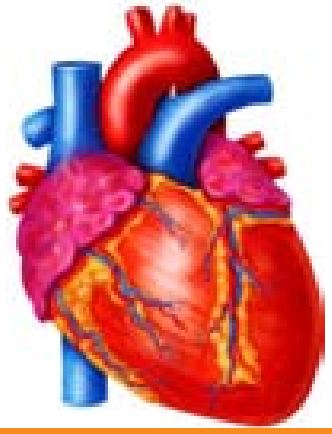
Chapter

3



Transportation - The circulatory system

All the living organisms need nutrients, gases, liquids etc., for growth and maintenance of the body.

All the organisms would need to send these materials to all parts of their body whether they are unicellular organisms or multicellular.

In unicellular organisms these may not have to be transported to longer distances while in multicellular forms have to be sent substances to long distances as far as say over 100 feet for the tallest plant on earth.

In lower organisms like amoeba, hydra etc., all the materials are transported through a simple processes like diffusion, osmosis etc.,

In higher animals with trillions of cells in their body adopt the method of diffusion and osmosis only for the bulk movement of materials, would takes years.

To avoid delay a separate system is needed to carry the materials much faster and more efficiently.

This specialized system that is developed by organisms is called 'the circulatory system'.

We eat solids, we drink liquids, and we breathe gases. Do you think that it is possible to transport all the three types of materials, through a single system?

Let us study how this circulation is carried out in our body.

Have you ever observed a doctor holding the wrist of the patient and looking at his watch for a minute? What is that he is trying to find out from the watch and the wrist of the patient? You may wonder to know that he is

counting the heart beat of the patient. Don't you think that is crazy, holding the hand to count the heart beat?

Activity-1

You could try to find out for yourself, what the doctor was doing. Keep your index and middle fingers on your wrist below the thumb as shown in the fig-1.

- *What did you feel?*

You feel something pushing your fingers rhythmically up and down. Now let us count the rhythm which is called the pulse, for a minute. Now stand up and jog for one minute at the same place. Note the pulse for a minute. Take readings atleast two of your parents in the same manner and record in the following table.

fig-1: Pulse

Table-1

S.No	Name of the person	Pulse rate per minute	
		at rest	after jogging

- *What did you observe? Is the pulse rate same in both conditions?*

Activity-2

We see that pulse rate varies from person to person and situation to situation. So it is not constant, when you are afraid or excited the pulse rate goes up. Observe your pulse rhythm in other ways as well such as climbing stairs, running, etc. There is a relationship between the pulse rate and the beat of our heart. Now let us try to find out more about this relationship.

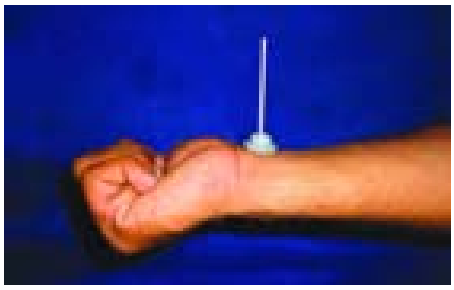


fig-2: Matchstick stethoscope

For this you have to make your own stethescope. Take a shirt button insert a matchstick as shown in fig-2. Place it on your wrist. Observe movements in matchstick.

- *What did you find?*
- *When do you think that our pulse rate goes up?*
- *What does the pulse rate show?*

Do you know?

Newborn (0–3 months)	Infants (3-6 months)	Infants (6–12 months)	Children (1-10 years)	Children over 10 years & adults, including senior citizens	Well-trainedadults athletes
100-150	90-120	80-120	70-130	60-100	40-60

In the year 1816, Rene Laennac discovered the Stethoscope. Before the discovery of stethoscope doctors used to hear heart beat by keeping ear on the chest of the patient. Laennac found that paper tube helps to hear the heart beat perfectly. Then he used a bamboo instead of paper tube to hear heart beat. Laennac called it stethoscope.

Activity-3

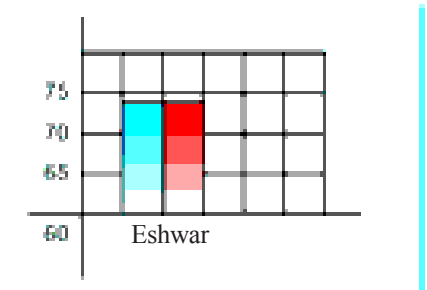
Let us repeat the work Laennac.

Make a paper tube 10 inch long and one inch in diameter. Keep one end of it on the chest of your friend on a point one inch to the left side to the centre around 6 inches below from his or her neck. Keep your ear at the other end. Listen carefully and count the heart beats for a minute.

Also count down your friend's pulse rate. Note observations of at least 10 students of your class in the following tabular form.

Table-2

S.No	Name of the student	Heart beat at rest/min	Pulse rate at rest/min
1	Eswar	72	72



x-axis: Name of the student
y-axis: Heart beat, pulse rate per minute

Let us plot histogram on heart beat and pulse rate of different persons as shown in the sample graph. Here blue bar indicates heart beat, red bar indicates pulse rate.

- *What is the relationship between the heart beat and the pulse?*
- *Can we say, the pulse rate is always equal to the heart beat?*

You might have studied there is a relation between pulse rate and heart beat.

Now try to understand the structure and method of working of this vital organ, the heart. It is the beat of the heart which keeps us alive. Heart is located in between the lungs and protected by rib cage. The size of your heart is approximately the size of your fist.

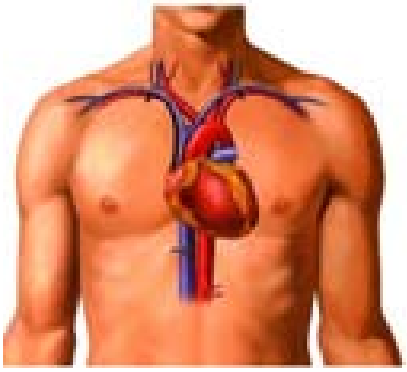


fig-3: Location of Heart

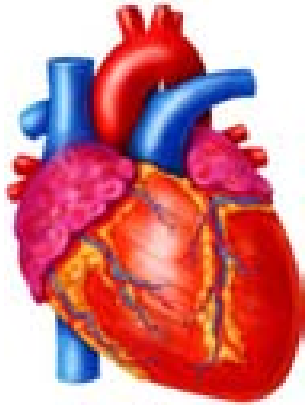


fig-4: Heart

Lab Activity

Aim: Observation of the internal structure of the mammalian heart.

Material required: Since the structure of all the mammalian hearts are similar, we take the sheep's or goat's heart for our observation. For this, we need following materials.

Freshly collected specimen of heart of sheep or goat from the butcher. Soda straws, sharp and long blade or scalpel, tray, a jug of water, Dissection scissors, forceps.

