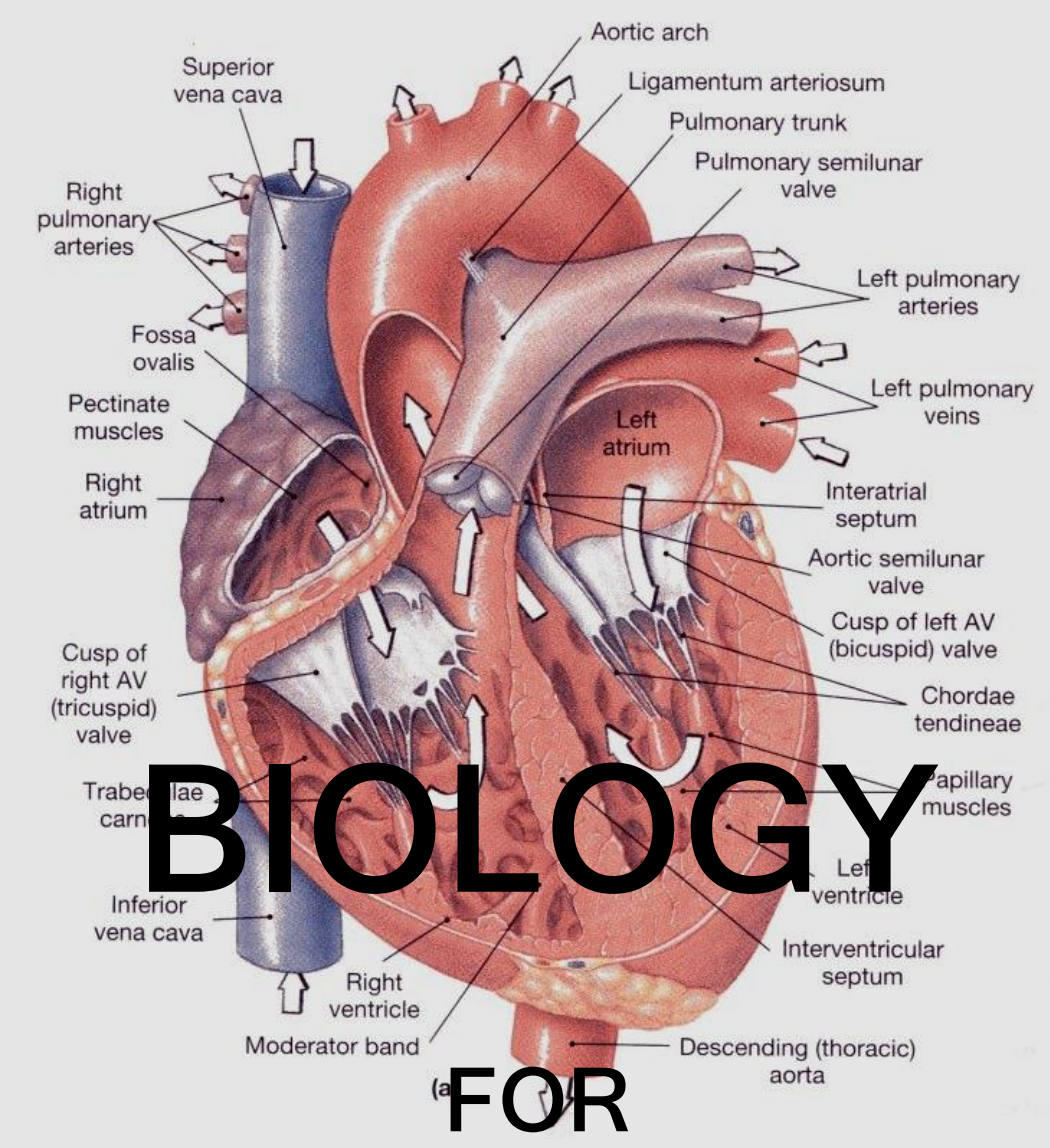


GENERAL SECONDARY CERTIFICAT

Unit (I)

Chapter (II)

Transport in Living Organisms

Transport in livings.

Concept of transport and the need for it:

Living organisms obtain what they need for feeding of various substances by different means:

In case of plants:

The green plant requires a supply of CO_2, H_2O, and mineral salts in order to carry out photosynthesis:

1. **In primitive plants as algae: These raw materials, together with products of photosynthesis move from one cell to another by diffusion and active transport. So, they are in no need for a specialized transport tissues.**
2. **in higher plants: Gases are transported by diffusion, while water, mineral salts and soluble products of photosynthesis are transported by means of a specialized vascular tissues.**

In case of animals:

Animals obtain their energy requirements in the form of food. After digestion of food, the soluble digested food substances are absorbed. These substances have to be transported to be distributed to various tissues that lie away from surface of absorption:

1. **In small animals as Protozoan and Hydra: Both respiratory gases and food substances move by diffusion.**
2. **In bigger and more complicated animals: Diffusion is not enough for transporting food and Oxygen to various tissues. Therefore, the presence of a specialized transport system is essential in these animals.**

Transport in higher plants:

1. Water and mineral salts:

Are absorbed by the root hairs and translocated across the root tissues, until they reach xylem vessels of the root. They are carried through the xylem of the stem to that of the leaves. Leaves carry out photosynthesis and produce high-energy carbohydrates, fats, and proteins.

2. High-energy carbohydrates, fats, and proteins:

Are transferred from centers of their manufacture to sites of storage and consumption in various tissues (roots, stems, fruits, and seeds). They pass through the sieve tubes in the phloem of the leaf, the stem, and the root.

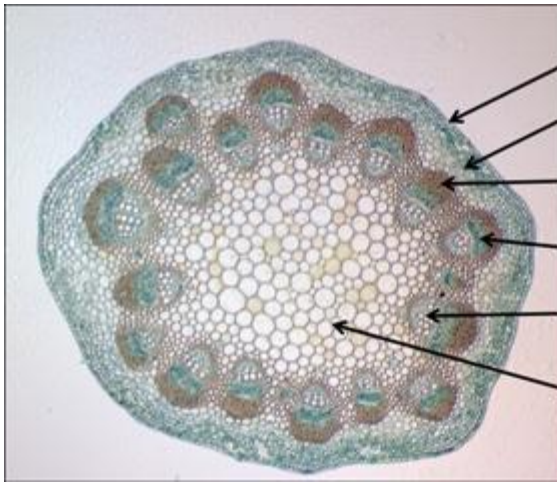
Examination of a transverse section in a young stem of a dicotyledonous plant.

1. The epidermis:

One row of adjacent, barrel-shaped parenchyma cells, their outer walls are thickened with a layer of cutin.

2. The cortex:

Is composed of several rows of collenchyma cells which their corners thickened with cellulose. So they have supporting function. These cells may contain chloroplasts, so they take part in photosynthesis. These cells are followed internally with several rows of parenchyma cells with plenty of intercellular spaces for aeration. The innermost row of the cortex is known as the starch sheath for the storage of the starch grains.



3. the vascular cylinder:

Occupies a large space in the stem. It consists of:

A. The pericycle:

Groups of parenchyma cells that are alternated with sclerenchyma cells (plant fibers). Each group of plant fibers lies next to a vascular bundle externally. To support the stem and to make it erect and flexible.

B. The vascular bundles:

Arranged as a circle. Each is a triangular in its shape that its base is directed outwards. Each vascular bundle contains the following tissues from out inwards:

(1) Phloem: Is the outer tissue in the vascular bundle. It consists of sieve tubes, companion cells, and phloem parenchyma. Its function is to transport the organic food substances.

(2) Cambium: One row or more of meristematic cells that lie between xylem and phloem. Cambium cells divide giving secondary phloem outwards and secondary xylem inwards.

(3) Xylem: Is the inner tissue in the vascular bundle. Its function is to transport water and dissolved salts. It supports the stem as well. Xylem tissue contains the following transporting elements:

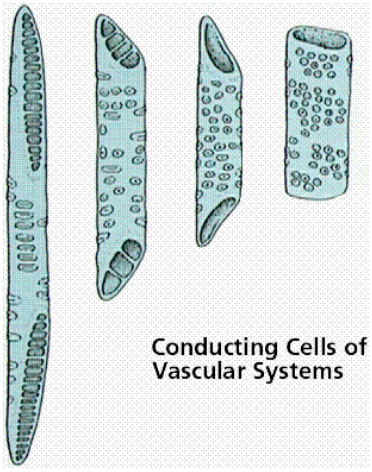
a) Vessels:

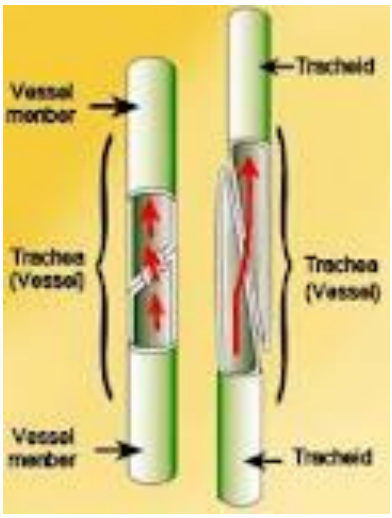
The vessel is formed of a chain of elongated cylindrical cells that are connected end to end. During the first stages of its formation, the transverse walls of these cells have completely dissolved, at the same time, the cellulosic walls have thickened with lignin which is impermeable for water and solutes. The protoplasmic contents of these cells have died leaving a hollow tube. Many pits are scattered all over the wall, where the primary wall is left without thickening. Pits allow water to pass from the inside of the vessel outwards. At the lining of the xylem vessels, strands of lignin taking various forms (sometimes spiral-shaped or annular) are seen. They support the xylem vessel and prevent the collapse of its wall.

