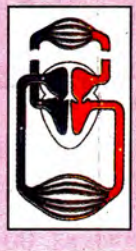
7 The Circulatory System

Syllabus : *Circulatory System : Main features; the structure and working of the heart, blood vessels, structure and functions of blood and circulation of blood (only names of the main blood vessels entering and leaving the heart, liver and kidney will be required).*

Scope of Syllabus : Composition of blood (Structure and functions of RBC, WBC and platelets). Brief idea of tissue fluid and lymph. Increase in efficiency of mammalian red blood cells due to absence of certain organelles should be explained with reasons. A brief idea of blood coagulation. Structure of vein, artery and capillary should be explained with the help of diagrams to bring out clearly the relationship between their structure and function. ABO blood group system, Rh factor; concept of double circulation; concept systole and diastole; blood pressure. Reference to portal system should be made. Working of the heart along with names of the main blood vessels entering and leaving the heart, the liver and the kidney must be taught. Examination of a blood smear under a microscope.



Almost all organisms, including humans, have some kinds of fluids circulating in their bodies. Such fluids constitute the **distributing system** (to supply substances) as well as a **collecting system** (to pick up substances) to and from the various parts of the body including the remotest cell. In this chapter, we will study about the circulating fluids in our body, its composition and function.

7 A. BODY FLUIDS

7.1 NEED FOR TRANSPORT INSIDE THE BODY

Every organ in our body requires the involvement of the circulating body fluids. *For example* :

- The **digestive system** digests and absorbs nutrients which are needed to be transported to every body cell.
- **The respiratory system** draws in air, and the oxygen picked up from it in the lungs has to be transported to all parts of the body. Similarly, the CO_2 collected from the entire body has to be carried to the lungs for giving out.
- All the extra water, excess salts, and the nitrogenous wastes such as urea have to be removed from different parts and have to be sent to the **excretory system** to be thrown out of the body.
- **Hormones** secreted by the endocrine system have to be carried throughout the body by the circulating blood to act wherever required, and so on.

All such functions that need transport are performed by the two ***circulating fluids*** – the **blood** and the **lymph**. Besides transport, these fluids have some other functions also.

7.2 FLUIDS IN OUR BODY

There are three principal fluids in our body :

(i) **Blood**, contained in the heart and in the blood vessels (arteries, veins and capillaries) of the circulatory system,

(ii) **Tissue fluid**, occupying spaces between cells in the organs, and

(iii) **Lymph**, which is contained within lymph vessels and lymphatic organs such as the spleen and the tonsils.

Fig. 7.1 shows a diagrammatic representation of the relationship between blood, tissue fluid and lymph as they *circulate in their respective vessels* or spaces between the cells in different organs. It is clear from the diagram that blood in our body circulates in a closed manner *i.e.* all the time through blood vessels.

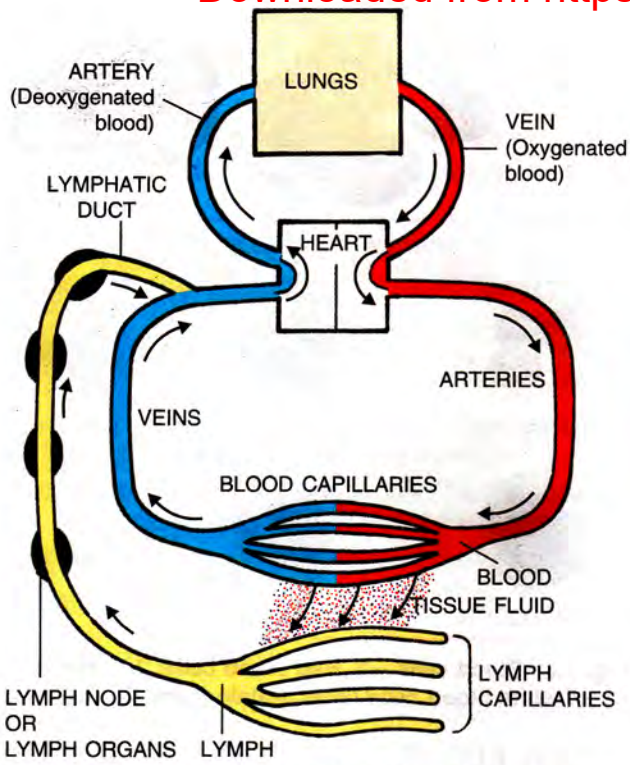


Fig. 7.1 Diagrammatic representation of blood and lymph circulation (Red-oxygenated blood, Blue-deoxygenated blood).

Such a type of blood circulation is called a **closed vascular system**. As against this, in certain animals such as insects, the blood mostly flows through open spaces, called an **open blood circulatory system**. Their blood flows from the heart to body tissue spaces without vessels.

[**Non-circulating fluids :** There are also some other fluids located in particular organs such as **synovial fluid** filled in the cavities of skeletal joints, **vitreous humour** in the eye, etc. They do not circulate.]

7.3 THE BLOOD

- **Never Stationary.** Blood is always in motion from the heart to the arteries and back through the veins.
- **Colour.** The blood is a somewhat thick fluid, **bright red** when taken from an artery or **dark red** when taken from a vein. [Conventionally, in the diagram, we show the **veins in blue** – this is just for contrast; the blood inside the veins is not blue, it is actually dark red].

  The above three principal fluids in our body are respectively described in section 7.5 (*blood*) and section 7.14 (*tissue fluid* and *lymph*).
- **Volume.** An average adult human contains 5 to 6 litres of blood by volume in his body.
- **Taste - saltish.** Perhaps we have all "tasted" our blood as in the case when there is a cut in the tongue or bleeding from the gums. The blood is slightly alkaline with a pH of 7.3 to 7.45 (7 is neutral, neither acidic nor alkaline).

7.4 FUNCTIONS OF BLOOD

The main functions of the blood in our body can be treated under two broad headings: (A) Transport and (B) Protection.

A. TRANSPORT BY BLOOD (Transport of digested food, oxygen, carbon dioxide, excretory substances, hormones, body heat).

1. **Transport of digested food** from the alimentary canal to the tissues. These substances are simple sugars like glucose, amino acids, vitamins, mineral salts, etc.
2. **Transport of oxygen** from the lungs to the tissues. It occurs by means of red blood cells in combination with haemoglobin in the form of an unstable compound oxyhaemoglobin, which on reaching the tissues breaks up to deliver oxygen.

$$Hb + O_2 \rightleftharpoons \underset{\text{oxyhaemoglobin}}{Hb.O_2}$$

3. **Transport of carbon dioxide** from the tissues to the lungs. It occurs partly in combination with haemoglobin and partly as solution in blood plasma.

$$Hb + CO_2 \rightleftharpoons \underset{\text{carbaminohaemoglobin}}{Hb.CO_2}$$

4. **Transport of excretory material** from the tissues to the liver, kidney or the skin for elimination or to render them harmless.
5. **Distribution of hormones** secreted by special glands (endocrine glands) directly into the blood.
6. **Distribution of heat.** The blood helps in keeping the temperature of the body uniform by distributing heat.

B. PROTECTION BY BLOOD

1. Blood forms a **clot** wherever there is a cut in a blood vessel. The clot serves to **prevent**
   (i) further loss of blood and
   (ii) the entry of disease-causing germs.

2. Its white blood corpuscles *protect the body* from diseases by **engulfing bacteria** which may have entered the body.
3. It produces **antitoxins** and **antibodies** which neutralise the poisonous substances or kill the germs which enter the body.

? PROGRESS CHECK

1. Name the two fluids that circulate in the body.
2. In the diagrams we conventionally show veins in blue. What is the actual colour of the blood flowing through the following ?
   (i) In arteries (ii) In veins (iii) In capillaries
3. In a coloured diagram why do we generally show the pulmonary artery in blue and pulmonary vein in red colour ?
4. Name any four substances transported by blood.

7.5 COMPOSITION OF BLOOD

The blood consists of :

(i) **Plasma –** fluid part, constitutes 55-60 per cent of blood.

(ii) **Cellular elements –** red and white cells, and platelets, 40-45 per cent of blood.

7.5.1 PLASMA — The liquid portion of blood

The plasma is a light-yellow coloured, alkaline liquid. It mainly consists of :

Water	–	90 - 92%
Proteins	–	7 - 8%
Inorganic salts	–	1%
Other substances	–	traces

The inorganic salts include mainly **sodium chloride** and **sodium bicarbonate**. Among other substances contained in the plasma are **glucose, amino acids, fibrinogen, hormones, urea**, etc.

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

7.5.2 CELLULAR ELEMENTS (Fig. 7.2)

The formed or cellular elements (i.e. shaped structures visible under magnification) of the blood are of three categories :

(1) Red blood cells (**erythrocytes**),

(2) White blood cells (**leukocytes**),

(3) Blood platelets (**thrombocytes**)

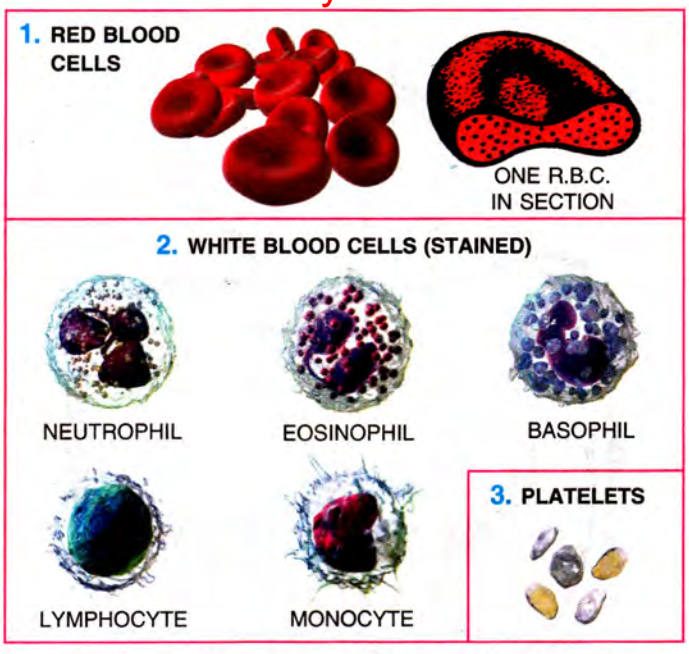


Fig. 7.2 : Blood cells – 1. Red blood cells; 2. various kinds of white blood cells (after staining) and 3. platelets.

(1) RED BLOOD CELLS (RBCs) — The oxygen carriers

Red blood cells are also called **erythrocytes** (*erythros*: red)

- These are minute biconcave disc-like structures, flat in the centre and thick and rounded at the periphery.
- These are very small — about 7 micron in diameter (1 micron = one-thousandth of a millimetre and is represented by the symbol "μ")
- The small size plus the concavities on either side provide a large surface area which makes them very efficient in absorbing oxygen.
- The small size enables the red blood cells to travel through very fine capillaries in the body where they have to travel in a single file.

An adult human male has about 5 million RBCs per cubic mm of blood and an adult female has slightly less about 4.5 million.

HAEMOGLOBIN – the effective chemical constituent of RBCs. The red blood cells have a colourless spongy body or *stroma* which contains a respiratory pigment **haemoglobin (Hb)**.

