UNIT : 1

Life Processes : Transport of Food and Minerals in Animals & Plants

BLOOD — THE CIRCULATORY FLUID IN OUR BODY

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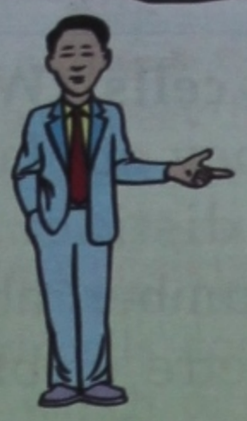


SYLLABUS

1. The circulatory system in human beings.
   * Counting of pulse — finding an average — noting changes after exercise and rest (E).
2. Different types of blood cells — blood groups — transfusion of blood.
   * Finding out more about blood groups and blood transfusion (E).
   * Viewing slides of RBC/WBC — if available (E).

Functions of the blood.

* Extension activity : Talking to a pathologist to find out how blood tests can reveal the presence of infection and other diseases like diabetes, HIV.

HUMAN CIRCULATORY SYSTEM

You have learnt that both human beings and the animals need food and oxygen to keep themselves alive. Simultaneously, they give out certain harmful substances like carbon dioxide and nitrogenous wastes. The intake of food and oxygen, and the removal of these wastes are carried out by a transport system. This transportation is carried out mainly by the blood. The blood is transported to all parts of the body by a pumping organ, *i.e.* heart.

The to and fro movement of the blood carried out by the heart is called the blood circulatory system.

Our circulatory system consists of blood, blood vessels and heart. Together, they transport substances to various parts of the body. The blood flows through blood vessels. Its flow is regulated by the heart. The heart acting like a pump pushes and receives the blood to and from the whole body through the vessels.

THE BLOOD

The blood is a red coloured fluid which consists of two parts :

(1) **Plasma,** the liquid part; and

(2) **Corpuscles,** the cellular part.

- The **plasma** is yellowish in colour. Most of it is water (about 90 per cent), and the remaining (10 per cent) consists of the following nutrients :
- **Food**, **vitamins** and **minerals**.
- **Blood proteins** which include antibodies that protect the body from the diseases and fibrinogen that helps the blood to clot.
- **Waste products** that include urea and carbon dioxide.
- **Hormones** : The chemical messengers

which help to coordinate different body functions.

- **Blood tastes** saltish due to the dissolved minerals, like sodium chloride.

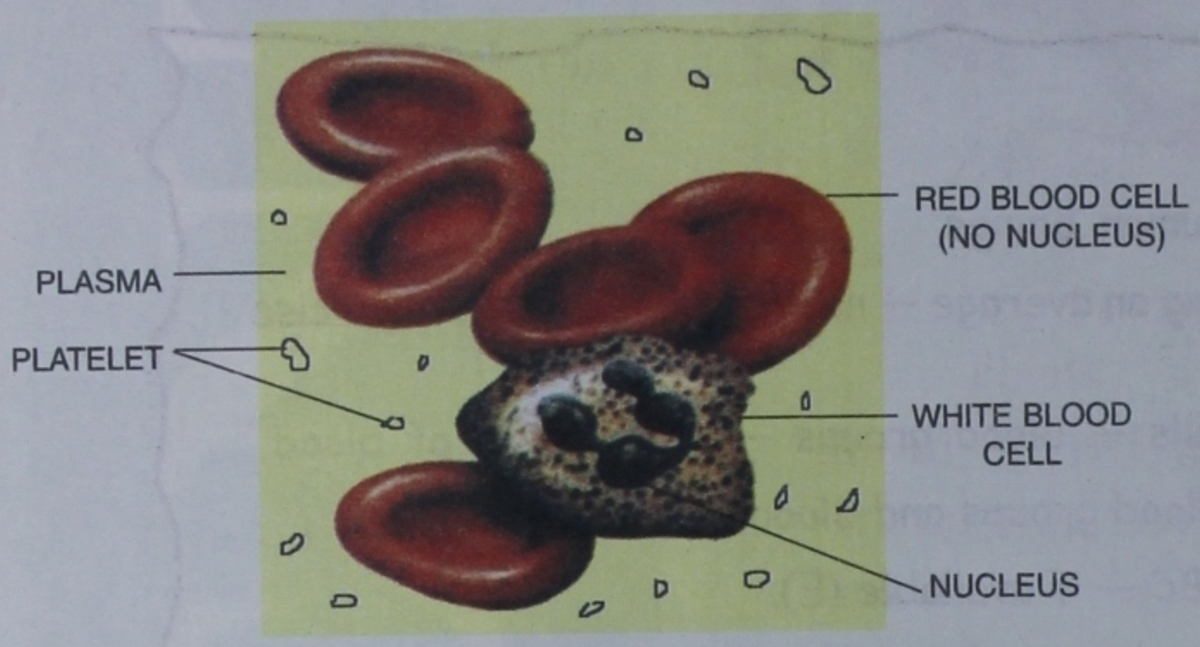


Fig. 1.1 The red blood cells, a white blood cell and platelets

Amazing Fact

In an adult human body, there is about 5.5 litres of blood which forms the most amazing transportation system in the body.

The corpuscles or the blood cells are of three types :

Red blood cells (RBCs), White blood cells (WBCs) and Platelets.

