

Body Fluids and Circulation

Blood

It is a fluid connective tissue composed of liquid plasma (forms the matrix) and cellular components (RBCs, WBCs and the platelets).

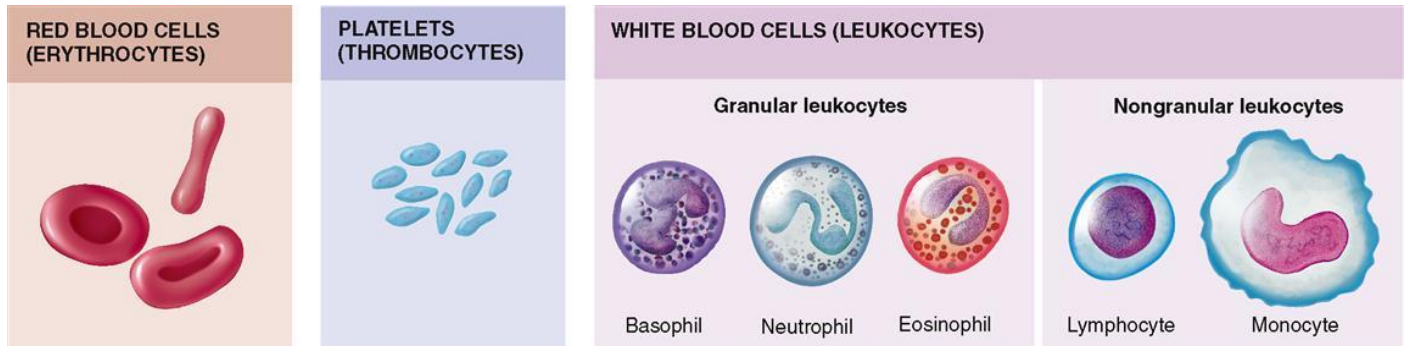


Fig. 1. Elements of the blood

Plasma

The matrix of blood is a fluid made of plasma. It is a straw colored, viscous fluid constituting about 55 percent of the blood. Different proteins are present in plasma such as fibrinogen, globulins, and albumins. Fibrinogens help clot blood. Albumins help to maintain osmotic balance in the body. Globulins functions as defensive proteins. Minerals such as sodium ions, calcium ions, magnesium ions, bicarbonate ions, are useful in maintaining equilibrium and also in transport and uptake of nutrients. Apart from these, amino acids and glucose are also present in plasma.

Formed elements

Formed elements include erythrocytes, leucocytes, and blood platelets. These are different types of blood cells that has different roles.

Erythrocytes also known as red blood cells. They are the most abundant cells in the blood. The site of formation of red blood cells is bone marrow. They are biconcave in shape and enucleated (without the nucleus). They carry iron containing protein known as hemoglobin. Hemoglobin helps in the transport of oxygen and carbon-dioxide in blood. The average life span of RBCs is 120 days. A healthy person has around 12-15 gm of hemoglobin per 100 ml of blood. Spleen is known as the graveyard of RBC.

Leucocytes also known as white blood cells. They appear colorless as they do not have hemoglobin. They have a short life span of 3 to 4 days. They are of two types- granulocytes and agranulocytes.

Neutrophils, basophils, and eosinophils are granulocytes. **Lymphocytes and monocytes** are agranulocytes.

Neutrophils are known as polymorphonuclear leucocytes. Out of all the three granulocytes, neutrophils are most abundant. They are phagocytic cells. Basophils are least in number in comparison to other granulocytes. They secrete serotonin, histamine, and basophils. So, basophils are involved in inflammatory reactions. Eosinophils are involved in allergic reactions.

Blood platelets, also known as **thrombocytes**. They are produced in bone marrow from the megakaryocytes. They are involved in blood clotting. Any decrease in the number of platelets can cause loss of blood from the body.

Blood groups

Blood grouping is divided into- ABO blood group and Rh group.

ABO blood grouping

ABO blood grouping is based on the presence or absence of certain antigens on the surface of RBCs. The two main surface antigen present on the red blood cells are A and B. There are 4 types of blood group are A, B, AB and O group.

	Group A	Group B	Group AB	Group O
Red blood cell type				
Antibodies in Plasma	 Anti-B	 Anti-A	None	 Anti-B and Anti-A
Antigens in Red Blood Cell	 A antigen	 B antigen	 A and B antigens	None

Fig. 2. Blood groups and antigen on red blood cells

The above table depicts blood groups and donor compatibility. As O blood group do not have any surface antigen, they are said to be universal donor whereas AB are considered universal recipients as they contain both the antigen of their surface. Blood transfusion is done safely based on the blood group of the donor and recipients.