– The haemoglobin is formed of an iron-containing part (**haemin**) and a protein (**globin**).

– It has the ability to combine readily with oxygen

to form **oxyhaemoglobin**, an unstable compound which readily gives up oxygen to the needy tissues.

– Haemoglobin can carry a very small quantity of carbon dioxide in the form of carbamino-haemoglobin.

Is it correct to say that veins carry CO_2 and no oxygen?

NO!

Veins too carry oxygen but only a little less than the arteries!

Inside the lungs the haemoglobin (Hb) becomes 97-99 per cent saturated with oxygen. Inside the respiring tissues Hb releases only about 23% of its oxygen and the blood returning in veins still contains about 75% oxygen.

Carbon Monoxide Poisoning

Haemoglobin has very strong affinity for carbon monoxide forming a stable compound carboxyhaemoglobin (HbCO). This cuts down the capacity of the blood of transporting oxygen, sometimes resulting in death. *For example*, **carbon monoxide poisoning** may cause death due to furnaces burning in small rooms without ventilation.

Life and death of RBCs.

- In adults, the RBCs are produced in the ***marrow of long bones***, especially in the ribs, breast bone and ilium of hip girdle.
- In an embryo they are produced in the liver and spleen.
- In children, the RBCs are produced in bone marrow of all bones until 5 years of age.
- ***The mature red blood cells have no nuclei,*** but when they are being produced, they have one. As they mature, the nuclei are lost, *i.e.*, they become enucleated.
- ***The average life of an RBC is about 120 days.***
- The old and weak red cells are ***destroyed in the spleen, liver and bone marrow***; their iron part is retained in the liver while the rest is excreted as a bile pigment (bilirubin).
- In a normal adult, approximately 20,000,000 RBCs are destroyed every minute. In other words, about 1 per cent of the total erythrocytes in the body are destroyed everyday.

DEFICIENT, BUT MORE EFFICIENT !

Mammalian red blood cells

Mammalian red blood cells when mature circulate in the blood system and are devoid of certain organelles. They have

— no **nucleus**
— no **mitochondria**
— no **endoplasmic reticulum**

Thus, though deficient of the above organelles, the mature red blood cells, in reality, are more efficient in carrying out their task of picking up and delivering oxygen. The factors making them more efficient in this work are as follows :

1. **Loss of nucleus**, makes the red cells biconcave, thus increasing their surface area volume ratio for absorbing more oxygen.

   — Space in between increased
   — More RBCs can be accommodated in the same space
2. **Loss of mitochondria** means that the red cells cannot use oxygen for themselves (cellular respiration occurs in mitochondria). Thus all the oxygen, absorbed from the lungs, is transported and delivered to the tissues unconsumed. Secondly, loss of mitochondria means full transport of glucose in blood plasma, unused by the RBCs.
3. **No endoplasmic reticulum** means increased flexibility of RBCs for their movement through narrow capillaries.

More about the number of RBCs

- New born infants have a larger number of RBCs — about 6-7 million per cubic millimetre (1 mm^3).
- RBC count is lower by 5% during sleep.
- RBC count is higher during physical activity, pregnancy and emotional upsets.
- **People living at a height of 4,200 m and above, increase their RBCs by nearly 30%.**
- **Abnormally increased number of RBCs is called *Polycythaemia*, and their abnormally decreased number is known as *Erythropenia*.**

(2) WHITE BLOOD CELLS (WBCs) — White blood cells, or **leukocytes** (*leuko* : white), differ from red blood cells in having a nucleus and do not contain haemoglobin. Their number is much less, usually about **4000-8000 per mm^3** of blood. Most WBCs are amoeboid and can produce pseudopodia with which they can squeeze through the walls of the capillaries into the tissues (**diapedesis** *dia* : across, *pedesis* : oozing out) (Fig. 7.3).

Fig. 7.3 A white blood cell oozing out of the blood vessel (diapedesis).

Based on shape and other characteristics, the white blood cells are classified into two major categories (granular and non-granular) and five distinct types (Table 7.1 given below and Fig. 7.2 on page 78) as follows:

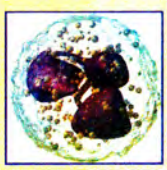
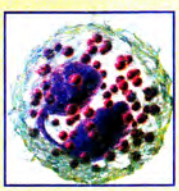
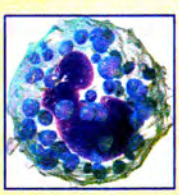
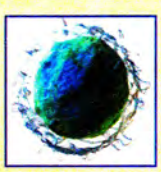
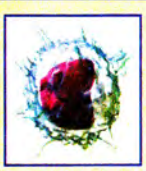
White blood cell Or White cells ?

Better term is "white cells" or Leukocytes (**leukos** : white) because they spend most of their time (90%) in tissue fluid or in the lymph and very little time (only about 10%) in the blood.

FUNCTIONS OF LEUCOCYTES (WBCs) — Body defence

1. ***Phagocytosis :*** This is a process in which most WBCs and particularly the **neutrophils engulf particle-like solid substances, especially bacteria**. This is a defensive mechanism against disease germs. An abnormal increase in WBC count up to about 50,000 or more per cubic mm indicates some infection in the body.
2. ***Inflammation :*** Inflammation occurs due to the reaction of tissues to injury and to localized invasion of germs. The inflamed spot has several characteristics: increased **local heat, redness, swelling, pain,** *etc.* Here the leucocytes (specially the monocytes and

Table 7.1 Different types of white blood cells (Leukocytes) after staining.

Two major categories of WBCs	Five cell type (abundance)	Appearance	Distinguishing features	Functions	Where produced
A. Granular • Cytoplasm contains granules • Nucleus usually constricted into lobes	**1.** Neutrophils (62%)		• Nucleus with 3-4 lobes • Granular cytoplasm • Stain with neutral dyes	Engulf bacteria (Phagocytosis)	Bone marrow
	2. Eosinophils (2·3%) count increases in allergies		• Nucleus with 2 lobes • Cytoplasmic granules large and stain dark red with eosin (acid dye)	• Engulf bacteria • Secrete antitoxins • Associated with allergy	Bone marrow
	3. Basophils (0·4%)		• Nucleus large indistinctly lobed Granules stain with basic dyes (e.g. methylene blue)	Release chemicals (histamine) for **inflammation** which dilate blood vessels	Bone marrow
B. Non-granular • Cytoplasm without granules, • a single large nucleus	**4.** Lymphocytes (30%)		• **Smallest** of WBCs • Single large nucleus	Produce **antibodies**	Bone marrow and Lymph glands (spleen, tonsils, etc.)
	5. Monocytes (5·3%)		• Nucleus large, kidney-shaped • At the site of infection, transform into macrophages	Ingest germs	Bone marrow

neutrophils) migrate through the walls of the blood vessels by **diapedesis** (Fig. 7.3), and fight against disease-causing germs. They also **destroy the damaged cells** by phagocytosis. **Pus** is mainly composed of the dead white blood cells together with the tissue cells destroyed by the bacteria.

3. ***Formation of antibodies :*** The WBCs (specially the **lymphocytes**) produce antibodies which kill or neutralise the germs, or the poisons from them. Introducing weakened germs or germ substances (vaccines) during vaccination stimulates formation of particular antibodies which, at a later period, would destroy the particular disease-causing germs if they enter into the body.

ANTIBODIES and "ANTITOXINS"

When disease-causing germs gain entry into the blood stream, they produce poisonous substances called **toxins** (meaning poisons). In response, the lymphocytes of the blood produce chemical substances called **antibodies** which circulate free in the blood plasma. The antibodies are specific to the toxins for which they are produced. The antibodies act as **antitoxins** which neutralise (detoxify) the poisonous effect of the toxins.

Antibodies may persist long after the disease has been overcome, and the person who has recovered becomes immune to the disease. This is the underlying principle of vaccination (a deliberate introduction of weakened disease germ to stimulate production of the specific antibodies).

ORIGIN AND LIFE OF WBCs :

The WBCs are produced in red bone marrow, lymph nodes and sometimes even in liver and the spleen. Their average life is about two weeks. The neutrophils live for only a few hours, and about 125 billion neutrophils are produced each day. The old and worn out WBCs are destroyed in the same manner as the RBCs.

***Leukemia** is a cancer of the tissue forming WBCs whose number increases manifold at the cost of RBCs. It is usually a fatal disease. Currently, the treatment is only blood transfusion.* ***Leucopenia** is the abnormal decrease in the number of WBCs.*

(3) BLOOD PLATELETS (Thrombocytes)
(Initiators of clotting of blood)

Blood platelets are minute oval or round structures, non-nucleated, floating in the blood. These are about 200,000 to 400,000 per cu. mm. of blood in an adult. The platelets are derived from some giant cells called megakaryocytes in the red bone marrow. These are budded off from the megakaryocytes in a manner that each one is completely surrounded with membrane. Their life span is 3 to 5 days and are destroyed mainly in the spleen (a lymphatic organ located in the abdomen). They are very important in clotting of blood. At the site of injury, the platelets disintegrate to release a chemical substance thrombokinase which initiates the process of clotting of blood.

? PROGRESS CHECK

1. Name the following :
   (i) The yellow coloured fluid part of the blood.
   (ii) The respiratory pigment contained in RBCs.
   (iii) Any two organelles absent in mature RBCs.
   (iv) The process of WBCs squeezing out through the walls of the blood capillaries.
2. Mention the following :
   (i) Average life span of RBCs.
   (ii) Range of RBCs per mm^3 in a normal adult human female.
   (iii) The two major categories of WBCs.
   (iv) Blood cells involved in leukaemia.

7.6 CLOTTING OF BLOOD (COAGULATION)

When a blood vessel is cut, blood escapes from it. But soon a clot is formed on the wound (Fig. 7.4) and the flow of blood is stopped. If it were not so, the injured person would bleed to death. Clotting (also called *coagulation*) occurs in a series of steps as follows :

1. The injured tissue cells and the platelets which disintegrate at the site of the wound release a substance **thrombokinase** (also called **thromboplastin**). (More recently it is called "Factor X" or Stuart factor).
2. The thrombokinase acts as an enzyme and with the help of the *calcium* ions present in the plasma, it converts a substance **prothrombin** (inactive) of the plasma, into **thrombin** (active).

3. Thrombin in the presence of calcium ions, reacts with the soluble **fibrinogen** of the plasma to convert it into insoluble **fibrin**. Fibrin is a solid substance that forms threads. These microscopic threads of fibrin are sticky and form a network (mesh) at the wound.
4. Blood cells are trapped in the network of the fibrin; the network then shrinks and squeezes out the rest of the plasma which is in the form of a clear liquid, the **serum**. The solid mass which is left behind is called **clot** (or **thrombus**).

