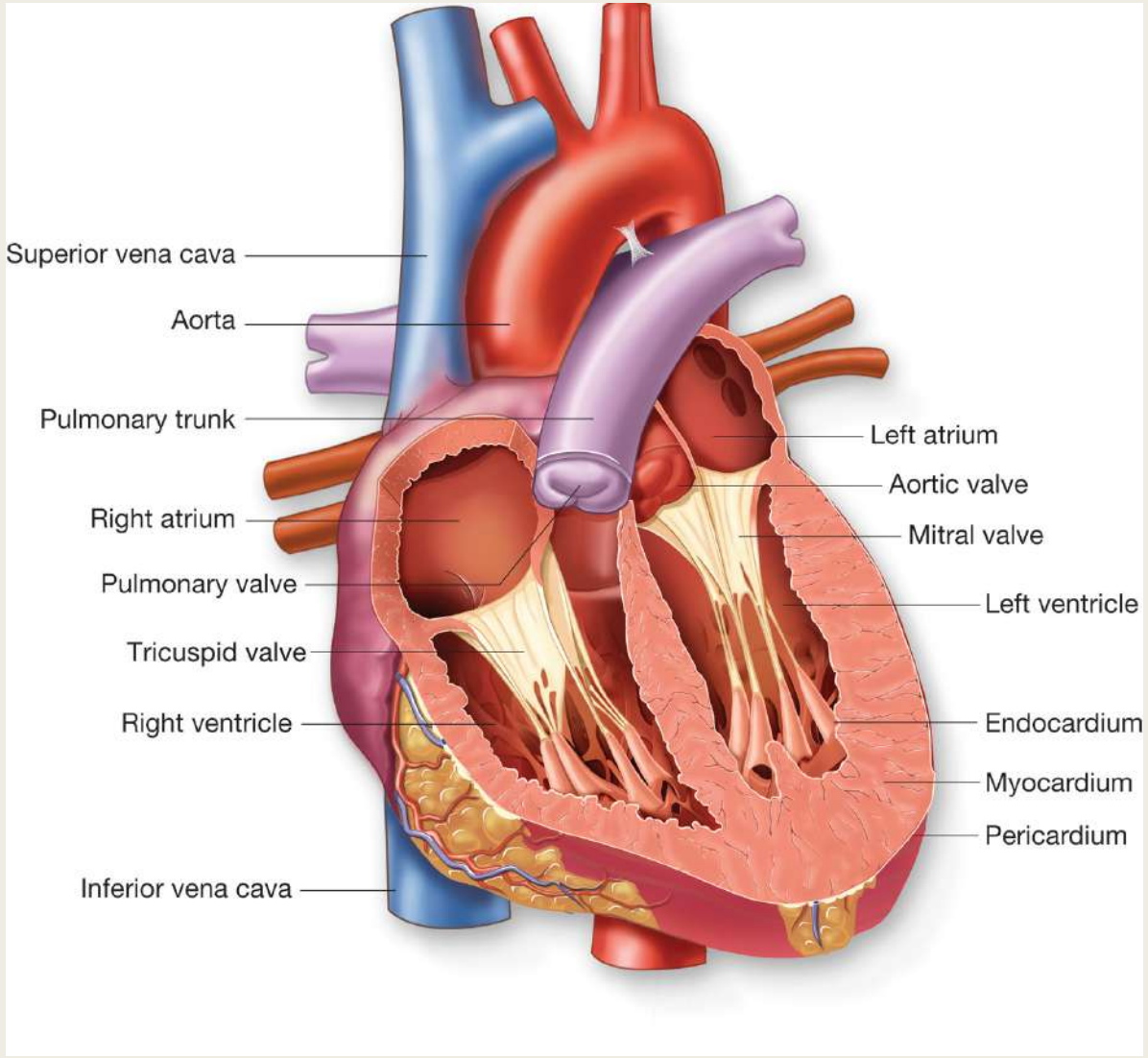


- Valves help **direct the flow of blood in the heart.**
  - Two lie between the atria and the ventricles called the **atrioventricular valves, supported by chordae tendineae.**
    - On the right is the **tricuspid valve**, on the left is the **bicuspid valve.**
  - The other two valves lie between the ventricle and their attached vessels, the **semilunar valves.**
    - There is the **pulmonary semilunar valve**, and the **aortic semilunar valve.**

Path of Blood through the Heart

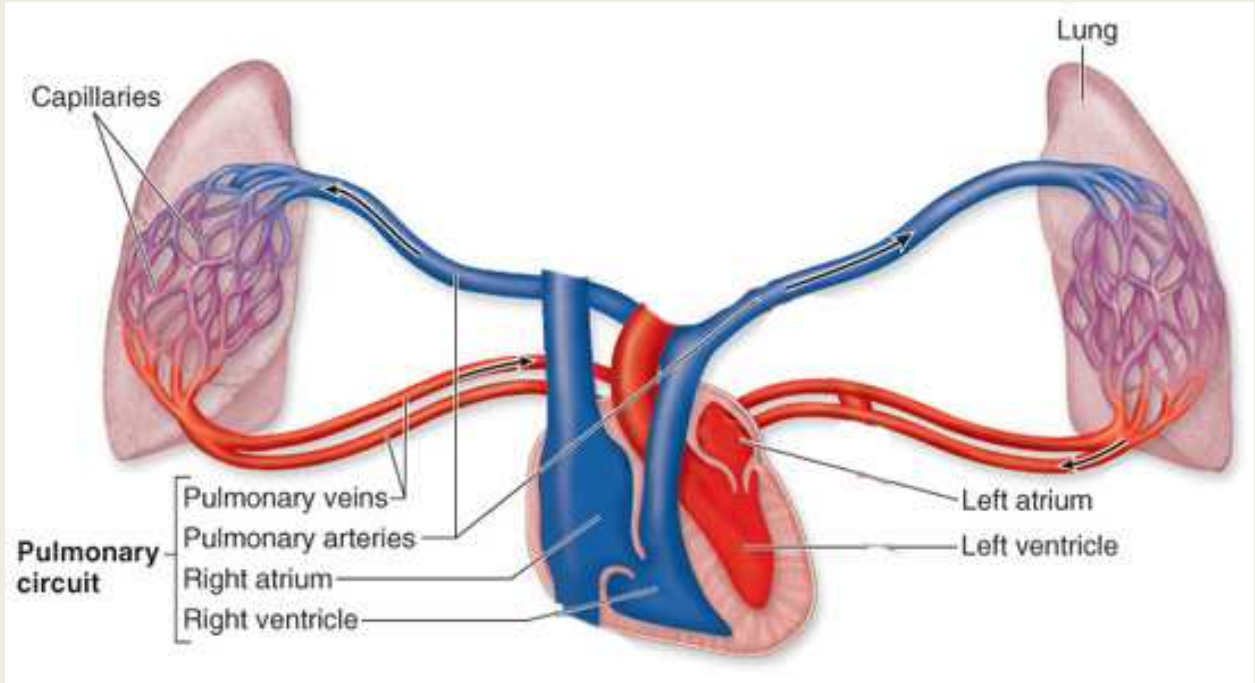
- The superior and inferior vena cava carry **O2-poor blood into the right atrium.**
- The right atrium sends blood through the **tricuspid valve to the right ventricle.**

