Chapter 14

TRANSPORT

Q.1 What is translocation?

Ans. **TRANSLOCATION**

The movement of substances through the conducting or vascular tissue of plants is called translocation.

Xylem translocates mainly H_2O, mineral salts, organic substances and hormones from the roots to the aerial parts of plants.

Phloem translocates variety of organic and inorganic solutes, mainly from the leaves or storage organs to other parts of plants.

Q.2 Define transport. What is the importance of transport in living bodies?

Ans. **TRANSPORT**

"The movement of any object from one place to another with help or without help of other body is known as transport".

Importance: Living cells or living bodies have reservoirs of making and breaking of different chemicals. These chemicals are formed or broken down in different chemical reactions. Energy is also obtained in such reactions. Maintenance of life taking of specific chemicals and removal of certain chemicals are essential. For these purposes transport is compulsory process.

In unicellular, transport is very easy and simplest. In multicellular, division of labour of different tissues or organs are found and transport is complex.

Q.3 Define Osmosis, Osmotic Potential, Water potential, solute potential and pressure potential.

Ans. **OSMOSIS**

The movement of water molecules from a region of their ***high concentration*** (a dilute solution) ***to the region of their low concentration*** (more concentrated solution) through a partially permeable membrane is called osmosis.

Solute Potential (or Osmotic Potential) (γ_S):

"The lowering of concentration of water molecules by the effect of dissolving of solute molecules in the pure water is called solute potential". In other words:

The measure of the change in water potential of the system due to the presence of solute molecules is known as solute potential.

Water Potential:

"The tendency of water molecules to move from one place to another is called water potential".

* Keep in mind for conception:

* { Greater of water molecules $\propto$ H_2O potential $\propto$ K.E. }
{ Increase of solutes means decrease of H_2O potential }

Pressure Potential (γ_P) (Turgor Potential):

"The pressure tending to force the water from one place to another is called pressure potential".

Examples: When water enters plant cells by osmosis, pressure may build up inside the cell making the cell turgid and increasing pressure potential. (OR) "The build up of pressure inside the cell after the endosmosis due to water or solution is called water potential".

* Pure water or water molecules $\propto$ pressure potential.

Q.4 (a) Explain water potential with reference to osmotic and pressure potentials.

Ans. Water Potential (Symbolized by Greek Letter Psi = Ψ_W):

Water molecules possess kinetic energy. Molecules of liquid or gaseous form they move about rapidly and randomly from one place to another. It means greater the concentration of the water molecules in a system the greater is the total kinetic energy of water molecules. In other words, water molecules are directly proportional to kinetic energy.

In plants cells two factors i.e., (1) Osmotic potential and (2) Pressure potential.

(1) **Solute concentration** = (Osmotic or solute potential = Ψ_S)

(2) **Pressure generated when water enters and inflates plant cells** = (Pressure potential = Ψ_p).

(a) *Pure water has maximum water potential which by definition is zero.*

(b) Water moves from a region of higher Ψ_w ——— to lower Ψ_w.

(c) All solutions have lower Ψ_w than **pure water** and so have negative value of Ψ_w (at atmospheric pressure and at a defined temperature).

(d) **Osmosis means:** "The movement of water molecules from a region of higher water potential to a region of lower water potential through a partially permeable membrane".

(1) Osmotic (Solute) Potential = Ψ_s:

The osmotic (solute) potential Ψ_s is a measure of the change in water potential (Ψ_w) of a system due to the pressure of **solute molecules**.

Ψ_s is always negative. More solute molecules present, lower (more negative) is the Ψ_s.

(2) Pressure Potential (Ψ_p) (Turgor Potential):

If pressure greater than atmospheric pressure is applied to pure water or a solution, its water **potential** increase.

It is equivalent to pumping water from one place to another. Such a situation may arise in living systems.

When water enters plant cells by osmosis pressure may be build up inside the cell making the cell turgid and increasing the pressure potential. Thus the total water potential is sum of Ψ_s and Ψ_p.

Ψ_w	=	Ψ_s	+	Ψ_p
water potential		solute potential		pressure potential

If we use the term water potential, the tendency for water to move between any two systems can be measure; not just from cell to cell in a plant but also from soil to root from leaf to air of from soil to air. The steeper the potential gradient the faster is the flow of water along it.

The following example would help understand the concept of water potential. Two adjacent vacuolated cells are shown with Ψ_w, Ψ_p and Ψ_s.

Q.4 (b) Examine the following diagram and give answers of the following questions.

Ans.

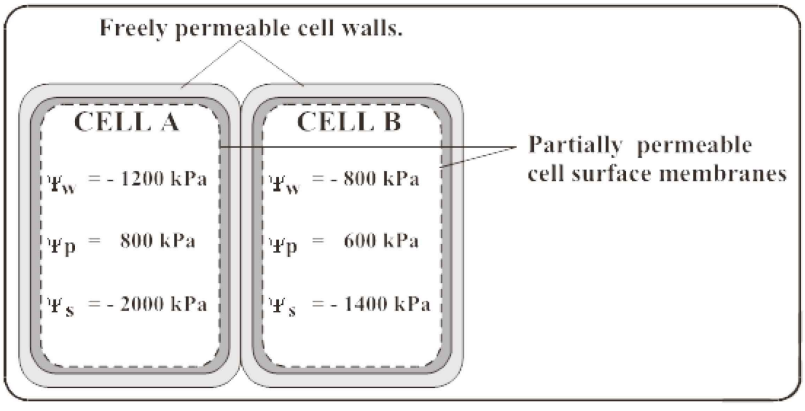


Fig. Two adjacent vacuolated cells

(a) Which cell has the higher water potential?

(b) In which direction will water move by osmosis?

(c) What will be the water potential of the cells at equilibrium?

(d) What will be the solute potential and pressure potential of the cells at equilibrium?

Kpa = 1000 Pascals – which is the pressure exerted by a vertical force of one Newton on an area of I metre square.

Q.4 Briefly describe the vascular system.

Ans. **Definition of Vascular System**

The system in which tubular structures carry fluids, which is transported from one place to another.

Both animals and plants have vascular systems.

In plants, the xylem and phloem form vascular system.

Q.5 Differentiate between Active transport and Osmosis.

Ans.

Osmosis	Active Transport
Movement of molecules from high concentration to low concentration through the partial permeable membrane is called osmosis. (High Conc.) $\xrightarrow{\text{Partial permeable membrane}}$ (low conc.)	The movement of molecules from low concentration to high concentration by the expenditure of energy is called active transport. (Low conc.) $\xrightarrow{\text{Expenditure of energy}}$ (high conc.)

Q.6 Differentiate between endosmosis and exosmosis.

Ans.

Endosmosis	Exosmosis

(1)	The kind of osmosis in which movement of water molecules takes place *inside from outside* the cell is called endosmosis.	(1)	The kind of osmosis in which movement of water molecules occurs from inside to outside the cell is termed as exosmosis.
(2)	Turgor pressure develops on cell wall due to endosmosis (or) Deplasmolysis occurs due to endosmosis.	(2)	Shrinkage of protoplast occurs due to exosmosis and plasmolysis takes place.
(3)	Living cell has higher water potential.	(3)	Living cell has lower water potential.
(4)	Pressure potential is increased by endosmosis.	(4)	Pressure potential is decreased by exosmosis.

Q.7 Briefly discuss structure and function of roots.

Ans. **MAJOR FUNCTIONS OF ROOTS**

(i) Roots *absorb minerals and water* from the soil.

(ii) Roots *anchor the plant* body in soil.

(iii) *Diffusion, osmosis* and *active transport* processes are involved in it.

Structures of Roots:

(i) Mostly, the roots are extensively *branched.*

(ii) Think tiny hair like structures known as *root hairs* are present in cluster forms.

(iii) Root hairs are extensions of *epidermal cells* which increase the absorbing area. These surround 67% area of root surface.

(iv) From roots hairs water enters in *Epidermis*. After it water reaches in *Cortex*. Then water goes into *endodermis* and *pericycle* respectively. Ultimately water enters into vascular bundle i.e. xylem *Tracheids* and *vessels* tissue involve in ascent of sap.

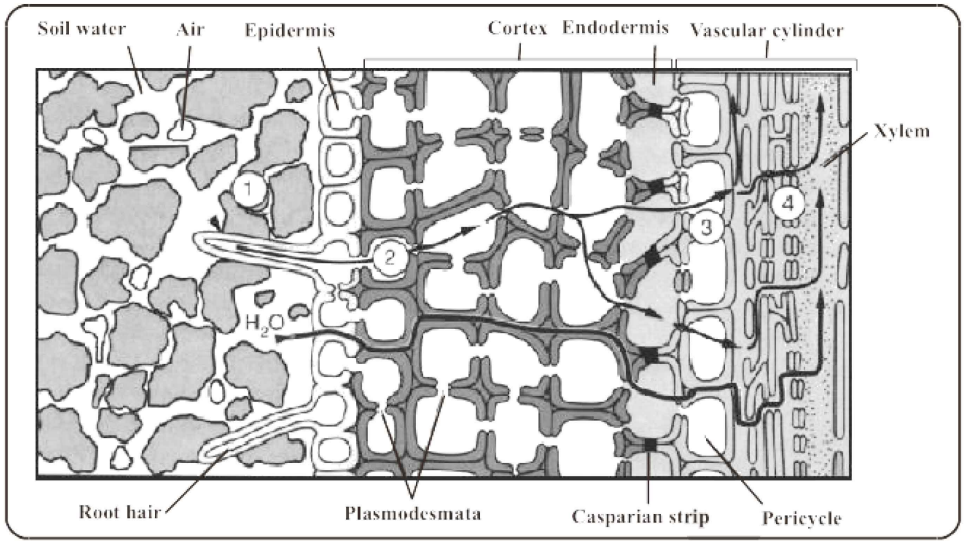


Fig. Mineral and water uptake by roots. The Caesarian strip separates the extracellular space in the root into two compartments: an outer compartment that is continuous with the soil water, and an inner compartment that is continuous with the inside of the conducting cells of the xylem. The black lines a pathway for both water and minerals; the blue line is an alternative pathway for water alone.

EASY TO DRAW

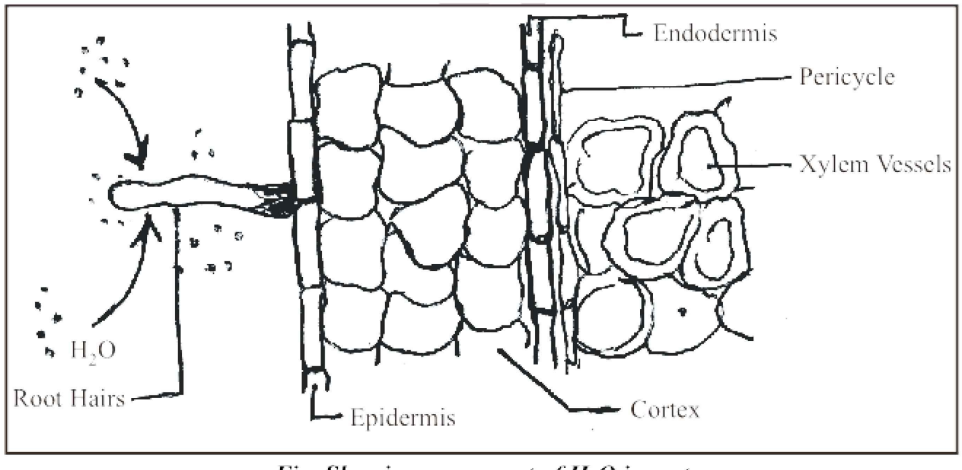


Fig. Showing movement of H_2O is root

Q.8 Give the details of the processes, which involved in absorption by roots.

Ans. **LIST OF INVOLVED PROCESSES**

(i) Diffusion
(ii) Osmosis
} Passive Transport

(iii) Cohesion and Adhesion

(iv) Active Transport

H_2O uptake and transport occurs by two main processes i.e. passive transport and active transport. In case of passive transport no expenditure of energy is involved while in case of active transport energy is involved.

PASSIVE TRANSPORT

Passive transport means diffusion and osmosis.

(i) Diffusion: Diffusion is the process in which ions or molecules move from higher concentration to lower concentration.

(ii) Osmosis: Osmosis is the process in which ions or molecules move from higher concentration to lower concentration via semi permeable membrane.

(a) Symplast Pathway:

The pathway through which molecules move due to osmosis via plasmodesmota, cortex, endodermis, pericycle and then to xylem respectively is called symplast pathway.

Keep in Mind: This movement occurs *through the free spaces* between the cells *without entering into cytoplasm*.

(b) Facilitated Diffusion:

The diffusion which carry nutrients from the soil to the epidermal cells of roots through their cell membranes is called facilitated diffusion.

(c) Apoplast Pathway:

The diffusion of ions with H_2O which takes place by mass flow *through cell wall and free spaces* between the cells is known as apoplast pathway.

In this pathway, the moving ions cross the endodermis and enter into cytoplasm or possibly their vacuoles by diffusion or active transport. These ions ultimately reach the to xylem cells.

(d) Vacuolar Pathway:

The pathway through which ions or molecules move via cell membrane cytoplasm and tonoplast (vacuolar membrane) and reach the xylem cells called vacuolar pathway.

(iii) Active uptake or Transport (OR) Active Transport:

The uptake of materials from lower concentration to higher concentration (against concentration gradient) by the help of energy is called active uptake. Energy is used in the form of ATP. Due to use of energy the active transport is dependable.

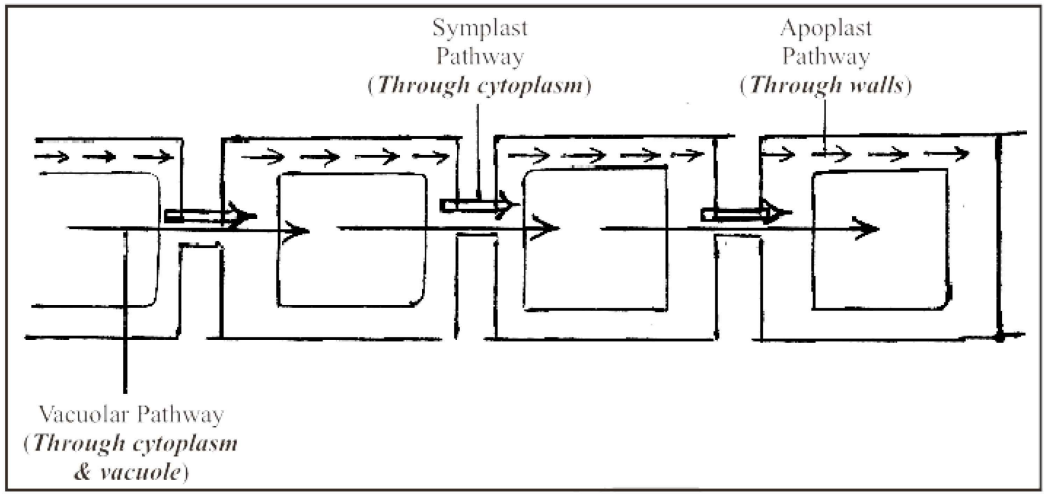


Fig. Different pathways through which molecules move

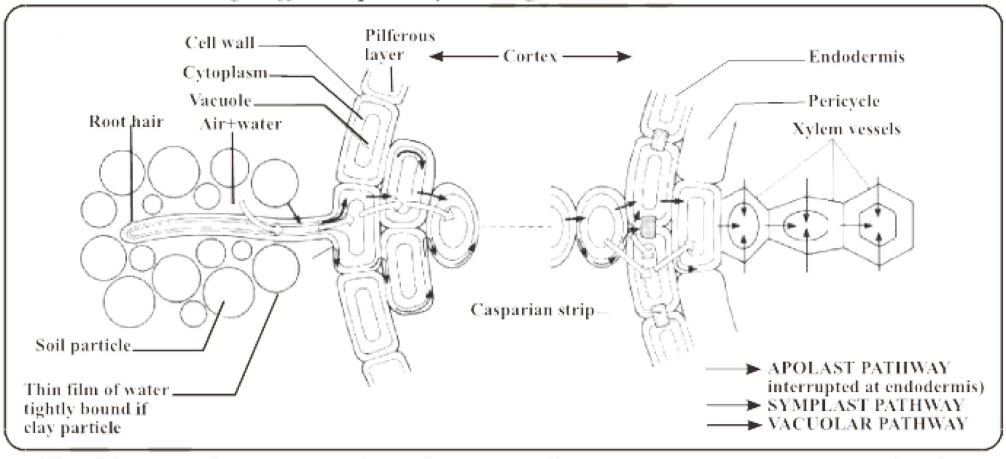


Fig. Diagramatic representation of water andion movement across a root showing transverse section. The apoplast pathway is of greatest importance for both water and solutes. The symplast pathway is less important, except for salts in the region of the endodermis. Movement along the vacuolar pathway is negligible.

Q.9 What are plasmolysis and Deplasmolysis?

Ans. **Plasmolysis**

The shrinkage of protoplast due to exosmosis of water from living cell when placed in more concentrated solution is called plasmolysis.

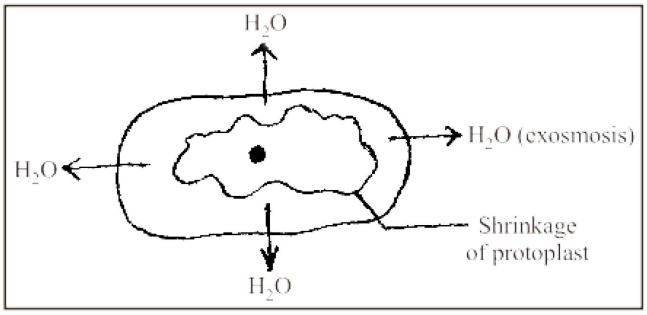


Fig. Plasmolysed cell

Deplasmolysis

The process in which shrinked protoplast of living cell becomes normal by the endosmosis when placed in H_2O.

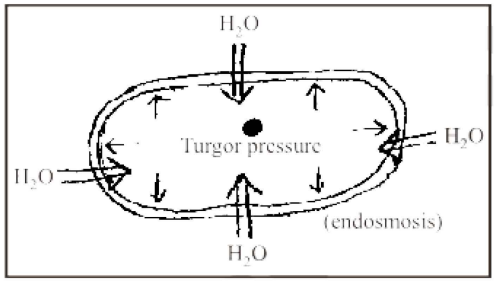


Fig. Deplasmolysed cell

Q.10 Write down relationship between plasmolysis and pressure potential?

Ans. When shrinked or plasmolysed cell is placed in pure water, in this way, water enters the cell by endosmosis. Endosmosis occurs because pure water has higher water potential than protoplast of living cell.

After entrance of water, pressure is exerted on the cell wall. So, the rigidity against the cell wall is due to pressure of H_2O. *"The pressure exerted by the protoplast against the cell wall is called pressure potential".*

The result of pressure potential is appeared in the form of turgidity.

(1) Turgidity $\propto$ Pressure Potential

(2) Pressure Potential $\propto$ pure water.

(3) Deplasmolysis $\propto$ endosmosis

(4) Plasmolysis $\propto$ 1/ pressure potential.

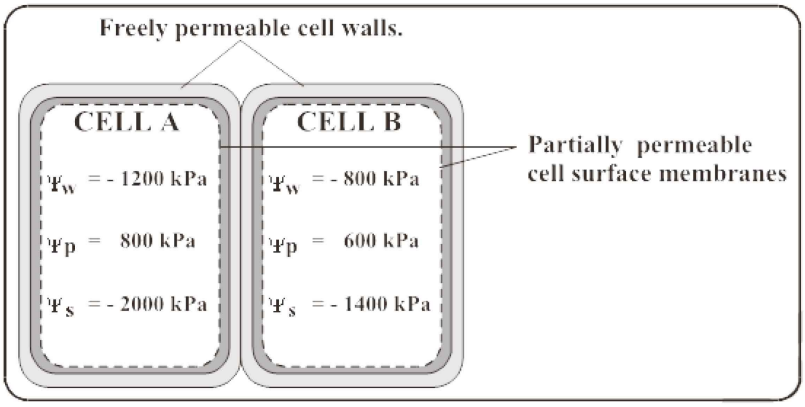


Fig. Two adjacent vacuolated cells

Q.11 Describe relationship of water potential to other potential.

Ans.

Ψ_W	=	Ψ_S	+	Ψ_P
Water	=	**Solute potential**		**Pressure potential**
Ψ_W	=	Ψ_π	+	Ψ_P

Q.12 What do you know about following terms:
(i) Turgor Pressure (ii) Matric Potential

Ans. The pressure of turgid state of cell due to hydrostatic pressure is known as turgor pressure;

(OR)

The force causing imbibition or H_2O holding capacity in a matrix of any sort γ_w water potential is called matric potential.

Q.13 What is imbibition? Give its importance.

Ans. **IMBIBITION**

"The process of take up of H_2O of components of cell wall (cellulose) in which volume of components is increased but they do not dissolve known as imbibition".

IMPORTANCE OF IMBIBITION:

(i) **Ascent of Sap:** In 1874, Sacks suggested that the water molecules move along the cell walls of xylem vessels due to imbibition.

(ii) **Without Dissolving in H_2O:** The component of cell wall i.e. cellulose can take up water and as a result increase in volume, but the components do not dissolve in water.

(iii) **Increase of Volume:** After take up of H_2O the components of cell wall increase in volume and in this way dissolving does not occurred.

(iv) Water Movement and Apoplast Pathway: The root cell walls imbibe water from soil and this water moves by apoplast pathway.

Q.14 (a) What is ascent of sap? Discuss ascent of sap with reference to Cohesion-Tension theory, root pressure and imbibition.

Ans. (1) ASCENT OF SAP

"The pull up of water and dissolved materials through the xylem tissues towards the leaves is known as ascent of sap".

Water and dissolved materials are collectively called sap and ascent means pulled up.

* *Dissolved minerals go upward via root hair → epidermis → cortex → endodermis → pericycle → xylem → branches or leaves.*

Factors Involved in ascent of SAP:

Following factors are involved in ascent of sap:

(1) Cohesion Tension Theory (2) Root Pressure (3) Imbibitions

(1) Cohesion Tension Theory:

It was proposed by *Dixon*. This theory produces a reasonable explanation of flow of water and minerals upwards from the roots to leaves of plants, in bulk flow or mass flow. The flow of water depends on the following:

(i) Cohesion:

It is the *attraction among water molecules*, which hold water together, forming a solid chain-like column within the xylem tubes. The water molecules form hydrogen bonds between the molecules.