Procedure for observation:

- Before coming to the class wash the heart thoroughly so that, blood is completely drained from the chambers of heart.
- Take soda straws and insert them into the stumps of the blood vessels. Note your observations as you proceed.
- *How many layers are covering the heart?*
  (Now remove the layers covering the heart, and observe)
- *What is the shape of the heart?*
- *How many large blood vessel stumps are attached to the heart?*
- *Which end of the heart is broader and which end is narrow?*

Observe the arrangement of blood vessels (coronary vessels) on the wall of the heart.

(In case you don't have a model or a goat's heart, look at the figures given carefully for observation)

Internal structure of the heart

- Keep the heart in the tray in such a way that a large arch like tube faces upwards. This is the ventral side.
- Now take a sharp blade or scalpel and open the heart in such a way that the chambers are exposed. Take the help of the fig-6.

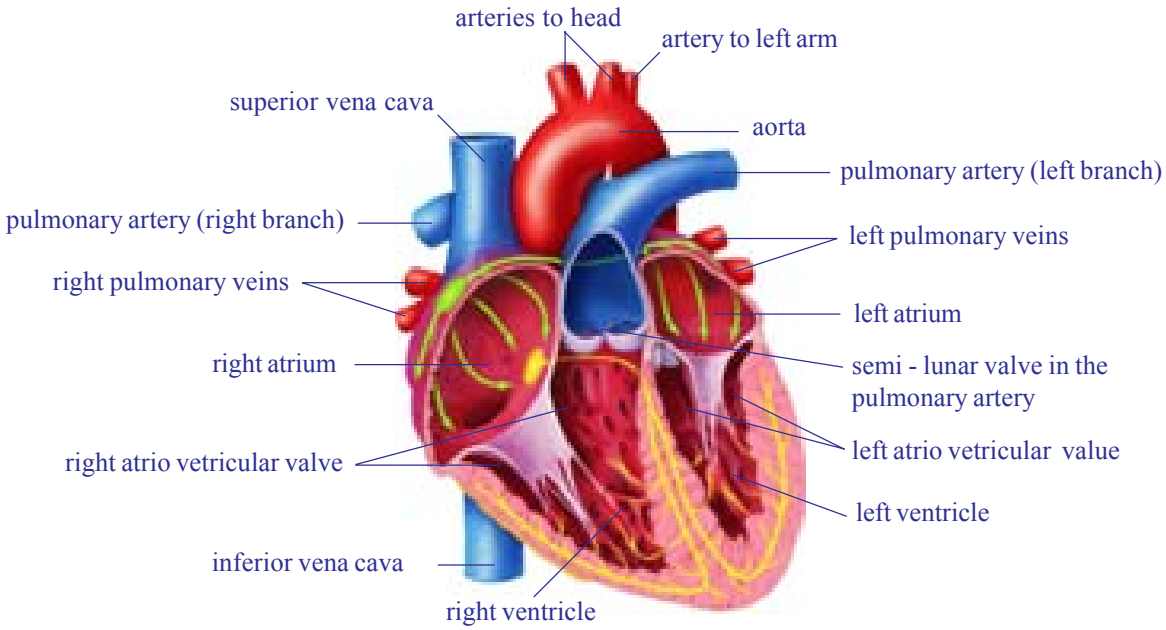


fig-5: Internal structure of heart

Now observe the internal structure. Observe the wall of the heart.

- *Is the thickness of the wall of the heart uniform throughout?*
- *How many chambers are there in the heart?*
- *Are all the chambers of the same size?*
- *What other differences could you observe between the chambers?*
- *Are all the chambers connected to each other?*
- *How are they connected to each other? How are they separated?*

You can observe white coloured structures in the lower part of the heart. Note down the size, shape and to which parts they are attached. Can you guess the function of these structures?

Write a note on your observations of the heart. Compare your notes with the description given below.

The heart is a pear shaped structure, triangle in outline, wider at the anterior end and narrower at the posterior end.

The heart is covered by two layers of membranes. The membranes are called pericardial membranes. The space between these two layers is filled with pericardial fluid, which protects the heart from shocks.

The heart is divided into four parts by grooves.

Two upper parts are called atria (auricles), and the lower ones are called ventricles.

The left atrium and ventricle are smaller when compared to that of right atrium and ventricle.

The blood vessels found in the walls of the heart are coronary vessels which supply blood to the muscles of the heart.

The walls of the ventricles are relatively thicker than atrial walls.

In our observation we found that the heart has four chambers in it. On the left side two chambers are present, one is anterior and the other is the posterior. On the right side also two chambers present, one upper (anterior), and one lower (posterior).

Observe the presence o blood vessels attached to the heart.

- *How many blood vessels are attached to the heart?*
- *Are all the blood vessels are rigid? How many of them are rigid?*
- *Do you think that the stiffness/rigidity of blood vessel is something to do with circulation?*

The rigid vessels are called arteries which originate from the heart and supply blood to various organs in the body. The larger artery is the aorta.

The relatively smaller one is pulmonary artery which carries blood from the heart to the lungs.

The less rigid vessels are the veins, which bring blood from all body parts to the heart.

The vein which is at the anterior end of the right side of the heart is superior venacava (precaval vein), which collects blood from anterior parts of the body.

The vein which is coming from posterior part of the heart is inferior venacava (postcaval vein), collecting blood from posterior part of the body.

The two atria and the two ventricles are separated from each other by muscular partitions called septa. The openings between atria and ventricles are guarded by valves.

In the right atrium we can observe the openings of superior and inferior venacava. In the left atrium, we can observe the openings of pulmonary veins, that bring blood from lungs.

From the upper part of the left ventricle, a thick blood vessel called aorta arises. It supplies oxygenated blood to the body parts. From the upper

part of the right ventricle pulmonary artery arises that supplies de-oxygenated blood to the lungs. After careful examination we can observe valves in the pulmonary artery and aorta as well.

The blood vessels and circulation

Let us study how we came to know about the structure and functions of the blood vessels.

It was not until 16th century that we really came to know how our blood vessels functioned. In 1574, an Italian doctor, Girolamo Fabrici, was studying the veins in the leg. He noticed that they had small valves in them. If the blood moved in one direction, the valves folded towards the walls of the vessel, so that the blood could pass without trouble. If the blood moved in the opposite direction, the valves closed.

This meant they are one-way valves. The valves permitted the blood to move even when a person is standing upright. But not move downward.

When a person moves his legs, or just tightens his leg muscles, those muscles squeeze the veins and force the blood in those veins to move upward against the pull of gravity (because that's the only way to go). If a person keeps his leg muscles relaxed, the blood isn't moving much, but at least it isn't being pulled down by gravity. The valves won't allow that.

Everyone thought that the blood leaving the left ventricle always moved away from the heart for which Fabrici paid no attention. He missed the importance of his own discovery.

But then, William Harvey (1578-1657), an Englishman who, after he became a doctor, went to Italy for further education and studied under Fabrici.

