

## SLO 9: Transport

### 9.1 Introduction

#### 9.1.1 Describe The Importance Of Transport System In Living Organisms

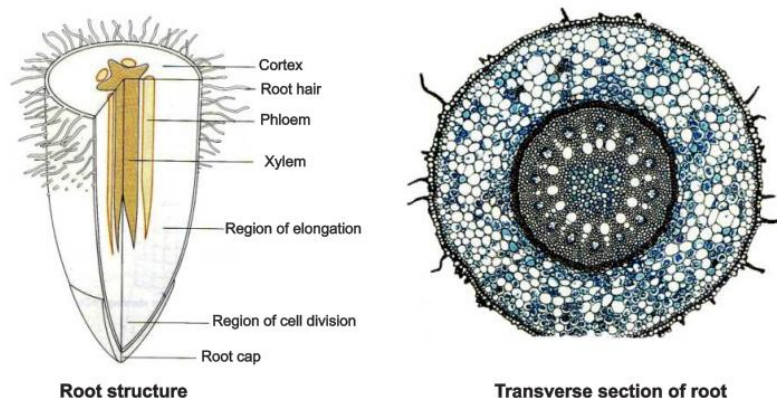
1. Delivers Essential Nutrients And Oxygen To All Cells
2. Removes Metabolic Waste Products
3. Enables Specialization Of Cells, Tissues, And Organs
4. Maintains homeostasis and internal balance
5. Supports overall survival, growth, and reproduction

### 9.2 Transport Of Water And Ions In Plants And Transpiration

#### 9.2.1 Explain Structural Adaptations Of Xylem And Phloem In Vascular Plants

- All land plants (except mosses and liverworts), have developed complex vascular tissues (xylem and phloem) that move water and food throughout plant body.
- Xylem tissue is responsible for the transport of water and dissolved substances from roots to aerial parts. Phloem tissue is responsible for the conduction of dissolved organic matter (food) between different parts of plant body.
- Xylem consists of vessel elements and tracheid. Phloem consists of sieve tube cells and companion cells.
- Xylem and phloem of root are grouped in the center to form a rod-shaped core. This rod extends throughout the length of root.

#### 9.2.2 Illustrate The Positions Of Tissues As Seen In Transverse Sections (Diagrams Or Photomicrographs) Of Non-Woody Dicotyledonous Roots And Stems



#### 9.2.3 Define:

##### **Root Pressure**

It is the osmotic pressure built up within the cells of the root system that causes sap to rise through a plant stem to the leaves.

##### **Capillary Action**

The tendency of a liquid in a narrow tube or adsorbent material to rise or fall as a result of surface tension.

##### **Transpiration**

The loss of water vapor from the aerial parts of the plant (mainly through the stomata of leaves) into the surrounding atmosphere.

## Transpiration Pull

The main force (suction) generated by transpiration that pulls water upward from the roots through the xylem.

### 9.2.4 Explain Pathways And Processes To Transport Water Through Root, Stem, Leaf

#### Osmosis

The cell sap has low tendency of water loss i.e. water potential, then the solution of soil which result in water movement from soil to root hair. This process of water movement from a solution of high-water potential to a solution of low water potential is called Osmosis. As a result of osmosis of water, the root hair becomes turgid and their cell-sap become dilute than that of adjacent cells so the water moves from root hair to their neighbor cells.

#### Capillary Action

As water moves through the xylem vessels of the stem, it forms a solid, unbreakable column due to two physical forces:

1. Cohesion: The attraction between water molecules themselves (due to hydrogen bonding). This keeps the water molecules "linked" in a continuous chain.
2. Adhesion: The attraction between water molecules and the lignified walls of the xylem. This prevents the water column from dropping back down due to gravity.

Because xylem vessels are very narrow, the combination of cohesion and adhesion allows water to rise slightly above the level of root pressure alone.

