

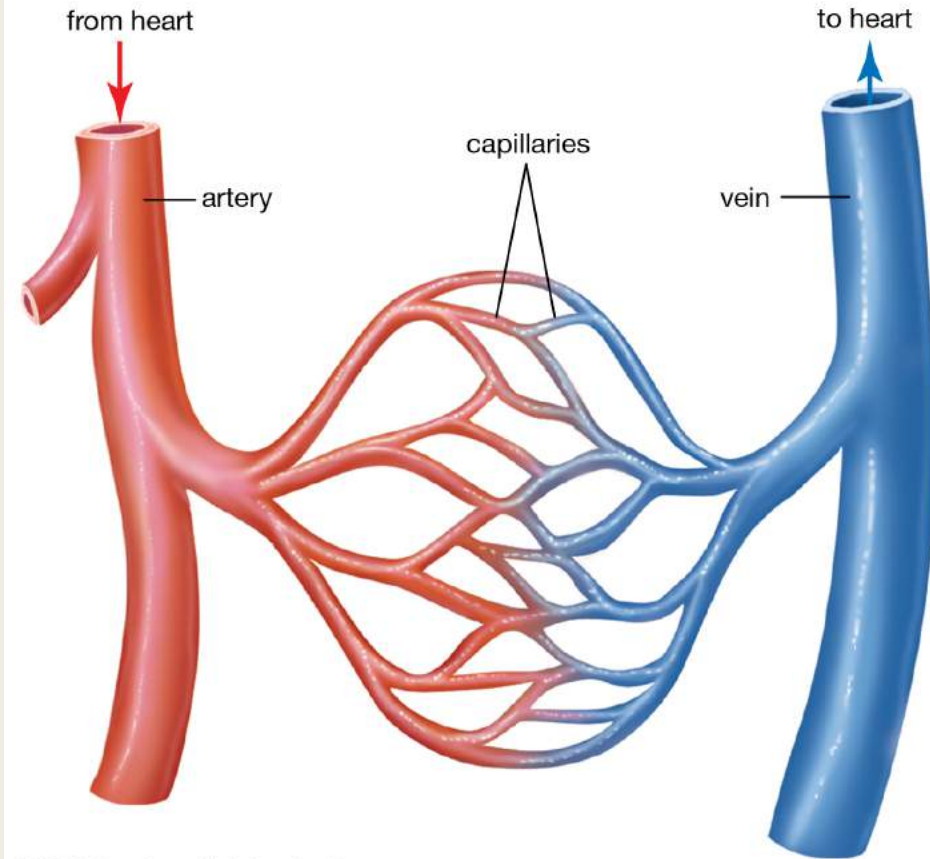
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CIRCULATORY & LYMPHATIC SYSTEMS

Ms. Martel

6.1 – 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.

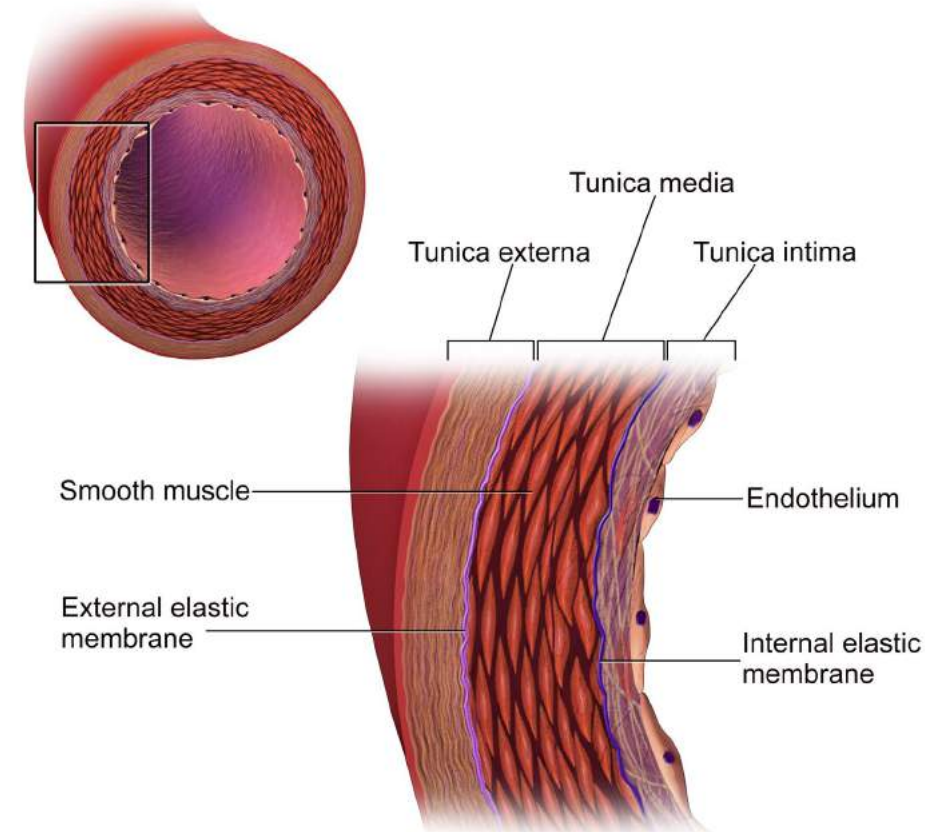


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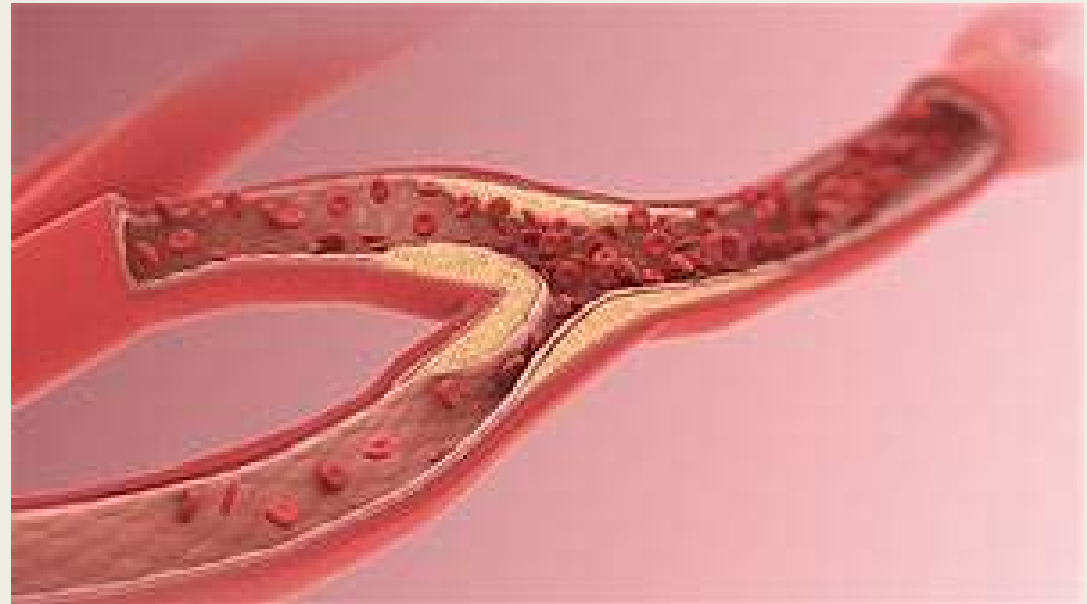
The Arteries

- 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.**

The Structure of an Artery Wall



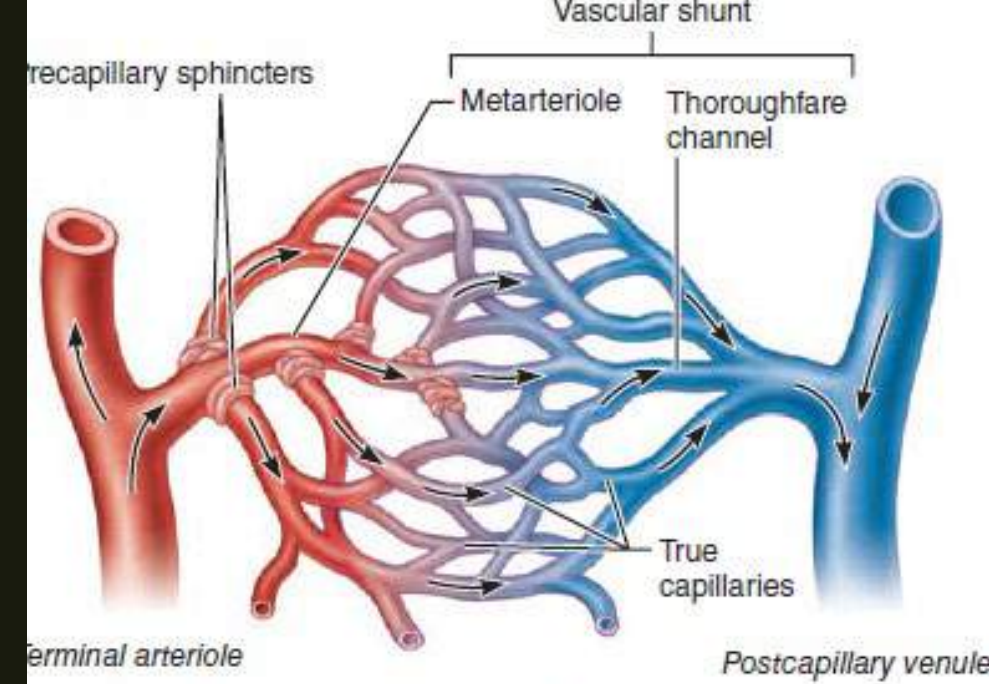
- Arterioles are **small arteries**.
- When the muscle fibers in arteries and arterioles are contracted (constricted), the **vessel is smaller in diameter**.
 - When they are relaxed (dilated), **the vessel has a larger diameter**.
 - Whether they are constricted or dilated, this **affects blood pressure**.



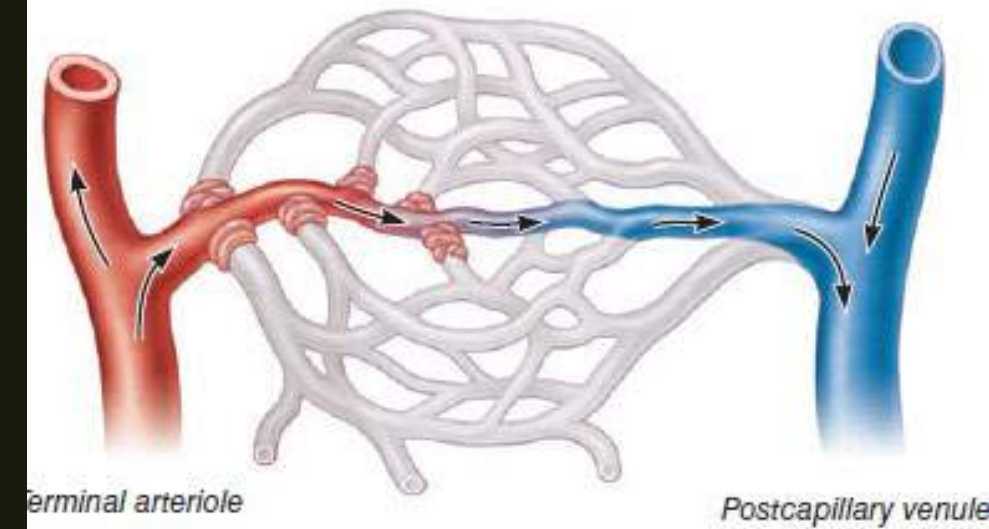
The Capillaries

- 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.



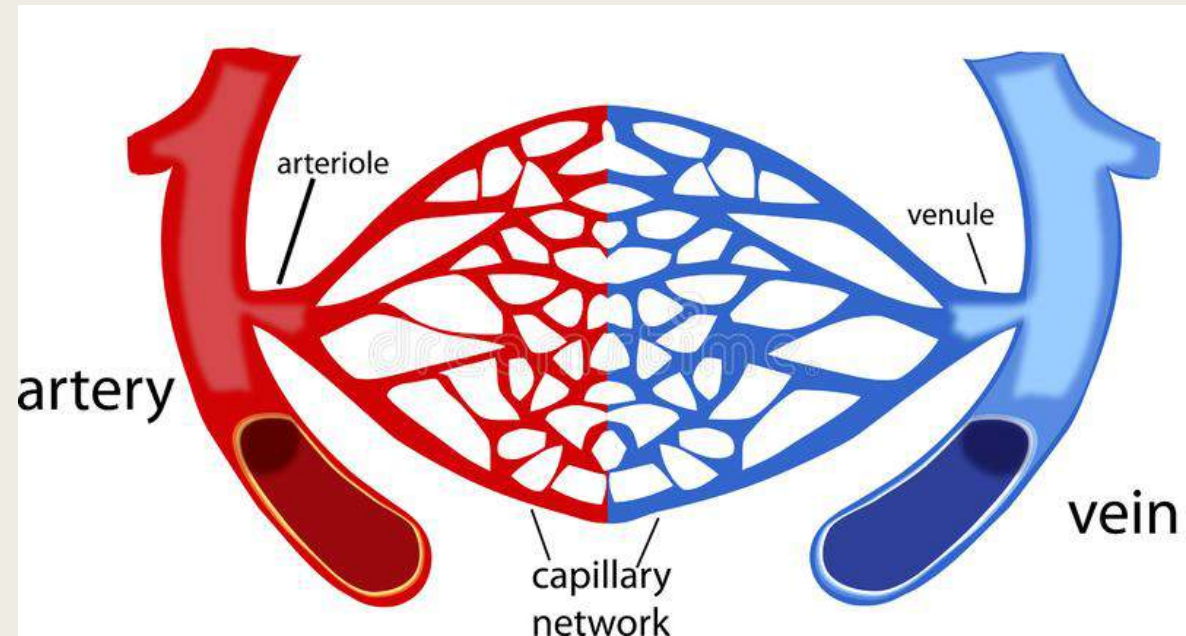
a) Sphincters open—blood flows through true capillaries.



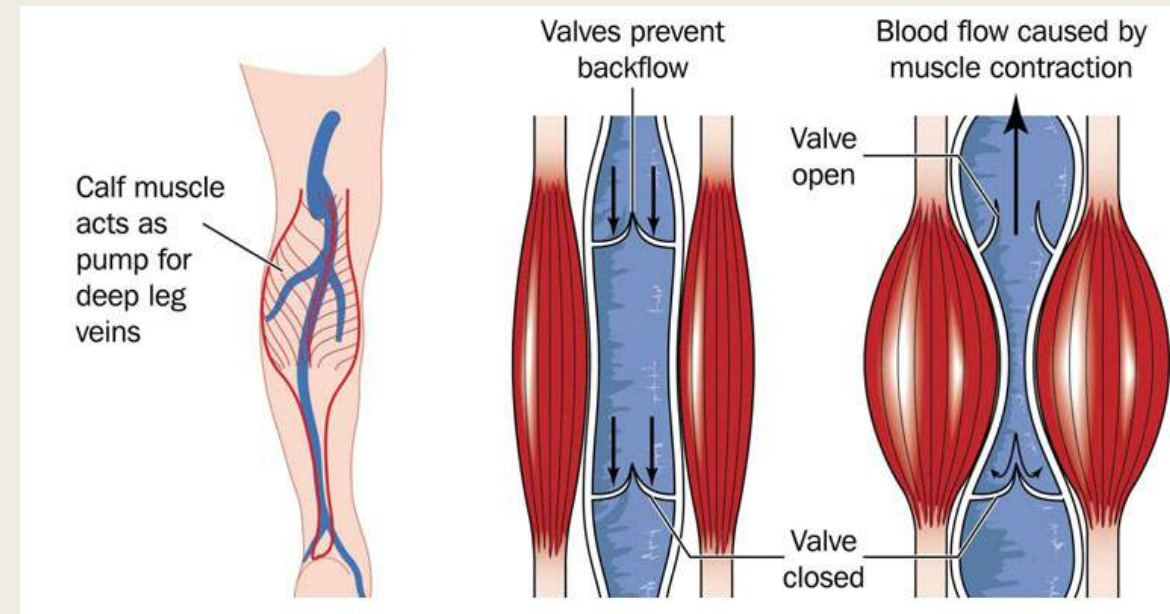
b) Sphincters closed—blood flows through metarteriole—thoroughfare channel and bypasses true capillaries.

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.**

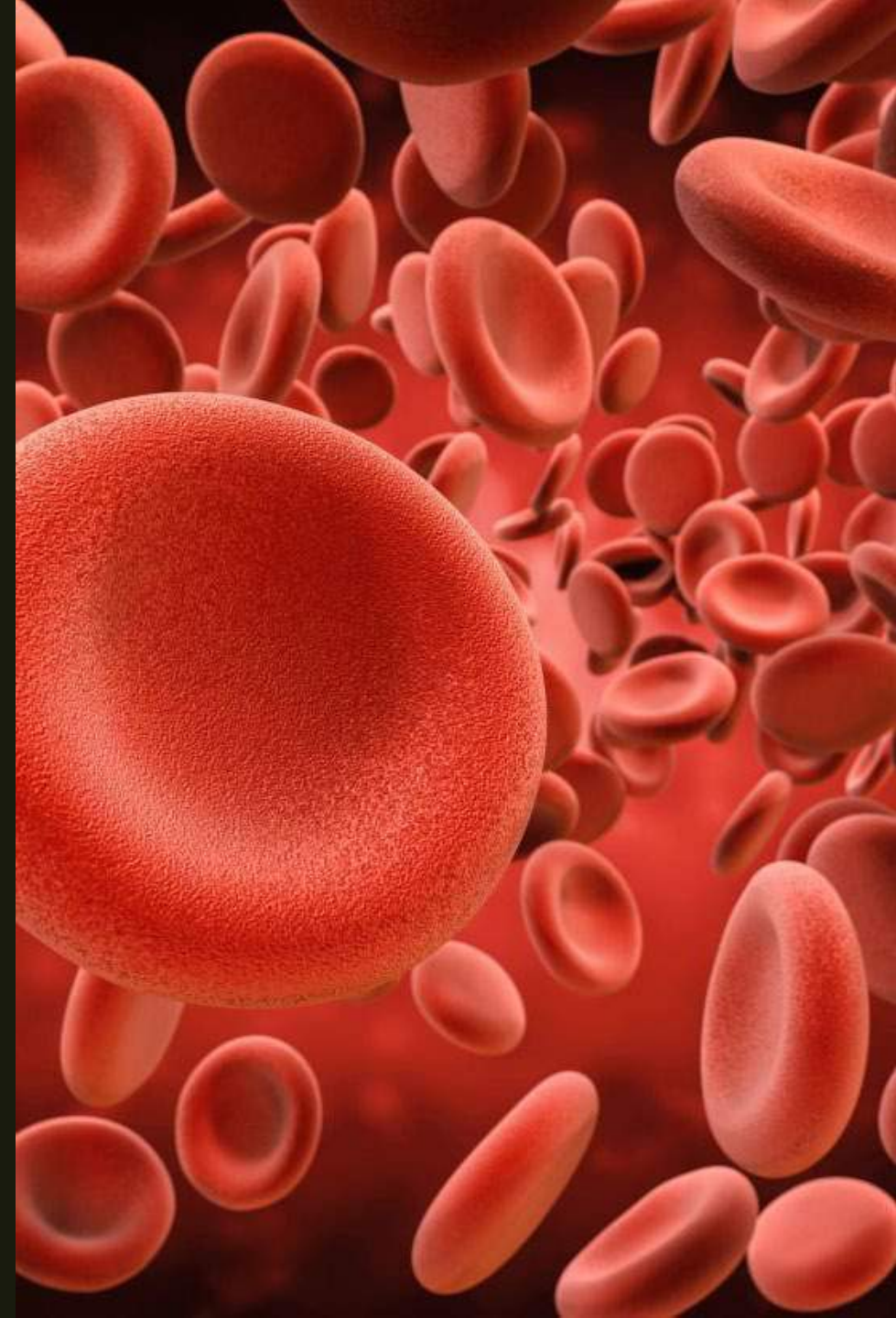


- Veins often have valves, which allow blood to flow only towards the heart.
- Valves are found in the veins that carry blood **against the force of gravity**.
 - Blood flow in the veins is primarily due to **skeletal muscle contraction**.
 - If the valves become damaged by disease or through normal 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**.

