The Circulatory System

Body Fluids and their Functions

What is blood and what are its functions?

Blood is a fluid connective tissue that flows in blood vessels. Its main function is to transport substances such as digested food and oxygen (from the small intestine and lungs respectively) to all parts of the body.

It also takes part in the removal of waste materials from the body. **How does blood perform all these functions? Does it have some special components that perform these functions?** Blood is made up of various types of cells that are suspended in a fluid part called **plasma**.

Plasma is a yellowish colour fluid, made up of water (~90%) and some dissolved nutrients, proteins, hormones and waste products. Let us study the various components of blood.

Blood consists of three types of cells. These are as follows.

- **Red Blood Cells or Erythrocytes -** They contain a red pigment called haemoglobin, which transports oxygen to all cells of the body by combining with oxygen to form a compound called oxyhaemoglobin. The mature erythrocytes do not have a nucleus.

- **White Blood Cells or Leukocytes -** They are larger than RBCs and do not have haemoglobin. They fight against germs that enter the body. Thus, they protect the body from diseases.

- **Blood Platelets or Thrombocytes -** You must have noticed that when you get injured, bleeding stops after some time. This happens because of the activity of platelets. Platelets help in the clotting of blood during an injury. The platelets are smaller than the RBCs.

Some interesting facts:

After blood donation, the fluid gets replaced in few hours and the red blood cells within four weeks. It takes around eight weeks to restore the iron lost after donation.
Platelets are produced at the rate of 200 billion per day in the human body.

Functions of blood:

- It transports nutrients and oxygen to the different parts of the body
- It also carries waste materials (from the different parts of the body) to be removed by the excretory organs.
- Chemical messengers like hormones are transported by the blood.
- Protects the body from disease carrying germs.
- Helps to maintain a constant body temperature.

Blood Clotting

- Clotting is an important character of blood, which helps in preventing blood loss at the time of any physical injury.
- The blood clot is formed with the help of platelets.
- When any physical injury damages a blood vessel, the platelets release an enzyme that help in production of a protein, thrombin.
- Thrombin protein converts fibrinogen protein present in the blood into fibrin.
- These fibrin proteins form a fine mesh work around the wound, in which the blood cells get trapped.
- This fibrin network then contracts along with the blood cells, and results in the formation of a solid clot which plugs the cut.

Lymph

Lymph is a watery clear fluid. It is blood minus RBCs. The cellular part of lymph constitutes only leucocytes. This fluid distributes immune cells and other factors throughout the body. It also interacts with the blood circulatory system to drain fluid from cells and tissues.

The lymphatic system contains immune cells called **lymphocytes**, which protect the body against foreign antigens (viruses, bacteria, etc.) that invade the body. Lymph also help in transporting nutrition and oxygen to various body parts.

Tissue Fluid (Intercellular Fluid)
As blood flows through the capillaries, the plasma and some leucocytes can escape out from the capillary walls. This fluid then fill in the intercellular spaces and bathes the surrounding cells. Thus, it is known as tissue fluid or intercellular fluid.

Blood transfusion and blood groups

Sometimes when we get seriously wounded and lose a lot of blood, this lost blood is replaced by blood taken from another person but we cannot just take blood from any person and hence the characteristics of the blood are to be studied before. The process of transfer of blood from one person to another is called **blood transfusion**.

Blood groups

Based on the presence or absence of certain substances called **antigens** on the surface of the RBCs , the blood of human beings can be divided into four blood groups, they are A, B, AB and O.

- Blood group A has A antigen
- Blood group B has B antigen
- Blood group AB has both A and B antigens
- Blood group O has neither A nor B antigens.

Do You Know?

Blood group O is known as the **universal donor** since it can be transfused into any person with any blood group
Blood group AB is known as the **universal acceptor** since it can receive any blood group

Blood Group Compatibility

During blood transfusion, we have to take special care of blood compatibility. If the blood group of donor is not compatible to that of patient's blood, the patient's body refuses to accept it and can react with the transfused blood. This can create a life-threatening situation for the patient.