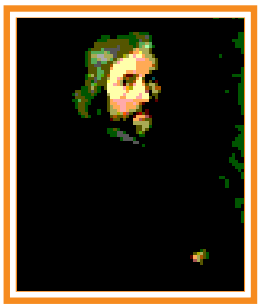


fig-6: William Harvey

Harvey dissected the hearts of dead people and studied the valves between each atrium and its ventricle. He noticed that they were one-way valves. They allowed the blood to flow from the atrium to the ventricle without any hinderance.

When the heart contracted, however, no blood in the ventricle could flow back into the atrium. Instead, all the blood was pushed out into the arteries.

Harvey began thinking about the valves his teacher, Fabrici, had discovered in the leg veins. They were one-way, and they forced the blood to move toward the heart.

He checked that by tying off and blocking different veins in animals he experimented on the veins always bulged on the side of the block away

from the heart. As though the blood as trying to flow toward the heart and to accumulate just below the block because it simply couldn't flow away from the heart. This was true of all veins.

In the arteries, the blood bulged on the heart side of any block he put in, as though it were trying to flow away from the heart and couldn't move in the other direction.

Harvey now saw what was happening. The heart pushed blood into the arteries, and the blood returned by way of the veins. It did this for both ventricles. The blood had a double circulation. If one started from the right ventricle, it left by way of the arteries to the lungs, and returned by way of the veins to the left atrium and from there into the left Ventricle.From the left ventricle, it left by way of the arteries to the rest of the body and returned (in a "greater circulation") by way of the veins to the right atrium and from there into the right ventricle. Then it started all over.

Harvey also showed that it was impossible, suppose that the blood was used up in the body and that new blood was formed. He measured how much blood the heart pumped in one contraction and also counted the number of contractions.

He found that in one hour, the heart pumped out a quantity of blood that was three times the weight of a man. The body couldn't use up blood and form new blood at such a rate. The same blood had to circulate and be used over and over again.

fig-7: Marcello Malpighi

Harvey still had some problem. The smallest arteries and veins that could be seen had to be connected by vessels too small to see. Were they really there?

In the 1650s, scientists had learned to put lenses together in such a way that objects too small to see with the naked eye could be magnified and made visible. Marcello Malpighi (1628-1694), with the microscope, he could see tiny blood vessels that were invisible with naked eye.

In 1661, four years after Harvey's death, Malpighi studied the wings of bats. He could see blood vessels in their thin membranes and, under the microscope; he could see that the smallest arteries and veins were connected by very fine blood vessels.

He called these blood vessels "capillaries" from the Latin word for "hair", because they were as thin as the finest of hairs.

With the discovery of capillaries, the idea of the circulation of the blood was complete, and it has been accepted ever since.

fig-8(a): Try like this

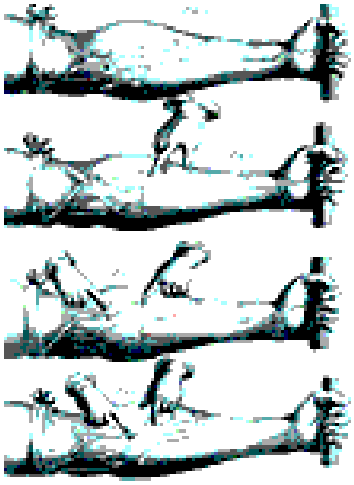


fig-8(b): Harvey's

Now, we know that blood circulates in the blood vessels. But how did the scientists find out that blood moves in blood vessels? Is it possible to demonstrate the movement of blood in vessels without damaging the vessels?

Let us repeat the classical experiment to demonstrate the movement of blood in veins conducted by William Harvey in early 17th century, when there was no compound microscope or any other modern equipment.

1. Tie a tornquit just above the elbow of a person, whose blood vessels are prominent in the hand.
2. Ask him/her to hold the fist with a piece of cloth rolled in the hand. Now the blood vessels can be seen more prominently.
3. Find undivided blood vessel, where we have to work for the next few minutes.
4. At the end of the vessel farthest from the elbow apply steady pressure, so as to close its cavity.
5. Now apply pressure from elbow towards the palm slowly and observe the changes in the blood vessels. (Take the help of the figures given here.) Observe changes and discuss in your class.

Arteries and veins

There are two types of blood vessels called arteries and veins. Arteries carry blood from the heart to body parts. Whereas, veins carry blood from body organs to heart. Let us observe the structural and functional differences between arteries and veins.

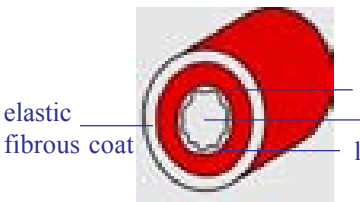


fig-9(a): T.S. of Artery

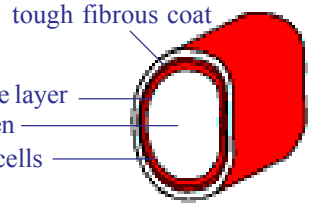


fig-9(b): T.S. of Vein

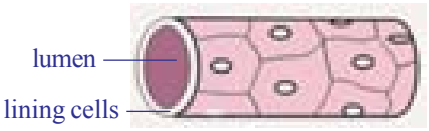


fig-9(c): T.S.of Blood capillary

Blood capillaries

Blood capillaries are the microscopic vessels made of single layer of cells. They allow diffusion of various substances. The leucocytes (WBC) can squeeze out of the capillary wall. They establish continuity between arteries and veins.

Answer the following after reading the experiment conducted by William Harvey.

- *In which blood vessels valves are found? What do you think is the function of the valves in them?*
- *Why do sub-cutaneous blood vessels bulge on the side away from the heart when the hand is tied?*
- *The deep seated blood vessels (the arteries) bulge on the side towards the heart when tied. What do you understand from it?*
- *There are valves in the heart between atria and ventricles. Is the purpose of valves in the veins and arteries same?*

After reading the experiments by Harvey fill in the following table. Use the clues/options given in the first column.

Table-2

	Structure / Function	Artery	Vein
1.	Thickness of walls(thick / thin)		
2.	Valves (present / absent)		
3.	Capacity to retain shape when blood is absent (can retain/collapse)		
4.	Direction of blood flow (heart to organs / body organs to heart)		
5.	Pressure in the vessel(low /high)		
6.	Type of blood transported (oxygenated / de-oxygenated)		
7.	Type of blood carried by pulmonary artery (de -oxygenated/ oxygenated)		
8.	Type of blood carried by pulmonary vein (oxygenated / de-oxygenated)		

Let us perform the following activities to observe arteries and veins.

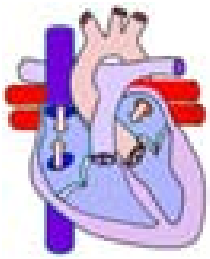
Sit on a table with one leg dangling and the other resting on it so that the back of one knee rests on the knee of the other. After a time you will see and feel the leg which is on top give a series of small movements with each heart beat. If you do it for long you will reduce the blood flow to the leg and so develop 'pins and needles'.