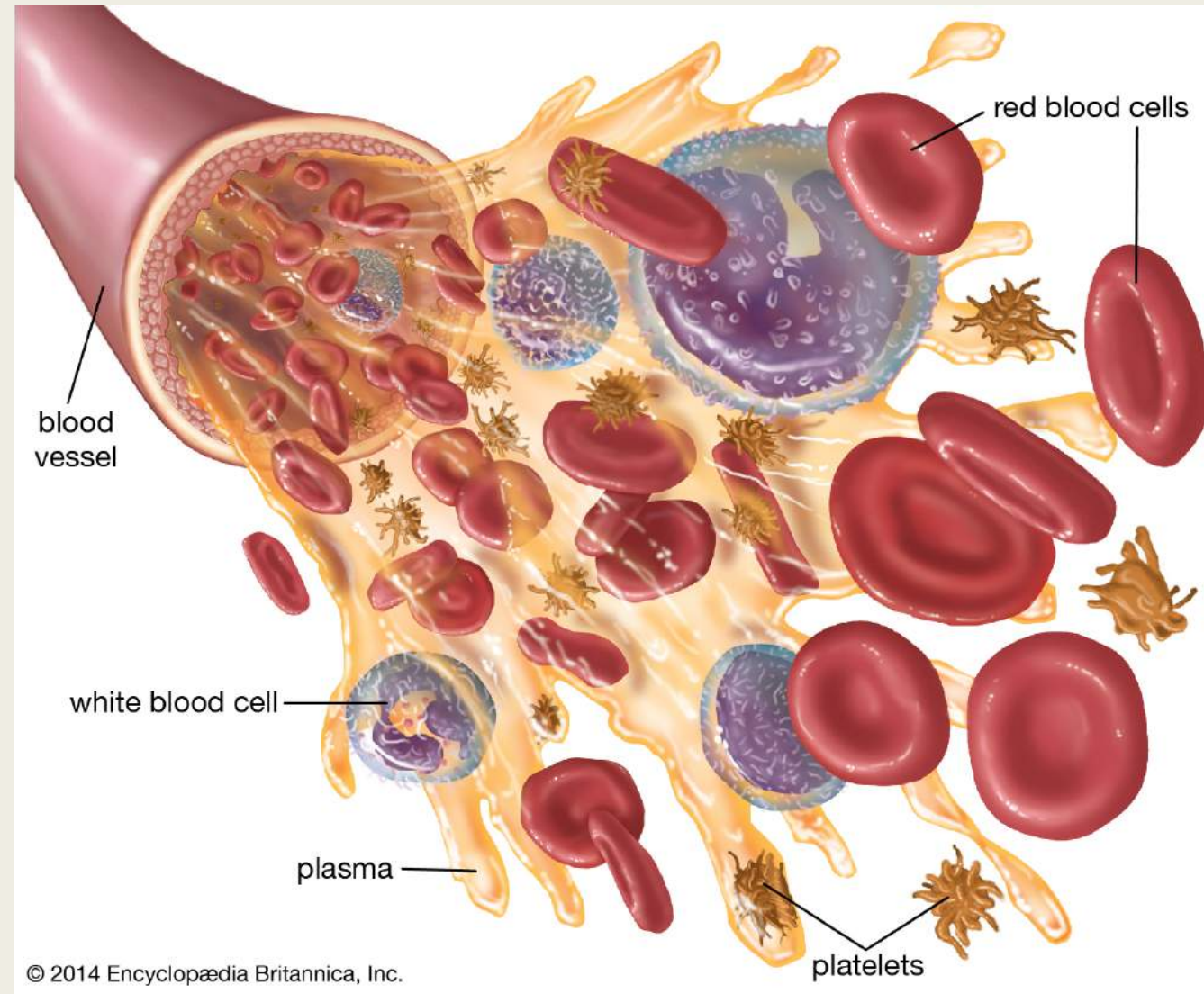


6.2 - BLOOD

- 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**.

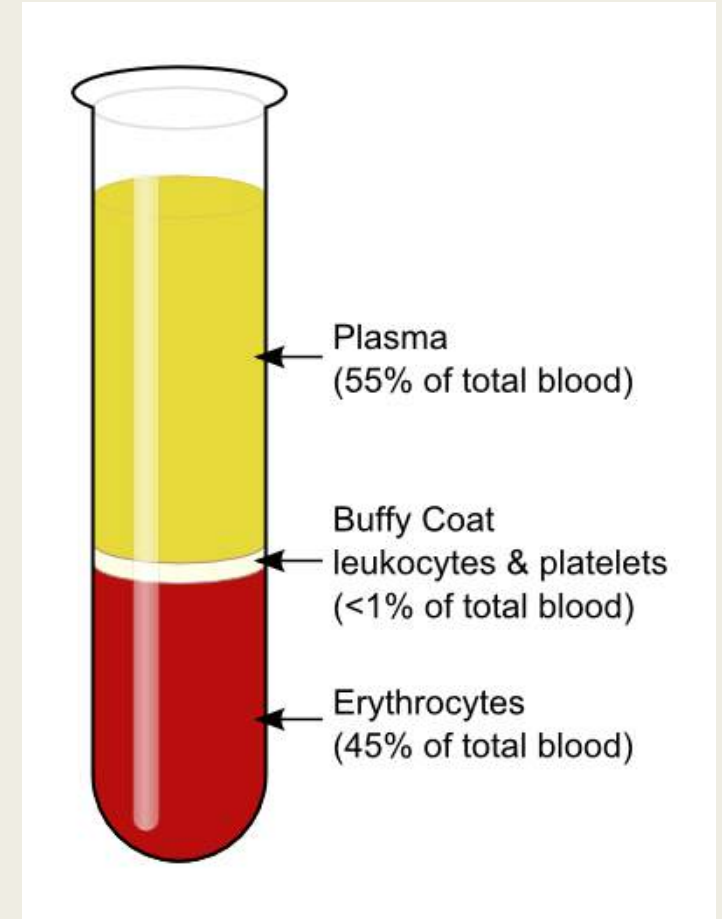


- Blood is separated into three components:
 - **Plasma** – the liquid portion of blood
 - **White blood cells and platelets** – formed elements
 - **Red blood cells** – formed elements



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**.

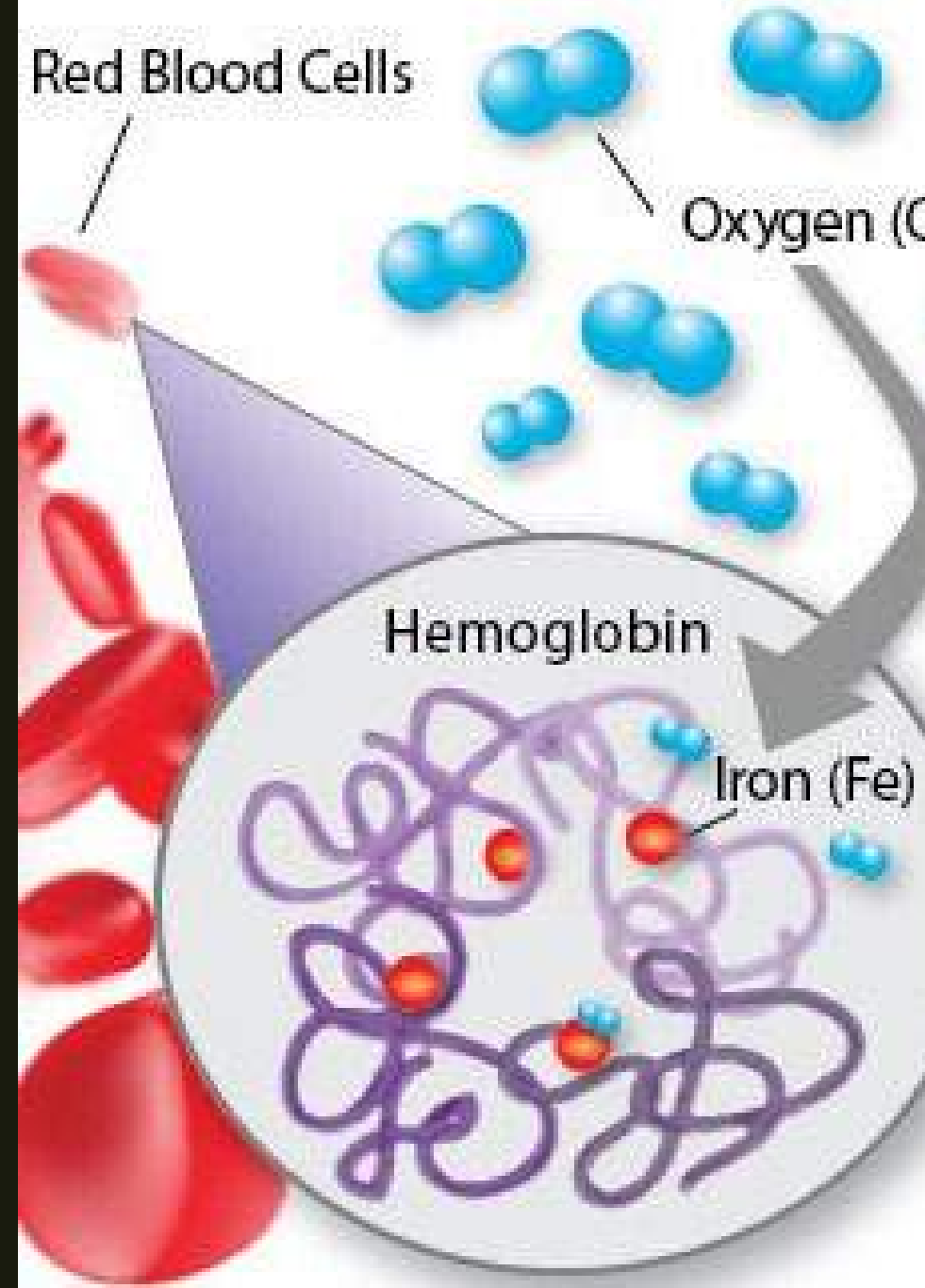


Red Blood Cells

- 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.**

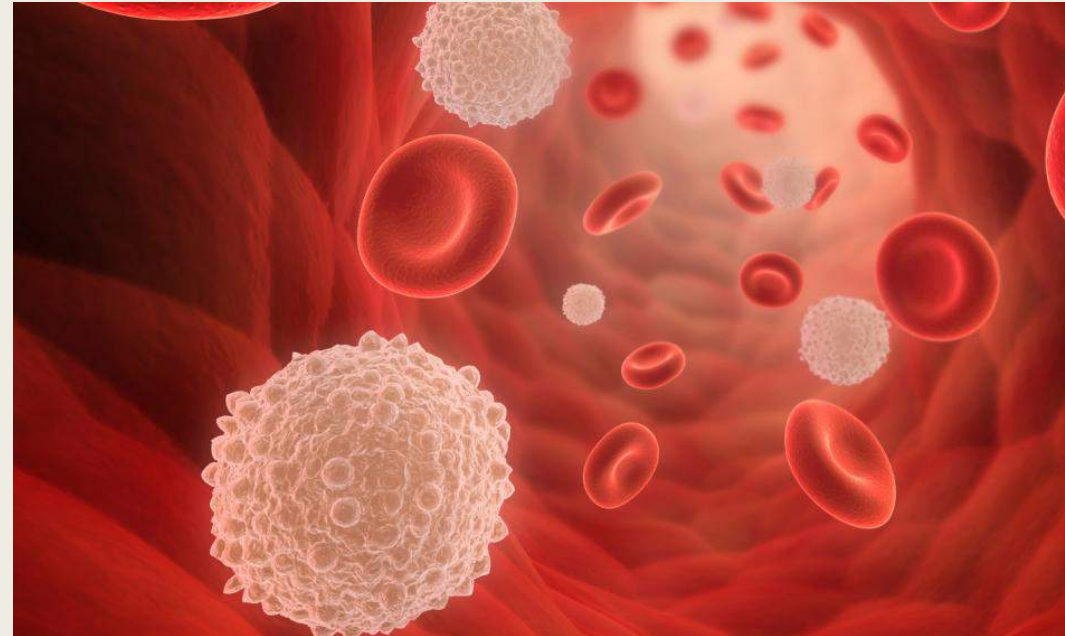


- RBC's only live for 120 days, they are **destroyed in the liver**, and the iron is mostly salvaged.
- When the body does not contain enough hemoglobin, and individual suffers from anemia. There are 3 basic causes of anemia:
 - **Decreased production of RBC's**
 - **Loss of RBC's from the body**
 - **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.

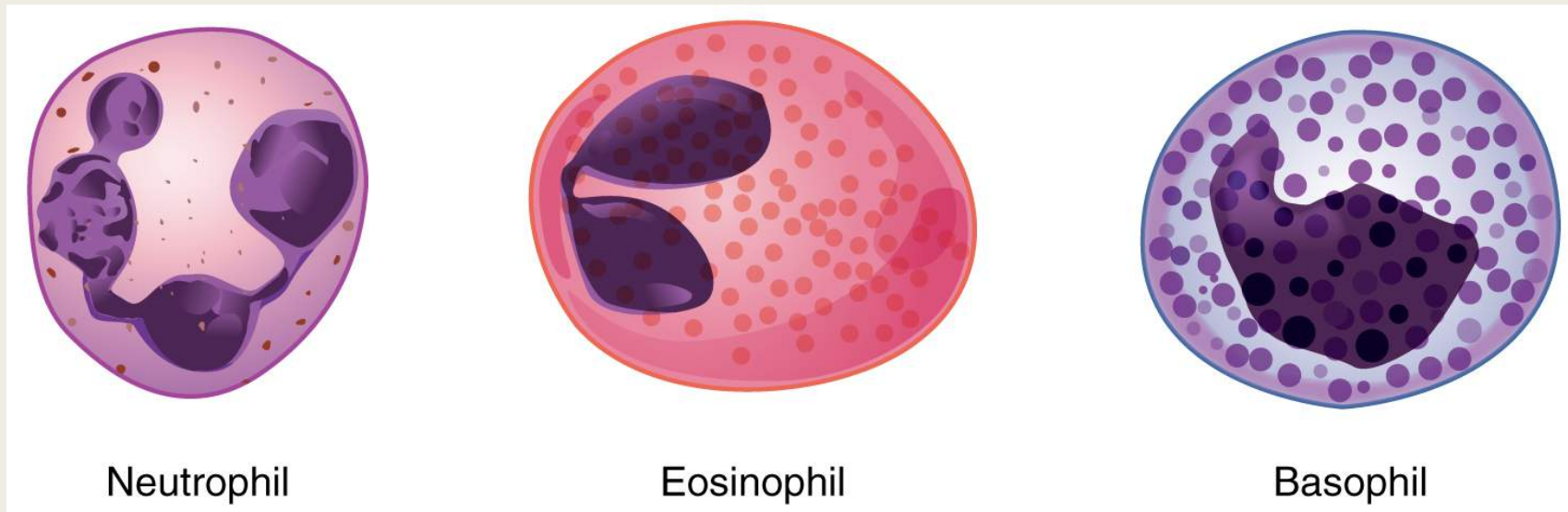


White Blood Cells

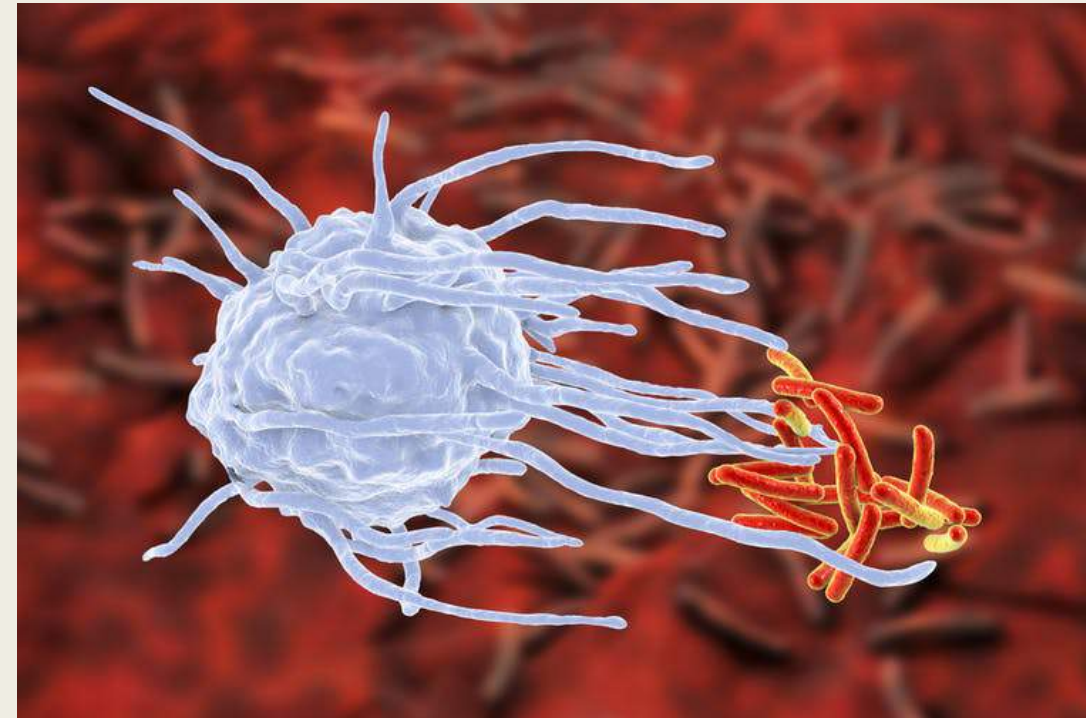
- White blood cells (leukocytes) fight infection and play a role in the **development of immunity**.
 - They are larger than RBC's and **have a nucleus**.
- Based on structure: it is possible to divide WBC's into **granular leukocytes and agranular leukocytes**.
 - Granular leukocytes (**neutrophils, 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**.