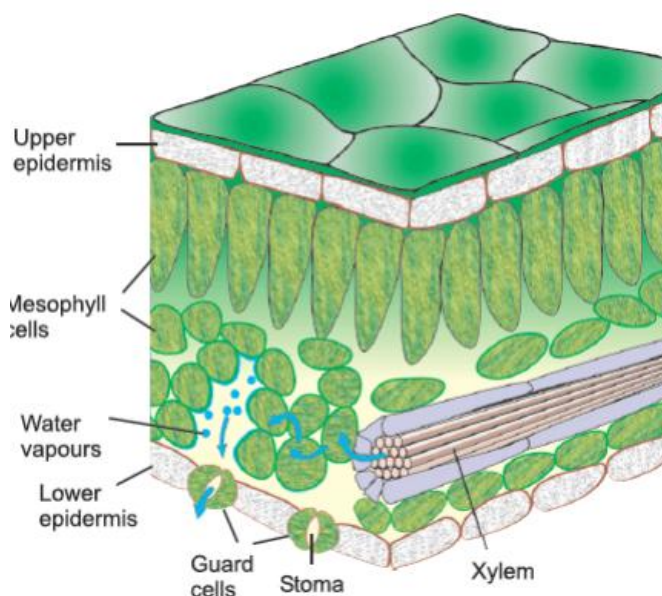
#### Transpiration

Some water is removed in the form of vapors. This loss of internal water of plant in the form of vapors from aerial part of plant is called transpiration. Transpiration mainly takes place through special pores guarded by specialized guard cells called stomata (sing: stoma).

### 9.2.5 Describe That Water Evaporates From The Surfaces Of The Mesophyll Cells Into Air Spaces And Then Diffuses Out Of The Leaves Through The Stomata As Water Vapor

The mesophyll cells of leaf provide large surface area for the evaporation of water. Water is drawn from xylem into mesophyll cells, from where it comes out and makes a water-film on the cell walls of mesophyll. From here, water evaporates into the air spaces of the leaf. Water vapors then diffuse from air spaces towards stomata and then pass to outside air.

Most plants keep their stomata open during the day and close them at night. It is the responsibility of stomata to regulate transpiration via the actions of guard cells. The two guard cells of a stoma are attached to each other at their ends. The inner concave sides of guard cells that enclose a stoma are thicker than the outer convex sides. When guard cells get water and become turgid, their shapes are like two beans and the stoma between them opens. When guard cells loose water and become flaccid, their inner sides touch each other and stoma closes.



## 9.2.6 Describe The Factors Affecting The Rate Of Transpiration

### Temperature

Higher temperature reduces the humidity of surrounding air and also increases the kinetic energy of water molecules. In this way it increases the rate of transpiration. The rate of transpiration doubles with every rise of 10C in temperature. But, very high temperatures i.e. 40-45C cause closure of stomata, so transpiration stops and plant does not lose the much-needed water.

### Air movement

Wind (air in motion) carries away the evaporated water from leaves and it causes an increase in the rate of evaporation from the surfaces of mesophyll. When air is still, the rate of transpiration is reduced.

### Leaf surface area

The rate of transpiration also depends upon the surface area of leaf. More surface area provides more stomata and there is more transpiration .

### Air humidity

When air is dry, water vapors diffuse more quickly from the surface of mesophyll cells into leaf air spaces and then from air spaces to outside. This increases the rate of transpiration. In humid air, the rate of the diffusion of water vapors is reduced and the rate of transpiration is low.

## 9.2.7 Relate Wilting With Excessive Transpiration

Due to non-availability or extra loss of water, the cells of herbaceous plants lose their turgidity and wilt. Wilting is defined as the loss of rigidity of non-woody parts of plants. This phenomenon can be observed by keeping an herbaceous plant without watering for a few days.

## 9.2.8 Describe The Significance Of Transpiration

1. By active transpiration, transpiration pull is created which helps in the ascent of sap.
2. Transpiration also increases the rate of absorption because the loss at one end increases demand on the other end.
3. Transpiration gets rid of the excess amount of water from plant.
4. Transpiration helps in maintaining the temperature of plant for its metabolism and survival because evaporation causes cooling.
5. Opening and closing of stomata is also regulated by transpiration, which indirectly influences upon the rate of photosynthesis and respiration.