(ii) Tension:

It is provided when this *water chain is pulled up* the xylem, transpiration provides the necessary energy or force. Tension is between the molecules, *by hydrogen bonds*. Column of water within xylem is at strong enough and as unbreakable as a steel wire of the same diameter. This xylem water is tension enough to pull water up to 200 meters (more than 600 feet) in plants.

(iii) Adhesion:

It may be added that the water molecules also *adhere to the cell wall of xylem cells*, so that the column of water in xylem tissue does not break. The composition of cell wall provides necessary adhesion to water molecules that helps water to creep up. The cellulose component of cell wall especially has great affinity with water. It can imbibe water.

(iv) Strong Xylem Walls:

It is essential that the xylem walls should **have high tensile strength** if they are not to buckle inwards, as happen when sucking up a soggy straw. The lignin and cellulose provides strength to cell wall of xylem vessels.

By cohesion-tension of water molecules, and the transpiration pull providing necessary energy, the sap (water and molecules) in xylem tissue is pulled upwards to the leaves.

The total water pulled up in the leaves is transpired, except about 1% which is used by plant in various activities including photosynthesis.

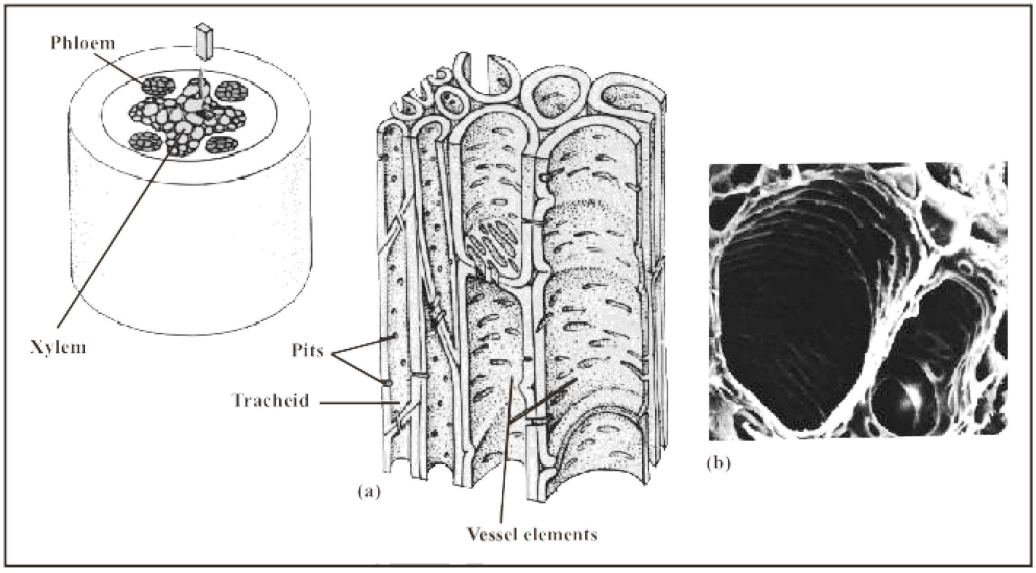


Fig. *(a) Xylem tissue elements involved din transportation of water and dissolved minerals*

(b) Scanning electron micrograph of two large vessel elements for a cucumber roots

Q.15 (a) Describe the mechanism of transpiration pull with reference to cohesion.

Ans. (1) Mechanism of Transpiration Pull in Cohesion Tension Theory

The evaporation of water from the aerial parts of the plant especially through stomata of leaves is a process called *transpiration*.

As a leaf transpires the water potential of its *mesophyll cell* drops.

This drop causes water to move by osmosis from the xylem cells of leaf into dehydrating mesophyll cells.

The water molecules leaving the xylem are attached to other water molecules in the same xylem tube by ***hydrogen bonds*** (cohesion of water molecules). Therefore when one water molecules moves in the xylem, the process continues all the way to the root where water is pulled from the xylem cells ***tracheids*** and ***vessels***.

This pull also causes water to move down its concentration gradient transversely from the root epidermis (root hairs) to cortex endosmosis and to pericycle.

In short, this pulling force or transpiration pulled is so strong that it also reduces the water potential of root epidermal cells. Then water in the soil moves from its higher water potential to lower water potential of epidermis of root by osmosis.

Q.15 (b) What is the role of root pressure in ascent of sap?

Ans. **ROOT PRESSURE**

Root pressure is the 2nd force which involved in the movement of H_2O and dissolved minerals in the xylem tissue.

Creation of Root Pressure:

* Root pressure is ***created by the active secretion of salts*** and other solutes from the other cells into the xylem sap.
* This ***lowers the water potential of xylem*** sap. Water enters the xylem cells by osmosis, thus increasing the level of sap in the xylem cells.
* As a result of root pressure the sap in the xylem ***does not rise to enough height*** in most plants. It is also least effective during the day. It has been estimated that a positive hydrostatic pressure of around 100 to 200 KPa (exceptionally 800 KPa) is generated by root pressure, which is not enough to push water upwards to required height in most plants. But it is no doubt a contributing factor in small plants, which transpire slowly.

* It is further added that the root pressure, is a prominent factor in those plants, ***which live in humid climate***, where the rate of transpiration is very low.

* Root pressure has not been observed in gymnosperms, which are tall plants. In these plants, and under normal transpiration rate, the xylem sap, which is responsible for development of root pressure, is under tension instead of pressure.

Q.15 (c) Discuss guttation, give its importance.

GUTTATION

"Occuring under condition of high humidity when of liquid-water on to a plant surface transpiration cannot occur but water absorption in high"

Closely associated with root pressure is a phenomenon called guttation or exudation. *Guttation is loss of liquid water through water secreting glands or hydathodes near terminal tracheids of the bundle ends around the tips and margins of leaf.* The *dew drops* that can be seen on the tips of grass leaves or strawberry leaves are actually guttation droplets exuded from hydathodes the specialized pores.

Guttation or exudation is more notable when transpiration is suppressed, and the relative humidity is high as at night. The guttation is in fact due to *positive pressure*, the root pressure developed in xylem tissue of roots.

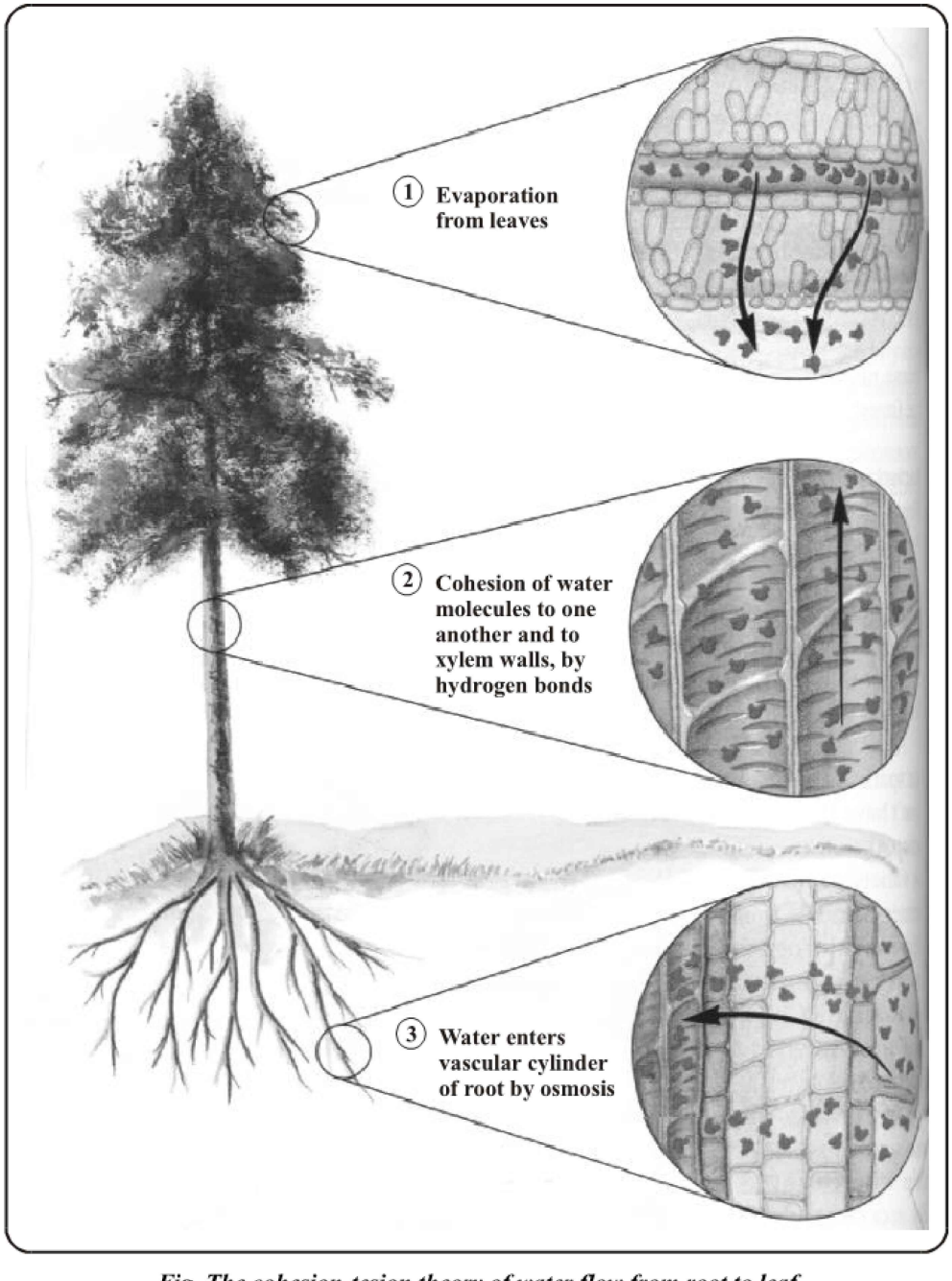


Fig. The cohesion-tesion theory of water flow from root to leaf

Imbibition

Another importance force in ascent of sap is imbibition. Sacks in 1874 suggested that the water molecules move along the cell walls of xylem vessels due to imbibition.

The cell wall components especially cellulose can take up water and as a result it increase in volume, but the components do not dissolve in water, this is called imbibition. In this process the constituent particles of a particular substance take up water by surface attraction and increase in volume. The amount of attraction and increase of dry cell walls of plant cells, and of protoplasm for water is often very great and considerable imbibition forces may be developed in plant body.

The root cell walls imbibe water from the soil and this water moves by apoplast pathway.

Fig. Guttation by strawberry leaves

Q. What is transpiration? Discuss its types.

Ans. **TRANSPIRATION**

The loss of water from the aerial parts of the plants is called transpiration.

(i) **Cuticular Transpiration**

The loss of water in the form of water vapours through the cuticle of leave is called cuticular transpiration. About 5-7% of total transpiration takes place through this route.

(i) The cuticle present on the upper and lower epidermis of leaves is not completely impermeable to water and some water is lost in the form of vapours through cuticle.

(b) Thinner the cuticle the greater is the rate of transpiration.

(c) At night when the stomata are almost closed cuticular transpiration takes place. Most of the factors, which affect rate of transpiration in general, are also important in controlling the rate of cuticular transpiration.

(ii) **Lenticular Transpiration**

Lenticular transpiration is the loss of water vapours through lenticels present in the stem of same plants. All plants do not possess lenticels.

(a) The lenticular transpiration is ***1-2%*** of the total transpiration by a plant.

(b) The openings like stomata are also involved in the exchange of gases between environment.

(c) When there is strong light and high temperature the loss of vapours is rapid because it is governed by diffusion.

Lenticels ***are aerating pores found in the bark through which exchange of gasses take place***, and water is lost in the form of water vapours (transpiration). Externally, they appear as scores or small protrusions on the surface of stem. The lenticels commonly develop below a stoma, and its cells increase in number and size, epidermis gets ruptured. Communication is thus established between the atmosphere and the internal tissues of the stem of the plant.

Structure of Lenticels:

Lenticels consist of a loose mass of small, ***thin-walled cells*** (complementary cells). At each lenticel the cork cambium instead forms oval, spherical, or irregular cells, which are very loosely arranged, having lots of intercellular spaces.

(iii) Stomatal Transpiration

It is a type of transpiration in which the water vapours escape through the stomata.

(a) ***Stomata are the openings guarded by guard cells*** are present in the epidermis of leaf and stem of plants.

(b) In isobilateral leaves the stomata are present, inboth upper and lower epidermis e.g. lily and maize leaf. Stomata only on lower epidermis. In dorsiventral leaves the stomata are confined to only the lower epidermis.

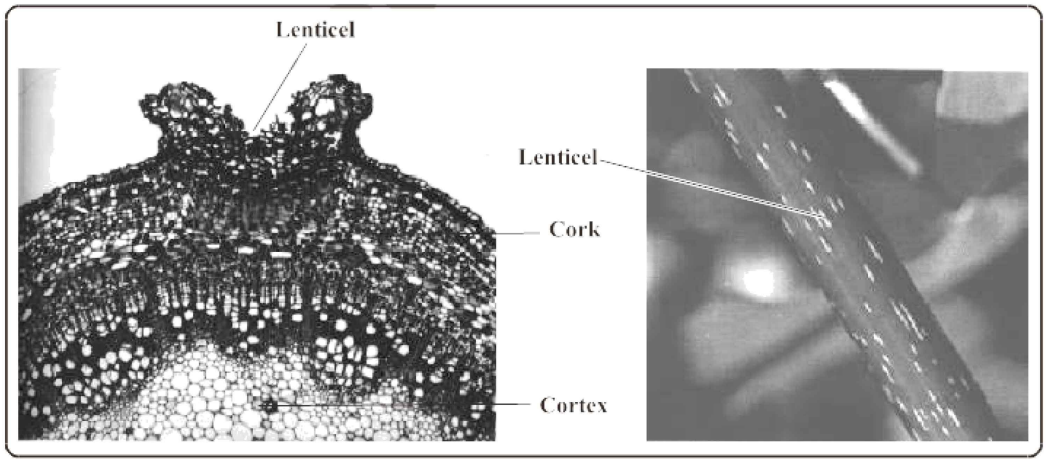


Fig. Left: the waterproof outer bark (layer of dark cells on the surface) on this section of stem is interrupted at the center of the lenticel. Thus the more loosely arranged cell layer beneath, with their numerous intecellular air spaces, are exposed to the atmosphere, right: the individual lenticels can be seen as white areas on the surface of a young stem.

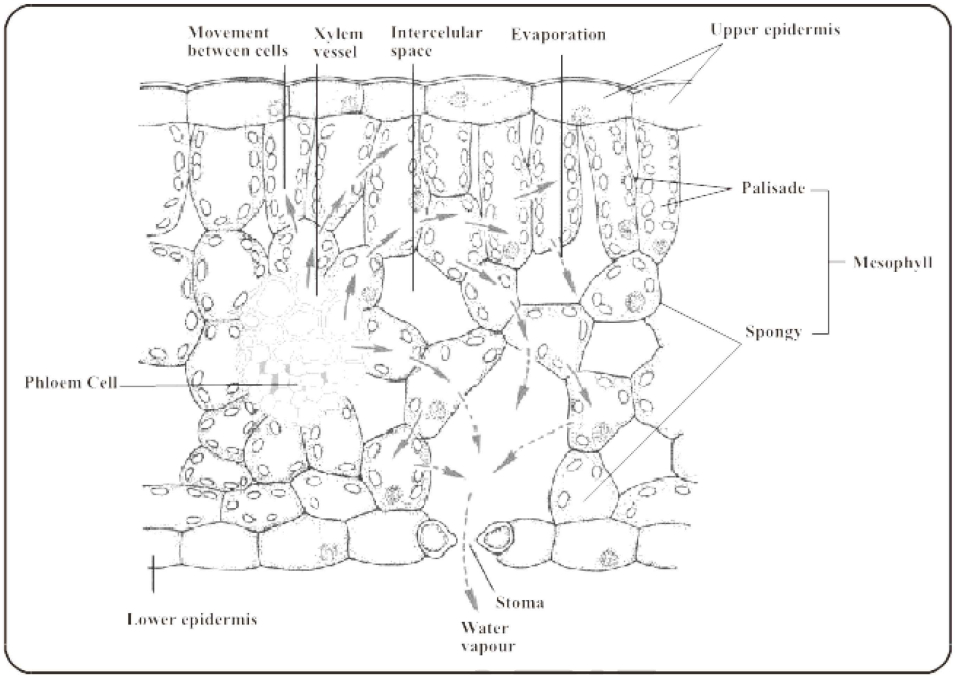


Fig. The water pathway through the leaf. Water is drawn from the xylem into the cell walls of the mesophyll, where it evaporates into the air spaces within the leaf. By diffusion water vapour then moves through the leaf air space, through the stomatal pore, and across the boundary layer of still air that adheres to the outer leaf surface CO_2 also diffuses into the leaf through stomata along a concentration gradient.

Structure of Guard Cells:

The guard cells are normally ***dumble or bean-seed-shaped***. In the inner concave side of two guards. Cells have very thick cell wall, but the ***outer convex side*** has thin cell wall. The guard cells are the only cells, of leaf epidermis, which have chloroplast and thus are involved in the process of photosynthesis.

In monocots e.g., grasses, there are also subsidiary cells on the outer side of each guard cell. It is interesting to note that radial dignment of cellulose microfibrils in the cell wall of guard cells. When these guard cells are turgid, the stoma between them then opens and when guard cells are flaccid the stoma between them closes. The degree of opening of stomatal pores also affects the rate of transpiration, 90% of total transpiration, is stomatal.

The cells of mesophyll of leaf provide enormous surface area for the loss of water in the form of vapours.

The ***pathway of water vapours*** loss to the atmosphere can be divided in the three regions:

(a) The air space inside the leaf.

(b) The stomatal pore (the size of the open stoma).

(c) Layer of still air next to the surface of leaf which depends on dimensions, and surface features of leaf, such as hairness and also on wind speed. The thinner layer of still air, the greater is the rate of transpiration.

The Water Pathway Through the Leaf:

Water is drawn from the xylem into the cell walls of the mesophyll, where it evaporates into the air spaces within the leaf. By diffusion, water vapour that moves through the leaf air space, through the stomata pore, and across the boundary layer of still air that adheres to the outer leaf surface. CO_2 also diffuses into the leaf through stomata along a concentration gradient.

EXAMINE YOUR SELF

Q.	***Differentiate between stoma and stomata.***
Q.	***Distinguish between lenticel and stomata.***
Q.	***Brief structure of guard cells.***
Q.	***Differentiate between imbibition and endocytosis.***
Q.	***Differentiate between adhesion and cohesion.***
Q.	***Distinguish between root pressure and transpiration pull.***

Q.15	*(b)*	***Write down the different hypothesis about the opening and closing of stomata.***

Ans. **OPENING AND CLOSING OF STOMATA**

Guard Cells:

The guard cells function as multisensory hydraulic valves. Environmental factors such as light intensity and quality temperature relative humidity and intracellular CO_2 concentration are revised by guard cells. These signals are integrated into well defined stomatal responses.

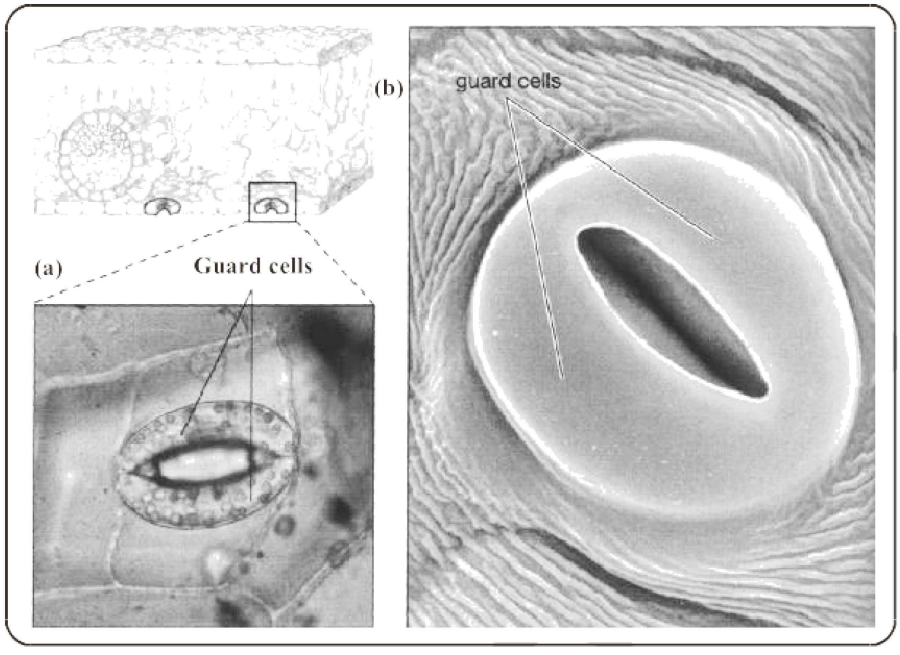


Fig. Stomata. Stomata seen through (a) the light microscope and (b) scanning electron microscope. In the light micrograph, note that the guard cells contain chloroplasts (the green ovals within the cells) but that the other epidermal cell do not.

HYPOTHESIS ABOUT THE OPENING AND CLOSING OF STOMATA

There are two hypothesis, which may explain the opening and closing of stomata:

(i) Starch Sugar Hypothesis:

H. Van Mohl proposed that guard cells are the only photosynthesizing cells in the guard cells of epidermis of leaf.

Opening:

As a result of photosynthesis sugars are produced in the guard cells during the day time when light is available. When sugar level sizes i.e. solute concentration increases or water potential decreases and the guard cells become turgid, and they separate from one another and stoma or pore opens.

Closing:

During night there is no photosynthesis in sugar the either converted into soluble starch or are used in respiration decreases free sugars in cells. So the osmotic potential of guard cells is lowered, and water leaves the guard cells. They became flaccid and stoma or pore between them closes. The thinner the layer of still air the faster is the rate of transpiration.

(ii) Influx of K+ Ions:

Potassium concentration in guard cell increases several folds when stomata open depending upon plant species and experimental conditions.

