Ratna Sagar

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Education, Our Mission

As per the latest ICSE syllabus 2022

Ratna Sagar
Education, Our Mission!

Revised and Updated

LIVING SCIENCE BIOLOGY

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EDUCATION, OUR MISSION

ICSE
Living Science
Biology

Class 10

Chapter 8 The Circulatory System

LEARNING OBJECTIVES

Circulation of fluids in humans

Circulatory medium – blood, tissue fluid and lymph

Blood – Composition and functions

- **Functions of blood**
- **Clotting of blood**
- **Blood groups and blood transfusion**

Parts of human circulatory system

- **Blood vessels**
- **The human heart**
- **Double circulation**
- **Cardiac cycle – systole and diastole**
- **Cardiac cycle – systole and diastole**
- **Portal system**

Lymphatic system

What are the main parts of the human circulatory system?

The circulatory system has three main parts.

1. Circulatory medium – Blood, tissue fluid and lymph

2. Blood vessels – Arteries, veins and capillaries

3. Pumping organ – Heart

Circulatory medium – blood, tissue fluid and lymph

Our body has three different types of fluids:

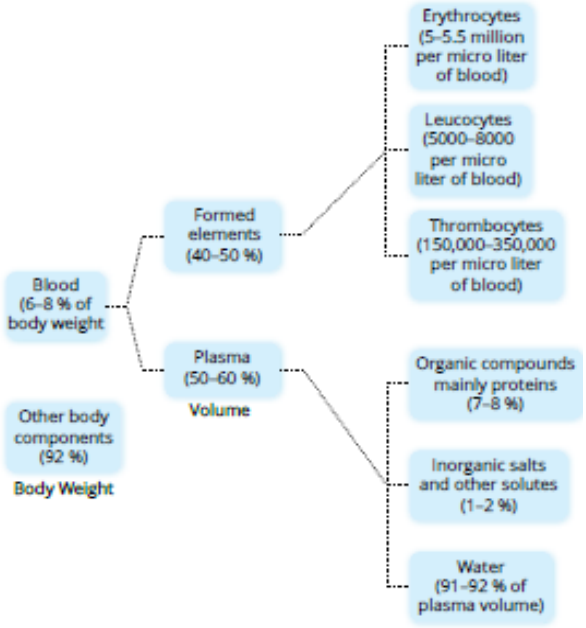
1. Blood: Found in the heart and blood vessels (arteries, veins and capillaries)

2. Tissue fluid: Found in the intercellular spaces

3. Lymph: Found in the lymph vessels and lymphatic organs (spleen and tonsils)

Blood – Composition and functions

An average human being has about 5.5 litres of blood in his body. About 50–60 per cent of the blood is a fluid called **plasma** and the remaining 40–50 per cent is made of cellular elements called **corpuscles** that are held in suspension. Blood always moves from the heart through the arteries and back to the heart through the veins.



Composition of blood

Composition of blood

Blood is made up of two main components – plasma (fluid part) and cellular or formed elements (blood corpuscles, solid part).

Plasma – the fluid part

Plasma contains water (about 90–92 per cent), inorganic salts (about 1–2 per cent) and organic compounds (about 7–8 per cent).

Plasma = Blood – Formed elements

Plasma from which the protein fibrinogen has been removed is called **serum**.

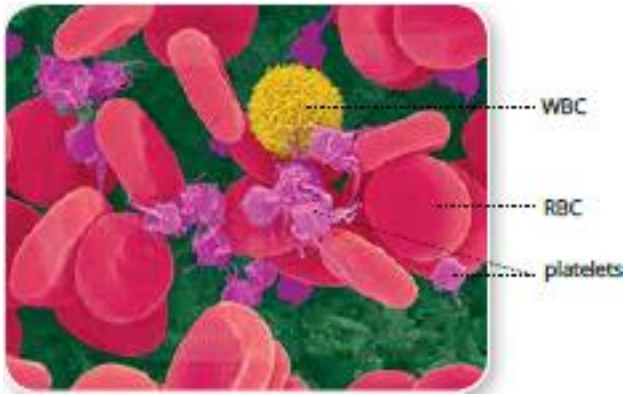
Serum = Plasma – Fibrinogen

Cellular elements

In human beings, three types of cellular elements are found suspended in the plasma :

- ❖ Red blood corpuscles (RBCs) or erythrocytes
- ❖ White blood corpuscles (WBCs) or leucocytes
- ❖ Platelets or thrombocytes

The process by which new blood cells are formed is called **haemopoiesis** or haematopoeisis.