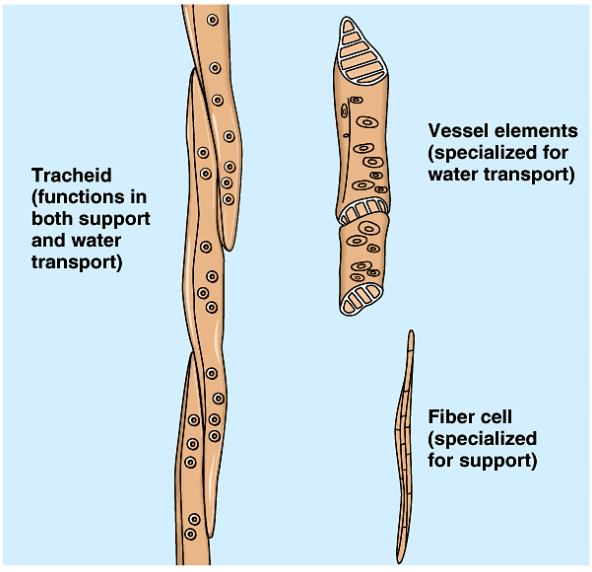
b) Tracheids:

They are similar to vessels except:

- **They appear in the T.S as pentagonal or hexagonal. (vessels appear circular in the T.S)**
- **They have pointed sharp ends which are pitted. (vessels are opened with no transverse walls)**







c) Xylem parenchyma:

Rows of parenchyma cells that are present between xylem vessels.

Its noticeable that xylem of the vascular bundles of the stem communicates with that of the root and the leaves. Similarly, phloem of the vascular bundles of the stem communicates with that of the root and the leaves. So, a network of vessels spread all over the plant.

C. Pith:

Exists at the center of the stem. It is composed of parenchyma cells for storage.

D. Medullary rays:

Extend between the vascular bundles, and connect the cortex with the pith in the form of parenchyma cells.

Mechanism of transport from the root to the leaves
Factors responsible for ascent of sap.

The xylem is responsible for the translocation of water and mineral salts from the root to the leaves. Several theories were put forwards to explain the ascent of this sap in the plant:

1. Root pressure theory:

Exudation:

If a plant stem is cut very near to the soil level, exudation of water from the stump occurs. This phenomenon is called exudation. It is due to the root pressure continuing to force water up the plant, which is due to the osmotic pressure mechanism that exists in the root tissues. So, water is forced vertically upwards through xylem vessels for a short distance to a certain level, at that level, ascending of water stops. Because the opposing pressure of the water column in xylem vessels has become equal to the root pressure.

Disadvantages of root pressure theory:

1. Experiments prove that there is no reasonable explanation of ascent of water to high levels in tall trees by root pressure.
2. The maximum root pressure doesn't exceed 2 atmospheres.
3. Pinus and other conifers have no root pressure.
4. The force of root pressure is affected quickly by external factors.

2. Imbibition theory:

The colloidal nature of the walls of xylem vessels (that is formed of cellulose and lignin) has allowed these walls to imbibe water.

Disadvantages of imbibition theory:

This phenomenon has a very limited effect in sap ascent because experiments have proved that water ascends through the cavities of xylem vessels not along their walls. The importance of this phenomenon is restricted to transport of water along the cells walls until it reaches the walls of vessels and tracheids in the root, also from these vessels and tracheids to the neighboring cells in the leaves.

3. Capillarity theory:

Water rises through tiny tubes by capillarity. Xylem vessels are considered as capillary tubes with a diameter of 0.02 mm up to 0.5 mm. Water will rise in these vessels by the phenomenon of capillarity.

Disadvantages of capillarity theory:

Capillarity has a weak secondary effect in sap ascent because the finest capillary tube doesn't allow the rise of water more than a height of 150 cm.

4. Transpiration pull, cohesion and adhesion theory:

This theory were put forward by H.H. Dixon and J. Joly in 1895. It states that:
Water column ascends through xylem vessels depending on three principal forces that pull water upwards to very high levels that may reaches 100 meters.
These three principal forces are:

a. Cohesive force:

The strong mutual attraction between water molecules inside xylem vessels and tracheids. This explains the existence of a continuous column of water.

b. Adhesive force:

That exists between water molecules and those of the walls of xylem vessels. It helps the water column to be held against gravity.

c. Transpiration pull:

That attracts the water column upwards due to the continuous process of transpiration in the leaves.

Water has a high pulling force inside tubes under the following conditions:

1. **The tube must be capillary.**
2. **The walls of the tube must possess an adhesive force to attract water.**
3. **The tube must be free of any gas or air bubbles. (to avoid any breaking and descending of the water column)**

All these conditions exist in xylem vessels.

Give reasons for:

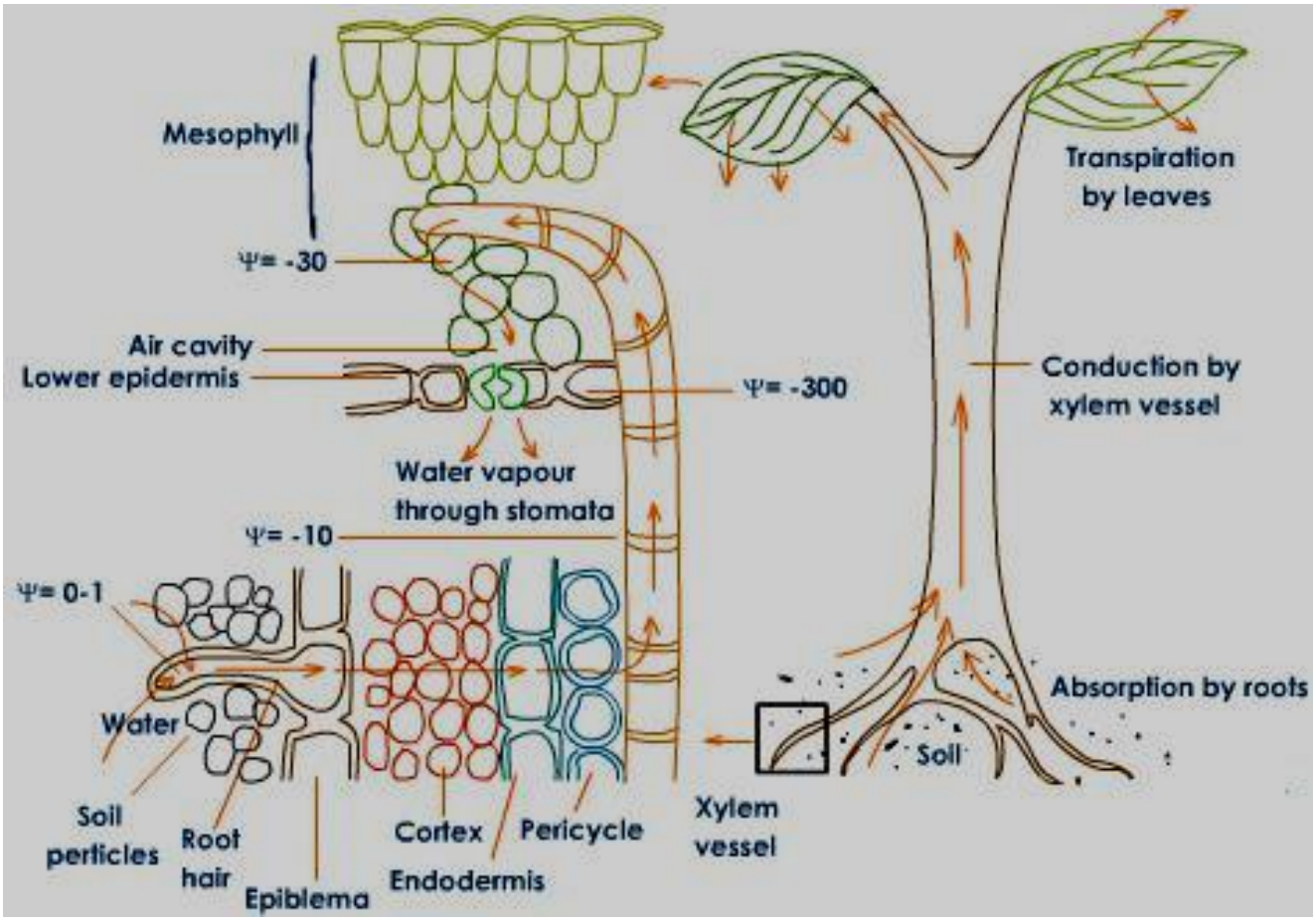
Some seedlings, when transplanted from a nursery to an open air, fail to grow if they remain exposed to the sun for a long time before they are transplanted in the new soil.

The answer:

Path of the sap during its ascent from the root to the leaves

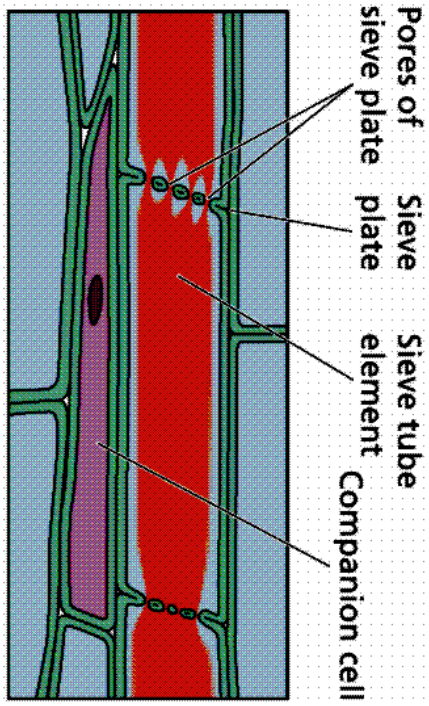
1. **Transpiration lessens the water concentration in the air chamber above the stoma in the leaf.**
2. **Evaporation increases from the cells of the mesophyll surrounding the stomata chamber.**
3. **The water content of these cells decreases, and the concentration of solutes inside them increases.**
4. **A diffusion pressure gradient for water is created. (i.e. a pulling force that attracts water from the surrounding cells that will continue as far as the xylem elements in the venules and veins, then finally from the mid-rib of the leaf)**
5. **Water ascends, under great force, through xylem vessels and tracheids of both the stem and the root as they are connected to one another.**

N.B.: Transpiration pull of the leaf will not only pull water that has reached the vascular cylinder of the root up, but it will also help in the lateral pull of water from the soil by means of the root hairs.