The light during daytime activates proton pump in the cell membrane of guard cells. The pigments in the chloroplasts of guard cells modulate this response. When epidermal peels floating in the solution of KCI_2 are illuminated stomatal opening can be observed.

The plants opening its stomata by actively pumping potassium in guard cell.

Q.15 (c) Write a note on factor and which affect on the rate of respiration.

Ans. **FACTORS AFFECTING THE RATE OF TRANSPIRATION**

Important factors, which affect the rate of transpiration in plant are:

(i) ***Light*** (ii) ***Temperature***

(iii) ***CO_2 Concentration*** (iv) ***Humidity and Vapour Pressure***

(v) ***Wind*** (vi) ***Availability of Soil Water***

(i) Light:

Light is the most important factor affecting the transpiration. We know 90% of transpiration is through the stomata of plant. The light directly controls the opening and closing of stomata.

In strong light the rate of transpiration is much as compared with dim-light or no light. Light causes potassium ions to be pumped through the stimulus via pigments of leaf cells actively through cell membrane of guard cells. As the potassium actively enters the guard cells, water follows and guards cells become turgid. Some of the stomata opens. At night light is not present to activate the pigments the potassium pumping stops. The extra potassium present within guard cells diffuses out and the water follows and guard cells become **flaccid.** So stoma closes and water is conserved in the plant causing water to follow by osmosis. Guard cells become turgid and stoma or pore opens. When potassium leaves the guards cell (during night) water leaves the guard cells by exosmosis and guard cells become flaccid and stoma or pore between guard cell closes.

(ii) Temperature:

When the sunlight is strong on a bright and sunny day the environmental temperature is increased by concentration and conduction. ***The higher temperature reduces the humidity of the surrounding*** air. Some water vapour diffuse at a faster rate. As steeper the gradient the faster is the rate of diffusion. So water diffuses rapidly from the air spaces in the leaves outside through stomata.

The evaporation of water from surfaces of mesophyll cells also increases, thus increase in the rate of transpiration. At high temperature when leaf cells start abscisic acid is released. This hormone stops the active transport of K^+ into guard cells, overriding the affect of light and CO_2 concentration. So pumping stops and stomata closes.

The rate of transportation doubles every rise in 10°C in the temperature. Every high environmental temperature i.e., 40-45°C causes closure of stomata, so that plant does not loose much needed water. It also stops wilting of leaves and of plants (herbaceous plant). If higher temperature are maintained in the environment for a longer duration and soil water is limited, the plants would wither and may die.

(iii) Carbondioxide Concentration:

Low carbon dioxide concentration, as during the daytime, stimulates the active transport of potassium ions into guard cells. The transport causes stomata to open and allow CO_2 to diffuse in the mesophyll cell of the leaves.

At night cellular respiration in the absence of photosynthesis raises CO_2 level. This halts the inward transport of K^+ and thus of water allowing the ***guard cells to close and transpiration almost stops***.

(iv) Humidity and Vapour Pressure:

When air is dry the rate of diffusion of water molecules, from the surface of more water is lost, increasing the rate of transpiration. In humid air. The steepness of gradients is much reduced and diffusion process rate is reduced. ***They decrease the rate of transpiration appreciably***.

(v) Wind:

The air in motion is called wind. It causes ***increase in rate*** of diffusion of water molecules.

The rate of evaporation from the surface of mesophyll cells increases, and these water vapours also diffuse from the leaf air spaces to outside at a faster rate through, stomata, when they are open during daytime.

During night the affect of wind does not significantly increases rate of transpiration. When air is still, the rate of movement of water molecules (diffusion) is slowed down thus ***reducing the rate of transpiration***.

(vi) Availability of Soil Water:

If there is little water in the soil, less is brought or transported to the leaf cells and less is lost in the environment by transpiration. If there is little water in the soil, the soil solution becomes more concentrated and its water potential decreases. So less water or no water enter by osmosis into the root cells through the cell membranes of these cells.

So when the rate of absorption of water in root cell is reduced, the rate of transpiration is reduced.

Q.16 What are the factors affecting the rate of transpiration? Describe them in detail.

Ans. **IMPORTANCE OF TRANSPIRATION**

Transpiration Steam: Rate of transpiration for plant is very important as the transpiration steam is necessary to distribute mineral salts throughout the plant, since these move with water.

Transport: Water is transported to photosynthesizing cells of leaves.

Cooling Effect: It cools the plant. This is important in higher temperatures.

Wilting: If the rate of transpiration is high, there would be much loss of water from the plant. So at high temperatures the stomata almost close and reduction in the rate of transpiration is noted. This stops wilting of leaves and of plants (herbaceous plants).

Q.17 Why is transpiration necessary evil? Also give its importance.

Ans. **TRANSPIRATION AS NECESSARY EVIL**

Transpiration has been described as necessary evil because it is an inevitable, but potentially harmful, consequence of existence of cell surfaces from which evaporation occurs.

Water vapours escape along the route used for gaseous exchange between the plant and its environment, which is essential for photosynthesis and respiration.

Loss of water from the plant can lead to wilting, serious desiccation and often death of plant if conditions of drought are experienced. There is good evidence that even mild water stress results in reduced growth rate and in crops to economic losses through reduction of yield.

Importance

Transpiration is of very great importance for the plant:

(i) ***Water is conducted*** or transported in most tall plants with the courtesy of transpiration pull.

(ii) ***Minerals dissolved*** in water are distributed throughout plant body by transpiration stream.

(iii) ***Evaporation of*** water from the exposed surface of cells of leaves has cooling affect on plant.

(iv) Wet surface of leaf cells allow ***gaseous exchange***.

Q.18 Give comparison between transpiration and exudation (Guttation).

Ans. **COMPARISON OF TRANSPIRATION AND EXUDATION**

Sr. No.	Transpiration	Exudation (Guttation)
(i)	The water is lost in the ***form of vapours***.	Water is lost in the ***form of liquid***.
(ii)	Water vapours are in the ***form of pure water***.	The water droplets also ***contain dissolved minerals***.
(iii)	When Vapours ***escape through stomata, cuticle leaf, lenticels*** of stem.	Water escapes ***through hydathodes***, present at the tip or margin of leaf.
(iv)	The opening and closing of stomata (which accounts for 90% of transpiration) is regulated by the guard cells.	***Hydathodes are always open***, and the flow of water outside is not regulated by cells surrounding the hydathodes.
(v)	The loss of vapours in transpiration is most effective when sunlight is available i.e. ***during daytime***.	Light is not necessary for exudation (guttation). ***During night the rate of loss of water is more*** as transpiration is almost absent.
(vi)	The loss of water from the surface of mesophyll cells produces the ***transpiration pull*** and water is brought on and conducted to the leaves.	The ***root pressure*** pushes water and forced out through hydathodes.
(vii)	All plants exhibit transpiration.	The plant exhibiting guttation (exudation) are pistia, rose, garden nasturtium etc.

Q.19 Describe the translocation of food through phloem. What are the patterns of transport of organic solutes?

Ans. **PHLOEM**

The phloem is generally found on the outer side of primary and secondary vascular tissue in plants with secondary growth.

Structure of Phloem:

The phloem constitutes the inner bark. The cells of phloem that conduct or transport ***sugars*** and other ***organic material*** throughout the plant are called ***sieve elements***.

In addition to sieve elements, phloem also contains companion cells, parenchyma and in some cases fibers, sclereids and latex containing cell (laticifers). However, only sieve tube cells are directly involved in transport.

Adaptations of Sieve Tube:

Sieve areas portions of cell wall; characterize sieve elements where ***pores interconnect the conducting cells***. Some of the sieve areas of sieve tube members are differentiated into ***sieve plates***. Sieve plates have larger pores than the other sieve areas in the cell, and are generally formed in and walls of sieve tube members where the individual cells are joined together to form the longitudinal series called a sieve tube. Sieve plate pores of sieve tubes are essentially open channels that allow transport between cells.

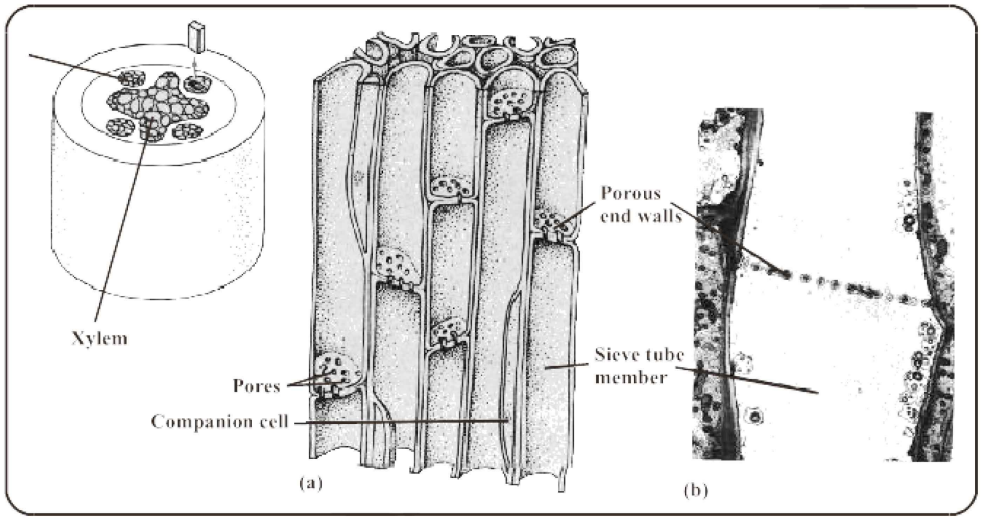


Fig. This diagram shows part of the root phloem consisting of sieve tube members stacked end to end. Adjoining end walls have common process. Each sieve tube member is associated with a companion cell (b) sieve tube member showing the pores in its end walls. Note the scarcity of cytoplasmic components in these sugar conducing cells.

Function of Phloem:

Each sieve tube member is associated by one or more ***companion cells***. Sieve tube and comparison cells are in communication with each other. ***Plasmodesmeta*** companion cells supply ATP and proteins to sieve tube. The photosynthetic products form photosynthesizing cells, the mesophyll.

Patterns of Transport:

Phloem transport does not occurs exclusively in an upward or downward direction and is not defined with respect of gravity.

Transport or translocation occurs from the areas of supply (sources) to areas of metabolism on shortage (sinks). The areas of sources include any exporting organ typically a mature leaf that is capable of:

(i) Storing photosynthate in excess of its own needs.

(ii) Storage organ during the exporting phase of its development, in biennials e.g. beet root (Beta meritinia) is a sink in first growing season, but becomes source in the next growing season, when sugars are utilized in growth of new shoots.

(iii) ***Sinks*** are the areas of metabolism or storage roots, tuber, developing fruits and for normal development.

The movement in phloem is from sources to sink in most of the plants during active photosynthesis. But when the plants are deciduous in which the leaves fall off during autumn, the movement in phloem is from sink to source i.e., growing tips of shoots of the plants.

Q.20 Describe the mechanism of phloem translocation.

Ans. **THE MECHANISM OF PHLOEM TRANSLOCATION/TRANSPORT**

There are two main theories about the translocation through phloem:

(1) Diffusion (2) Pressure Flow Theory

(1) Diffusion:

Diffusion is far too slow to account for the velocities of sugar movements in phloem i.e., one meter per hour, while the rate of diffusion is 1 meter per eight year. So we are left with pressure flow theory.

(2) Pressure Flow Theory:

Ernst Munch first proposed the hypothesis in 1930. Now this hypothesis has been given status of theory.

Accounting to this Theory:

The flow of solution in the sieve elements to be driven by an osmotically generated pressure gradient between source and sink.

Transport of Sucrose:

(i) The ***glucose*** is converted to non-reducing sugar i.e., ***sucrose***, which is actively transported through the bundle sheath cells to the companion cell of the smallest vein in leaf short distance transport (involving 2-3 cells).

(ii) ***The sucrose diffuses through plasmodesmata to sieve element or sieve element.*** It raises the concentration of sucrose the sieve element on sieve tube cell. The pathway taken by sucrose is symplastic in most cases but some apoplast movement does take place.

(iii) The sucrose is actively transported to sieve elements as the ***water moves by osmosis from the near by xylem in leaf vein***.

The increase hydrostatic pressure of the sieve tube or element.

(iv) ***Hydrostatic pressure*** moves the sucrose and other substance in the sieve tube cells and move to sink. The movement of sucrose is ***apoplastic***. In the shortages sinks, such as sugar beet root and sugar cane stem, sucrose is removed into apoplast prior to entering ***symplast*** of the sink.

(v) ***In symplastic pathway*** sucrose (on sugar) move through plasmodesmata to the receiver cell. Thus according to pressure flow theory, the pressure gradient is established as a consequence of entry of sugars in the sieve elements at the source, the removal of sugar (sucrose) at the sink. The energy driven entry of sugars in sieve tube ***generate high osmotic pressure*** in the sieve tube elements of source causing a steep drop in the water potential.

(vi) ***The presence of sieve plates greatly increases the resistance along the pathway*** and results in generation and maintenance of substantial pressure gradient in the sieve elements between sources and sink.

(vii) The sieve elements contents are physically pathway by ***bulk flow***, much like water circulates throughout the plant between the transpiration (xylem) and ***translocation*** (phloem) pathway.

The pressure flow theory accounts for the mass flow molecules within phloem. It may be noted that photosyntheate or carbohydrates from the mesophyll cells to phloem tissue involves diffusion and active transport (carrier, mediated transport). Then in phloem tissue the movement of materials is according to pressure flow theory.

Again in sink cells when the sugar are the carbohydrates are passed from the phloem tissue diffusion and carrier mediated, either passive or active take place.

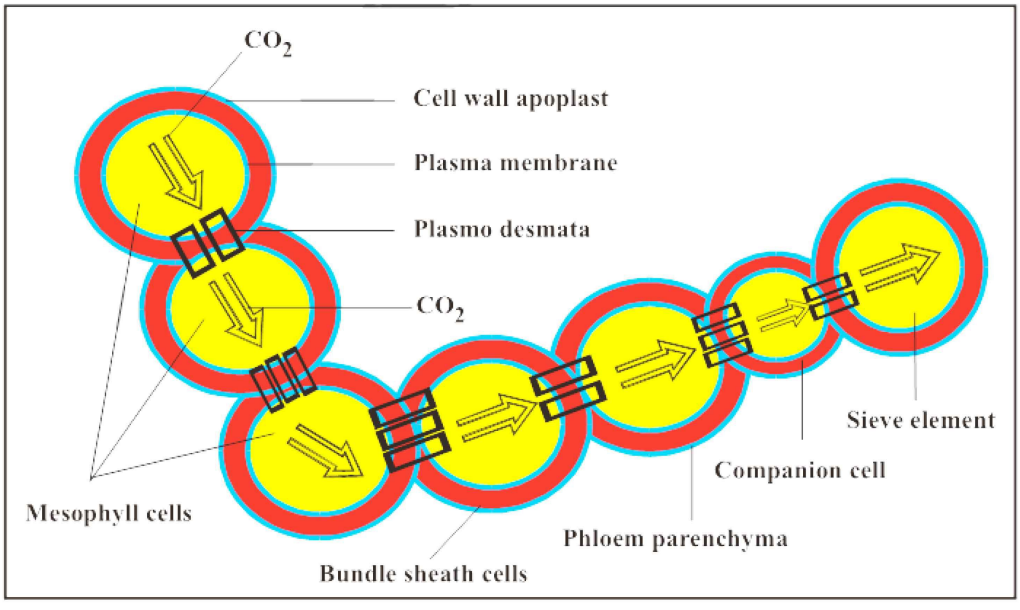


Fig. Movement of sugars from mesophyll cells to sieve elements

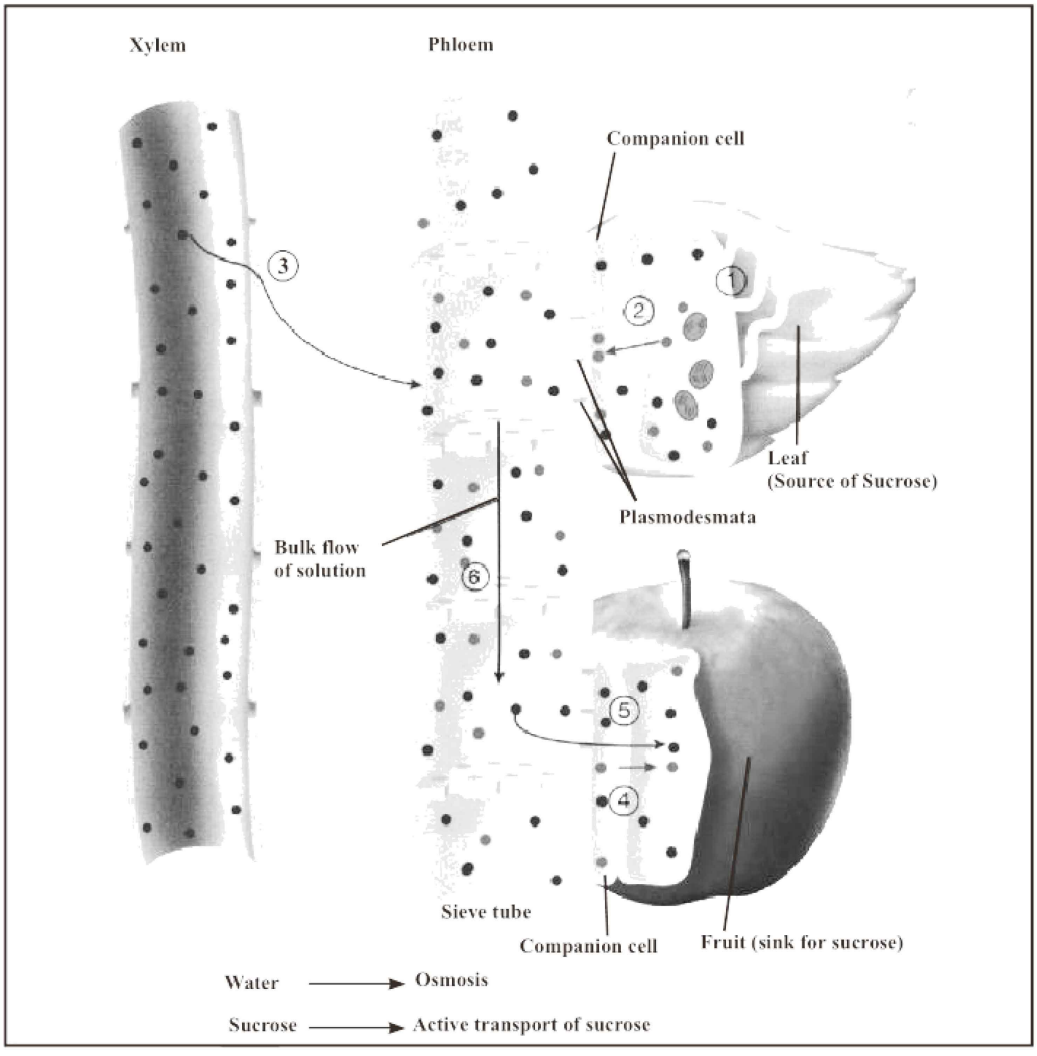


Fig. The Pressure-flow theory (a) A photosynthesizing leaf manufactures sucrose (red dots), which (2) is actively transported (red arrow) into a nearby companion cell. The sucrose diffuses to sieve-tube element through plasmodesmata, raising the concentration of sucrose. (3) Water (blue dots leaves nearby xylem and moves into the "leaf end" of the sieve tube by osmosis (blue arrow), raising the hydrostatic pressure. (4) The same sieve tube connects to a developing fruit (sink); sucrose enters the companion cells by diffusion through plasmodesmata. It is then actively transported out of the companion cells and into the fruit cells. (5) water moves out of the sieve tube by osmosis, lowering the hydrostatic pressure within the tube. (6) High pressure in the leaf end of the phloem and low pressure in the fruit end cause water, together with any dissolved solutes, to flow in bulk from leaf (source) to fruit. (Black arrow).

Q.21 Why is transport system not necessary in unicellular organism? Describe the process of transportation in:
(a) Hydra (b) Planaria

Ans. **TRANSPORT IN UNICELLULAR ORGANISMS**

Unicellular animals have maximum surface area to volume ratio and most of the substances move in or move out by simple diffusion. Osmosis, active transport and facilitated diffusion. So there is no special transport system involved.

Transport in Multicellular Organisms

It belongs to group **Cnidaria**. It is ***fresh water*** in habit.

Body Structure:

The body is two layered and outer ectoderm and inner **endoderm**. In between them in **mesoglea**, which is non cellular gelatinous layer. The outer surface of the **ectoderm** cells are exposed to the water in which the animal lives.

Intake of Materials:

Water, dissolved O_2, and food are taken into **coelenteron (enteron)** of Hydra by movement of ***tentacles*** and ***flagella***, which are present in most cells of endoderm. The food material may be absorbed by cells or are taken up by **endocytosis.**

Transport:

The endoderm cells take up the food and O_2 along with water directly from the water in the coelenteron. The wastes pass from endoderm cells in the water is coelenteron. The water escapes through mouth by movement of ***tentacles*** and flagella to the outside. The ectoderm cells directly exchange materials with the surrounding water and get nutrition from endodermal cells.

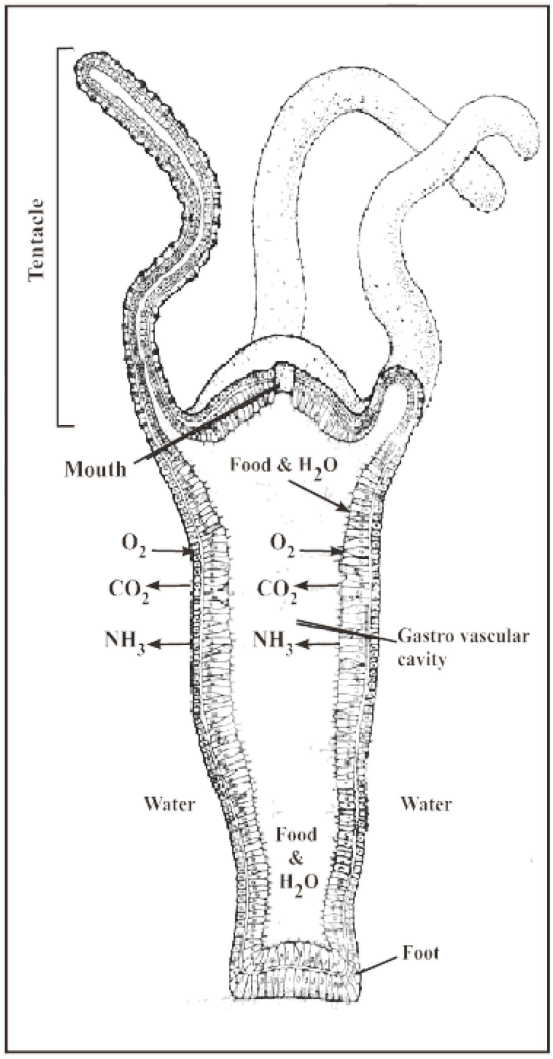


Fig. Transportation in Hydra

Excretion (By Diffusion):

The indigestible and partly digested food is removed by exocytosis or diffusion.