Swing your arm round several times to fill the veins with blood, hold the arm vertically downwards and gently press your finger along a prominent vein-stroking it in the reverse direction to the blood flow, i.e., towards the

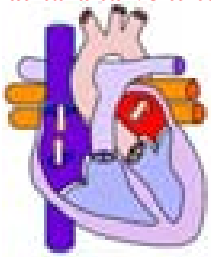
hand. Can you see the swellings where you have pushed blood against the valves? Discuss with your teacher about reasons.

Think and discuss

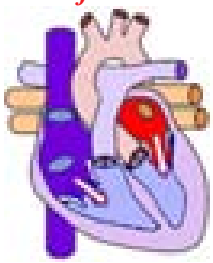
- Artery walls are very strong and elastic. why?
- Why we compare arteries like tree which devides into smaller and smaller branches.
- The lumen size is bigger in vein when compared with artery. Why?



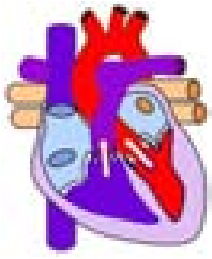
1. Imaginary relaxation of atria and ventricles.



2. Blood flows into atria.



3. Contraction of atria and flow of blood into ventricles.



4. Contraction of ventricles. A.V. Valves closed (Lub) blood flows into artries.

The cardiac cycle

The human heart starts beating around 21st day during the embryonic development (refer reproduction chapter). If it stops beating, it results in the death of a person.

One contraction and one relaxation of atria and ventricles is called one cardiac cycle.

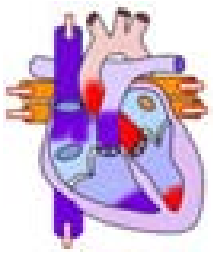
1. We start with the imagination that all the four chambers of the heart are in relaxed state (joint diastole).
2. Blood from venacava and pulmonary veins enters the right and left atria respectively.
3. Now the atria contract, forcing the blood to enter into the ventricles.
4. When the ventricles are filled with blood they start contracting and atria start relaxing. On ventricular contraction due to pressure the blood moves into the aorta and pulmonary artery. The aperture between the atria and ventricles is closed by valves. When the valves are closed forcibly, we can listen to the first sharp sound of the heart lub.
5. When the ventricles start relaxing the pressure in the ventricles is reduced. The blood which has entered the arteries tries to come back into the ventricles. The valves which are present in the blood vessels are closed to prevent backward flow of blood into the ventricles. Now we can listen to a dull sound of the heart dub. The atria are filled up with blood and are ready to pump the blood into the ventricles.

The sequential events in the heart which are cyclically

repeated are called cardiac cycle. The cardiac cycle includes an active phase systole and a resting phase the diastole of atria and ventricles. The whole process is completed in approximately 0.8 second.

The time needed for atrial contraction is 0.11-0.14 seconds. The time needed for ventricular contraction is 0.27-0.35 seconds.

Hence, naturally the blood is pumped into the blood vessels at regular intervals. The tissues will not receive the blood continuously, but in the form of spurts. When we keep our finger at the wrist, where the artery is passing into the hand we feel the pressure of blood moving in it. This is the pulse. The rate of the pulse will be equal to the number of heart beats.



5. Relaxation of ventricles. The closing of arterial valves (Dub).

fig-10(1-5): Cardiac cycle

Do you know?

Name of the animal	Weight of the body	Weight of the heart	No. of beats/min
Blue whale	1,50,000 kg	750 kg	7
Elephant	3000 kg	12 - 21 kg	46
Man	60-70kg	300 gm	76
Coaltit (Bird)	8 gm	0.15 gm	1200

Single /double circulation

We know that blood flows in the blood vessels. To keep the blood moving the heart pumps it continuously. The blood that is pumped by the heart reaches the body parts and comes back to the heart. But course taken by the blood is not the same in all the animals. Let us observe the fig-11(a) and (b). Start from any point in the fig-11(a) and (b). Move in the direction of arrow. Note down the parts which are in the way in cyclical form.

(Try to identify different parts of the body in both figures.)

fig-11(a): Single circulation

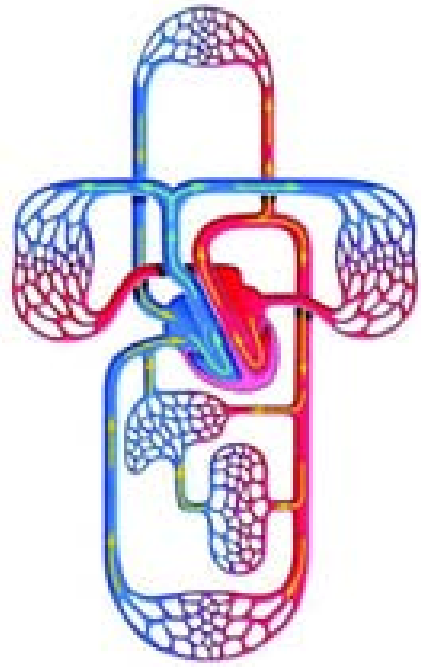


fig-11(b): Double circulation

Compare the two flow charts and answer the following.

- *How many times did your pointer touch body parts in fig-11(a) and (b)?*
- *How many times did your pointer touch the heart in fig-11(a) and (b)?*
- *How many times did your pointer touch the respiratory organs in fig-11(a) and (b)?*

From your observation it is clear that in fig -11(a) blood flows through heart only once to complete one circulation.

If blood flows through heart only once for completing one circulation it is called single circulation.

If the blood flows through the heart twice for completing one circulation it is called double circulation.

Lymphatic system

As blood flows through tissues some amount of fluids and certain solid materials are constantly flowing out of them at different junctions. Such materials are to be collected and sent back into blood circulation.

Have you ever observed what happened to your feet after overnight journey, in sitting position without moving? We feel that our foot wear is little tight. In elders it will be clear that the lower part of the legs will be swollen. This stage is called edema.

- *Why do our legs swell?*

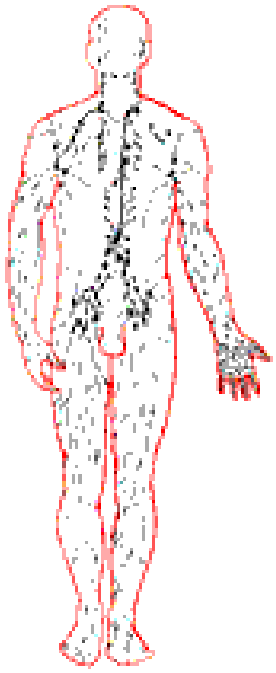


fig-12: Lymphatic system

We know that blood circulates in the blood vessels, pushed by the heart. From the heart it flows into the arteries and finally into the capillaries. To supply nutrients to the cells (tissues), the liquid portion of the blood with nutrients flows out of the capillaries. This is called tissue fluid.

The tissue fluid which is present in the tissues should be transported into the blood vessels again. Some portion of the tissue fluid enters into the venules, which in turn form the veins, which carry blood to the heart. What about the remaining tissue fluid? To transport the tissue fluid in to the main blood stream, a separate system is present. That is called lymphatic system. In latin lymph means water.