Rh grouping

Rh is also an antigen similar to that present in Rhesus monkey. Individuals having Rh antigen on RBCs are considered as Rh positive whereas those which do not have Rh antigen are considered Rh negative. If Rh -ve person receives Rh +ve blood, the Rh -ve individual will start producing antibodies against it. So, Rh group should also be tested before blood transfusion.

An important case of Rh mismatching has been observed when the Rh -ve pregnant mother carry Rh +ve fetus. Rh antigens of the fetus do not get exposed to the Rh-ve blood of the mother in the first pregnancy, due to a barrier known as placenta. But at the time of delivery of the first child, there is a possibility of mixing of the blood of mother with child.

Due to this, mother starts to produce antibodies against the Rh antigen. If the mother conceives again, the Rh antibodies from the Rh -ve mother can leak into the blood of the Rh +ve fetus and can destroy the fetal RBCs. This leads to agglutination of red blood cells. This disorder is known as *erythroblastosis foetalis*. Fetus will be anemic and suffers from jaundice. To avoid this, mother should get injected with anti-Rh antibodies instantly after the delivery of the first child.

Coagulation of blood

Blood clotting is also known as blood coagulation. Blood clotting is observed after any injury or trauma. This helps in preventing excess loss of blood. When an individual gets injured, after some time reddish brown scum is formed at the point of injury. This is known as clot. Clot is made up of network of threads known as **fibrils**. This network contains dead and damaged formed elements of blood. Fibrils are formed from the conversion of inactive fibrinogen in presence of enzyme **thrombin**. Thrombin is also formed from inactive form known as **prothrombin**. **Thrombokinase** is required for the conversion of prothrombin into thrombin.

Platelets release certain factors to begin blood clotting. Calcium ions play an important role during blood clotting.

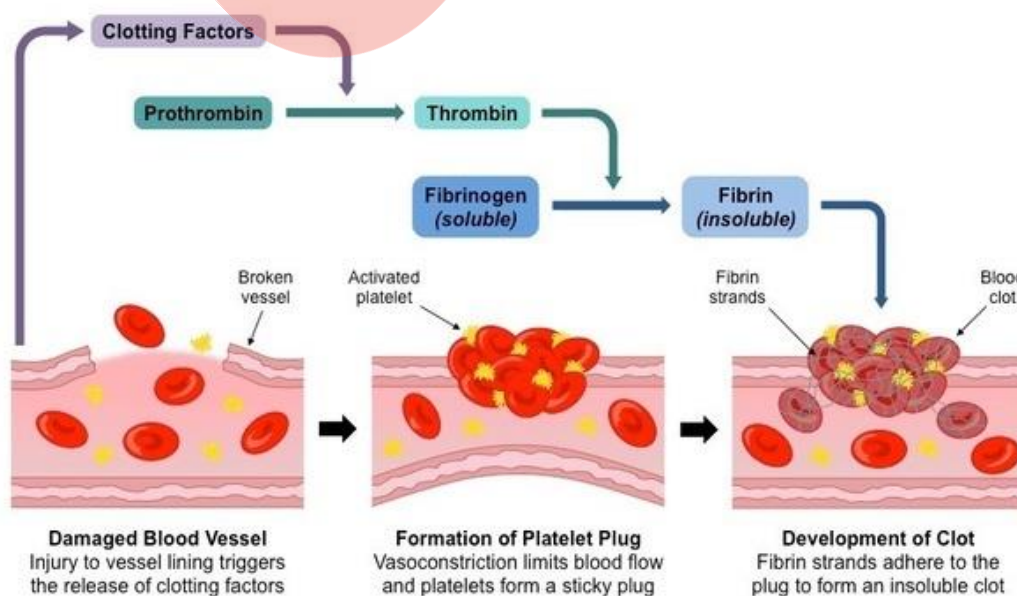


Fig. 3. Blood coagulation

Lymph

Apart from the blood, another fluid found in the body is lymph. Blood circulates in blood capillaries in tissues. Some water along with some water-soluble substances leak out and enter the interstitial spaces. This is known as tissue fluid or interstitial fluid. Exchange of gases, nutrients between the blood and the cells occurs through this fluid.

A network of vessels that collects interstitial fluid and drain it to major veins is known as lymphatic system. Lymphatic system contains a fluid known as lymph. Lymphocytes which are an important cell of the immune system are present in lymph.