1. The **red blood cells** (RBCs) are circular or disc-shaped. These cells initially had a nucleus to start with, but they loose it during maturation.

The RBCs are about 4·5 to 5·0 million in one cubic millimetre of blood. They are produced by our bone marrow (central hollow part of the bone) and have a lifespan of 120 days. Their red colour is due to the iron and protein compound called **haemoglobin** which **acts as the "oxygen–carrier"**.

Do You Know ?

In human blood, more than two million red blood cells get destroyed every second but they are replaced immediately by the new ones.

2. The **white blood cells (WBCs)** are also called **leucocytes.** They are larger than the RBCs and have a distinct nucleus. They are much less in number, about 5000 to 8000 per cubic millimetre of blood. The WBCs capture and destroy the germs that try to enter the human body. Thus, they protect us from diseases as far as possible *i.e.*, they provide us immunity.

The white blood cells are basically of two types depending upon the presence or absence of granules in their cytoplasm.

- Granulocytes (granular) and agranulocytes (non-granular).
- Granulocytes are further distinguished into neutrophils, eosinophils and basophils, while the agranulocytes are classified into monocytes and lymphocytes.

3. The **platelets** are somewhat round in shape and the smallest in size. They are about 2-3 lacs per cubic millimetre (cu mm) of blood. The platelets help in the clotting of blood which prevents excessive blood loss.

You must have sometimes experienced a prick in your skin by a thorn, a needle or a cut by a razor blade. The blood flows out from the pricked spot for a short time and then it stops.

Do you know that the blood stops flowing after sometime by itself ? Why ? It happens because our body has its own mechanism of preventing this loss by forming a blood clot. This clot plugs the injury to stop bleeding.

Blood clotting is a complex process and its mechanism is given below :

- The damaged blood vessels and platelets release an enzyme.
- This enzyme helps in the production of a protein called thrombin.
- This, in turn, helps in the conversion of fibrinogen (present in the blood plasma) into fibrin.
- Fibrin forms a fine mesh work into which the red blood cells get trapped, and a watery liquid (serum) oozes out of the wound. **Serum** is actually the blood plasma without its fibrinogen.
- The fibrin network together with the blood cells contract. This makes a solid clot, which plugs the cut.

In certain diseases, the number of platelets get reduced to a great extent. Dengue fever is one such disease in which the number of platelets get reduced to as low as 25–30 thousand per cu mm of blood and the body shows bleeding symptoms. Delhi and many other parts of the country lose a number of lives due to dengue fever every year.

Activity 1

To examine the red and white blood cells with the help of prepared slides.

- Place the prepared slide of human blood under the microscope. First, try to focus the slide under low power magnification. Observe the red blood cells and the white blood cells.
- Request your teacher to help you to focus the slide under high power magnification. Examine the slide again. The red and white blood cells will now be more clearly visible.
- The RBCs are comparatively small, disc-shaped and without a nucleus.
- The WBCs are larger with a distinct nucleus.

Conclusion :
Apparently, the blood appears to be a thick "homogenous" fluid, but when observed under the microscope, its two main cellular components, RBCs and WBCs, are distinctly seen.
[**Note :** The platelets are too small to be seen at this magnification].

FUNCTIONS OF THE BLOOD

1. The blood transports the digested food (nutrients) from the intestines to those organs where they are either stored or utilised (*e.g.* the liver).
2. It carries oxygen from the lungs to the tissues and carbon dioxide produced in the tissues to the lungs from where it is breathed out.
3. It carries the cellular waste products to the kidneys from where they are removed from the body.
4. It maintains water balance in the tissues. It takes in excess water, if any, from our tissues and also provides them water when they need it.
5. It regulates body temperature by distributing the heat (produced in our tissues) in different parts of the body.
6. It protects against diseases by destroying the disease-causing germs.
7. It prevents excessive bleeding by blood clotting.

THE BLOOD VESSELS

The blood is carried to different parts of the body through tubular **blood vessels**.

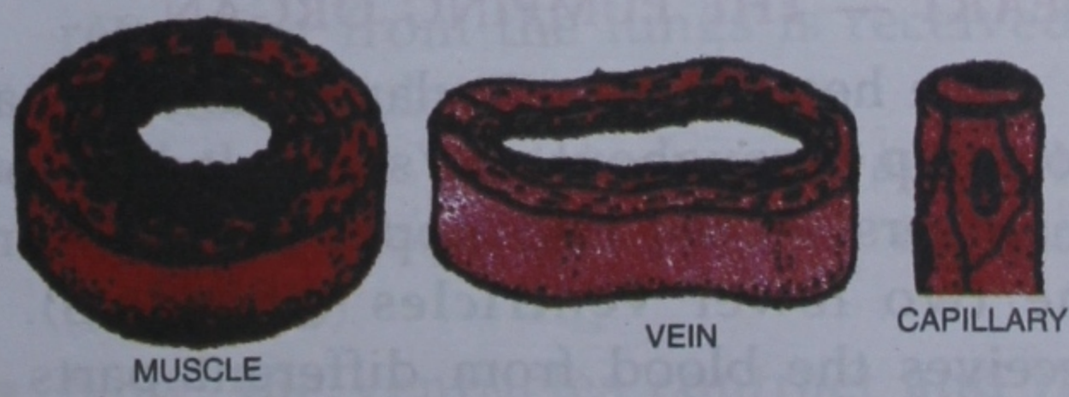


Fig. 1.2 Three kinds of blood vessels

The blood vessels are of *three* kinds — **arteries, veins** and **capillaries.**

An **artery** is a vessel which carries the blood away from the heart to other parts of the body. It has thick, elastic and muscular walls, and the blood in it flows with jerks (as felt in the pulse).