Lymph is the vital link between blood and tissues by which essential substances pass from blood to cells and excretory products from cells to blood. The lymphatic system is a parallel system to venous system which collects tissue fluid from tissues and transports it to the venous system.

Blood is a substance which contains solid and liquid particles.

Lymph is the substance that contains blood without solid particles. Tissue fluid is lymph present in the tissues. The liquid portion after formation of blood clot is serum.

The muscles which are attached to the skeleton (skeletal muscles) act as pumps when they contract and help in pushing the lymph flowing in lymphatic vessels and the blood flowing in veins towards the heart.

The valves that are present in the lymphatic vessels and veins stop the reverse flow of blood. We shall read about this as the system of ***lymph circulation*** in detail in higher classes.

Evolution of the transport (circulatory) system

When the unicellular organisms separated themselves from the sea with the formation of the limiting membrane, the problem of transportation arose. The nature has found the solution, by creating a microscopic ocean which has its own currents.

In unicellular organisms like Amoeba the protoplasm shows natural movements. These movements are called Brownian movements, because of which the nutrients and oxygen are distributed throughout the protoplasm equally.

This simplest intracellular transportation system, present in unicellular animals has been retained in multicellular animals including humans. The protoplasm of any cell in our body is mobile and protoplasmic currents exist even in the nerve cells.

The multicellular animals have to develop more complicated system for transportation of materials.

The parazoas like sponges, use sea water for transportation. Since the natural water currents are not reliable, the sponges create their own currents by beating of flagella that are present in their body.

The cnidarians which are better evolved than sponges (e.g. Hydra and jelly fish) have developed blind sac like gastrovascular cavity, which has taken up the function of digestion and transportation of nutrients to each and every cell of the body.

In platyhelmenthes (e.g. Fasciola hepatica), the digestive system is highly branched and supplies digested food to all the cells directly. In these animals the excretory system collects wastes from each cell individually. In these organisms most of the body is occupied by digestive and excretory systems.

In animals belonging to Nematyhelmenthes, the pseudocoelom has taken up the function of collection and distribution of materials.

The Annelids, the first Eucoelomate animals have developed a pulsatile vessel, to move the fluid and the transporting medium is blood.

The Arthropods have developed a pulsatile organ to pump the blood, the heart. The blood instead of flowing in blood vessels floods the tissues, directly supplying the nutrients to the tissues. Oxygen is directly supplied to the tissues directly by the respiratory system.

Such type of transportation system which supplies nutrients to the tissues directly is called open type of circulatory system.eg. Arthropods, many molluscs and lower chordates.

The other type of transportation system where the blood takes the responsibility of delivering the materials, which flows in the blood vessels is called closed type of circulatory system. Such type of closed circulatory system is present in annelids echinoderms, cephalopod molluscs (e.g. Octopus) and all the higher animals.

Do you know?

The human circulatory system can move one ml of blood from heart to a foot and back which is approximately 2 meters, in about 60 seconds.

It would take more than 60 years for the substance to move across this distance by diffusion.

Blood pressure (B.P.)

In class 9th we studied about blood and it's components, blood grouping, etc., in the chapter animal tissues. Now we will discuss some other points related to blood.

Generally you have heard the word B.P. What is B.P.? To move the blood through this network of vessels, a great deal of force is required. The force is provided by the heart and is at its highest when the ventricles contract, forcing the blood out of the heart and into the arteries. Then there is a drop in the pressure as the ventricles refill with blood for the next beat.

fig-13: Sphygmomanometer

B.P. is always measured in the upper arm artery. B.P. varies throughout the body, so a standard place must be used so that a person's blood pressure can be compared over a period of time. Doctors measure the blood pressure (B.P.) with a device called sphygmomanometer.

There are two pressure readings. One measures the strongest pressure during the time blood is forced out of the ventricles. This is called systolic pressure. For a healthy

young adult it will be 120 mm of Hg. The second reading is taken during the resting period, as the ventricles refill with blood. This is called diastolic pressure. It will be 80 mm of Hg.

B.P. will change according to the activity in which the person is engaged, such as resting, walking and running. People who have high B.P. during resting period are said to have hypertension. Discuss with your teacher about low blood pressure.

Coagulation of blood

Another important part in the story of blood is coagulation. Only because of this character animals survive when they meet severe injuries.

When there is an injury blood clots in 3-6 minutes. How does the blood clot? What chemistry involved in blood coagulation. You know that when you cut yourself, the blood flows out of the wound for only a short time. Then the cut is filled with a reddish solid material. This solid is called a blood clot. If blood did not clot, anyone with even a slight wound bleeds profusely.

- When the blood flows out, the platelets release an enzyme called thrombokinase.
- Thrombokinase acts on another substance present in the blood called pro-thrombin converting it into thrombin.
- Thrombin acts on another substance called fibrin, that is present in dissolved state converting it into insoluble fibrin.
- The blood cells entangle in the fibrin fibers forming the clot.
- The fibrin fibers are attached to the edges of the wound and pull them together.

This straw yellowish coloured fluid portion after formation of the clot is *serum*.

Discuss with your teacher about vitamin K in relation to coagulation of blood.

fig-14(a): Blood in the blood vessel

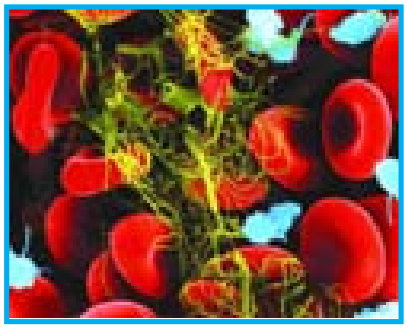


fig-14(b): Clot formation

Normally the blood that oozes from a wound clots in 3-6 minutes. But in some people due to vitamin K deficiency it takes more time. Because of genetic disorder the blood may not coagulate. This type of disorder is called haemophilia. Haemophilia is common disorder in the children who have born from marriages between very close relatives. Thalassemia an inherited disorder is also related to blood. For more details see annexure.

HOW MATERIALS TRANSPORT WITH IN THE PLANT

There is a vast transport system in continual supply of essential nutrients and oxygen to perform metabolic activities, and to remove excretory substances which are found in each cell of animal body.

Is there anything like that in plants which corresponds to circulatory system?

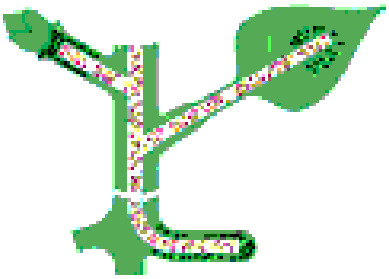


fig-15: Transportation

In previous classes we studied about Van Helmont's experiments on plants, which get water that contain minerals from soil through their roots. The water absorbed by roots and food prepared by leaves are supplied to the remaining parts of the plant by vascular bundles having xylem and phloem.