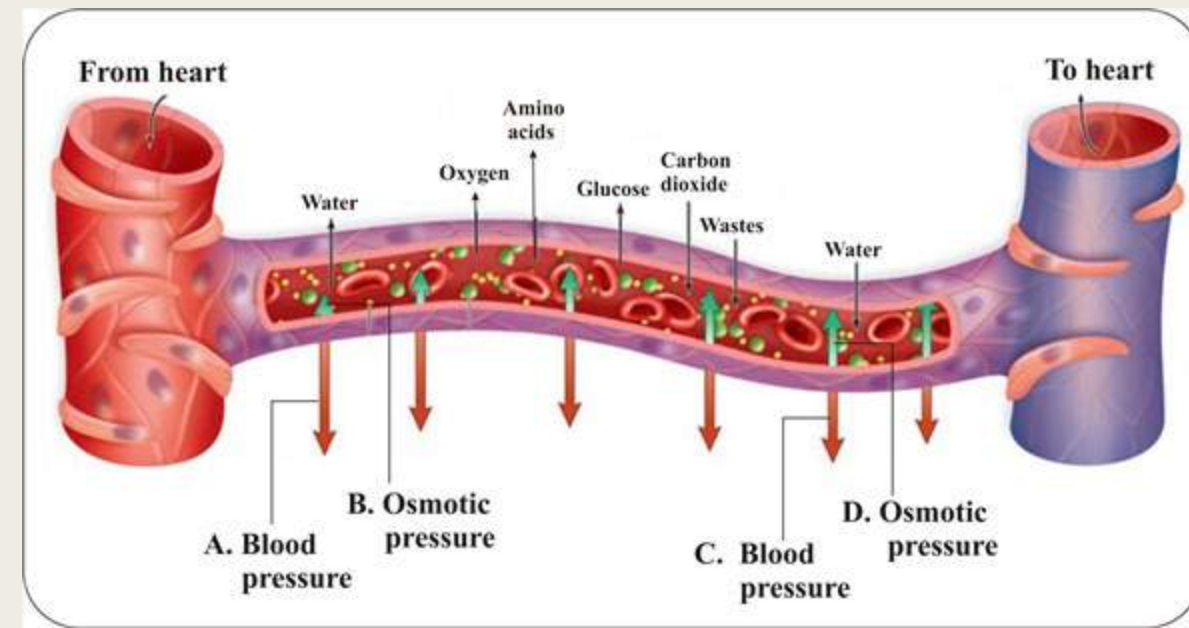
Bone Marrow Stem Cells

- A stem cell is a cell 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**

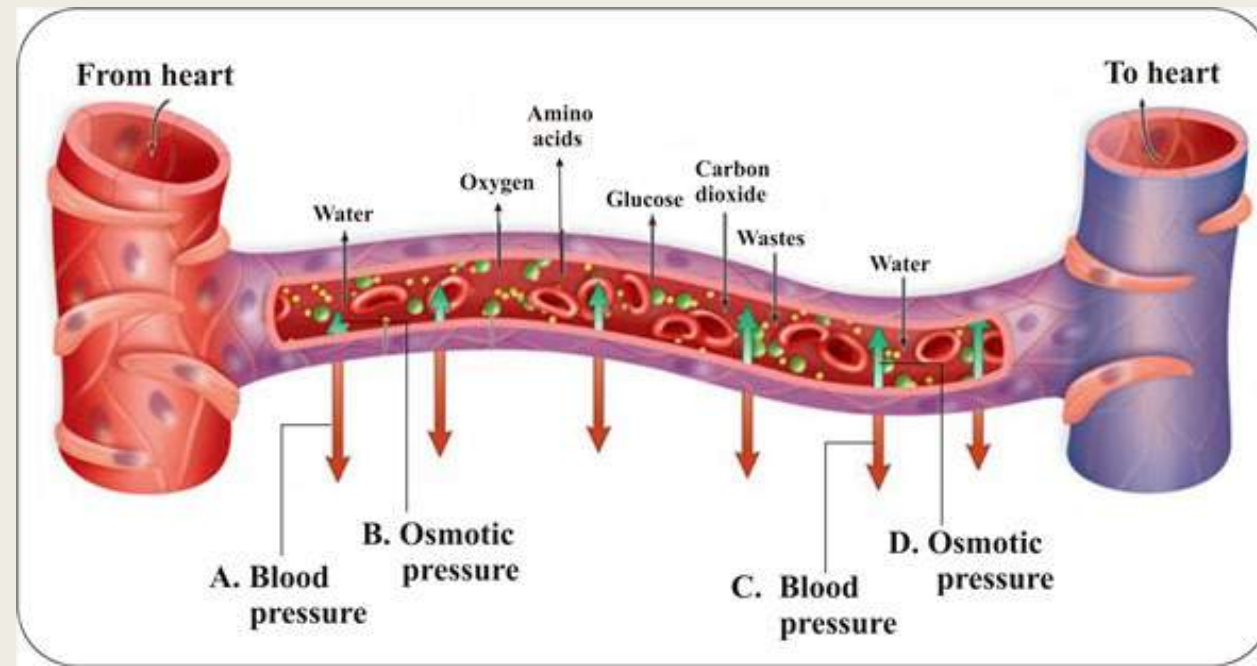
- **The use of a patients own bone marrow** could be used to treat conditions such as diabetes, heart disease and liver disease.
- The use of a persons own stem cells is ideal because they **won't reject the transplant.**
- Some researchers also work with embryonic stem cells which can be collected from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

Capillary Exchange

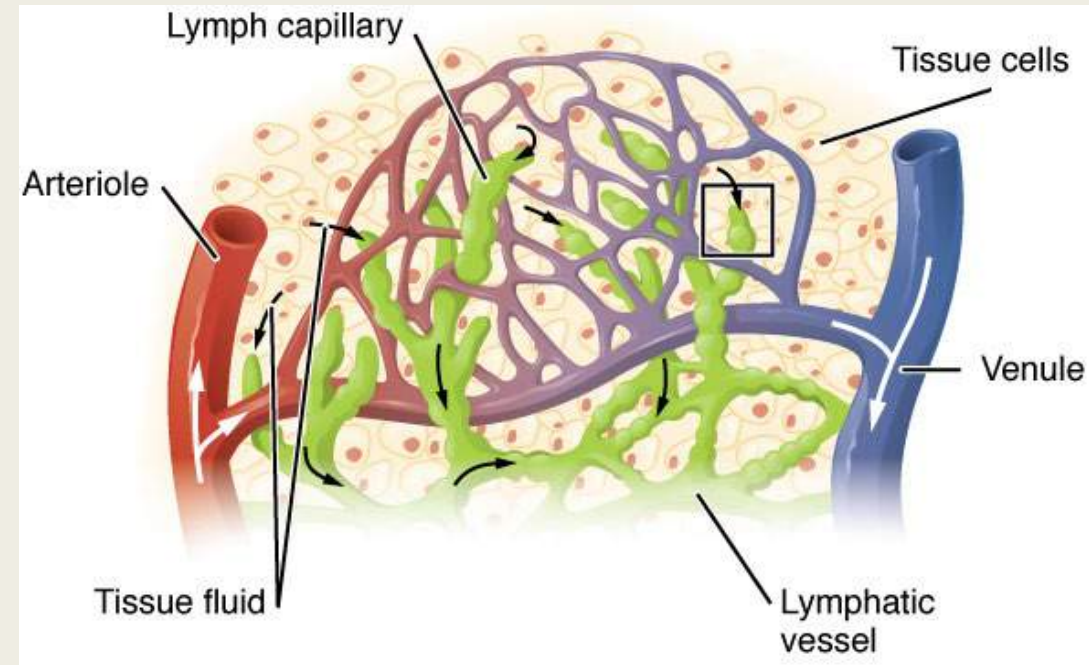
- Two forces primarily control movement of fluid through the capillary wall:
 - **Osmotic pressure, created by salts and plasma proteins.** Here water moves from the tissue into the blood
 - **Blood pressure** tends to cause water to move in the opposite direction.



- 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 H₂O.**
 - 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.**

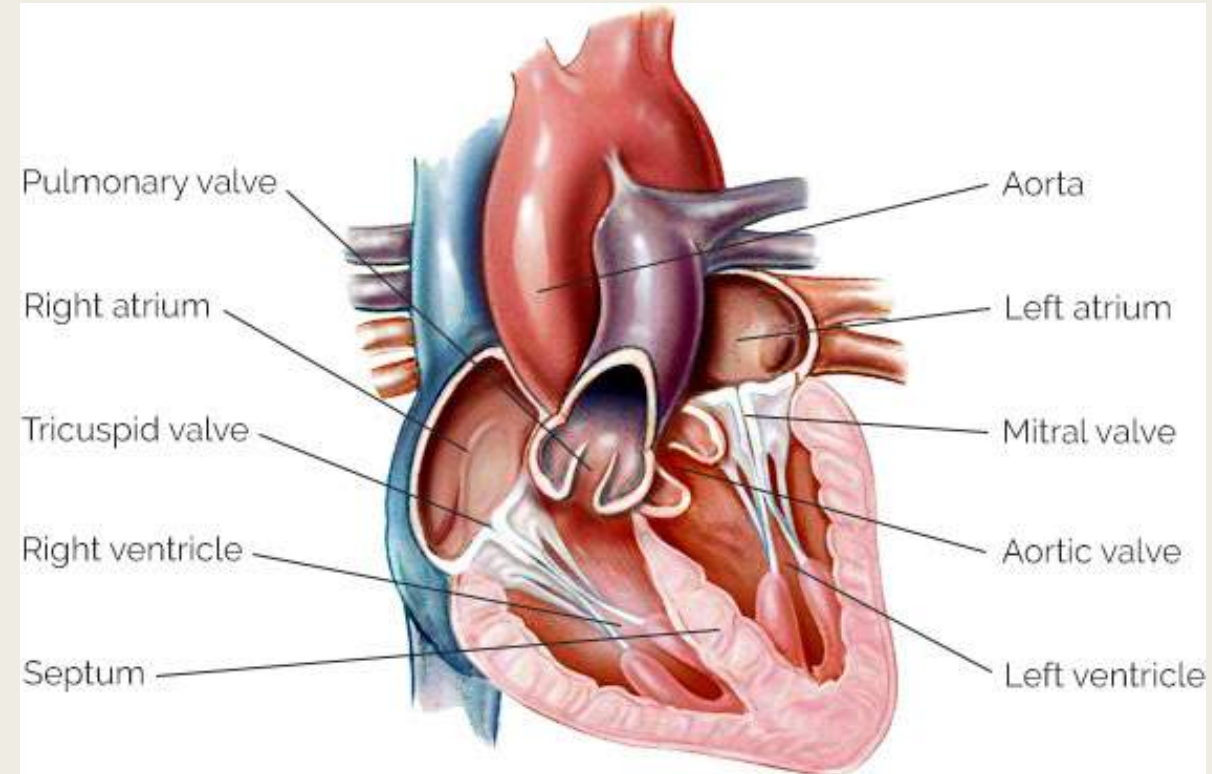


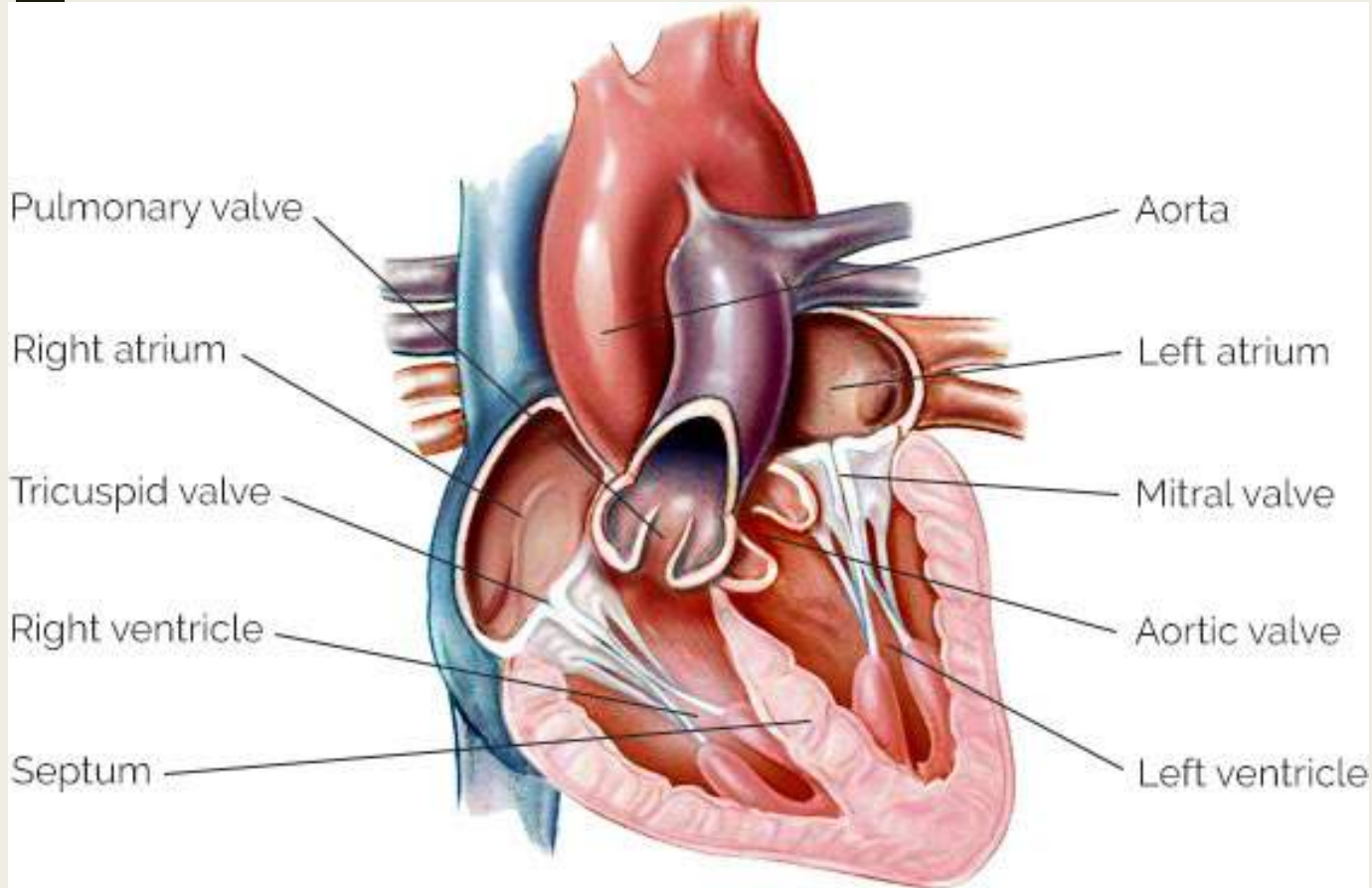
6.3 – THE HUMAN HEART

- 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 is 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.

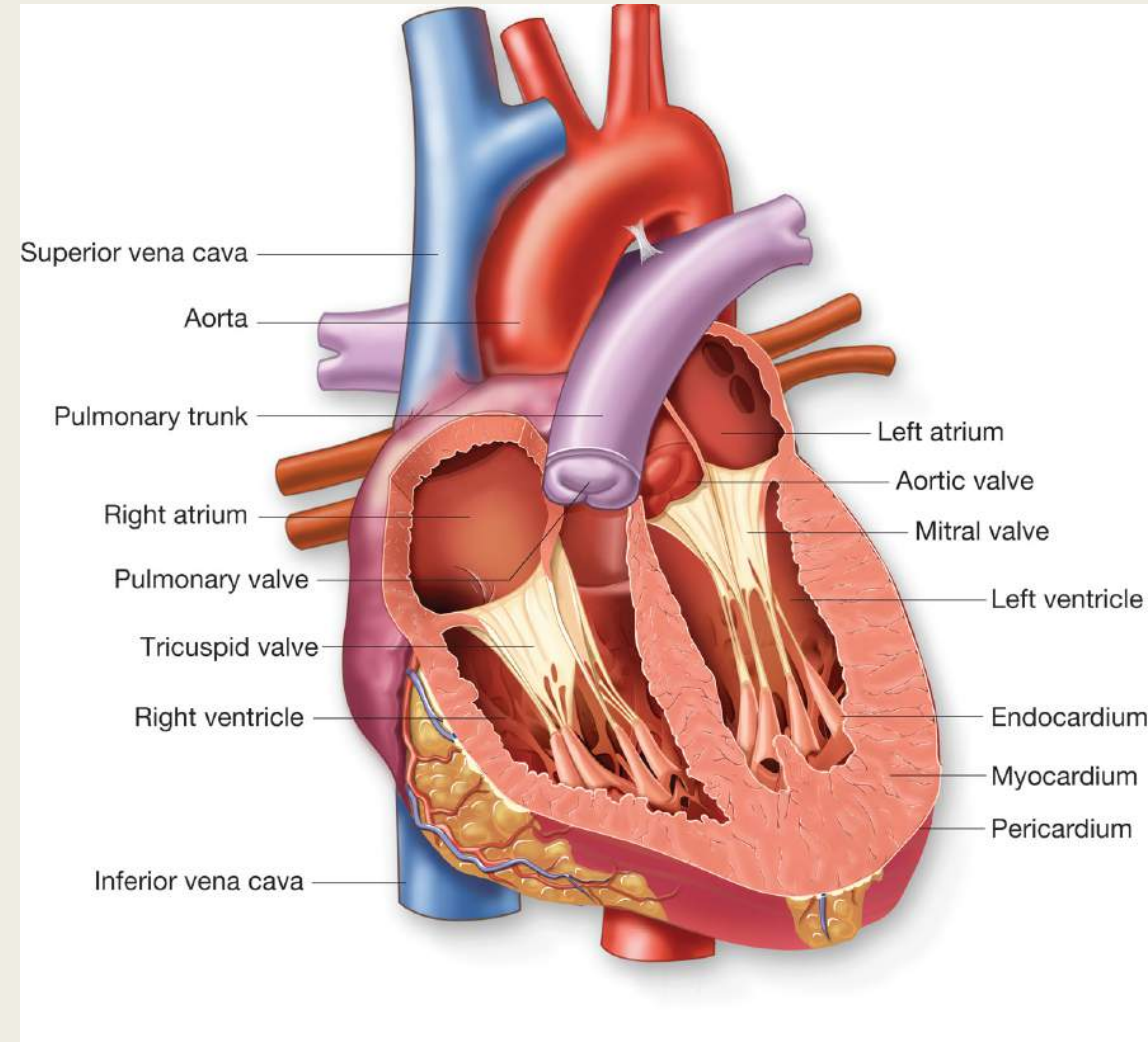


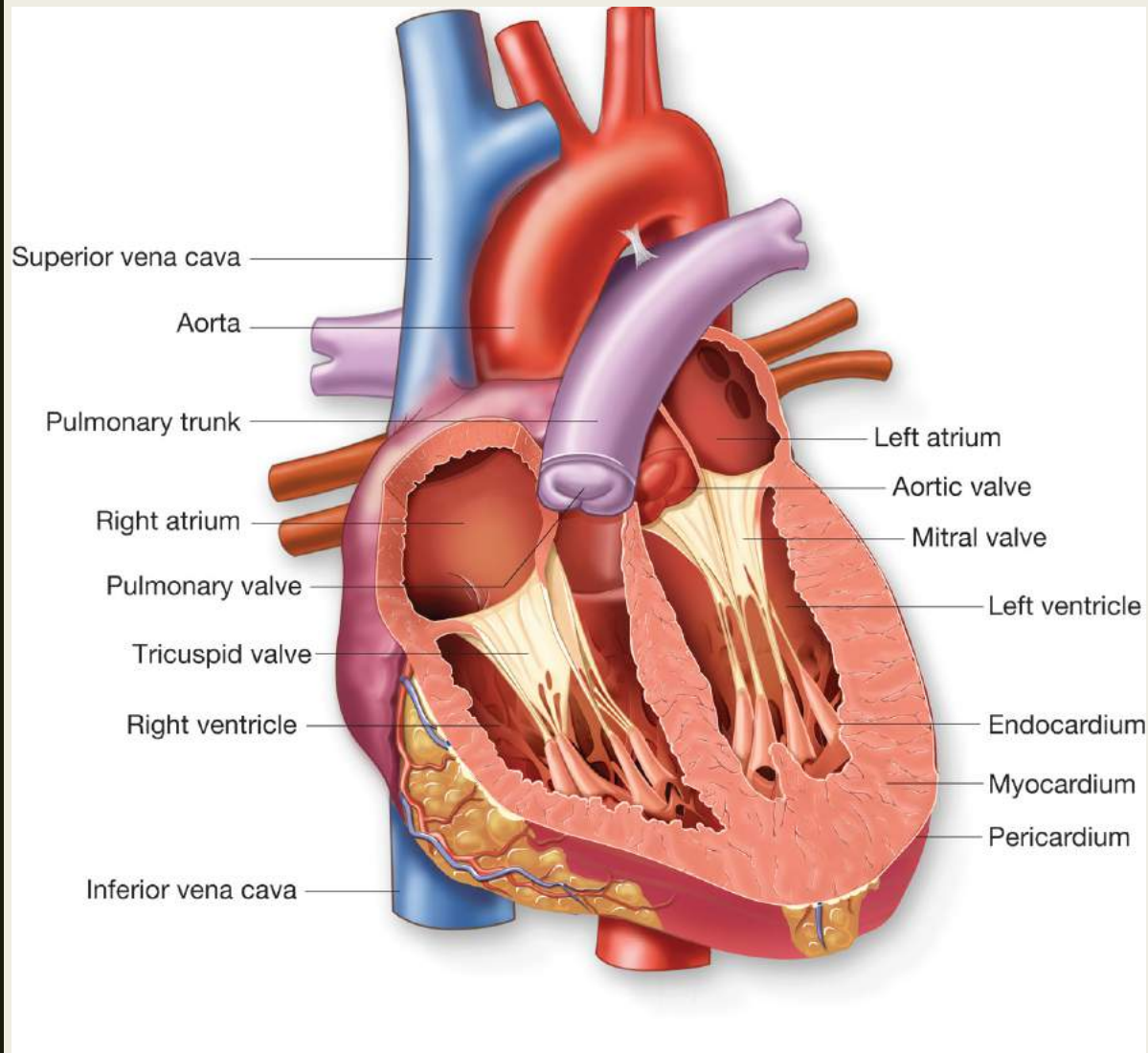


- Valves help **direct the flow of blood in the heart.**
 - Two lie between the atria and the ventricles called the **atrioventricular valves, supported by chordae tendineae.**
 - On the right is the **tricuspid valve**, on the left is the **bicuspid valve.**
 - The other two valves lie between the ventricle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