## 9.3 Phloem Translocation

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### 9.3.1 Define Phloem Translocation

Phloem Translocation is the active process by which organic solutes are transported through the sieve tube elements of the phloem from sources to sink.

### 9.3.2 Describe The Terms 'Source' And 'Sink' With Reference To Translocation In Plants

In pressure-flow mechanism, food is moved from sources to sinks.

- Sources include the exporting organs, typically a mature leaf or storage organ.
- Sinks are the areas of active metabolism or storage e.g. roots, tubers, developing fruits and leaves, and growing regions.

### 9.3.3 Explain Pressure Flow Mechanism Of Translocation In Plants

Transport of food is through pressure-flow mechanism. A storage organ is capable of storing food and exporting the stored materials. For example; root of beet is a sink in first growing season, but becomes source in next growing season, when sugars are utilized in the growth of new shoots.

At source, food (sugars) is moved by active transport into the sieve tubes of phloem. Due to the presence of sugar in sieve tubes, their solute concentration increases and water enters them from xylem (via osmosis). This results in higher pressure of water in these tubes, which drives the solution of food towards sink.

Xylem is a one-way street from roots to leaves for water and salts. Phloem is a two-way street for food. The direction of the movement of food is decided by supply and demand in sources and sinks.

At the sink end, food is unloaded by active transport. Water also exits from the sieve tubes. The exit of water decreases pressure in sieve tubes, which causes a mass flow from the higher pressure at the source to the now lowered pressure at the sink.

## 9.4 Types And Efficiency Of Circulatory Systems

### 9.4.1 Describe The Circulatory System As A System Of Blood Vessels With A Pump And Valves To Ensure One-Way Flow Of Blood

The system involved in the transport of various substances within the body of an animal is called Circulatory System. The circulatory system transports gases like  $O_2$ ,  $CO_2$ , nutrients, wastes, hormones and defense proteins. Closed circulatory system allows blood to flow inside the closed tubular blood vessels and never comes out in direct contact with tissues. It consists of following components:

1. Blood: A fluid with cells and other dissolved substances.
2. Heart: A pumping, pulsatile organ.
3. Blood vessels: Tubes i.e. Arteries, veins and capillaries.

### 9.4.2 Relate The Circulatory System To Other Transport Systems In Terms Of The Delivery Of Materials To And Removal Of Waste Products From The Body

Plumbing Component	Circulatory Equivalent	Functional Relationship
The Water Pump	The Heart	Both provide the mechanical pressure needed to move fluid against gravity.
Pipes (Main & Small)	Arteries & Arterioles	Transport clean "water" (Oxygen/Nutrients) under high pressure to various "rooms."
Drainage Pipes	Veins	Carry "used water" ( $CO_2$ /Waste) back to be cleaned or recycled.
Filters/Purifiers	Lungs & Kidneys	Remove contaminants from the fluid before it is pumped back out.

#### Postal/Courier System (Logistics)

- Sorting Hub (Lungs): This is where the "mail trucks" (Red Blood Cells) drop off the "trash" ( $CO_2$ ) and pick up "new packages" (Oxygen).
- Delivery Trucks (Red Blood Cells): These move through "highways" (Blood vessel) to reach specific address.
- Doorstep Delivery (Capillaries): This is where the actual exchange happens. The truck stops, hands over the "delivery" (Oxygen/Nutrients), and collects the "outgoing mail" (Waste products).
- The Addresses (Cells): Every house (cell) in the city (body) must be reached, or it cannot function.

### 9.4.3 Compare Different Types Of Circulatory Systems

**Open circulatory system:**

In this type of Circulatory System blood flows through the spaces among tissue so it directly comes in contact with tissues. It remains filled in the open tissue spaces called Sinuses. After exchange of materials with tissues, blood enters the pumping organs or heart which pumps it into blood vessels. These vessels again drain out blood into sinuses so it remains in Circulation. This type of circulatory system found in arthropods and mollusks.

**Closed circulatory system:**

This type of system allows blood to flow inside the closed tubular blood vessels and never comes out in direct contact with tissues.