A **vein** is a vessel which takes the blood from an organ towards the heart. It has thin muscular walls and the blood in it flows smoothly.

Differences between arteries and veins :

ARTERIES	VEINS
1. Carry blood away from the heart.	1. Carry blood into the heart.
2. Have thick and more muscular walls.	2. Have thin and less muscular walls.
3. Carry oxygenated blood (except pulmonary artery which carries deoxygenated blood).	3. Carry deoxygenated blood (except pulmonary vein which carries oxygenated blood).
4. The blood flows with jerks and under great force.	4. The blood flows smoothly and under little pressure.
5. Usually, deeply placed.	5. Usually placed more superficially.

Capillaries are the terminal branches of an artery, which rejoin to form a vein. A **capillary** is a very narrow tube whose walls have a single layer of cells with no muscles. Although the wall of a capillary is very thin, yet an exchange of nutrients, waste products and gases can take place between the blood and the body fluids.

HEART — THE PUMPING ORGAN

The heart is a muscular organ. It beats non-stop throughout one's life. It has four chambers — the two upper **auricles** and the two lower **ventricles** (Fig. 1.3). It receives the blood from different parts of the body and then pumps it into the lungs for gaseous purification [pulmonary (lung) circulation]. The oxygenated blood from the lungs returns to the heart, which it pumps again into different parts of the body [systemic (body) circulation]. In this way, blood passes *twice through the heart*, making one complete round through the body. It is called **double circulation.**

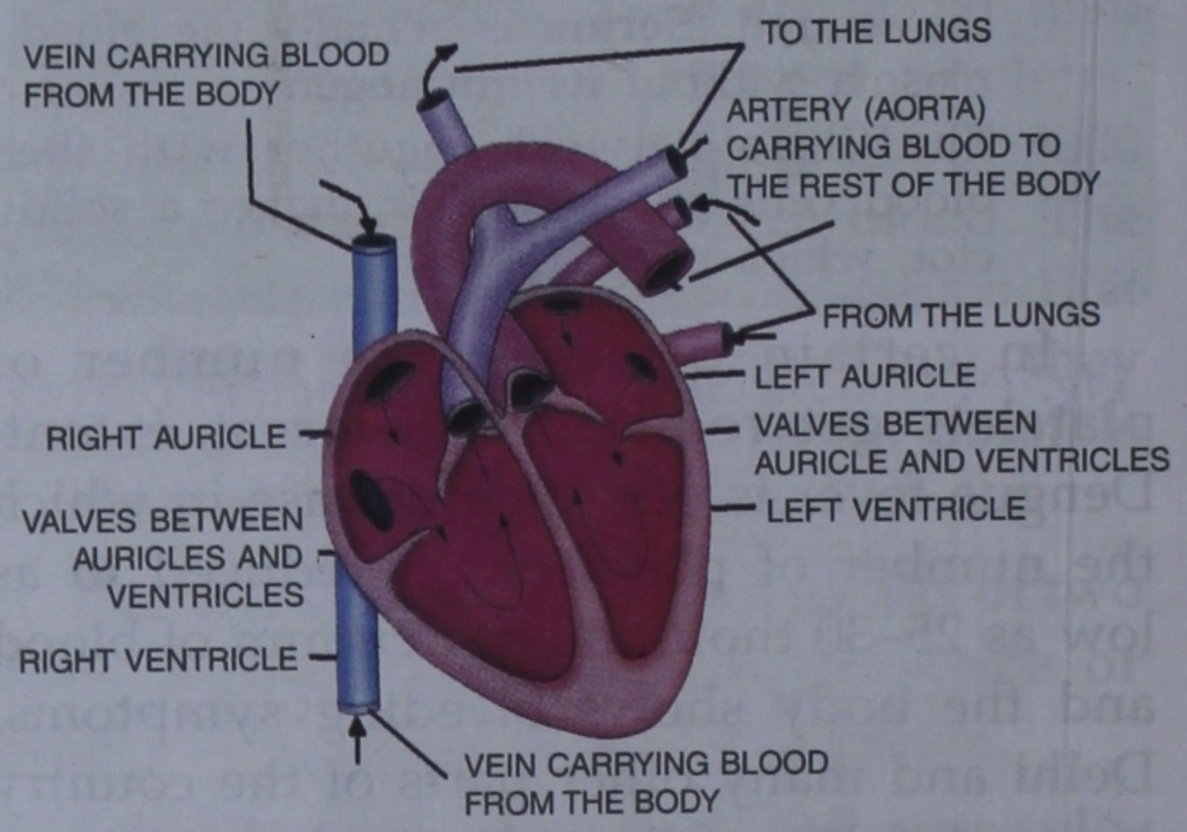


Fig. 1.3 Internal structure of the human heart (Diagrammatic)

Double circulation :

(i) **Pulmonary (lung) circulation** – In this circulation, the blood flows from the right ventricle (RV) into the vascular system of the lungs, gets oxygenated and then returns to the left auricle through the pulmonary veins.