Path of Blood through the Heart

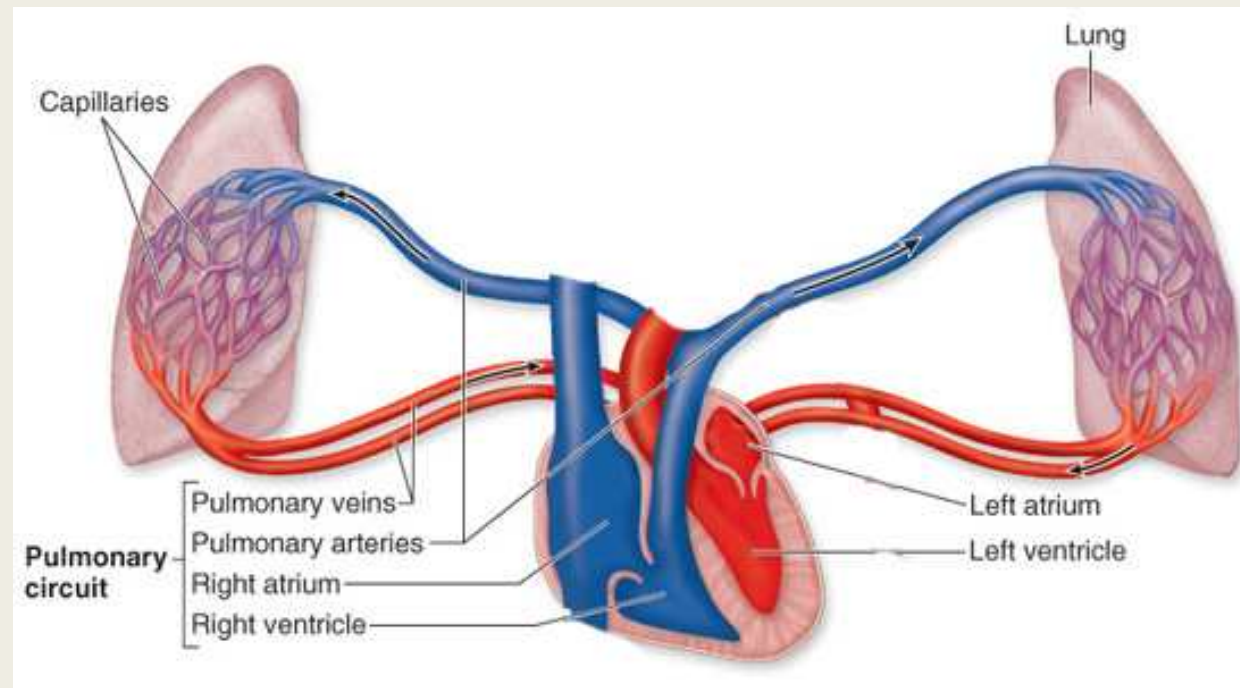
- The superior and inferior vena cava carry **O₂-poor blood into the right atrium.**
- The right atrium sends blood through the **tricuspid valve to the right ventricle.**

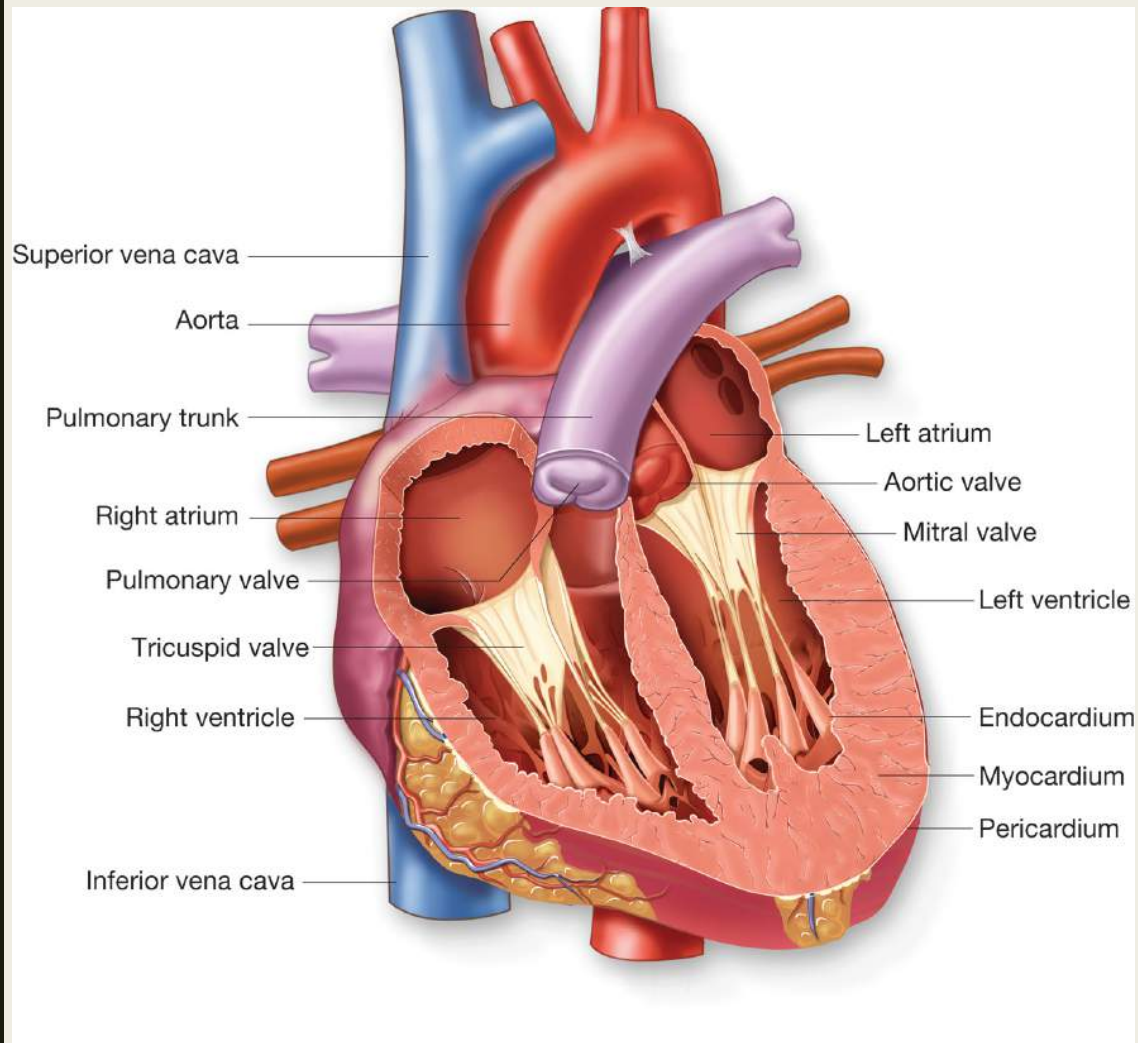




- Right ventricle sends blood through the **pulmonary SLV**, into the pulmonary trunk and through the **pulmonary arteries** to the **lungs**.
- Four pulmonary veins, carrying **O₂ rich blood**, enter the **left atrium**.
- The left atrium sends blood through the **bicuspid valve** to the **left ventricle**.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

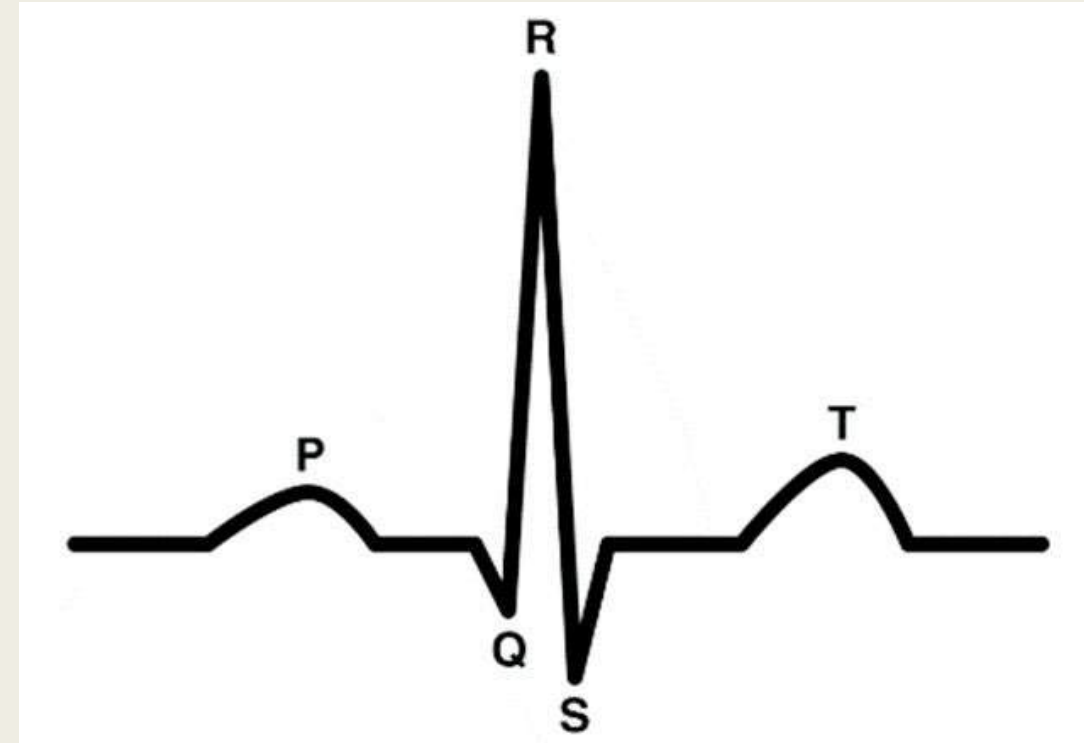
- The SA node initiates the heartbeat, and **sends an impulse to the atria and AV node.**
 - The AV node delays the impulse for a fraction of a second to ensure the **atria and ventricles do not contract at the same time.**
 - The AV node sends the impulse down the septum through the **Purkinje fibers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

Extrinsic Control of Heartbeat

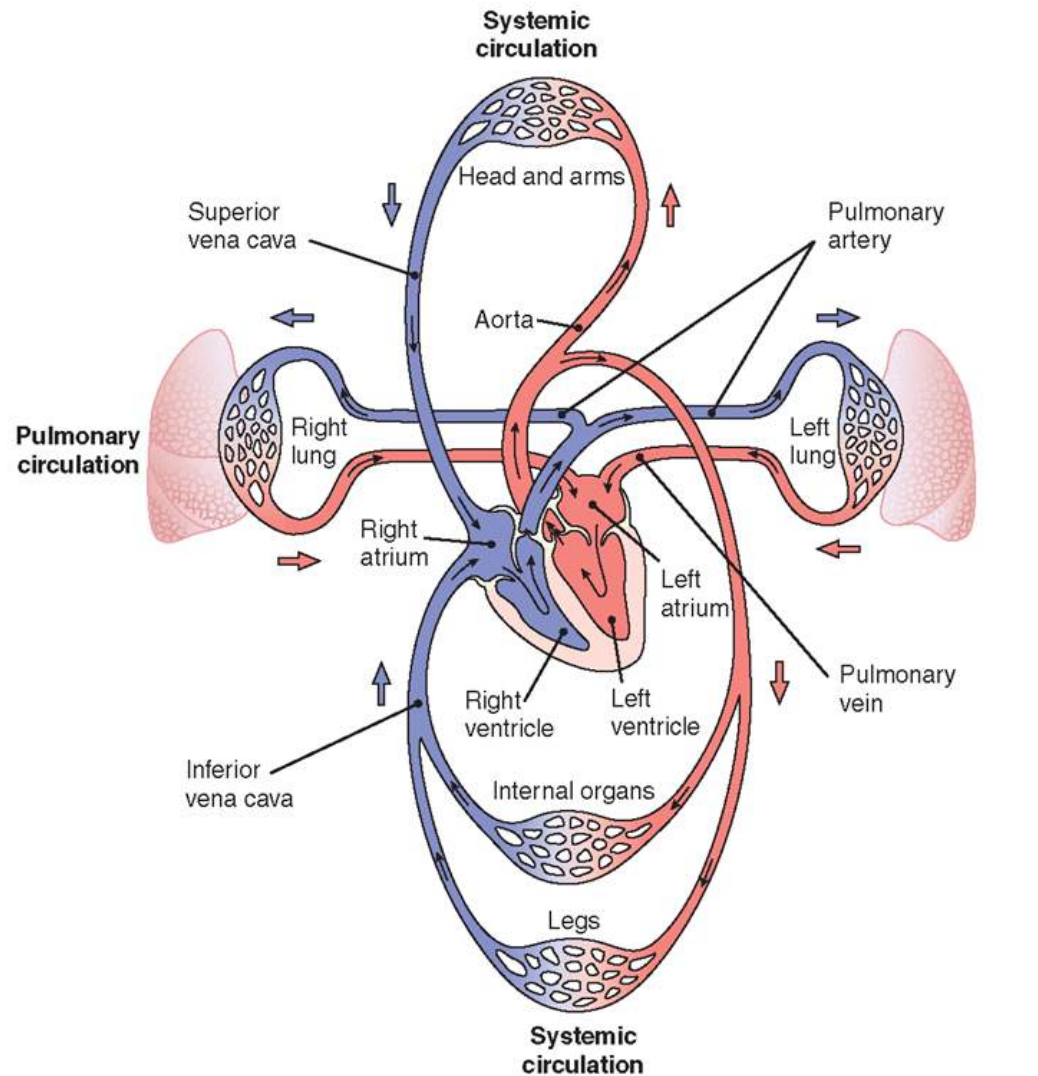
- The body has an external way to control the heartbeat in the **medulla oblongata located in the brain stem.**
- This is part of the **autonomic nervous system** that divides further into two systems:
 - The parasympathetic division which **promotes resting state.**
 - The sympathetic division which **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.**



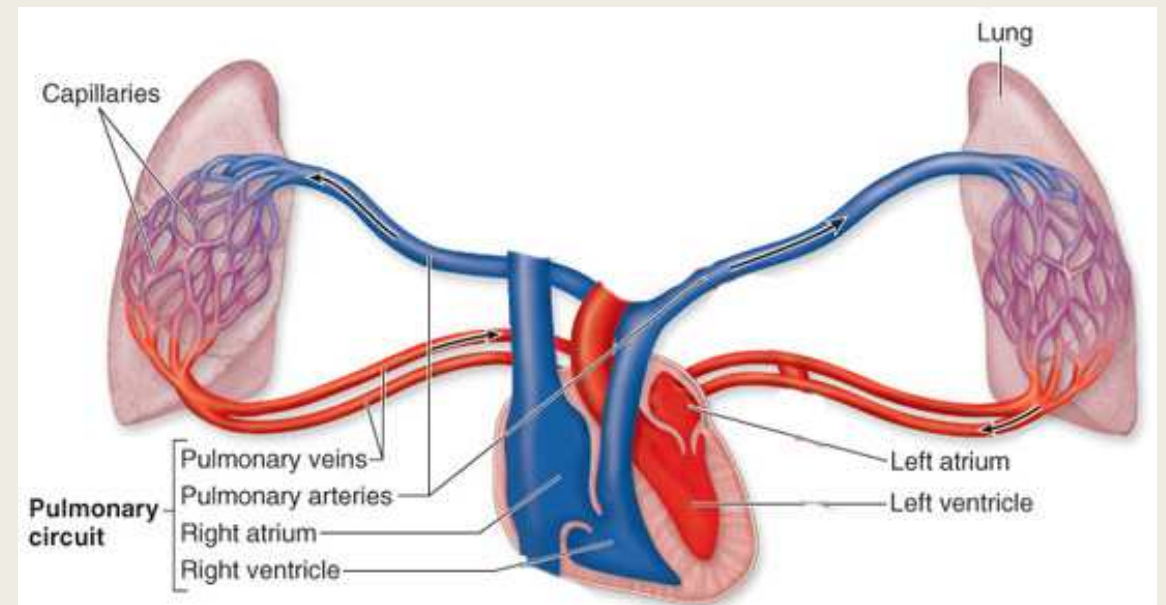
6.4 – THE VASCULAR PATHWAYS



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

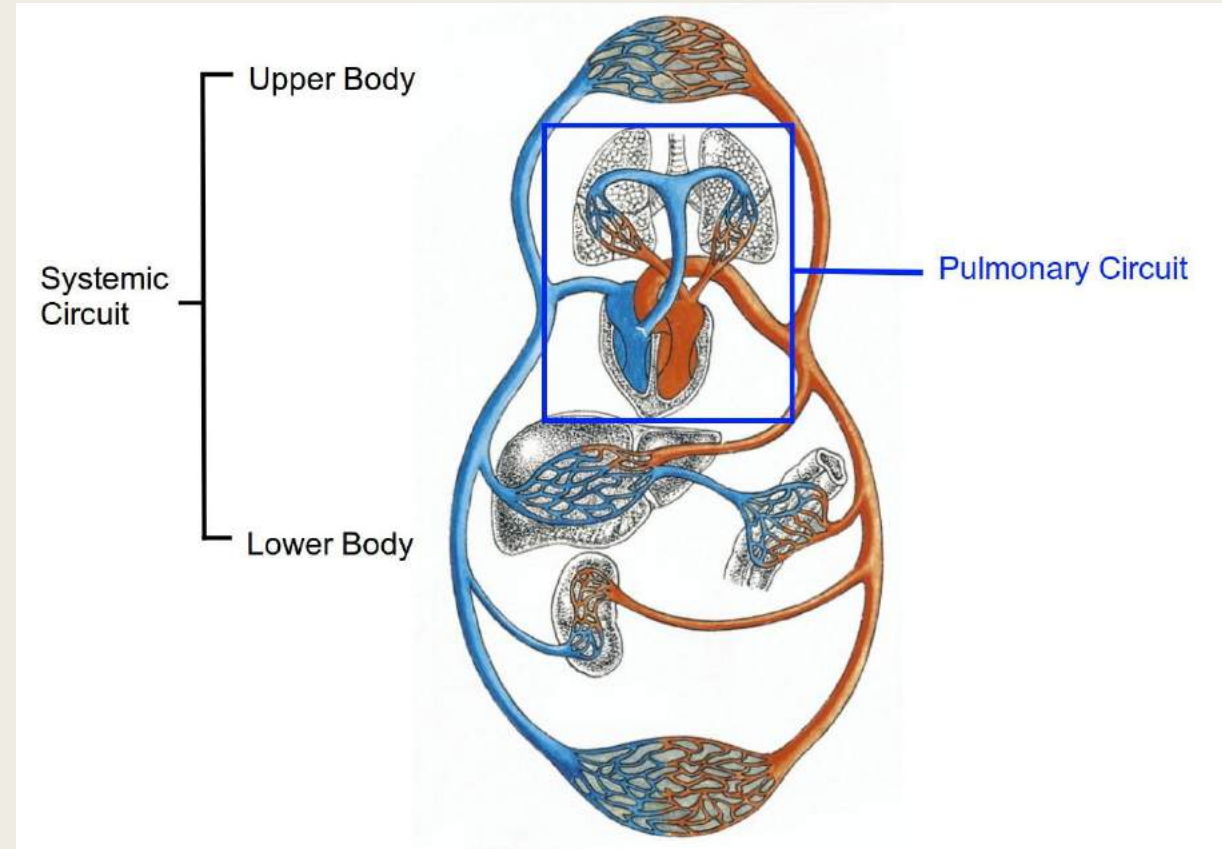
The Pulmonary Circuit

- 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**.