Three types of cellular elements suspended in the plasma

Red blood corpuscles (RBCs): Red blood corpuscles or erythrocytes red) are **biconcave** and **enucleated** (i.e. without a nucleus), **disc-like biconcave-shaped** cells which are flat in the centre, and thick and rounded at the periphery

Erythrocytes

❖ **RBCs are produced in the bone marrow** of long bones, ribs, vertebrae and skull bones. **The average life span of erythrocytes is about 120 days.**
❖ Their average number ranges from 5–5.5 millions in human male and 4.5–5 millions in human female.

White blood corpuscles (WBCs): White blood corpuscles or leucocytes are rounded or irregular-shaped cells. They are capable of amoeboid movement. They are colourless since they lack haemoglobin. They are produced in the bone marrow.

Leucocytes

Leucocytes are of two types –
1. granulocytes (contain granules in their cytoplasm and have lobed nuclei) and
2. agranulocytes (lack granules in their cytoplasm and have unlobed nuclei).

Functions of WBCs

❖ WBCs help in destroying solid substances and germs, specially bacteria, by engulfing them. This defensive process of fighting against disease-causing germs is termed as phagocytosis. Neutrophils are most active in this role. By doing so they protect the body from diseases, i.e. they are responsible for **immunity**.
❖ They also help in the formation of antibodies which neutralize or kill the germs that enter our body.

Blood platelets (Thrombocytes): Blood platelets are colourless, oval or round, cytoplasmic fragments formed from giant cells of the bone marrow**.** These are found floating in the blood.

Blood platelets

These are **enucleated** (without a nucleus), bound by a membrane and contain a few organelles. Their life span is about 5–10 days. **Thrombocytes help in blood clotting.** They release a chemical, thromboplastin, which initiates the process of clotting of blood. They can repair slightly damaged blood vessels

Functions of blood

Blood is a complex fluid that performs a number of roles in our body. It transports, regulates and protects.

Transportation

(a) Transport of nutrients: The digested food substances are absorbed by blood at the site of absorption (small intestine) and transported to different organs of the body.

(b) Transport of respiratory gases: Blood transports oxygen from the lungs to the tissues and carbon dioxide from the tissues back to the respiratory surface, i.e. lungs.

(c) Transport of waste products: The metabolic waste substances produced in the body are transported by blood to the excretory organs.
(d) Transport of body secretions: Blood transports chemical secretions like hormones, from the site of their secretion to the target organ.

2. Regulation

(a) Regulation of body temperature: Blood helps to control the body temperature by evenly distributing the heat produced in one part of the body to different parts.
(b) Maintenance of pH: The plasma proteins are amphoteric in nature, i.e. they act as a buffer and thus maintain the pH of blood.
(c) Water balance: Blood maintains water balance to a constant level by bringing about constant exchange of water between the circulating blood and the tissue fluid.

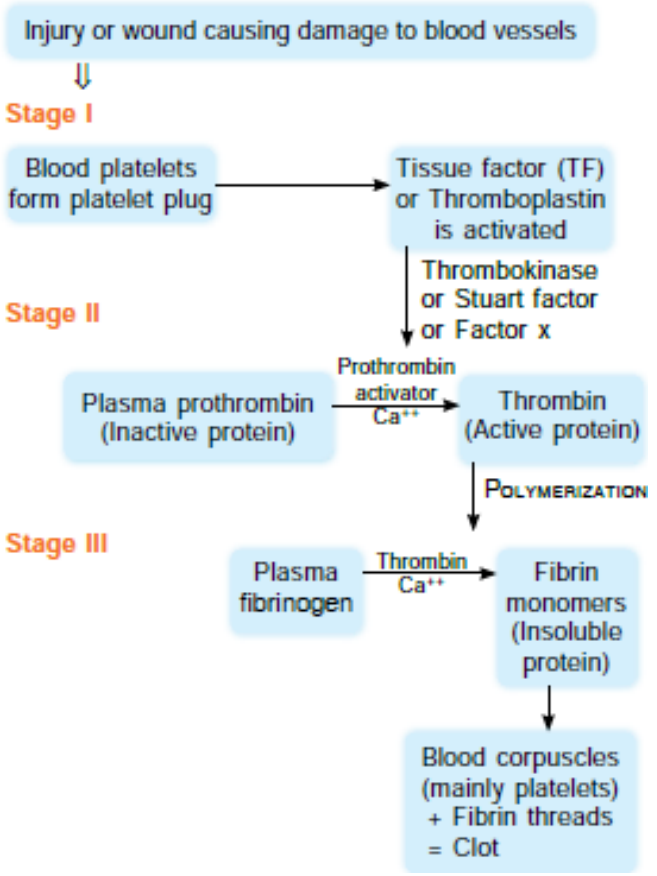
3. Protection

(a) Clotting of blood protects against blood: loss: Prothrombin and fibrinogen proteins of plasma help in blood clotting at the site of injury. This prevents blood loss.
(b) Defence against infection: Blood contains white blood corpuscles that are phagocytic in nature. WBCs also produce antibodies which destroy the bacteria, after neutralizing their toxins.