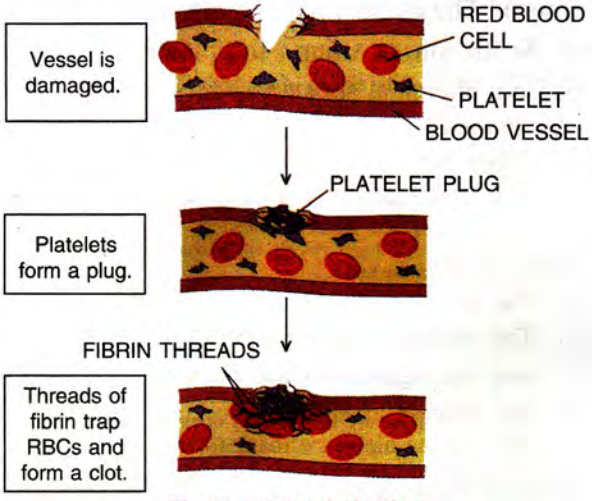


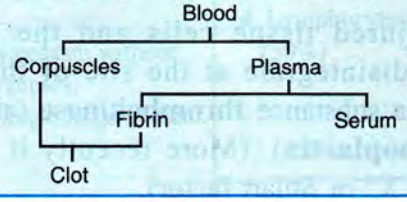
Fig. 7.4 Blood clotting

Main reactions in blood clotting

1. **Injured** Tissue Cells & Platelets —release→ Thromboplastin (or Thrombokinase) Presently called Factor X
2. **Prothrombin** (Inactive) Found in blood plasma (also called thrombinogen) —+Ca ions→ Thrombin (Active) Acts like an enzyme
3. **Fibrinogen** (Soluble) → Fibrin (Insoluble) Threads make a network

+ RBCs → CLOT

The fate of blood in blood clotting :



BLOOD CLOTTING IN A TEST-TUBE

If some blood is taken in a test-tube, a clot will form in the usual way and the serum squeezed out from the clot will collect on the surface (Fig. 7.5).

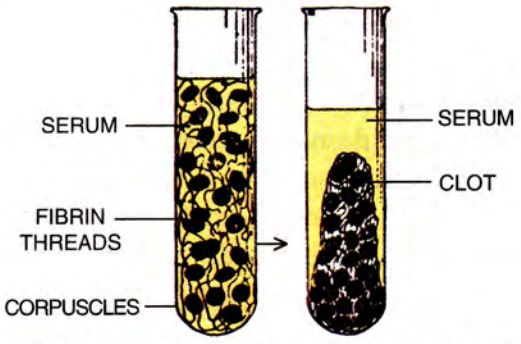


Fig. 7.5 Left, coagulated blood; the fresh clot consists of fibrin strands, corpuscles and serum. Right, coagulated blood after standing for some time; clot has separated from the serum. (*Highly diagrammatic*)

If the **number of platelets** falls to an abnormally **low count**, then also the coagulation occurs very slowly and often leads to haemorrhage. Such a situation occurs in certain diseases as in the **viral dengue fever** which has taken hundreds of lives in Delhi and other states of India since 1996 till date.

It is a wrong notion that clotting is dependent on the exposure of blood to air. In fact, clotting can be caused by the movement of blood over a rough surface as on cholesterol deposit on the inside of a blood vessel.

7.7 BLOOD TRANSFUSION AND BLOOD GROUPS (ABO and Rh systems)

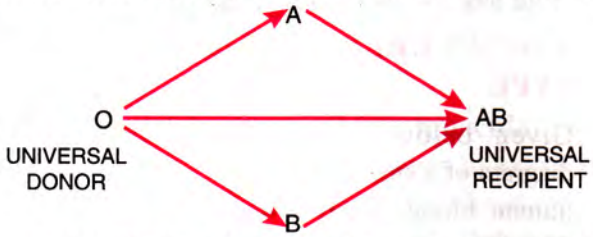
Sometimes it becomes necessary to inject blood into the body of patients undergoing surgical operation. This is called ***blood-transfusion***. Blood taken from a healthy person (*donor*) is introduced through one of the patient's veins. But for doing so, it is necessary that the kind or the type of blood to be transfused should match (or be compatible) with the type of blood of the receiving person (*recipient*).

The concept of blood grouping was discovered by Karl Landsteiner. RBC's of human beings have specific proteins on their surface. These proteins are called antigens. The plasma of the blood has its complementary antibodies. In humans there are two types of antigens. 1. *Antigen A* 2. *Antigen B*. Depending on the presence or absence of these antigens there are four types of blood groups as shown in the table.

Blood group	*Antigens on RBC*	*Antibodies in plasma*
A	Antigen A	anti b
B	Antigen B	anti a
AB	Antigen A & B	no antibody
O	No antigen	Both anti a and anti b

There are several systems of blood grouping. But two of them, **ABO system** and **Rh system** are most important.

ABO System : According to the ABO system, the human blood is classified into four types — A, B, AB and O. Besides the transfusion of one's own type of blood (A to A, AB to AB, etc.), the other possible transfusions can be made as follows :



Accordingly, O type blood can be given to persons of all types of blood *i.e.* to O, A, B & AB. Hence a person with O type is called **universal donor**. A person with AB type of blood can receive blood from all types, *i.e.*, from AB, A, B & O, and is, therefore, called **universal recipient**. A person with A type can receive blood from A and O types and a person with B type from B and O types only.

The summary of matching (**compatibility**) and mismatching (**incompatibility**) in ABO system is given in the table below:

Table 7.2 Summary of ABO Blood Group matching (Compatibility)

Blood group of Donor	Blood group of recipient			
	A	B	AB Universal recipient	O
A	✓	×	✓	×
B	×	✓	✓	×
AB	×	×	✓	×
O Universal donor	✓	✓	✓	✓

Rh system : The blood of most people contains a substance called Rh factor. (Rh *stands for Rhesus, our common monkey, in which the factor was first discovered*). When the blood of such an individual (Rh-positive) is transfused into persons lacking it (Rh-negative), the blood of the recipient develops an antibody for Rh substance (gets sensitized) within about two weeks of transfusion. Now, if a second transfusion be given to such Rh-negative person, the antibody produced by the first transfusion causes a reaction with the transfused blood, which may even lead to death. This is similar to the development of an allergy.

Rh factor in pregnancy : An Rh-negative woman may become sensitive if she carries an Rh-positive child in her uterus (when the husband is Rh-positive). The first Rh-positive child will be normal, but if it sensitizes the mother, the second positive child if conceived soon, may have a problem, sometimes leading to the death of foetus and abortion.

[**Rh-positive** may be written in short as **Rh+ve** or as Rh^+ and similarly, the **Rh-negative** may be written as **Rh-ve** or as Rh^-]

? PROGRESS CHECK

1. State which of the following statements are **True**.
   (i) Process of coagulation starts with the release of a substance from RBCs.
   (ii) Blood fails to clot readily in the case of deficiency of calcium.
   (iii) The solid fibrin and thrombin are one and the same thing.
   (iv) The clear liquid that oozes out after the formation of a clot is serum.
2. Name the following :
   (i) The category of vitamin required for clotting of blood.
   (ii) Any two diseases related with blood clotting .
   (iii) The antibodies present in the plasma of O type blood group.
   (iv) The animal for which Rh stands in the context of blood group.

REVIEW QUESTIONS

A. MULTIPLE CHOICE TYPE

(Select the most appropriate option in each case)

1. Agranulocytes are :
   (a) lymphocytes and monocytes
   (b) lymphocytes and basophils
   (c) eosinophils and basophils
   (d) eosinophils and monocytes
2. White blood cells engulf bacteria in a process called:
   (a) diapedesis (b) phagocytosis
   (c) active transport (d) passive transport

B. VERY SHORT ANSWER TYPE

1. Given below are certain structures, write the term for the functional activity.
   (a) Blood platelets and .....
   (b) Neutrophils and .....
   (c) Erythrocytes and .....
   (d) Lymphocytes and .....
   (e) Bone marrow and .....
2. Name the following :
   (a) The cells which transport oxygen to the different parts of the human body.
   (b) The cells that initiate blood clotting.

C. SHORT ANSWER TYPE

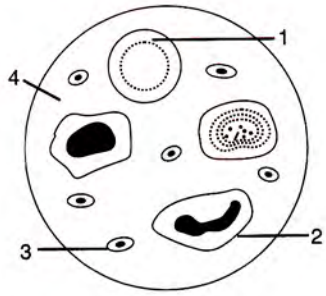
1. **Enumerate** the structural differences between white blood cells and red blood cells.
2. **Why is it necessary** to know the blood groups before giving transfusion?
3. **Differentiate** between members of each of the following pairs with reference to phrases in brackets:
   (a) Antibodies and antibiotics (Source)
   (b) RBC and WBC (Structure)
   (c) Serum and vaccine (Composition)
4. Complete the following statement by **filling in the blank** from the choices given in the brackets.
   An anticoagulant present in the blood is ..... (heparin, hirudin, thromboplastin, calcium).

D. LONG ANSWER TYPE

1. **What** are the functions of blood plasma?
2. **What** are the main steps in coagulation of blood?
3. **What** are the following?
   (a) Rh factor (b) Universal donor (c) Diapedesis
4. **Is it possible** for the blood to clot under the skin? **Give reason** in support of your answer.
5. **State** any five functions of the blood.

E. STRUCTURED/APPLICATION/SKILL TYPE

1. Given below is a diagram of a smear of human blood. Study the same and answer the questions that follow :-



   (a) **Name** the parts 1, 2, 3 and 4 indicated by guidelines.
   (b) **Mention** two structural differences between the parts labelled '1' and '2'.
   (c) **What** is the main function of the parts labelled 1, 2 and 3 respectively ?
   (d) **What** is the life span of the part labelled '1'?
   (e) **Name** a soluble protein found in '4' which helps in the clotting of blood.

7 B. THE CIRCULATORY SYSTEM

7.8 BLOOD CIRCULATORY SYSTEM

The circulatory system consists of **heart, arteries, veins** and **capillaries**.

7.8.1 The Heart

Location (not on the left side, but it is felt so.)

The heart is right in the centre between the two lungs and above the diaphragm. The narrow end of the roughly triangular heart is pointed to the left side (Fig. 7.6) and during working, the contraction of the heart is most powerful at this end giving a feeling that the heart is on the left side.

Covering : The heart in adult humans is about the size of our closed fist – 12 cm in length and 9 cm in width. It is protected by a double walled

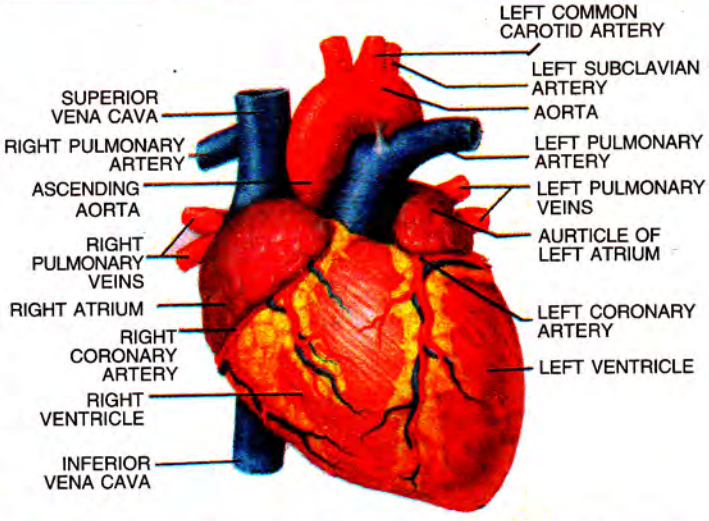


Fig. 7.6 Human heart (front view) showing the blood vessels arising and entering it.

membranous covering called **pericardium**. It contains lubricating pericardial fluid which reduces friction during heart beat and protects it from mechanical injuries.