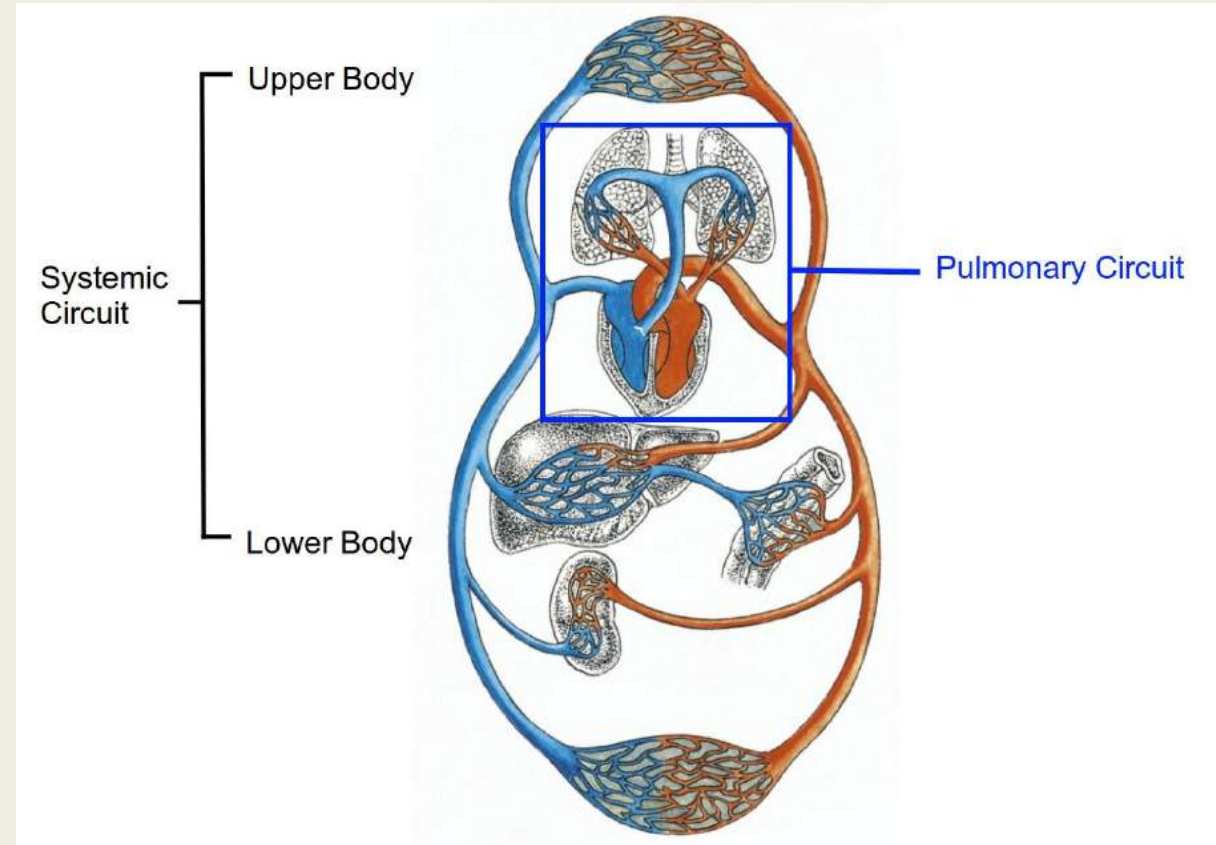


The Systemic Circuit

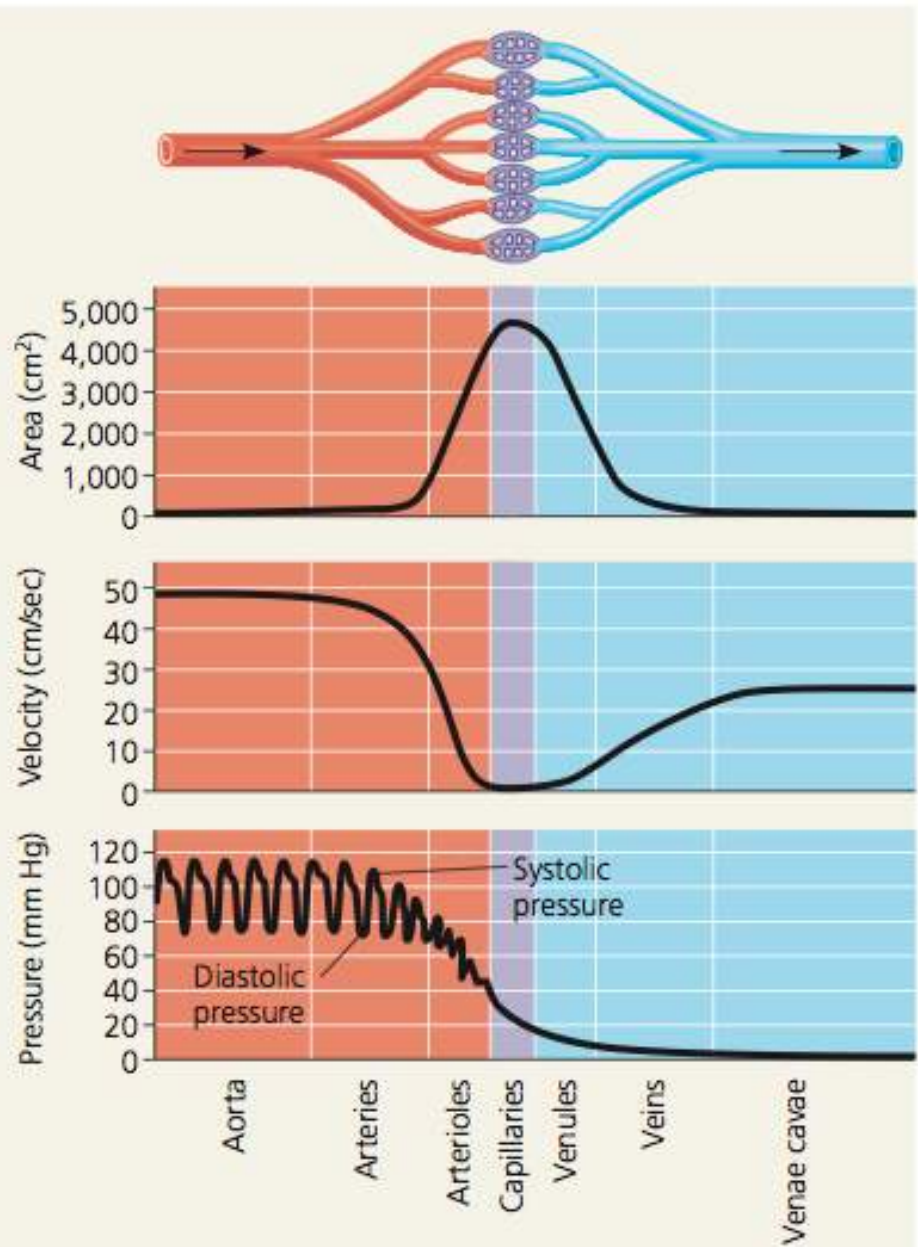
- The path of systemic blood to any organ in the body begins in the left ventricle.
- In most instances, the artery and the vein that serve the same region are given the same name.



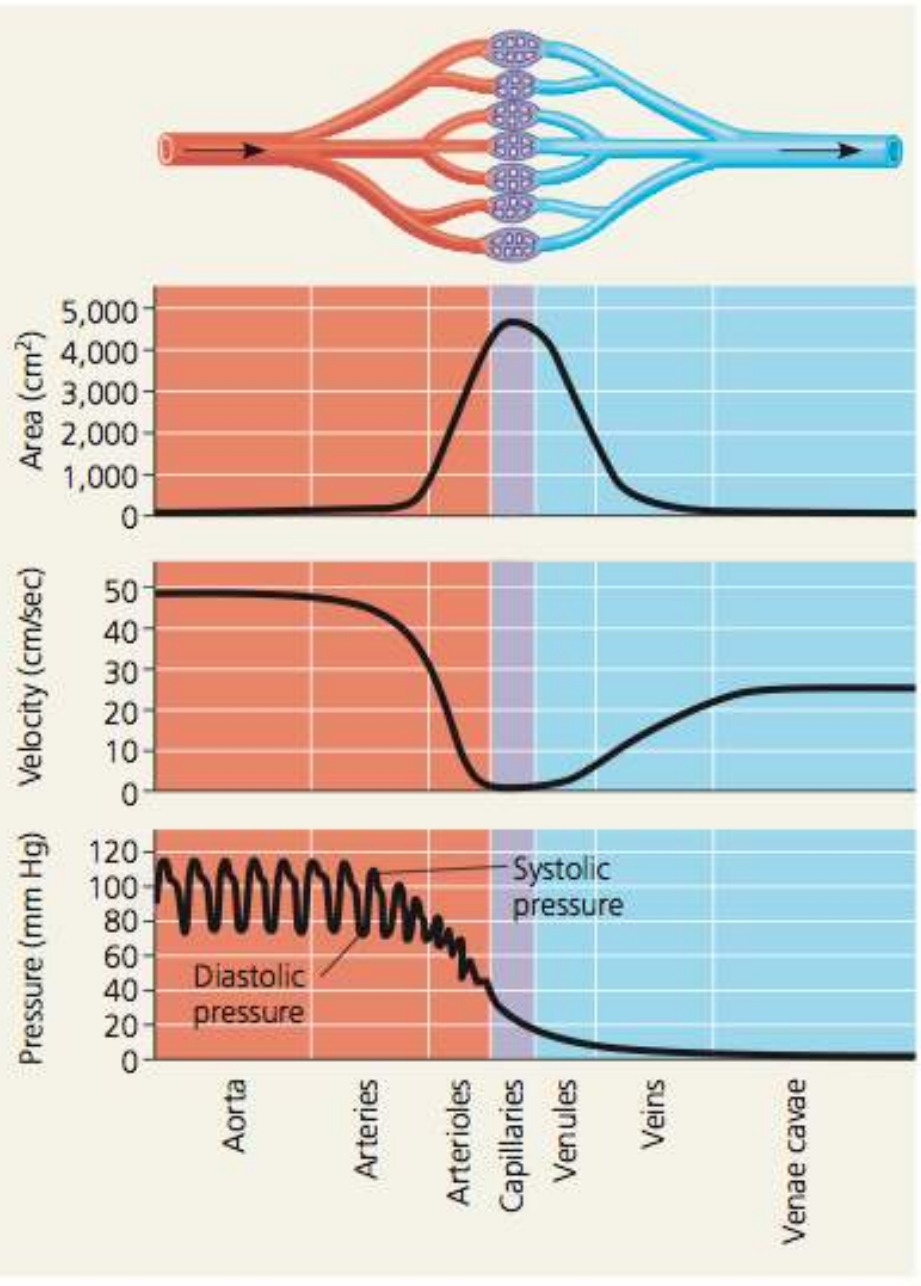
- A portal system in blood circulation **begins and ends in capillaries.**
 - **The hepatic portal system is associated with the liver.**
 - Capillaries in the villi of the small intestine, **pass into venules that join to form the hepatic portal vein.**
 - This vein carries the blood to a set of capillaries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



Blood Pressure

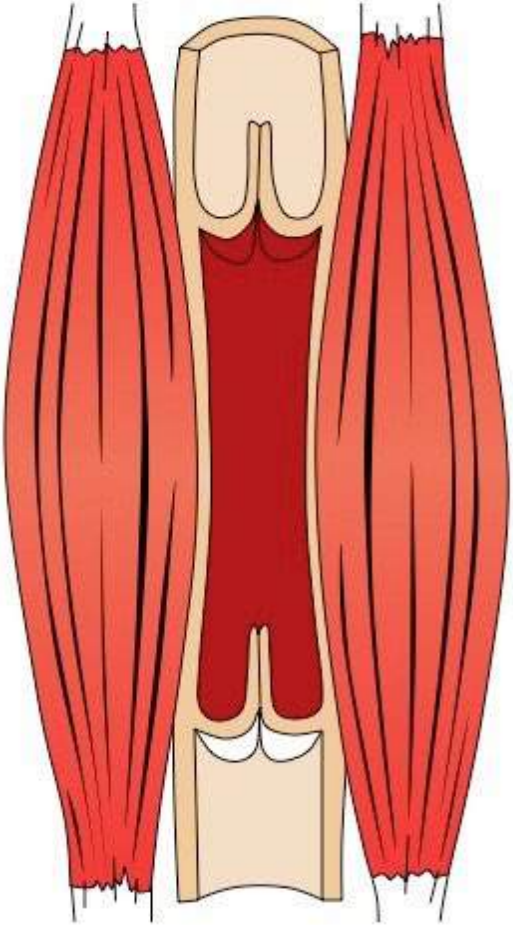


- Systolic pressure results from blood being forced into the arteries during ventricular systole.
- Diastolic pressure is the pressure in the arteries during ventricular diastole.
- As blood flows from the aorta into the arteries and arterioles, blood pressure falls.
 - In the capillaries blood flow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

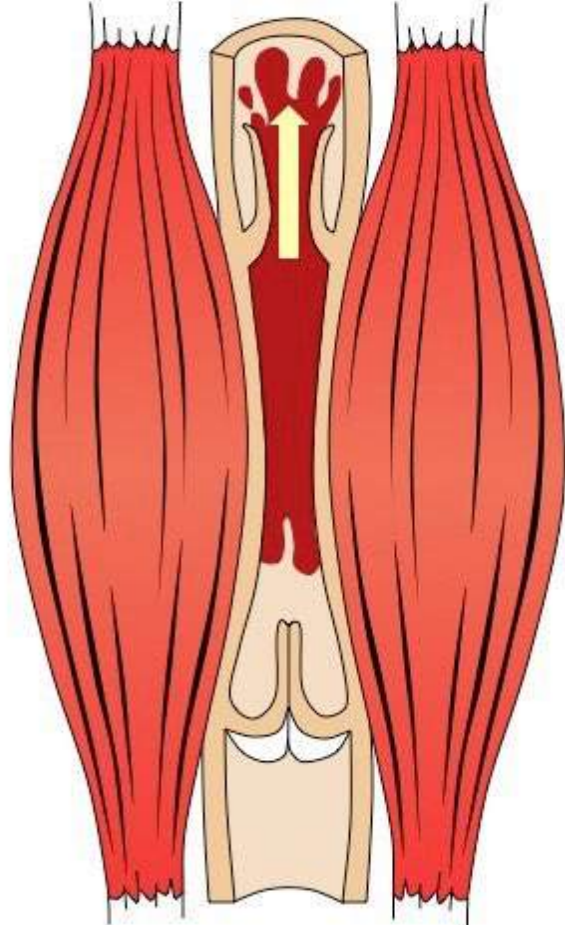


- Blood pressure can be measured with a **sphygmomanometer** (a pressure cuff), that determines the amount of pressure required to stop the flow of blood through an artery.
 - Blood pressure is expressed in mm of Hg.
 - Blood pressure consists of two numbers that **represent systolic and diastolic pressures**.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

Muscles relaxed,
valves closed



Muscles contracted,
valve above muscle opens

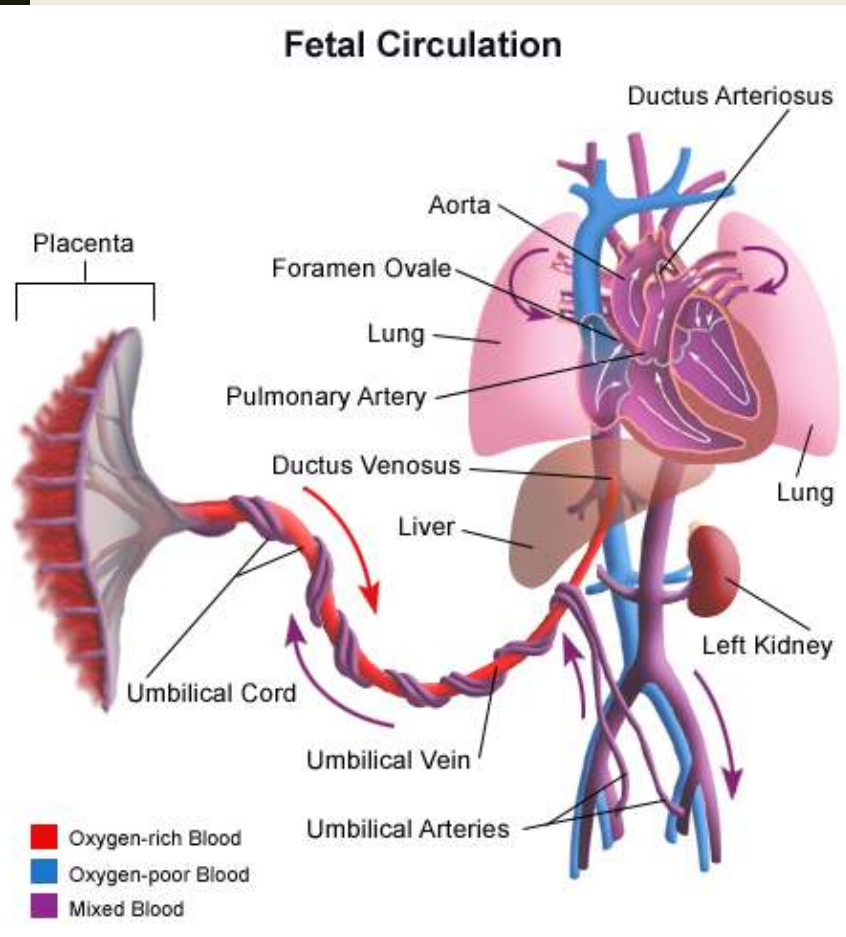


- Blood pressure in the veins is low, and **cannot efficiently move blood back to the heart by itself.**
 - When skeletal muscles near veins contract, **they put pressure on the veins and the blood they contain.**
 - Valves in the veins prevent backflow of blood, therefore **muscle contraction is sufficient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