Transport of manufactured food from the leaves to other parts of the plant.

The phloem translocates the manufactured food (which consists of high energy organic substances produced by the leaves during photosynthesis) in all directions upwards in order to feed buds, flowers, and fruits, and downwards in order to feed the stem and the root system.



The role of sieve tubes in transport:

The phloem tissue consists of:

1. Sieve tubes:

Sieve tubes appear in the longitudinal section as elongated cells arranged end to end. They contain cytoplasm without a nucleus. The sieve tubes are separated from each other by cross walls (sieve plates) which are perforated by tiny pores, through which cytoplasmic strands extend from one tube to another.

2. Companion cells:

Each sieve tube has a nucleated companion cell. Vital functions of the sieve tube are organized by ribosomes and mitochondria present in the companion cell.

3. Phloem parenchyma:

Parenchyma cells join sieve tubes and companion cells together.

Experiments have proved that the role of the sieve tubes is the transport of ready-made food substances to various parts of the plant. These experiments include the following:

A. Rapeden and Bohr experiment:

They supplied green bean leaf with CO_2 gas (containing radioactive Carbon C_{14}) in order to carry out photosynthesis and to produce carbohydrates. These carbohydrates being radioactive could be traced during their path in the plant. It was discovered that they are Translocated upwards as well as downwards in the stem.

B. Mittler Experiment:

He managed, using the Aphid insects to describe the contents of sieve tubes in order to identify these contents. Aphid insect penetrates the tissues of the plant until it reaches the sieve tubes using its piercing mouth parts.

During the process of feeding the scientists separated the whole body of the insect from its mouth parts. In this way He managed to collect a sample of the sieve tubes contents. By analyzing this sample, it was shown to consist of the same organic substances manufactured in the leaves (sucrose and amino acids). To make sure that this was the phloem contents, He sectioned the region of the plant where the proboscis of the insect was inserted. It appears to be inserted in a sieve tube.

C. Thain and Canny Experiment:

Transport of organic substances in the phloem:

Thain and Canny could see long cytoplasmic threads which contain organic substances inside the sieve tubes and these threads extend through tiny pores from one tube to another.

They explained the transportation of the organic substances in the phloem on the basis of cytoplasmic streaming (The cytoplasmic circular movement inside the sieve tubes and companion cells) during that the organic substances translocate from one end of the sieve tube to the other end, and then they pass to the other neighboring sieve tubes through the cytoplasmic threads.

They explained that this activity (cytoplasmic streaming) needs more of ATP molecules which exist in the companion cells, this is proved later by experiments which show that the transportation process delays with the decrease of temperature or Oxygen in cells thus delaying the cytoplasmic streaming

Revision IV
Transport in plants.

1. give the scientific term that represents each of the following:

a. The tubes in which the products of photosynthesis are transferred from centers of their manufacture to sites of storage and consumption. (----------)

b. One row of adjacent, barrel-shaped parenchyma cells in the stem, the outer walls of which are covered by cutin. (----------)

c. Covers the epidermis of the stem. (----------)

d. The tissue that has its cells with walls that are thickened by deposition of cellulose at their corners, and helps as a mechanical tissue that supports the stem. (----------)

e. The tissue that follows the collenchyma cells internally in the cortex of the stem of dicot. Plants, that has plenty of intercellular spaces for aeration. (----------)

f. The innermost row of cells of the cortex that store the starch grains. (----------)

g. The outer tissue of the vascular bundles. (----------)

h. The internal tissue of the vascular bundles. (----------)

i. Lies between the phloem and the xylem of the stem as one row of meristematic cells. (----------)

j. Meristematic cells the divide giving rise externally to secondary phloem and internally to secondary xylem. (----------)

k. The tissue that its function is to transport organic food. (----------)

l. The tissue that translocates water and solutes and acts as a supporting tissue. (----------)

m. The layer that follows the epidermis of the stem internally and consists of several rows of collenchyma cells followed by several rows of parenchyma cells. (----------)

n. Occupies the center of the stem, and consists of parenchyma cells for the purpose of storage. (----------)

o. Parencyma cells that extend between the vascular bundles to join the cortex with the pith. (----------)

p. The transport structures in xylem tissue. (----------)

q. Tubes that are formed from vertical rows of elongated cylindrical cells joined end to end, and the transverse walls dissolved forming one hollow tube with lignified wall. (----------)

r. The substance that is deposited on the cellulosic wall of xylem vessels and tracheids, and which is impermeable to water and solutes. (----------)

s. The structures that scattered all over the walls of xylem vessels and tracheids where the primary wall is left without thickening that permit water to pass from the inside outwards. (----------)

t. Xylem structures that appear in a T.S. in a pentagonal or hexagonal form, and which are pitted and their ends are pointed and closed. (----------)

u. Exudation of water from the stump if a plant stem is cut very near to the soil level. (----------)
v. The theory that explains exudation. (----------)
w. Ascent of water vertically upwards through xylem vessels for a short distance to a certain level due to the existence of an osmotic pressure mechanism in the root tissues that leads to continuous and direct absorption of water from the soil. (------)
x. The opposing force that stops ascent of sap at certain level by root pressure.-----)
y. The theory that does not explain ascent of sap to high levels in tall trees. (--------)
z. Group of trees that have no root pressure. (----------)
a. The phenomenon that explains the transport of water along the cell walls until it reaches the walls of vessels and tracheids in the root and from these vessels and tracheids to the neighboring cells in the leaves, and that does not explain the ascent of water. (----------)
b. Rising of water through tiny tubes. (----------)
c. The principal forces that pull the sap to very high levels in plants. (----------)
d. The strong mutual attraction between water molecules inside xylem vessels and tracheids and that explains the existence of a continuous column of water. (---------)
e. The scientists that put forward transpiration pull, cohesion, and adhesion theory. (----------)
f. The force between water molecules and those of the walls of xylem vessels, and that helps the water column to be held against the effect of gravity. (----------)
g. The force that attracts water column upwards inside xylem vessels and tracheids due to evaporation of water from the leaves. (----------)
h. The tubes that appear in the longitudinal section as elongated cells, arranged end to end, and that contain cytoplasm without a nucleus. (----------)
i. The cells that their ribosomes and mitochondria organize the vital functions of sieve tubes. (----------)
j. Run through the tiny pores of the perforated cross-walls that separate the sieve tubes from each other, and extend from one tube to another. (----------)
k. One of the components of phloem tissue that its role is to transport the ready-made food substances to various parts of the plant. (----------)
l. The scientists that used C_{14} to prove that carbohydrates are translocated upwards as well as downwards in the plant stem. (----------)
m. The scientist that carried out an experiment to prove the role of sieve tubes in translocation of high-energy food using the Aphid insect. (----------)
n. The scientists that explained the transportation of the organic substances on the basis of cytoplasmic streaming. (----------)
o. The cytoplasmic circular movement inside the sieve tubes. (----------)
p. Two main factors that affect the cytoplasmic streaming inside the sieve tubes. (-)

2. Give reasons for:

a. Primitive plants are in no need for specialized transport tissue.
b. The presence of a specialized transport system is essential in higher animals.
c. Cortex of the stem helps as a mechanical tissue that supports the stem.
d. Cortex of the stem may take part in photosynthesis.
e. The inner row of the cortical layer in the stem is called the starch sheath.
f. Cambium lies between the phloem and the xylem as one row of meristematic cells.
g. Pits are scattered all over the wall of xylem vessels and tracheids.
h. Lignin is laid down on the inner lining of xylem vessels and tracheids taking various forms.
i. Exudation of water from the stump if a plant stem is cut near to the soil surface.
j. Water forced vertically upwards through xylem vessels of the plant stem under the effect of root pressure stops at certain level.
k. Root pressure does not explain the ascent of water to high levels in tall trees.
l. Imbibition has a very limited effect in the ascent of sap.
m. Capillarity is a very weak secondary force for the ascent of sap.
n. Existence of a continuous column of water inside xylem vessels.
o. Water column is held against the effect of gravity inside xylem vessels.
p. Xylem vessels possess all the conditions needed for water to have high pulling force in it.
q. Water column is pulled upwards inside xylem vessels.
r. Some seedlings fail to grow if they remain exposed to the sun for a long time before they are transplanted in an open soil.
s. Each sieve tube has a nucleated companion cell.
t. Using of Aphid insect in an experiment to prove the role of sieve tubes in translocating the organic substances manufactured in the leaves.
u. Transportation of high energy food inside sieve tubes is delayed with the decrease of Oxygen.
v. The organic substances are transported from one sieve tube to another.

3. Draw a diagram to show:

a. Xylem vessels and tracheids.
b. The role of transpiration in sap ascent.
c. T.S and L.S in the phloem tissue.

4. Compare between:

a. Vessels and tracheids.
b. Xylem and phloem in terms of:
   1. The structure.
   2. The function.