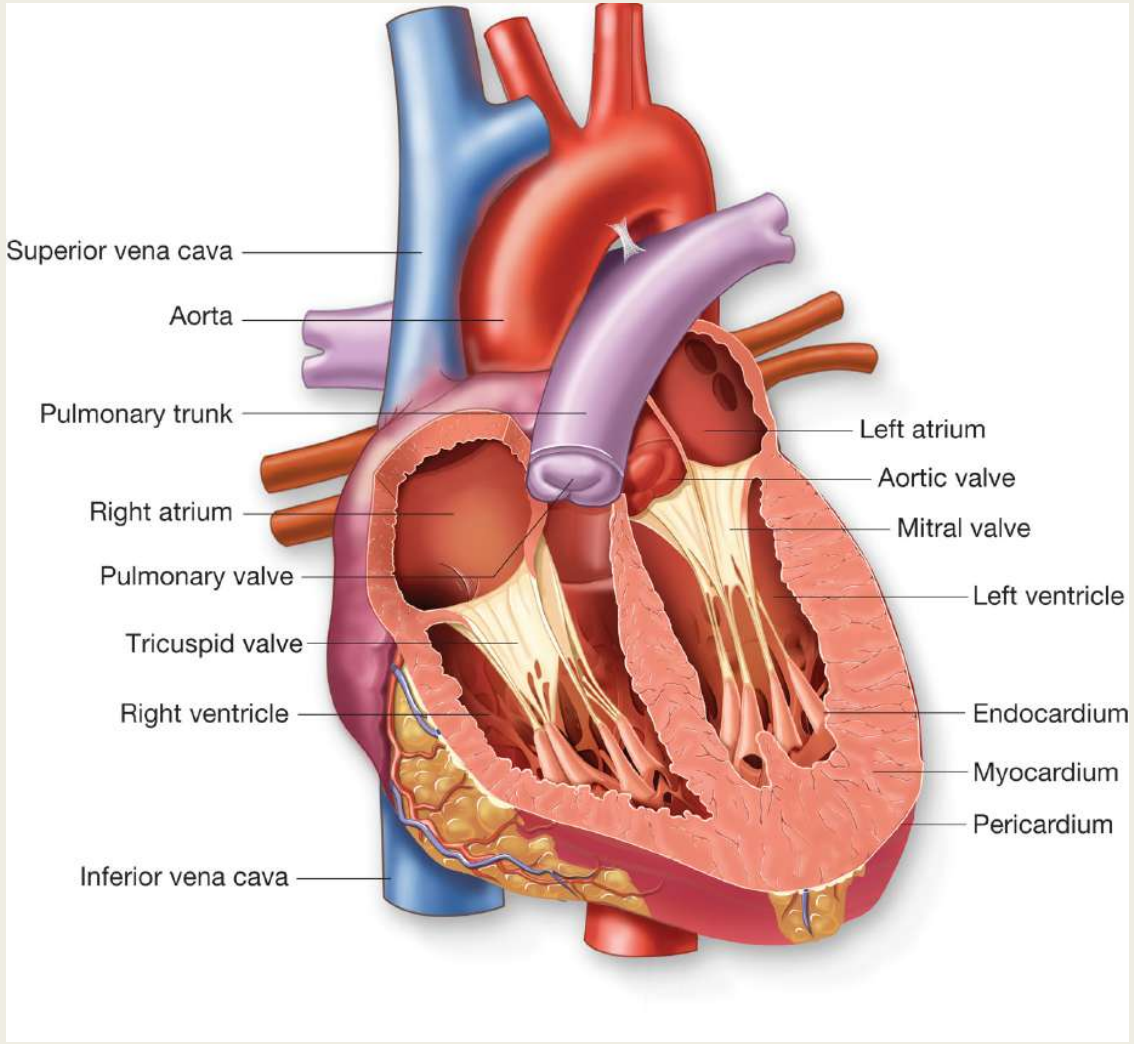




- Right ventricle sends blood through the **pulmonary SLV**, into the pulmonary trunk and through the **pulmonary arteries to the lungs.**
- Four pulmonary veins, carrying **O2 rich blood, enter the left atrium.**
- The left atrium sends blood through the **bicuspid valve to the left ventricle.**
- Left ventricle sends blood through the **aortic SLV into the aorta.**

- O2-poor blood **never mixes with O2-rich blood.**
- Blood must go through the lungs to pass from the **right to the left side of the heart.**
- The heart is a **double pump.** The right ventricle sends blood to the lungs, and the **left sends blood to the rest of the body.**
  - The left ventricle has a bigger job, **therefore its walls are much thicker than the right side.**





- The volume of blood that the left ventricle pumps per minute is called **cardiac output.**
- The pumping of the heart sends **blood out under pressure into the arteries.**
- The pulse is a wave effect that passes down the walls of the **arteries when the aorta expands and then recoils.**

The Heartbeat

- Each heartbeat is called a **cardiac cycle.**
- When the heart beats, first the **atria contract at the same time**, then the **ventricles contract at the same time**, then all the **chambers relax.**
  - Systole is the **contraction of heart muscle.**
  - Diastole is the **relaxation of heart muscle.**
- The heartbeat sounds like “lub-dub” through a stethoscope.
  - The “lub” sound comes from the **closing of the atrioventricular valves.**
  - The “dub” sound comes from the **closing of the semilunar valves.**

Intrinsic Control of Heartbeat

- The rhythmic contraction of the heart is due to the **internal conduction system made possible by nodal tissue.**
  - Nodal tissue has both **muscle and nerve characteristics**, and is located in two regions of the heart.
    - **The SA (sinoatrial) node** is in the upper back wall of the right atrium.
    - **The AV (atrioventricular) node** is located in the base of the right atrium near the septum.

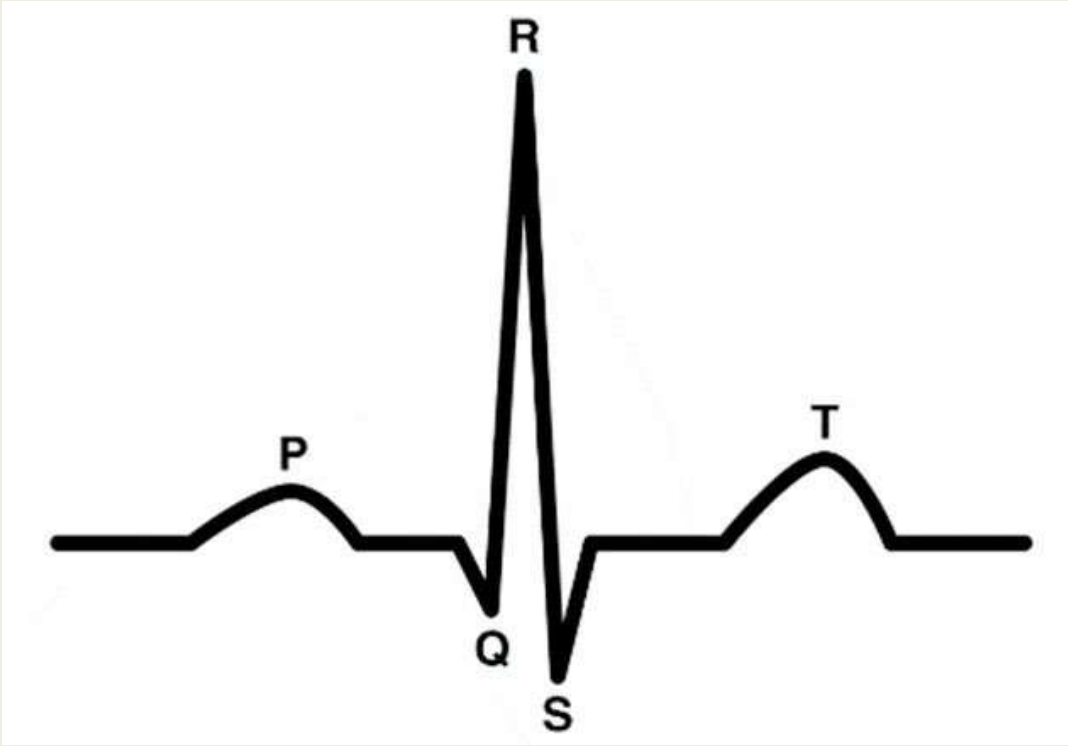
- The SA node initiates the heartbeat, and **sends an impulse to the atria and AV node.**
  - The AV node delays the impulse for a fraction of a second to ensure the **atria and ventricles do not contract at the same time.**
  - The AV node sends the impulse down the septum through the **Purkinje fibers that initiate ventricular contraction.**

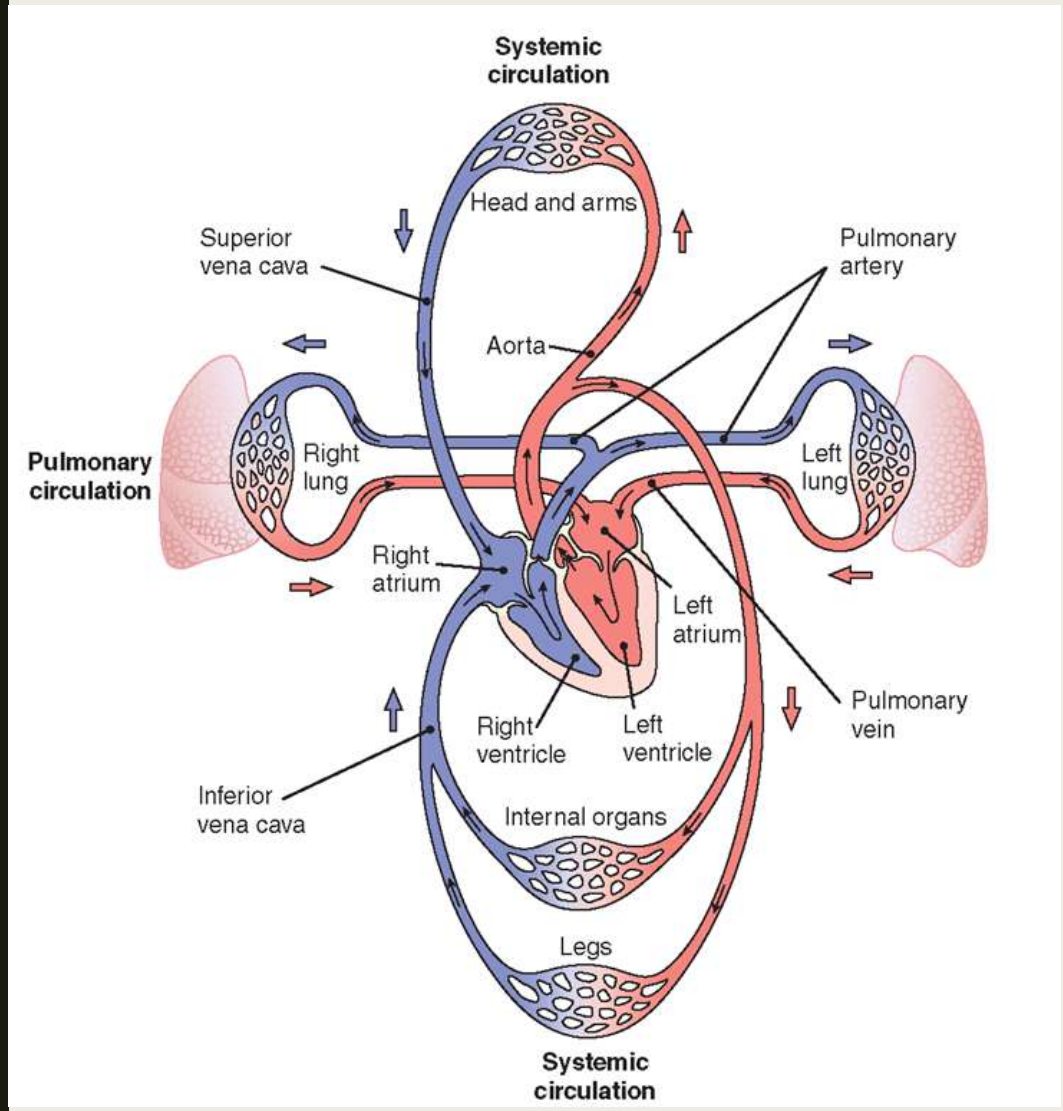
Extrinsic Control of Heartbeat

- The body has an external way to control the heartbeat in the **medulla oblongata located in the brain stem.**
- This is part of the **autonomic nervous system** that divides further into two systems:
  - The parasympathetic division which **promotes resting state.**
  - The sympathetic division which **brings responses to increased stress.**
- The hormones **epinephrine and norepinephrine also stimulate the heart.**