Q.22 How does transportation occur in unicellular and simple aquatic animals?

Ans. **Transportation in unicellular** and simple aquatic animals takes place by means of ***simple diffusion***, osmosis, active transport and facilitated diffusion. These animals especially unicellular have maximum surface area to volume ratio. They do not posses well organized and developed transport system.

Q.23 Discuss transportation system in Hydra.

Ans. **Hydra** lives in fresh water. The animal is ***diploblastic*** i.e., the body is divided into two layers; the outer ectoderm and inner endoderm; in between them is **mesoglea** which is non-cellular or jelly like. The animal is completely exposed to the water thus dissolved oxygen, food and water are taken into the ***coelentron*** (entron) of Hydra by the movement of tentacles, and flagella which are present in most cells of endoderm.

The absorption of food material is done by **endocytosis** by endodermal cells. The indigestible and partly digested food is removed by **exocytosis** from these cells, into digestive cavity (coelentron), ectodermal cells get food from endodermal cells by diffusion. The ectoderm cells directly exchange materials with the surrounding water. They also obtain nutrients from endodermal cells.

Q.24 Why is planaria not has special transport system?

Ans. (i) The body of planaria is ***dorsoventrally compressed*** i.e. ***flat***. Most of its cells are exposed to the outer water and by diffusion exchange of material takes place.

(ii) The animal being ***acoelomate*** do not have body cavity and the mesodermal layer (***mesenchyma***) is composed of loosely packed cells between ectoderm and endoderm. The materials such as oxygen diffuses in the ectoderm, mesoderm and lastly into endoderm cells whereas removal of waste occurs through the same route but in reverse direction. Digestive system possess ***intestinal caecae*** which reach to almost every cell of the body and digested food is provided to the cells by diffusion. The endoderm cells, can also acquire water, dissolved minerals, little oxygen and remove waste into the ***gut***.

Q.25 Write down the characteristics of circulatory system in complex multicellular animals.

Ans. **CHARACTERISTICS OF CIRCULATORY SYSTEM**

A circulatory system is meant for the ***rapid mass flow of materials*** form one part of the body to the other, where diffusion would be too slow. Circulatory system has the following three characteristics:

(i) A circulatory fluid—the ***blood***.

(ii) A contractile pumping device—may be ***modified blood vessel*** or a ***heart***.

(iii) Tubes, which can transport, the circulatory fluid (blood) to and from cells of the body. These tubes are the ***blood vessels*** through which exchange between blood and body cells takes place.

Q.26 Differentiate between open and close circulatory system. Discuss with reference to the circulatory system of earthworm and cockroach.

Ans. (a) Open Circulatory System

In such type of circulatory system ***blood does not flow in vessels*** rather if flows freely in the body cavity e.g., such circulatory system is present in phylum. **Arthropoda** (crustaceans, spiders, insects), phylum **Mollusca** (snails and clams) and group of **protochordates**, the **tunicates.**

(b) Closed Circulatory System

In such circulatory system ***blood is transported within blood vessels*** throughout the body such type of circulatory system is present in annelids, cephalopod, mulluscs (squids and octopus), echinoderms and vertebrates.

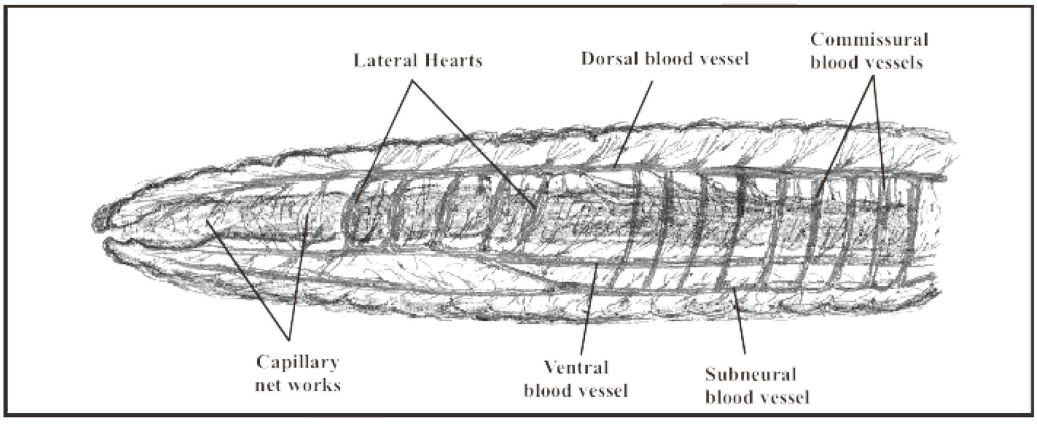


Fig. Closed circulatory system of earthworm

COMPARISON BETWEEN CLOSED AND OPEN CIRCULATORY SYSTEM

	Close Circulatory System (Earthworm)	Open Circulatory System (Cockroach)
1.	***Blood always remain in the blood vessels***, and does not come in direct contact with other cells of the body.	***Blood does not remain enclosed in the blood*** **vessels** and come in direct contact with other body cells, and bathes them.
2.	Inter connected system of ***arteries, veins***, and ***capillaries*** present.	There are ***no typical arteries***, **veins and** ***capillaries*** and for much of the time the blood called ***haemolymph*** flows in the cavities orisinuses of body cavity (haemocoel) around the viscera (***perivisceral sinus***) and around the nerve cord (***perineural sinus***).

3.	Exchange of nutrients and waste products between the blood and tissues via tissue fluid occurs through ***capillaries***.	Exchange of nutrients and waste products between the blood and tissue occurs when ***blood directly bathes the tissues***.
4.	The system also transport gases i.e., oxygen and carbondioxide.	This system does not transport gases i.e., oxygen and carbon dioxide. (The gases transported by ***tracheal system***).
5.	***Respiratory pigment haemoglobin*** is dissolved in blood. Nucleated white blood cells are present.	***No respiratory pigment*** and blood is colourless in which nucleated white blood cells float.
6.	This is regarded as the most advanced type, having greater efficiency, ***maintainance of blood pressure*** and economy of blood volume.	This is regarded as primitive having lesser efficiency and does not maintain ***blood pressure***.
7.	In earthworm there are ***4 or 5 pairs of lateral hearts*** present on the lateral side of oesophagus in 7^{th} to 13^{th} segments. Hearts pumps the blood from the dorsal to the ventral vessel.	In cockroach the heart is ***13-chambered*** tubular vessel present in the ***pericardial sinus*** and placed in mid-dorsal region below terga in abdominal region. On the side of the heart chambers there are alary muscles helping in the flow of blood. Each heart chamber has a pair of lateral openings, the ***ostia***.
8.	There are three main longitudianally running blood ***vessels***: ***dorsal***, ***ventral*** and ***sub-neural***, which are interconnected through capillaries and commissural vessels.	The portion of the tubular dorsal vessel which extends in the thoracic and head region is called the ***'aorta'***. It opens anteriorly in the haemocoel of the head by funnel shaped opening.
9.	The ***dorsal vessel collects blood from the 14^{th} segment backwards***. In the first 13 segments it becomes distributing channel and sent its blood to hearts and anterior end of the body ***Ventral vessel is the chief distributing*** vessel with backward flow. The ***subneural vessel is collecting vessel and the flow of blood is backwards***. It communicates with dorsal blood vessel through ***commissural vessels***.	The flow of blood from heart to, aorta to, haemocoel in head, to perivisceral sinus, to perineural sinus, to perivisceral sinus, to ***pericardial sinus***, and to heart through ostia.

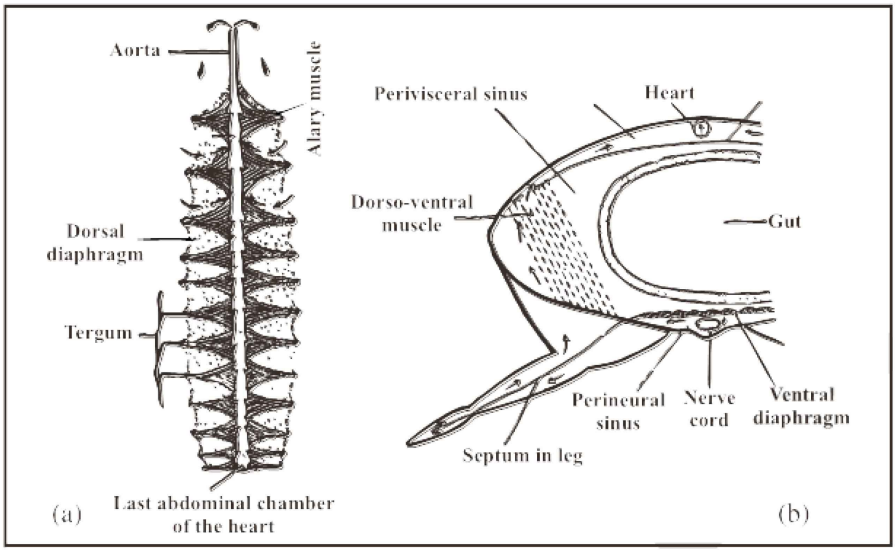


Fig. Open circulatory system of cockroach
(a) Heart with alary muscle and dorsal diaphragm.
(b) T.S. of cockroach through thorax showing various sinuses.

Q.27 *Write a short note on blood circulatory system in vertebrates.*

Ans. ***Close type blood circulatory system is present in vertebrates***. Blood flows in ***arteries, veins*** and ***capillaries***. In addition ***lymphatic system*** is also involved in transportation.

Heart is the pumping organ which pumps blood to the body via aorta and arteries.

Arteries carry oxygenated blood (except pulmonary artery) and veins carry deoxygenated blood (except pulmonary vein which carries oxygenated blood) as in man.

The ***capillaries*** are the sites where exchange of materials between blood and body tissues takes place.

Q.28 *Discuss the comparative study of vertebrate heart?*

Ans. **HEART OF AMPHIBIA**

In amphibians the *heart is* ***three chambered*** with regard to auricles and ventricles.

- There are two **auricles** and one **ventricle.**
- In addition **sinus venosus** and **truncus artiosus** are also present. Sinus venosus *receives deoxygenated blood from two superior vena cava* (precavals) and one inferior vena cava (postcaval) from different parts of the body. This blood passes to the right auricle.

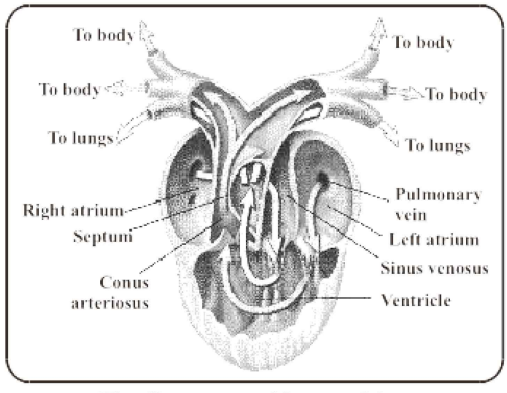


Fig. Structure of heart of frog

- The oxygenated blood from lungs is poured via pulmonary veins into left auricle.
- Both auricles contract simultaneously and blood is passed onto the ventricles. There is a ***complete mixing of oxygenated and deoxygenated blood*** in the ventricle. When ventricle contracts, it pushes blood via truncus arteriosus, to two **carotids**, two **systemics**, and two **pulmocutaneous arches.**

Heart of Reptiles

The heart of reptiles and all other **amniotes** practically function as ***four chambered heart***. There are ***two autricles*** in the heart of reptiles.

The reptiles have **incompletely partitioned ventricle**; but in crocodiles, the **interventricular septum** is complete and heart is four chambered.

In all reptiles the left and right systemic arches carry oxygenated blood and arise from a region of ventricle called **cavum venosum** into which left ventricle directs its blood.

The deoxygenated blood from the right atrium is directed towards the entrance of the pulmonary trunk which is also located or starts from a pocket the ***cavum pulmonale****, on right side of ventricle – in the animals (reptiles)* which do not have completely divided ventricle.

Although the two systemic arches start from the ventricle separately, they are also interconnected at their base by an opening. The hearts of reptiles, birds and mammals function as **double circuit heart.**

Heart of Birds and Mammals

In the birds and mammals, the **heart is four chambered**, and *oxygenated and deoxygenated blood* does not mix at all.

The **ventral aorta** is divided into two trunks, the **pulmonary trunk** arises from right ventricle and leads to the lungs.

The ***aortic trunk*** *emerges from the left ventricle and leads to carotid and systemic arches.*

The left systemic disappears in birds and right systemic, most of it, disappears in mammals.

In reptile, birds and mammals, as a result of these modifications, all blood returning to the right side of the heart passes to the lungs. After oxygenation, blood returns to left atrium from the lungs via pulmonary veins.

Left atrium passes this blood to left ventricle – which on contraction pumps it to different parts of the body, and again blood returns to right atrium.

Pulmonary circulation is by pulmonary arch carrying deoxygenated blood from right ventricle of heart to lungs, and the blood returns to left atrium after oxygenation via pulmonary veins.

Likewise the systemic arch distributes blood to different parts of the body, and then the blood from the body returns to the heart, in the right atrium via precaval and postcaval. This is **systemic circulation**.

*So the hearts of amphibians, reptiles, birds and mammals have both **pulmonary** and **systemic circulation**.*

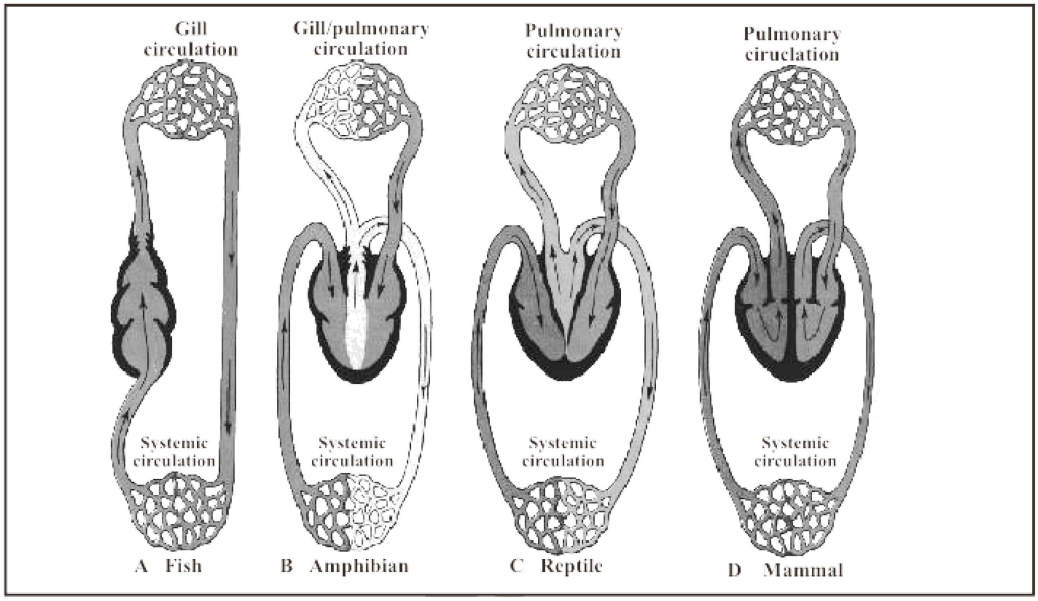


Fig. A schematic comparison of vertebrate heart and circulation of blood. (A) In modern fish the blood is pumped to the gills, where it picks up oxygen. The oxygenated blood (red) then passes without further pumping to the systemic circulation, where it gives up its oxygen before returning to the heart. (B) In amphibians the blood that has picked up oxygen in the gills and/or lungs returns to the heart, from which it is pumped into the systemic circulation. Extensive mixing (purple) of the pulmonary and systemic flows occurs in the heart. (C) In reptiles the pattern is much the same, except that the ventricles are partially divided, so less mixing takes place. (D) in mammals and birds the two halves of the heart are effectively separated.

Transport in Man

In humans, in addition to blood circulatory system, there is also another transport system, the *lymphatic system*.

Blood Circulatory System:

The circulatory system of humans have the same 3 basic components

(a) *Circulatory fluid* : the ***blood***

(b) The *pumping organ* : the ***heart***

(c) The *blood* ***vessels***, arteries, capillaries and veins.

Q.29 What is the composition of blood? Discuss the composition and function of Plasma.

Ans. **COMPOSITION OF BLOOD**

The blood is the medium in which dissolved nutrients, gases, hormones, and wastes are transported through the body.

It is made up of two main components,

(i) plasma and

(ii) cells or cell like bodies (white blood cells, red blood cells, platelets).

The weight of the blood in our body is about 1/12th of our body.

Plasma:

It has been estimated that in normal person plasma constitutes about **55% by volume** of the blood, and cells or **cell-like bodies about 45% by volume** of the blood.

Plasma is primarily water in which *proteins, salts, nutrients and wastes are dissolved.*

Water constitutes about **90% of plasma, 10% are dissolved substances**. Most of the dissolved substances are maintained at a constant or nearly constant level, but other occurs in varying concentrations.

The substances dissolved or present in plasma vary in their concentrations, with the condition of the organism and with the portion of the system under examination.

The solutes can be divided into six categories:

(i) Inorganic Ions or Mineral Ions:

Together the inorganic ions and salts make up **0.9 per cent of the plasma**, of humans, by weight; more than two thirds of this amount is sodium chloride the ordinary table salt. Even if the total concentration of dissolved substances remains the same, shifts in the concentration of particular ion can create serious disturbances. The normal **pH of human blood is 7.4**; and it is maintained between narrow limits, because the change in *pH would affect the chemical reactions of the body.*

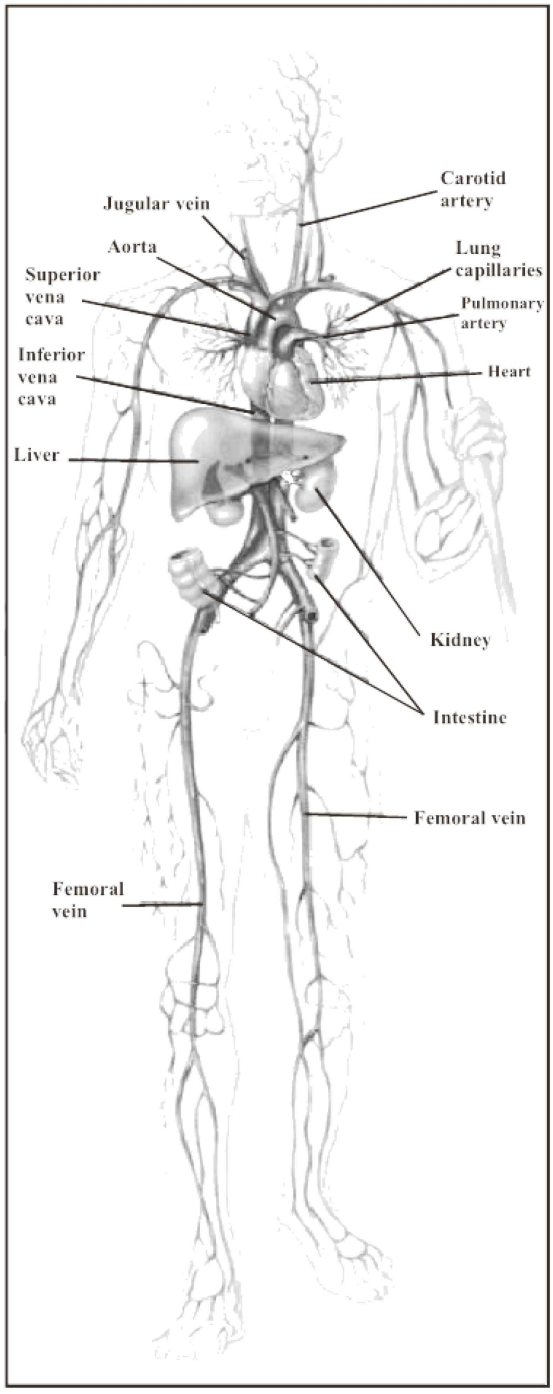


Fig. The human circulatory system

(ii) The Plasma Proteins:

The plasma proteins constitute **7-9 percent** by weight of the plasma. Most of these proteins are synthesized in the liver. Some of the globulins, called **immunoglobulins** or antibodies, are produced in response to antigens, by **lymphocytes** cells; and then are passed to plasma, and lymph.

The proteins like **prothrombin** acts as a catalyst in blood clotting process. Fibrinogen takes part in the blood clotting process. Immunoglobulins play important role in body's defences against disease.

(iii) Organic Nutrients in the Blood:

Organic nutrients in the blood include, *glucose, fats, phospholipids amino acids* and lactic acids. Some of them enter the blood from the intestine (absorption). *Lactic acid* is produced in muscles as a result of glycolysis, and is transported by blood to liver. *Cholesterol* is an important constituent, it is metabolized to some extent, but also serves as precursor of steroid hormones.

(iv) Plasma Contains Nitrogenous Waste Products:

Plasma also contains nitrogenous waste products as a result of cellular metabolism. These products are carried from the liver where they are produced, to the organs from where they are removed i.e., kidneys. **Urea** and small amounts of **uric acid** are present in plasma.

All the hormones in the body are carried by blood – so they are present in the plasma.

The gases such as CO_2, O_2 are present in the plasma of the blood.