Clotting of blood

Blood is in a fluid state when inside the blood vessels. Blood does not clot in uninjured vessels due to the presence of natural anticoagulant called **heparin** and **antithrombin**, produced in the liver. Blood usually clots after it escapes from the blood vessels.

The process of clotting of blood is known as **coagulation**. A **clot** is a network of insoluble protein fibres called fibrin in which the cellular components of the blood get trapped.



Mechanism of clotting of blood

Blood groups and blood transfusion

Blood groups: There are two types of proteins in the human blood.

1. Agglutinogen or **antigen** is present on the surface of RBCs. It is called the **corpuscle factor**.

2. Agglutinin or **antibody** is a protein present in blood plasma and is called the **plasma factor**.

There are two kinds of **antigens A** and **B**, and two kinds of **antibodies a** and **b**, in the blood.

Antigen A and **antibody a** are antagonistic or incompatible and cause self-clumping. Similarly, **antigen B** and **antibody b** are incompatible and cause self-clumping. **Antigen A** is compatible with **antibody b** and **antigen B** is compatible with **antibody a**.

On the basis of type of antigen present on the surface of RBCs as given below, a system of blood groups known as **ABO system**, in which there are four blood groups, is recognized in the human blood.

- **Group A** with **antigen A** and **antibody b**.
- **Group B** with **antigen B** and **antibody a**.
- **Group AB** with both **A** and **B antigens** but **no antibody**.
- **Group O** has **no antigen** but **both antibodies a** and **b**.

Blood transfusion: The RBCs of blood group **O** individuals lack antigens and are not clumped by antibodies present in the serum of the recipient's blood. It means blood group **O** can be given to persons with blood group **O**, **A**, **B** or **AB**. Hence, **persons with blood group O are called universal donors**. However, persons with blood group **AB** lack antibodies in their plasma, so they can receive blood from **A**, **B**, **O** or **AB** blood groups. Such persons are called **universal recipients**.

Rh factor (Rhesus antigens) : The surface of human RBCs contains a protein that is also found in the RBCs of Rhesus monkeys. So, it was termed as **Rh antigen** or **Rh factor**. Those persons who have this factor are called Rh-positive and others as Rh-negative. Both **Rh-positive** and **Rh-negative** persons are quite normal. The problem arises when **Rh–** blood comes in contact with **Rh+** blood either due to blood transfusion or during pregnancy.

Note: Refer to Table 8.2 for Human blood groups and their compatibility

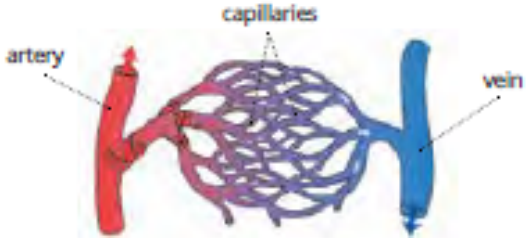
Parts of human circulatory system

Blood vessels

The blood vessels are a system of channels through which the blood flows. There are three kinds of blood vessels – arteries, veins and capillaries.

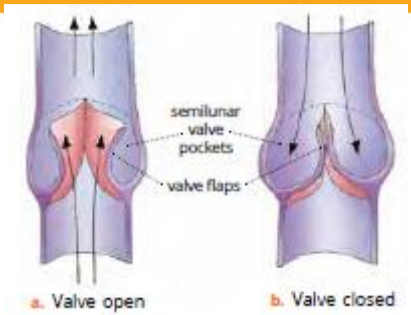
1. Arteries are the blood vessels that carry blood away from the heart to the various parts of the body.All arteries (except the pulmonary artery) carry oxygenated blood.

2. Capillaries are microscopic, thin vessels that carry blood from arterioles to small veins or venules. They are found abundant in those tissues or organs where the rate of metabolism is very fast.