**Single Circuit Circulation:**

The blood, pumped by the heart, travels all around the body in blood vessels. It leaves the heart in arteries and returns in veins. Valves, present in the heart and veins, ensure a one-way flow of the blood.

*Single circulation of fish*

Fish have the simplest circulatory system of all the vertebrates. A heart, made of one blood-collecting chamber (the atrium) and one blood-ejection chamber (the ventricle), sends blood to the gills where it is oxygenated. The blood then flows to all the parts of the body before returning to the heart (Figure 9.1). This is called a single circulation because the blood goes through the heart once for each complete circulation of the body. However, as the blood passes through capillaries in the gills, blood pressure is lost, but the blood still needs to circulate through other organs of the body before returning to the heart to increase the blood pressure. This makes the fish circulatory system inefficient.

**Double Circuit Circulation:**

As blood enters an organ, the arteries divide into smaller arterioles, which supply capillaries. In these vessels the blood moves much more slowly, allowing the exchange of materials like oxygen and glucose, carbon dioxide and other wastes. Blood leaving an organ is collected in venules, which transfer it on to larger veins.

*Double circulation of mammals*

The blood passes twice through the heart during one complete circuit: once on its way to the body and again on its way to the lungs. On average, a red blood cell would go around the whole circulation in 45 seconds.

### 9.4.4 Advantages Of Double Circulation System Over Single Circulation System

A double circulation has the advantage of maintaining a high blood pressure to all the major organs of the body. The right side of the heart collects blood from the body, builds up the blood pressure and sends it to the lungs to be oxygenated. The pressure drops during this process. The left side of the heart receives oxygenated blood from the lungs, builds up the blood pressure again and pumps the oxygenated blood to the body.

## 9.5 Components Of Blood And Blood Group Systems

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### 9.5.1 Describe The Components And Functions Of Blood

Blood is a special type of tissue, found in the form of fluid which circulates in the body. It transports substances in the body of an organism. It consists of two parts: Plasma and Corpuscles

### 9.5.2 Describe The Composition Of Blood Plasma

Plasma is the fluid part of blood and constitutes about 55% by volume of whole blood. It is pale yellowish liquid. About 90% of plasma is water in which complex mixture of various substances is dissolved. There are dissolved mineral salts like bicarbonates, sulphates, chlorides and phosphates of sodium (Na) and potassium (K). All these are found in the form of ions.

Salts of calcium are also present in blood for clotting of blood. Soluble proteins are also present in plasma i.e. Serum albumin, Serum globulin, fibrinogen and prothrombin. The last two play important part in clotting of blood. Antibodies are also present in plasma, which are involved in fighting diseases.

Plasma contains digested food substances such as glucose, amino acids, fatty acids and vitamins. It also contains excretory products such as Urea, Uric acid and creatinine. Carbon dioxide (CO<sub>2</sub>) is also present as bicarbonate ions. It also contains hormones.

### 9.5.3 Structure And Functions of Red Blood Cells, White Blood Cells And Platelets

#### Red Blood Cells (Erythrocytes)

Shape	Bi-Concave; Circular Like Disc
Place of destruction	Spleen and liver
Function	Transports O <sub>2</sub> from lungs to body cell, Transports CO <sub>2</sub> from body cell to lungs
Size	0.007-0.008 mm in diameter
Life	120 days on Average
Composition	Non-nucleated, contain red pigment hemoglobin protein containing iron.
Place of production	Bone marrow
Quantity	5,000,000/cubic millimeter

#### White Blood Cells (Leukocytes)

Leucocytes or WBCs are colorless, irregular in shape, nucleated and larger sized cell than R.B.Cs. They protect the body by killing germs that enter the body. There are several types of White blood cells which perform different functions.