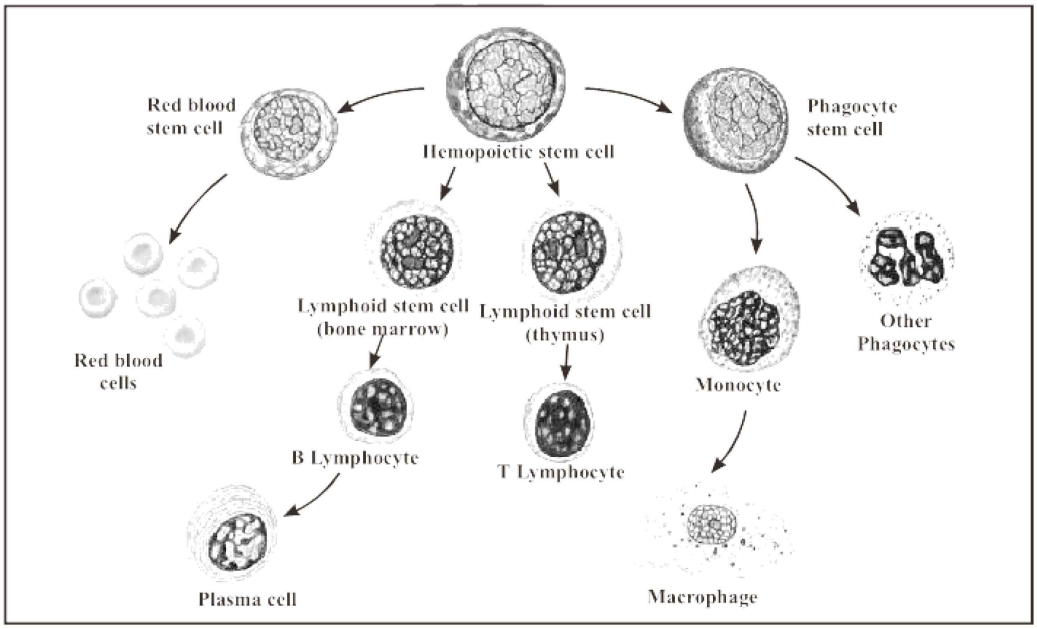
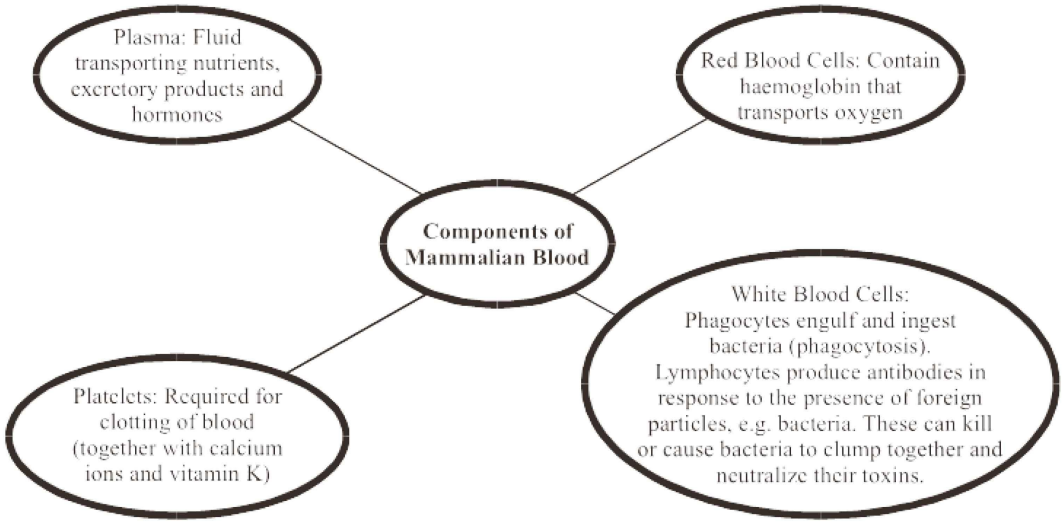


Fig. Red blood cells (erythrocytes) and white blood cells (Leucocytes) both develop from stem cells in bone marrow.

➢ **Concept map showing the components of the mammalian blood**



➢ **Differences between red blood cells and white blood cells:**

Red blood cell	White blood cell
♦ Contains haemoglobin ♦ No nucleus ♦ Circular, biconcave in shape ♦ Transports oxygen	♦ Haemoglobin absent ♦ Nucleus present ♦ Irregular in shape ♦ Phagocytosis or production of antibodies
➢ ♦ Mammals have a double circulation: pulmonary and systemic circulation. ♦ The transport system consists of the blood system and the lymphatic system. ➢ Essential features of blood circulatory system: ♦ Heart: to pump blood round the body. ♦ Thick-walled arteries: to carry blood from heart. ♦ Thin-walled veins: to bring blood back to heart. ♦ Microscopic blood capillaries: to allow exchange of substances. ♦ Valves in heart, veins and the arteries emerging from heart ventricles: to ensure unilateral blood flow, thus preventing backflow.	➢ A heartbeat consists of a ventricular systole and diastole. ➢ The lymphatic system helps to return most of the excess tissue fluid back to the bloodstream. ➢ Tissue fluid is plasma without the proteins, but it contains white blood cells. Serum is plasma without fibrinogen. ➢ Atherosclerosis is the deposition of fatty substances (cholesterol) on the inner walls of an artery. ➢ The formation of a local blood clot in an artery is called a thrombosis.

Q.30 Write down the properties of blood cells and cell like bodies?

Ans. BLOOD CELLS AND CELL LIKE BODIES:

These include red blood cells, (**Erythrocytes**), white blood cells (**leucocytes**) and platelets.

(a) Red Blood Cells (*Erythrocytes*):

Most Numerous: These are most numerous of the cells in the blood.

In males: *A cubic millimeter contains* ***5-5 ½ million*** of them in males.

In females: **4-4 ½ million** in females

Absence and Presence of Nucleus: These cells, when formed, have nucleus, but is lost before they enter the circulatory fluid or blood.

Cytoplasmic Compositions: 5% of the cytoplasm of red blood cells is the *red pigment, called haemoglobin*. The remaining 5% consists of *enzymes, salts* and other *proteins*.

Limited Division: The red blood cells once mature, do not divide.

Biconcave and Elastic: These cells are biconcave and have an elastic cell membrane.

Production in Red Bone Marrow: Red blood cells are formed principally in the red bone marrow of short bones, such as the sternum, ribs and vertebrae.

Formation in Embryo: In the embryonic life, they are formed in the liver and spleen.

Life Span: The average life span of red blood cell is about four months after which it breaks down and disintegrated in the liver and spleen – partly by phagocytes by Phagocytosis.

Destroying Period: About 2-10 million red blood cells are formed and destroyed every second in a normal person.

Transport CO_2 and O_2: Their main function is to transport O_2 and CO_2.

(b) WHITE BLOOD CELLS (*leucocytes*):

Colourless: These blood cells are colourless, as they do not contain pigments.

Amount: One cubic milimetre of blood contains 7000 to 8000 of them.

Larger than RBCs: They are much larger than the red blood cells.

Cytoplasmic and Nuclear Variety: There are at least five different types which can be distinguished on the basis of the shape of the nucleus and density of granules in the cytoplasm.

Main Types of WBCO: They can be grouped into two main types, granulocytes and agranulocytes.

(1) **Granulocytes** include (a) ***neutrophils***, (b) ***eosinophils*** and (c) ***basophils***. They are formed in the red bone marrow.

(2) **Agranulocytes** are formed in lymphoid tissue, such as those of the lymphocytes (B and T).

(a) **Monocytes** stay from 10-20 hours in the blood, then enter tissues and become tissue macrophages, performing phagocytic function.

(b) **Lymphocytes** have life spans of months or even years; but this depends on the body's need for these cells.

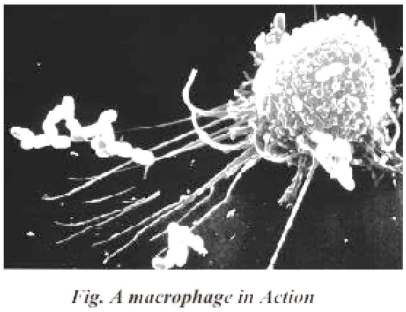


Fig. A macrophage in Action

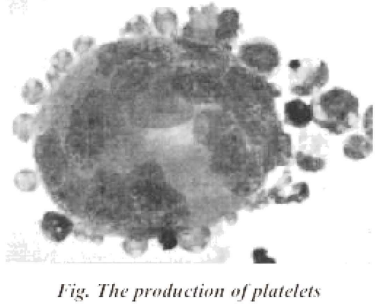


Fig. The production of platelets

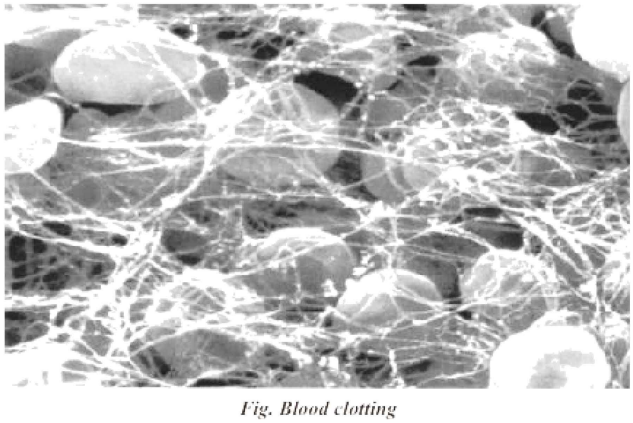


Fig. Blood clotting

CONCEPTUAL VIEW

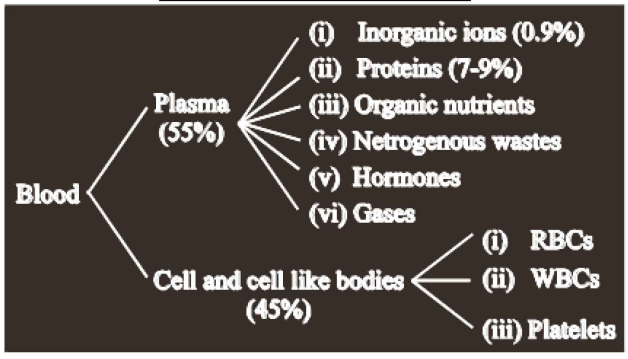
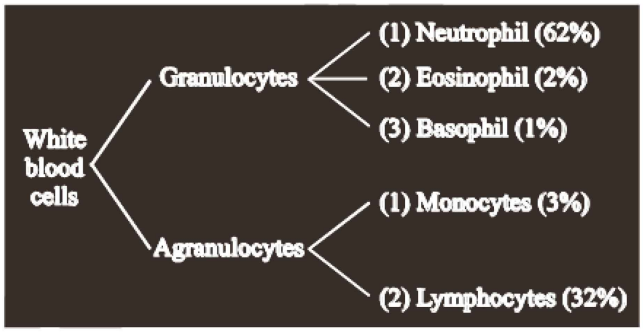


TABLE: SHOWING DIFFERENT CELL TYPES COMPARING THEIR CHARACTERISTICS & FUNCTIONS

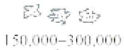
Cell Type	Description	Average Number Present	Major Functions
Red blood cell (erythrocyte)	*Biconcave disc without nucleus, Approximately **8 μm** in diameter*	***5,000,000 per mm^3***	***Transports oxygen*** and a small amount of carbon dioxide.
White blood cell (leucocytes) (a) Granulocytes		***7500 per mm^3***	
1. Neutrophil	*About twice the size of red blood cells, nucleus **two to five lobed**.*	***62% of white cells***	Destroys small particles by **phagocytosis**.
2. Eosinophil	*About twice the size of red blood cells, **nucleus bilobed**.*	***2% of white cells***	Inactivates inflammation-producing substances; attacks parasites.
3. Basophil	*About twice the size of red blood cells nucleus bilobed.*	***Less than 1% of white cells***	**Releases heparin** to prevent blood clots and **histamine**, which causes **inflammation**.

(b) Agranulocytes			
4. Monocyte	*Two to three times larger than red cells, nuclear shape from round to lobed.*	***3% of white cells***	Gives rise to macrophage, which destroys larger particle by **phagocytosis**.
5. Lymphocyte	*Slightly larger than red cell, nucleus nearly fills cell.*	***32% of white cells***	Functions in the **immune response** by producing **anti bodies**.
Platelet	*Membrane bounded cytoplasmic fragment of cells in bone marrow called megakaryocytes*	***250,000 per mm^3***	Involved in **blood clotting**.

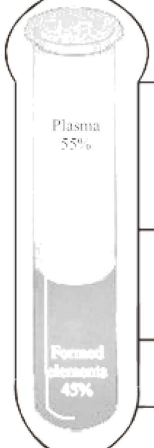
CONCEPTUAL VIEW



Scheme shows kinds and % age of white blood cells

Formed Elements	Function and Description	Source
Red Blood Cells (erythrocytes)  4 million–6 million per mm^3 blood	Transport O_2 and help transport CO_2 7–8 µm in diameter Bright-red to dark-purple biconcave disks without nuclei	Red bone marrow
White blood cells (leukocytes)	Fight infection	Red bone marrow
Granular leukocytes*		
 Basophil 20–50 per mm^3 blood	10–12 µm in diameter Spherical cells with lobed nuclei; large, irregularly shaped, deep-blue granules in cytoplasm	
 Basophil 100–400 per mm^3 blood	10–14 µm in diameter Spherical cells with bilobed nuclei; coarse, deep-red, multi-lobed sized granules in cytoplasm	
 Neutrophil	10–14 µm in diameter Spherical cells with multi-lobed nuclei; fine, pink granules in cytoplasm	
Agranular leukocytes*		
 Lymphocyte 1,500–3,000 per mm^3 blood	5–17 µm in diameter (average 9–10 µm) Spherical cells with large, round nuclei	
 Monocot 100–700 per mm^3 blood	14–24 µm in diameter Large spherical cells with kidney-shaped, round, or lobed nuclei	
Platelets* (thrombocytes)  150,000–300,000 per mm^3 blood	**Aid clotting** 2–4 µm in diameter Disk-shaped cell fragments with no nuclei; purple granules in cytoplasm	**Red bone marrow**

Plasma	Function	Source
Water (90–92% of plasma)	Maintains blood volume; transports molecules	Absorbed from intestine
Plasma proteins (7–8% of plasma) Albumin	Maintain blood osmotic pressure and pH Maintain blood volume and pressure	Liver
Fibrinogen immunoglobuline	Clotting transport, fight infection	Absorbed from intestinal villi
Salts (less than 1% of plasma)	Maintain blood osmotic pressure and pH; aid metabolism	Lungs Tissues
Gasses Oxygen Carbon dioxide	Cellular respiration End product of metabolism	Absorbed from intestinal villi
Nutrients Fats Glucose Amino acids	Food for cells	Absorbed from intestinal villi
Urea	Nitrogenous waste	Liver
Hormones, vitamins, etc.	Aid metabolism	Varied



*with Wright's stain

Fig. Composition of blood.
When blood is transferred to a test tube and is prevented from clotting, it forms two layers. The transparent yellow top layer is plasma, the liquid portion of blood. The formed elements are in the bottom layer. The tables describe these components in detail.

Functions

Protect from Invaders: Leucocytes protect the body against foreign invaders, and use circulatory system to travel to the site of invasion.

Destroy Bacteria: Monocytes and neutrophils travel through capillaries and reach the site of wound where bacteria have gained entry.

Feed on Bacteria: Macrophages and neutrophils feed on bacterial invaders or other foreign cells, including cancer cells.

Pus Result: They typically die in the process, and their dead bodies accumulate and contribute to the white substance called pus, seen at infection sites.

Produce Heparin: Basophils produce heparin – a substance that inhibit blood clotting.

Chemical Productions: These also produce chemicals, such as histamine, that participate in allergic reactions and in response to tissue damage and microbial invasion.

Provide Immunity: Lymphocytes help to provide immunity against the disease.

(c) PLATELETS:

Fragments: They are not cells, but are fragments of large cells called megakaryocytes.

Nucleus Absent: There is no nucleus in them.

No Pigments: There is no pigment in them.

Conversion of Fibrinogen: Platelets help in conversion of fibrinogen, a solid plasma protein, into insoluble form, fibrin.

Enumash RBCs: The fibrin threads enumash red blood cells and other platelets in the area of damaged tissue, ultimately forming a blood clot.

Clot Formations: The clot serves as a temporary seal to prevent bleeding until the damaged tissue can be repaired.

Q.31 What are the major functions of human blood?

Ans. **FUNCTIONS OF BLOOD**

The overall functions of blood in humans can be listed as follows:

Maintain Osmotic Pressure:

The plasma proteins maintain colloid osmotic pressure of blood (75% by albumins, 25% by globulins and almost none by fibrinogen).

Transport Material:

Blood helps in transport of materials, in the body including nutrients, water, salts and waste products. All hormones are transported by blood from the endocrine tissues to the larger cells.

Transport Gases:

Gases O_2 and CO_2 are transported by blood.

Defence Mechanism:

Blood helps in body defences against disease Neutrophils and monocytes engulf and destroy invading microorganisms e.g. bacteria.

Immunity:

Blood provides immunity by the lymphocytes.

As Buffer: Blood produces interferon, and antitoxins which are proteins, and protects our body from nuclete aids of invading organism; and toxins of the invaders. Blood acts as a buffer to maintain the acid – base balance i.e., concentration of H^+ and OH ions of the body.

Homeostasis: Helps in maintaining the body temperature, concentration of water and salts, thus helps in homeostasis.

Exchange Material:

Blood helps in the exchange of material between blood and body tissue through blood capillaries.

Maintain Internal Environment: Blood helps the body in maintaining the internal environment, by producing heparin, histamines, and also maintaining the amounts of chemicals in the body to a constant or nearly constant level.

Blood Clotting: Helps in blood clotting process.

CONCEPT

Table Body Fluids

Name	Composition
Blood	Formed elements and plasma
Plasma	Liquid portion of blood
Serum	Plasma minus fibrinogen
Tissue fluid	Plasma minus most proteins
Lymph	Tissue fluid within lymphatic vessels

Q.32 Discuss various diseases which are result due to the disorder in blood.

Ans. DISORDERS:

There are certain disorders, related to the blood. Some of them are discussed below:

(i) Leucaemia (Blood Cancer):

(1) It is the result of **uncontrolled production of white blood cells** (leucocytes). This is called by a cancerous mutation of a **myelogenous** or **lymphogenous** cell.

(2) The **leucaemia** is usually characterized by greatly increased numbers of abnormal white blood cells in the circulating blood.

(3) Myelogenous cells (bone marrow cells) are in the bone marrow – and may spread throughout the body, so that white blood cells are produced in many other organs. These white blood cells are not completely differentiated, and so are defective.

(4) Leucaemia may be of different types depending on the type of white blood cells, which are undifferentiated and being produced at a faster, **basophilic leucaemia**, **monocytic or lymphocytic leucaemia**.

(5) It is a very serious disorder and the **patient needs to change the blood regularly with the normal blood, got from donors**. *It can be cured by bone marrow transplant – which is in most cases effective, but very expensive treatment.*

(ii) Thalassaemia (*G. Thalassa = The Sea; Haema = Blood*):

It is also called Cooley's anaemia on the name of Thomas B. Cooley American pediatrician. **It is genetically transmitted haemoglobin abnormality.** It is characterized by the **presence of microcytes by spleenomegaly (enlargement of spleen) and by changes in the bones and skin.**

Common in Children:

This disease is more common in children especially of Mediterranean parents. The blood of these patients is to be replaced regularly, with normal blood.

Cure:

It can be cured by ***bone marrow transplant*** – which is very expensive – and does not give 100% cure rate. Haemoglobin molecule in most cases, does not have β chains in it, instead F. chain is present (F is foetal haemoglobin).

(iii) Oedema:

It means the **presence of excess fluid in the tissues of the body. The excess fluid may be in the cells, or outside the cells.**

Caused by Osmosis of H_2O:

The intracellular oedema is caused by osmosis of water into the cells, and cause, depression of metabolic systems (due to lack of nutrition and O_2 in the tissues) especially and the Na-pump.

(i) Abnormal leakage of fluid from the blood capillaries or failure of the lymphatic system or return fluid from the interstitial fluid.

(ii) *Oedma is caused be renal retention of salts and water.*

Disturbs the Mineral Exchange:

Oedema disturbs the exchange and concentration of, minerals and ions in the blood and body cells. Affects blood pressure, increases heart load etc.

Q.33 Describe the structure and function of human heart.

Ans. **STRUCTURE OF HEART**

Human heart is located in the chest cavity. It is enclosed in a double membranous sac called pericardial cavity which is filled with pericardial fluid. Pericardium protects the heart and prevent it from over extension. Heart is formed of three layers:

(i) **Epicardium** - outermost

(ii) **Myocardium** - middle

(iii) **Endocardium** - inner most

The myocardium is formed of special type of muscles called cardiac muscles formed of myofibrils and myofilaments of ***myosin*** and ***actin***. The arrangement and mechanism of contractility of there is similar to those in skeletal muscle fibre. The difference is that myocardium have branched cells, in which the successive cells are separated by junctions called intercalated discs.

Action of Heart

It contracts ***automatically*** and ***rhythmically***, ***imposed by automatic nervous system*** of the body.

Functions of Heart

It is divided into ***four chambers***, two upper ***thin-walled atria*** and two lower ***thick walled ventricles***. The atria receives blood and pass on to the ventricle which distribute it to the body. Human heart functions as a ***double pump*** and is involved in ***pulmonary and systemic circulation***. There is a complete separation of deoxygenated blood (right side) and oxygenated blood (left side) in heart.

Pathway of Blood Circulation

Right atrium receives deoxygenated blood from ***pre-caval*** collected from head, shoulder, arms etc. and from ***post-caval*** collected from abdomen, hind limbs etc. The blood is passed on to right ventricle through tricuspid valve having 3 flaps.

Flaps

The flaps are attached with fibrous cords called **chordeae tendinae**, to the **papillary muscles** which are extensions of wall of the right ventricle.

Ventricles

When right ventricle contracts, the blood is passed to trunk, which carry blood via left and right ***pulmonary arteries*** to the lungs. ***Semilunar valves*** are present at the base of ***pulmonary trunk***. After oxygenation in lungs the blood is brought by pulmonary veins to the left atrium, which passes this blood via ***bicuspid valve*** (having two flaps) to the left ventricle. The flaps of ***bicuspid valve*** are similarly attached through chordeae tendinae, with ***papillary muscles*** of wall of ***left ventricle***. The left ventricle contracts and pushes the blood through aorta to all parts of the body (except lungs). At the base of ***aorta*** semilunar valves are also present. The valves of the heart control the direction of flow of blood. The wall of left ventricle is thicker (about 3 times) than that of the ***right ventricle***.