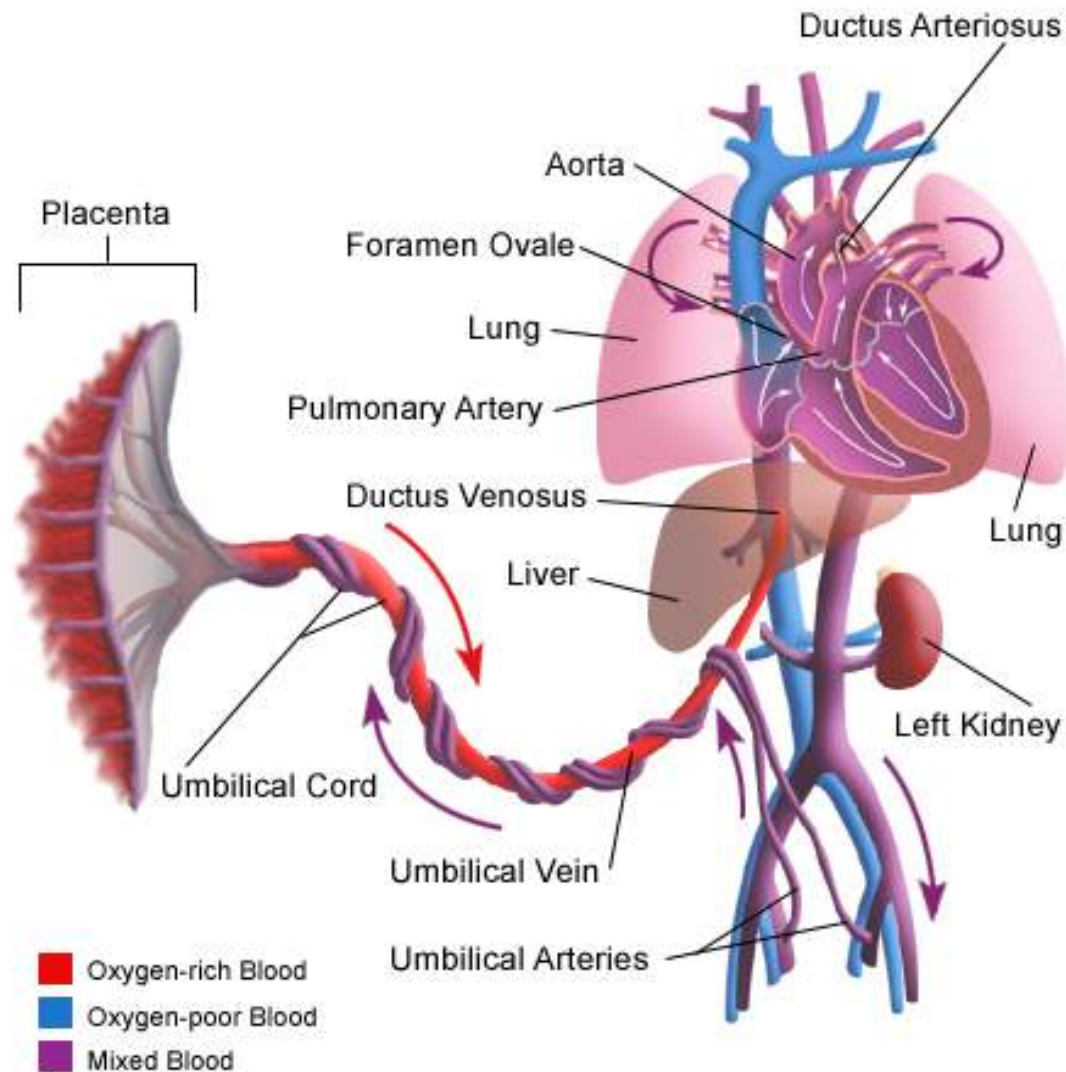


6.5 – FETAL CIRCULATION

- The fetus has circulatory features that are **not present in the adult circulation.**
 - These are necessary because the **fetus cannot use its 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.**

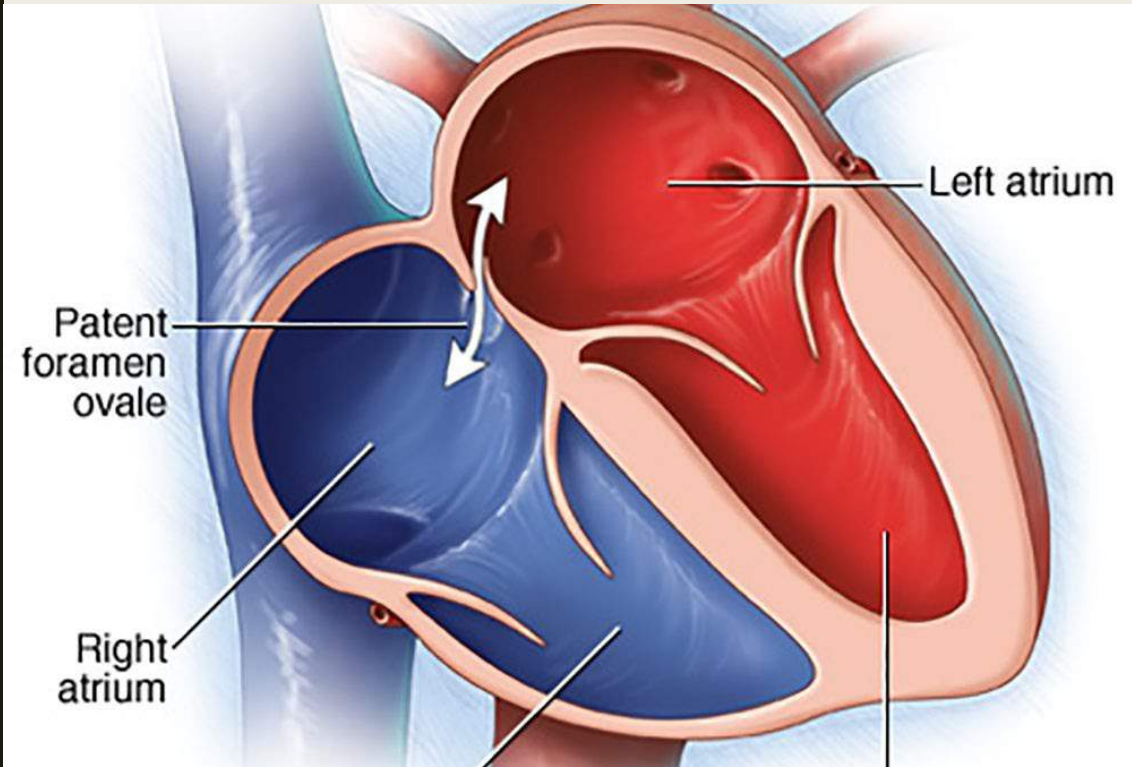


Fetal Circulation



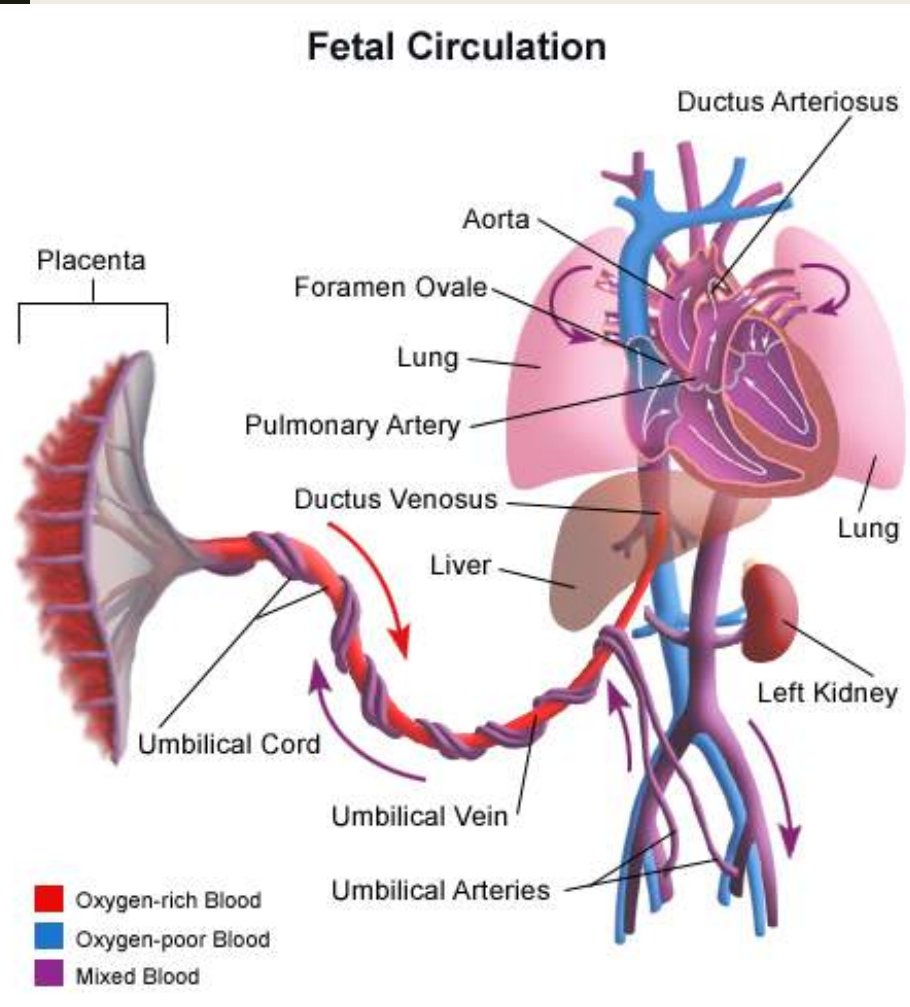
- Other features include:
 - Umbilical arteries that lead to the placenta.
 - The placenta facilitates exchange of gases and nutrients **between maternal blood and fetal blood.**
 - Umbilical veins carry blood rich in nutrients and **O₂** to the fetus.
 - The umbilical vein enters the liver, and then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

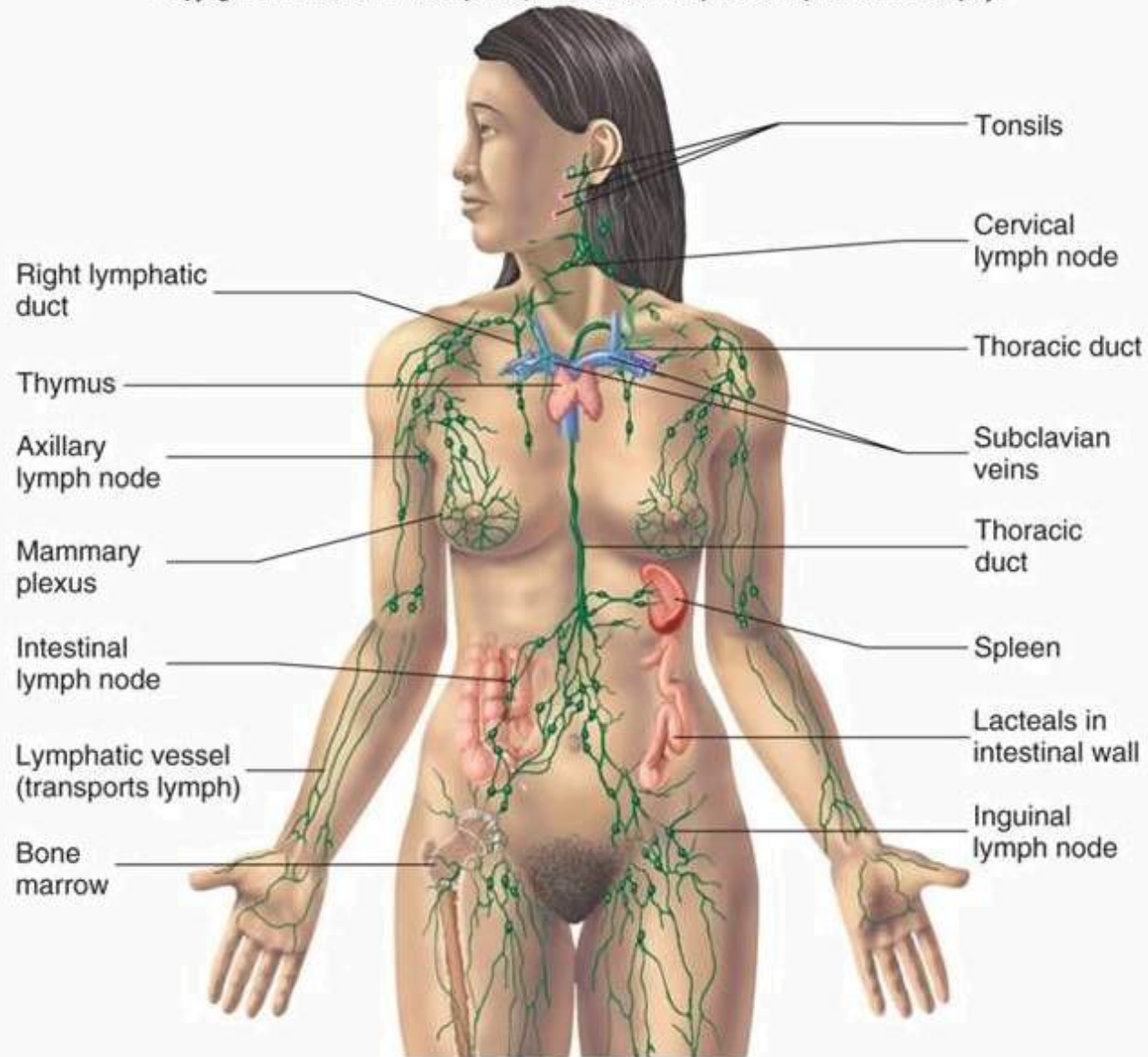
- Humans belong to the group of mammals called **placental mammals**.
 - It functions in **gas, nutrient, and waste exchange** between mother and baby.
 - The umbilical cord **stretches between placenta and fetus**.
 - The umbilical cord is the **lifeline of the fetus**.



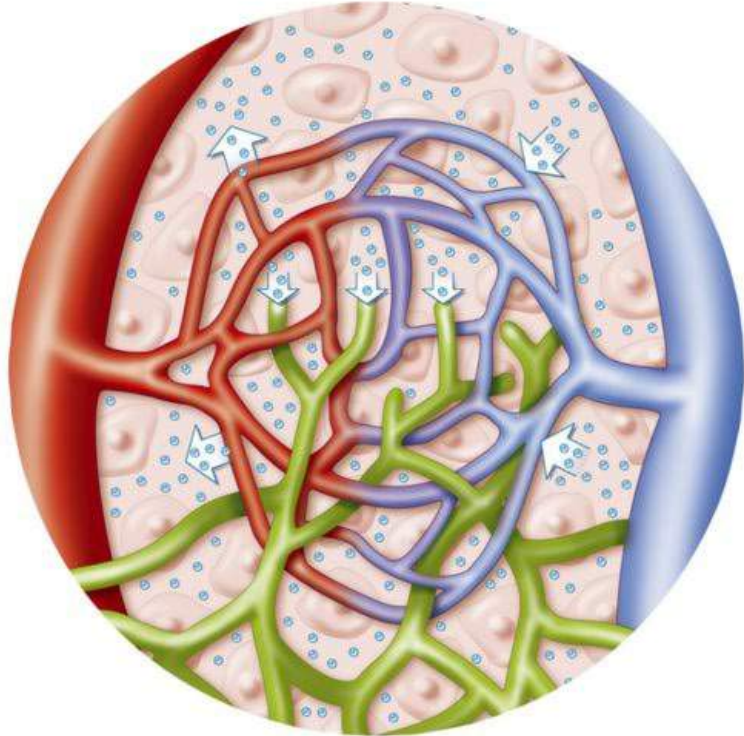
6.6 – THE LYMPHATIC SYSTEM

- The lymphatic system consists of **lymphatic vessels and the lymphoid organs.**
- This system is closely associated with the circulatory system and has 3 main functions:
 - Lymphatic capillaries **absorb excess tissue fluid and return it to the blood stream**
 - Lymphatic capillaries **absorb fats from the digestive tract and transport them to the bloodstream**
 - Lymphoid organs **help to defend the body against disease.**

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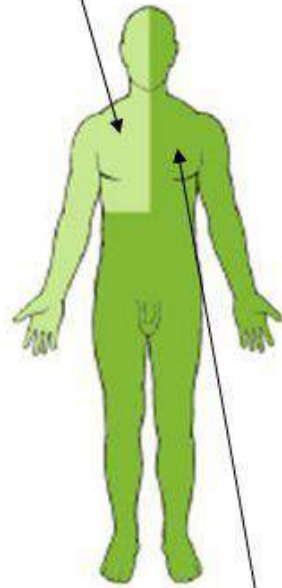
Lymphatic Vessels



- Lymphatic vessels form a one way system that **begins with the lymphatic capillaries.**
 - Most regions of the body are **richly supplied with lymphatic capillaries.**
 - These absorb excess tissue fluid, which is made of water and solutes.
 - This fluid is called lymph.