Types of WBCs	Description	Average number	Function	
Granulocytes	Neutrophils	About twice the size of RBCs, nucleus 2 to 5 lobed	62% of W.B.Cs	Destroy small particles by phagocytosis
	Eosinophils	Nucleus bilobed	2% of W.B.Cs	Inactivates inflammation produces substances attack parasites
	Basophils	Nucleus bilobed	<1% of W.B.Cs	Release heparin to prevent blood clots and histamine which causes inflammation
Agranulocytes	Monocytes	3 to 4 times larger than RBCs, nuclear shape from round to lobed	3% of W.B.Cs	Macrophages, destroys large particles by phagocytosis
	Lymphocytes	Slightly larger than RBCs, nucleus nearly occupies cell	32% of W.B.Cs	Immune response by producing antibodies

#### Platelets (Thrombocytes)

They are not cells, but are fragments of large cells of bone marrow, called megakaryocytes. They do not have any nucleus and any pigment. One cubic millimeter of blood contains 250,000 platelets. The average life span of a blood platelet is about 7 to 8 days. Platelets help in blood clotting.


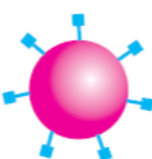


### 9.5.4 Explain The Blood Group Systems

Blood group systems are a classification of blood based on the presence or absence of antigens on the surface of red blood cells. An antigen is a molecule that can stimulate an immune response (antibody production etc.).

#### ABO Blood Group System

It is the most important blood group system in humans. In this system, there are four different blood groups which are distinct from each other on the basis of specific antigens (antigen A and B) present on the surface of RBCs.

1. A person having antigen A has blood group A
2. A person having antigen B has blood group B
3. A person having both antigens has blood group AB
4. A person having none of the A and B antigens has blood group O.

	Blood group A	Blood group B	Blood group AB	Blood group O
Red Blood Cells				
Antigens on RBCs	antigen A	antigen B	Antigen A & B	None
Antibodies in serum	Anti-B	Anti-A	None	Anti-A & Anti-B

After birth, two types of antibodies i.e. anti-A & anti-B antibodies appear in the blood serum of individuals. These antibodies are present according to the absence of corresponding antigen.

- In persons with blood group A, antigen A is present and antigen B is absent. So, their blood will contain anti-B antibodies.
- In persons with blood group B, antigen B is present and antigen A is absent. So, their blood will contain anti-A antibody.
- In persons with blood group AB, antigens A & B are present i.e. neither is absent. So, their blood serum will contain no antibody.
- In persons with blood group O, neither antigen A nor antigen B is present i.e. both are absent. So, their blood serum will contain both antibodies i.e. anti-A & anti-B.

#### Rh Blood Group System (+ive & -ive Blood Group System)

In this system, there are two blood groups i.e. Rh-positive and Rh-negative. These blood groups are distinct from each other on the basis of antigens called RH factors present on the surface of RBCs. A person having Rh factors has blood group.

Rh-positive while a person not having Rh factors has blood group Rh-negative. Unlike the naturally occurring anti-A & anti-B antibodies of the ABO-system, an Rh-negative person does not produce anti-Rh antibodies unless Rh-factor enters in his / her blood.

### 9.5.5 Determine The Risk Of Incompatibility In Blood Transfusion Due To Antigen-Antibody Reactions

Blood transfusion is the process of transferring blood or blood-based products from one person into the circulatory system of another. Blood transfusions can be life-saving in some situations, such as massive blood loss due to injury, or can be used to replace blood lost during surgery. People suffering from anemia, hemophilia, thalassemia or sickle-cell disease may require frequent blood transfusions.

Transfusion of blood is done after confirming that no agglutination (clumping of cells) results in the blood of recipient. If agglutination occurs, the clumped cells cannot pass through capillaries. For the confirmation of no agglutination, blood samples of donor and recipient are cross-matched for compatibility. Antibodies of recipient's blood may destroy the corresponding antigen-containing RBCs of donor or antibodies of donor's blood may destroy antigen-containing RBCs of recipient.

- O Blood group individuals are called universal donors, because they can donate blood to the recipients of every other blood group.
- AB blood group individuals are called universal recipients, because they can receive transfusions from the donors of every other blood group.
- Rh-positive blood group can be transfused to Rh-positive recipient because recipient's blood already has Rh-antigens and it will not produce anti-Rh antibody.
- Rh-negative blood group can be transfused to Rh-negative because donor's blood does not have Rh-antigen and so recipient's blood will not produce anti-Rh antibody.
- If Rh-negative person receives Rh-positive blood, they will produce anti-Rh antibodies against Rh-factors.
- Rh-negative blood can be transfused to Rh-positive recipient, only if donor's blood (Rh-negative) has never been exposed to Rh-antigens and does not contain any anti-Rh antibody.