The Electrocardiogram

- An electrocardiogram (ECG) is a recording of the **electric changes that occur in the myocardium during a cardiac cycle.**
- When the SA node triggers an impulse:
  - Atrial fibers produce the P wave – **indicating the atria are about to contract.**
  - The QRS complex signals that **ventricles are about to contract.**
  - The T wave indicates that the **ventricular muscle fibers are contracting.**



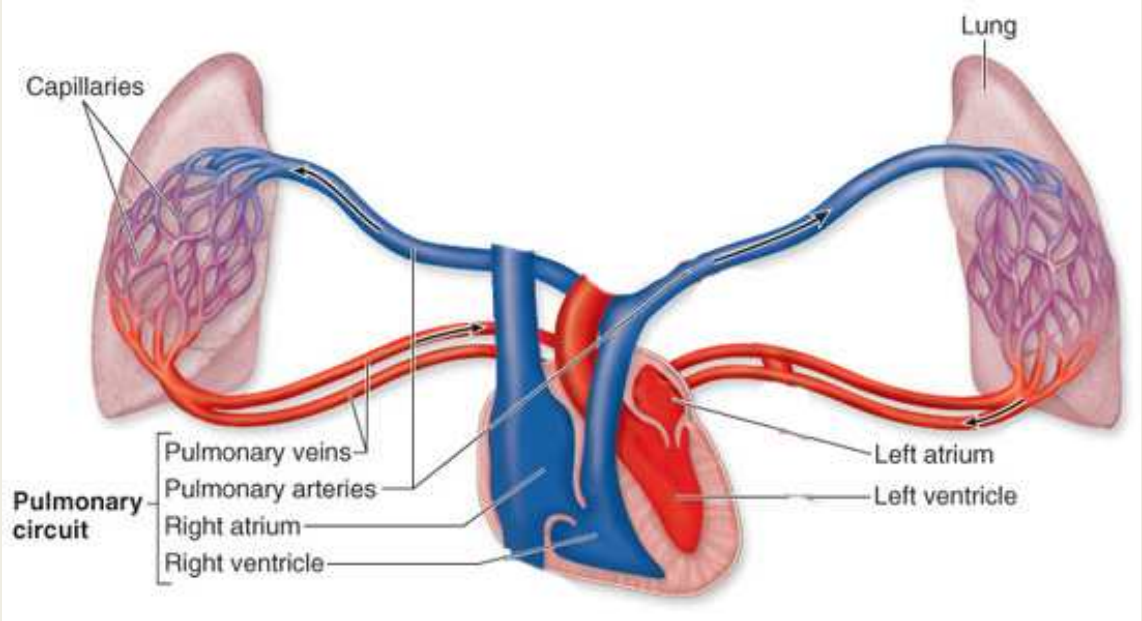


6.4 – THE VASCULAR PATHWAYS

- The circulatory system has two circuits:
  - The pulmonary circuit – **circulates blood through the lungs.**
  - The systemic circuit – **circulates blood through the body tissues.**

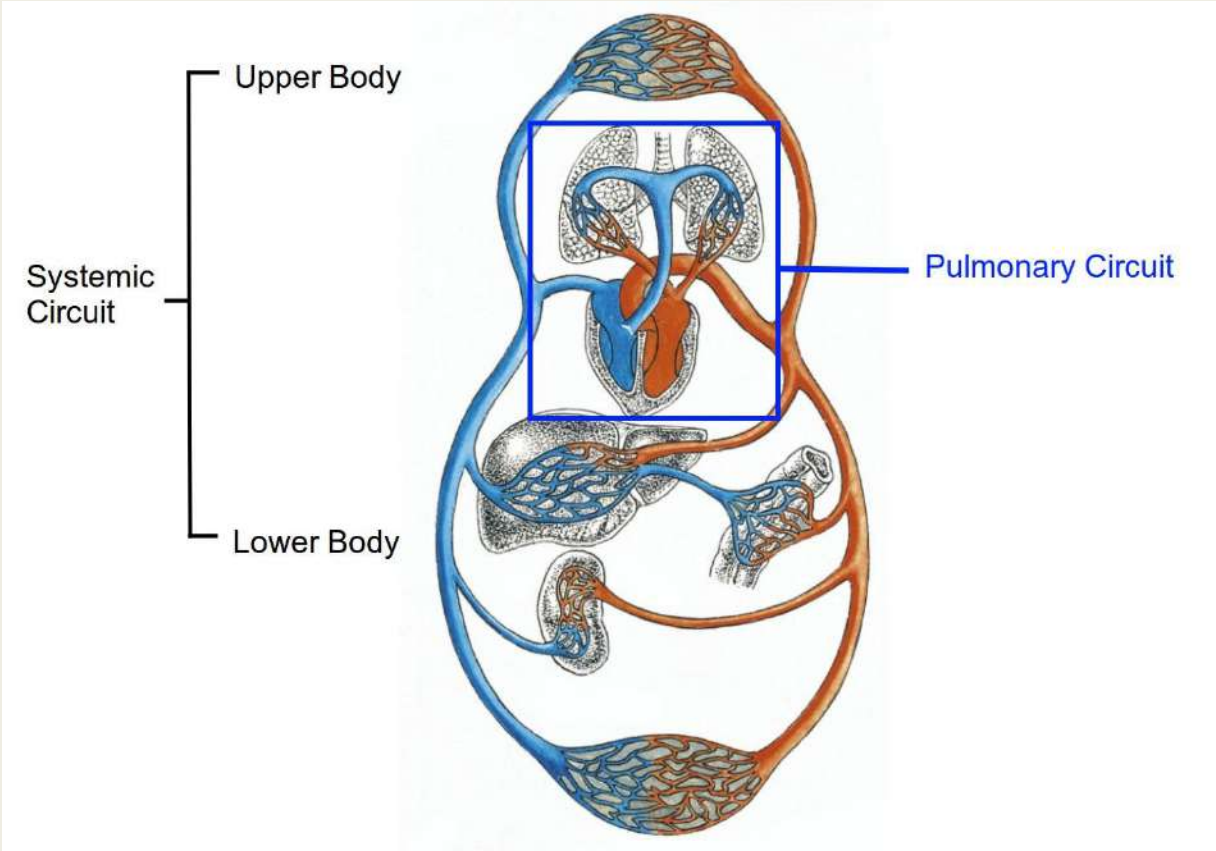
The Pulmonary Circuit

- Blood from the body collects in the **right atrium before entering the right ventricle.**
  - The right ventricle pumps de-O2 blood **into the pulmonary trunk before dividing into our lungs.**
  - Once O2 and CO2 have been exchanged at the pulmonary capillaries, **blood passes into the four pulmonary veins that enter the left atrium.**