In the root the xylem tissue is situated towards the exterior while in the stem it is arranged in bundles towards the center.

How is water absorbed?

We know that roots absorb water with minerals from soil.

- *What is the mechanism behind this?*
- *Are roots directly in contact with water?*
- *How is water absorbed?*

Activity-4

Absorving root hairs

To perform this activity, you need to germinate bajra or mustard seeds.

Examine some mustard seedlings which have been grown on wet filter paper. Observe the mass of fine threads coming from the seed by hand lens. These are roots. They have fine microscopic structures called root hairs. These are root hairs trough which water enters the plant. Gently squash a portion of the root hair between slide and cover slip in a drop of water and examine under a microscope. Note the thinness of the walls of root hairs. It is not completely understood how the water enters the root

hairs and passes inwards from cell to cell until it gets into the xylem vessels, but there is no doubt that osmosis plays an important role.

Every living cell acts as an osmotic system, the cytoplasm lining of the cell wall acts as the semipermeable membrane. Observe the following figure, notice how do roots penetrate into soil? You will find that the root hairs grow out into the spaces between the soil particles and that the hairs are surrounded by moisture.

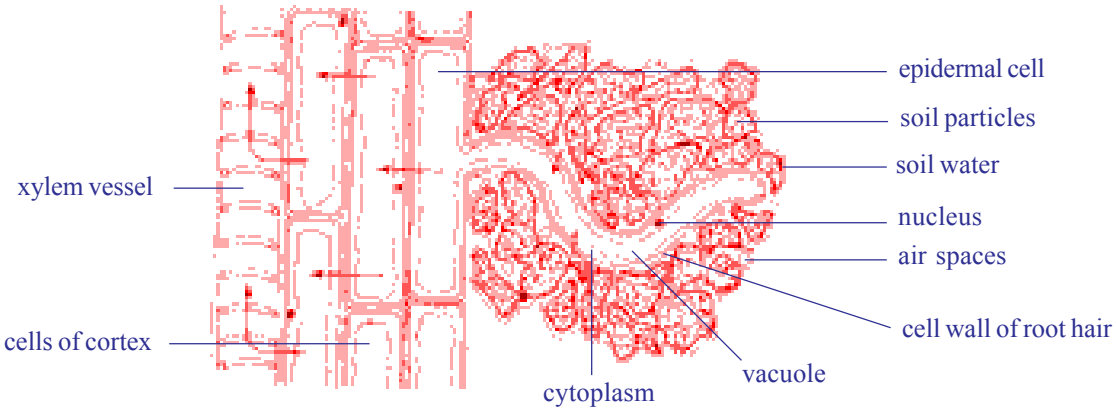


fig-16: L.S of root showing relationship of root hair and soil water

Note: *In fig-16 Arrow marks shows the direction of flow of water.*

The soil water is an extremely dilute solution of salts, water molecular concentration is more dilute than that of the cell sap in the root hair; therefore water will pass into the vacuole of the root hair by osmosis. Recall the process of osmosis that you have learnt in the chapter "moving of substances through plasma membrane" in class IX. The entry of water dilutes the contents of the root hair vacuole so that it becomes more dilute than it's neighbouring cell.

So, water passes into the neighbouring cell which in turn becomes diluted, finally water enters the xylem vessels. As there are vast number of root hairs and root cells involved, a pressure in the xylem vessels develops which forces the water upwards. This total pressure is known as root pressure. Root pressure is not the main cause of movement of water in xylem but it is certainly one of the factor. The other factors are also there. You will learn about those reasons in higher classes in detail.

Activity-5

What is root pressure

Take a regularly watered potted plant and cut the stem portion 1 cm above the ground level. Then connect a glass tube by means of strong rubber

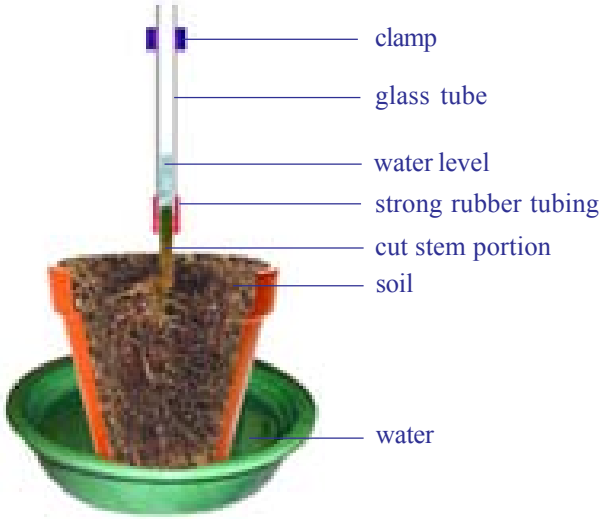


fig-17: Root pressure

tubing as shown in the figure. The size of glass tube should be equal to the size of the stem. Take care while joining tube and stem being bound tightly, so that water cannot escape from the tube. Now, pour some water in the glass tube until water level can be seen above the rubber tube. Mark the level of water (M_1) in the tube. Keep your arrangement aside for 2 to 3 hours. Then observe and mark the water level (M_2) in the tube.

- *Is there any increase in the water level?*
- *What is the role of xylem in this action?*

The difference between M_2 and $M\text{-}_1$ indicates the level of water raised in the stem. Because of the root pressure, the water level increases in the tube.

The mechanism by which the water travels through the plant

We have seen that there is a push from below due to root pressure on the columns of water in the xylem vessels, but this is seldom high and in some seasons it is nil. How does the water reach 180 metres high to the top of a tree like a eucalyptus?

Let us recall the activity that you performed in lower classes. Why inner sides of cover become moist? Where do these water droplets or water vapour come from?

fig-18: Transpiration

We know that this type of evaporation of water through leaves is called transpiration. Water evaporates through stomata of leaves and lenticels of stem.

When the leaves transpire, there is a pulling effect on the continuous columns of water in the xylem vessels. The top ends of these vessels are surrounded by the leaf's mesophyll cells which contain cell sap, so the water is continuous from the xylem vessels to the walls of the mesophyll cells from which it evaporates into the air spaces causing the pull. The water column does not break because of its continuous molecular atraction. This is a property of water you demonstrate every time you drink through a straw.

Now we have a picture of the water-conducting system of a tree. Water is absorbed by osmosis from the soil by

the root hairs. This is passed into the xylem vessels which form a continuous system of tubes through root and stem into the leaves. Here the water evaporates and releases into the atmosphere. The evaporation creates the main pull of water above root pressure which gives a variable and minor push from below. This results in a continuous column of moving water, the 'transpiration stream'.

Is there any relation between transpiration and rain fall?

The amount of water passing through a plant is often considerable. For example, an oak tree can transpire as much as 900 liters of water per day. It follows therefore that areas of forest significantly affect the degree of saturation of the air above them, so that when air currents bring air which is already nearly saturated to a forest area, it becomes fully saturated and comes down as rain; this is why forest areas often have a higher rainfall than areas nearby.