Chambers of the heart (Fig. 7.7)

The heart consists of four chambers – two upper **atria** *(sing. atrium)* and two lower **ventricles**. The **atria** (also called **auricles**) **have thinner walls** because their major function is to receive blood from the body and *pump it into the very next ventricles*.

The **ventricles have thick muscular walls** (Fig. 7.7) because they have to pump blood to long distances. The right ventricle pumps blood only up to the lungs for oxygenation. But the left ventricle pumps it up to the farthest points in the body, such as, up to the toes in the feet or up to the brain against gravity, and so its walls are thicker.

7.8.2 Blood vessels entering and leaving the heart (Figs. 7.6, 7.7 and 7.8)

A. Blood vessels entering the heart

The right atrium receives two large vessels – **anterior vena cava** and **posterior vena cava**.

(1) **Anterior vena cava** (also called superior vena cava or precaval) brings deoxygenated blood from the anterior or upper regions of the body including head, chest and arms.

(2) **Posterior** (or inferior) **vena cava** brings blood from the posterior or the lower region of the body including abdomen and legs.

The left atrium receives 4 pulmonary veins (two from each lung). The pulmonary veins bring oxygenated blood.

B. Blood vessels leaving the heart

Arising from the ventricles are two large blood vessels.

1. The **pulmonary artery** arises from the right ventricle and carries deoxygenated blood to the lungs for oxygenation.
2. The **aorta** arises from the left ventricle and carries oxygenated blood to supply it to all parts of the body.

Coronary arteries. You can also see in Fig. 7.6 two **coronary arteries** (right and left) arising from the base of the aorta. These supply the heart muscles. When there is blockage in any coronary artery or in any one or more of their branches there is a **"deadening"** of the corresponding area of heart muscles leading to **"myocardial infarction"** or a heart attack in popular language. The cardiac veins

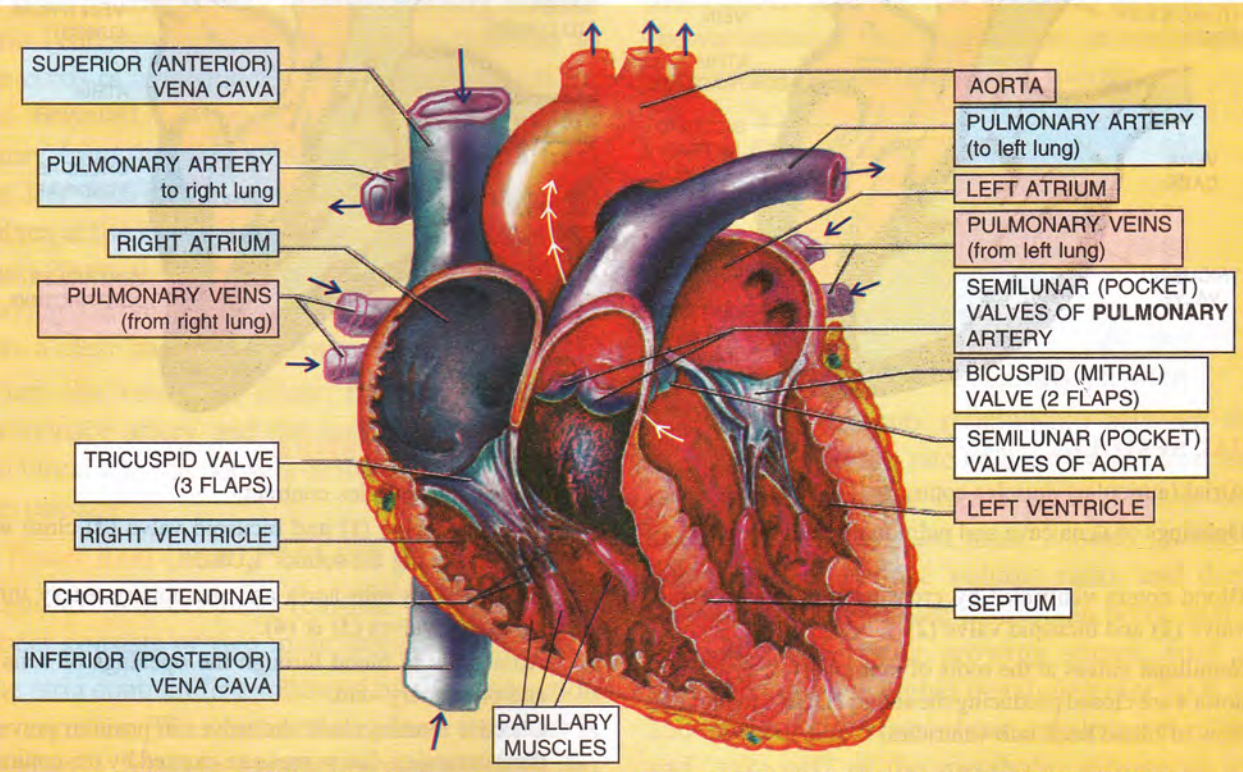


Fig. 7.7 Internal structure of the human heart and the associated blood vessels (diagrammatic)

collect blood from heart walls and pour it into the right auricle. **"Angina pectoris"** is the chest pain due to insufficient supply of blood to the heart muscle.

Heart — A bank cashier!

The bank cashier handles so much money everyday, but what he can use for himself is only the salary he gets. Is it not similarly true for the heart? It handles so much blood every minute but it can use only that much which it gets through coronary arteries supplying its muscular walls.

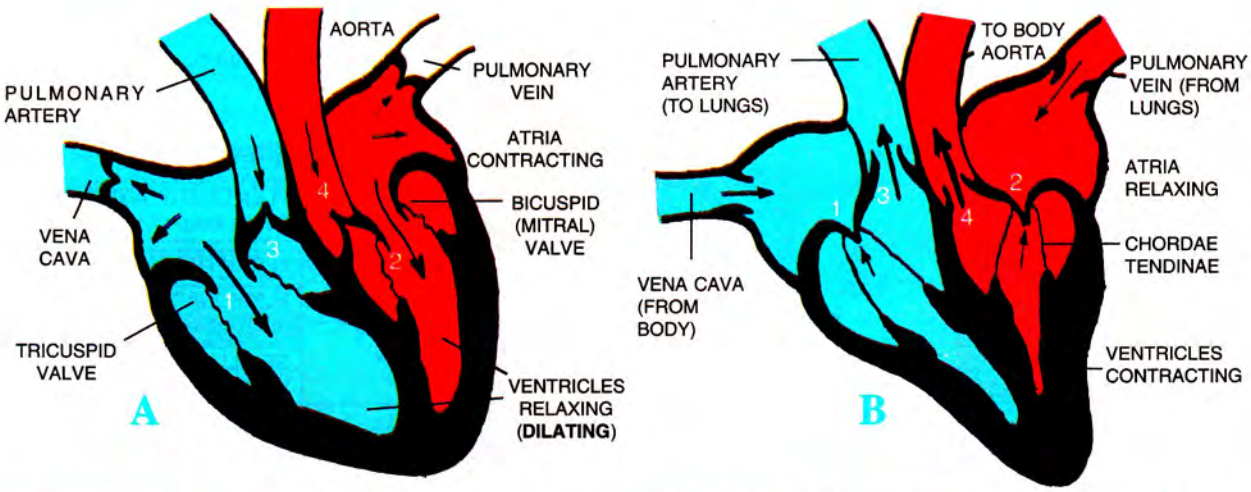
7.8.3 Valves regulate the flow of blood in a single direction

There are four valves in the heart as follows :

1. **Right atrio-ventricular valve** is located at the aperture between the right auricle and the right ventricle. It has **three** thin triangular leaf-like flaps (cusps) and is therefore also called **tricuspid valve**. The apices (pl. of apex) of the flaps are held in position by tendinous cords (**chordae tendinae**) arising from the muscular projections of the ventricle wall known as **papillary muscles**.
2. **Left atrio-ventricular valve** is located in a similar way on the left side of the heart. It has **two** cusps, and is, therefore, called **bicuspid** (also **mitral**) **valve**.
3. **Pulmonary semilunar valves** are located at the opening of the right ventricle into the pulmonary artery. These are pocket-shaped and three in number.
4. **Aortic semilunar valves** are located at the point of origin of aorta from the left ventricle. These are also three in number and pocket-shaped.

Fig. 7.8 Two main phases of heart beat: A – Atrial systole and B – Ventricular systole.

ATRIAL SYSTOLE AND VENTRICULAR DIASTOLE — [Note the valves that are closed or open] — VENTRICULAR SYSTOLE AND ATRIAL DIASTOLE



ATRIAL SYSTOLE

- Atrial (auricular) muscles contract
- Openings of vena cava and pulmonary vein close
- Blood enters ventricles by crossing through tricuspid valve **(1)** and bicuspid valve **(2)**.
- Semilunar valves at the roots of pulmonary artery **3** and aorta **4** are closed producing the sound "DUP", to prevent flow of blood back into ventricles.

VENTRICULAR SYSTOLE

- Ventricular muscles contract.
- Tricuspid valve **(1)** and bicuspid valve **(2)** close with a jerk producing the sound "LUBB".
- Blood passes into aorta and pulmonary artery through semilunar valves **(3)** & **(4)**.
- Atria draw in blood through the openings of vena cava and pulmonary vein.
- Chordae tendinae hold the valves in position preventing their upturning due to pressure exerted by the contracting ventricles

PROGRESS CHECK

1. Fill in the blanks :
   (i) Ventricles have ..... walls when compared with those of auricles.
   (ii) Ventricles give rise to two large blood vessels called ..... and .....
2. Where are the following located ?
   (i) Tricuspid valve (ii) Mitral valve
   (iii) Pulmonary semilunar valves
3. Can you answer why the pulmonary artery shown in Fig. 7.6 is blue in colour ?

7.9 CIRCULATION OF BLOOD IN THE HEART

- It starts with the **contraction of the two atria** (auricles). The ventricles at this time are **relaxing** (or **dilating**) and are empty (Fig. 7.8A). Therefore, the blood from the atria passes into the ventricles easily.
- Next, the **ventricles contract**, and the atria relax. The blood from the ventricles under pressure tends to return to the atria, but the flaps of the two **cuspid** (meaning pointed projection) **valves** get tightened and puffed up, thus closing the passage and preventing the return of blood (Fig. 7.8B). The chordae tendinae hold the flaps of the valves in position and prevent their overturning into the atria (you can compare the chordae tendinae to the cords of a parachute). The only course left for the ventricular blood is to enter the pulmonary artery from the right ventricle and the aorta from the left ventricle. The mouths of the pocket-like valves at the bases of these two blood vessels face away from the ventricles. Therefore, the blood leaving the ventricles presses the valves flat and gets a clear passage in between.
- When the ventricles dilate, the blood from the pulmonary artery and the aorta tends to return, the blood fills the pockets of the valves and closes the passage.