(ii) **Systemic (body) circulation** – In this circulation, the blood flows from the left ventricle (LV) to the body parts and returns to the heart in the right auricle (RA) Fig. 1.4.

The heart contracts to push out the blood to various parts of the body and then relaxes (attains the normal size) to receive back the blood from different parts. Both these phases occur in a rhythmic manner one after the other, and together they form a **CARDIAC CYCLE.**

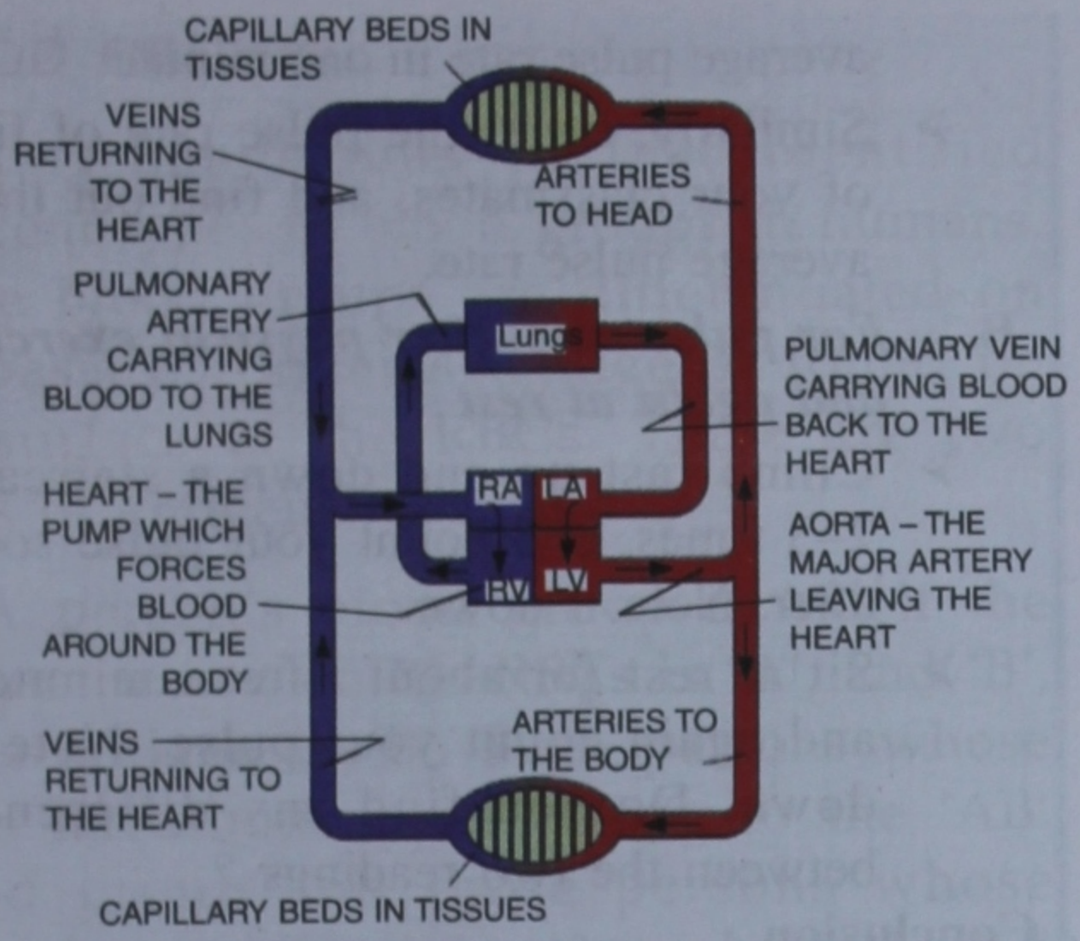


Fig. 1.4 Double circulation of blood in the body

Overall, the contraction phase of the heart is called **systole** and the relaxation (dilation) phase is called **diastole.**

The right auricle opens into the right ventricle and the left auricle opens into the left ventricle. Their openings inbetween are guarded by valves. The valves allow the blood to flow only in one direction – *i.e.*, from the auricles into the ventricles.

Hepatic portal circulation : It is the circulation of the food-laden **blood** from small intestine to the liver and then from liver to heart. Liver **monitors** the substances before passing them into the body, e.g., excess glucose is retained in the form of glycogen (insoluble form) and the excess amino acids are broken down by the liver (deamination). Harmful chemicals are detoxified and bacteria are destroyed, and excess minerals, water and vitamins are stored in the liver.