Do you know?

How much water is transpired by plants? Each fully grown maize plant transpires 15 liters per week. One acre of maize may transpires more than 13,25,000 liters of water in a hundred day growing season. A big mango tree will transpire from 750 to more than 3500 liters of water per day during growing season.

Transport of mineral salts

You know that mineral salts are necessary for plant nutrition (micro and macro nutrients) and that they are obtained from the soil solution through the root hairs. The salts are in the form of electrically charged ions. Sodium chloride (NaCl) is in the form of Na^+ and Cl^-, and Magnesium Sulphate ($MgS0_4$) occurs as Mg^{2+} and $S0_4^{2-}$. But, they are not absorbed into the root hairs by the simple process of diffusion, but it involves the use of energy by the cytoplasm which will be discussed in later classes. Once ions are absorbed, the ions travel along with water in the xylem vessels and pass to the growing points of the plants where they are used for growth purpose. They may also pass laterally from xylem to phloem. Thus, mineral salts are one of the natural factors in plant growth phenomena.

Transport of manufactured food

Food such as sugar is synthesised in the green parts of plants, mainly the leaves, but this food has to be transported to all the living cells, especially to actively growing cells and the cells which stores food.

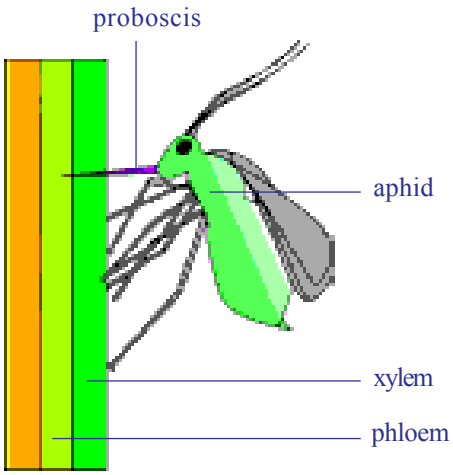


fig-19: Aphid extracting food material from plant

The veins of a leaf consist of xylem and phloem, and these tissues are continuous with the stem. The following experiments provide evidence that food is transported in the phloem cells.

Phloem sieve tubes are extremely small and the analysis of their contents is not easy. Biologists studied about food transportation in plants with the help of aphids (greenfly). When you see aphids clustering round the young stems of plants as they feed on the plant juices. To obtain this juice an aphid pierces the plant tissues with its long needle like organ "proboscis". It can be shown when a feeding aphid is killed and the stem carefully sectioned, the proboscis only penetrates upto a phloem sieve tube. This proboscis also provides a ready-made means of obtaining the juice for analysis! The experiment can be done in this way. An aphid is killed while in the act of feeding and the body is then carefully cut away, leaving the hollow proboscis still inserted into the phloem. It is found that because the contents of the phloem sieve tubes are under slight pressure the fluid slowly exudes from the cut end of the proboscis in the form of drops; these drops are then collected and analysed. The fluid is found to contain sugars and amino acids.

Not surprisingly, aphids absorb so much sugar from the phloem that they cannot assimilate all of it and it excretes out of the out of the body as a sticky syrup called honey dew. Leaves which have been attacked by aphids often feel sticky as a result of honey dew.

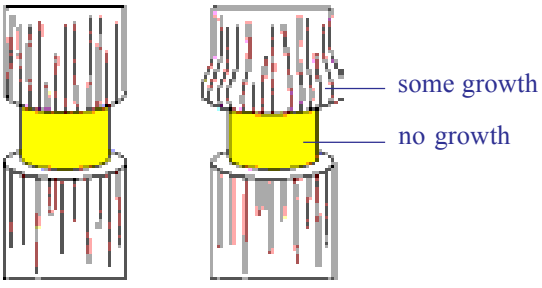


fig-20: Removing ring of bark

You may notice that sometimes barks of the tree damaged more than a half, even then the tree is alive. How is this possible?

Further experiments to illustrate the conduction of sugars by the phloem have been done by removing a ring of bark from a shoot to expose the wood. Remove all tissues from the center outwards, including the phloem. After a few days, when the tissues above and below the ring were analyzed it was shown that food had accumulated above the ring, but was not present below it. If it is left for some more time, the stem increases in thickness immediately above the ring, but no growth occurred

below it. So, any damage to the phloem all around the stem will prevent the food from passing down to the roots and the tree will eventually die. This is a fact of great economic importance because certain mammals scratching the bark of trees to get the food stored in the phloem, especially during hard winters when food is scarce. Voles do this to young saplings at ground level and rabbits can do much damage to older ones. Foresters find it economically worthwhile to enclose new plantations with wire netting to prevent rabbits from entering.

Foresters also encourage predators such as foxes, badgers, hawks and owls as they help to keep down the population of voles and rabbits. Grey squirrels too do great damage, particularly to beech and sycamore, and for this reason, in some parts it is impossible to grow these trees as a crop. Observe barks of trees in your surroundings for evidence of bark having been gnawed off saplings and trees. Note the species of tree, the position of the damage, whether the damage is recent or old, and the size of tooth marks if these are visible. From these observations you could find out which species had caused the damage. Also look out for the effect of such damage on the tree as a whole.

Key words

Circulation, Right atrium, Left atrium, Right ventricle the lower right chamber of the heart, Left ventricle, Pulse, Artery, Vein, Stethoscope, Aorta, Capillary, Systole, Diastole, Cardiac cycle, Blood pressure, Lymph, Single circulation, Double circulation, Coagulation of blood, Sphygmomanometer, Prothrombin, Thrombin, Fibrinogen, Fibrin, Root hair, Radical, Root pressure, Plant nutrients, Xylem, Phloem, Vascular bundles.

What we have learnt

- The pulse rate is equal to heart beat. We can count the heart beat without the aid of any instrument.
- Rene Lennac discovered the first stethescope.
- The heart is covered with two pericardial membranes filled with pericardial fluid which protects it from shocks.
- Six blood vessels are attached to the heart. The two rigid blood vessels are arteries which supply blood to body parts aorta and lungs and pulmonary artery.
- The less rigid vessels are various, which bring is blood from body parts.
- Heart has four chambers, two upper atria and two lower ventricles.
- Atrium and ventricle of the same side are connected by atrium ventricular aperture.
- Atria are separated from each other by interatrial septum, ventricles by interventricular septum.

- The atrioventricular apertures are guarded by valves. There are valves in the aorta and pulmonary artery also.
- The right side of heart receives blood from body and sends to lungs.
- The left side of the body receives blood from lungs and send it to body parts.
- The arteries carry oxygenated blood except pulmonary artery. The veins carry deoxygenated blood except pulmonary veins.
- One contraction and relaxation of heart is called cardiac cycle.
- If the blood goes to heart only once before it reaches all the body parts. It is called single circulation. If it goes twice it is called double circulation.
- Vitamin K deficiency leads to delayed coagulation of blood.
- Plants absorb soil water through roots by the process of osmosis.
- Water travels through xylem vessels and food material travels through phloem tissues.
- There is a relation between tranportation and transpiration in plants.
- Biologists studied about phloem tubes with the help of aphids.

