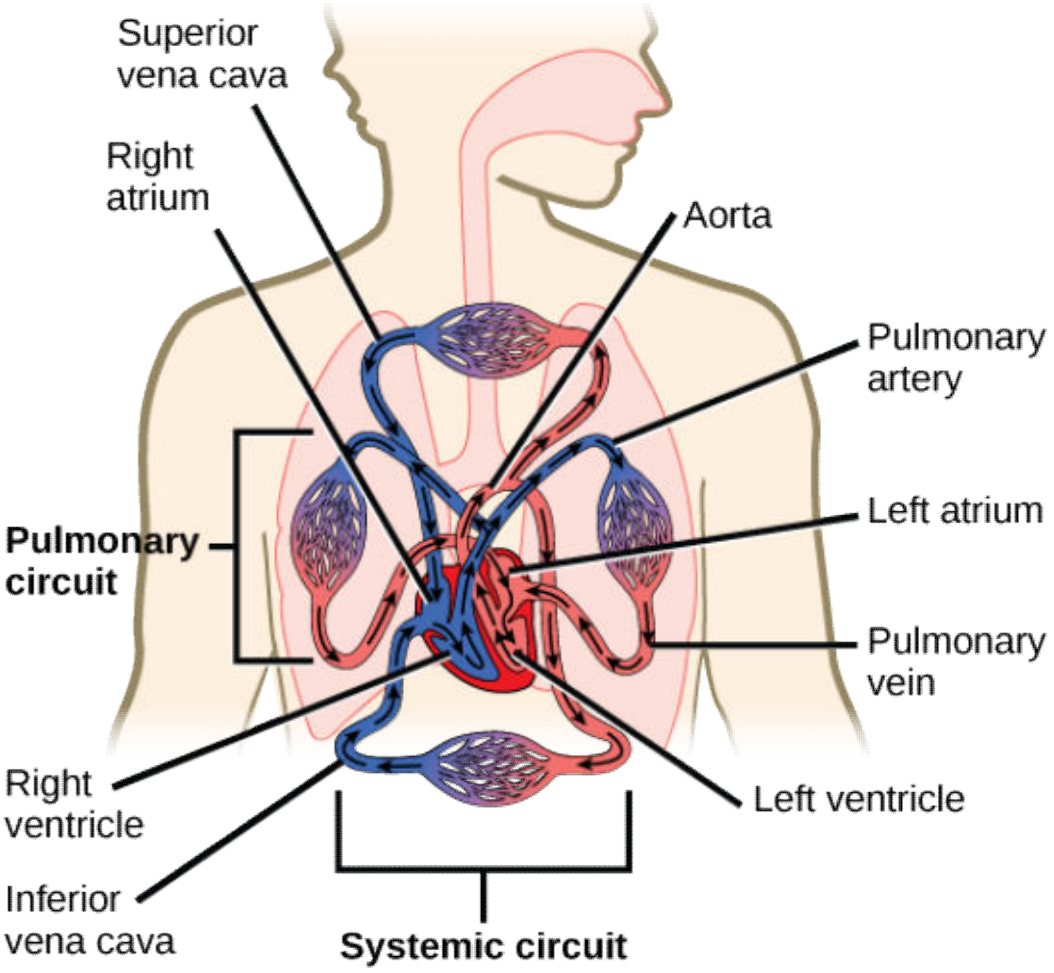
11 Transport in humans

11.1 Circulatory system.

Describe the circulatory system as a system of blood vessels with a pump and valves to ensure one-way flow of blood.

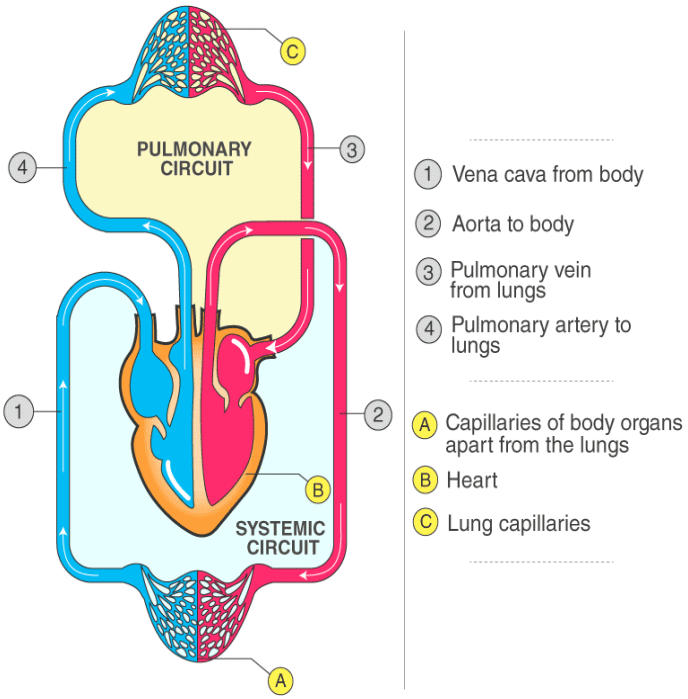
The circulatory system is a complex network of blood vessels, a pump, and valves working together to facilitate the one-way flow of blood throughout the body.
Right atrium of the heart receives deoxygenated blood through vena cava whereas the left atrium receives oxygenated blood from the lungs through pulmonary veins. When atria contract the blood moves to ventricles. After that ventricles contract which forces bicuspid and tricuspid valve to close. It prevents back flow of blood from ventricles to Atria. Oxygenated blood from left ventricle is carried to the body through aorta whereas pulmonary arteries carry oxygenated attacked blood to the lungs from right ventricle.



Describe a double circulation as a system in which blood passes through the heart twice for each complete circuit.

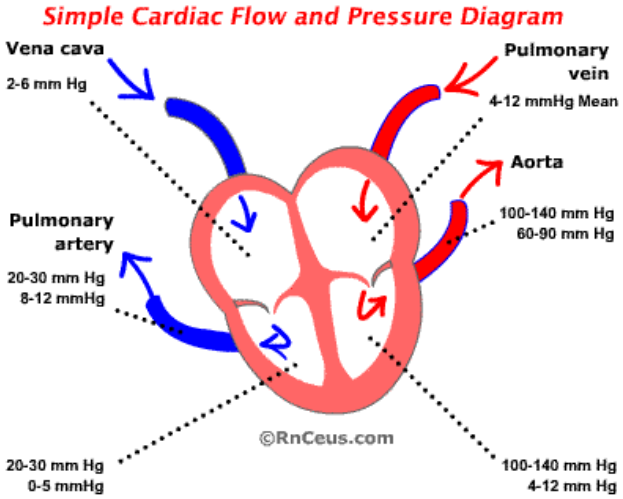
Understand that a double circulation provides a low pressure circulation to the lungs and a high pressure circulation to the body tissues.

Double circulation is a cardiovascular system in which blood passes through the heart twice for each complete circuit This design enhances the efficiency of oxygenation and nutrient delivery to body tissues.