Let us see what type of blood groups are compatible to each other.

Blood Group of Donor	Blood Group of Recipient
A	A, AB
B	B, AB
AB	AB
O	A, B, AB, O

Rh-factor

There is another antigen present on the surface of the RBCs which is known as the Rh-factor. About 85% of the people have Rh factor and are called Rh positive and those who do not have the Rh factor are known as Rh negative.

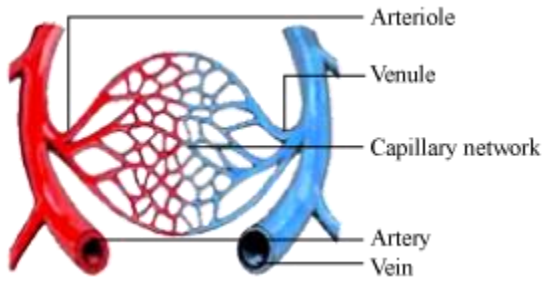
Before blood transfusion, the Rh factor as well as the blood group of the donor and the recipient have to be matched or it may lead to serious illness.

Heart and Blood Vessels

We know that blood flows inside the blood vessels and it performs functions such as transporting oxygen and nutrients to all cells of the body. We also know that it helps in removing waste materials, including carbon dioxide, from the body.

How does blood perform these functions without getting the food and nutrients and the waste materials mixed up? Let us study how this is possible.

Blood Vessels



Arteries: They are tough, elastic tubes that carry blood from the heart and supply it to various organs of the body. Blood flows under high pressure in the arteries. As the arteries move away from the heart (i.e. on reaching organs and tissues), they divide into smaller vessels. The smallest vessels called **capillaries** have very thin walls. Arteries are red in colour because they carry oxygenated blood.

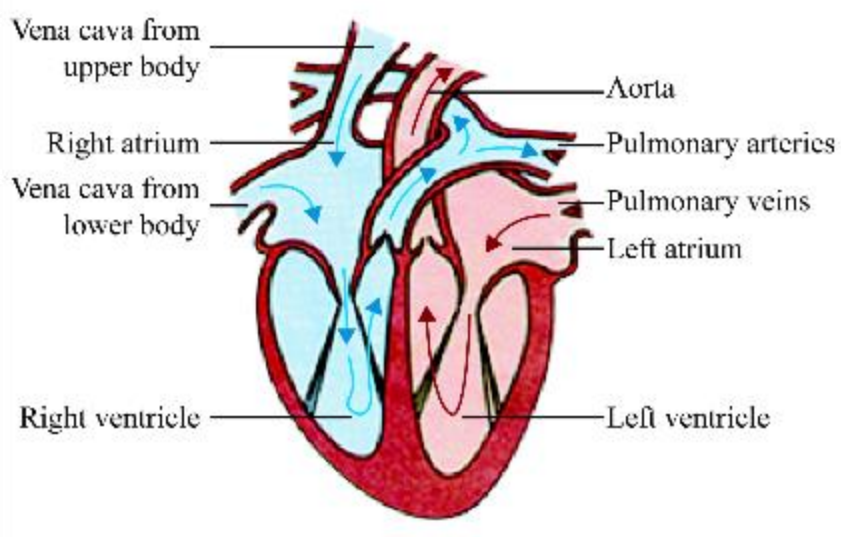
Capillaries (in organs and tissues) join together to form **veins**.

Veins collect blood from different organs and tissues. Veins are thin-walled as compared to arteries. This is because, they bring back blood from the organs to the heart and blood is no longer under pressure. These veins carry deoxygenated blood into the heart.

The pulmonary artery is the only artery that carries carbon dioxide-rich blood, while the pulmonary vein is the only vein that carries oxygen-rich blood.

Heart

In human beings, the heart is a muscular organ. The walls of the heart are made up of a special muscle called **myocardium**, which contracts continuously and rhythmically to distribute blood to all the body cells.



It is enclosed by a double membrane known as the **pericardium** filled with a fluid known as the **pericardial fluid**. It is divided into four chambers − the right auricle, the right ventricle, the left auricle, and the left ventricle. The auricles are thin-walled and receive blood from the different parts of the body.