Aorta

(i) At the base of aorta, first pair of arteries, the ***coronary arteries***, *arise, and supply blood to the heart.*

(ii) The ***aorta*** forms an arch, and before descending down gives three branches *supplying blood to head, arms and shoulders.*

(iii) Aorta moves down in the chest cavity. It gives many small branches to the chest wall and then passes down to the ***abdominal region***.

(iv) The branches supply blood to different parts of alimentary canal, kidneys and the lower abdomen.

(v) Aorta bifurcates into **iliac** arteries. Each of which divides into two femoral and sciatic arteries supplying blood to legs.

(vi) The blood from the upper part of the body is collected by different veins, which join to form ***superior vena cava***, which passes blood to ***right atrium***.

Iliac Vein

Two iliac veins are formed by veins which collect blood from legs and unite to form ***inferior vena cava***. It receives renal vein from each kidney, hepatic veins from liver before it enters to right atrium. The liver receives ***hepatic portal vein*** which is formed by many veins collecting deoxygenated blood with absorbed food from different parts of alimentary canal.

Q.34 Describe the cardiac cycle in detail.

Ans. **THE CARDIAC CYCLE:**

It is the sequence of events, which take place during the completion of one heartbeat. Heart beat involves three distinct stages.

Relaxation Phase-Diastole:

The deoxygenated blood enters right atrium through vena cava and oxygenated blood enters left atrium through pulmonary veins. The walls of the atria and that of ventricles are released. As the atria are filled with blood, they become distended and have more pressure than the ventricles. This relaxed period of heart chambers is called diastole.

Atria Contract with Systole:

The muscles of atria when they are filled and distended with blood, simultaneously contract. The blood passes through tricuspid and bicuspid valves, into the two ventricles which are relaxed.

Ventricle Contract-Ventricular Systole:

When the ventricles receive blood from atria, both ventricles contract simultaneously and the blood is pumped to pulmonary artery and aorta. The tricuspid and ***bicuspid*** valves close and bulb sound is made. Ventricular systole ends and ventricles relax at the same time semilunar valves at the base of pulmonary artery and aorta dose (***Lubb, dub*** can be heard with the help of ***stethoscope***).

The complete ***heartbeat*** consists of one systole and one diastole and lasts for about ***0.8 seconds***. In one's life heart contracts about ***2.5 billion times***, without stopping.

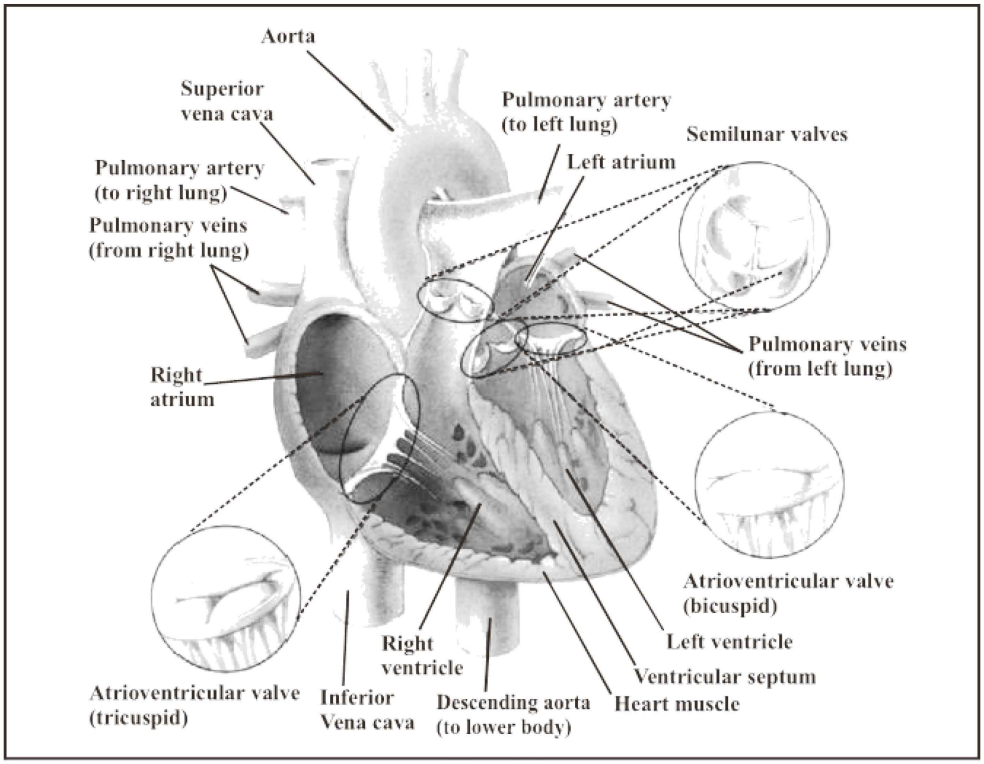


Fig. The human heart and its valves and vessels.

EASY TO DRAW

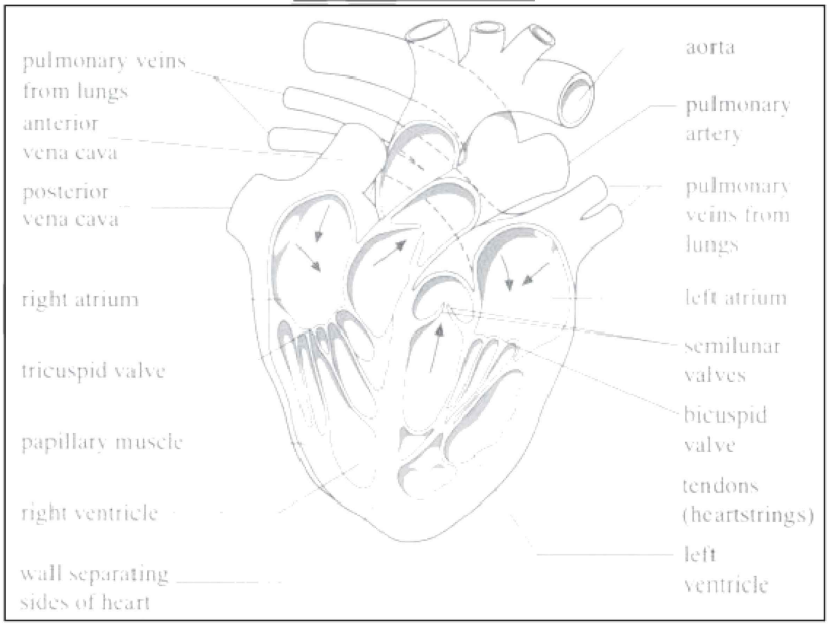


Fig. Human heart

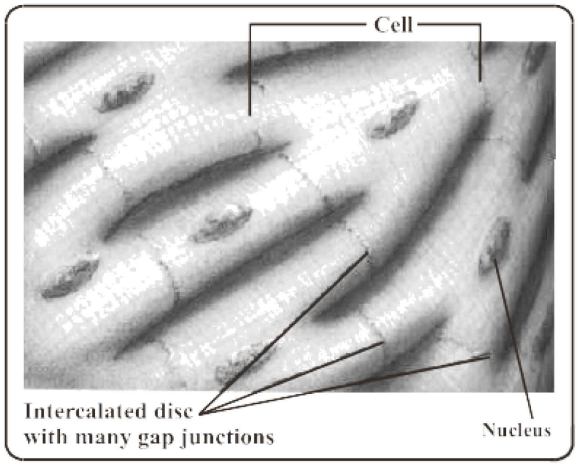


Fig. The structure of cardiac muscle

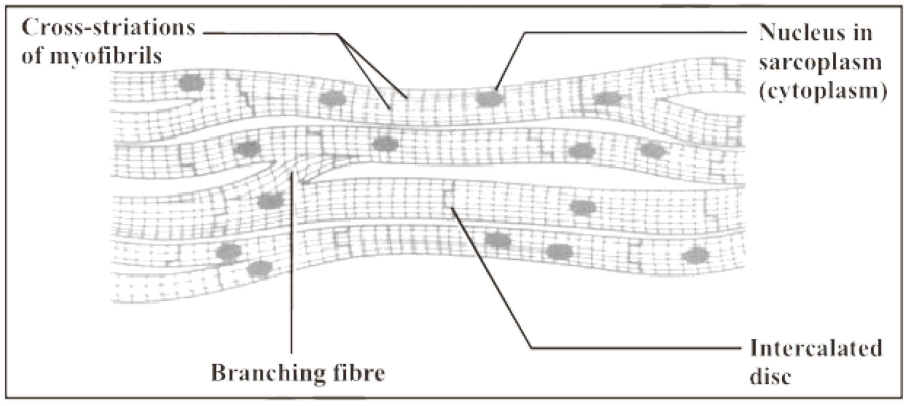


Fig. Structure of cardiac muscle

Q.35 Write notes on:

(a) Mechanism of heart excitation and contraction

(b) Electrocardiogram

(c) Artificial pace maker

(d) Blue babies

Ans. **MECHANISM OF HEART EXCITATION AND CONTRACTION**

The heartbeat cycle starts when **sino-atrial** node (***pace maker***: *a small group of specialized muscle cells at the top of right at rium*) at the upper end of right atrium sends out electrical impulses to the atrial muscles. It causes both atria to contract. The sino-atrial node is a vestige of the sinus venosus seen in the heart of lower vertebrates.

It is close to the point of entry of the vena cava. It consists of a small number diffusely oriented cardiac fibers, possessing few myofibrils, and few nerve endings from the nervous system.

Impulses from the node are propagated by the special electro conductive muscle cells to the musculature of the atrium and to an ***atrioventricular node***.

The atrial muscle fibers are completely separated from those of the ventricles by atrioventricular septum of connective tissue, except for the region in the right atrium called atrioventricular node (AV node). From atrioventricular node, an atrioventricular bundle of muscle fibers propagate the regulatory impulses via the interventricular septum to the ***myocardium*** of the ventricles. ***There is a delay of approximately 0.15 second*** in ***conductance from*** the S-A node to A-V node, thus permitting fatrial systole to be completed before ventricular systole begin. The heart's electrical activity during heart beat can be studied by E.C.G. machine i.e., ***electrocardiogram machine***.

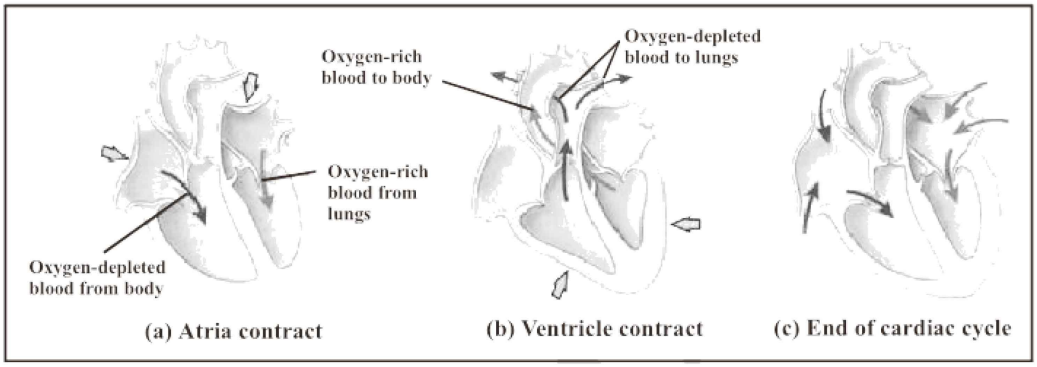
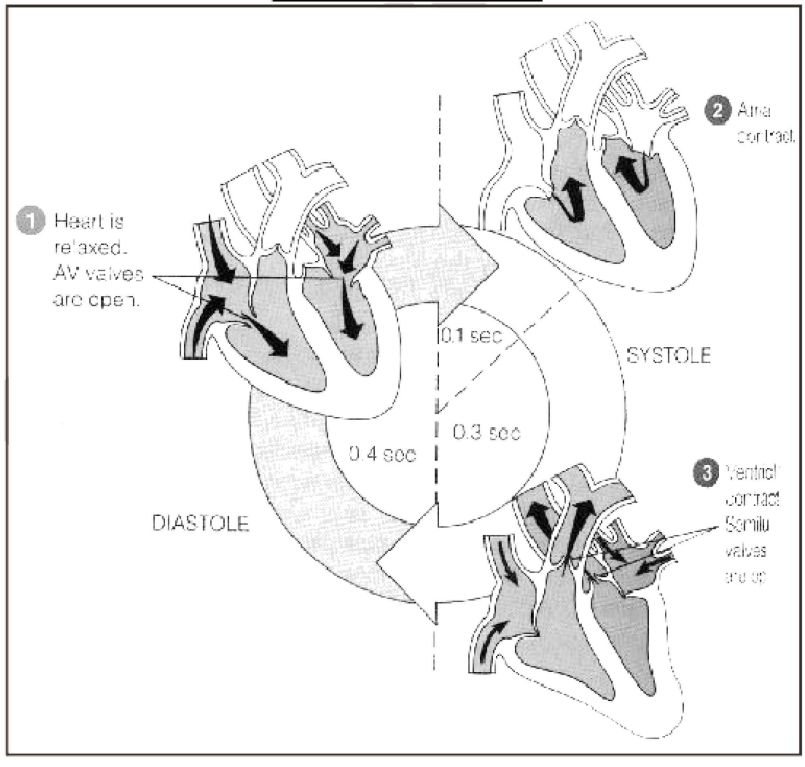


Fig. The cardiac cycle

THINKING ROOM



Electrocardiogram (E.C.G.)

It is an electrographic interpretation of the electrical flour of impulses, in the heart and is taken by E.C.G. machine and its record is called electrocardiogram.

Method:

As the cardiac impulse possess through the heart, electrical currents spread into the tissues surrounding the heart. A small proportion of these spread all the way on the surface of the body. If electrodes are placed on the skin on opposite sides of the heart, electrical potentials generated by these currents can be recorded.

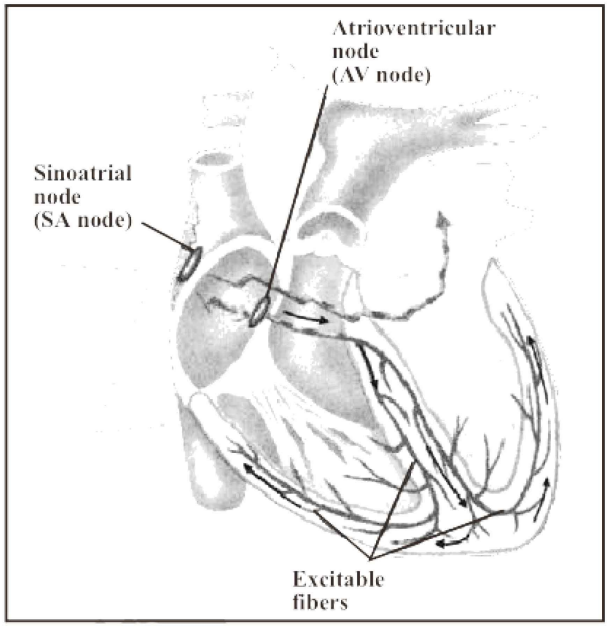
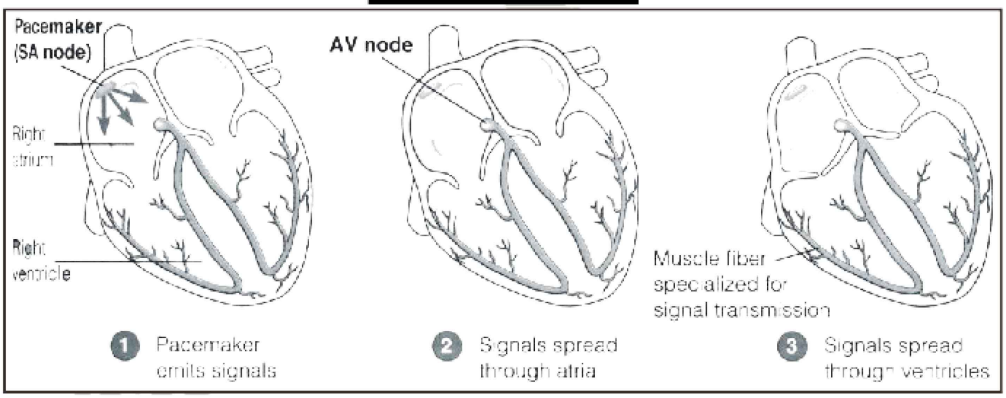


Fig. The Heart's Pacemaker and its connections

THINKING ROOM



Artificial Pacemaker:

Pacemaker is responsible for initiating the impulses, which trigger the heart beat rate. The impulses pass from S-A node to musculature (muscles) of arteries and atrio-vertricular node. (A-V node) From here these impulses are passed on to the myocardium of ventricles via artioventricular muscle fibers.

If there is some block in the flow of the electrical impulses, or if the impulses initiated by pacemaker are weak; it may lead to death of the indivi. So artificial pacemaker which is battery operated electrical stimulus e.g., if A-V pathway is blocked, the electrodes of artificial pacemaker are attached to the ventricle. Then this pacemaker provides continued ***Rhythmic impulses*** that take over the control of the ventricles. Batteries are replaced once every five years.

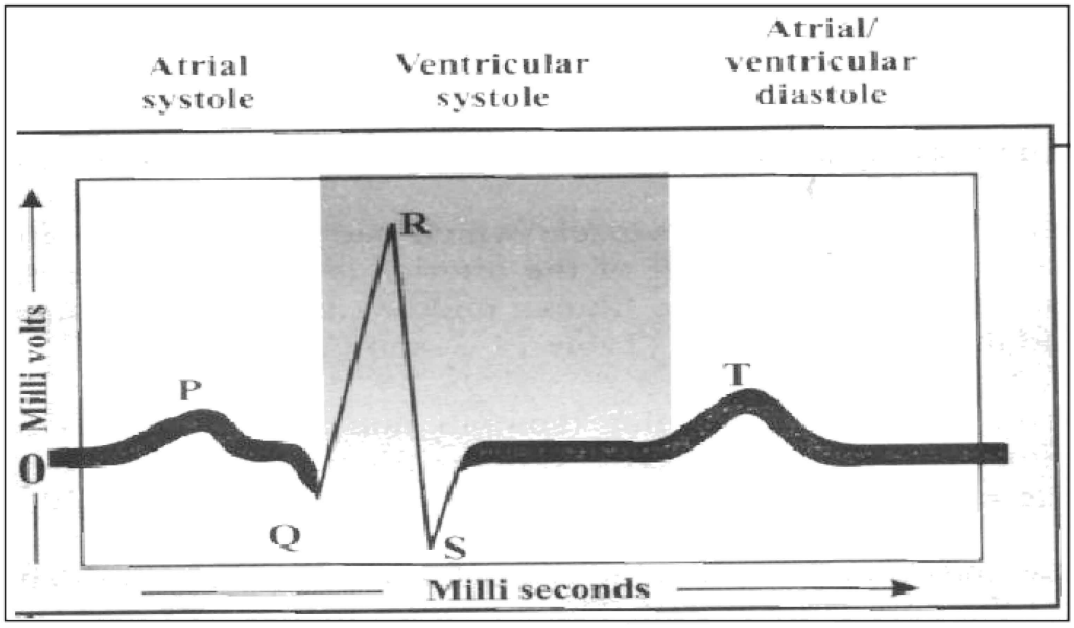


Fig. A normal electrocardiogram (ECG) indicates that the heart is functioning properly. The P wave occurs just prior to atrial contraction; the QRS waves occurs just prior to ventricular contraction; and the T wave occurs when the ventricles are recovering from contraction.

Blue Babies:

"Hole in the heart". Failure of ***interatrial foramen*** to close or of ***ductus arteriosus*** to fully contrict results in ***cyanosis*** (blueness of skin) of newborn, because blood continues to be shunted away from the lungs resulting in insufficient oxygen in the blood. Changes, after birth, are slow to take place resulting in mixing of blood between two atria and the mixed blood is supplied to the body of new born babies that produces blue babies. In some cases the interatrial foramen is not completely closed.

Atrial Septal Defect (Blue-babies):

This is commonly known as ***hole in the heart***. Before birth, most oxygenated blood from the placenta enters the left atrium from the right atrium through the ***foramen ovale*** in the septum. There is a valve-like structure across the opening, consisting of two partly overlapping membranes. The 'valve' is open when the pressure in the right atrium is higher than in the left. This diverts blood flow from the right to the left side of the heart, bypassing the pulmonary circulation, which in the unborn child is not functional because the fetus derives his oxygen supply through the placenta. After birth, when the pulmonary circulation is established and the pressure in the left atrium is the higher, the two membranes come in contact, closing the 'valve'. Later the closure becomes permanent due to ***fibrosis***.

When the membranes do not overlap, an opening between the atria remains patent after birth. In many cases it is too small to cause symptoms in early life but they may appear later. In severe cases blood flows back to the right atrium from the left. This increases the right ventricular and pulmonary pressure, causing ***hypertrophy of the myocardium and eventually cardiac failure***.

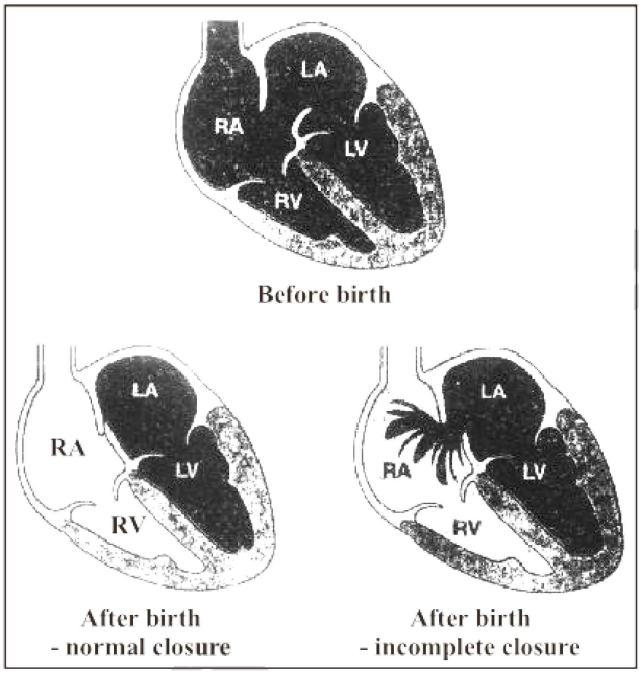


Fig. Atrioseptal valve: normal and defective closure after birth.