### 9.5.6 Describe Symptoms, Causes And Treatments Of Anemia, Leukemia, Thalassemia And Hemophilia

Disease	Symptoms	Causes	Treatment
Anemia	Patient is weak and there is shortage of oxygen supply to body's cells. Number of red blood cells is reduced than the normal.	If body fails to receive sufficient amounts of iron, adequate number of hemoglobin molecules are not formed.	supplements of vitamin B12, and folic acid tablets. Bone Marrow or Stem Cell Transplant:
Leukemia	Cancerous mutation in bone marrow or lymph tissue cells, uncontrolled production of defective WBCs.	production of great number of immature and abnormal WBCs.	change blood regularly with normal blood, bone marrow transplant
Thalassemia	defective hemoglobin and the patient cannot transport oxygen properly	genetic problem due to mutations in the gene of hemoglobin	change blood regularly with normal blood, bone marrow transplant
Hemophilia	Excessive external bleeding, easy bruising, joint pain and swelling	Genetic; faulty gene is located on the X chromosome.	missing clotting factors (Factor VIII or IX) are infused intravenously into blood.

## 9.6 Blood Vessels And Tissue Fluid

### 9.6.1 Relate The Structure Of Arteries, Veins And Capillaries With Their Respective Functions In Transporting Blood Throughout The Body

#### Structure of Arteries:

- Thick, Three-Layered Walls: Consisting of epithelial tissue, smooth muscle, and elastic fibers to provide the strength needed to withstand high pumping pressure from the heart.
- Elasticity: The middle layer of elastic fibers allows arteries to stretch and recoil, maintaining blood pressure as oxygenated blood travels from the aorta to various organs.

- **Narrow Lumen:** Helps maintain the high pressure required to push blood to distant parts of the body, such as the brain and extremities.

**Structure of Veins:**

- **Thinner Walls:** Since blood pressure is much lower after passing through tissues, veins do not need thick muscular walls.
- **Large Lumen:** The wide lumen reduces resistance to blood flow returning to the heart.
- **Semilunar Valves:** These structures act as one-way gates to prevent backflow, ensuring deoxygenated blood from the vena cava moves toward the heart against gravity.
- **Skeletal Muscle Assistance:** Because their walls are less muscular than arteries, veins rely on the contraction of surrounding skeletal muscles to help squeeze blood upward.

**Structure of Capillaries:**

- **Single-Layer Endothelium:** Their walls are microscopic and made of a single layer of flattened cells, creating a short distance for diffusion.
- **Partial Permeability:** This allows oxygen, nutrients, and waste products to pass readily between the blood and tissue cells during oxidation.
- **Extensive Branching:** By branching repeatedly from arterioles, they provide a large surface area to maximize the efficiency of substance exchange throughout all body tissues.

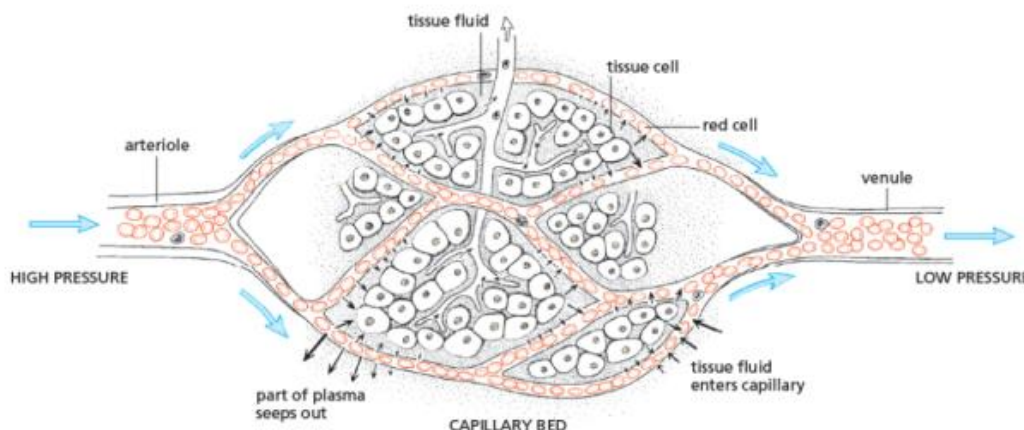
**9.6.2 Define Tissue Fluid (Interstitial Fluid)**