- The heart has two distinct circuits: pulmonary circulation and systemic circulation.
- Pulmonary circulation involves the right side of the heart pumping blood to the lungs for oxygenation.
- Systemic circulation involves the left side of the heart pumping oxygenated blood to the body tissues.
- This double circuit ensures efficient oxygenation and nutrient delivery while maintaining separation between oxygen-rich and oxygen-poor blood.
- On average red blood cell would go around the whole circulation in 45 seconds.

The concept of double circulation encompasses the establishment of two distinct circuits, each tailored to meet specific requirements and adjusting to the diverse demands of various organs throughout the body. A Double circulation has the advantage of maintaining a high blood pressure to all the major organs of the body. The right side of the heart collects blood from the body and builds up the pressure to send it to lungs to be oxygenated. As lungs are at a shorter distance from the heart so lower blood pressure is required for the transport of blood to lungs. The left side of the heart receives oxygenated blood from the lungs builds up the pressure again, but higher and pumps the oxygenated blood to the body. For this movement of blood the blood has to be carried too far apart in the body so it must be at a higher pressure.

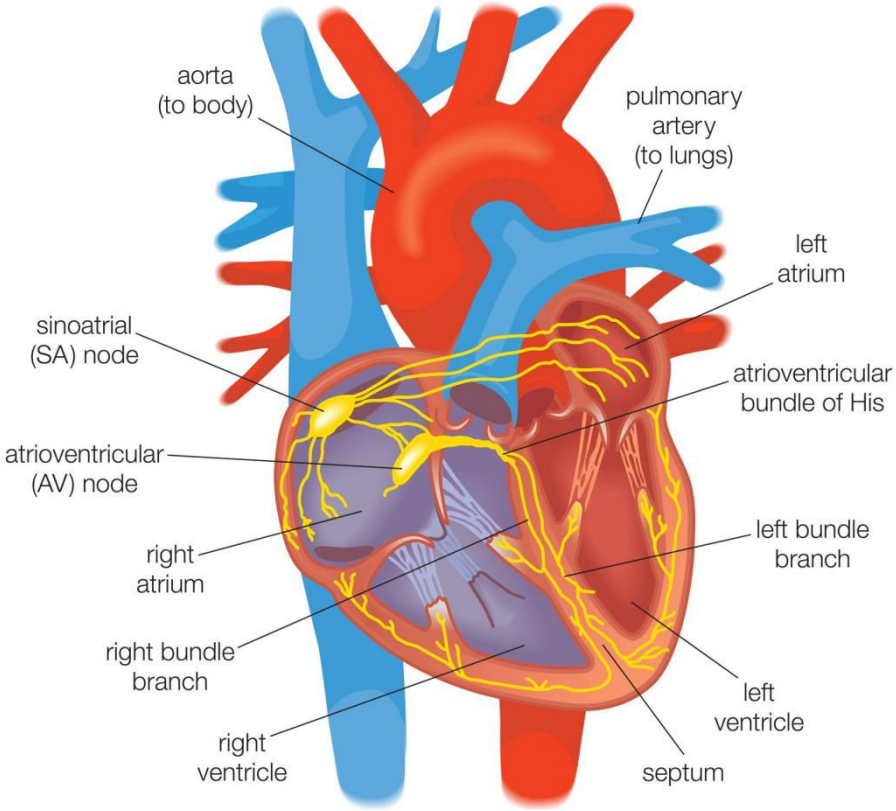


11.2 Heart

Identify the structures of the mammalian heart, limited to: the muscular wall, the septum, the left and right ventricles and atria, atrioventricular and semilunar valves and coronary arteries.

Structures of the human heart are explained in the following.

- The heart is made up of thick muscular tissue surrounded by a double-walled sac called a pericardium. Cardiac muscles are responsible for contracting and pumping blood throughout the circulatory system.
- The septum is a partition within the heart that separates it into left and right sides, ensuring the distinct flow of oxygenated and deoxygenated blood.
- There are four Chambers of the heart right and left atria and ventricles.
- The Atria are the upper chambers of the heart. These are relatively thin, collects blood returning to the heart and pump it into the ventricles.
- The heart has two ventricles: the left ventricle, which pumps oxygenated blood to the body, and the right ventricle, responsible for pumping deoxygenated blood to the lungs.
- Between both the atria and the ventricle there is a valve called as atrioventricular valve.
- Semilunar valves, including the pulmonary and aortic valves, are situated at the exits of the ventricles. They prevent blood from flowing back into the ventricles after contraction.
- The heart muscle is supplied with food and oxygen by the coronary arteries.



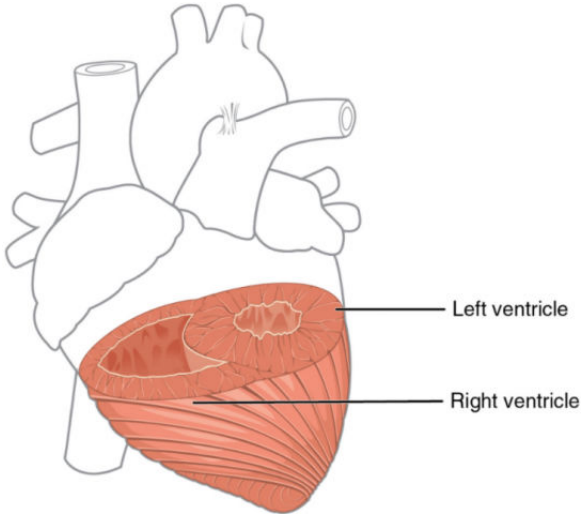
Explain the relative thickness:

(a) of the muscle walls of the left and right ventricles.
(b) of the muscle walls of the atria compared to those of the ventricles.

Muscle Walls of the Left and Right Ventricles.

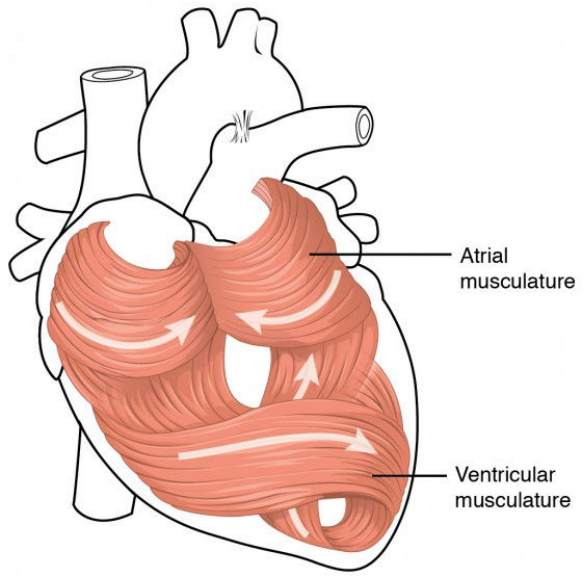
The left ventricle exhibits a greater thickness in its muscular wall when compared to the right ventricle. This increased thickness is essential due to the left ventricle's role in pumping oxygenated blood throughout the entire body via the systemic circulation. The heightened pressure demands a more robust contraction, hence necessitating a thicker muscular wall in the left ventricle.