Q.36 Describe the structure and function of different types of blood vessels.

Ans. **BLOOD VESSELS**

There are three types of blood vessels:

(1) Arteries (2) Capillaries (3) Veins

(1) **ARTERIES**

(i) The arteries ***carry blood away from the heart to different parts*** of the body.

(ii) ***Structure:*** The wall of the arteries is made up of ***three layers***:

(a) Tunica intima (b) Tunica media (c) Tunica extrema or adventitia

(iii) **Tunica media** has thick muscular wall, along with elastic fibers. This is important to withstand higher blood pressure during ventricular systole.

(iv) The arteries divide into two smaller vessels called ***arterioles***.

In arterioles there is more circular muscle than elastic tissue.

(v) **Functions:** The contraction of the circular (***smooth muscles***) of arteries and arterioles is under the control of nervous and endocrine systems. When, the muscle contracts, the arterioles (***vasoconstriction***) and reducing the flow of blood in them.

(vi) When the muscles are relaxed the arteries are dilated (***vasodilatation***) more blood flows in them, and the cavity's diameter is increased.

(vii) The arterioles themselves divide repeatedly until they form a dense network of microscopic vessels. These final branches are called capillaries.

Arteriosclerosis:

It consists atheromo and arteriosclerosis i.e., ***deposition of hard yellow plague of lipoid material*** in the inner most layer of the arteries.

They may be related to light level of ***cholesterol*** in the blood.

Atherosclerosis:

It is the ***degenerative arterial change*** associated with advancing age.

Primarily, a ***thickening of middle layer of arteries*** is usually associated with some degree of ***atheroma***.

So, Atheriosclerosis causes narrowing and hardening of arteries. This increases the risk of formation of thrombus and if thrombus is formed in the brain or heart it is fatal. So atherosclerosis is a major condition predisposing a person to heart attack.

(2) **CAPILLARIES**

(i) These are blood vessels with walls only ***one cell thick***.

(ii) The blood appears confined within the capillary walls.

(iii) The capillaries with the result that water and dissolved substances pass through it. They exchange oxygen, carbon dioxide dissolved food and excretory products with the tissue around capillary.

(iv) The capillary network is so dense that no living cell is far from a supply of oxygen and food.

(v) In the liver every cell is in direct contact with capillary.

Exchange of Material:

The capillaries are the sites where the materials are exchanged between the blood and body tissues, which occur in three ways:

(vi) Active transport, diffusion and through the cells lining the capillary wall into the interstitial or extracellular fluid, and then to the body cell, and vice versa.

(vii) Materials from the cavity of capillaries are also taken up by endocytosis, and then passed to the other side by exocytosis. It is true for some materials entering from the intercellular spaces (extra cellular fluid) to the blood.

Thus the exchange of materials takes placed between blood and tissues via extra cellular or interstitial fluid.

(viii) Capillaries join with one another to form venules.

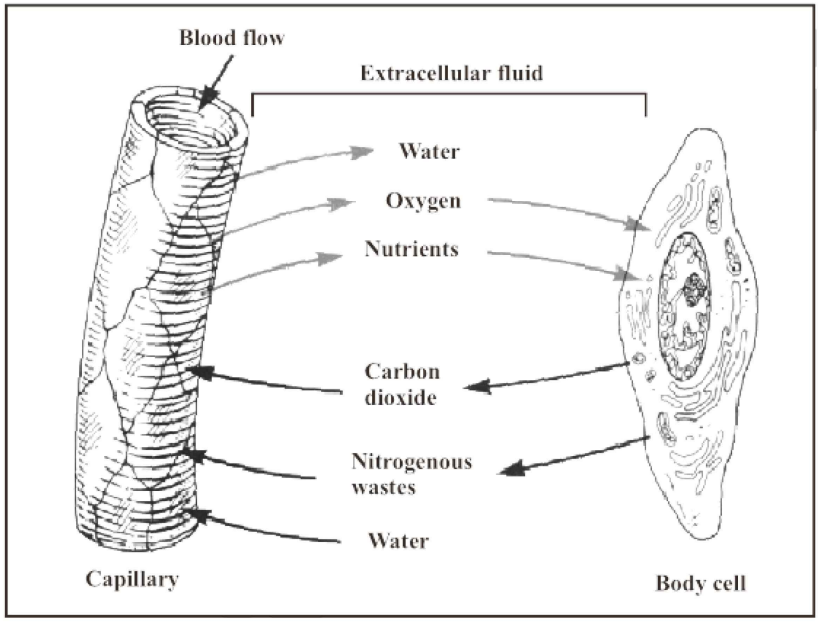


Fig. The exchange of gases and nutrients in a capillary

(3) VEINS

(i) The veins are blood vessels, which ***carry blood from different parts*** of the body, towards the heart.

(ii) Capillaries join to form ***venules*** which further join to form veins.

(iii) They are wider and have thinner walls than arteries.

(iv) They have ***inextensible fibrous tissue*** replacing the elastic tissue of the latter.

(v) The ***semilunar valves*** are present in the veins. These valves prevent back flow of blood.

(vi) The pressure of surrounding ***muscles***, when they contract, tends to squash the veins or assist the return of blood towards heart.

(vii) The walls of veins have the same ***three layers*** present as in arteries.

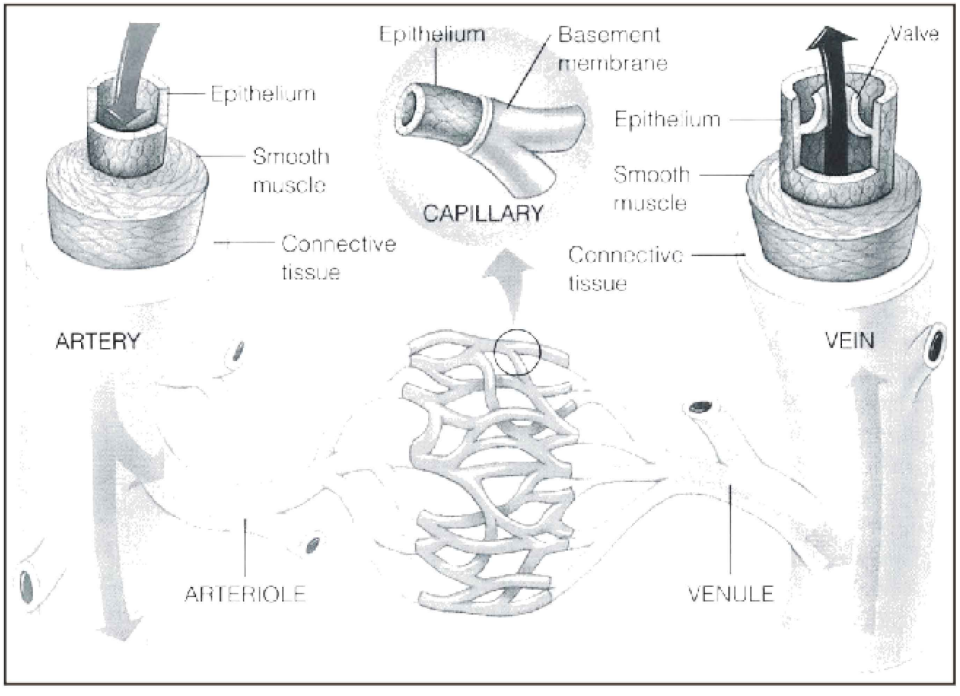
(viii) Veins join to form larger veins, and ultimately form ***vena cava***, (inferior vena and superior vena cava) which pour the blood into atrium, of the heart, as the blood is collected from the body.

(ix) The oxygenated blood from the lungs is brought to the left atrium by ***pulmonary veins***. In the veins the pressure of the blood is low.

(x) The pressure within capillaries causes a continuous leakage of fluid from the blood plasma into the spaces that surround the capillaries and tissues. This fluid, known as ***interstitial fluid*** consists primarily of water, in which the dissolved nutrients, hormones, gases, wastes and small proteins from the blood are present.

Larger proteins, red blood cells and platelets cannot go to the intercellular spaces of capillary wall, so they remain within capillaries. But some white blood cells can squeeze out through the interventricular spaces of capillary spaces of capillary wall. Interstitial fluid is the medium through which the exchange of material between the blood and nearby cells occurs.

CONSIDERABLE VIEW



COMPARISON IN STRUCTURE AND FUNCTION OF AN ARTERY, CAPILLARY AND VEIN

	Arteries	Veins	Capillaries
(1)	These ***transport blood*** away from the heart to the various parts of body through capillaries.	These ***collect blood*** from body through capillaries and transport it towards heart.	These link arteries with veins.
(2)	All arteries carry ***oxygenated blood*** except pulmonary artery.	All veins carry ***deoxygenated blood*** except pulmonary veins.	These have ***mixed*** oxygenated and deoxygenated blood.
(3)	There are ***no valves*** in them except at the base of pulmonary trunk and aorta.	***Valves are present***. These prevent the back flow of blood.	There are ***no valves***.
(4)	Have high blood pressure.	Have low blood pressure.	Failing pressure in these.
(5)	Wave of blood pressure of pulse due to heartbeat can be detected.	No pulse	No pulse
(6)	Blood flow rapid ***400-500 mm per second*** in aorta and decreasing in arteries and arterioles.	Rate of blood flow increase from smaller to larger ones.	Blood ***flow slowest***, less than 1 mm per second.
(7)	Have ***smaller bore*** and thick wall.	Have ***larger bore*** and ***thin walls***.	Large bore ***wall one cell*** in thickness.
(8)	***Thick muscle layer*** and elastic fibres present. The elasticity helps changing the pulsating flow of blood.	***Thin muscle layer*** and less elastic fibre. So are less elastic.	***No muscles*** of elastic fibres.
(9)	***No exchange*** of materials.	***No exchange*** of materials.	***Responsible for exchange*** of materials.

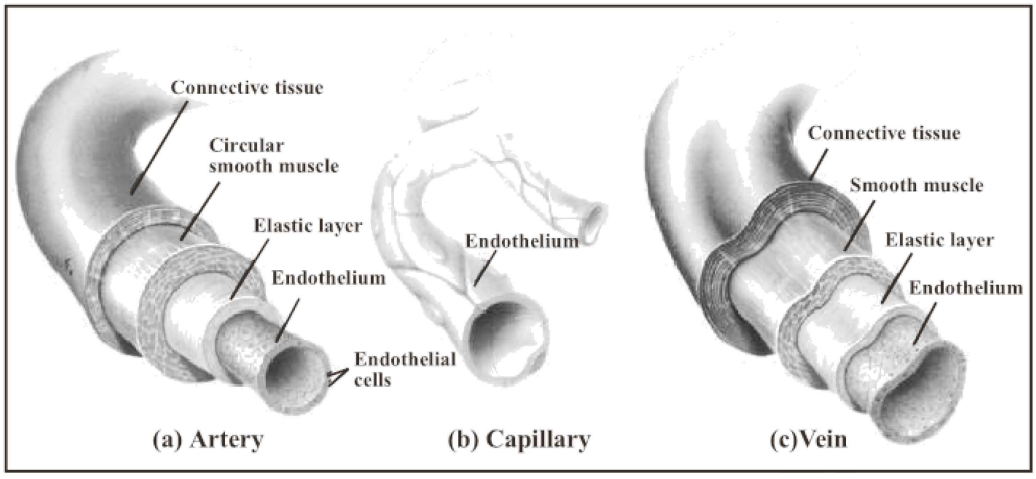


Fig. Showing the comparison in structure of artery, capillary and vein

Q.37 Write notes on rate of flow of blood and blood pressure. Write down some disorders of circulatory system related with blood pressure.

Ans. **BLOOD PRESSURE**

It is the measure of **force with which blood pushes up against blood vessel walls**. It is the force that keeps blood flowing from the heart to all the capillary networks in the body. (OR) ***The pressure of the blood on the walls of vessels depend on the energy of heart action.***

The pressure is generated by the contraction of ventricles (ventricle systole) and is the highest in aorta, then gradually reduces in arteries.

The walls of arteries are elastic and during systole the flow of blood stretches them and it is felt as pulse. Please shows the differences between systolic and diastolic pressures. During diastole, the relaxation phase of the cardiac cycle, the heart is not exerting pressure on the blood in the arteries and pressure in them falls. The elastic recoil of the previously stretched artery walls maintain same pressure on the blood.

Normal Blood Pressure:

There is a regular cycle of pressure in the larger arteries.

The pressure reaching is high point during systole (systolic pressure which in normal individuals is 120 mm Hg) and at low point during diastole (diastolic pressure which in normal individuals ranges between 75-85 mm Hg).

Thus blood moves from a region of higher pressure towards a region of lower pressure.

The decline of the blood pressure in successive parts of systemic circuit is the result of friction between the flowing blood and the walls of the blood vessels.

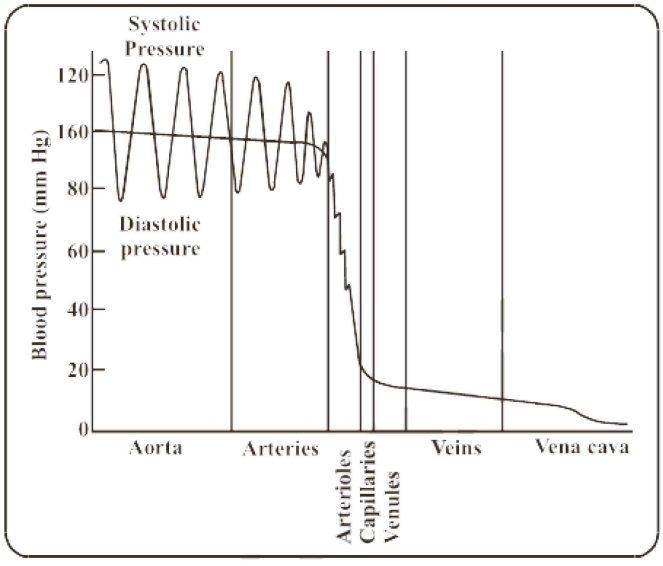


Fig. (a) Graph of blood pressure in different parts of the human circulatory system.

Several other changes occur along the route of blood flow:

(i) The ***difference between systolic and diastolic pressure*** diminishes until it disappears in the capillaries and veins.

(ii) The ***rate of blood flow*** tends to fall as the blood moves through the branching arteries and arterioles.

(iii) The ***rate is lowest in the capillaries,*** and increases again in the venules and veins.

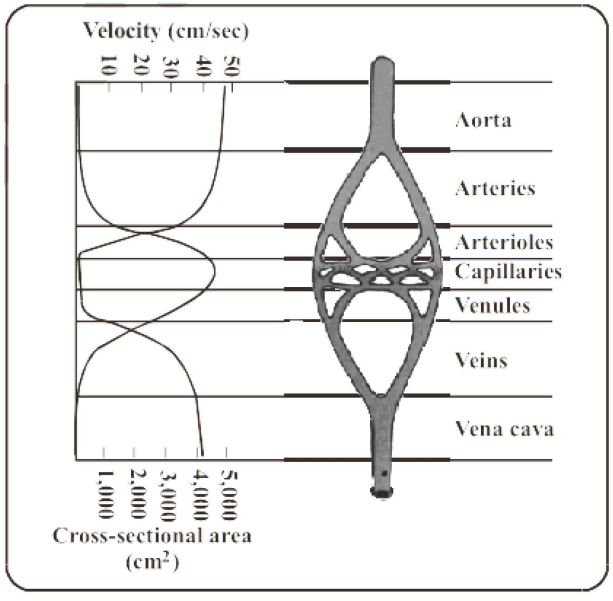


Fig. (b) charge in the velocity of blood flow in the various parts of a systemic circulatory pathway.

These changes in rate of blood flow result from changes in the total cross section of the vessel system. Linear rate of flow is inversely proportional to cross sectional area.

Blood Flow in Veins:

The flow of blood in veins is maintained by the *contraction of surrounding muscles* and *the action of semilunar valves,* which prevent back flow of blood; when standing still on your feet for a long period, you may have noticed your feet beginning to swell, and sudden onset of fatigue. The reason is that, there is not enough muscle action in your legs to push the blood forward towards the heart. Likewise if someone is hospitalized and is bedridden, for a longer time, pooling of blood may lead to formation of a clot in a leg in (thromophlebitis) a potentially fatal, development which may block supply of blood to vital organs of the body i.e., brain and heart. Muscular activity including breathing movements help normal flow of blood in the body.

Q.38 Write notes on the following:

(a) Hypertension

(b) Heart attack (Myocardial infarction)

(c) Haemorrhage

Ans. **HYPERTENSION**

It is condition of high blood pressure.

(1) Prolonged high blood pressure ***damages the lining of the blood vessels***. Hypertension also leads to (2) ***weakening heart muscles*** (which has become thickened due to the continuous strain imposed on it) and ***declining efficiency of its pumping action***. Blood may then back up in the heart and lungs are other are other fatal condition called ***congestive heart failure***. Hypertension is associated with *thrombus formation*.

Thrombus:

Aggregation of blood factors like platelets and other cellulary elements.

Thrombus is a solid mass on plug of blood constituents (***clot***) in a blood vessel. This mass may ***block the vessels in which it forms***. It may ***be dislodged and carried to some other location in the circulatory system in this*** case it is called an ***embolus***. It may be a sudden blocking.

Thrombosis:

Thrombous formation is called thrombosis. ***Thromboembolism*** is ***leading cause of deaths in western civilization***.

Reasons: Thrombus formation may be due to the following reasons:

(i) *Irration* or *infection* of living blood vessels.

(ii) *Reduced rate of blood flow*, due to long periods of inactivity.

(iii) *Pneumonia and tuberculosis, emphysema* etc.

Thrombophlebitis (*Thrombus in Leg*):

When thrombus is formed in the leg veins, the condition is called ***thrombophlebitis***.

HEART ATTACK (*MYOCARDIAL INFARCTION*)

Blockage of blood vessel in the heart by an embolus or by locally formed (thrombus) causes necrosis of portion of heart muscles, a condition familiarly known as a heart attack a myocardial infraction.

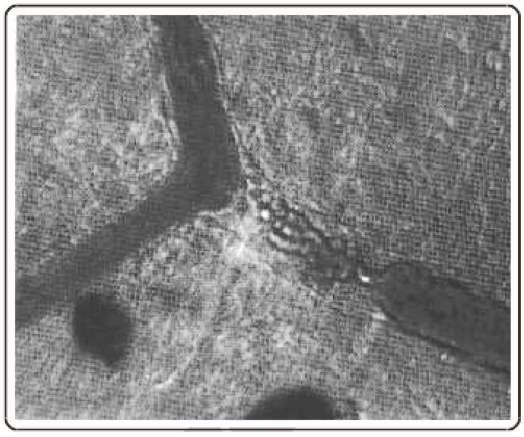
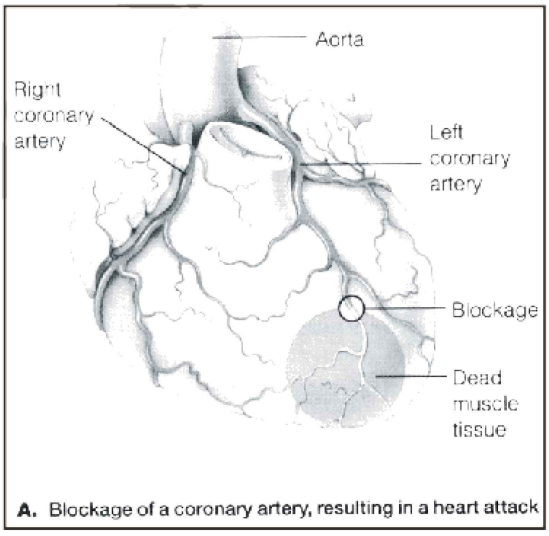


Fig. A thrombus in a small blood vessel. The thrombus (tangled red mass) has blocked blood flow near a point where the vessel branches. The blood has pulled away from the left end of the thrombus and is beginning to pull away from the right end also.



A. Blockage of a coronary artery, resulting in a heart attack

Causes: Heart attack is due to disruptions of control system of the heart with accompanying arrhythmias, especially ventricular fibrillation.

Prevention:

We can prevent or avoid these situations or malformation/functions to:

(i) Avoid too much *fatty food* (especially rich in cholestrol).

(ii) Maintain normal *body weight.*

(iii) *Avoid stress* and tension.

(iv) *Control our blood pressure* by regular walk and exercises.

(v) Do not smoke.

STROKE: (*Cerebral Infaraction*)

If the normal flow of blood is blocked by an embolus (or a locally formed thrombus) a blood vessel in the brain, and calluses ***necrosis*** of the surrounding neural tissue (owing to lock of O_2) the condition is called a stroke or cerebral infarction. The symptoms of the stroke very depending on the part of the brain that has been damaged.

Haemorrhage

It is the discharge of blood from the blood vessels. Especially important is a brain haemorrhage.