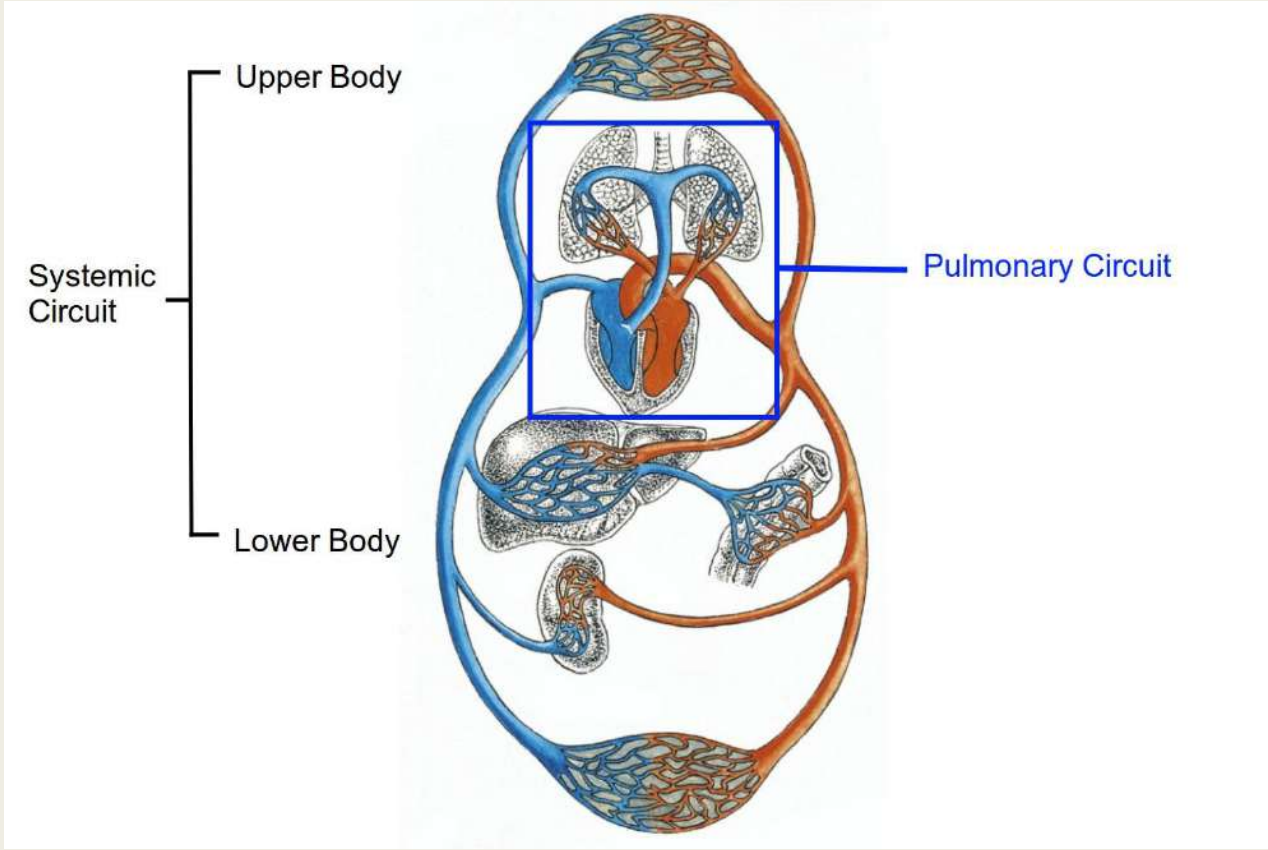


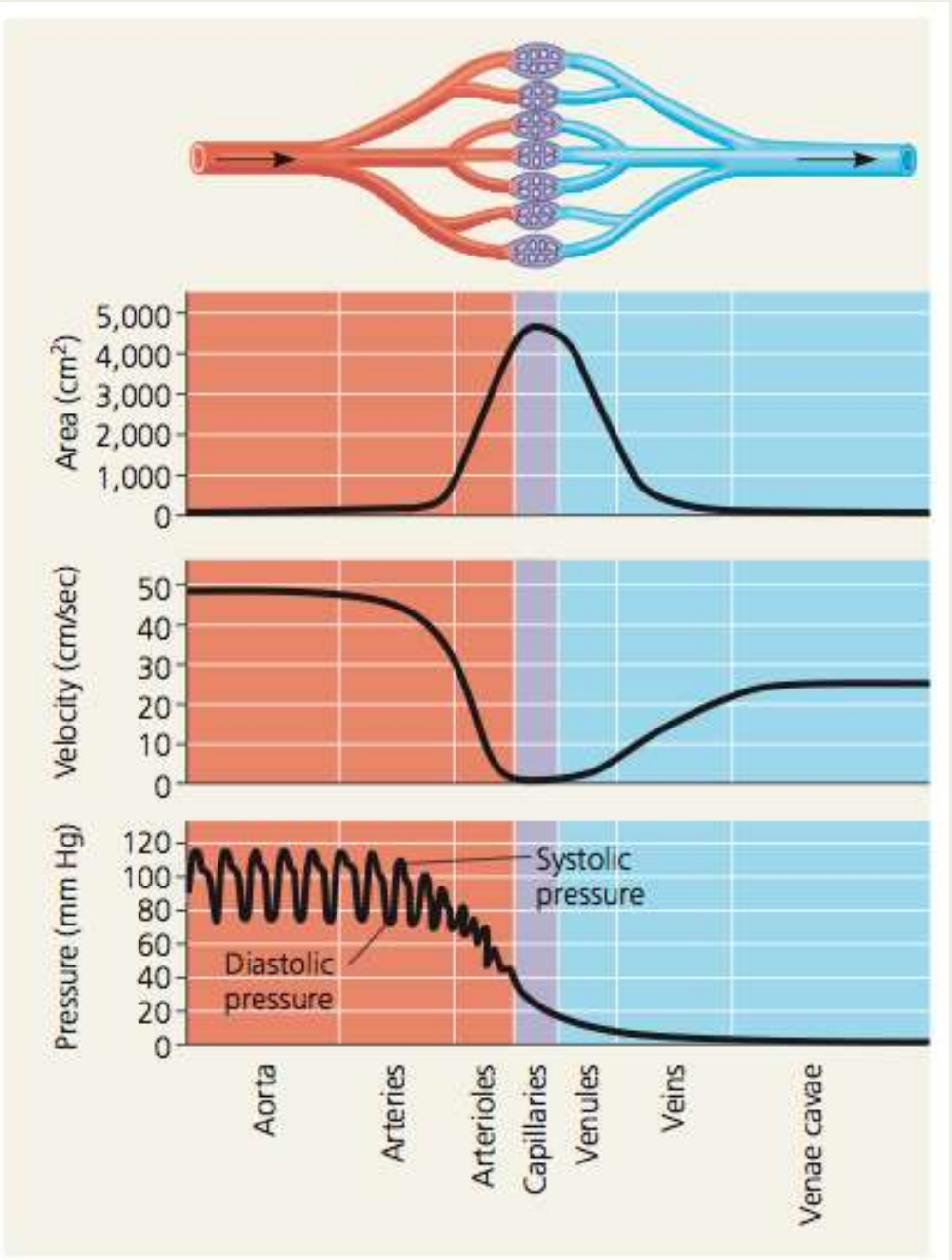
The Systemic Circuit

- The path of systemic blood **to any organ in the body begins in the left ventricle.**
- In most instances, the artery and the vein **that serve the same region are given the same name.**



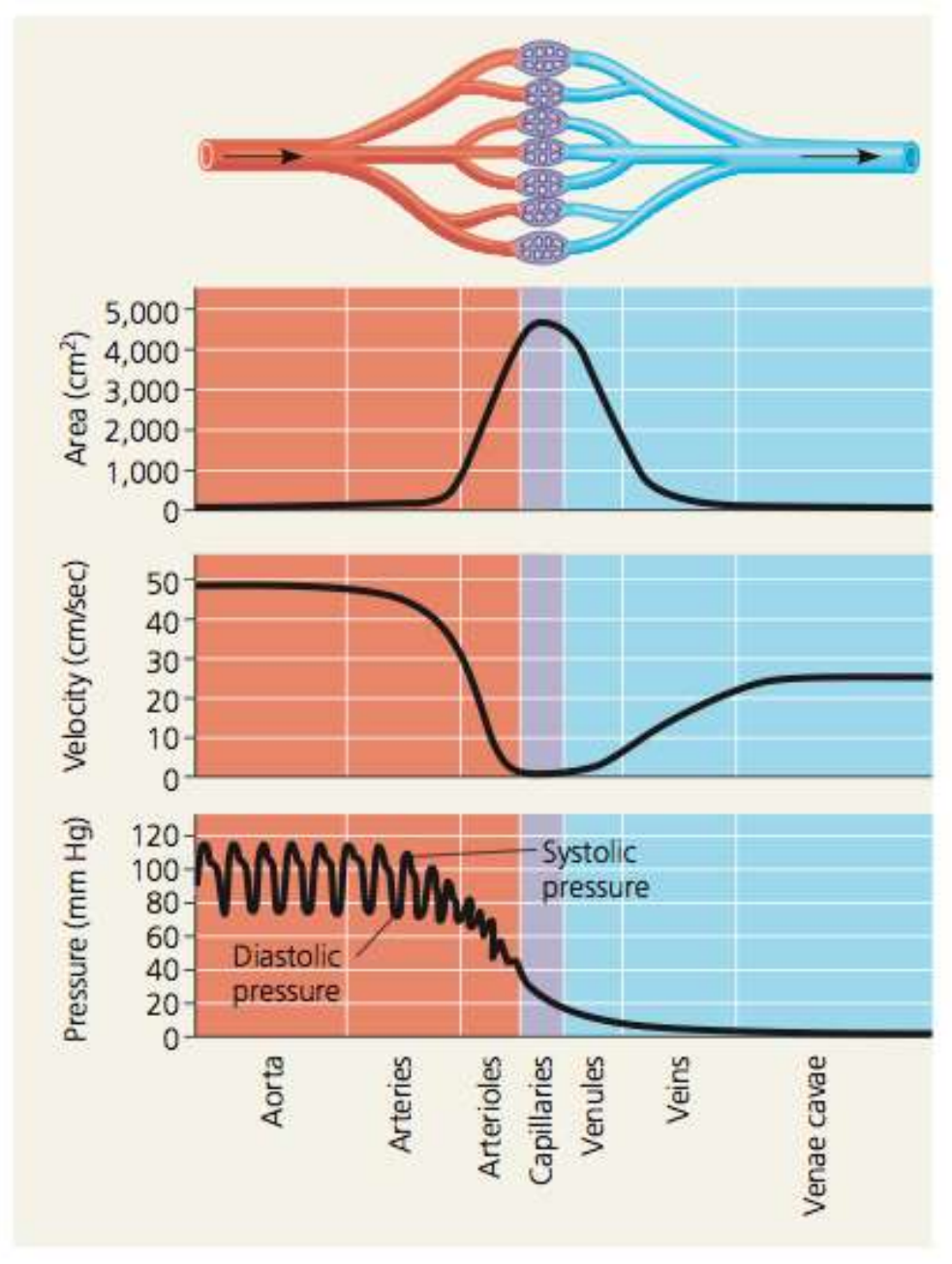
- A portal system in blood circulation **begins and ends in capillaries.**
  - **The hepatic portal system** is associated with the liver.
    - Capillaries in the villi of the small intestine, **pass into venules that join to form the hepatic portal vein.**
    - This vein carries the blood **to a set of capillaries in the liver.**
    - The hepatic vein leaves the liver and **enters the inferior vena cava.**