7.9.1 Heart Beat (nearly 1,03,680 times in a day)

Steps of a heart-beat (cardiac cycle) – Each heart-beat consists of two main steps :

The atria contract first followed by the contraction of the ventricles. The **contraction phase** (**systole**) is followed by a relaxing **expansion phase** (**diastole**) (Fig. 7.8).

Each full beat of the human heart lasts for about 0.85 seconds.

Systole of atria (auricles)	–	0.15 sec
Systole of ventricles	–	0.30 sec
All chambers in relaxed state	–	0.40 sec

At the end of ventricular systole, the ventricles start relaxing (**ventricular diastole**). Meanwhile the atria (auricles) have also been relaxing (**atrial diastole**) and for a short period, both the atria and the ventricles are in a relaxed state (joint diastole). The whole sequence of events in the heart beat is called **cardiac cycle.**

The Heart Sounds–"LUBB" and "DUP"

If you hear your heart sound by placing a stethoscope on your chest, you will hear two sounds "LUBB and "DUP" in short succession followed by a gap.

The first sound "LUBB" is produced when the **atrio-ventricular** ***(tricuspid and bicuspid)*** valves get closed sharply at the start of ventricular systole.

The second sound "DUP" is produced when at the beginning of ventricular diastole, the **semilunar valves** at the ***roots of aorta and pulmonary artery*** get closed.

Rate of heart-beat varies among different species and even in individuals of the same species. Some of the variations in beats per minute (at rest) in different species are (approximately) as follows :

Whale	15
Elephant	25
Horse	40
Adult men	64–72
Adult women	72–80
Cat	120
New born infant	140
Rat	250
Sparrow (in vigorous activity)	800 – 900

Do you find any relationship between the size of the body and the rate of heart beat ? Yes, **smaller the size, faster the heart rate**. This is because smaller the animal, the more it loses its body heat due to higher surface volume ratio, and therefore, the increased heart-rate distributes body heat faster. Secondly, the young growing stages, such as the human baby, have higher metabolism for body growth and therefore, the faster heart rate keeps the "supply" and "take off" of the metabolic substances in right quantities.

7.9.2 Pacemaker

The impulse or command which starts the heart-beat arises in **"Pacemaker" (sinu-atrial node, "SAN")** located in the walls of the right auricle (Fig. 7.9). This impulse is relayed to the ventricles with the help of special conducting fibres.

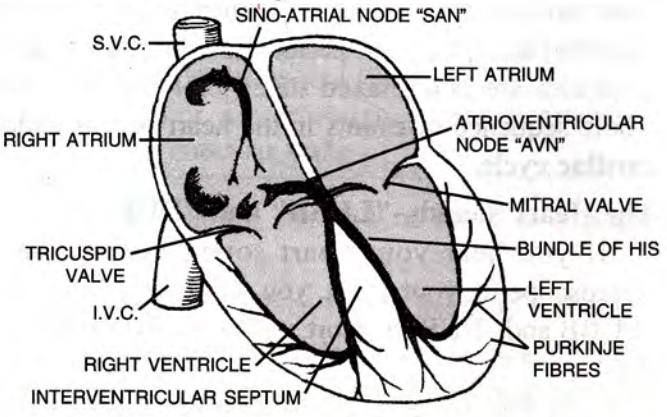


Fig. 7.9 : Internal structure of heart, showing location of "pacemaker" (SAN) and another contraction centre; "AVN" (atrioventricular node).

The Pacemaker (SAN) is present near the opening of the superior vena cava and the AVN node (atrio-venticular node) is found near the interauricular septum near the tricuspid valve. A bundle of muscle fibres called 'Bundle of HIS' begins from AVN and extends to the interventricular septum. Bundle of HIS consists of branches of fibres running along the wall of the ventricle, called 'Purkinje fibres'. All these together form a system which creates an impulse and conducts it to every part of the heart.

Sometimes the "pacemaker" becomes faulty causing heart trouble. An artificial "pace-maker" may be fixed in the heart of such a person.

? PROGRESS CHECK

1. Name the following :
   (i) Contraction phase of heart.
   (ii) The structure that holds the heart valves in position.
2. Mention the phase of heart beat in which both the atrio-ventricular valves are closed.

7.10 THE BLOOD VESSELS

The blood vessels are branched tubes extending from the heart to all parts of the body. They are of three kinds – arteries, capillaries and veins.

An ARTERY is a vessel which carries blood away from the heart towards any organ. It has

- ***thick muscular walls*** (Fig. 7.10),
- a ***narrow lumen*** (the central bore), and
- the ***blood in it flows in spurts*** which correspond to the ventricular contractions of the heart.

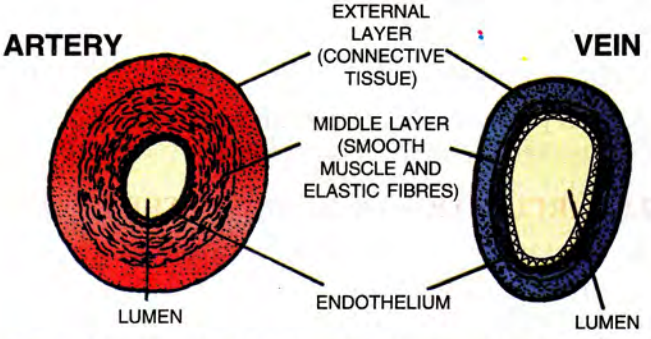


Fig. 7.10 : Structural difference between artery and vein

A *VEIN is a vessel which conveys the blood away from an organ towards the heart.*

Characteristics of vein :

- ***thin muscular walls***,
- a ***wider lumen,***
- the ***blood in it flows uniformly***, and
- it contains ***thin pocket-shaped valves*** (Fig. 7.11) whose openings face in the direction of the heart; these valves prevent the backflow of the blood.

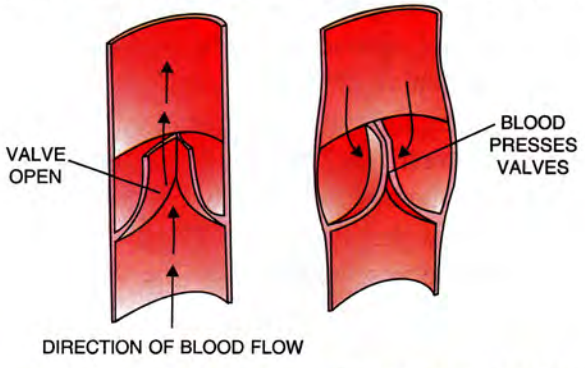


Fig. 7.11 : Valves in a vein regulate the flow of blood in the direction of the heart.

The smallest or the final branch of an artery is called an **arteriole**. Arterioles are highly muscular and can change their diameter manifold. The arteriole breaks up into capillaries (Fig. 7.12A).

A ***CAPILLARY*** is a very ***narrow tube*** (about 8 micrometres in diameter);

- its wall consists of a single layer of squamous epithelial cells (endothelium), and

has ***no muscles*** (Fig. 7.12B). The total number of blood capillaries present in the whole body is almost inconceivable.

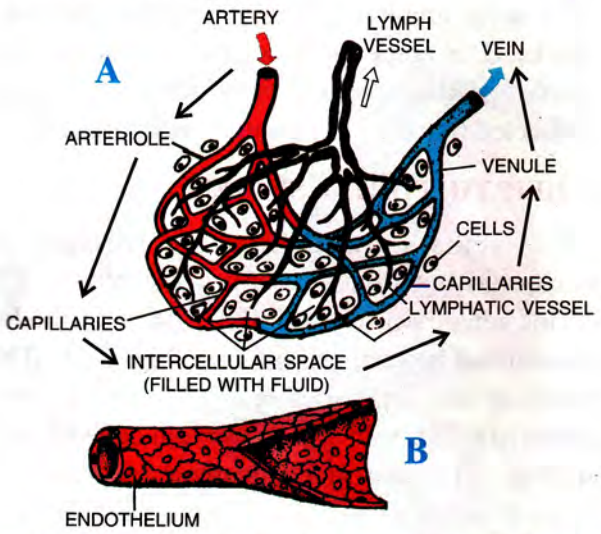


Fig. 7.12 : A. Diagrammatic relationship of artery, capillaries and vein (Blindly ending lymphatic vessels are also usually associated with blood capillaries). B. A capillary, formed of a single layer of epithelial cells.

If all the blood capillaries of the body were placed end to end in a row they could extend to a length of 100,000 kilometres. Their total wall surface would be more than 500 square metres.

Functions of capillaries :

(i) To allow **outward diffusion of oxygen** into the intercellular fluid and from there into the tissue cells.

(ii) To allow **inward diffusion of carbon dioxide** from the intercellular fluid.

(iii) To allow inward and outward **diffusion of substances** like glucose, amino acids, urea, hormones, etc.

(iv) To allow **leucocytes** (WBCs) **to squeeze out** through the capillary walls by means of amoeboid movement.

The capillaries have the power of dilating **(vasodilation)** and contracting **(vasoconstriction)** which respectively increases or decreases the blood supply to the body parts. Evidence of these changes in capillaries is seen in the colour of the skin.

- Walk in the hot sun– Face turns pink (increased blood flow).
- When it is too cold, face turns bluish (reduced blood flow).

The capillaries gradually reunite and increase in size assuming the same three layers (connective tissue layer, muscular layer and endothelium) as in arteries and veins. The smallest united common branch is called a **venule**. The venules join to form larger veins. Compared with arterioles the venules are larger with much weaker muscular coat.

Table 7.3 Differences between arteries and veins

ARTERIES	VEINS
A. Definition :	
Blood vessels which carry blood **away from the heart and into an organ.**	Blood vessels which carry blood **away from an organ and towards the heart.** (Except hepatic portal vein).
B. Structure :	
1. Progressively branched, **decreasing in size.**	1. Progressively unite **increasing in size.**
2. Smallest artery **breaks into arterioles.**	2. Smallest vein **arises from venules.**
3. Have **thick and more muscular walls.**	3. Have **thin and less muscular walls.**
4. Walls are **elastic.**	4. Walls are **non-elastic.**
5. Have **narrower lumen.**	5. Have **wider lumen.**
6. Have **no valves** in their inner lining.	6. **Have valves** in their inner lining to prevent backward flow of blood.
7. Can constrict or dilate to control blood flow.	7. Can not constrict.
8. Usually **deeper** placed.	8. Usually more **superficial** (nearer the skin).
9. **Do not collapse** when empty.	9. **Collapse** when empty.
C. Blood composition and flow	
1. Carry fully **oxygenated blood** (except pulmonary artery).	1. Carry partially **deoxygenated & CO_2 laden blood** (except pulmonary vein).
2. Blood flows with **jerks** and under **great pressure.**	2. Blood flows **continuously** and under very little pressure.

PROGRESS CHECK

1. Fill in the blanks

(i) The ..... have thin and less muscular ....., and have ..... to prevent back flow of .....

(ii) ..... carry blood to an organ and break up into ..... ending in capillaries.

(iii) Walls of capillaries consist of a single layer of squamous ..... cells.

(iv) The substances to and from the tissues diffuse through the walls of .....