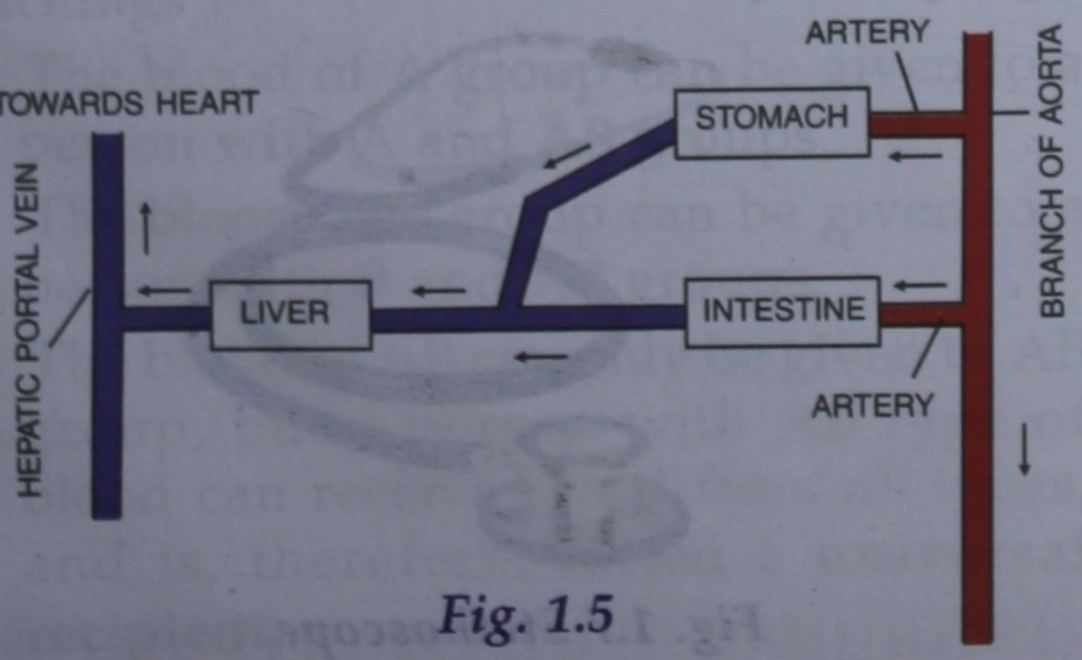


Fig. 1.5

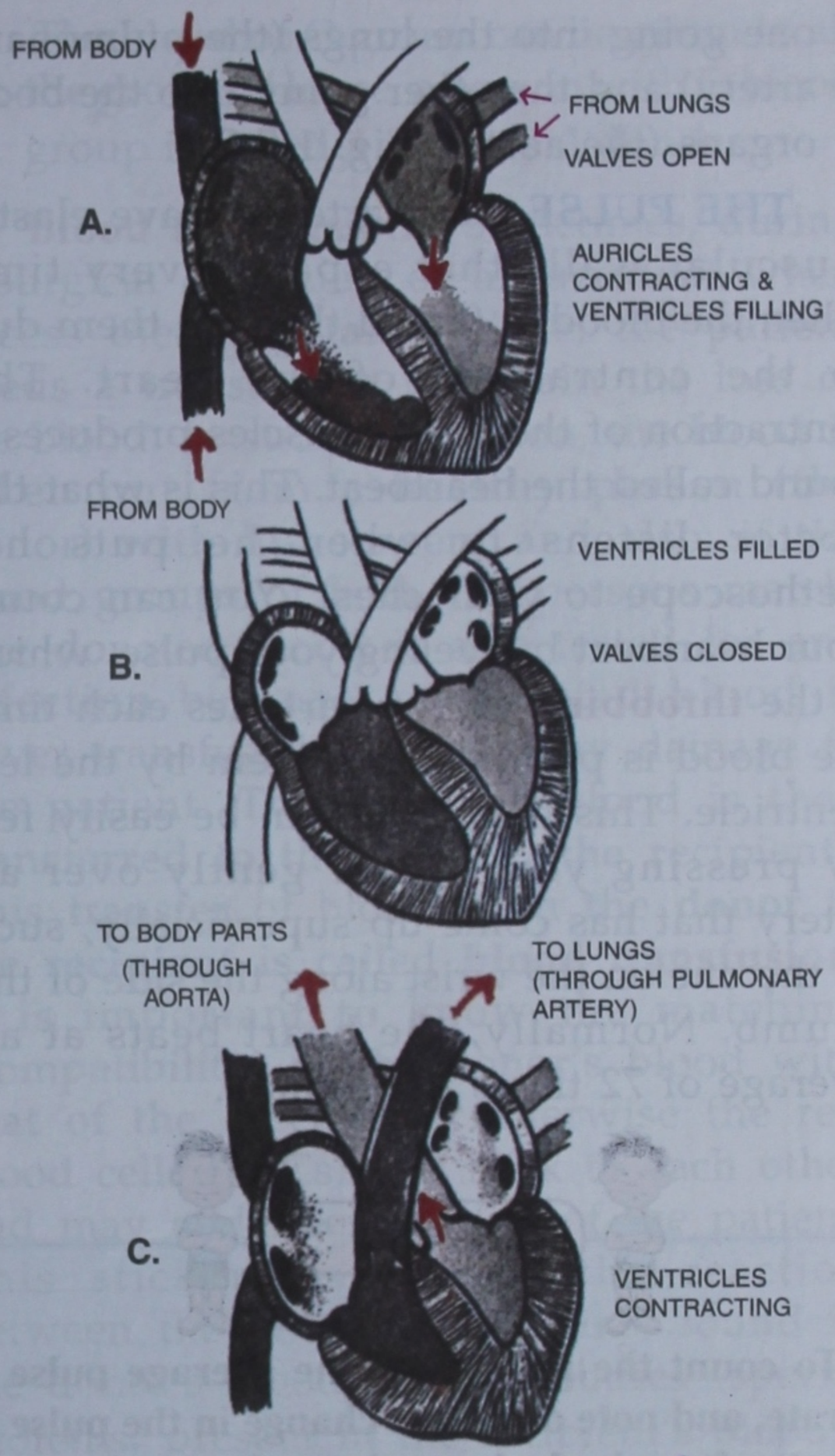


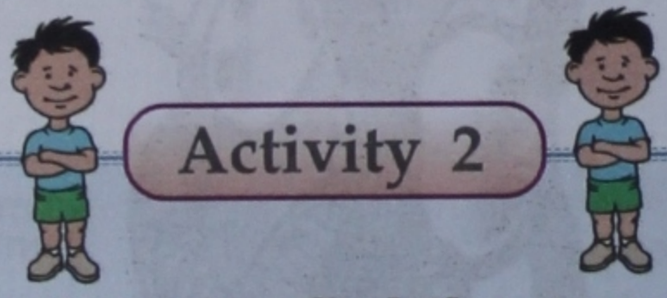
Fig. 1.6 How the heart works

BLOOD CIRCULATION

- The blood returning from the body to the heart is received in the right auricle. It contains carbon dioxide.
- Simultaneously, the oxygen-rich blood returning from the lungs is received in the left auricle (Fig. 1.6 A).
- When the auricles contract, they force the blood into the two ventricles (Fig. 1.6 B).
- Now, the ventricles contract and they force the blood into two large arteries —

one going into the lungs (the pulmonary artery) and the other going into the body organs (the aorta) (Fig. 1.6 C).

THE PULSE : The arteries have elastic muscular walls that expand every time when the blood is forced through them due to the contraction of the heart. The contraction of the heart muscles produces a sound called the heartbeat. This is what the doctor listens to when he puts his stethoscope to your chest. You can count your heartbeat by feeling your pulse, which is the **throbbing** of your arteries each time the blood is pumped into them by the left ventricle. This throbbing can be easily felt by pressing your finger gently over an artery that has come up superficially, such as the one on the wrist along the side of the thumb. Normally, the heart beats at an average of 72 times per minute.

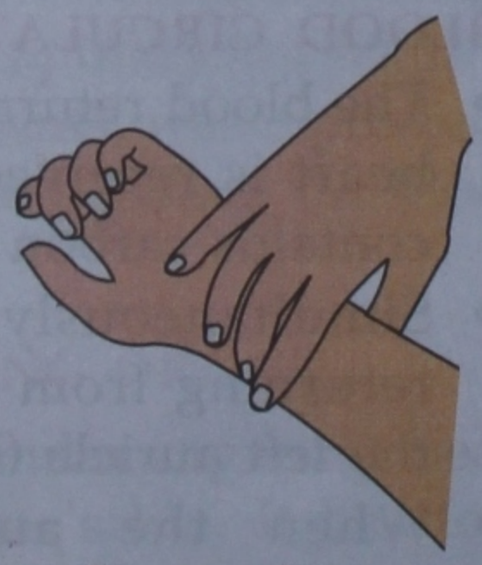


Activity 2

To count the pulse, find the average pulse rate, and note down the change in the pulse rate after physical exercise and at rest.

A. ***For pulse rate at rest***

- Sit down comfortably in a chair with your one palm facing upwards.
- Gently place the first three fingers of your other hand on your wrist as shown in the diagram. Can you feel your pulse as a repeating throb ? If necessary, adjust the position of your fingers, until you feel the pulse really well.