5. Define:

a. Exudation. **b. Capillarity.** **c. Cohesive force.**
d. Adhesive force **e. Transpiration pull.** **f. Cytoplasmic streaming.**

6. Describe the biological function(s) of:

a. Transportation in animals.
b. Transportation in higher plants.
c. Collenchyma tissue of the cortex in the plant stems.
d. Parenchyma tissue of the cortex in the plant stems.
e. Phloem of the stem.
f. Xylem of the stem.
g. Cambium of the vascular bundles in the stem.
h. Pith of the stem.
i. The medullary rays.
j. Lignin of xylem vessels and tracheids.
k. Imbibition phenomenon in water transportation.
l. Cohesive force between water molecules inside xylem vessels.
m. Adhesive force between water molecules and those of the walls of vessels.
n. Transpiration in sap ascent.
o. Companion cells of phloem tissue.
p. Cytoplasmic streaming in transportation of high energy food.
q. Pits scattered all over the walls of xylem vessels and tracheids.

7. How did Thain and Canny explain the transport of the organic substances in the phloem?

8. Describe:

a. The formation of xylem vessel.
b. The structure of phloem tissue.
c. The root pressure theory to explain the sap ascent in xylem vessels.
d. The capillarity theory to explain the sap ascent in xylem vessels.
e. The transpiration pull, cohesion, and adhesion theory of Dixon and Joly to explain the sap ascent in xylem vessels.
f. The path of the sap during its ascent from the root to the leaves.
g. The experiment done by Mittler to prove the role of sieve tubes in translocation of high-energy food.
h. The experiment done by Rapeden and Bohr to prove that the high-energy food is translocated out of the leaves to various parts of the plant.

9. Mention the disadvantages of the following theories:

a. Root pressure theory.
b. Capillarity theory.
c. Imbibition theory.

Transport in animals.
Human transport system.

Transport in Humans is a process that takes place through 2 closely related systems:

I. Blood vascular system. (Circulatory system)

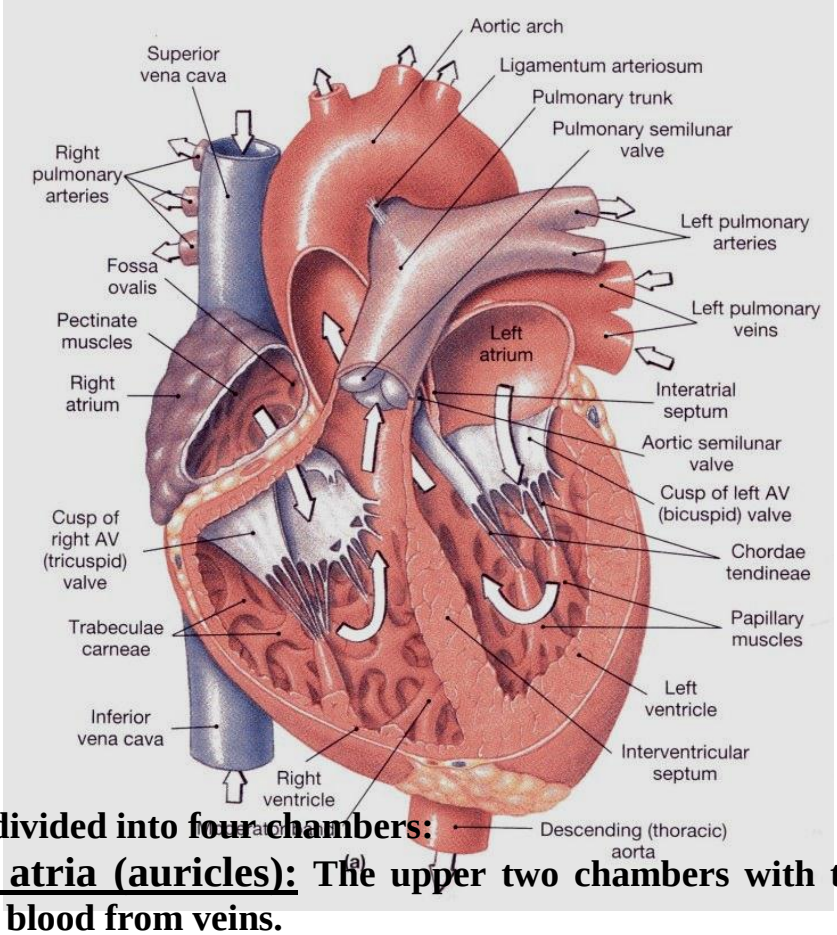
II. Lymphatic system.

I. The circulatory system:

It consists of the heart and the blood vessels through which the blood passes. These vessels form a complete circuit. (A closed circulatory system)

1. The heart:

The heart is a hollow muscular organ which lies in the middle of the chest cavity. It is enclosed in the pericardium that protects the heart and facilitates its pumping action.



The heart is divided into four chambers:

- **<u>The 2 atria (auricles):</u> The upper two chambers with thin walls. Those receive blood from veins.**
- **<u>The 2 ventricles:</u> The lower two chambers with thick muscular walls. Those pump blood through arteries.**

The heart is divided longitudinally into two sides by means of muscular walls. Each atrium is connected to its own ventricle through an opening which is guarded by means of a valve. Each valve consists of thin flaps. In order for these flaps not

to turn inside out, the free edges of these flaps are attached to the ventricle wall by means of tendons. Thus blood is permitted to flow only from the atrium to the ventricle not in the reverse direction. The right valve (The tricuspid valve) is made up of three flaps, while the left valve (the bicuspid valve or the mitral valve) is similar in structure and action, except it is formed up of 2 flaps. There are also semi-lunar valve at the connection of the heart with both Aorta and pulmonary artery. The heart beats regularly throughout the whole life time.

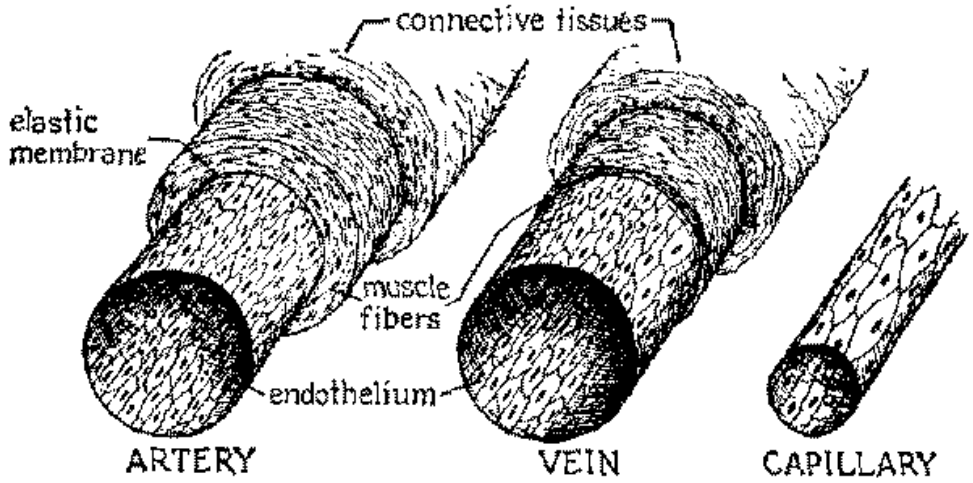
2. The blood vessels:

A. Arteries:

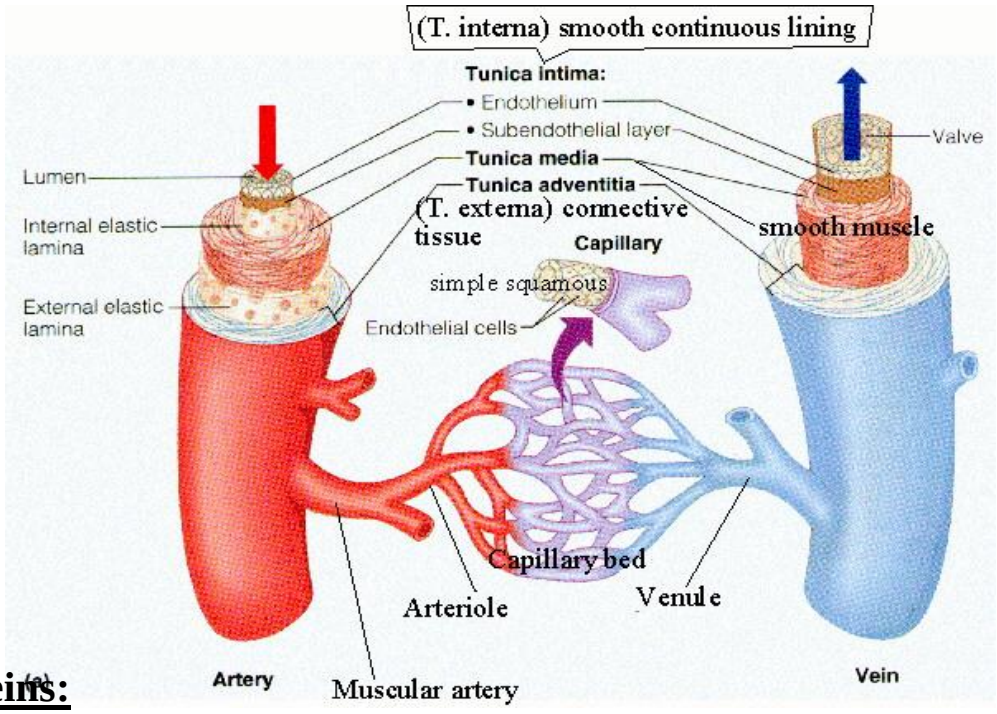
Arteries are wide vessels that carry blood from the heart to other organs of the body. The wall of an artery is build up of three layers of tissues:

- **The outer layer: A coat of connective tissue.**
- **The middle layer: Is relatively thick and consists of involuntary muscles which contract and relax under the control of nerve fibers.**
- **The inner layer: The endothelium, which consists of one row of tiny epithelial cells followed by elastic fibers that give the elasticity of the artery.**

Arteries are usually buried among the body muscles. They carry oxygenated blood except the pulmonary artery which comes out of the right ventricle to the lungs (that carries deoxygenated blood).