7.11 THE TWO BLOOD CIRCULATIONS — PULMONARY AND SYSTEMIC

The general plan of blood circulation in our body is shown in Fig. 7.13. Blood flows twice in the heart before it completes one full round : (1) the short **pulmonary** (lung) **circulation** and (2) the long **systemic** (general body) **circulation**. For this reason the blood circulation in the human body is also called **"double circulation"** (see also Fig. 7.15).

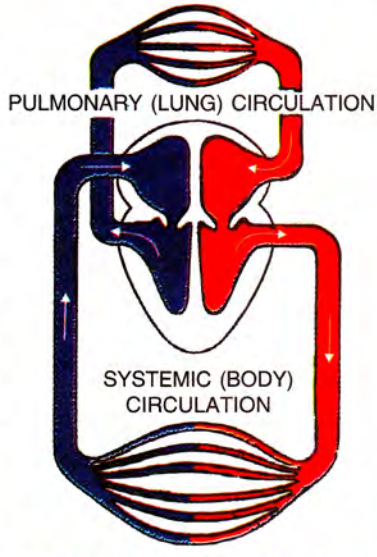


Fig. 7.13 : General plan of double circulation of blood in the human body.

(1) The **pulmonary circulation** pertains to the lungs. It starts in the **pulmonary artery** arising from the right ventricle which soon divides into two branches that enter the respective lungs. **Pulmonary veins** collect the oxygenated blood from the lungs and carry it back to the left auricle of the heart.

(2) The **systemic circulation** pertains to the major circulation in the body. It starts with the **aorta** that arises from the left ventricle (Figs. 7.8 & 7.14). The aorta arches back and continues behind as **aorta**. The aorta sends arteries to various body parts and their tissues. From there the blood is collected by veins and poured back into the heart.

7.12 HEPATIC PORTAL SYSTEM

The veins starting from the stomach and intestines do not directly convey the blood to the posterior vena cava. Instead they first enter the liver as a combined **hepatic portal vein** (Fig. 7.14). There it breaks up into capillaries in contrast to the general characteristic of a vein and a new vein called **hepatic vein** (Fig. 7.15) is formed by their reunion which joins the posterior vena cava. By definition, therefore, ***a portal vein is one which starts with capillaries and also ends in capillaries.***

UTILITY OF HEPATIC PORTAL SYSTEM

The food absorbed by the stomach and intestines is first brought to the liver which acts like a store to regulate the quantity of nutrients flowing into the general blood circulation, for example, excess sugar is stored as glycogen. Also, certain poisons if absorbed through food, are detoxified (rendered harmless) in the liver.

MAIN BLOOD VESSELS

The syllabus prescribes only the names of main blood vessels of the **liver** and the **kidney** and those entering and leaving the **heart**. These are listed as follows :

HEART

A. Blood vessels entering the heart

1. Anterior vena cava (from upper parts of our body into **right** atrium). It is formed by the union of jugular vein and subclavian vein.
2. Posterior vena cava (from lower parts of body into **right** atrium)
3. Pulmonary veins (two veins from each lung into **left** atrium)

B. Blood vessels leaving the heart

1. Pulmonary artery (from right ventricle **to lungs**)
2. Aorta (from left ventricle to all other parts of body)

LIVER

A. Blood vessels entering the liver

1. Hepatic artery (from aorta into liver)
2. Hepatic portal vein (from stomach and intestine into liver)

B. Blood vessel leaving the liver

1. Hepatic vein (from the liver into posterior vena cava)

KIDNEY

A. Blood vessel entering the kidney

1. Renal artery (from aorta into kidney)

B. Blood vessel leaving the kidney

1. Renal vein (from kidney into posterior vena cava)

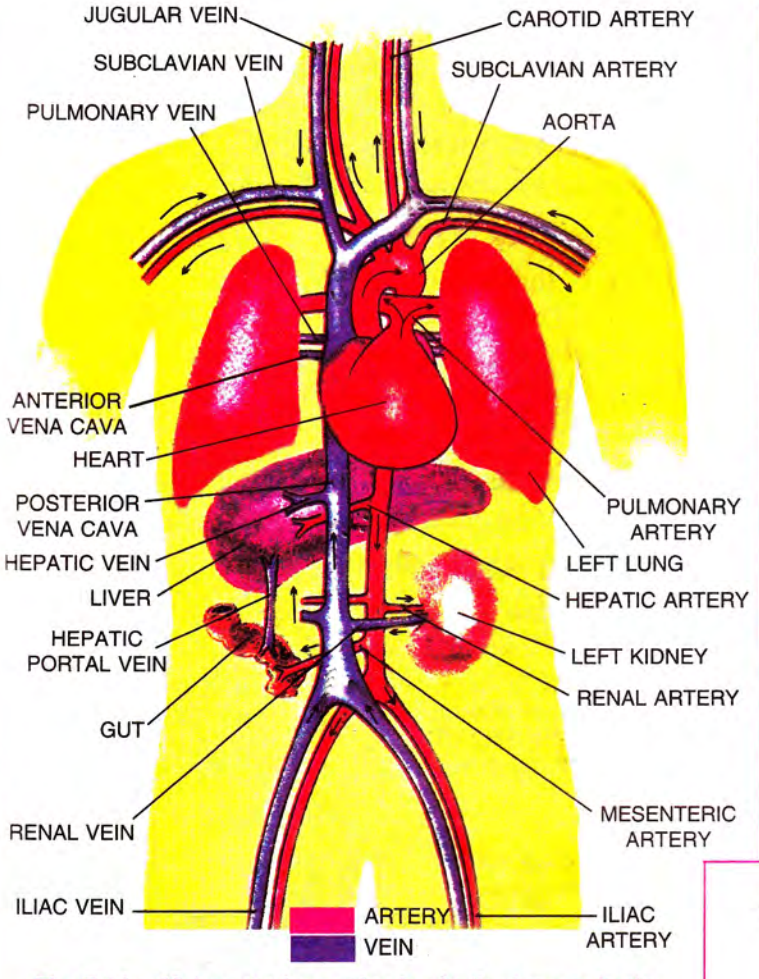


Fig. 7.14 : Major arteries and veins in the human body.

PROGRESS CHECK

1. Name the two major circulations of blood in the human body.
2. From *where to where* do the following blood vessels carry blood ?
   (i) Pulmonary artery
   (ii) Posterior vena cava
   (iii) Renal artery
   (iv) Hepatic vein
   (v) Hepatic portal vein
3. Define portal vein.

The colour differentiation

Arteries — Red
Veins — Blue

Conventionally in the diagrams, we show arteries in red colour and veins in blue. This colour differentiation is not wholly true. The oxygenated blood transported by the arteries is *bright red,* but the deoxygenated and CO_2 transporting blood is pale red (certainly not blue). But if you ever look at the prominent veins on the arms or hands especially of the old people outwardly they do look bluish and that is due to the much thicker muscular walls of the veins.

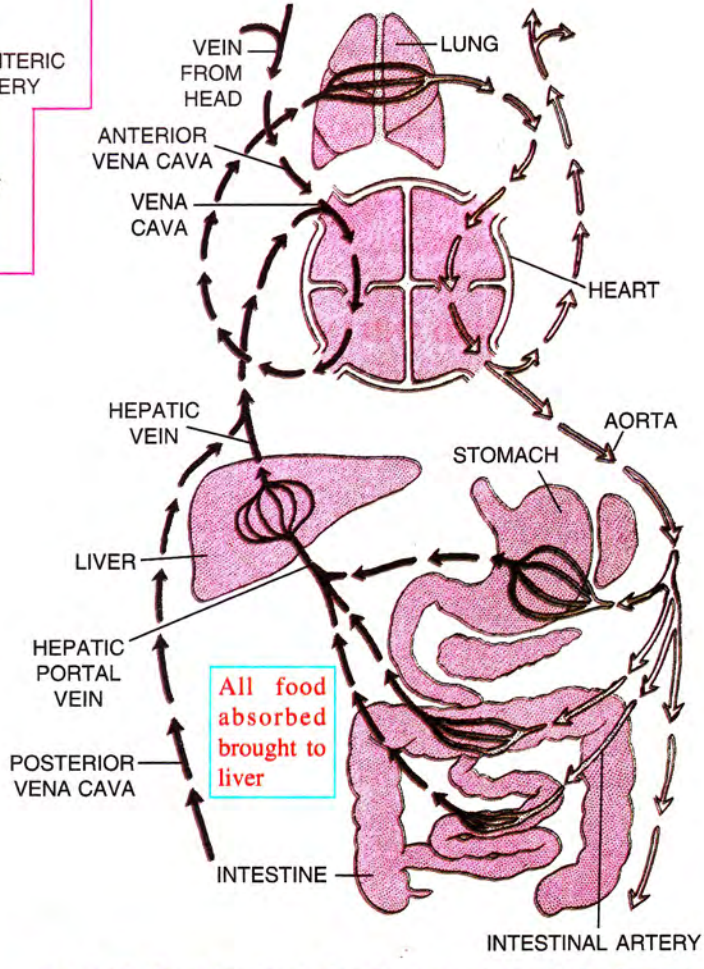


Fig. 7.15 Double circulation in the heart and the hepatic portal system through liver (highly diagrammatic)

7.13 THE PULSE

The arteries on account of their elastic muscular walls distend every time blood is forced through them due to the contraction of the heart. This distension can be easily felt by pressing your finger gently over an artery that has come up superficially, such as the radial artery of the wrist on the side of the thumb. ***Counting of the pulse is indirectly the counting of the heart beat.*** The pulse rate increases due to physical exercise or even under certain emotions.

PULSE is the alternate expansion and elastic recoil of the wall of the artery during ventricular systole. This is how you count it. →

BLOOD PRESSURE (useful to know)

Blood pressure is the pressure which the blood flowing through the arteries exerts on their walls. There are two limits of this pressure – the upper limit (**systolic pressure**) which is at the time when fresh blood is pushing through the artery as a result of the ventricular contraction of the heart. The lower limit (**diastolic pressure**) is the one recorded when the wave has passed over. The normal blood pressure for the adults is 100 - 140 mm (systolic) and 60-80 mm (diastolic). A rise in blood pressure above 140/90 is known as **hypertension** (high blood pressure in popular language).

7.14 TISSUE FLUID AND LYMPH

A. Tissue Fluid (or Intercellular Fluid)

As the blood flows in the capillaries of the tissues, the plasma and the leucocytes "leak out" through their walls. This fluid bathes the cells and is called the **tissue fluid** or the intercellular or extracellular fluid (Fig. 7.1). It is from this fluid that the cells absorb oxygen and other required substances, and in turn, give out carbon dioxide and other wastes back into it.

B. Lymph and Lymphatic System

Some of the tissue fluid may be reabsorbed into the blood vessels, but most of it enters another set of minute channels named lymph vessels where it is called **lymph**.

The main lymph vessels are shown in Fig. 7.16. The lymph flows in these vessels due to contraction of the surrounding muscles. This again is a beneficial effect of physical exercise. The lymph vessels on the way drain lymph into **lymph nodes** from where fresh lymph channels arise and ultimately pour the lymph into the major anterior veins close to their entry into the right auricle, and is again in circulation.