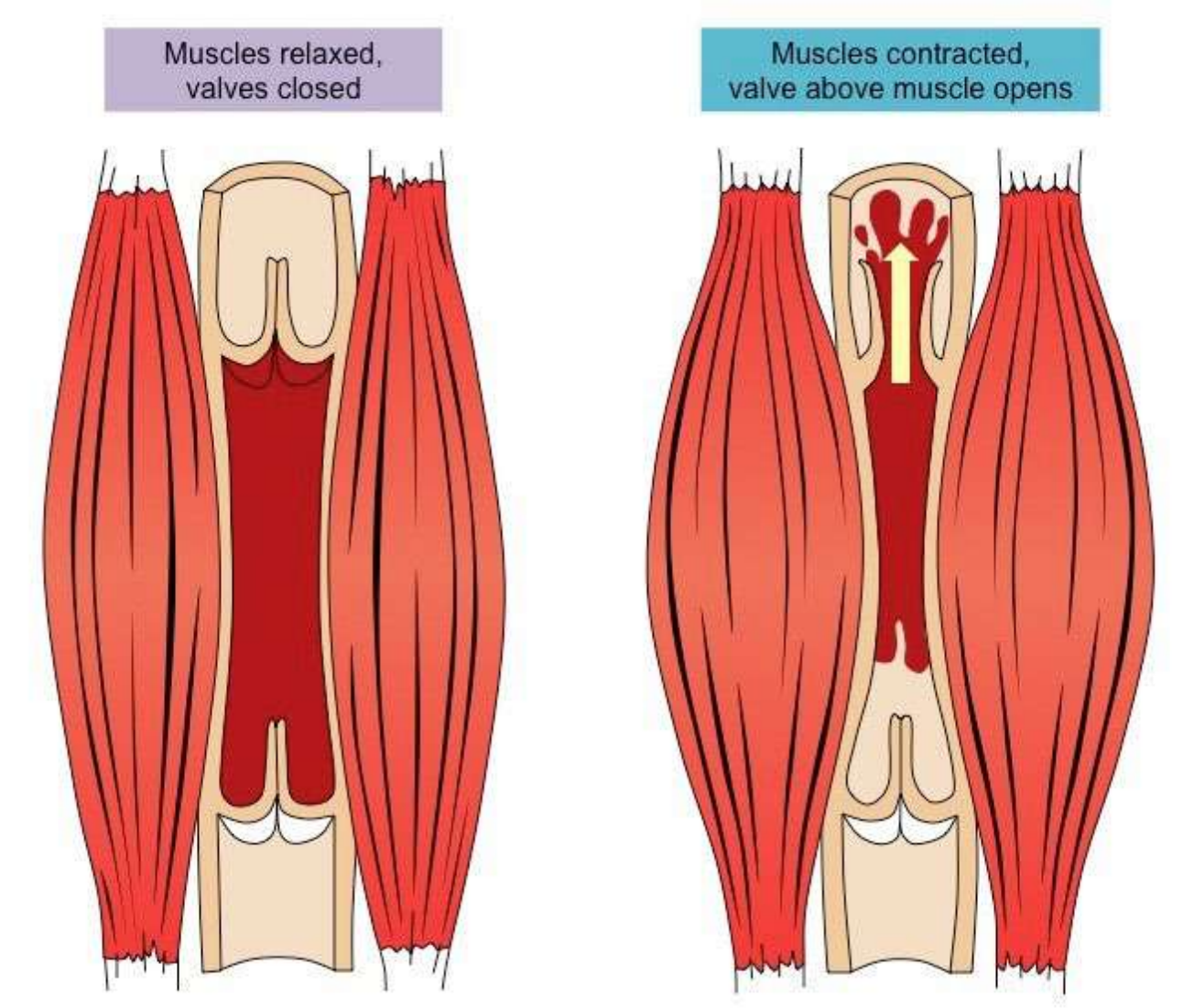


Blood Pressure

- Systolic pressure results from blood being **forced into the arteries during ventricular systole.**
- Diastolic pressure is the pressure in the **arteries during ventricular diastole.**
- As blood flows from the aorta into the arteries and arterioles, **blood pressure falls.**
  - In the capillaries blood flow **is slow and fairly even.**

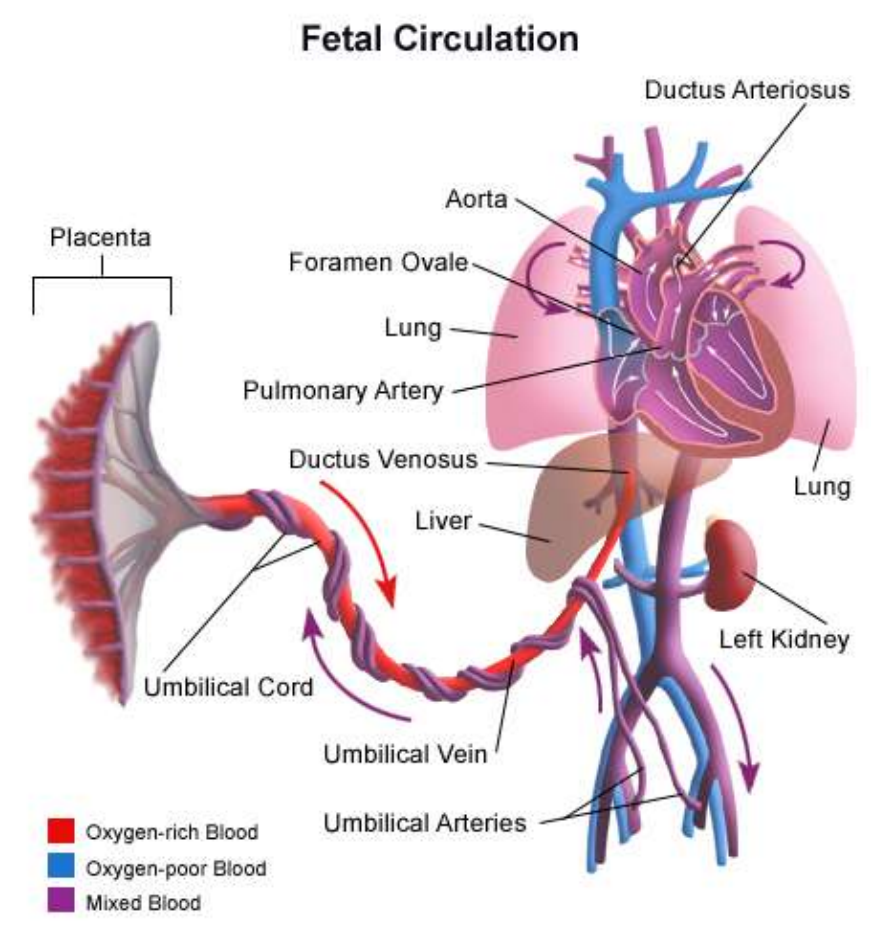


- Blood pressure can be measured with a **sphygmomanometer** (a pressure cuff), that determines the **amount of pressure required to stop the flow of blood through an artery.**
  - Blood pressure is expressed in mm of Hg.
  - Blood pressure consists of two numbers that **represent systolic and diastolic pressures.**
    - A typical adult blood pressure is **120/80 mm Hg.**