- Count the rate of the pulse in 15 seconds and multiply it by 4. This gives your average pulse rate in one minute.
- Similarly, count the pulse rate of five of your classmates, and find out their average pulse rate.

B. ***For pulse rate after physical exercise and again at rest***

- Climb fast up and down a staircase 2–3 times, and count your pulse soon after. Note it down.
- Sit at rest for about fifteen minutes, and again count your pulse. Note it down. Do you find any difference between the two readings ?

Conclusion :

- The average pulse rate of normal healthy adults while at rest is about 72 times per minute.
- The pulse rate increases after strenuous physical exercise. The rate may reach even 120 or more per minute after an exercise.

The doctor counts the pulse of an ailing person to get an idea about the patient's heart beat.

- **Faster heart** beat is usually an indication of hypertension or fever.
- **Very low pulse** rate may indicate poor functioning of the heart.

The pulse can also be measured by using a stethoscope (Fig. 1.7). A stethoscope is an instrument that amplifies the sound of a heart beat and is used to hear heart beats in the chest, by placing its chest piece at the appropriate place.

Fig. 1.7 Stethoscope

BLOOD GROUPS

Karl Landsteiner in 1900 identified different types of blood groups in humans. These blood groups are differentiated on the basis of proteins (antigens) found on the surface of the RBCs. There are two types of antigens — A and B.

A person's blood group is 'A' if the antigen present in his RBCs is 'A', and 'B', if the antigen is 'B'. Such persons whose RBCs have both types belong to the 'AB' blood group and those persons whose RBCs do not have an antigen, have the 'O' blood group.