Composition of Lymph :

(a) Cellular part

- Only leukocytes (mostly *lymphocytes*) (No blood platelets)

(b) Non-cellular part

- Water – 94%.
- Solids (proteins, fats, carbohydrates, enzymes, antibodies, etc.) – 6%.

Functions of Lymph :

(i) ***Nutritive :*** Supplies nutrition and oxygen to those parts where blood cannot reach.

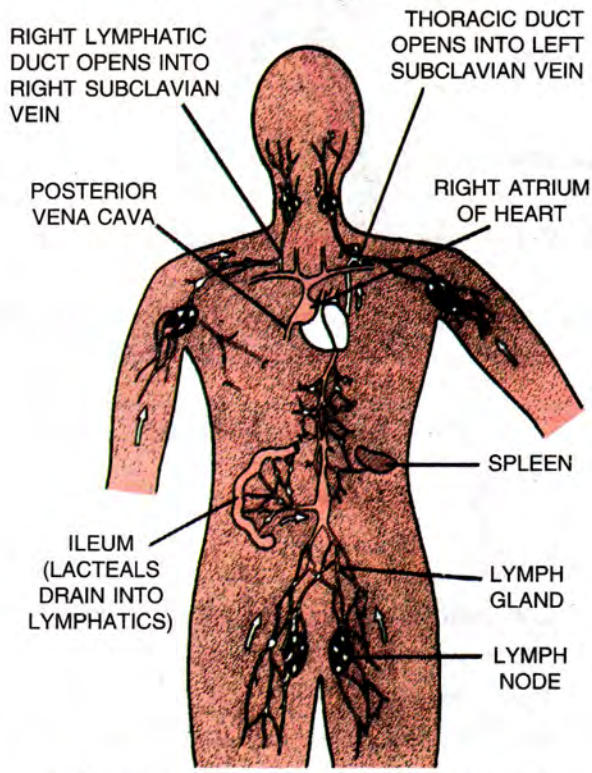


Fig. 7.16 Distribution of main lymph vessels in the human body.

(ii) ***Drainage :*** It drains away excess tissue fluid and metabolites and returns proteins to the blood from tissue spaces.

(iii) ***Absorption :*** Fats from the intestine are absorbed through lymphatics (lacteals located in the intestinal villi.)

(iv) ***Defence :*** Lymphocytes and monocytes of the lymph function to defend the body. The lymphatics

also remove bacteria from the tissues. Haven't you ever experienced painful swellings in your groins or in the axils of arms when you get a boil or injury in the limbs ? This is a protective sign.

The lymph nodes tend to localize the infection and prevent it from spreading to the body as a whole. The **tonsils** on the sides of the neck are also lymph glands.

7.15 THE SPLEEN

The spleen is a large lymphatic organ, about the size of a clenched fist, reddish brown in colour and situated in the abdomen behind the stomach and above the left kidney.

Functions of spleen

1. It acts like a **blood reservoir**. In an emergency such as haemorrhage, physical or emotional stress, or in carbon monoxide poisoning, the spleen releases the stored blood into the blood stream.
2. It **produces lymphocytes**.
3. It **destroys worn-out red blood cells** (sharing this function with the liver).
4. In an **embryo it produces RBCs**.

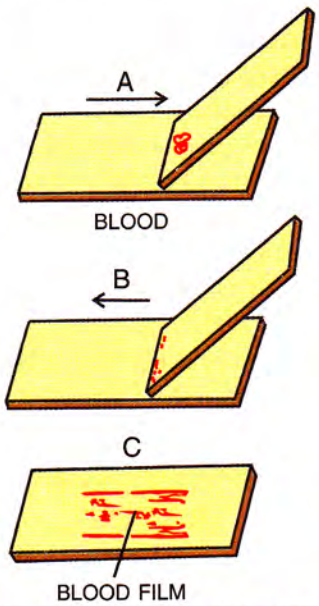


Fig. 7.17 Making a blood film

7.16 EXAMINATION OF BLOOD CORPUSCLES UNDER A MICROSCOPE

Take two clean slides. Clean the skin of your finger tip and prick it with a **sterilized** needle. Wipe off the first blood which oozes out. Gently squeeze the finger tip and take a drop of blood near the right end of one slide. Immediately put the second slide held at an angle of about 60° over the first slide close to the drop of blood and pull it gently to touch the drop (Fig 7.17A) Wait until the blood gets evenly distributed across the touching margin of the second slide (Fig 7.17B). Now push the second slide over the first one smoothly and a bit quickly and take it off. A very fine layer of blood will be formed on the first slide and that is the blood smear or the blood film (Fig. 7.17C). Allow the blood smear to dry and stain it with **Leishman stain**. Cover the smear with a few drops of the stain. After two minutes, add an equal volume of distilled water. Allow the mixture to remain for another two minutes. Pour off the mixture and rinse in tap water. Examine under the microscope after the slide is dry. You will find the cells as shown in Fig. 7.18.

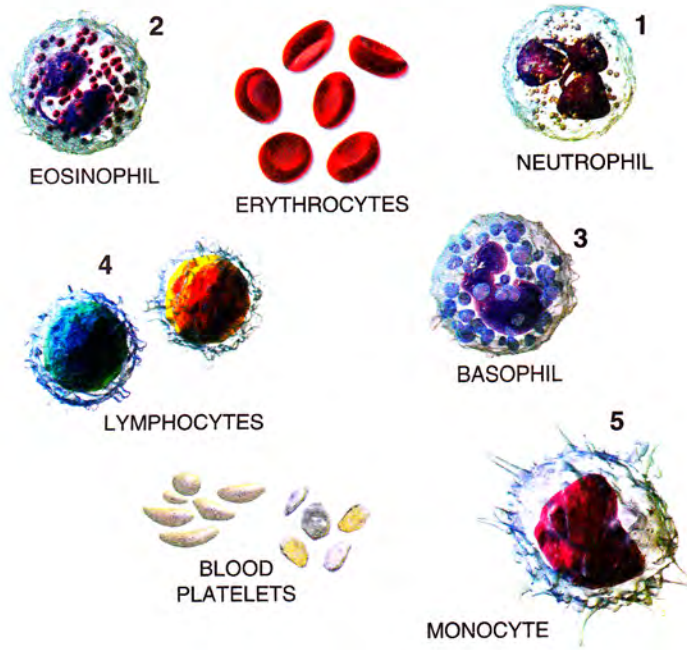


Fig. 7.18 Different kinds of blood cells (highly magnified)

PROGRESS CHECK

1. What is pulse ?
2. What are the normal values of blood pressure in a normal human adult ?
3. Which kind of cells are mostly found in lymph?
4. List the three functions of lymph.
5. Name the two main lymphatic organs in humans.
6. Name the following:
   (i) The most numerous kind of leucocytes.
   (ii) Part of lymphatic system concerned with absorption of fats from the intestine.
   (iii) A special lymphatic node on the sides of the neck.

REVIEW QUESTIONS

A. MULTIPLE CHOICE TYPE

(Select the most appropriate option in each case)

1. The nearest organ to which the heart supplies oxygenated blood is
   (a) Lung (b) Stomach
   (c) Intestine (d) Heart itself
2. When a doctor is recording your pulse, he is pressing on your wrist exactly on a
   (a) vein (b) capillary
   (c) artery (d) arteriole
3. The valve present between the right atrium and the right ventricle is the
   (a) tricuspid valve (b) bicuspid valve
   (c) semi-lunar valve (d) mitral valve
4. The blood vessel supplying blood to the kidney is the
   (a) renal vein (b) renal artery
   (c) dorsal aorta (d) hepatic vein
5. Angina Pectoris is due to
   (a) defective nutrition
   (b) inadequate supply of oxygen to the heart muscle
   (c) defective functioning of mitral valve
   (d) infection by a virus
6. The chief function of lymph nodes is to
   (a) produce WBCs (b) produce hormones
   (c) destroy old RBCs (d) destroy pathogens
7. Heart sounds are produced due to
   (a) Closure of tricuspid and bicuspid valves.
   (b) Rushing of blood through valves producing turbulence.
   (c) Closure of atrioventricular and semilunar valves.
   (d) Entry of blood into auricles.

B. VERY SHORT ANSWER TYPE

1. **What** are the average values of blood pressure in a normal adult human ?
2. **Is it true** that your heart beats more than one lac times per day ?
3. **Name** the following :
   (a) Any one vein which starts from an organ and ends in another organ besides the heart.
   (b) The kind of blood vessels which have no muscular walls.
   (c) An artery which carries impure (deoxygenated) blood.
   (d) The kind of blood cells which can squeeze out through the walls of one category of blood vessels.
   (e) The smallest common blood vessels formed by the union of capillaries.
   (f) The blood vessel which start from capillaries and end in capillaries.
   (g) The phase of the cardiac cycle in which the auricles contract.
   (h) The valve present in between the chambers on the right side of the human heart.
   (i) The phase of the cardiac cycle in which the ventricles get filled with blood from the atrium.
   (j) The fluid found between the membranes of the heart.
4. **State** the chief functional activity of each of the following :
   (a) Blood platelets .....
   (b) Neutrophils .....
   (c) Erythrocytes .....
   (d) Lymphocytes .....
   (e) Bone marrow .....
5. **Complete** the following statements by **filling in the blanks** from the choices given in the brackets.
   (a) The blood vessel that begins and ends in capillaries is the ..... (hepatic artery, hepatic portal vein, hepatic vein)
   (b) A blood vessel which has small lumen and thick wall is ... (capillary, lymphatic duct, artery, venule)
   (c) The valve which prevents back flow of blood in the veins and lymph vessels ... (mitral valve, tricuspid valve, semilunar valve).
6. Note the relationship between the first two words and **suggest** the suitable word/words for the fourth place :
   (a) Lubb : Atrioventricular valves :: Dup : .....
   (b) Coronary artery : Heart :: Hepatic artery: .....
7. Give **reason**, why a matured mammalian erythrocyte lacks nucleus and mitochondria?

C. SHORT ANSWER TYPE

1. **What** does the term "double circulation" mean?
2. **When** are the sounds "LUBB" and "DUP" produced respectively during heart beat ?
3. **Why** do people have a common belief that the heart is located on the left side of the chest ?
4. **Differentiate** between members of each of the following pairs with reference to the aspect asked within brackets :
   (a) Erythrocytes and leucocytes (function)
   (b) Artery and vein (direction of blood flow)

(c) Artery and vein (type of blood primarily flowing through)

(d) Tricuspid and bicuspid valves (location).

5. **Match** the items in Column 'A' with those in Column 'B'. Rewrite the correct matching pairs.

Column A	Column B
(a) SA Node	Plasma
(b) Defective haemoglobin in RBC	Serum
(c) Muscle fibres located in heart	Pacemaker
(d) The liquid squeezed out of blood during clotting	Sickle cell anemia
(e) Never tires, keep on contracting and relaxing	Purkinje fibres
(f) Cardiac cycle	Cardiac muscle
(g) Liquid part of the blood without corpuscles	0·85 sec

6. The table below is designed to indicate the transport of certain substances in our body. **Fill in the blanks** with suitable answers.