Conversely, the right ventricle primarily propels deoxygenated blood to the lungs for oxygenation. Given the shorter distance and lower pressure involved in pulmonary circulation, the muscular wall of the right ventricle is relatively thinner. This variation in wall thickness reflects the specific functional demands and pressures associated with each ventricle's respective circulatory pathway.



Muscle Walls of the Atria Compared to Ventricles.

Atria are blood receiving chambers so they have walls thinner than the walls of the ventricles. Ventricles contract and distribute the blood to the body so to flow the blood at higher pressure in the arteries. The ventricles have thicker walls for the purpose of generating a high blood pressure.



Describe the functioning of the heart in terms of the contraction of muscles of the atria and ventricles and the action of the valves in a heartbeat.

The cardiac cycle refers to the complete sequence of events that occur during one heartbeat. It involves the contraction and relaxation of the heart's chambers and the opening and closing of the heart valves, resulting in the rhythmic pumping of blood through the circulatory system.

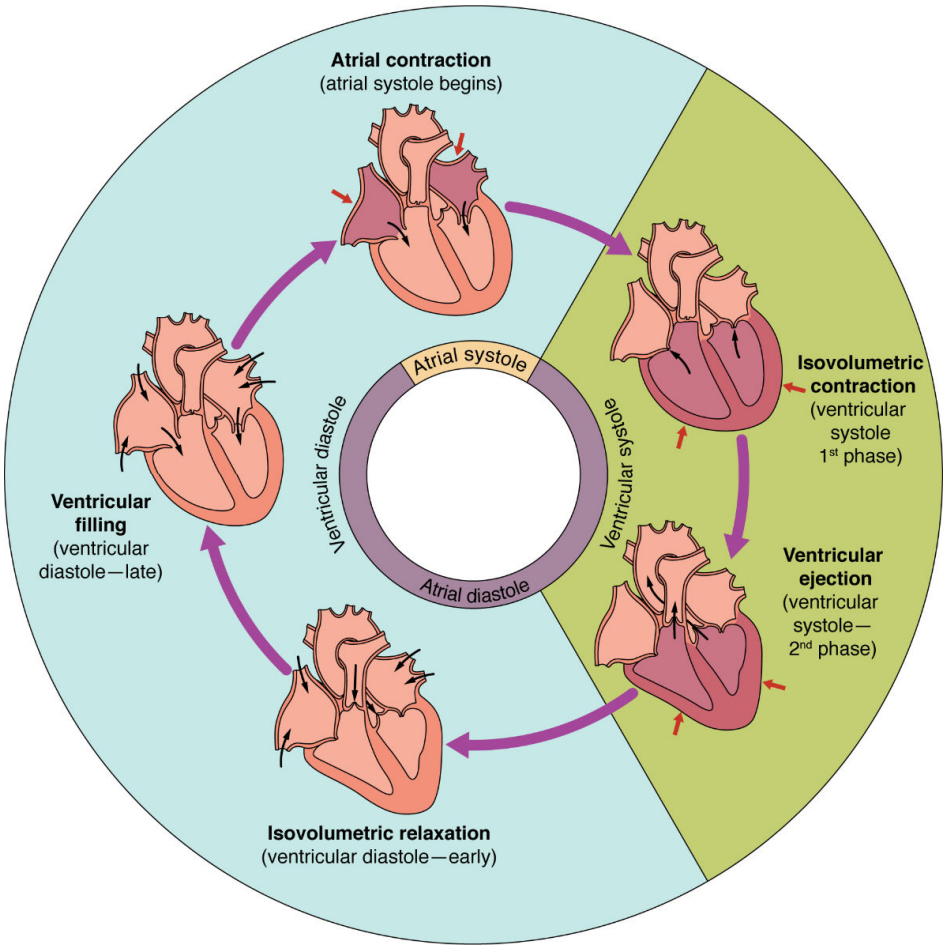
The cycle starts when the whole heart is relaxed. The right atrium receives blood from the superior and inferior vena cava and the left atrium receives blood from the pulmonary veins.

The next stage is atrial systole. The muscles in the walls of the left and right atria contract simultaneously. This contraction forces blood into the ventricles through the open atrioventricular (AV) valves (tricuspid and bicuspid/mitral valves).

Next, there a is brief pause followed by the muscle contraction in the walls of the left and right ventricles. This contraction results in increased pressure, causing the atrioventricular valves to close to prevent backflow of blood into the atria. This is called ventricular systole.

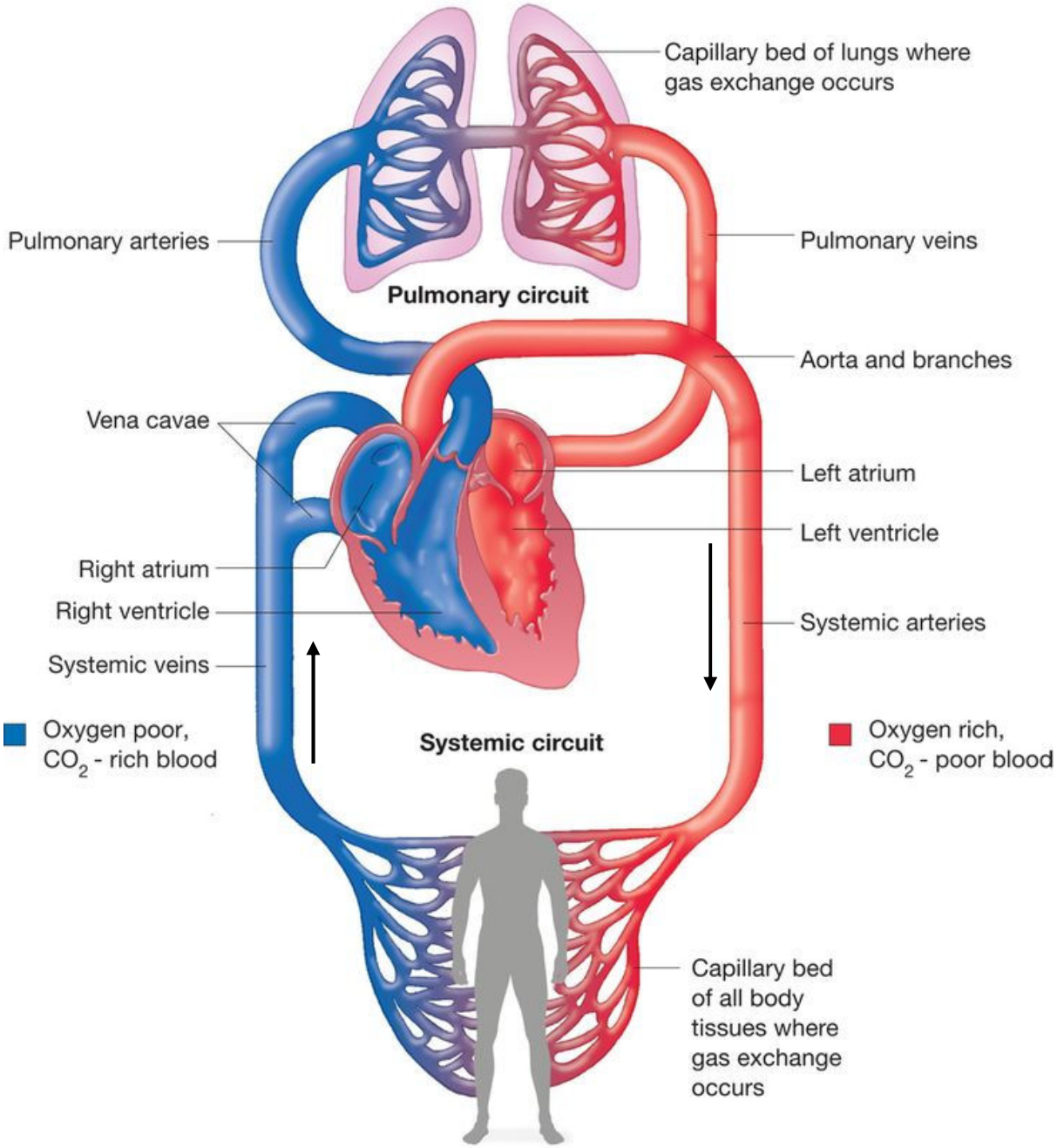
As the pressure in the ventricles increases it causes the semilunar valves in the pulmonary artery and Aorta to open. Blood is ejected into the pulmonary artery and aorta, respectively for distribution to the lungs and the rest of the body.