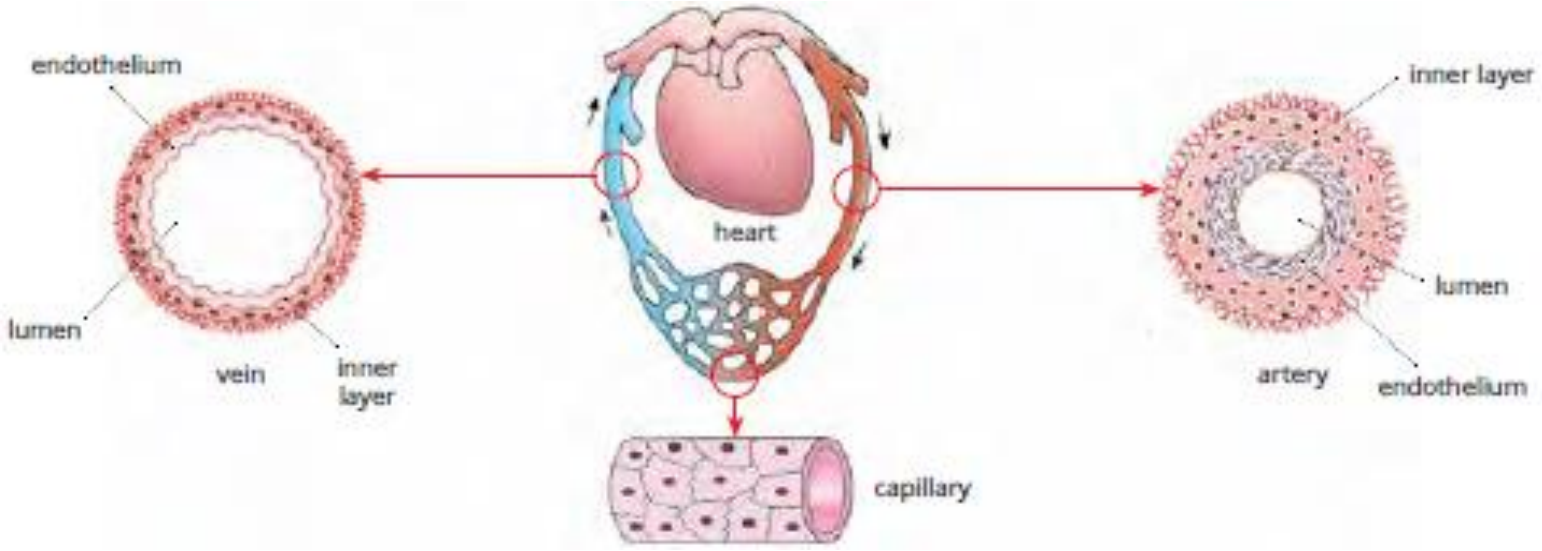


Capillaries connect arteries and veins.

3. Veins are the blood vessels that carry blood from the body parts to the heart. All veins (except the pulmonary vein) carry deoxygenated blood. Veins have semilunar valves, which prevent the backward flow of blood.



Action of a semilunar valve in a vein



Diagrammatic relationship between arteries, veins and capillaries

The human heart

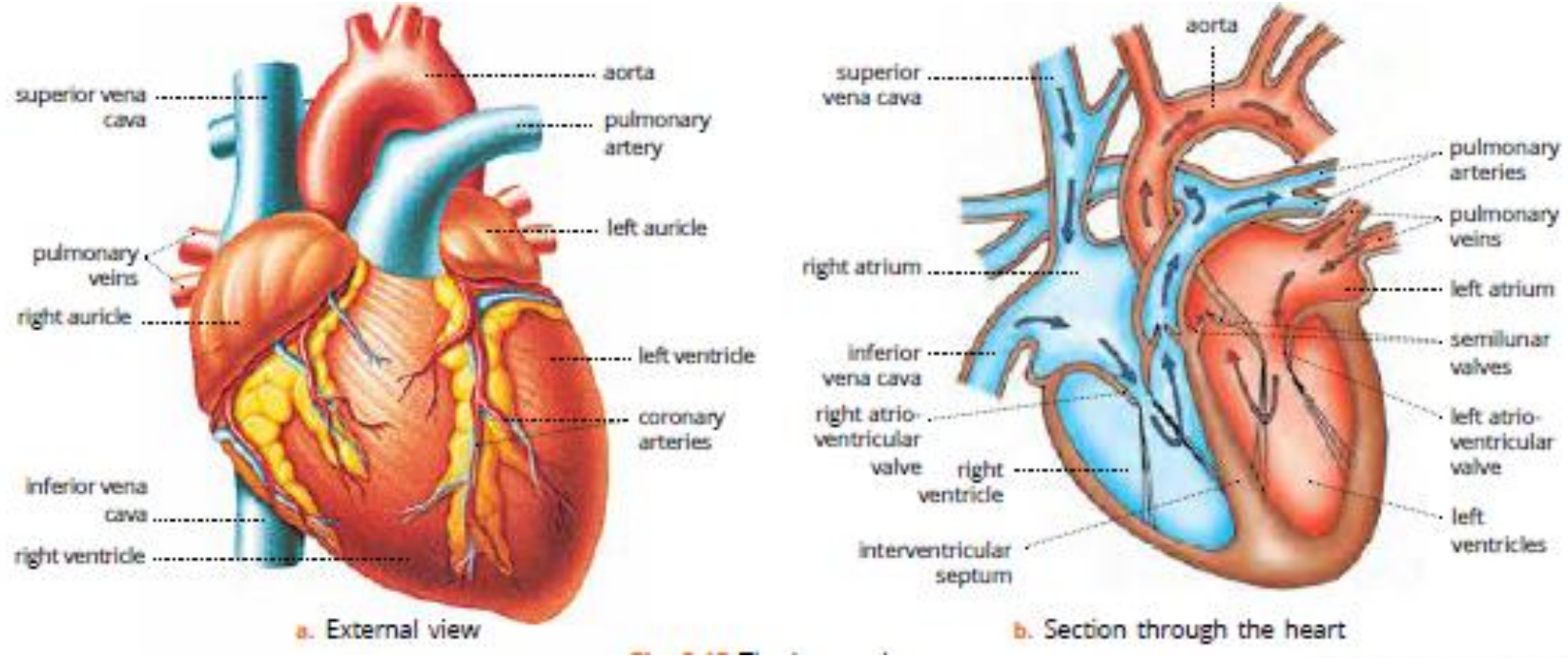
The human heart is located between the lungs in the thoracic cavity with its lower end inclined towards left. The heart is a hollow, fibromuscular organ and is somewhat conical in shape. It is about the size of one's fist. Human heart is made of cardiac muscles or **myocardia** which contract rhythmically by self-generated impulse.