MATCHING OF BLOOD GROUPS

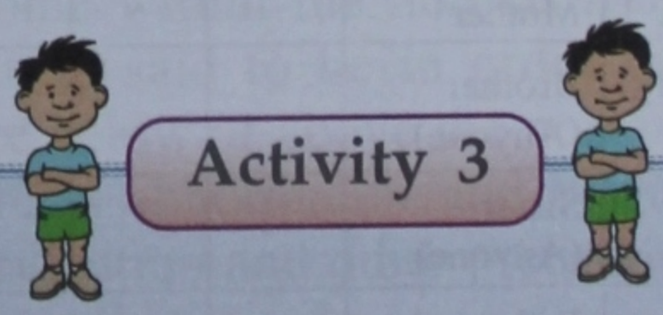
Matching of blood groups (compatibility) under the ABO system is done as follows (√ = Yes, × = NO) :

Blood group of donor	**Blood group of recipient**			
	A	B	AB Universal recipient	O
A	√	×	√	×
B	×	√	√	×
AB	×	×	√	×
O Universal donor	√	√	√	√

What do you conclude from the above matchings ?

1. The blood of A group can be given to a person with A and AB groups.
2. The blood of B group can be given to a person with B and AB groups.
3. The blood of AB can only be given to AB group, but a person with AB type of blood can receive blood from all types, and is, therefore, called a **universal recipient.**
4. The blood of O group can be given to all the groups. Hence, a person with O blood group is called a **universal donor.**

Blood transfusion : Sometimes, during a surgical operation or an accident when excess bleeding takes place, the patient needs a transfusion to regain the loss of the blood. In such a situation, the blood is taken out from a healthy person (the donor) with his consent and also, if the blood groups of both the persons match. The donated blood is also tested for any infection because an infected blood is never transfused to avoid any damage to the patient. The collected blood is then transferred to the patient (the recipient). This transfer of blood from the **donor** to the **recipient** is called **blood transfusion.** It is important to know the matching (compatibility) of the donor's blood with that of the recipient, otherwise the red blood cells (RBCs) will stick to each other and may endanger the life of the patient. This sticking is due to the reaction between the **antigens** (proteins) found in the donor's blood and **antibodies** (special proteins) present in the recipient's blood.



Activity 3

To collect information about the blood group of persons around you, and to know about blood transfusion.

This activity is based upon the information you have collected from your own family members as well as from some of your friends.

Write the type of blood groups in the columns provided in the table. In case, the person does not know his/her blood group, place a "dash" (–) in the column.

A girl child is being given a blood transfusion

You should also ask the blood donors if they have ever given blood to other persons or received it from others. Also, ask whether any matching of the blood groups of the donor and the recipient was earlier done or not. The matching of blood groups is also called ***blood group compatibility***.

Chart For Recording Blood Groups

Serial No. of family	Member of the family	Blood group			
		A	B	AB	O
Family No. 1 (Own family)	Father				
	Mother				
	Brother (Anyone)				
	Sister (Anyone)				
Family No. 2	Father				
	Mother				
	Brother (Anyone)				
	Sister (Anyone)				
Family No. 3	Father				
	Mother				
	Brother (Anyone)				
	Sister (Anyone)				

Conclusion :

Based on the above survey, you can find out who can donate blood to whom or who can receive it from whom under the ABO system. In the table given below, indicate the matching blood groups by a (√) and a (×) for non-matching blood system.

Blood group of donor	Blood group of recipient			
	A	B	AB	O
A				
B				
AB				
O				

[Sometimes, people may respond by saying "B (+)" (B-positive) or "B (–)" (B-negative). In such cases, "positive" or "negative" refers to another blood group system called "Rh" system, which is further discussed in this chapter.

Rhesus (Rh) Factor :

Besides the ABO system of blood groups, there is another system called Rhesus Factor (Rh factor). It is a special factor which was first found in the Rhesus monkey. People who have this factor are called **Rh–positive** and those who do not have it are called **Rh–negative**. In the whole human population, a large portion (90%) of people are Rh+(ve) and the rest 10% are Rh–(ve). If Rh+(ve) blood is transfused into a Rh–(ve) person, the blood of the recipient develops antibodies against the Rh+(ve) factor. The Rh-antibodies survive for a few months only. In such a case, if an individual is given a second transfusion of the Rh-positive type of blood after a short interval, his antibodies will react with the transfused blood and cause problems.

Blood pressure : The pressure exerted by the blood on the walls of the arteries while flowing through them is called **blood pressure**. There are two limits of this pressure –

The upper limit *i.e.*, the **systolic pressure** of ventricle contraction to pump blood into the aorta and pulmonary artery.

The lower limit *i.e.*, the **diastolic pressure** is the minimum pressure when blood flows from the auricles to the ventricles.

The instrument used to find out blood pressure is called **sphygmomanometer.**

The two normal levels of blood pressure of a healthy person are, systolic/diastolic = 120/80. A rise in blood pressure above 140/90 is known as **hypertension** (high blood pressure) and below the normal is called **hypotension** (low blood pressure). (Elderly people have the tendency of having slightly higher blood pressure at both levels). Nowadays, handy machines have been developed which people can keep at their homes for a regular monitoring of their blood pressure.

Activity 4

Detection of disease by blood test

The doctor prescribes certain blood tests to be carried out before diagnosing the disease. Accompany the patient to a nearby pathological laboratory and see how the blood test is done.