- Lymphatic capillaries **join to form lymphatic vessels**, that merge before entering one of two ducts:
 - **The thoracic duct**
 - Returns lymph collected from the body below the chest, the left arm, and the left side of the head and neck.
 - **Feeds into left subclavian vein.**
 - **The right lymphatic duct**
 - Returns lymph from the right arm, and right side of the head and neck.
 - **Feeds into right subclavian vein.**

Drainage of right
Lymphatic duct

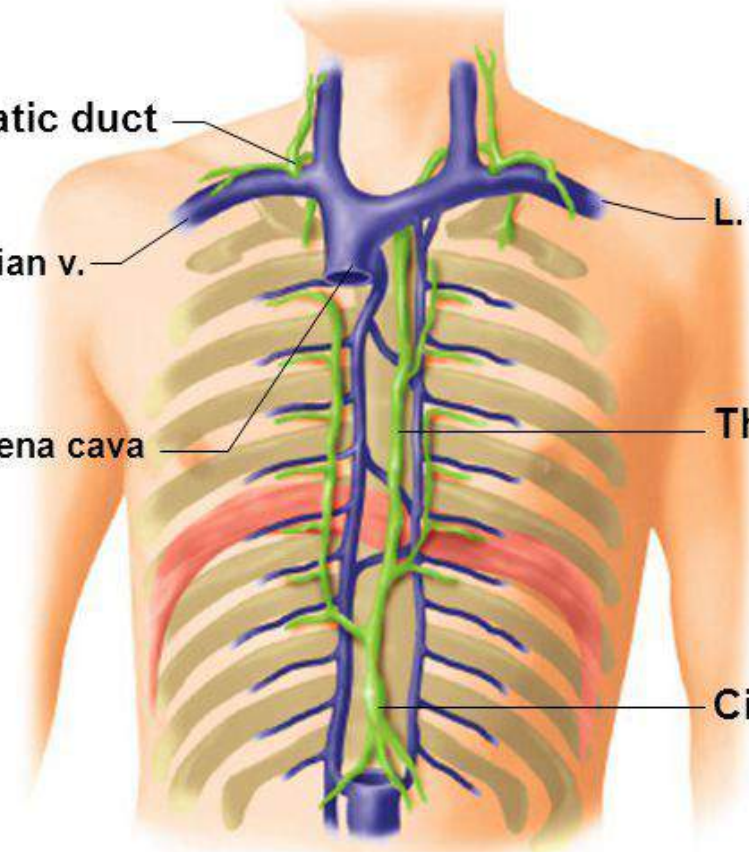


Drainage of thoracic
duct (left lymphatic duct)

R. lymphatic duct

R. subclavian v.

Superior vena cava

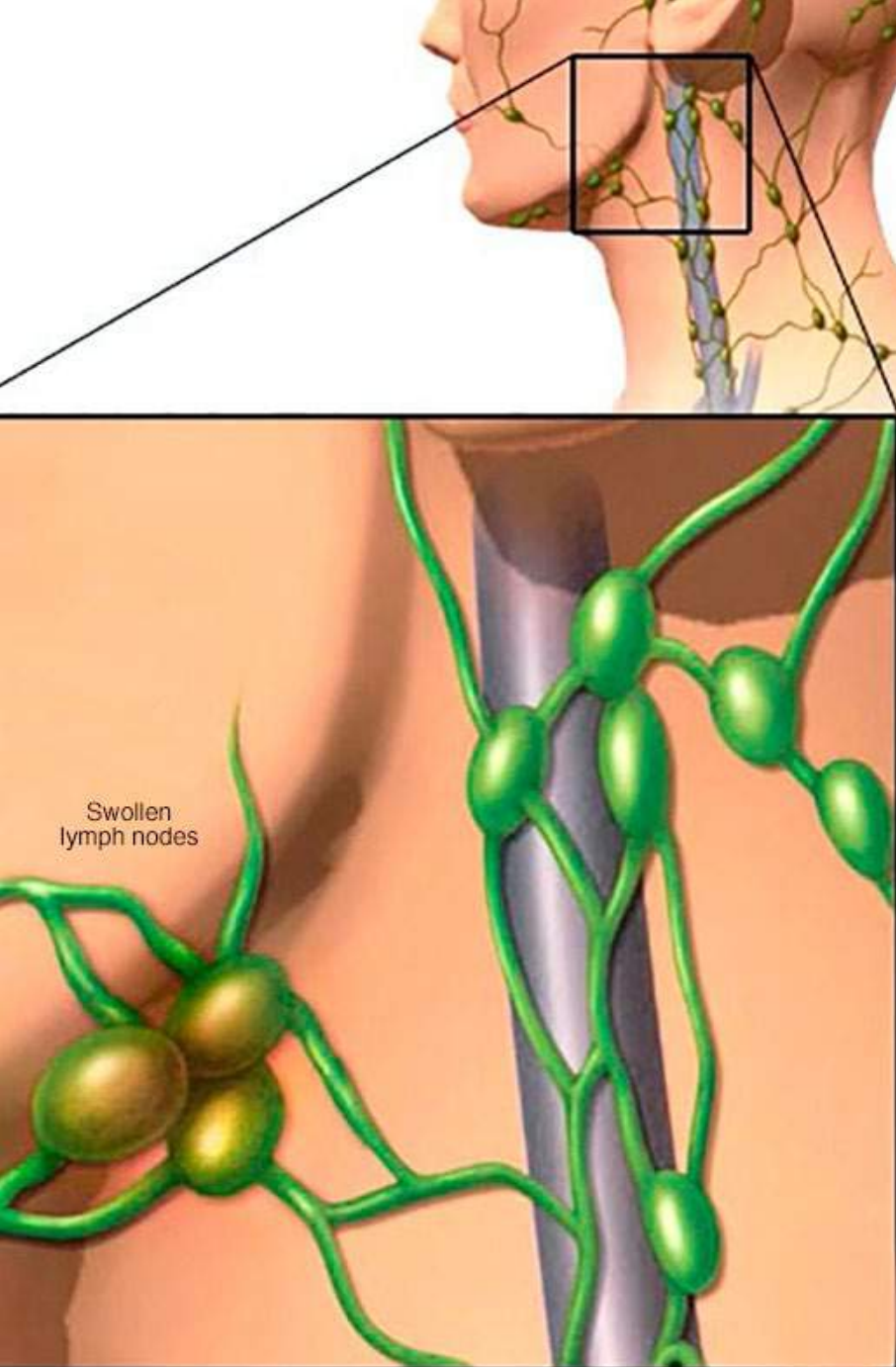


L. subclavian v.

Thoracic duct

Cisterna chyli

Lymph drainage from left and right sides of the body is different



- Lymph travels through lymph nodes, where **foreign material can be recognized by the immune system.**
- The movement of lymph is dependent upon **skeletal muscle contraction.**
 - Backflow is **prevented by valves.**
- Edema is localized swelling caused by accumulation of tissue fluid that has **not been collected by the lymphatic system.**

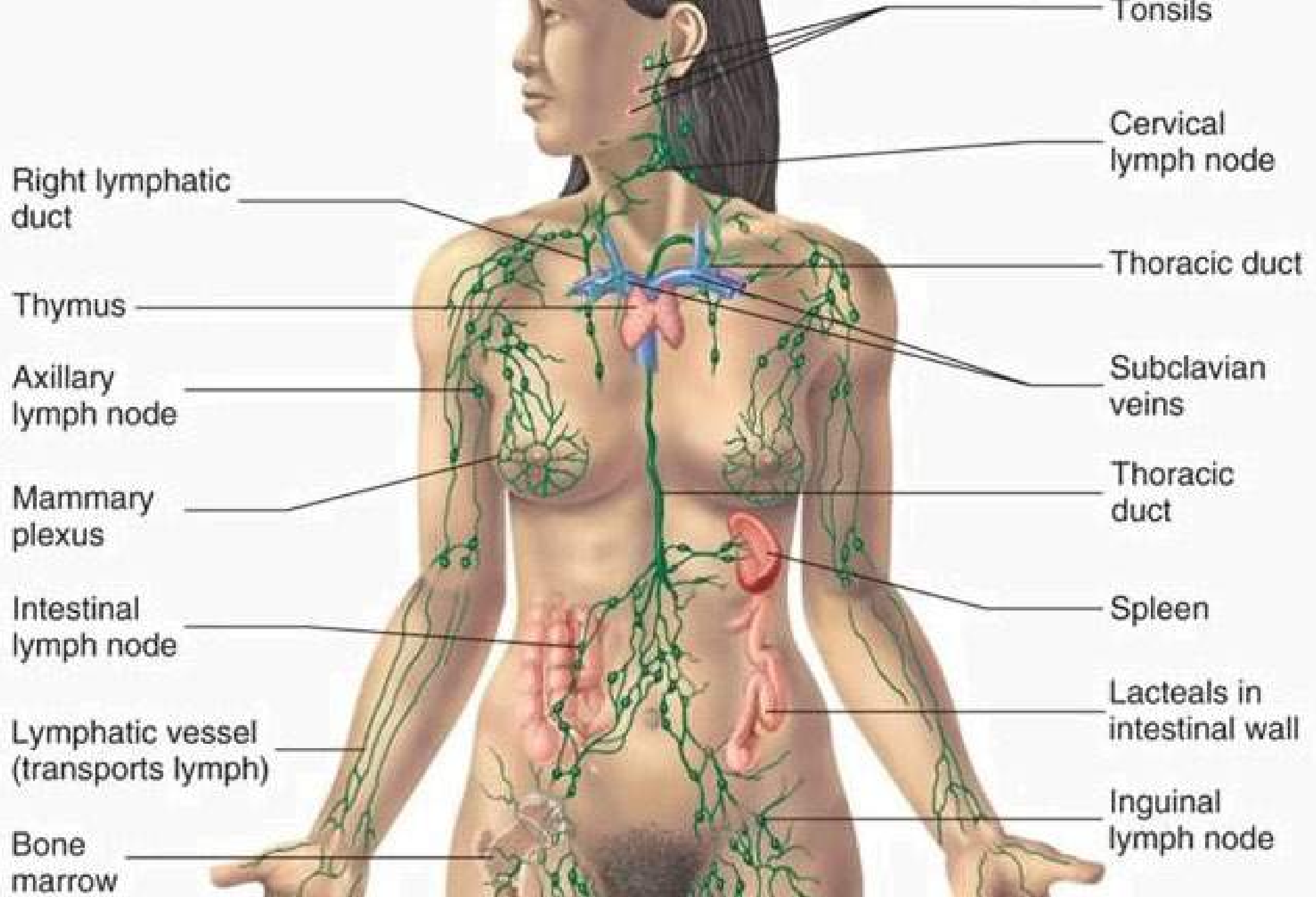


Lymphoid Organs

- Lymphoid organs contain a large number of **lymphocytes** (a type of WBC responsible for adaptive immunity)
- There are two types of lymphoid organs:
 - Primary lymphoid organs: **red bone marrow and thymus**
 - Where **lymphocytes develop and mature**
 - Secondary lymphoid organs: **lymph nodes and spleen.**
 - Where **lymphocytes become activated**

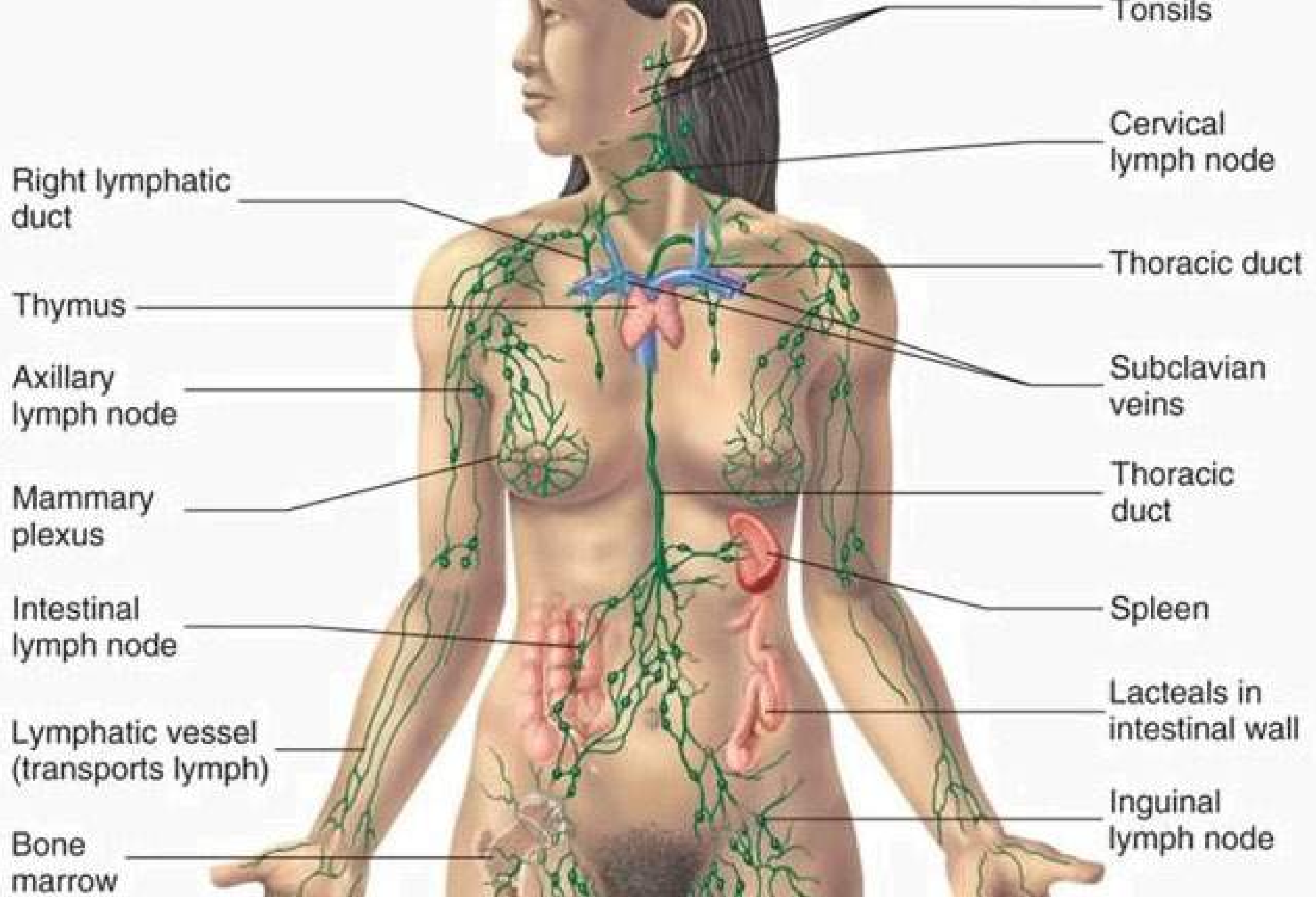
Primary Lymphoid Organs

- In adults, red bone marrow is found in the skull, sternum, ribs, clavicle, pelvis, and vertebrae.
 - **B cells and T cells are produced here.**
- The thymus is located between the trachea and the sternum above the heart.
 - The thymus releases the **hormone thymosins, that help in the differentiation of T cells.**



Secondary Lymphoid Organs

- The spleen is located **behind the stomach**.
 - Most of it consists of blood vessels and sinuses where **macrophages remove old and defective blood cells**.
 - It can also react to **foreign invaders in the blood**.
- Lymph nodes occur along **lymphatic vessels**.
 - They are packed with B and T cells, and **macrophages that engulf pathogens**.
 - Swollen or tender lymph nodes can indicate the **body is fighting an infection**.



6.7 – INNATE & ADAPTIVE IMMUNITY

- Immunity refers to a condition where the body is **protected from various threats.**
- There are two main types of immunity:
 - Innate immunity: mechanisms that are **fully functional without previous exposure to these substances.**
 - Adaptive immunity: is initiated and amplified after **specific recognition of these substances.**

Innate Immunity

- Mechanisms of innate immunity are divided into four types:
 - Physical & chemical barriers
 - Inflammation
 - Phagocytes & natural killer cells
 - Protective pathogens

Physical & Chemical Barriers

- Skin and mucous membranes **lining the respiratory, digestive, and urinary tracts** serve as mechanical barriers.
- Secretions of oil glands in the skin contain chemicals that **weaken or kill certain bacteria on the skin.**
- The stomach has an **acidic pH.**
- Bacteria that reside in the intestine and vagina remove **nutrients and block binding sites for pathogens.**

Inflammatory Response

- Damage to tissue initiates a series of events known as the inflammatory response.
 - **This helps prevent infection and initiates an immune response.**
- An inflamed area has four signs:
 - **Redness**
 - **Heat**
 - **Swelling**
 - **Pain**

- Most of these signs are due to **capillary changes** in the damaged area.
- Mast cells are a type of immune cell that **respond to damage by releasing histamine**.
- This causes capillaries to dilate and become more permeable **allowing fluids to escape**.
- Increased blood flow also causes **skin to redden and feel warm**.
- **Macrophages and dendritic cells release cytokines** that influence the activity of other immune cells.

FIG 10.23 – Inflammatory Response

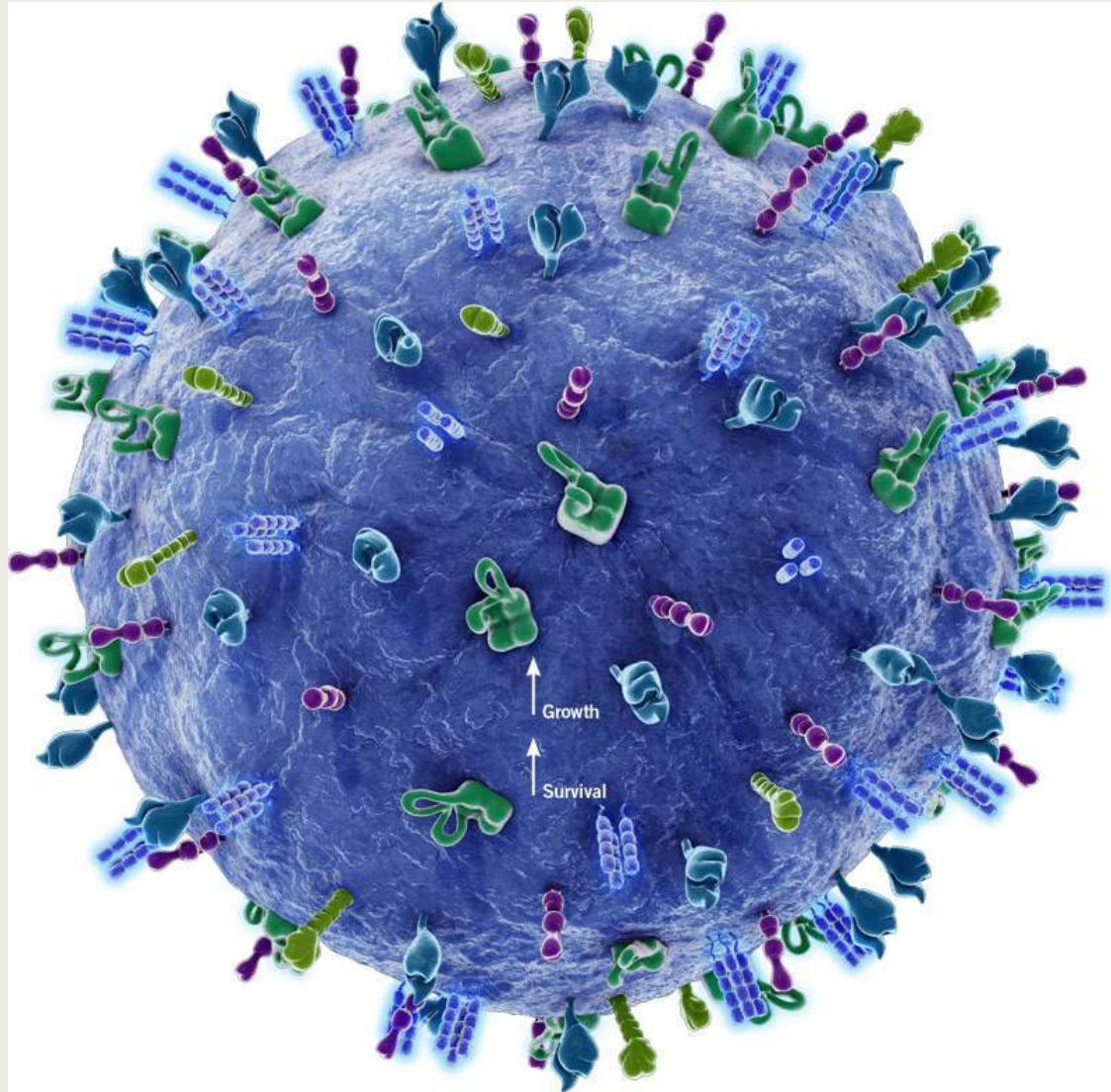
Phagocytes & Natural Killer Cells

- At inflammation sites, types of WBC's migrate through the walls of dilated capillaries.
 - **Phagocytes eat pathogens**
 - Neutrophils enter an inflamed area and **accumulate to form pus.**
 - When a neutrophil or macrophage encounters a pathogen, it will engulf the pathogen and **fuse it with a lysosome inside the cell.**

- Natural killer cells are large lymphocyte-like cells that kill some **virus-infected and cancer cells by cell-to-cell contact.**
- NK cells seek out and kill cells that lack a “self” **MHC-I molecule on the cells surface.**
 - Some virus-infected and cancer cells lack the MHC-I molecules and are **susceptible to being killed by NK cells.**

Adaptive Immunity

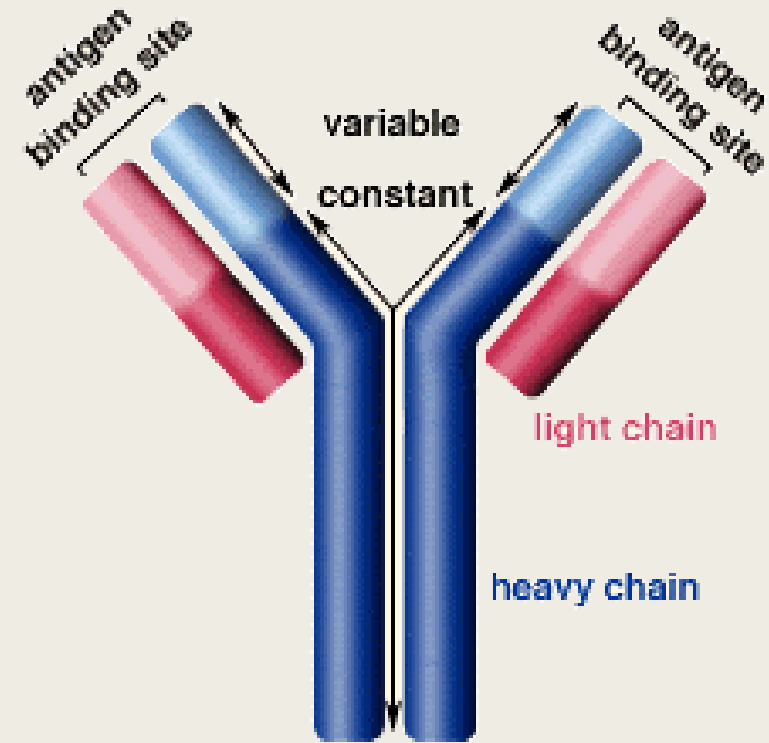
- When innate defences have failed to prevent an infection, adaptive immunity comes into play.
 - This system **recognizes, responds to, and usually eliminates antigens from the body.**
 - An antigen is any molecule that **stimulates an adaptive immune response.**
 - Adaptive defences usually take 5-7 days to become fully activated, and may **last for many years.**



- Adaptive immune system depends on the activity of B and T cells, because they are capable of **recognizing antigens due to their antigen receptors.**
 - Each lymphocyte only has **one type of receptor.**

B Cells & Antibody-Mediated Immunity

- When B cells are activated, they divide to become **plasma cells** that are specialized to secrete **antibodies**.
 - Antibodies are typically Y-shaped molecules that **bind to antigens**.
 - This marks the **invading cell** for destruction.