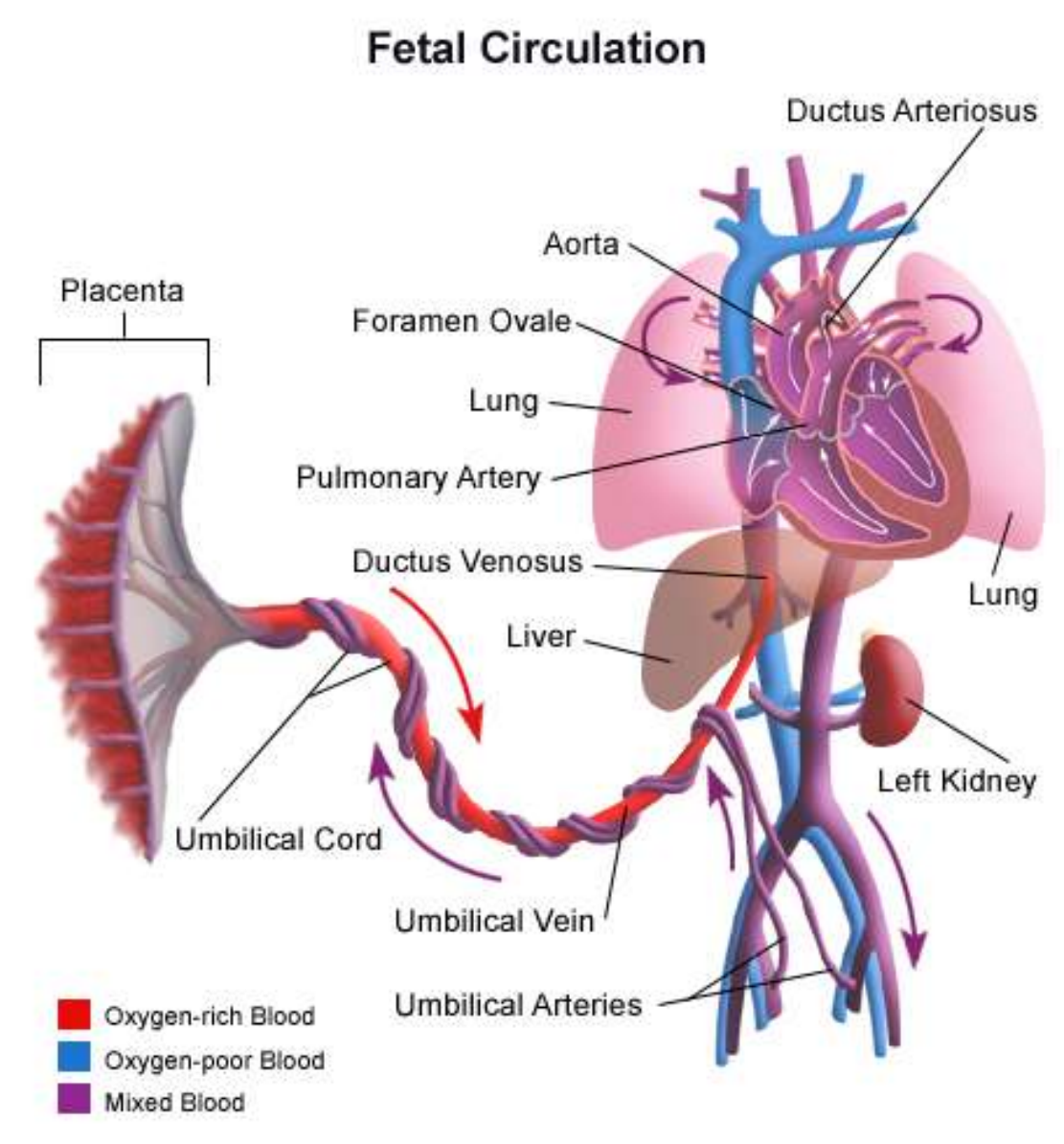


- Blood pressure in the veins is low, and **cannot efficiently move blood back to the heart by itself.**
  - When skeletal muscles near veins contract, **they put pressure on the veins and the blood they contain.**
  - Valves in the veins prevent backflow of blood, therefore **muscle contraction is sufficient to move blood toward the heart.**

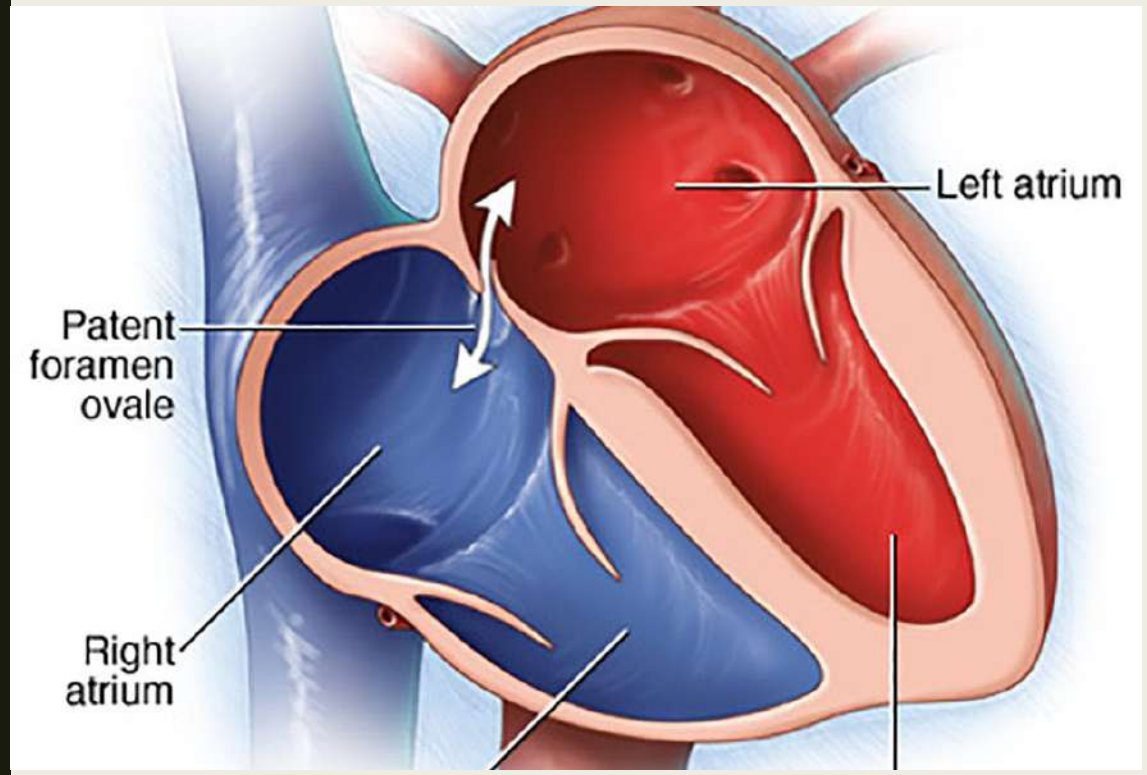
10.5 – FETAL CIRCULATION



- The fetus has circulatory features that are **not present in the adult circulation.**
  - These are necessary because the **fetus cannot use it's lungs for gas exchange.**
- Features in the heart include:
  - **Foramen ovale** – an opening between the two atriums so the blood entering the right atrium can be shunted to the left, **bypassing the lungs.**
  - **Ductus arteriosus** – a vessel that shunts blood that enters the right ventricle from the **pulmonary trunk into the aorta.**

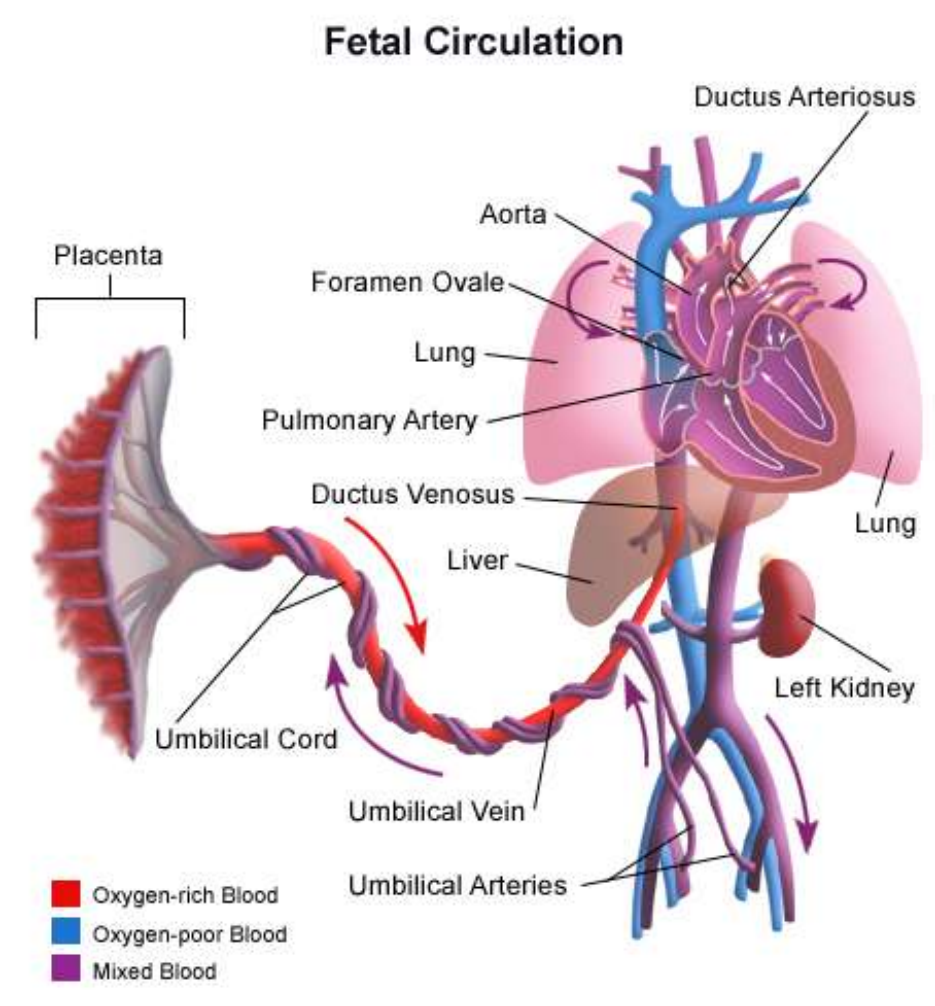


- Other features include:
  - **Umbilical arteries that lead to the placenta.**
  - The placenta facilitates exchange of gases and nutrients **between maternal blood and fetal blood.**
  - Umbilical veins carry blood rich in **nutrients and O2 to the fetus.**
    - The umbilical vein enters the liver, and then joins the ductus venosus, **which merges with the inferior vena cava.**