Next the ventricles relax, reducing pressure within them. Semilunar valves close to prevent the backflow of blood from the pulmonary artery and aorta into the ventricles. This is called as ventricular diastole. The closing of atrioventricular valve produces the "lub" sound and the closing of semilunar valves produces the "dub" sound. Together these produces the "lub dub" sound of the heart.



State that blood is pumped away from the heart in arteries and returns to the heart in veins.

Blood, carrying oxygen, is pumped by the heart into arteries, branching throughout the body. Arteries carry oxygenated blood (except pulmonary artery) away from the heart. After delivering oxygen to tissues, deoxygenated blood (except pulmonary vein) returns to the heart through veins. Veins gradually merge, forming larger vessels on the way back to the heart. This cyclical process ensures efficient circulation and facilitates the exchange of oxygen, nutrients, and waste products.

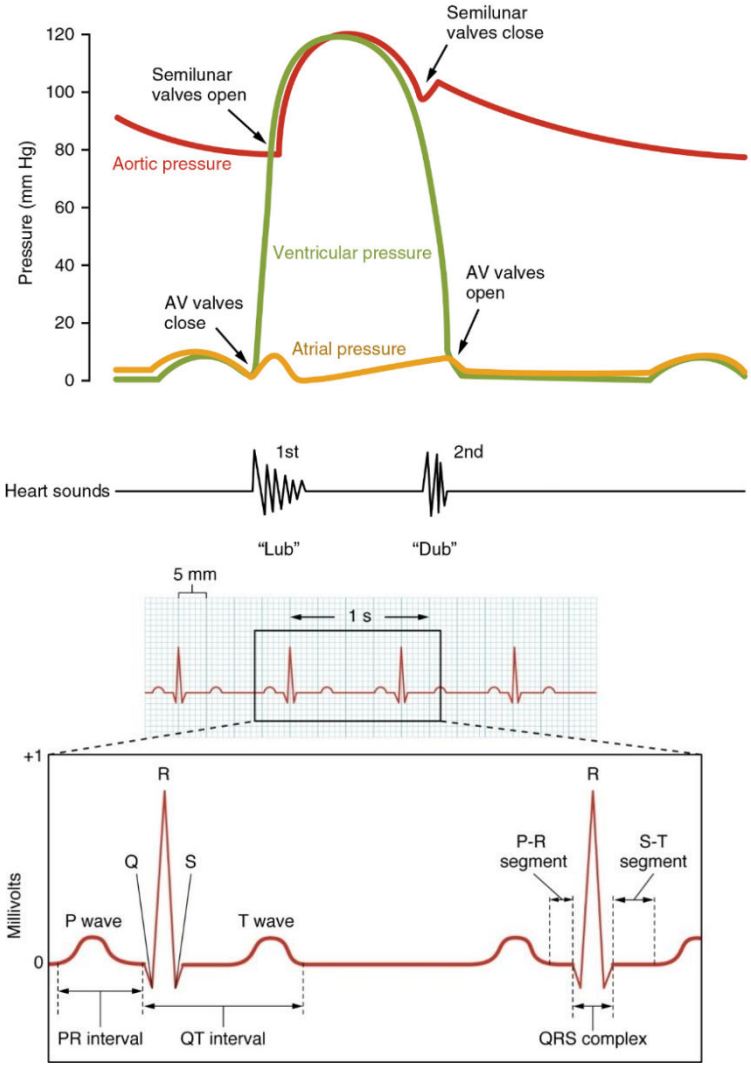


State that the activity of the heart may be monitored by electrocardiogram (ECG), pulse rate and listening to sounds of valves closing.

ECG measures electrical impulses in the heart, providing information about its rhythm and any abnormalities. To obtain an ECG, electrodes attached to an ECG recording machine are stuck on to the skin on the arms, legs, and chest. Electrical activity to do with heartbeat is then monitored and viewed on a computer screen or printed out. Any unusual pattern on the trace can be used to identify heart problems.

Pulse rate is the number of heart beats per minute, often measured at the wrist (radial artery)or neck (carotid artery) . It reflects the heart's activity and overall cardiovascular health. One can feel the pulse in a radial artery by pressing the fingertips (not thumb because it has its own pulse) of one hand on the rest of the other. Digital pulse rate monitors are also available.

Sounds of valves closing, heard through a stethoscope, help assess the functioning of heart valves and identify any irregularities in blood flow. A healthy heart produces a regular "lub dub" sound.



Investigate and explain the effect of physical activity on heart rate.

- Take three students of same age gender and body mass.
- Make sure they take the same food two hours before experiment.

- Count the pulse in 30 seconds and multiply it by 2 to work out a pulse rate in beats per minute.
- Carry out 2 minutes of exercise then sit down and immediately start a stopwatch and measure your rate over 30 seconds as before.
- Allow the stopwatch to keep timing. Measure your pulse rate every minute for 10 minutes.
- Convert all the readings to beats per minute. Plot a graph of pulse rate after exercise against time with the first reading being zero minutes.
- Finally draw a horizontal line across the graph representing your average resting pulse rate.

Result.

The pulse rate immediately after exercise should be much higher than the average resting pulse rate. With time the pulse rate gradually falls back to the average resting pulse rate.

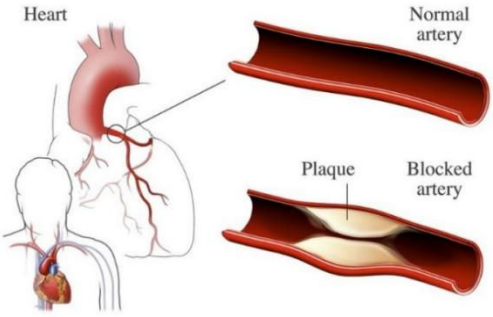
Describe coronary heart disease in terms of the blockage of coronary arteries and state the possible risk factors including diet, sedentary lifestyle, stress, smoking, genetic predisposition, age and gender.