T Cells & Cell-Mediated Immunity

- There are two major types of T cells:
 - **Helper T cells**
 - **Cytotoxic T cells**
- Each has a receptor that can recognize an antigen fragment in combination with an MHC molecule.
 - Helper T cells can only recognize the antigen and **recruit other immune cells to destroy the pathogen.**
 - Cytotoxic T cell recognize an antigen and **can kill the cells they recognize.**

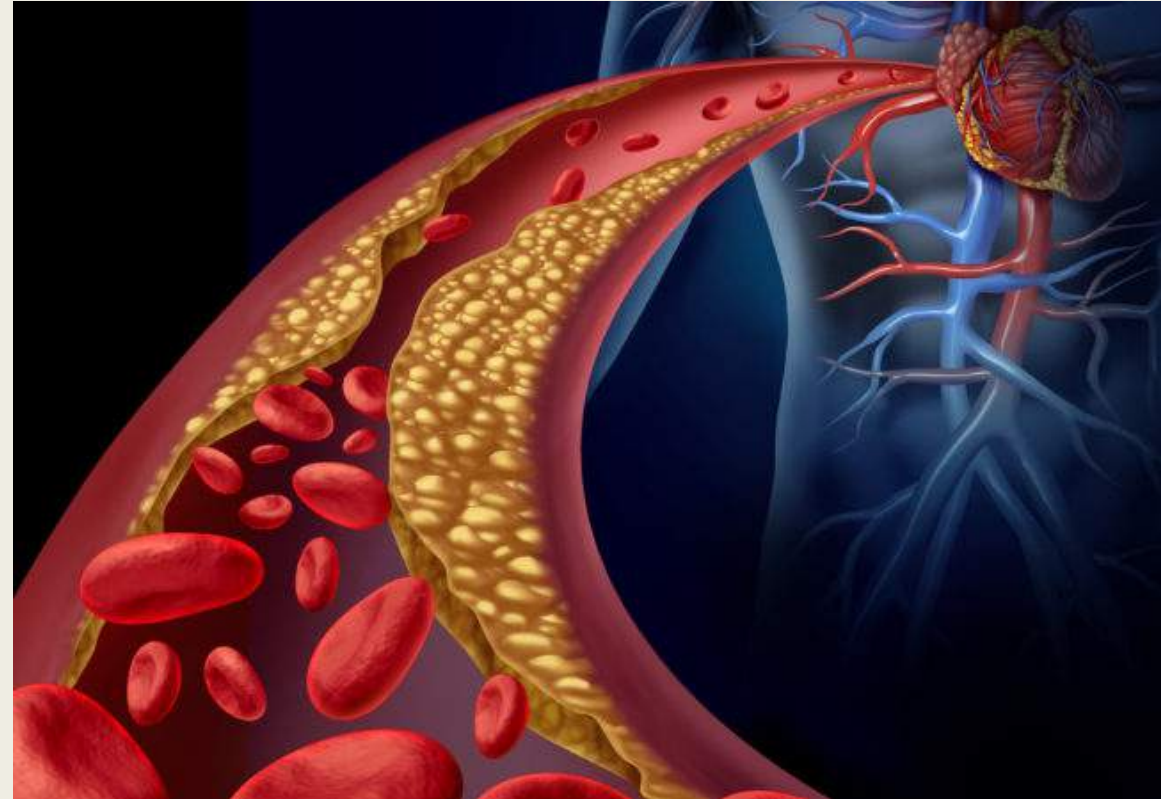
6.8 – CIRCULATORY SYSTEM DISORDERS

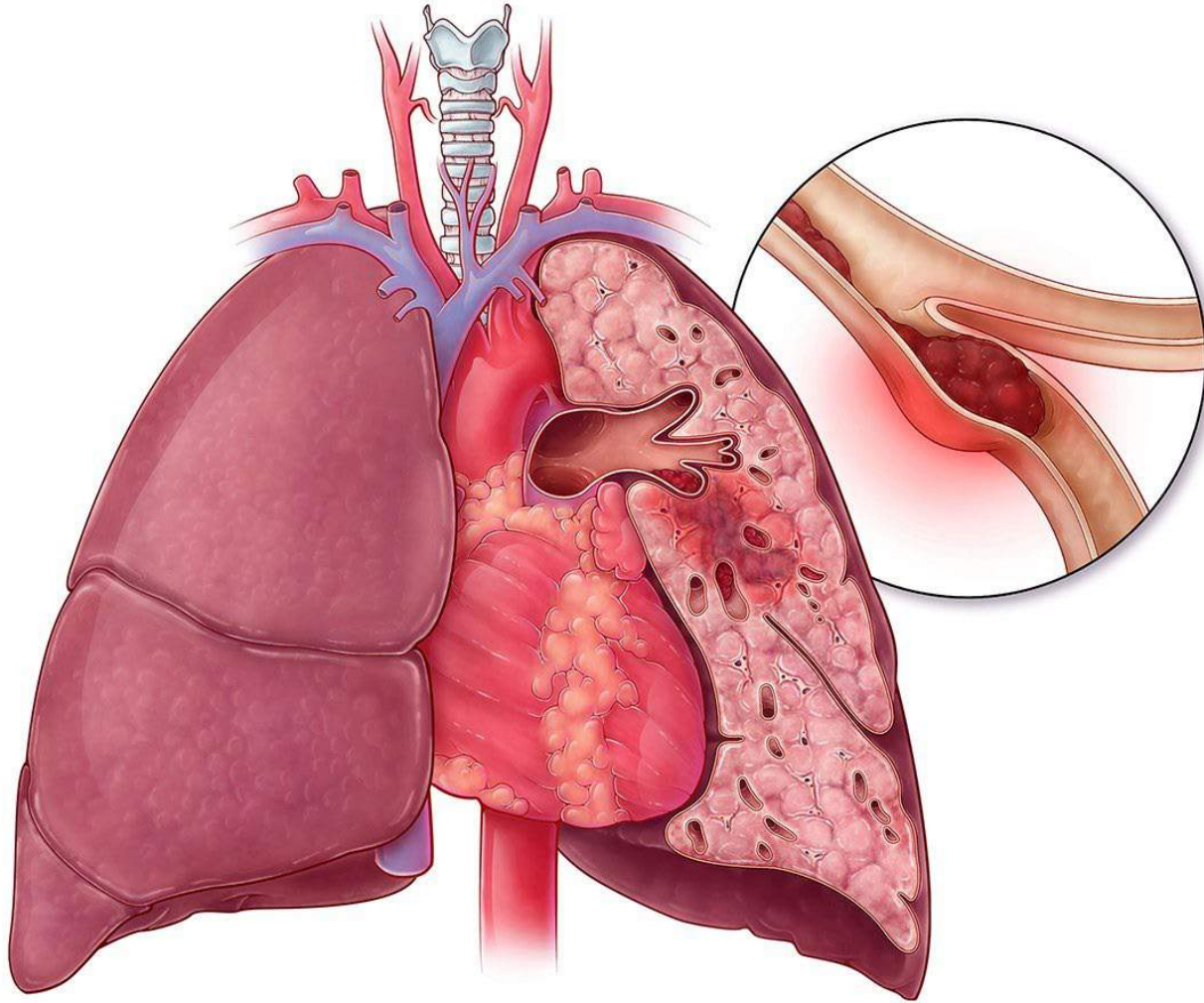
- Cardiovascular diseases are the leading cause of **untimely death** in **western countries**.
- Research efforts have resulted in **improved diagnosis, treatment, and prevention**.



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.**





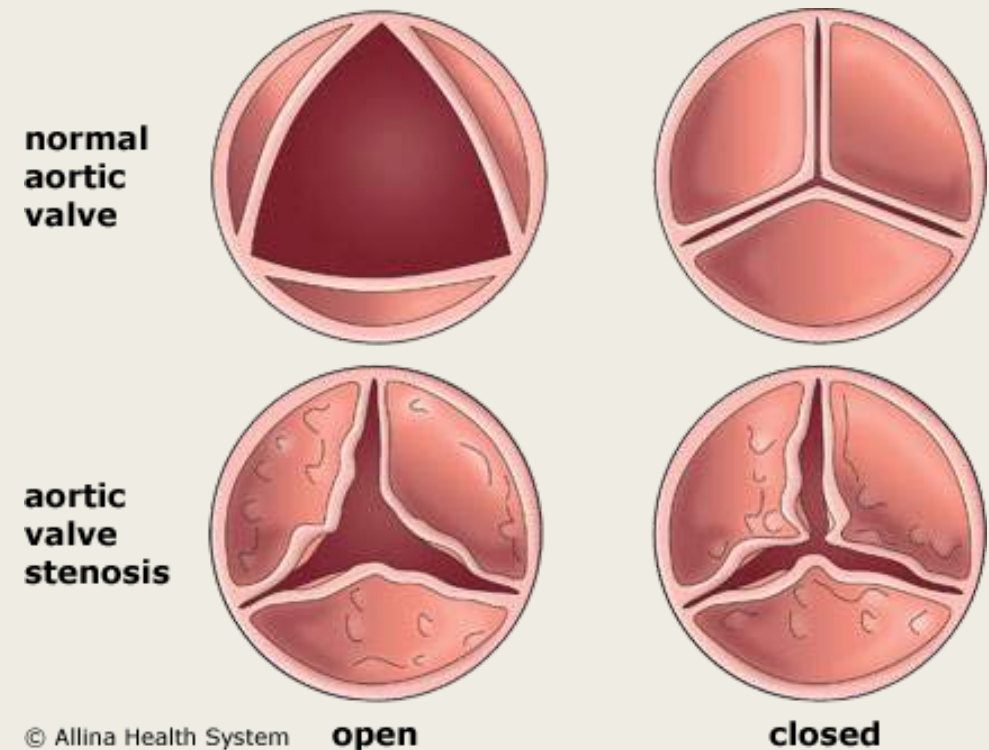
- When the clot is stationary it is called a thrombus, **but if it dislodges it becomes an embolus.**
- Thromboembolism, is a clot that is carried in the blood stream, **then blocks blood flowing through a blood vessel.**

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.**

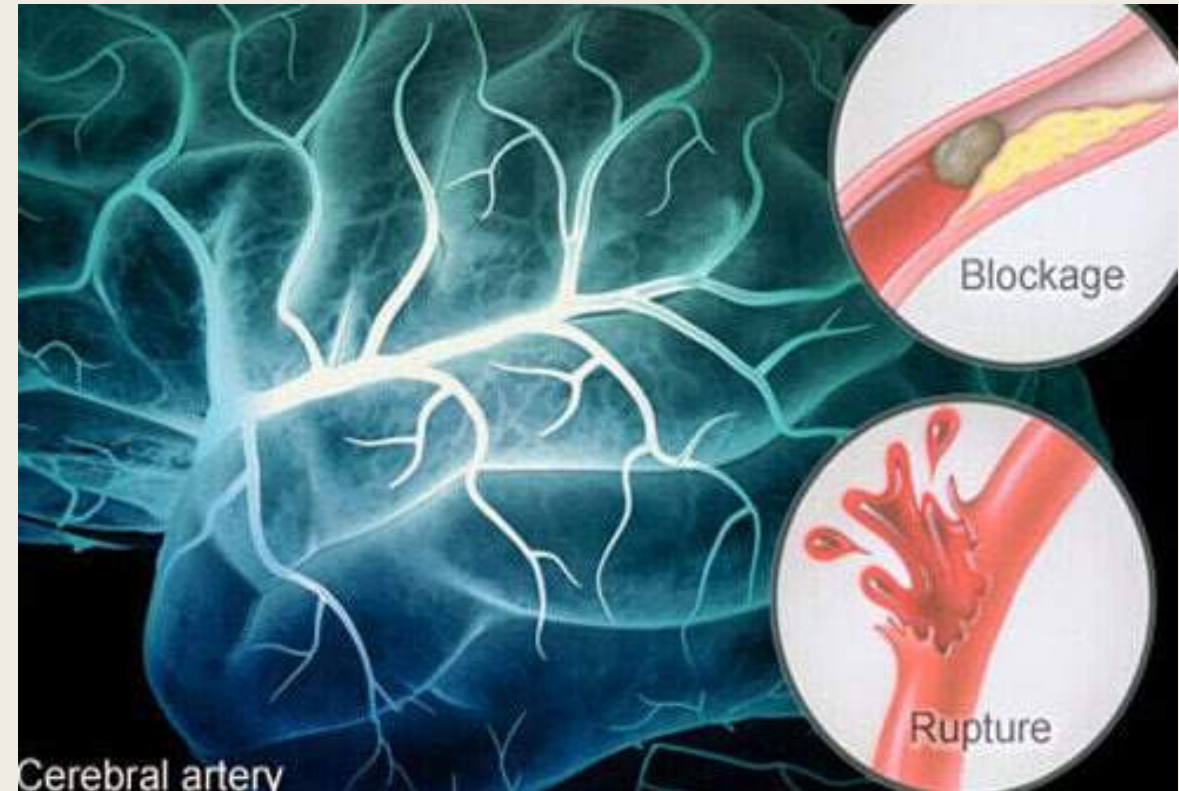
Heart Valve Disease

- 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

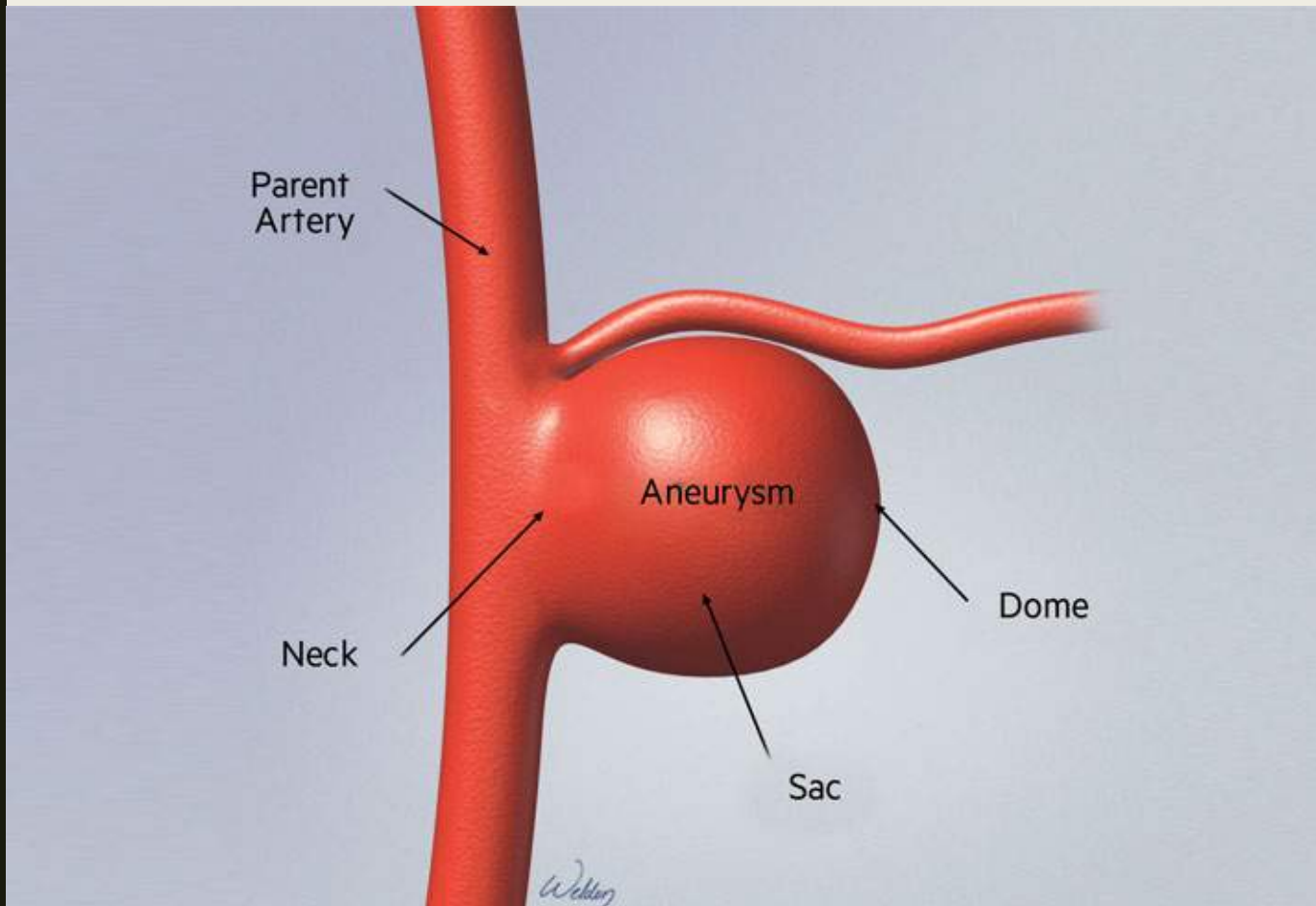
- A stroke often results when an arteriole in the brain bursts or is blocked by an embolus.
 - The lack of O₂ causes a portion of the brain to die, and paralysis or death can result.





- **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.**