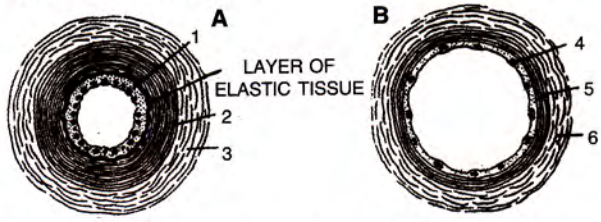
	Substance	*From*	*To*
1.	.....	Lungs	Whole body
2.	Carbon dioxide	.....	.....
3.	Urea	.....	.....
4.	Digested carbohydrates	Intestine	.....
5.	.....	.....	Target organs

D. LONG ANSWER TYPE

1. **Explain** the following terms :
   (a) Endothelium (b) Lymph nodes
   (c) Venule (d) Diastole
2. **Give** the structural differences between an artery and a vein.
3. **What** are the functions of tonsils and spleen?
4. **How** do you account for the following differences?
   (a) The left ventricle has thicker walls than the right ventricle.
   (b) The walls of the right ventricle are thicker than those of the right auricle.
5. **Give reason** for the following :
   (a) The walls of the left ventricle are thicker than the walls of all other chambers.
   (b) Blood flowing away from the stomach and intestines is put into circulation via the liver and not directly.
   (c) The blood groups of both the donor and recipient must be known before transfusing blood.
   (d) Only the veins and not the arteries are provided with valves.
   (e) Atrial wall is less muscular than the ventricular wall.
   (f) The arteries are deep seated in the body.

E. STRUCTURED/APPLICATION/SKILL TYPE

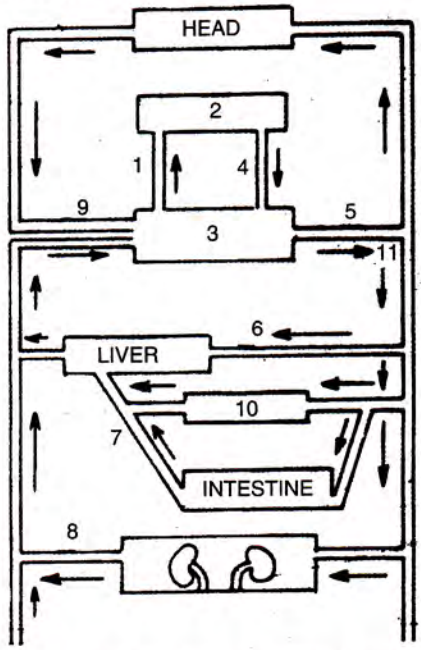
1. Given below are the diagrammatic sketches of two kinds of blood vessels.



   (a) **Identify** the blood vessels A and B.
   (b) **Name** the parts numbered 1 to 6.
   (c) **Mention** any two main differences between A and B.

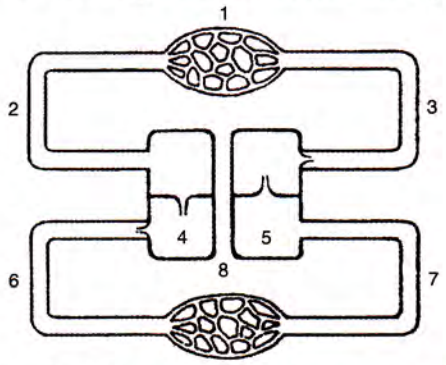
2. Given below is a highly schematic diagram of the human blood circulatory system.
   (a) **Which part** (state the number) represents the heart? Give reason in support of your answer.
   (b) **Which numbers** represent the following respectively?

Aorta	Renal Vein
Hepatic portal vein	Stomach
Pulmonary artery	Dorsal aorta
Superior vena cava	



3. Given on the next page is a simple diagram of the circulation of blood in a mammal showing the main blood vessels, the heart, lungs and body tissues. The

blood vessel, labelled 6, contains deoxygenated blood and the valve leading to it has three semi-lunar pockets.

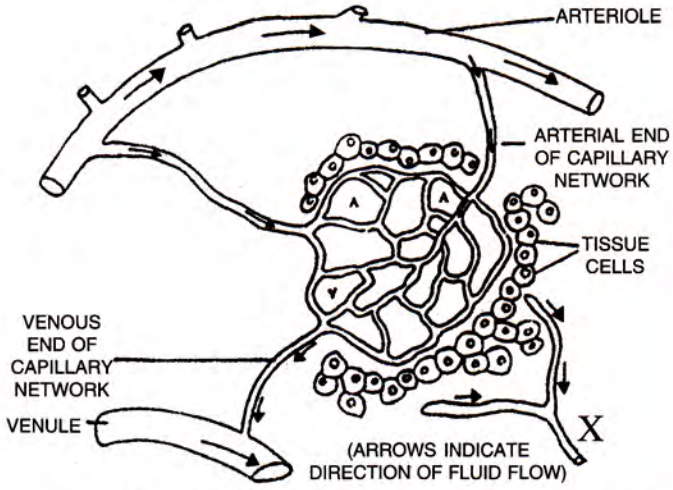


(a) **Name** the blood vessels and organs marked by numbers 1 to 8.

(b) **What is meant** by the term 'double circulation' of blood in mammals?

(c) **What** is diastole?
[There is an "error" in the diagram. According to the usual practice the pulmonary (lung) circulation is shown upward and the systemic downward, but here it is reversed].

4. The diagram below shows part of the capillary bed in an organ of the human body. Some of the blood arriving at the capillaries at points labelled A, moves out into the spaces between the tissue cells. **Study the diagram** and **answer** the questions that follow :



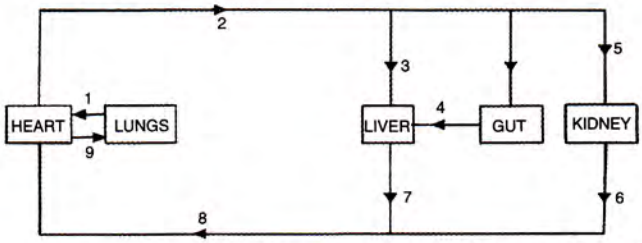
(a) **When** the liquid from the blood surrounds the cells, what is it called?

(b) **Name** any one important component of the blood which remains inside the capillaries and fails to move out into the spaces.

(c) Some of the liquid surrounding the cells does not pass directly back into the blood but eventually reaches it by another route through vessel X. **Name** the fluid present in vessel X.

(d) **State** two important functions performed in our body by the fluid present in the vessel X.

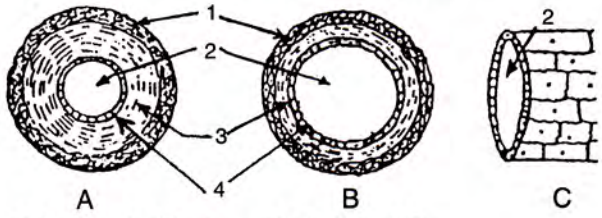
5. The following simplified diagram refers to the outline plan of the circulation of blood in a mammal. **Study the diagram** and **write** the number and the name of the blood vessel in each case as mentioned ahead.



(a) Several hours after a meal containing a lot of protein, **which vessel** will contain the highest concentration of urea ?

(b) **Which vessel** would contain the highest concentration of amino acids and glucose soon after a meal?

6. The figures given below show diagrammatic cross sections of three kinds of blood vessels.



(a) **Identify** the blood vessels A, B and C.

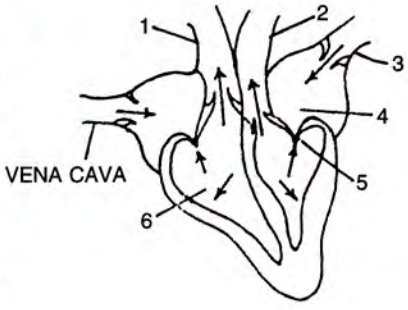
(b) **Name** the parts labelled 1-4.

(c) **Mention** two structural differences between A and B.

(d) **Name** the kinds of blood that flow through A and through B respectively.

(e) In **which** one of the above vessels referred to in (a) above does the exchange of gases actually take place?

7. The diagram given alongside represents the human heart in one phase of its activity. Study the same and then answer the questions that follow :



(a) **Name** the phase.

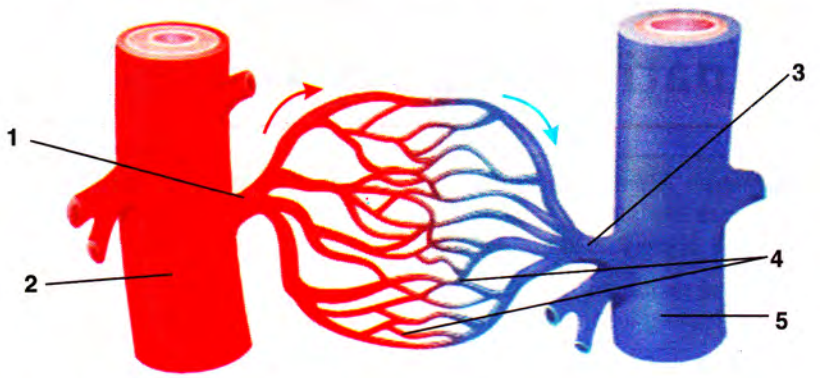
(b) **Which part** of the heart is contracting in this phase? Give a reason to support your answer.

(c) **Name the parts** numbered 1 to 6.

(d) **What type of blood** flows through the parts marked '1' and '2' respectively?

(e) **How many valves** are closed in this phase?

8. Given below is a diagrammatic representation of certain types of blood vessels in human body.



(a) Identify the types of blood vessels numbered 1 to 5.

(b) Where can such an arrangement be found as an example — in lungs or in heart walls ?

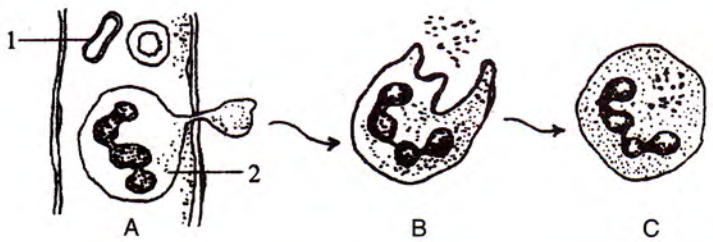
9. Study the following diagram carefully and then answer the questions that follow:

(a) Name the cell labelled 1.

(b) Identify the phenomenon occurring in A.

(c) Mention two structural differences between 1 and 2.

(d) Name the process occurring in B and C and state the importance of this process in the human body.



Extra Knowledge

Why the blood types named as A, B, AB and O ?

Why not A, B, C & D ?

This is related to the two types of antigens (antigen A and antigen B) present on the RBCs either singly (**blood group A** and **blood group B** respectively) or both together (as **AB**), but having no antigen on RBCs meaning "Zero" antigen, refers to the blood group "O" (actually Zero).

Blood groups in common parlance

"A+ve" / "B–ve" / "O+ve", etc., etc.

Are these the types of a single blood group? ..... No!!

But a common man when required to get blood transfusion, thinks so.

Actually, these are the possible combinations from two blood group systems : *one*, the **ABO system** and *two*, the **Rh system**.

Check up the details in section 7.7 page 82.