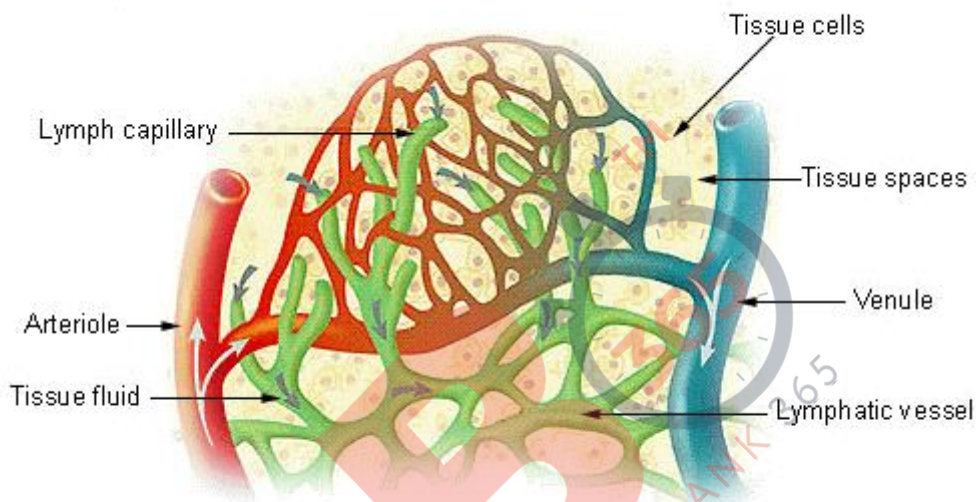


Fig. 4. Lymph

Circulatory pathways

There are two types of circulatory pathways found- open circulatory system and closed circulatory system. When blood flow in lacunae and sinuses, it is known as open circulatory system. It is found in molluscs, arthropods, etc.

When blood flow in closed vessels it is known as closed circulatory system. For example, humans. Closed circulatory have an advantage over open circulatory system, as blood can flow in a controlled manner in case of closed circulatory system.

Vertebrates have muscular, pumping organ known as heart. Fishes have 2 chambered heart. Amphibians have 3 chambered heart except crocodiles (4 chambered heart). Birds, reptiles, and humans have 4 chambered heart.

Human circulatory system

Human circulatory system consists of heart, blood vessels, and blood. **Heart** is mesodermal in nature. It is situated in the thoracic cavity, in between the two lungs.

The double membrane that surrounds the heart is known as pericardium. **Pericardium** circles the pericardial fluid. Heart is 4 chambers with 2 atria and 2 ventricles. A thin wall separates the left and the right atria. It is called **intra-atrial septum**. The left and right ventricle are separated by thick **intra-ventricular septum**.

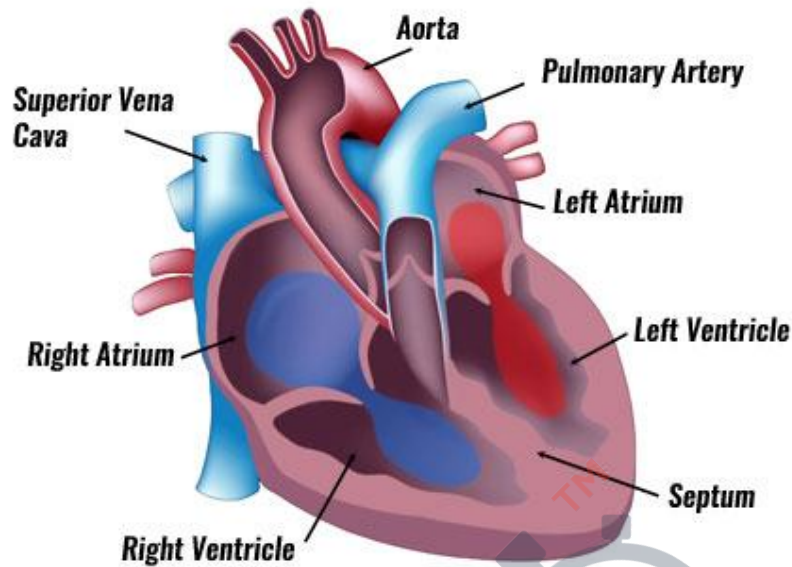


Fig. 5. Human heart

The opening between the right atrium and right ventricle is guarded by a valve known as **tricuspid valve**. The **bicuspid or mitral valve** guards the opening between the left atrium and the left ventricle. The openings of the right and the left ventricles into the pulmonary artery and the aorta respectively are provided with the **semilunar valves**. Valves in the heart allows the blood to flow in one direction and thus preventing backflow of blood.

Heart is a muscular organ. Heart muscles are known as cardiac muscles. A specialized cardiac musculature called the nodal tissue is also dispersed in the heart. One is present in the upper right corner of the right atrium is known as sinoatrial node or SA node. And one is present in the upper left corner of the right atrium is known as atrio-ventricular node or AV node.