Structure of blood vessels (not to scale). An artery has a thicker muscular layer than a vein, and a vein is usually larger than its corresponding artery. The wall of a capillary consists only of endothelium.



B. Veins:

Veins are the vessels that carry blood to the heart. Walls of veins are composed of the same three layers of that of arteries with the following modifications:

- **There are less elastic fibers.**
- **The middle layer is less thick.**

Accordingly, The wall of the vein is thinner than that of the artery, and it doesn't pulsate. Veins carry deoxygenated blood except the pulmonary veins that open in the left atrium (that carries oxygenated blood).

A number of veins possess a system of internal valves along their length to prevent the backflow of blood, and allowing it to pass only in the direction of the heart. Sites of these valves can be observed in the arm veins. (when the arm is tied tightly with a bandage above the elbow). This was done by William Harvey the English doctor, who discovered the blood circulation in the 17th. Century.

C. The Capillaries:

Capillaries are tiny, microscopic vessels which connect the arterioles with the venules. This fact was discovered by Malpighi, the Italian scientist at the end of the 17th. Century, thus he completed the work of Harvey.

The average diameter of capillaries ranges between 7 – 10 microns. Their walls are very thin and consist of one row of thin epithelial cells with tiny pores between them. The wall of the capillary is about 0.1 micron thick, which facilitates quick exchange of substances between the blood and the tissue cells. Capillaries spread in the spaces between cells all over the body tissues. Capillaries reach all the body cells and supply them with their requirements. If all capillaries in the Human body were put end to end, their overall length would be about 80000 kilometers.

3. Blood:

Blood is a liquid tissue. It contains red blood cells, white blood cells, and blood platelets. The fluid part of this liquid tissue is the blood plasma. Blood is the principal medium in the process of transport. It is a viscous red liquid. Blood is weakly alkaline. (PH = 7.4). The Human body contains 5 to 6 liters of blood in average.

Components of blood:

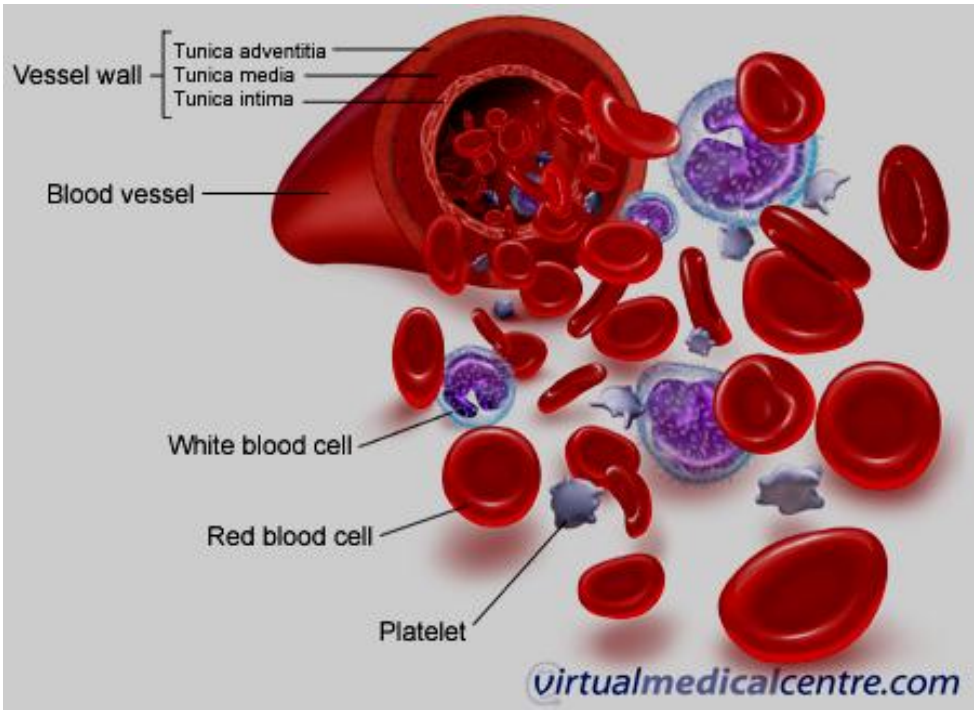
a. Plasma:

Plasma is about 54% of blood volume. It contains:

- **90% water.**
- **1% inorganic salts as Ca^{++}, Na^{+}, $(HCO_3)^{-}$**
- **7% proteins as albumin, globulin, and fibrinogen.**
- **2% other components as:**
  . Absorbed food as (sugar, amino acids)
  . Hormones.
  . Enzymes.
  . Antibiotics.
  . Wastes as urea.

b. Red blood cells (Erythrocytes) (R.B.Cs)

Red blood cells are the most abundant blood cells. They are about:
- 4 up to 5 million cells/mm^3 in males.
- 4 up to 4.5 million cells/mm^3 in females.
Each is destroyed after 120 days. They circulate about 172000 circulations.
They are produced in bone marrow of backbones. They are round in shape, biconcave and enucleated. They contain hemoglobin (Protein + Iron), which gives the blood its red colour.
Inside the two lungs the hemoglobin combines with Oxygen to form pale red Oxyhemoglobin that carries Oxygen to different parts of the body, where it leaves Oxygen and unites with Carbon dioxide to form dark red Carboxyhemoglobin. So the venous blood is darker than the arterial blood.
Red blood cells are destroyed in the liver, the spleen, and bone marrow. The proteins in the hemoglobin are used in the formation of bile.



c. White blood cells (Leucocytes) (W.B.Cs):

They are about 7000 cells/mm3 and increase during diseases. They are colorless and nucleated. They live for 13 up to 20 days and continuously formed in the bone marrow, spleen, and lymphatic system. There are different types of leucocytes, each with a specific function. The main function of W.B.Cs is the protection of the body against the infectious diseases. They circulate continuously in the blood vessels, attack foreign particles, destroy and engulf them. Some of them produce antibodies.

d. Blood platelets:

They are very small in size (one-fourth of the R.B.Cs), enucleated, and live for about 10 days. They are about 250000 cells/mm3. They are produced in bone marrow. They play a role in blood clotting.

Functions of blood:

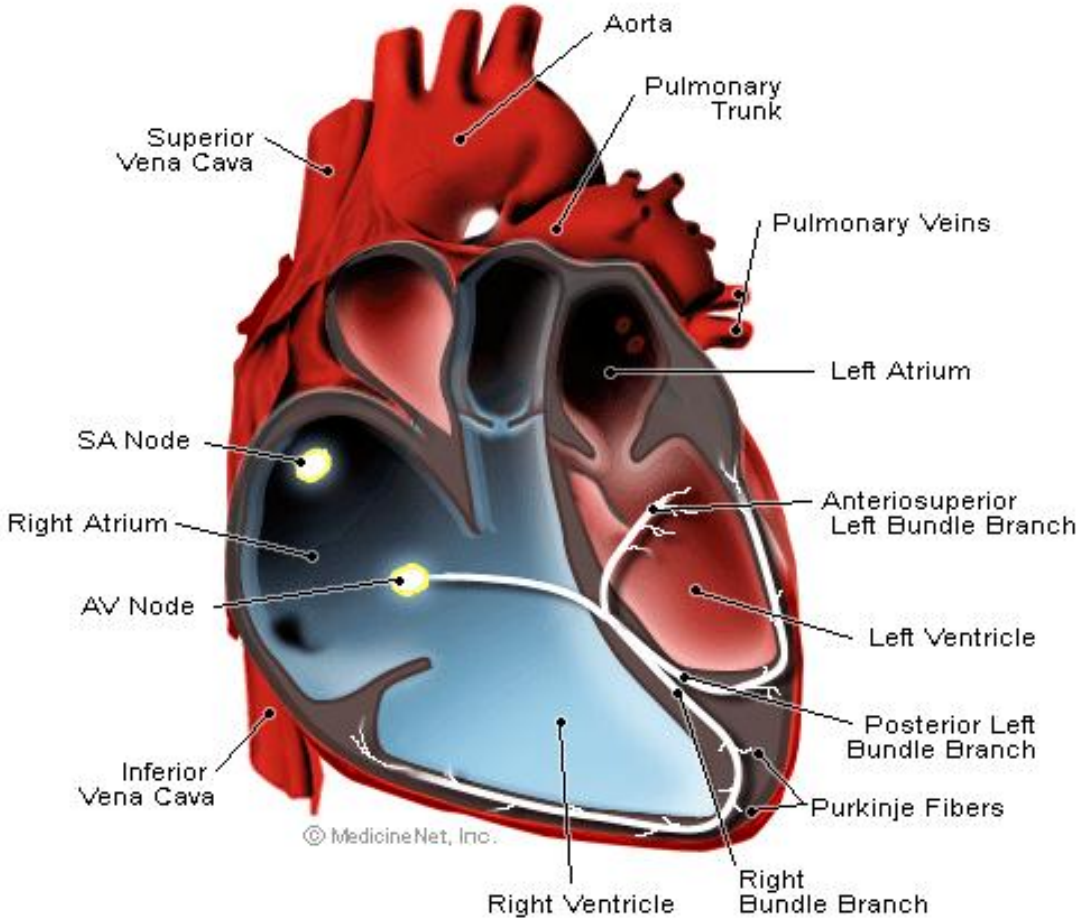
1. Transport the digested food substances, together with Oxygen, Carbon dioxide, waste nitrogenous compounds, hormones, and some active and inactive enzymes.
2. Control the processes of metabolism and keep the body temperature at 37 degree C. In addition, it regulates the internal environment (homeostasis) such as osmotic potential.
3. Protect the body against microbes and pathogenic organisms through immunity involving the lymphatic system.
4. Protect the blood itself against bleeding by formation of the blood clotting.