Improve your learning

1. What is transport system? How this helps to the organism?(AS1)
2. What is the relationship between blood and plasma?(AS1)
3. Which type of blood vessels carry blood away from the heart?(AS1)
4. What are the three main types of blood vessels in the body?(AS1)
5. Which is the largest artery in the body? Why is it big in size?(AS1)
6. Which blood vessel carries blood for oxygenation?(AS1)
7. Name the structures which are present in veins and lymph ducts and absent in arteries.(AS1)
8. What is the use of platelets?(AS1)
9. Write differences betweenm(AS1)

   a) systole - diastole b) veins - arteries c) xylem - phloem
10. Explain the way how plants get water by osmosis through root hair?(AS1)
11. What is root pressure? How it is useful to the plant?(AS1)
12. Phloem is a food source for some animals. How can you justify this statement?(AS1)
13. Read the given para and name the parts of the heart.(AS1)

    We have observed that the heart is divided into four chambers by muscular structure. Any structure that divides two chambers is known as ***septum***. Now let us try to name the septa present in the heart.

    a) The septum that divides the two atria can be named as *inter atrial septum*

b) The septum that divides the two ventricles can be named as_____.

c) The septum that divides the atrium and ventricle can be named as_____.

The holes that connect two chambers are called ***apertures***. Let us try to name the apertures which connect the atria and ventricles.

d) The aperture that is connecting the right atrium and right ventricle can be named as_____.

e) The aperture that is connecting the left atrium and left ventricle can be named _____.

Any structure that closes an aperture, and allows one way movement of materials is called as ***valve***. Now let us name the valves that are present in the chambers of the heart.

f) The valve that is present between left atrium and left ventricle can be named as_____.

g) The valve that is present between right atrium and right ventricle can be named as _____.

14. If the valves in veins of the legs fail to stop the flow of blood what could be the consequences of this failure?(AS2)
15. What will happen if cell sap of root hair cells contain high concentration of ions?(AS2)
16. John prepared stethoscope with paper cup and plastic tube. Write down the procedure of preparation. (AS3)
17. How can you prove that the water is transported through the xylem?(AS3)
18. What is your inference about experiments with aphids?(AS3)
19. Collect information about blood pressure of your school teachers or your nighbours prepare a report on their help problems. (AS4)
20. Draw a block diagram to explain single and double circulation. Write differences between them.(AS5)
21. Prepare a block diagram showing from water absorption by roots to transpiration by leaf . (AS5)
22. What do you want to compare with the transportation in blood vessels? (AS6)
23. How do you feel about transportation of water in huge trees? (AS6)
24. Prepare a cartoon on heart beating? (AS7)
25. After reading this lesson what precautions you would suggest to your elders about edima.(AS7)

Choose the correct answer

1. The term cardiac refers to which organ in the body? ( )

   a) heart b) vein c) lymph d) capillary

2. On which side of the human heart is low in oxygen? ( )

   a) left vetricle b) right ventricle c) left atrium d) right atrium

3. Which structures of the heart control the flow of the blood? ( )

   a) arteries b) veins c) valves d) capillaries

4. Which of the following opinion is correct? ( )

a) Ravi said, xylem and phloem cells arranged one upon the other to form a tube like structure.

b) John said, xylem and phloem are not separate tube like structures.

c) Salma said, xylem and phloem cells connect together to form a tube like structure.

d) Hari said, because of its shape they said to be tube like structures

5. An aphid pierces its proboscis into the ..... to get plant juices ( )

a) Xylem b) phloem c) cambium d) vascular bundle

Annexure-I

The rhesus factor

There is another antigen of red blood cells which is present in 85% of the people of Britain, this is known as the rhesus factor, as it was first discovered in rhesus monkeys. People who have this are said to be rhesus positive (Rh+). Those who do not have this factor are termed rhesus negative (Rh-). Normally they do not carry an antibody to this factor in their plasma. However, if Rh+ blood is transfused into the blood of a Rh- person, antibodies will be formed and these are capable of destroying Rh+ red cells. Under certain circumstances this is a potential hazard for babies.

If a Rh+ man marries a Rh- woman, some of the children are likely to be Rh+. At birth there is always some mixing of blood between the circulation of mother and baby and this may occasionally happen during pregnancy. So, if a child is Rh+ some of its blood will leak into its mother's circulation and cause antibodies to form in her blood. If the mother has more children, not all will necessarily be Rh+, but if they are, the amount of ant bodies in her blood often increases with each pregnancy, and in some instances the antibodies in her blood may pass into the baby's blood in sufficient quantities to produce very serious anaemia and even death. Fortunately these cases are not frequent, and when they do occur, the baby is given a complete transfusion soon after birth so that that baby's blood is replaced by blood containing no antibodies to the rhesus factor. It is now possible for this transfusion to be carrried out before birth. Another recently developed technique is for the mother to be given an injection shortly after the birth of her first child which prevents the Rh+ cells from stimulating the production of the harmful antibody.

Annexure-II

Thalassemia

Thalassemia is a group of inherited blood disorders characterized by mild to severe anaemia caused by haemoglobin deficiency in the red blood cells. In individuals with thalassemia, the production of the oxygen carrying blood pigment haemoglobin is abnormally low. There are two main types of thalassemia: alpha thalassemia and beta thalassemia. In each variant a different part of the haemoglobin protein is defective. Individuals with mild thalassemia may have symptoms, such as anaemia, enlarged liver and spleen, increased susceptibility to infections, slow growth, thin and brittle bones, and heart failure.

Facts about Thalassemia

- Thalassemia is a serious Inherited Blood Disorder.
- 4.5% of world population (250 million) suffering with thalassemia minor.
- There are over 35 million Indians are carriers of the abnormal Gene for Thalassemia.
- It is estimated that about 1,00,000 infants are born with major Haemoglobinopathies every year in the world.
- 10,000 – 12,000 Thalassemic children are born every year in our country.
- Survival depends upon repeated blood transfusion and costly medicines.
- Thalassemia can be prevented by awareness, pre marital or pre conceptual screening followed by antenatal diagnosis is required.

Treatment

Thalassemia major should be diagnosed as early as possible in order to prevent growth restriction, frail bones and infections in the first year of life. The infant's haemoglobin levels and development should therefore be monitored closely. If Hb is less than 70% or the child shows signs of poor growth and development. Regular transfusion is the treatment of choice. According to the WHO, the aim of this treatment is to retain a median haemoglobin value of 115–120 grams per liter. This can usually be achieved by carrying out transfusions of concentrated red blood cells at intervals of every three to four weeks.

Today thalassemia major can be cured by stem cell transplantation. A prerequisite is usually that the affected individual who has siblings with identical tissue type (HLA type) a transplantation of blood stem cells referred to as a "bone marrow transplant", can be carried out.