A bundle of nodal fibers, **atrioventricular bundle (AV bundle)** continues from the AVN which passes through the atrio-ventricular septa and divides into a right and left bundle. These branches give rise to minute fibers known as **purkinje fibers**. SA node is known as the pacemaker of the heart as it has the ability to get excited and can generates an action potential.

Cardiac cycle

Sequence of electrical and mechanical events at the time of each heart beat is known as cardiac cycle. It consists of two phases- diastole and systole. At the time of diastole, heart ventricles relax which fills them with blood. During systole, ventricles contract to pump the blood into the arteries.

Phases of cardiac cycle are as follows-

Atrial systole consists of contraction of the right and left atria which is followed by electrical stimulation. This increases blood pressure in the both left and right atria. So that the blood can be pumped into ventricles. During this AV valves are open and semilunar valves are closed. It takes about 0.1 seconds.

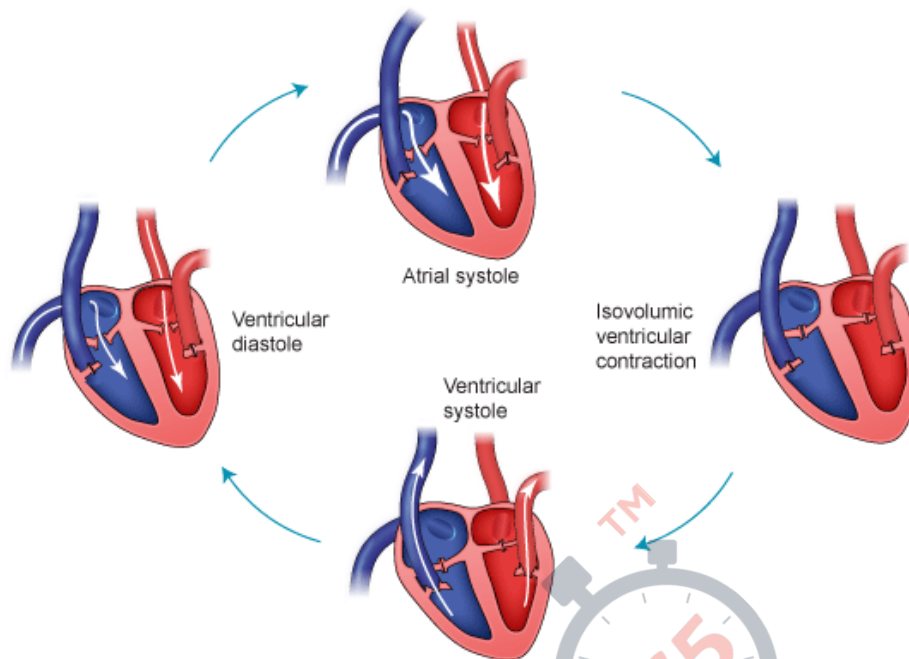


Fig. 6. Cardiac cycle

Ventricular systole consists of contraction of the right and the left ventricles which will be followed by electrical stimulation. AV valves are closed during ventricular systole and semilunar valves are open. It takes about 0.3 seconds.

Cardiac diastole is a period when heart relaxes to fill the blood. When atria and ventricles relax together, they form complete cardiac diastole. During ventricular diastole, pressure in the ventricles drops below the left atrial pressure, mitral valve opens, and left ventricle gets filled with the blood. Similarly, when the pressure in the right ventricle drops below that in the right atrium, the tricuspid valve opens, and the right ventricle gets filled with blood. During diastole, the pressure within the left ventricle is lower than that in aorta, which allows the blood to circulate in the heart itself with the help of the coronary arteries.

Heart sound

The heart sound is known as “lubb-dubb” sound. The first heart sound lubb is produced when mitral and tricuspid valves gets closed at the beginning of the ventricular systole. The second sound dubb is produced when aortic and pulmonary valves gets closed at the end of ventricular systole.