External structure of the heart

The human heart is a four-chambered organ divided by septa into two halves – the right half and the left half. Each half consists of two chambers – the upper, small-sized auricle or atrium and the lower, large-sized ventricle.

Internal structure of the heart

Internally, the heart has the following main components – **four chambers (two auricles and two ventricles)**, **great blood vessels** that carry blood to the heart and away from it, and various **apertures** and **valves.**



The human heart

Chambers of the heart

1. Auricles – The receiving chambers: The auricles or atria are thin-walled chambers and are separated from each other by an **inter-auricular septum**.
2. Ventricles – The discharging chambers: The ventricles are thick-walled chambers and are separated from each other by an obliquely placed **inter-ventricular septum**.

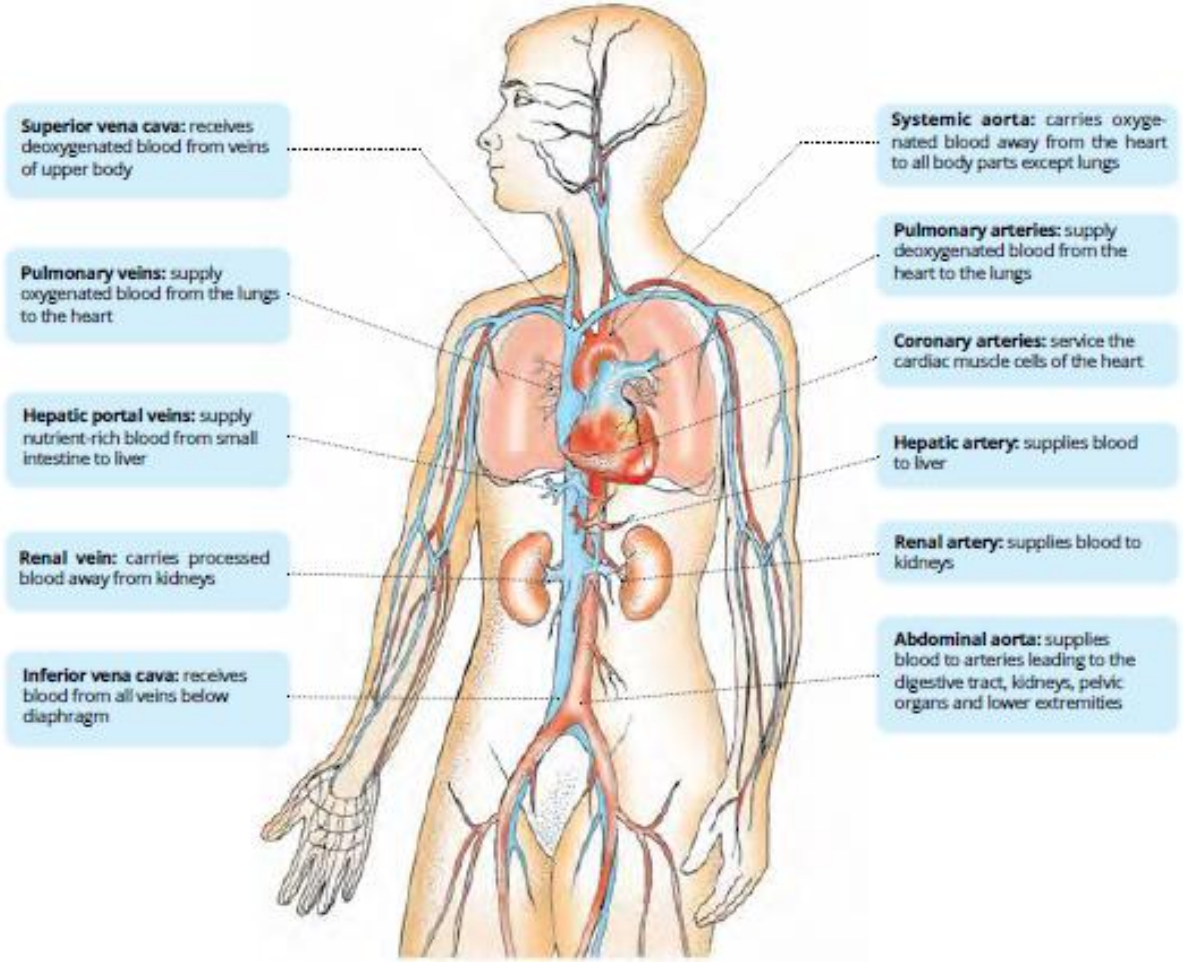
Blood vessels entering the heart

1. The right auricle receives three blood vessels.
❖ **Superior (Anterior) vena cava or precaval** brings deoxygenated blood from the head and upper region of the body.
❖**Inferior (Posterior) vena cava or postcaval** brings deoxygenated blood from lower region of the body.
❖ **Coronary sinus** brings deoxygenated blood from the heart's wall itself into the right auricle. It consists of two **coronary arteries** arising from the base of the aorta. **These supply blood to the heart muscles.** If coronary arteries get blocked, then it can cause heart attack.