Coronary Heart Disease (CHD) occurs when the coronary arteries, essential for providing oxygen and nutrients to the heart muscle, undergo narrowing or blockage. The presence of cholesterol, fatty deposits (plaque), and other substances on the walls of these arteries results in diminished blood flow to the heart. This restriction in blood flow can have significant consequences for the heart's functionality. Fatty deposit or plaque that forms on the inner lining of arteries is called as atheroma. This can be a direct cause of heart attack.

Possible risk factors of coronary heart disease.

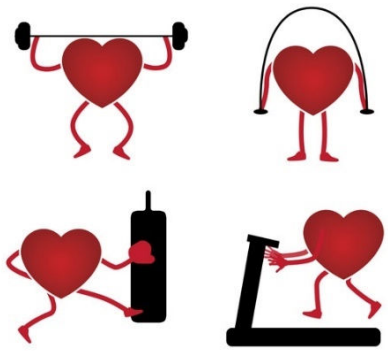
Following are the possible risk factors of coronary heart diseases.

Diet.



Unbalanced diet with high intake of saturated and trans fats, cholesterol, and excess salt can contribute to plaque buildup in arteries. Being overweight puts extra strain on the heart and makes it more difficult for the person to exercise. Fats may form deposit in our arteries restricting the flow of blood through them. This can cause blood clots which can result in a heart attack.

Sedentary Lifestyle



Lack of regular physical activity is a significant risk factor for CHD. Heart muscle loses its tone and becomes less efficient at pumping blood when we do not exercise. Exercise helps maintain cardiovascular health, control weight, and improve overall well-being.

Stress

Emotional stress often leads to raised blood pressure. Chronic stress may contribute to unhealthy behaviors and increased atheroma risk.

Smoking

Smoking damages blood vessels, reduces oxygen levels, and accelerates plaque formation. A smoker is two to three times more likely to die from a heart attack than non-smokers of a similar age. The carbon monoxide and carcinogens in the cigarette smoke may damage the lining of the arteries.

Genetic Predisposition

Coronary heart diseases appear to be passed from one generation to the next in some families. Genetic factors may influence cholesterol levels, blood pressure, and overall heart health.

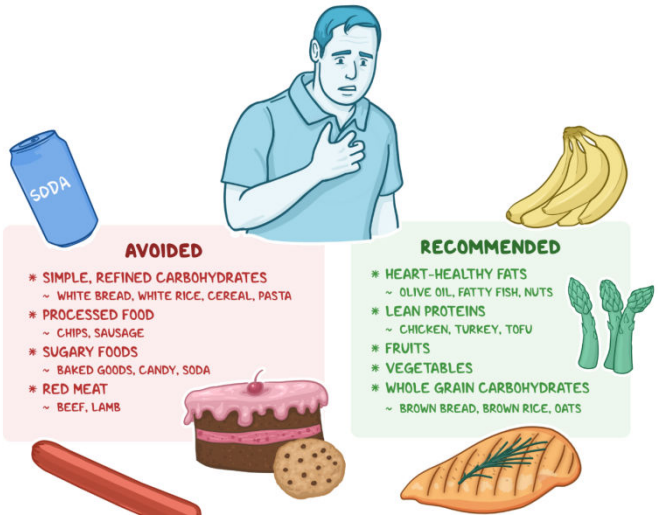
Age and Gender

Males are at a more risk of heart attacks than females. This may be because of unhealthy lifestyle. Female hormone oestrogen also offers a protection from heart diseases. Aging is a non-modifiable risk factor; risk increases with age. Aging processes, coupled with accumulated exposure to risk factors, contribute to CHD.

Discuss the role of diet and exercise in reducing the risk of coronary heart disease.

Role of diet.

To lower the risk of elevated cholesterol levels, it's advisable to cut down on saturated and trans fats commonly found in fried foods and processed snacks. Enhance heart health by incorporating sources of omega-3 fatty acids, such as fatty fish (like salmon and mackerel), flaxseeds, and walnuts into your diet. Opt for a nutritionally rich approach by consuming a variety of fruits, vegetables, whole grains, and legumes, as they offer essential nutrients, fiber, and antioxidants that contribute to cardiovascular well-being. Additionally, reducing salt intake supports blood pressure control, diminishing the risk of hypertension.



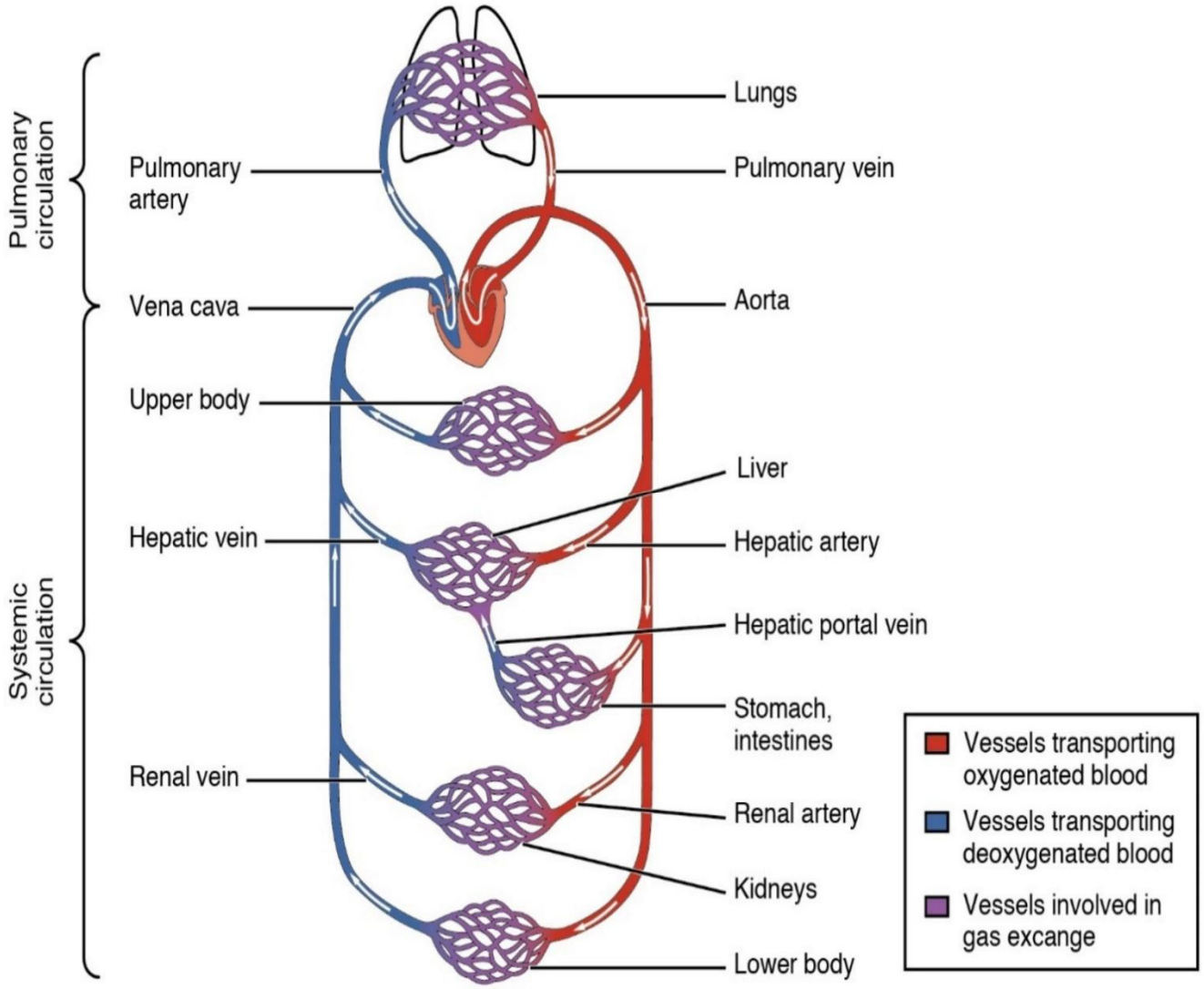
Role of Exercise.