Heart beats:

The rhythmic heart beats are spontaneous as they originate from the cardiac tissue itself. It has been proven that the heart continues beating regularly even after it has been disconnected from the body and the cardiac nerves.

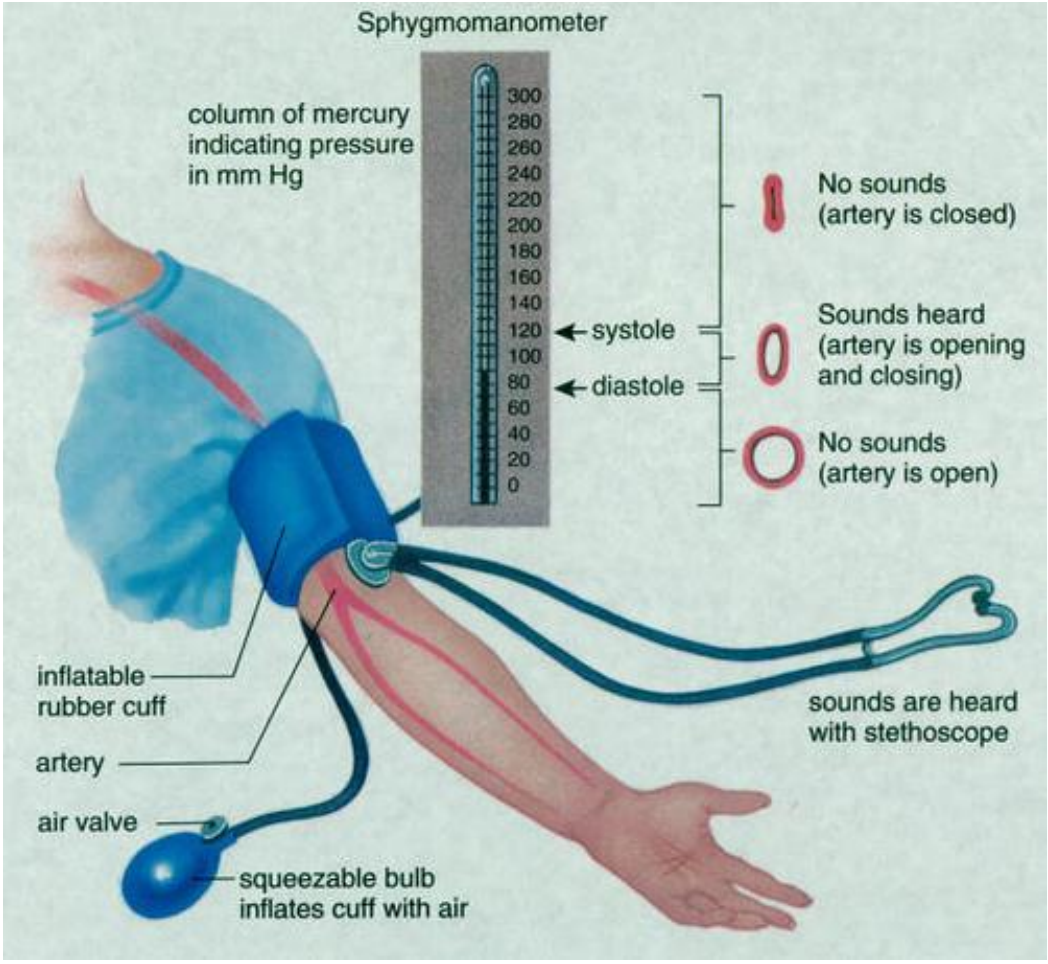
So, what is the source of the regular rhythm of heart beats?

There is a specialized bundle of thin cardiac muscular fibers buried in the right atrial wall near the connection between the right auricle and the large veins. This bundle is called the sino-atrial node which is considered as the pace maker of the heart. The sino-atrial node sends impulses over the two atria which are stimulated to contract. When the electrical impulses reach the atrio-ventricular node (at the junction between atria and ventricles) the impulses will spread rapidly through special fibers from the inter-ventricular septum to the walls of both ventricles, where their muscles are stimulated to contract.



The sino-atrial node (the pace maker) beats at a regular rate of 70 beats/minute. It is connected to two nerves: one lowers down its rate (the vagus nerve), and the other accelerates it (the sympathetic nerve), so that the number of cardiac beats changes according to the physical and psychological state of the body.

For example, the number of heart beats is lowered during sleep, and gradually increases after waking up. It is also lowered in states of grief and increases in states of joy. It also increases with sever physical effort.
We can distinguish two sounds in the heart beat, one long and low-pitched (lubb), and is due to closure of the two valves between the atria and the ventricles during ventricular contraction. The other is shorter and high-pitched (dupp) and is due to the closure of the aortic and pulmonary valves during ventricular relaxation.



Blood pressure:

Blood is a viscous liquid. It circulates within the arteries and veins smoothly by the process of heart beats. But to pass within the microscopic blood capillaries it needs pressure. The largest blood pressure is measured in the arteries nearer to the heart. The maximum blood pressure is measured as the ventricles contract and the minimum as the ventricles relax. The blood pressure is measured by means of mercuric instruments, sphygmomanometers. Its reading consists of two numbers, for example 120/80 mm Hg, which is the normal value at youth. The two measurements represent the blood pressure as the ventricles contract and relax respectively. Measurements of blood pressure at other various points along the arteries show progressive decrease. Blood pressure in the venules is very low (about 10 mm Hg). The very low blood pressure in the veins is not sufficient to

move blood back to the heart. When the skeletal muscles near the veins contract, they put pressure on the collapsible wall of the vein and the blood contained in these vessels. Veins, however, have valves that prevent backward flow, and therefore pressure from muscle contraction is sufficient to move blood through veins towards the heart. The blood pressure increases gradually by aging and it must be under medical control to avoid its harmful effects. The values of blood pressure are determined by listening to the heart beats. As the ventricles contract, the doctor can listen to the heart beat, while as the ventricles relax the sound disappears. The blood pressure can be measured when the heart beats also between one beat and another. There are some digital instruments to measure the blood pressure, but they are not accurate as mercury instruments.

Blood Circulation

There are 3 pathways for blood during its circulation:

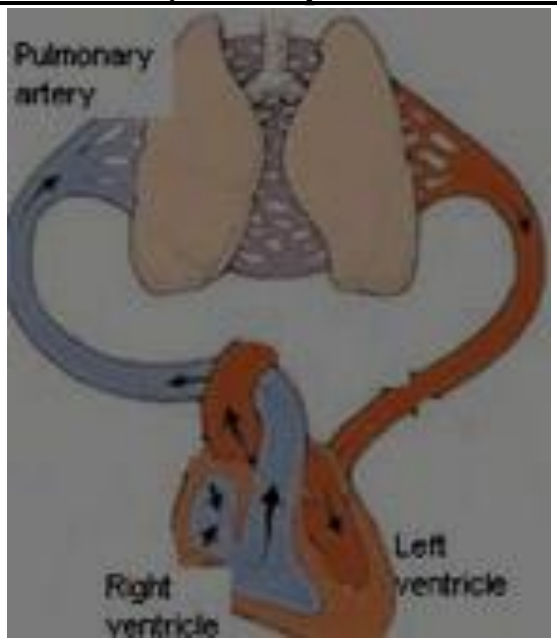
1. Pulmonary Circulation:

It starts from the right ventricle and ends at the left atrium. When the right ventricle contracts, the tricuspid valve closes the opening of the right atrium. The deoxygenated blood will therefore rushes through the pulmonary artery through the three-flapped semi-lunar valve. This valve prevents the backflow of blood to the ventricle (when it relaxes).

The pulmonary artery gives rise to two branches, each branch goes to a lung, where it branches to form several arterioles which terminate in blood capillaries. Blood capillaries spread around the alveoli, where exchange of gases takes place. Carbon dioxide and water vapor will diffuse from the blood and Oxygen will move towards it, so that blood becomes oxygenated.

Oxygenated blood returns from the lungs through the 4 pulmonary veins (two veins from each lung) to open into the left atrium.

When the left atrium contracts, blood passes to the left ventricle through the bicuspid valve.