2. The left auricle receives four blood vessels.
❖ **Pulmonary veins** – The left auricle receives two pairs of **pulmonary veins**, one pair from each lung. These bring oxygenated blood from the lungs.

Blood vessels leaving the heart

❖ **Pulmonary artery** arises from the right ventricle and carries deoxygenated blood to the lungs for purification.

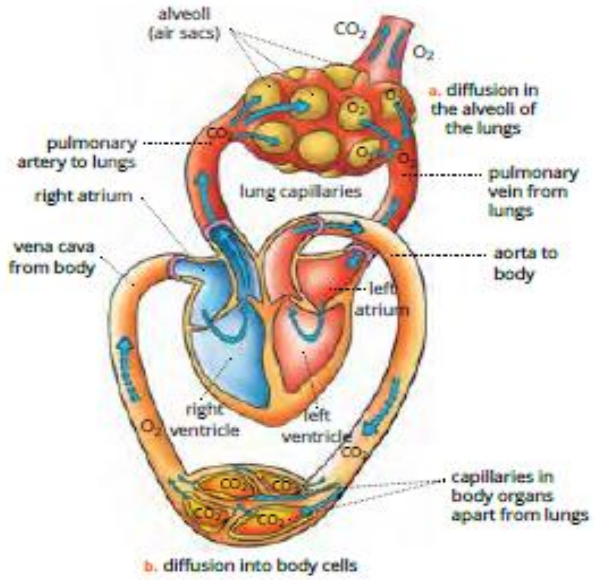
❖ **Systemic aorta** originates from the left ventricle and supplies oxygenated blood to all body parts, except the lungs.

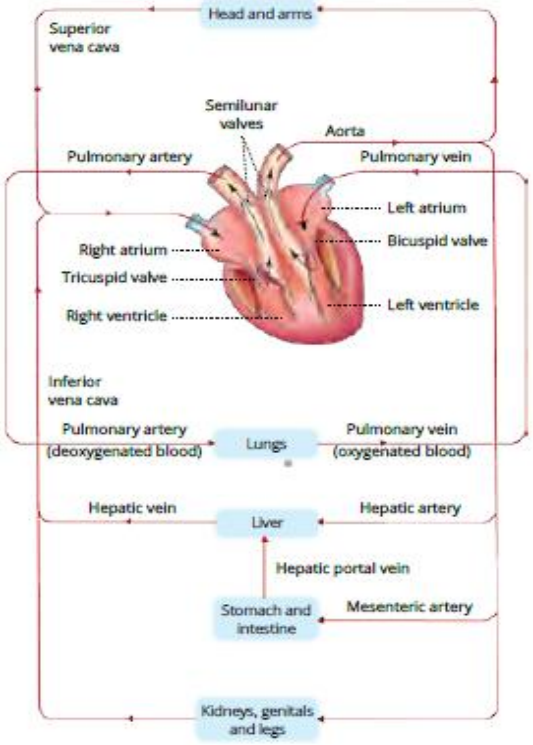


The location and functions of major blood vessels of human cardiovascular system

Double circulation

The circulation of blood in the human heart is called **double circulation** because the blood enters and leaves the heart twice in each heart beat. Circulation of blood between the heart and body organs (except lungs) is called **systemic circulation**. Circulation of blood between the heart and the lungs is called **pulmonary circulation.**





Systemic circulation

This part of circulation from the left ventricle to the right auricle of the heart via body tissues (except lungs) is called **systemic circulation.**

Pulmonary circulation

The circulation of blood from the right ventricle to the left auricle of the heart via lungs is called **pulmonary circulation**. The right ventricle pumps deoxygenated blood to the lungs for oxygenation (purification). Oxygenated blood from the lungs is returned to the left auricle by four pulmonary veins.