Engaging in regular exercise diminishes the likelihood of experiencing a heart attack. Just as exercise strengthens other muscles, it enhances the efficiency of the heart, allowing it to pump blood throughout the body more effortlessly. Consistent physical activity contributes to various positive factors, including reduced blood pressure, improved cholesterol levels, and enhanced regulation of blood sugar. This underscores the comprehensive benefits that exercise brings to cardiovascular health.

11.3 Blood vessels

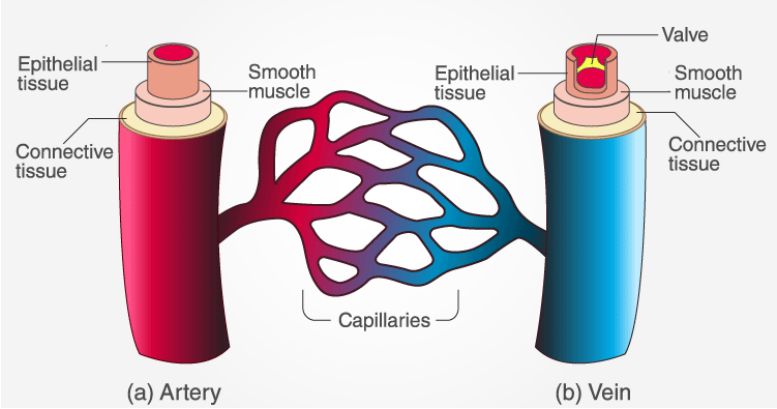
Name the main blood vessels that carry blood to and from the heart, lungs, liver and kidneys, limited to:
aorta, vena cava, pulmonary artery, pulmonary vein, hepatic vein, hepatic artery, hepatic portal vein, renal artery and renal vein.

- The Aorta transports blood away from the heart to the wholr body.
- Vena cava brings blood back from the body to the heart.
- Pulmonary artery conveys deoxygenated blood from the heart to the lungs.
- Pulmonary vein restores oxygenated blood from the lungs to the heart.
- The Hepatic vein carries blood from the liver to the heart.
- Hepatic artery delivers oxygenated blood to the liver.
- The Hepatic portal vein moves nutrient-rich blood from the digestive system to the liver.
- Renal artery transports blood from the heart to the kidneys.
- Renal vein brings filtered blood from the kidneys back to the heart.



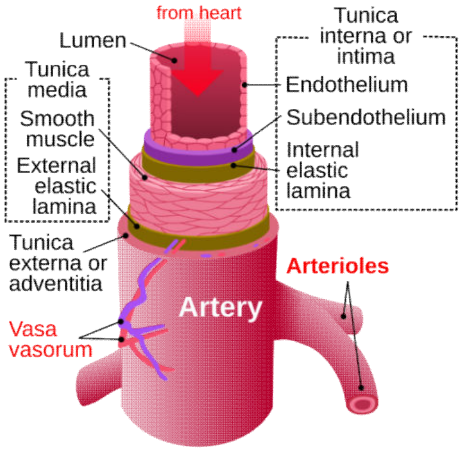
Describe, and identify on diagrams and photomicrographs, the structure of arteries, veins and capillaries, limited to:
(a) relative thickness of wall (b) composition of wall (muscle and elastic tissue) (c) diameter of lumen (d) presence of valves.
Explain how the structure of arteries, veins and capillaries is related to the pressure of the blood that they transport.

Aspects	Artery	Vein	Capillary
Definition	Vessels that carry blood away from heart.	Vessels that carry blood towards heart.	Microscopic vessels facilitating nutrient and waste exchange in circulatory system.
Blood type	Oxygenated (except pulmonary artery)	Deoxygenated (except pulmonary vein)	Mixed
Lumen Size	Small	Large	Very Small
Blood flow	Very fast	Slow	Very Slow
Blood pressure	High	Low	Very low
Valves	Absent except pulmonary artery	Present except pulmonary vein	Absent



Arteries.

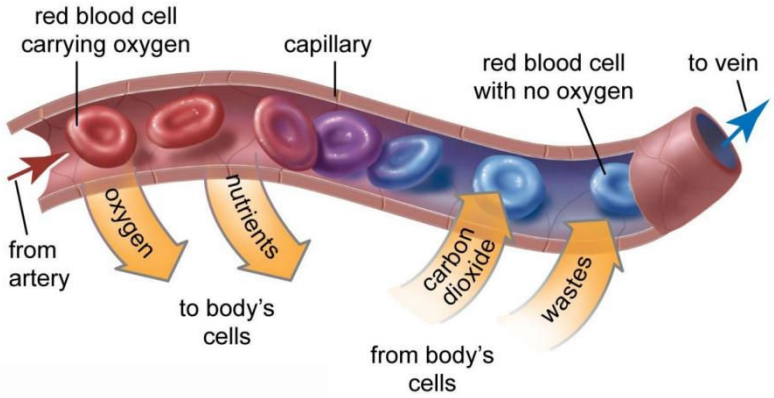
- Arteries are the vessels that carry blood away from the heart to the limbs and organs of the body. All the arteries except pulmonary artery have oxygenated blood in them.
- The walls contain smooth muscle and elastic tissue, providing strength and elasticity.
- They have thick muscular and elastic walls which can withstand high pressure of the blood.



- Arteries have narrow lumen. Arteries generally lack valves.
- They arteries divide to form arterioles. Which upon further division form network of microscopic vessels called as capillaries.