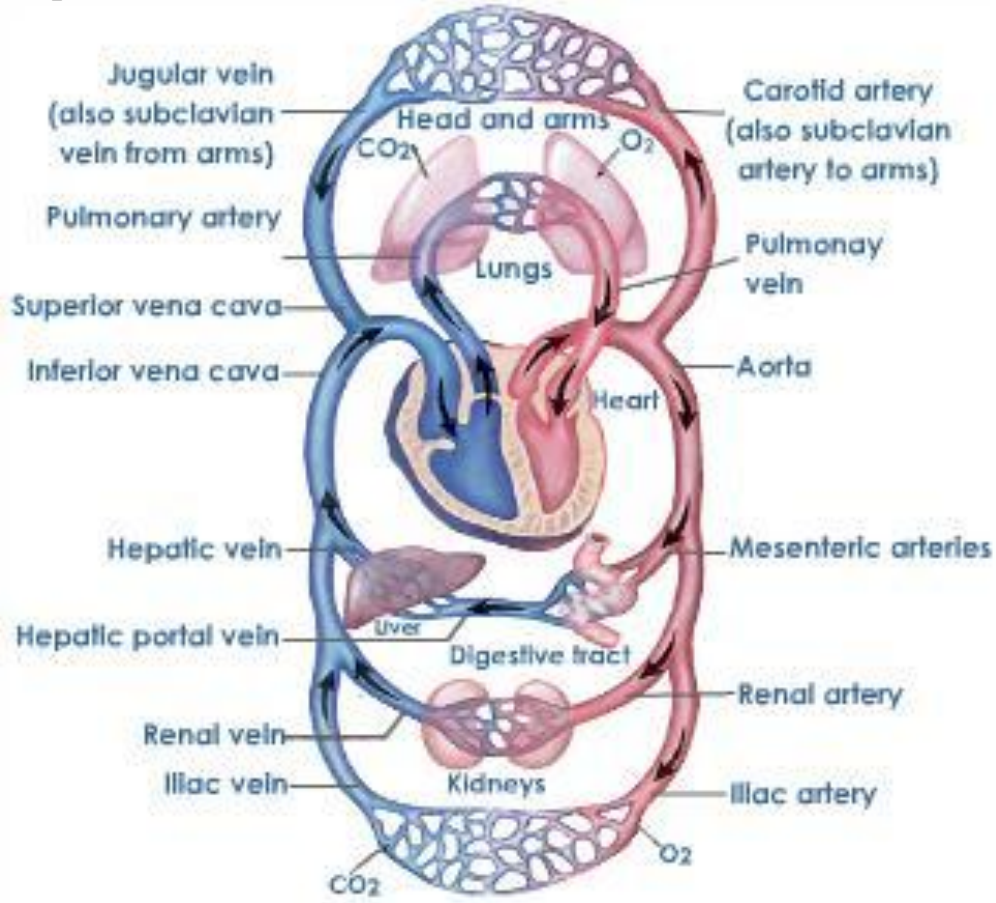


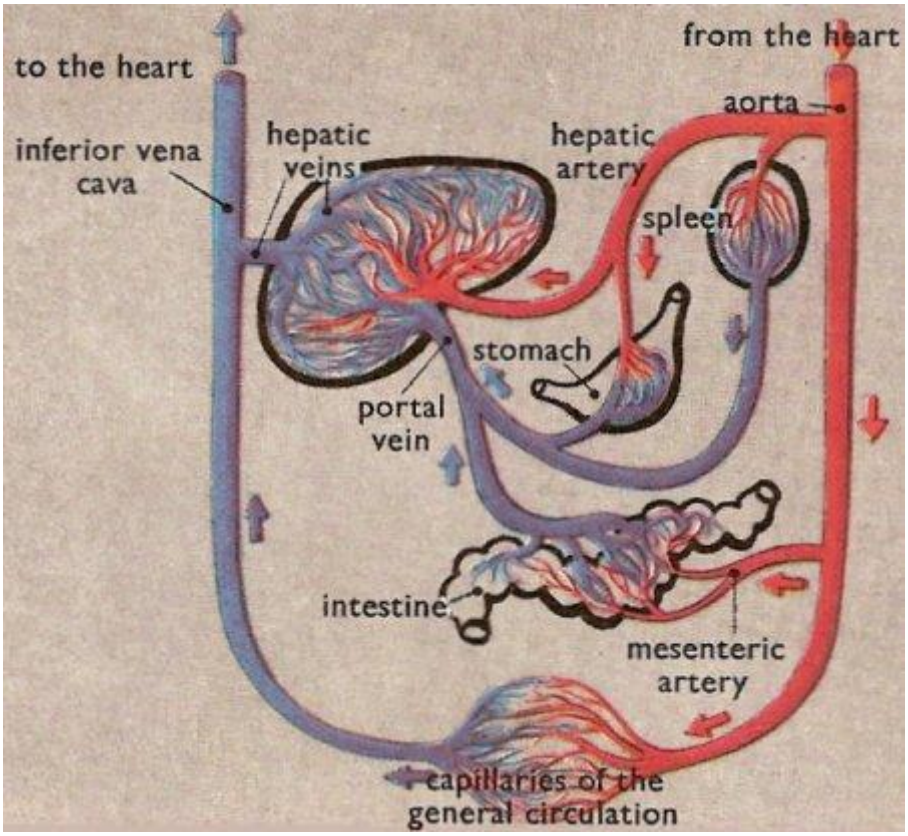
2. Systematic Circulation:

It starts from the left ventricle and ends at the right atrium. When the left ventricle contracts after being filled with oxygenated blood, the mitral valve closes. As a result, blood under great pressure rushes from the left ventricle to the Aorta through an opening which is controlled by a semi-lunar valve to prevent the backflow of blood. The Aorta gives rise to several arteries, some of which move upwards while others go downwards. Arteries then branch to form smaller and smaller arterioles which end by blood capillaries. These capillaries spread through the tissues in between the cells transporting Oxygen, water, and dissolved food substances to them. On the other hand, products of catabolism such as Carbon dioxide resulting from oxidation of sugar and fat diffuse through the walls of blood capillaries and reach the blood which changes in color from right red to dark red, and is now called deoxygenated blood.

Blood capillaries collect to give rise to larger and larger venules and finally veins, which pour the deoxygenated blood into the superior and the inferior vena cava which carry blood to the right atrium.

When it is filled with blood, the walls of the right atrium contracts and so blood is forced to the right ventricle which become filled with deoxygenated blood. Its worth noting that contraction of the right side of the heart occurs at the same time of contraction of the left side. Therefore, pumping of the deoxygenated blood from the right ventricle, and pumping of the oxygenated blood from the left ventricle, both take place at the same time.





3. Hepatic Portal Circulation:

After being absorbed by the villi of the small intestines, both glucose and amino acids are transported to the blood capillaries inside these villi. These blood capillaries aggregate into small venules, then large venules and finally they pour the contents into the hepatic portal vein. This also receives veins from the pancreas, the spleen, and the stomach.

When it first enters the liver, the hepatic portal vein branches into venules which end with minute blood capillaries. Excess food substances which exceed the body needs, filter through the capillary walls cells and passes to the liver where they undergo certain changes. Finally, blood capillaries unite into the hepatic vein, which leaves the liver to pour its contents into the upper part of the inferior vena cava just before it enters the right atrium.

Blood Clot:

When a blood vessel is cut, blood soon forms a clot to prevent bleeding before it lead to death.

The mechanism of blood clotting:

It is initiated by a blood vessel cut and involved a sequence of steps:

1. When blood becomes exposed to air or to friction with a rough surface such as damaged vessels and cells, the blood platelets form together with the destroyed cells, a protein substance called thromboplastin.

2. In presence of Calcium ions (Ca^{++}) and blood clotting factors in the plasma, thromboplastin activates the conversion of prothrombin to active thrombin (prothrombin formation occurs in the liver with the help of vitamin K and is passed directly into the blood).
3. Thrombin, being an active enzyme catalyzes the conversion of fibrinogen (soluble protein in plasma) into an insoluble protein which is fibrin.
4. Fibrin precipitates as a network of microscopic interlacing fibers. The blood cells aggregate into this forming a clot which blocks the hole in the damaged blood vessels. In this way, bleeding stops.

Why doesn't blood clot inside blood vessels?

Blood never clots inside blood vessels as long as:

1. **It runs in a normal fashion, and does not slow down.**
2. **Blood platelets should also slide easily and smoothly inside the blood vessels in order not to broken.**
3. **Prevention of clotting inside blood vessels is, also due to the presence of heparin (secreted from the liver) which prevents the conversion of prothrombin into thrombin.**

The mechanism of blood clotting is illustrated by the following simplified representation:

1. Blood platelets + Destroyed cells $\xrightarrow{\text{Factors of blood clotting}}$ **Thromboplastin**

2. Prothrombin $\xrightarrow[\text{Factors of blood clotting / Ca++}]{\text{Thromboplastin}}$ **Thrombin**

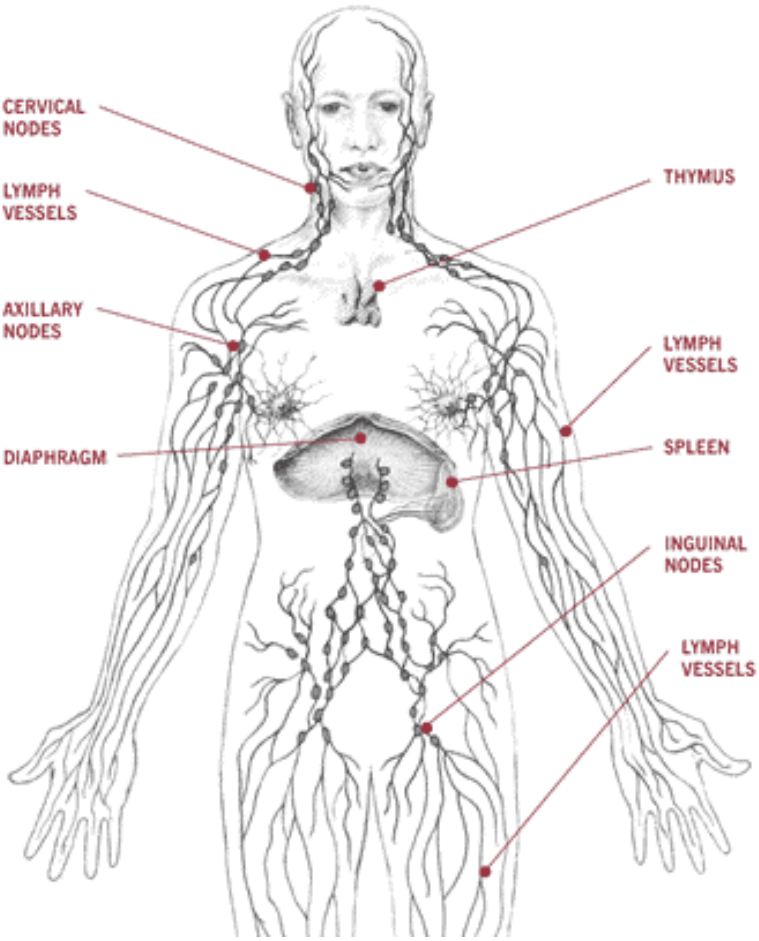
3. Fibrinogen $\xrightarrow{\text{Thrombin}}$ **Fibrin**