Causes: Brain haemorrhage results from *bursting of any of the arteries supplying the brain.* When the wall of the arteries become hard and losses its elasticity and higher blood pressure would result in ***brain haemorrhage.***

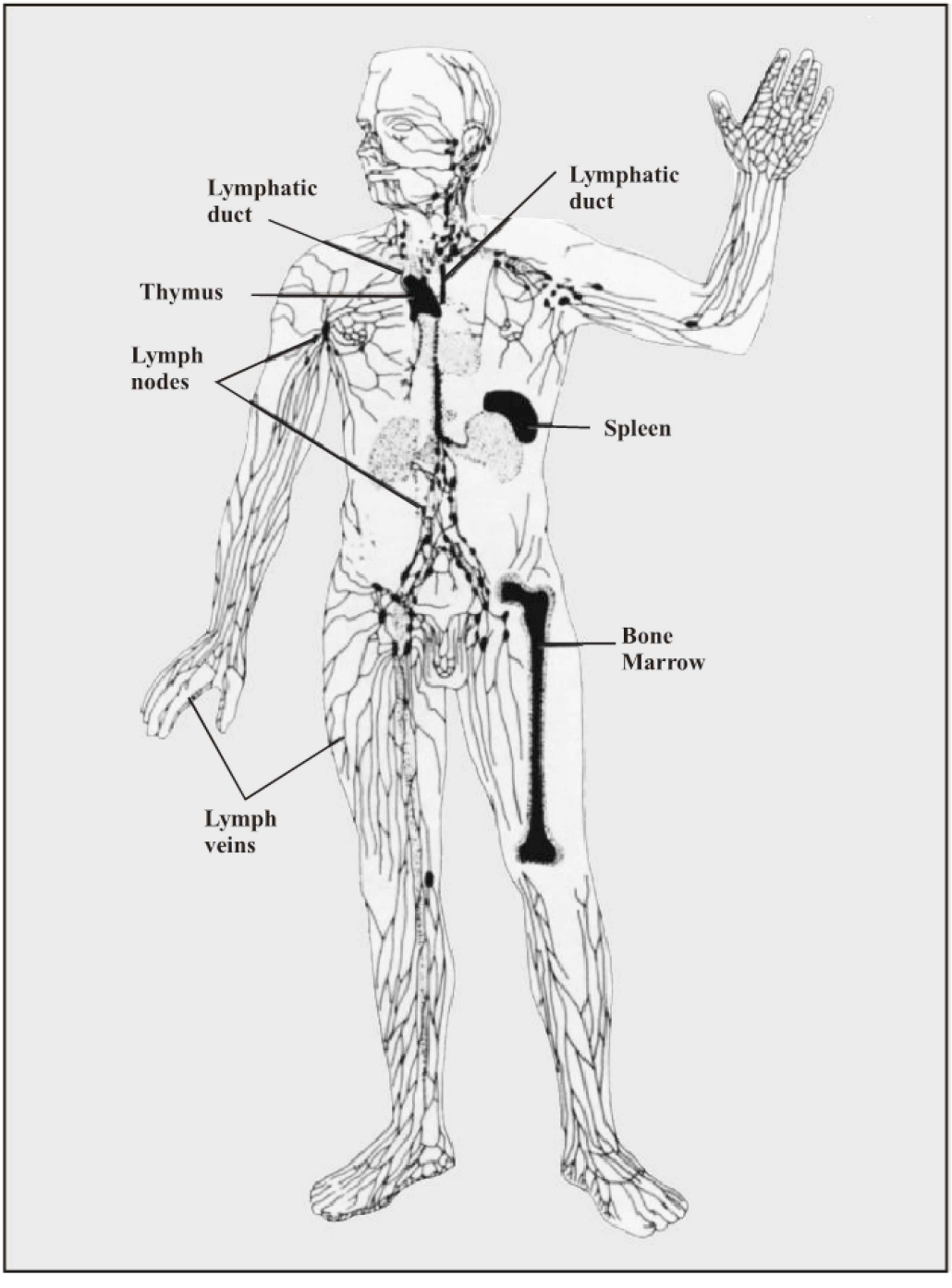


Fig. Human lymphatic system

Prevention:

To avoid brain haemorrhage the blood pressure must be controlled between normal limits:

To prevent the haemorrhage, following measures should be taken:

- ***Less cholesterol*** should be included in our food.
- Maintenance of ***normal blood pressure***.
- Avoid *over weight*.
- *No smoking*
- Do *regular exercise*.
- *Avoid stress* and tension.

Q.39 Describe the lymphatic system of human in man. Also gives its functions.

Ans. **LYMPHATIC SYSTEM**

Lymphatic system is responsible for the transport of materials from the tissues of the body to the blood.

Components of Lymphatic System:

The system comprises of lymph capillaries, lymph vessels, lymphoid masses, lymph nodes, and the fluid. It flows in the system called lymph.

Lymph Capillaries:

The lymph capillaries, like the blood capillaries, have walls ***made up of a single layer of cells***, but the intercellular opening in the walls of *lymph* vessels are larger than those of the capillaries of blood vascular system.

So larger molecules, from the interstitial fluid can also enter the lymph capillaries.

Lymph:

Lymph capillaries and blindly in both tissues, where pressure from the accumulation of interstitial fluid or extra cellular fluid forces the fluid into the lymph capillaries.

When this fluid enters the lymph capillaries, it is called "lymph". The lymph vessels empty in veins, so lymph is a fluid in transit between interstitial fluid and the blood.

LYMPH VESSELS:

Lymph vessels join to form larger lymph vessels and ultimately from ***thoracic lymphy duct***, which open into ***subclavian vein***. The flow of lymph is always towards the ***thoracic duct***.

In the intestine, the branches of lymph capillaries within villi are called ***lacteals***, because after absorption of digested food, these appear milky. The lymph like veins have valves.

Maintenance of Lymph Flow:

The flow of lymph in lymph vessels is maintained by:

- *Activity of skeletal muscles.*
- *Movement of viscera.*

Rhythmical changes in the intrathoracic pressure that results from breathing. The valves which prevent back flow of lymph.

Lymph Nodes:

Along the pathway the lymph vessels have at ***certain points, masses of connective tissue where lymphocytes are present***. These are Lymph evades. Several afferent lymph vessels enter a lymph node, which is drained by a single, efferent lymph vessels.

Lymph nodes are present in the neck Lymph nodes are present in ***neck region, maxilla*** and ***groin*** of humans.

Lymphoid Masses:

In addition several lymphoid masses are present in the walls of digestive tract, called ***Peyer's patches*** in the mucosa and submucosa. The largest mass is ***spleen*** and ***thymus, tonsils*** and ***adenoids*** are all lymphoid masses. They produce lymphocytes.

Function of Lymphatic System

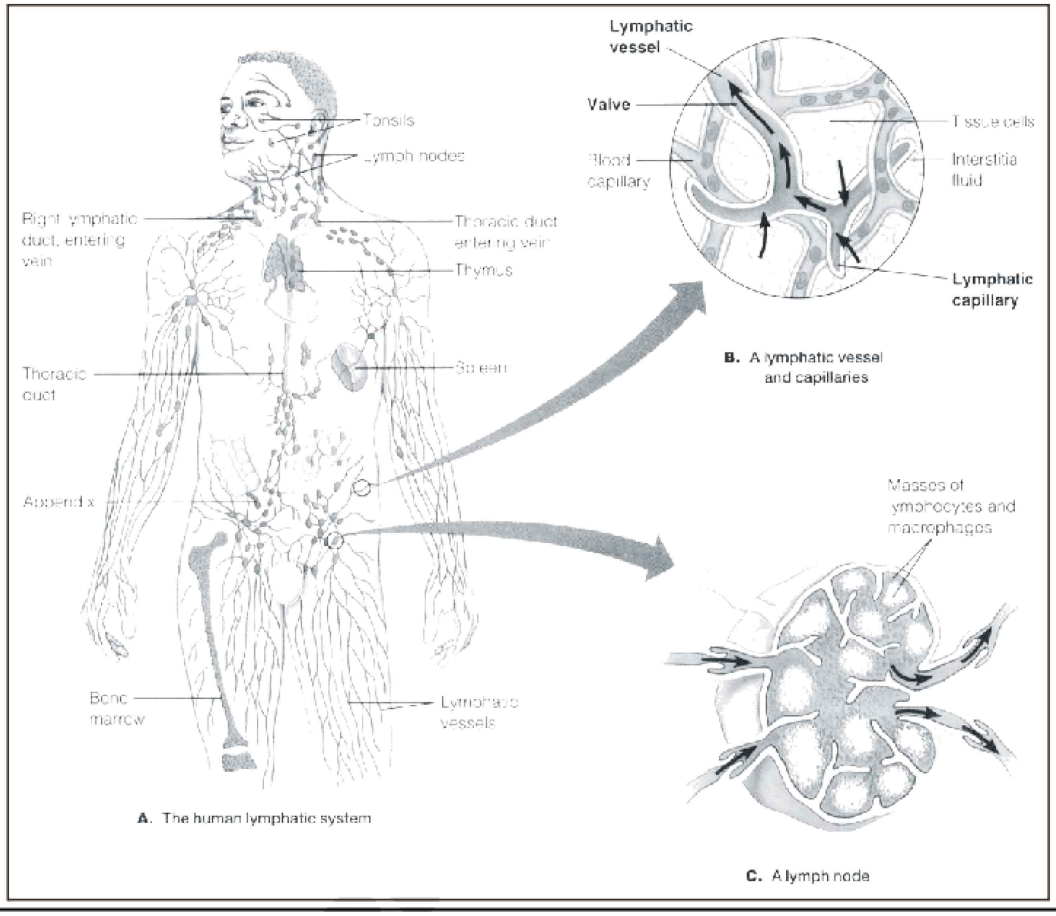
These are several functions performed by lymphatic system:

(1) In an average person, about three litres more fluid more fluid leaves the blood capillaries than is reabsorbed by them each day. Lymphatic system returns this excess fluid and its ***dissolved proteins*** and other substance to the blood.

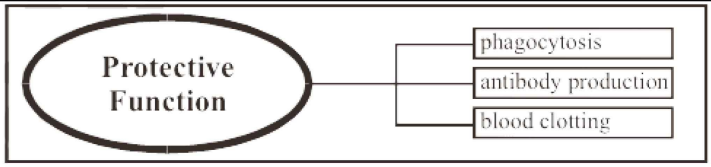
(2) The ***lacteals of villi absorb large fat globules*** which are released by interstitial cells after the product of digestion of fats are absorbed. *After a fatty meal these fat globules may make up 1% of the lymphatic fluid or lymph.*

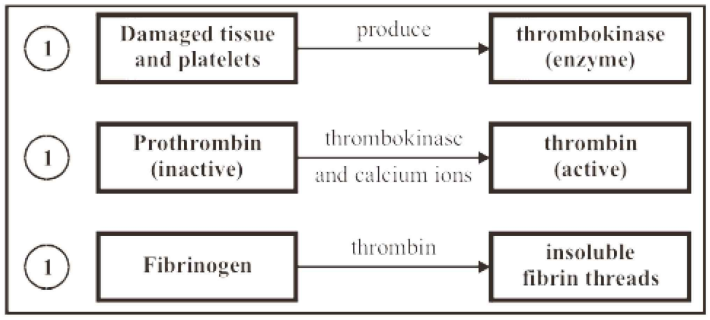
(3) The lymphatic system helps ***defend the body against foreign invaders***, such as bacteria and viruses. Lymph nodes contain *lymphocytes*, and *macrophages*. Lymphocytes and macrophages destroy the bacteria and viruses. *The painful swelling of lymph nodes that certain diseases (**mumps is an extreme example**) is largely a result of the accumulation of dead lymphocytes and macrophages and dead viruses infested cells they have engulfed.*

(4) Just as the lymph nodes filter lymph, the ***spleen filters blood***, exposing it so macrophages and lymphocytes that destroy foreign particles and aged red blood cells.



Q.40 (a) What is immunity?
(b) Describe its types in details.





Ans. IMMUNITY (*SECRUITY AGAINST A PARTICULAR DISEASE*):

Sir Mc Faland Burnet has defined immunity, as:

"The capacity to recognized the intrusion of any foreign material to the body and to mobilize cells and cell products to help remove the particular sort of foreign material with greater speed and effectiveness".

The vertebrates have a mechanism to defined their bodies against the foreign invaders called the immune system.

Component of Immune System: Immune system includes:

(a) ***The antibodies***

(b) ***The lymphocytes (B & T)***

(a) Antibodies:

Antibodies are special types of **protein**.

These antibodies are ***immunoglobulins***, which are synthesized by vertebrates in response to antigen and immobilize it, or sets in motion events that ultimately cause its destruction.

Antigen or ***immunogen*** is a foreign substance, often a protein that stimulates the formation of antibodies. Antibodies are specific i.e., cause the destruction of the antigen which stimulated their production.

(b) Lymphocytes:

Antibodies are manufactured in B-lymphocytes and then secreted into the lymph and blood where they circulate freely:

Types of Lymphocytes:

Lymphocytes are of two types:

(i) ***T-Lymphocytes*** (ii) ***B-Lymphocytes***

They have been named due to their relationship with **Thymus** gland, and **Bursa** of **Fabricius** respectively. The influence of the thymus gland is essential in making T-cells immunolgoically competent. Bursa of Fabricius is lymphoid structure present in the wall of cloaca of young bird from where B-lymphocytes were discovered, to have role in immune system.

Responses: There are two types of responses depending on the type of lymphocyte involved:

(i) Cell-mediated Response:

T-cells (pressing membrane receptors) recognize antigen are stimulated to proliferate and produce a clone of T-cells. These cells then either combat (to fight) microorganisms or effect the rejection of foreign tissues (in case a transplant of tissue is involved).

(ii) Humoral Immune Response:

B-cells recognize antigen in a similar way to T-cells. However their response is different:

(a) *They form plasma cell clone.*

(b) *These plasma cells synthesize and liberate antibodies into the blood plasma and tissue fluid.*

(c) *Antibodies attach to the surfaces of bacteria and speed up their* ***phagocytosis****, or combine with and neutralize toxins produced by microorganism, by producing antitoxins.*

Antitoxins are always protein and destroy the toxin, in response of which they were produced.

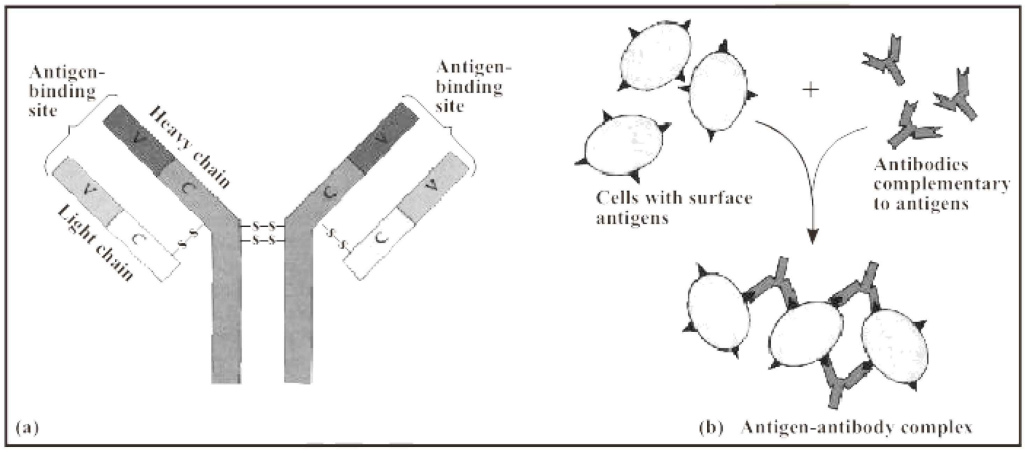


Fig. (a) An antibody molecule consists of four polypeptide chains – two identical light chain and two identical heave chains – linked by disulfide (- S – S -) bridges. Variable amino acid sequences (V) in the light chains and upper regions of the heave chains determine which antigen will bind to that particular antibody. Constant amino acid sequences (C) are the same for all the antibodies in one class (b) Large antigen-antibody complexes will form it there are multiple copies of the antigenic molecule on the foreign cell's surface.

The variable regions of the antibody, present at the tips of its molecule arms, form highly specific binding sites for antigens. These ***binding sites*** a lot like the active sites of enzymes. Each binding site has a particular shape and electrical charge, so only certain molecules can fit in and bind. The binding sites are so specific that each antibody can bind at most a few types of antigen molecule perhaps only certain molecules can fit in and bind. The binding sites are so specific that each antibody can bind at most a few types of antigen molecule perhaps only one. That is why it is said that antibodies are memory cells, remain in the spleen and lymph nodes long after the initial exposure to the antigen, and they may persist for the life time of the animal.

This is why when we get ***vaccination***, against a specific disease (antigen), we become immune to that infection or disease. We get vaccination against, Polio, Smallpox, measles, mumps etc., once in our life time and then protected or become immune to that infection in our future life.

(b) **TYPES OF IMMUNITY** Immunity is of two types:

"Production of antibodies by use of vaccines."

(1) Active Immunity:

*The **use of vaccines**, which stimulate the **production of antibodies** in the body and making a person immune against the disease or infection, is called immunity.*

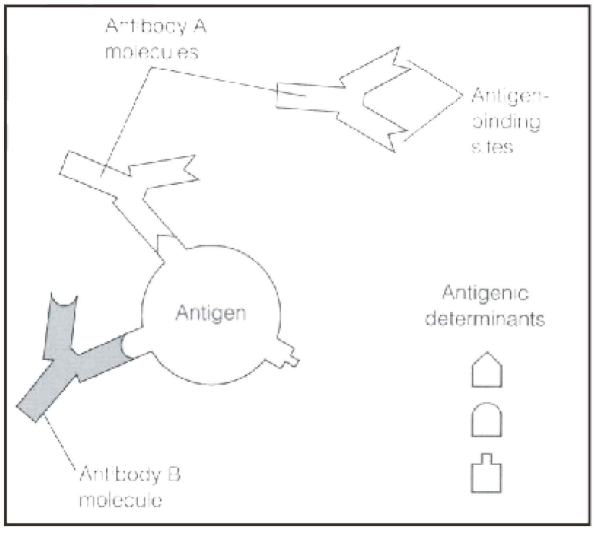
The production of memory cells and the immunity that provide is the underlying mechanism of vaccination. Most of the vaccines consist of non-virulent, mutant strains of the poliovirus. These mutants are unable to cause polio but they have at least one antigenic determinant in common, with the virulent poliovirus and thus activate the production of memory cells that recognize and respond to the erippling attain likewise, we can protect our bodies by vaccines of certain other disease. Small pox, a major killer disease of the past, has been completely eradicated. It is of two types:

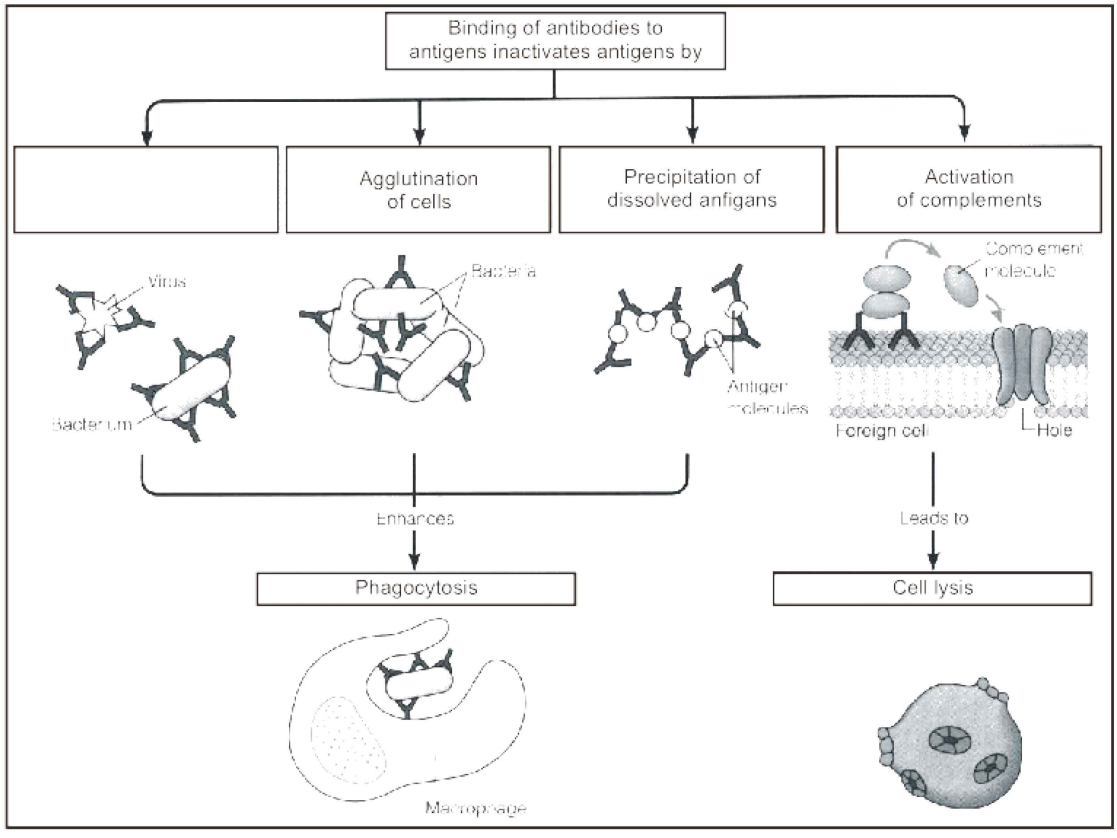
(a) Artificially Induced Active Immunity:

If active immunity has been achieved by ***artificially introducing antigens*** in the body, so it is called artificially induced active immunity. In short, as vaccine is given for immunity purpose.

(b) Naturally Induced Immunity:

When a person is ***exposed to an infection*** (antigen) becomes ill and in most cases survives then this immunity, developed against that disease is called naturally induced immunity. In short, antigens are produce itself due to disease or attack of pathogens.





(2) PASSIVE IMMUNITY:

"Immunity produced by injecting blood or serum". In passive immunity, ***antibodies are injected*** in the form of antisera to make a person immune against a disease (infection). In this way, no antigens are given for production of antibodies, actually antibodies are given.

Antisera:

Antisera are the sea, containing specific antibodies. Blood serum taken from another individual or animal that has been recently exposed to a particular pathogen (or snake bite venom = toxin) will have high concentration of antibodies targeted against that antigen, partially pumped serum containing the appropriate antibody is injected into blood of a person, (to be made immune) ***antigen antibody complexes*** are formed which are taken up by phagocytes and destroyed. The patient is spared the complications (or possibly death) caused by the infection or venom.

Importance:

Passive immunity ***response is immediate***, but not long lasting. Because 120 time is taken for the production of sufficient level of antibodies, (as antibodies are being injected) and after the level of antibodies is reduced or they are used up. *No more antibodies production is there.*

Methods of Immunizations:

The method of passive immunization is ***used to combut active infections of tetanus, infection hepatitis, rabies snake bite venom*** etc. In the case of snake bite venom, immunity is produced as the person is injected in the blood stream, not the antibodies, but the antitioxins so the serum is called **antivenom serum**.

The fundamental purpose of immune system is to distinguish between the animal's own cells and large molecules, and those from another source (antigens) and then to destroy the later.

CONCEPTUAL VIEW