Tissue fluid is the liquid that surrounds and bathes the individual cells of all tissues in the body.

**9.6.3 Differentiate Between Tissue Fluid And Lymph**

Feature	Tissue Fluid	Lymph
Location	intercellular spaces of tissues.	inside specialized lymphatic vessels.
Formation	leakage of blood plasma from capillaries due to high pressure.	excess tissue fluid is drained into lymphatic capillaries.
Function	medium for the exchange of nutrients and gases between blood and cells.	Returns filtered fluid to the blood and transports fats and immune cells.
Flow	Static/Slow; moves via diffusion and osmotic pressure between cells.	Moves in a one-way system toward the heart, aided by muscle contractions.
Immune Role	General environment for cells; contains some white blood cells.	Highly active; passes through lymph nodes to be filtered for pathogens.
Fat Content	Very low-fat content.	Can be high in fats

**9.6.4 Illustrate The Transfer Of Materials Between Capillaries And Tissue Fluid**



### 9.6.5 Identify Origin, Location And Target Areas Of Main Arteries

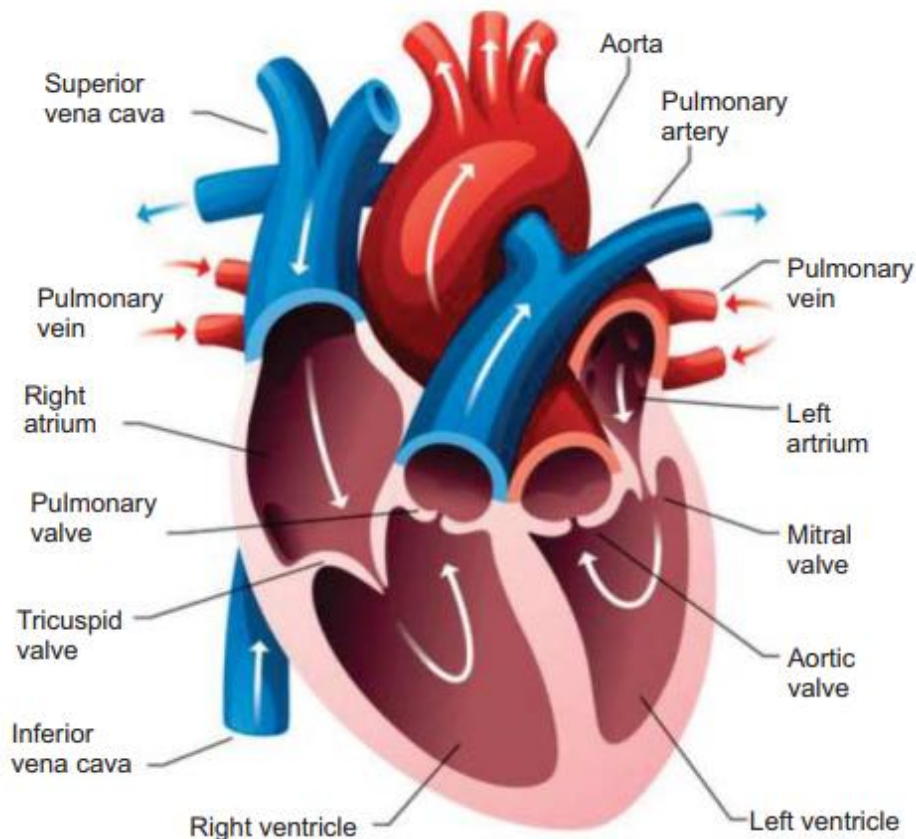
The pulmonary artery which originates from the right ventricle carries deoxygenated blood towards the lungs and aorta which originates from the left ventricle carries oxygenated blood towards the body. Aorta terminates into arteries of the head, neck and arms. Aortic arch curls backward to the left side of the heart and continues downwards as the dorsal aorta, which distributes blood to regions of the body below the heart. For example, it supplies blood (oxygenated) through hepatic artery to the liver, renal artery to kidney and femoral artery to lower limb.