The lower two chambers (ventricles) have thick walls and they pump blood out of the heart. The flow of blood is from the auricles to the ventricles, but blood cannot flow from one auricle to another or from one ventricle to another because a muscular wall separates the left side from the right side.

Valves in the Heart

Tricuspid valves: The right auricle is separated from the right ventricle by the tricuspid valve, which opens in only one direction i.e., from right auricle to the right ventricle.

Bicuspid valve: The left auricle and the left ventricle are separated by the presence of the bicuspid valve, which allows the flow of blood from the left auricle to the left ventricle.

Blood Vessels of the Heart

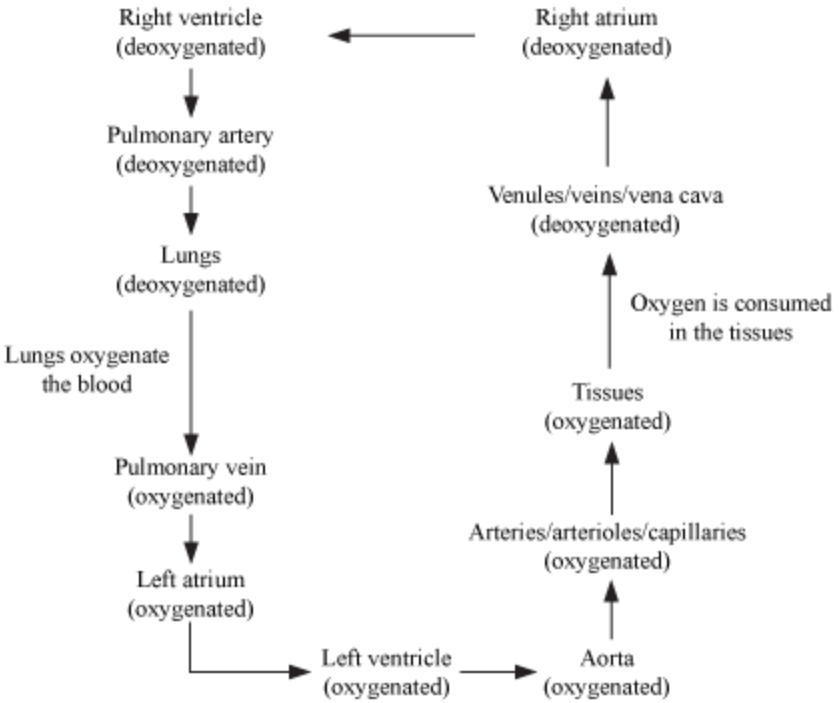
Vena cavae: These are the large veins that carry deoxygenated blood from the whole body to the heart. Superior vena cava bring deoxygenated blood from the upper parts of the body, whereas inferior vena cava bring deoxygenated blood from the lower parts of the body. Both these veins open into the right auricle.

Pulmonary artery: It carry deoxygenated blood from the right ventricle of the heart to both the lungs for oxygenation.

Pulmonary vein: It carries oxygenated blood from lungs to the left auricle of the heart.

Aorta: It is a large artery that carry oxygenated blood from the left ventricle of the heart to the whole body.

Circulation of Blood



The heart pumps blood to all parts of the body. The superior vena cava and inferior vena cava bring in deoxygenated blood from the anterior and posterior parts of the body respectively into the right auricle. From the right auricle, the blood passes on to the right ventricle and then to the lungs through the pulmonary artery. The blood gets oxygenated in the lungs and is transported back to the heart via the pulmonary vein into the left auricle. Then it is passed to the left ventricle.

Do You Know?

The pulmonary artery is the only artery in the human body, which carries deoxygenated blood; and the pulmonary vein is the only vein, which carries oxygenated blood.
The aorta is the largest artery in the human body.

From the left ventricle, the blood is carried by the aorta from where it is supplied to the rest of the body.

Pulse

The pulse rate!