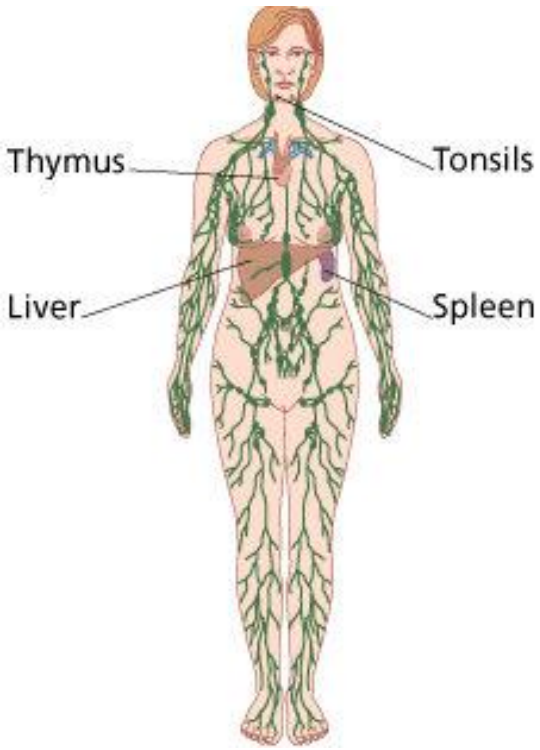
II. The Lymphatic System

The lymphatic system is considered as the immune system of the body due to its ability for defense and the production of the antibodies that give the body its immunity.

The lymphatic system consists of large number of lymphatic capillaries. They take up blood fluid that comes out from the blood capillaries. This fluid is called the lymph. The lymph contains nearly most of the plasma constituents and leucocytes. The lymphatic capillaries empty the lymph into the circulatory system along the superior vena cava.

The lymph passes across the lymph nodes which are found at certain points along the lymph capillaries. Lymphocytes are packed into the space of lymph nodes which trap microbes by white blood cells which they produce. The spleen is considered one of the most important lymphatic organs in the body.





Revision V
Transport in Animals

1. Give the scientific term that represents each of the following:

a. The two closely connected systems through which the process of transport takes place in the Human body. (----------)
b. The type of the circulatory systems in which there is a heart and blood vessels that form a complete circuit inside which blood passes. (----------)
c. A hollow muscular organ that lies in the middle of the chest cavity of the Human body. (----------)
d. A double-layered sac-like membrane containing fluid that encloses the Human heart. (----------)
e. The two main functions of the pericardium. (----------)
f. The upper two thin-walled chambers of the heart. (----------)
g. The lower two thick-walled chambers of the heart. (----------)
h. A valve which is made up of 3 flaps that guards the opening between the right atrium and the right ventricle. (----------)
i. A valve which is made up of 2 flaps that guards the opening between the left atrium and the left ventricle. (----------)
j. Blood vessels that carry blood from the heart to other organs. (----------)
k. Blood vessels that carry blood from the body organs to the heart. (----------)
l. The tissue that forms the outer layer of the arterial wall. (----------)
m. The tissue that forms the middle layer of the arterial wall. (----------)
n. The inner layer of the arterial wall. (----------)
o. The artery that carries deoxygenated blood. (----------)
p. The veins that carry oxygenated blood. (----------)
q. The blood vessels that are actually buried among the body muscles. (----------)
r. The blood vessels that don't pulsate. (----------)
s. Tiny microscopic vessels that connect the arterioles with the venules. (----------)
t. Thickness of the wall of the blood capillary in microns.(----------)
u. The diameter of the blood capillary in microns. (----------)
v. A liquid tissue that runs inside the human body. (----------)
w. The principal medium in the process of transport in Man. (----------)
x. Volume of blood in the human body in liters on average. (----------)
y. The PH value of human blood. (----------)
z. Substances that are transported by blood. (----------)
a. Its formation leads to protection of the blood against bleeding. (----------)
b. Percentage of blood plasma in blood. (----------)
c. Inorganic salt ions present in the blood plasma. (----------)
d. Proteins in the blood plasma. (----------)
e. A component of the human blood which is parts of cells produced in bone marrow and important in blood clotting. (----------)

f. Blood cells with no nuclei. (----------)
g. Blood cells containing Hemoglobin. (----------)
h. Blood cells that contain a nucleus for each. (----------)
i. Count of Erythrocytes per mm3 of the human blood. (----------)
j. Count of Leucocytes per mm3 of the human blood. (----------)
k. Count of blood platelets per mm3 of the human blood. (----------)
l. A specialized bundle of thin cardiac muscular fibers buried in the right atrial wall near its connection with the large veins. (----------)
m. A node at the junction between the two atria and the two ventricles. (----------)
n. The wall in between the two ventricles. (----------)
o. A nerve which is connected to the pacemaker of the heart, and slows down the heart beats. (----------)
p. A nerve which is connected to the pacemaker of the heart, and accelerates heart beats. (----------)
q. Number of heart beats / minute in average. (----------)
r. The conditions that lead to an increase in the heart beats. (----------)
s. The conditions that lead to a decrease in the heart beats. (----------)
t. The sound of the heart beat which is long and low-pitched. (----------)
u. The sound of the heart beat which is short and high-pitched. (----------)
v. The source of lubb sound of the heart beat. (----------)
w. The source of dupp sound of the heart beat. (----------)
x. The three main pathways of blood during its circulation. (----------)
y. A blood circulation that starts from the left ventricle and ends at the right atrium. (----------)
z. A blood circulation that starts from the right ventricle and ends at the left atrium. (----------)
a. The valve that closes when the right ventricle contracts. (----------)
b. The valves that prevent the backflow of blood to the ventricles when they relax. (----------)
c. The artery that branches into two branches, each goes to a lung. (----------)
d. Structures that are presents in the lungs around which capillaries spread where exchange of gases takes place. (----------)
f. The valve that closes when the left ventricle contracts. (----------)
g. The veins that open in the left atrium. (----------)
h. The artery that comes out of the left ventricle carrying oxygenated blood. (----------)
i. The veins that carry deoxygenated blood to the right atrium. (----------)
j. Type of blood that is pumped out of the right ventricle. (----------)
k. Type of blood that is pumped out of the left ventricle. (----------)
l. The circulation of blood that involves loading of blood with absorbed food substances. (----------)
m. The vein that comes out of the small intestines and also receives veins from the pancreas, the spleen, and the stomach. (----------)

n. The vein that leaves the liver to pour its contents into the inferior vena cava before it enters the right atrium. (----------)
o. A protein substance that forms when blood becomes exposed to air. (----------)
p. The 3 factors that activate prothrombin. (----------)
q. The 3 factors that form thromboplastin. (----------)
r. Its formation occurs in the liver with the help of vitamins k. (----------)
s. The enzyme that catalyzes the conversion of fibrinogen into fibrin. (----------)
t. An insoluble protein that precipitates as a network of microscopic interlacing fibers, so blood cells aggregate in this forming a clot. (----------)
u. The three factors that prevent blood clotting inside blood vessels. (----------)
v. The substance that prevents the conversion of prothrombin into thrombin. (----------)
w. The site at which the largest blood pressure is measured. (----------)
x. The situation during which the maximum blood pressure is measured. (----------)
y. The situation during which the minimum blood pressure is measured. (----------)
z. The average normal value of blood pressure at youth. (----------)
a. The average value of blood pressure inside venules. (----------)
b. The site at which the hemoglobin combines with Oxygen to form pale red Oxyhemoglobin. (----------)
c. The site at which Oxyhemoglobin leaves Oxygen and unites with Carbon dioxide to form dark red Carboxyhemoglobin. (----------)
d. Sites at which red blood cells are destroyed. (----------)

2. Draw a labeled diagram to represent:

a. The structure of the human heart, and the blood vessels connected to it.
b. The structure of the wall of arteries and that of veins.
c. Components of blood.
d. Blood circulation.
e. The hepatic portal circulation.
f. The origin of the regular heart beats.

3. Give reasons for:

a. The circulatory system in Humans is said to be closed one.
b. The heart is surrounded by the pericardium.
c. Tendons attach the flaps of the bicuspid valve and the tricuspid valve to the ventricular walls.
d. semi-lunar valves exist at the connection of the heart with both Aorta and pulmonary artery.
e. The lymphatic system is considered the immune system in the human body.
f. the venous blood is darker than the arterial blood.

4. Compare between:

a. The artery and the vein.
b. The wall of an artery and that of a vein, with drawing.
c. RBCs, WBCs, and blood platelets.
d. The two sounds of a heart beat.
e. The hepatic portal vein and the hepatic vein.
f. The bicuspid valve and the tricuspid valve.
g. Oxyhemoglobin and Carboxyhemoglobin.

5. Describe:

a. The functions carried out by the blood.
b. The source of the regular rhythm of heart beats. And the factors affecting its rate.
c. The origin of the 2 sounds of a heart beat.
d. How does the blood clot form, if blood bleeds?
e. How does blood circulate, and what is the purpose of its circulation during:
1. **The systematic circulation.**
2. **The pulmonary circulation.**
3. **The hepatic portal circulation.**

f. How does blood move back in the veins to the heart.
g. Why does blood not clot inside blood vessels.

6. How does the structure of each of the following suit its function:

a. the human heart.
b. blood capillaries.
c. Red blood cells.

7. What do you know about each of the following:

a. The semi-lunar valves.
b. The internal valves of veins.
c. The lymph and the lymphatic system.

8. Mention the main components of the blood plasma.

9. What is meant by blood pressure? How does it be measured? Mention the factors that affect its value.