BLOOD OF AN ADULT BEING TAKEN FROM A VEIN

BLOOD OF A CHILD BEING TAKEN FROM A FINGER TIP

The blood is taken from a vein or by pricking the finger tip. A tight band is usually placed around the upper arm so that the vein becomes visible and is full of blood. In this way, it becomes easier for the blood sample to be taken. The skin over the vein is cleaned with a gauze dipped in an antiseptic. A needle is then inserted into the vein. The needle is either connected to a syringe or directly to blood sample bottles. When the required amount of blood is taken, the needle is removed and the band is opened. The small wound is pressed on with an antiseptic lotion dipped cotton wool for a few minutes to stop bleeding. A sticky plaster (like band aid) may be put on. The blood is placed in bottles and the name of the patient and a proper numbering of the lab are put on them.

Suppose some one in your family is **diabetic** and he is getting his sugar level checked in his blood. First, he will give his blood sample empty stomach which is called the fasting sample. Then he will take his normal breakfast and after two hours, he will give the second sample. This is called the post-prandial sample.

There are normal values for every test. If his values come within the normal limits, then his health is said to be in order but if the values are below or above the normal limits, then there is abnormality and he has to be under medication and other precautions. *For example*, in the case of testing the sugar level in the blood, the normal values while fasting should be in the 70-110 range and 2 hours after breakfast, the value range is 110-140. In every blood report, the values obtained on the patient's blood and the normal values are given, so it can be verified on the spot.

Similarly, HIV (Human Immunodeficiency Virus) infection is also detected by a blood test. The governments are organising lot of awareness programmes through various activities regarding the HIV disease.

REVIEW QUESTIONS

Multiple Choice Questions :

1. Put a tick mark (√) against the correct alternative in the following statements :

(a) Function of WBCs is to

(i) Transport oxygen (ii) Help in clotting of blood

(iii) Provide immunity (iv) Provide storage of food.

(b) Blood Capillary is a

(i) Broad tube (ii) Artery with thick wall

(iii) Vein with large lumen (iv) Narrow tube made up of endothelium only.

(c) Nucleus is absent in

(i) RBCs (ii) WBCs (iii) All blood cells (iv) Liver cells.

(d) The only artery which carries deoxygenated blood is called,

(i) Hepatic artery (ii) Pulmonary artery

(iii) Aorta (iv) Renal artery.

(e) Sphygmomanometer measures

(i) Pulse rate (ii) Heart beat

(iii) Blood pressure (iv) Brain activity

(f) Pulmonary vein carries

(i) Oxygenated blood (ii) Deoxygenated blood

(iii) Glucose-rich blood (iv) CO_2 laden blood

(g) The blood tastes saltish due to the dissolved :

(i) Sodium chloride (ii) Potassium chloride

(iii) Ammonium nitrate (iv) Sodium nitrate

Short Answer Questions :

1. Define the following terms :

Pulse rate .....

Blood pressure .....

Blood group .....

Double circulation .....

Systole .....

Diastole .....

2. State any ***five*** functions of the blood :

(a) .....

(b) .....

(c) .....

(d) .....

(e) .....

3. What is the role of haemoglobin in the blood ?

.....

.....

4. Fill in the blanks with suitable words given below :
(serum, fibrinogen, haemoglobin, pulmonary, sphygmomanometer, ventricles).

(a) The colour of a red blood cell is due to .....

(b) The two lower chambers of the heart are called .....

(c) The blood plasma contains a dissolved substance called .....

(d) The liquid part of coagulated blood is known as .....

(e) The ..... artery takes the blood from the ventricles to the lungs.

(f) The instrument used to find out the blood pressure is known as .....

5. Name the main artery which takes the blood to different parts of the body :

.....

6. What is the rate of heart beats in a normal human adult person ?

.....

7. Complete the following sentences by filling the blanks with suitable words :

(a) The blood loaded with carbon dioxide from the body comes into the ..... of the heart.

(b) The oxygen–rich blood from the lungs comes into the ..... of the heart.

(c) The oxygen–rich blood is pumped into different parts of the body through ..... .

(d) The carbon dioxide loaded blood from the right ventricle is pumped into the lungs through ..... artery.

7. Give any *three* differences between an artery and a vein :

(a) .....

(b) .....

(c) .....

8. Name different types of WBCs ?

.....

.....

9. Name the disease in which the number of platelets reduces to 25,000-30,000 per cu mm of blood.

.....

.....

Long Answer Questions (*Write the answers in your note-book*) :

1. Name the *three* kinds of blood vessels found in human beings. With the help of suitable diagrams, differentiate between them.
2. "In the human heart, blood circulates twice for making one full round through the body." Explain briefly this statement.
3. During surgical operations or during accidents, the patient may be given blood from outside to save his life. What is the technical name of this process ? Briefly explain the precautions to be taken in this process.
4. Briefly describe the 'cardiac cycle' in humans.
5. Differentiate between the pulmonary circulation and systemic circulation.
6. State briefly, the difference between white blood cells and the red blood cells.
7. Describe in brief, the process of blood–clotting.
8. Answer very briefly, the following :
   (a) Red blood cells have no nucleus, then why do we call them cells ?
   (b) Why is it necessary to know the blood groups of the donor as well as the recipient ?
   (c) Why should the blood going away from stomach and intestines pass through liver and not directly to heart ?
   (d) You can see some blood vessels on the outside of the hands specially in older people. Are those veins or arteries ? How can you confirm your answer ?