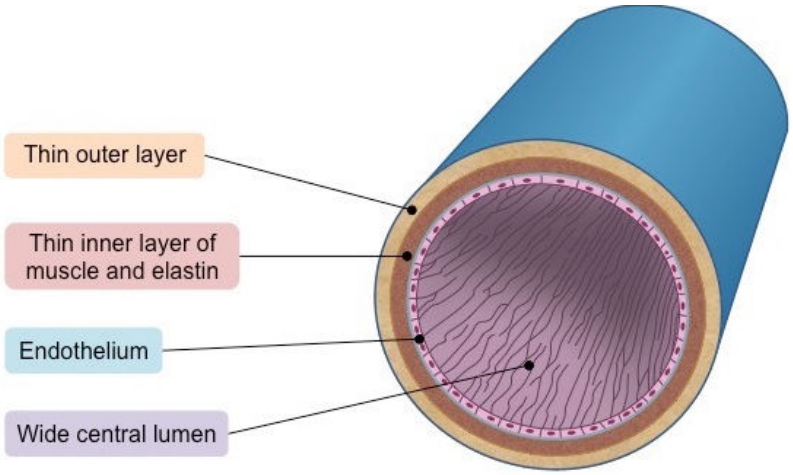
Capillaries

- These are single layered endothelium vessels, often only 0.001mm in diameter.
- These are microscopic structures.
- They have a narrow lumen, no valves and no muscle or elastic in their walls.
- The endotherm is partially permeable, allowing diffusion to occur.
- Blood pressure in the capillaries forces part of the plasma out through the walls.
- The extensive branching increases the total cross-sectional area of the vessels, lowering the blood pressure in the capillaries and hence the rate of blood flow, giving more time for the exchange of substances.



Veins

- Veins return blood from the tissues to the heart.
- They also consist of three layers.
- The middle wall contains less smooth muscle and elastic fibers hence are less elastic.
- They have a wider lumen.
- Veins carry deoxygenated blood except the pulmonary vein.
- Blood flow through the veins is associated by the presence of Semilunar valves and skeletal muscles action.
- Blood is prevented from flowing backwards by the presence of semi lunar valves.

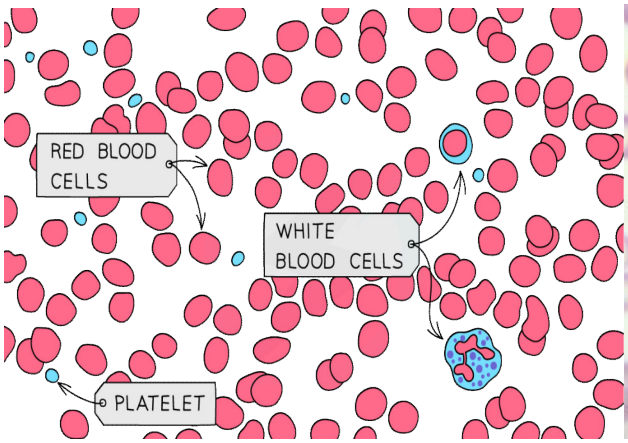


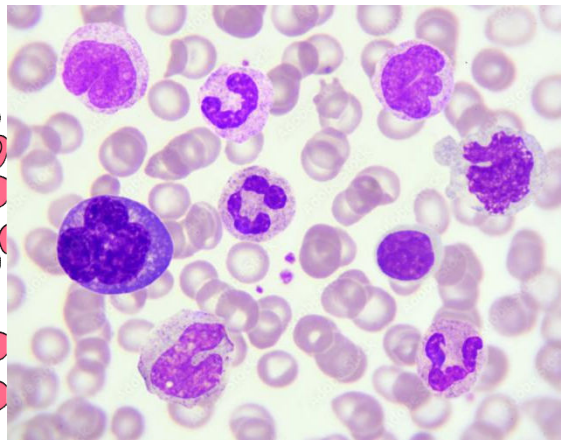
11.4 Blood

Identify red and white blood cells (lymphocytes and phagocytes) as seen under the light microscope on prepared slides, and in diagrams and photomicrographs.

List the components of blood as red blood cells, white blood cells, platelets and plasma. State the functions of the components of blood:

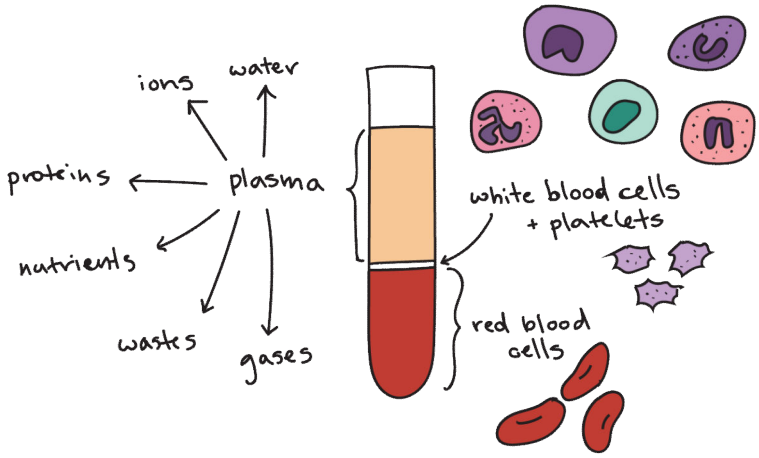
(a) red blood cells (b) white blood cells (c) platelets (d) plasma.





Components of blood:

The following diagram illustrates the components of the blood and their functions are explained in next pages.



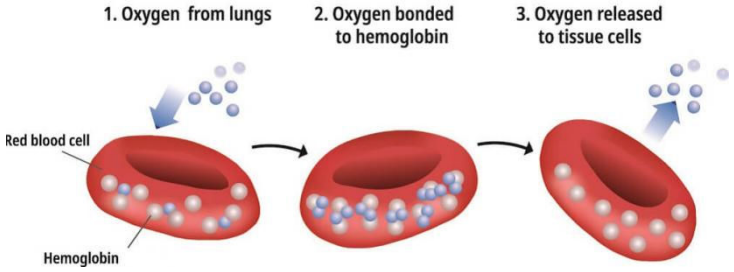
Red blood cells (erythrocytes)

These are disc-shaped cells carrying hemoglobin for oxygen transport. It oxygenates the tissues and give blood its red color.

- As air enters the lungs, oxygen dissolves in the fluid covering the moist epithelium of the alveoli.
- The oxygen diffuses into the capillaries of the lungs where they bind reversibly with haemoglobin in red blood cells to form oxyhaemoglobin.
- When blood is transported to oxygen-poor respiring tissues, oxyhaemoglobin releases its oxygen which then diffuses into tissue cells.

Adaptations to this function are:

- Flattened, biconcave shape without nucleus or organelles at maturity, increasing the surface area to volume ratio for faster diffusion of oxygen.
- Contains haemoglobin, an iron-containing protein which is able to bind reversibly with oxygen.
- Flexibility to turn bell-shaped in order to pass through the narrow lumen of the capillaries.