- The most common cause of cardiac defects in a newborn is the **persistence of the foramen ovale.**
  - When a baby takes their first breath, blood enters the lungs, the return of this blood to the **left side of the heart usually causes a flap to cover the opening.**
  - In a small number of cases, this passageway does not close resulting **in a blue baby.**
    - This can be corrected by **threading a catheter into the heart, sealing the defect.**

Structure & Function of the Placenta



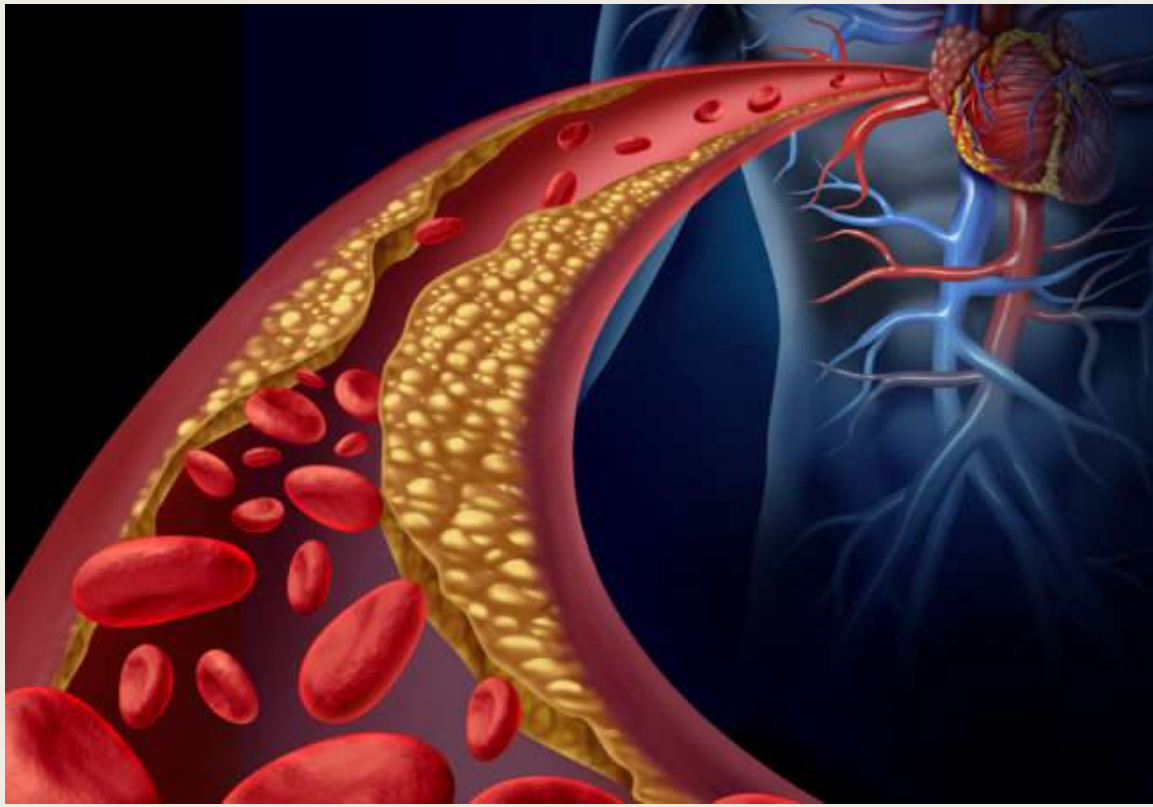
- Humans belong to the group of mammals called **placental mammals.**
  - **It functions in gas, nutrient, and waste exchange** between mother and baby.
  - The umbilical cord **stretches between placenta and fetus.**
  - The umbilical cord is the **lifeline of the fetus.**

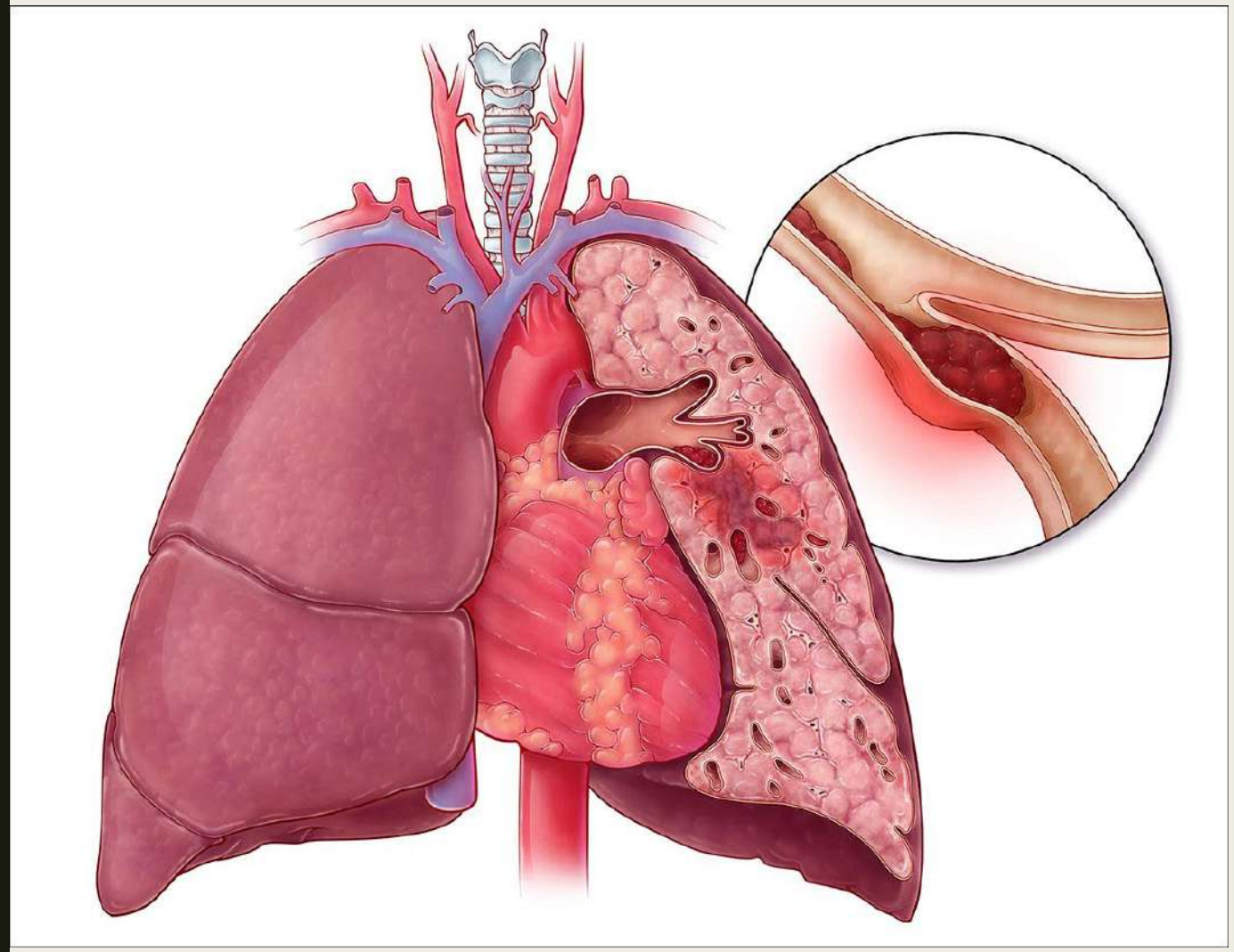
10.8 – CIRCULATORY SYSTEM DISORDERS

- Cardiovascular diseases are the leading cause of **untimely death in western countries.**
- Research efforts have resulted in **improved diagnosis, treatment, and prevention.**

Atherosclerosis

- Atherosclerosis is an accumulation of soft masses of fatty materials, **particularly cholesterol, beneath the inner linings of arteries.**
  - Such deposits are called **plaques.**
  - Plaque can cause **platelets to adhere to the irregular arterial wall, forming a clot.**





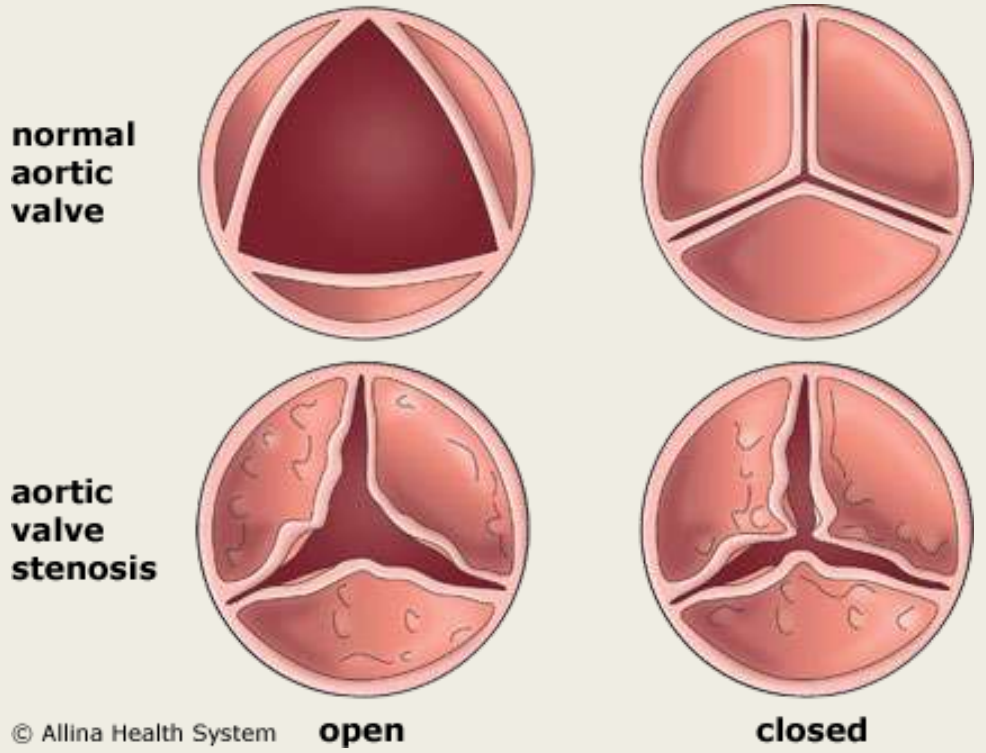
- When the clot is stationary it is called a thrombus, **but if it dislodges it becomes an embolus.**
- Thromboembolism, is a clot that is carried in the blood stream, **then blocks blood flowing through a blood vessel.**