Cardiac cycle – systole and diastole

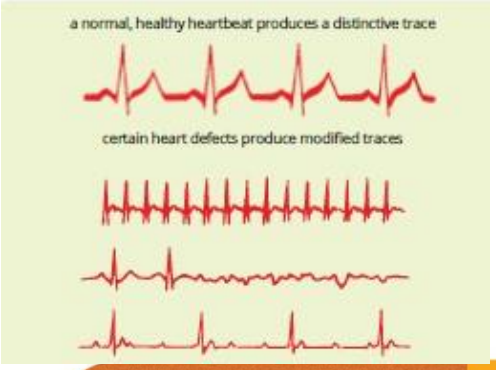
The sequence of events, which take place during the completion of one heartbeat, is known as **cardiac cycle**. It involves repeated contraction and relaxation of the heart muscles. A contraction is termed **systole** and a relaxation is termed **diastole**. The events that take place during the completion of one heartbeat are – the auricular systole, the ventricular systole and the joint diastole or complete cardiac diastole.

How is cardiac cycle conducted?

The heart is supplied by a network of nerves but these are not responsible for initiation of the cardiac cycle. The heart can keep on contracting and relaxing without any stimulation from these nerves. However, the heart has a regulating system of its own called the conduction system. It is a system of specialised muscle tissue which initiates and spreads the electrical impulses to stimulate a cardiac cycle.

Electrocardiogram (ECG)

The muscle cells or fibres of the heart are specialised at certain parts of heart to generate electric currents that cause normal rhythmic heartbeat. A recording of the electrical events that control the cardiac cycle is called an electrocardiogram (ECG).



The instrument used to record the changes is an electrocardiograph.

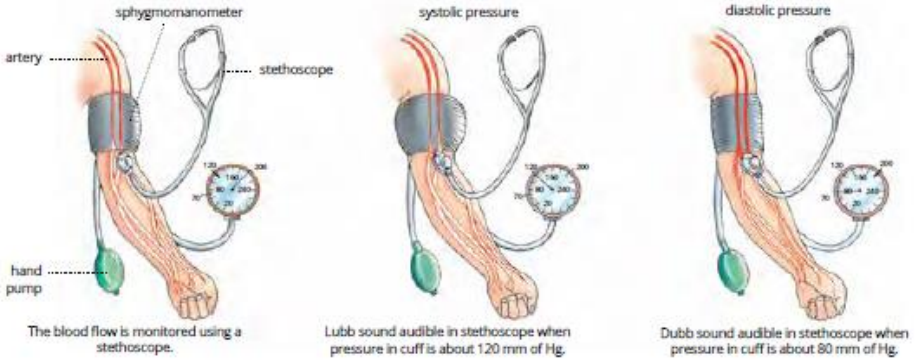
Pulse rate

The rhythmic contraction of the heart can be felt as a jerk in certain arteries which are superficial in position. This is the **arterial pulse**. **Each ventricular systole starts a new pulse**. It proceeds as a wave of expansion throughout the arteries and disappears in the capillaries. **Pulse rate is the same as the heartbeat rate.** The pulse rate in a normal adult man is about 64–72 beats per minute while in a woman 72–80 beats per minute. The pulse rate in infants is about 140 beats per minute.

Heart sounds – Lubb and dub

The lubb sound (first heart sound): This sound is caused by the vibrations set upon by the closure of tricuspid and bicuspid valves accompanied by the contraction of ventricular muscles at the start of ventricular systole. It is also called **systolic sound**. Lubb sound is low-pitched, not very loud and of a long duration.

The dubb sound (second heart sound): This sound is caused by the closure of the semilunar valves and marks the end of ventricular systole and beginning of ventricular diastole. The dubb sound is high-pitched, louder and shorter in duration.



Blood pressure

It is the force with which blood pushes against the walls of the arteries. It is generally measured in terms of how high it can push a column of mercury.

When the ventricles contract, pressure of blood inside the arteries is highest and this pressure is termed as **systolic blood pressure**. When ventricles relax, pressure of blood inside the arteries is comparatively less and this pressure is termed as **diastolic pressure**.

Blood pressure = systolic/ diastolic

= 120/ 80 mm of Hg

Portal system

A vein that does not carry deoxygenated blood directly to the heart but forms a network of capillaries on another organ before reaching the heart is called a portal vein.