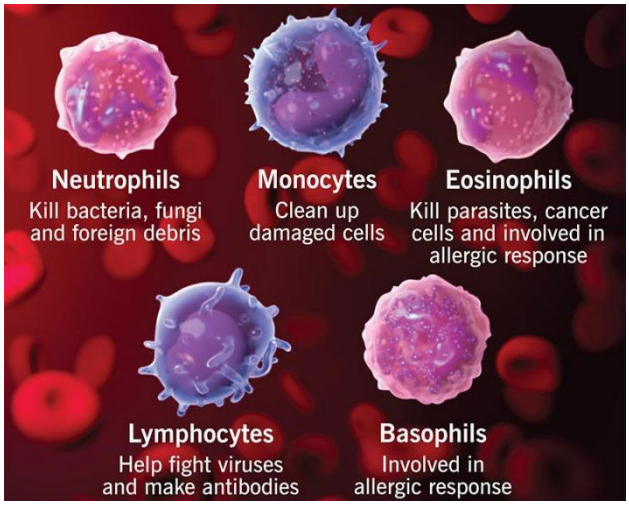
White blood cells (leukocytes)

Varied types (neutrophils, lymphocytes, monocytes, eosinophils, basophils). It's function involve immune response; defense against infections and foreign substances. There are two main types of white blood cells:

- Phagocytes have lobed (bi-lobed, tri-lobed, multi-lobed) nuclei and granular cytoplasm. They engulf and digest foreign particles such as bacteria.
- Lymphocytes have a large rounded nucleus and a small amount of cytoplasm. They produce antibodies to protect the body from pathogens.

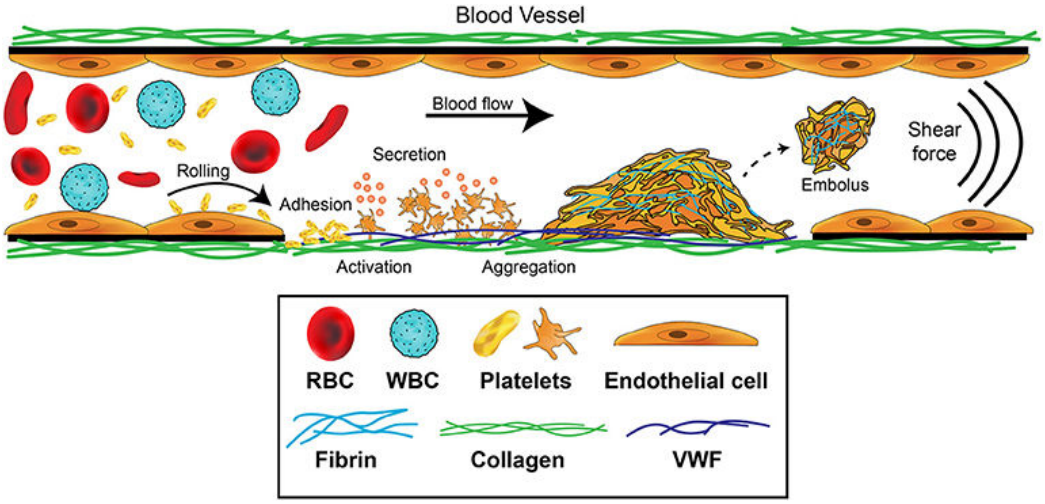
Immune function of white blood cells are as follows.

- Phagocytosis refers to the ingestion of harmful foreign particles, bacteria and dead or dying cells by certain types of white blood cells called phagocytes.
- When phagocytes detect a foreign particle, it engulfs it by stretching itself around the particle and enclosing it. It then digests the particle and kills it.
- After phagocytosis, these cells die and form pus.
- Antibodies are special proteins found in blood and other bodily fluids that help phagocytes identify and neutralise foreign particles. Antibodies also activate other immune responses.
- When pathogens enter the blood, they stimulate lymphocytes to produce antibodies.
- Antibodies may be present in the blood long after infection has been cured, conferring immunity to that particular infection.



Platelets (thrombocytes)

Platelets are fragments of cells that are used to clot the blood. Without platelets, there would be excessive bleeding every time you cut yourself and had a wound. When the skin is broken (i.e. there is a wound) platelets arrive to stop the bleeding. A series of reactions occur within the blood plasma which is called the clotting cascade. Platelets release stored proteins that cause soluble fibrinogen proteins to convert into insoluble fibrin. This forms an insoluble mesh across the wound. Red blood cells become trapped, forming a clot. The clot eventually dries and develops into a scab. This process helps to prevent excessive blood loss and protect the wound from bacteria entering until new skin has formed.

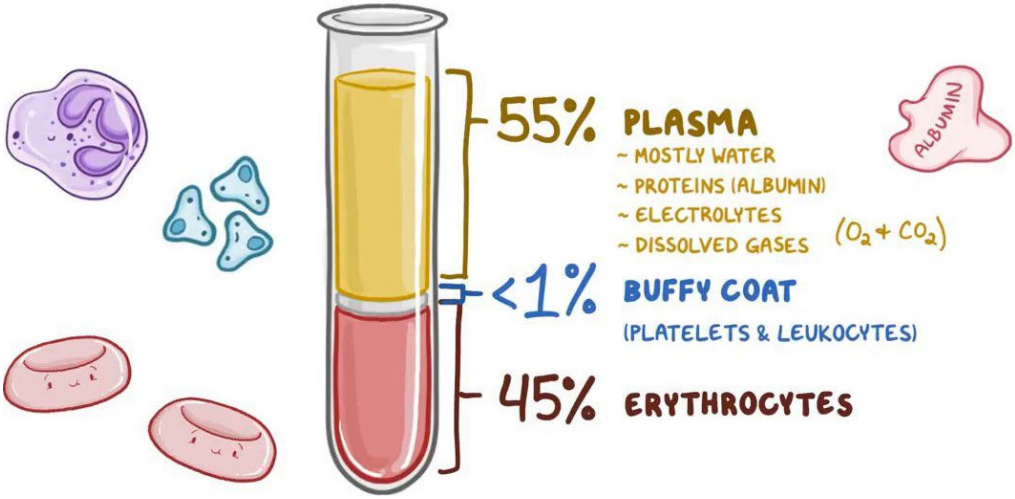


Blood plasma.

Fluid component of the blood is called plasma. It is straw-colored liquid. It carries cells and platelets, transports nutrients, hormones, and waste material.

It transports:

- Simple sugars, amino acids, fatty acids and glycerol from the capillaries in the small intestine.
- Waste products of metabolism from tissues.
- Carbon dioxide in the form of bicarbonate ions.
- Nitrogenous waste products such as urea, uric acid and creatinine to the kidneys to be removed.
- Hormones from the glands to target tissues. Heat from muscles and liver throughout the body.



Describe the transfer of substances between blood in capillaries, tissue fluid and body cells.

- Capillaries are found between tissue cells.
- As blood enters the capillaries, the narrow lumen of the capillaries forces red blood cells to travel in a single line.
- Rate of blood flow decreases, allowing more time for the exchange of materials between tissue cells and red blood cells.
- At the arterial end of capillaries, the blood pressure is high, forcing plasma through capillary walls into tissues. Plasma proteins are unable to pass through capillary walls.
- The solution bathing tissue cells becomes known as tissue fluid, or interstitial fluid.
- There is a higher concentration of nutrients and oxygen in blood than in the interstitial fluid. They diffuse across the endothelium of the capillary into the interstitial fluid, and from there, across the plasma membranes of tissue cells.
- Waste materials from the tissue cells diffuse into the interstitial fluid, where they are present in higher concentrations than within the blood. They diffuse across the endothelium of the capillary into blood and are transported to excretory organs for removal.