Hypertension

- Normal blood pressure values vary among **different age groups, body sizes, and levels of athletic conditioning.**
  - Approximately 1 in 5 Canadian adults have hypertension, which is high blood pressure.
  - Hypertension often occurs **secondary to atherosclerosis.**
  - Forcing blood through narrowing arteries over time creates **additional pressure on the circulatory system.**
  - This condition can lead to a **heart attack or stroke.**

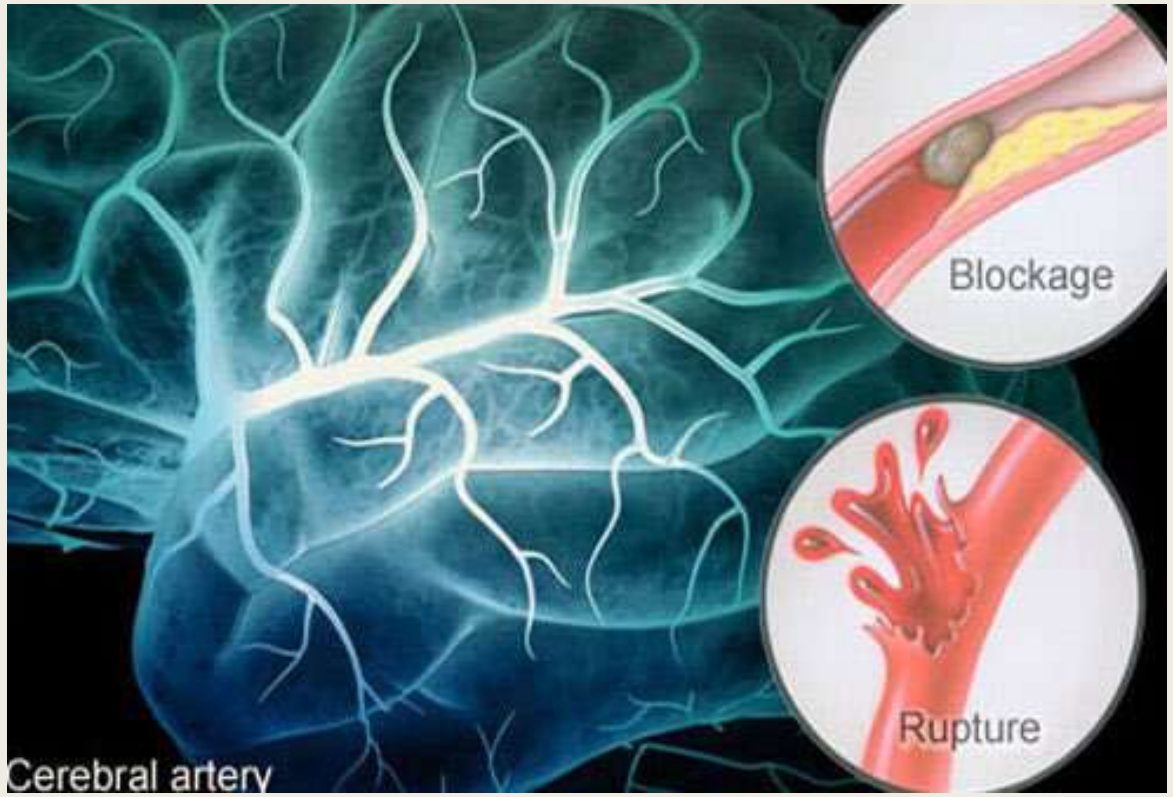
Heart Valve Disease

- Heart valve disorders can range from **mild to severe.**
- In some cases, heart valves are malformed at birth, but more commonly they **degenerate due to age or infection.**
  - A narrowing of the aortic valve is the most common followed by a **bicuspid valve prolapse.**
  - Sometimes the valves can be repaired, more commonly though they are **replaced using artificial valves or valves from a pig.**

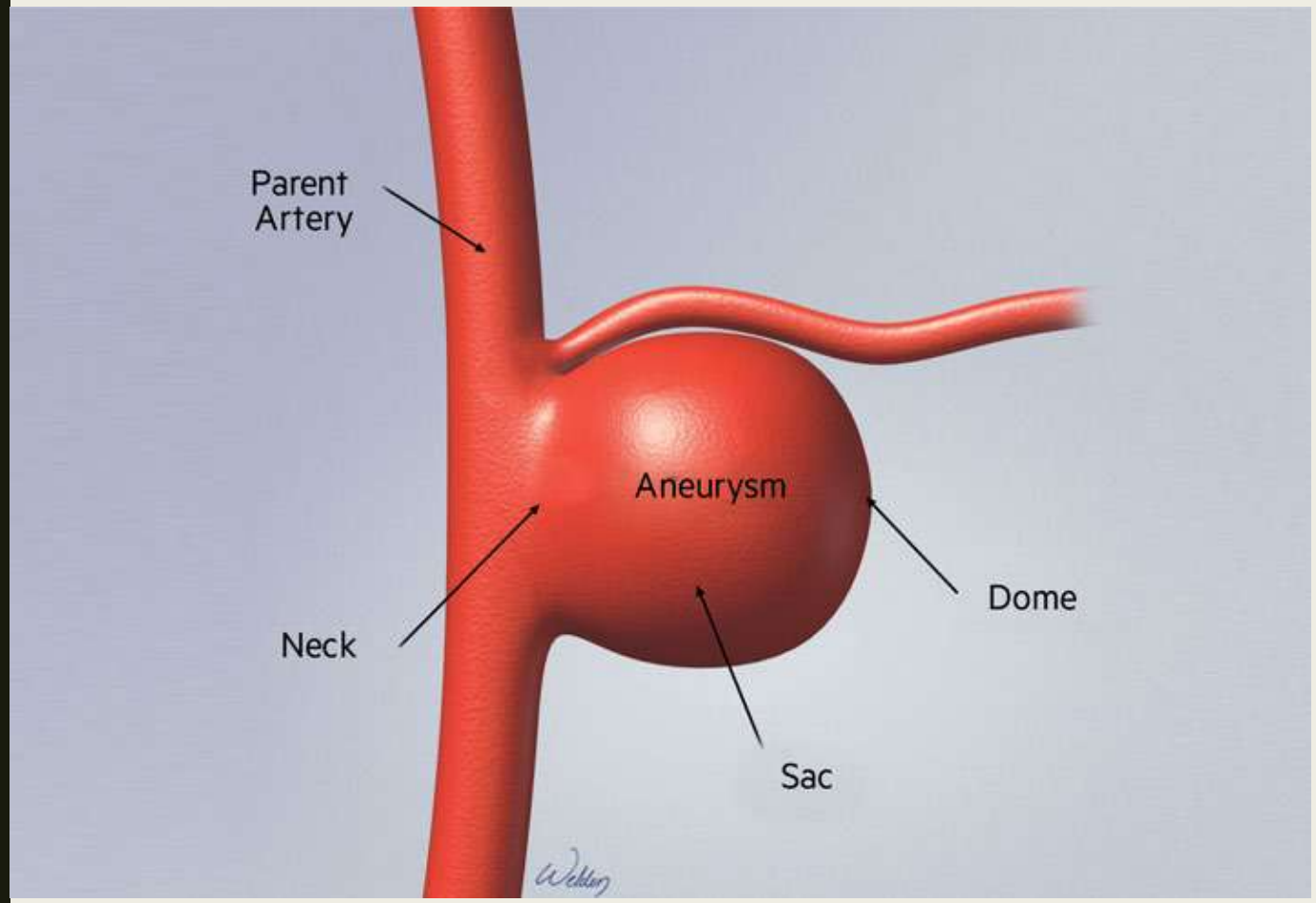


Stroke, Heart Attack, and Aneurysm

- A stroke often results when an arteriole in the brain **bursts or is blocked by an embolus.**
  - The lack of O2 causes a **portion of the brain to die, and paralysis or death can result.**



- If a coronary artery **becomes partially blocked**, the individual may suffer from angina pectoris.
  - Characterized by a **squeezing or burning sensation in the chest.**
  - When a coronary artery is completely blocked, a **portion of the heart muscle dies due to a lack of O2 and a heart attack occurs.**



- **An aneurysm is the ballooning of a blood vessel**, most often the abdominal aorta or the arteries leading to the brain.
  - Atherosclerosis and high blood pressure **can weaken the wall of an artery to the point an aneurysm develops.**