Lymphatic system

The lymphatic system comprises **a colourless fluid – lymph** and a network of fine channels – **lymphatic capillaries (lacteals) and vessels (ducts)**, and **the lymph nodes**

Lymph

Lymph is a colourless fluid. It is a part of the tissue fluid which in turn is a part of blood plasma. So, the composition of tissue fluid and lymph is the same as that of blood plasma but tissue fluid and lymph have lower protein contents.

Functions of the lymph

The lymph performs many functions.

- ❖ It carries carbon dioxide and nitrogenous waste materials that diffuse into the blood through the tissue fluid.
- ❖ It carries lymphocytes and antibodies from the lymph nodes to the blood.
- ❖ It transports fats (fatty acids and glycerol) from the intestine to the blood.
- ❖ It destroys microorganisms and foreign particles in the lymph nodes.
- ❖ It drains excess tissue fluid from the intercellular spaces back into the blood.
- ❖ It carries the plasma protein macromolecules, synthesized in the liver cells and hormones, from endocrine glands to the blood.

Lymph vessels or lymphatics

The lymph capillaries join to form the lymphatic vessels. These lymph vessels are like capillaries but have comparatively thin walls and numerous valves. The smaller lymphatic vessels unite to form larger vessels and they unite to form two main lymphatic ducts.

Lymph nodes

At specific points in the lymph vessels, there are enlargements like beads of a string. These are called **lymph nodes**. **Lymph nodes contain lymphocytes, plasma cells and macrophages.** The lymph is filtered through the lymph nodes. The macrophages remove microorganisms and foreign particles from the lymph. The lymphatic nodes also add lymphocytes and antibodies to the lymph from where these are carried to the blood. Lymph nodes are abundant in the regions of neck, armpit and groin.

Tonsils

Tonsils are aggregation of lymphatic nodules enclosed in a mucous membrane. They are located in a ring at the junction of oral cavity and pharynx.

Significance of tonsils

❖ Their location is best suited to protect the body against entry of any foreign substance through the oral cavity.

❖ They also produce lymphocytes and antibodies.

Spleen

Spleen is the largest mass of lymphatic tissue found in our body. It measures about 12 cm in length and is situated in the region between the fundus of stomach and diaphragm.

It is covered by the peritoneal membrane. The tissue of spleen is of two types:

1. White pulp – The lymphatic tissue

2. Red pulp – Sinuses filled with venous blood and tissue cords consisting of macrophages, lymphocytes and ganulocytes.

Significance of spleen

- It produces antibodies, phagocytic cells and destroys dead RBCs and platelets.
- In embryonic stage, it produces RBCs.
- It also acts as reservoir of blood which is released during emergency such as haemorrhage.

Note: Refer to the Table 8.5 for the Differences between blood and lymph

SUMMARY...

❖ The flow of extracellular fluid in the body is called circulation and the organs concerned with this transport form the circulatory system.

❖ Human beings have an efficient circulatory system. It consists of:

- A circulatory medium – blood
- A system of blood vessels – arteries, veins and capillaries
- A pumping organ – heart

❖ Blood is made up of plasma and cellular elements. The cellular elements include RBCs, WBCs and platelets.

❖ Blood does not clot in uninjured vessels due to the presence of a strong, natural anticoagulant called heparin or antithrombin, produced by the liver.

❖ The glycoprotein or corpuscle factor present on the surface of RBCs and a protein or the plasma factor present in the blood plasma determine the type of blood group of a person.

❖ Blood of group O can be given to any blood group, hence people with blood group O are called universal donors.

❖ Persons with blood group AB can receive blood from all blood groups, hence, are called universal recipients.

❖ All arteries carry oxygenated blood, except pulmonary arteries, which carry deoxygenated blood from the heart to the lungs for purification.

❖ All veins carry deoxygenated blood except pulmonary veins, which carry oxygenated blood from the lungs to the heart.
❖ The human heart is a fibromuscular organ somewhat conical in shape. It is about the size of a fist. Its weight is about 300 g in an adult human being.
❖ The human heart is a four-chambered structure, divided by a septa into two halves – the right and the left.
❖ The left auriculo-ventricular aperture is guarded by the bicuspid valve, which consists of two flaps or cusps, and the right auriculo-ventricular aperture is guarded by the tricuspid valve made up of three flaps or cusps.
❖ Circulation of blood in the human heart is called double circulation because it enters and leaves the heart twice. Circulation between the heart and body organs except lungs is called systemic circulation.
❖ The sequence of events that take place during the completion of one heartbeat is known as cardiac cycle. It lasts for about 0.8 seconds.
❖ The rhythmic contraction of heart is felt as a jerk in certain arteries that are superficial in position. This is the arterial pulse.
❖ Blood pressure is the force with which blood pushes against the walls of arteries.
❖ The lymphatic system comprises – lymph, lymphatic capillaries and vessels, and lymph nodes.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