The heart muscles contract and relax at regular intervals and this can be heard as two sounds (lub, dub). Doctors listen to this using a stethoscope. When the left ventricle contracts, the blood is forced into the arteries under high pressure; and when they relax, the pressure goes down.

This stretching and relaxing of the arteries is felt as a throbbing called the **pulse.**

Place your middle and index fingers on the inner side of the right hand and record your pulse rate per minute. Tell your classmates to do the same.

Now, compare the obtained values. **Is there any difference between your pulse rate and that of your classmates? What is the normal range of pulse rate?**

The normal pulse rate is 72 beats/min.

Do You Know?

The human heart continues to beat even after it is taken out of the body or cut into pieces!
William Harvey was an English physician who discovered the circulation of blood.

Blood Pressure

The average pressure produced in the ventricles when they contract and when the blood is pumped into the aorta and the pulmonary artery is known as the **systolic pressure**. It is equal to the pressure exerted by a column of 120 mm of mercury.

The average pressure produced in the ventricles when they relax and are filled with blood is known as the **diastolic pressure**. It is about 80 mm of mercury. Hence, the value of blood pressure in an adult is about **120/80**.

The blood pressure is measured by an instrument known as the **sphygmomanometer**. If the blood pressure rises above 140/90 mm, it is known as hypertension, or high blood pressure. The blood pressure below the normal level causes hypotension, or low blood pressure.

Heartbeat

If you place your hand on the left side of your chest, then you will feel your heartbeat. **What causes a heartbeat?** We know that heart is a muscular organ and its walls are made of muscles. The periodic contraction and relaxation of these muscles causes a heartbeat.

Stethoscope

Have you ever seen doctors using a stethoscope? What is the use of a stethoscope?

Doctors use stethoscopes to listen to heartbeats. They draw conclusions about the condition of the heart from the sound of the heartbeats.

Don’t skip a beat!

Take a small funnel and fix a rubber tube to its stem. Stretch a rubber sheet over the mouth of the funnel and fix it tightly with a rubber band. Now, put the open end of the tube in one of your ears and place the mouth of the funnel on your chest.

Listen to your heartbeat and record its rate

- at rest
- after running for 4–5 minutes

Similarly, record your pulse rate (using your fingers)

- at rest
- after running for 4–5 minutes

Disorders of Circulatory System

- **Hypertension**

- Normal blood pressure − 120/80 [120 mm Hg − systolic and 80 mm Hg − diastolic]
- If blood pressure of an individual comes out to be equal to or more than 140/90, then we say that he suffers from high blood pressure or hypertension.
- It affects heart, kidneys, brain, and other vital organs.

- **Coronary Artery Disease (CAD)**

- Blood vessels supplying blood to heart muscles are blocked by deposits of calcium, fat, cholesterol, or fibrous tissues.
- Common term used − Atherosclerosis

- **Angina (Angina Pectoris)**

- Enough oxygen does not reach heart muscles.
- Main symptom − Acute chest pain
- Can occur at any age but common in middle aged and elderly

- **Heart Failure**

- Pumping of blood is not enough to meet the requirements of body.
- Common term − congestive heart failure since congestion of lungs is one of the main symptoms

- **Heart attack**

- Situation when the heart muscles get damaged due to short supply of blood

- **Cardiac Arrest**

  It is a serious medical emergency which occurs when the heart suddenly stops pumping blood around the body. It mostly occurs due to any coronary artery disease, however, major blood loss, lack of oxygen or potassium, or intense physical exercise can also be a reason.

  The main symptoms of a cardiac arrest are loss of consciousness, abnormal breathing, chest pain and nausea.
  A cardiac arrest must not be confused with a heart attack. A heart attack is a situation of sudden interruption of blood supply to any part of cardiac muscle. It causes chest pain and permanent damage to the heart. It may also result in causing cardiac arrest in the patient.

  Both cardiac arrest and heart attack are life-threatening medical emergencies and thus immediate medical treatment must be given to the patient.

  Some immediate emergency steps can be taken to increase the chances of patient's survival, which include chest compression and mouth-to-mouth resuscitation.