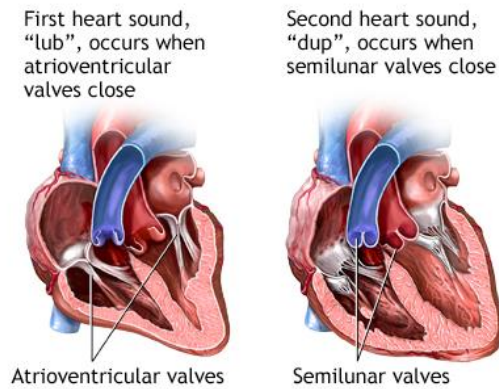
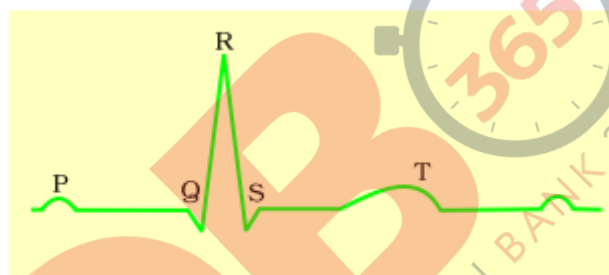


Fig. 7. Heart sound

Electrocardiograph (ECG):

ECG is the graphical representation of heart's electrical activity during cardiac cycle.

The standard ECG consists of various peaks represented by letters P through T.



- **P-Wave:** Represents electrical excitation of atria. It shows the atrial depolarization.
- **QRS Complex:** Represents the ventricular depolarization. This initiates ventricular contraction. The contraction starts soon after Q.
- **T-Wave:** Represents ventricular repolarization. It signifies the return of ventricles to their normal state after excitation. End of T-Wave signifies the end of ventricular systole.

Double Circulation:

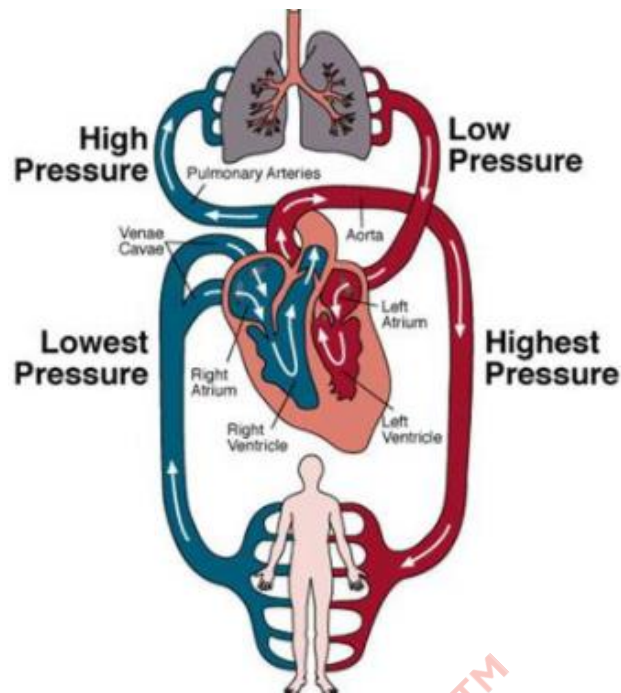
It is a system of circulation in where in a single cycle of circulation, blood passes through the heart twice. It consists of two parts: Pulmonary circulation and systemic circulation.

Pulmonary Circulation: Circulation of blood between heart and lungs. Deoxygenated blood from the heart enters the lung for oxygenation and oxygenated blood is returned to the heart.

Systemic Circulation: Circulation of blood between the heart and the rest of the body. Oxygenated blood is supplied from the heart to all parts and deoxygenated blood is returned to the heart.

Coronary Circulation: Circulation of blood between the heart and the cardiac muscles

Hepatic Portal Circulation: System of blood vessels that connect the intestines, liver and the systemic circulation.



Regulation of cardiac activity:

Cardiac activity is regulated by the Autonomous Nervous System (ANS) through the neural center in the medulla oblongata. The sympathetic nervous system will increase cardiac output by increasing heart rate and the strength of ventricular contractions. The parasympathetic nervous system will decrease the cardiac output by decreasing the heart rate and the strength of the ventricular contractions. Cardiac output can also be influenced by certain adrenal medullary hormones.

Disorders of circulatory system:

Hypertension: When blood pressure is higher than normal, a person suffers from hypertension or high blood pressure. Normal blood pressure is 120/80 mm of Hg. 120mm Hg is the systolic pressure whereas 80mm Hg is the diastolic pressure. When the blood pressure rises above 140/90 mm of Hg it indicates hypertension. It causes problems with the vital organs like heart, kidneys and brain.

Coronary heart disease: Also called as **atherosclerosis**, this disease is characterized by narrowing of lumen of the arteries due to deposition of calcium, fat, cholesterol and fibrous tissue. It affects blood supply to the heart muscles.

Angina: Also called as angina pectoris, it is characterized by acute chest pain due to insufficient oxygen reaching the heart muscles.

Heart failure: Inefficient pumping of blood by the heart caused usually due to congestion of heart. Hence it is also called as congestive heart failure.