### 9.6.6 Identify Origin, Location And Target Areas Of Main Veins

- Pulmonary veins bring oxygenated blood from the lungs to the left atrium of the heart.
- Superior vena cava brings deoxygenated blood from the head, neck and arms to right atrium.
- Inferior vena cava runs upwards parallel to dorsal aorta and brings deoxygenated blood from lower body.
- Femoral veins bring blood from lower limb to the right atrium.
- Renal vein bring blood from kidneys to the right atrium.
- Hepatic vein bring blood from the liver to the right atrium.

## 9.7 Human Heart

### 9.7.1 Identify The Components Of The Mammalian Heart



### 9.7.2 Explain The Functional Demands On The Heart Chambers That Lead To Differences In Their Muscle Wall Thickness

The function of atria is to stretch to receive blood as it returns to heart and then contract with enough force to push blood through the atrioventricular valves into the ventricles. This requires a lower pressure than that developed in the ventricles, so the walls of the atria are much thinner and more elastic than those of ventricles.

### 9.7.3 Explain The Functioning Of Heart In Terms Of The Contraction Of Atria And Ventricles And The Action Of The Valves In A Heartbeat

1. When blood is collected in the left and right atria, the heart receives an electrical signal that causes the atria to contract. This contraction pushes blood into the right and left ventricles through tricuspid and bicuspid valves respectively.
2. The second phase of pumping blood begins when the ventricles are full of blood. The electrical signals travel along a pathway of cells to the ventricles, this causes ventricles to contract. The relaxation of heart muscle and allowing the chambers to fill with blood, this phase of heartbeat is called diastole. The contraction of heart muscle and pumping the blood from the chambers into the arteries named as systole.

### 9.7.4 Describe The Reason For Low-Pressure Circulation To The Lungs And A High-Pressure Circulation To The Body Tissues

The circulation of blood in our body is called double circuit system because it circulates blood in two separate circuits and enter twice in heart during complete circulation. These two circuits are:

1. Pulmonary Circuit; from heart to lungs and back from lungs to heart.
2. Systemic Circuit; from heart to different organs and from organs back to heart.

#### **Pulmonary circuit:**

It transports blood from right ventricle to lungs through pulmonary arteries and flow back to heart in left atrium through pulmonary veins. The deoxygenated blood from all over the body except lungs received in right atrium and then collected into right ventricle, upon contraction of ventricle this deoxygenated blood enters into pulmonary arch which supply this blood to the lungs, where blood gives up its CO<sub>2</sub> and receives O<sub>2</sub> from air at capillary level. Deoxygenated blood now becomes oxygenated which flow back to the left atrium through pulmonary veins. This oxygenated blood now circulates through the body by Systemic Circulation.

#### **Systemic circuit:**

Circulation of oxygenated blood from left ventricle through systemic aorta to all organs of body and back to heart by superior and inferior vena cava as deoxygenated blood is called systemic circulation or circuit. Upon contraction the left ventricle forces oxygenated blood into systemic aorta, the largest artery of our body. Initially, the aorta gives off three branches which supply blood to head, arms and shoulders. This aorta then descends down and gives off many branches which supply blood to their respective organs e.g. a branch which supplies blood to liver called Hepatic artery, another branch called renal artery supplies blood to the kidney and coronary artery to heart etc.

### 9.7.5 Define The Terms Heartbeat And Pulse Rate

The pumping of blood by the rhythmic pulsation of heart throughout the body is called heartbeat. The number of heartbeats in a minute i.e. the heart rate can be measured by the beating of heart. On average, a healthy heart beats 72 times in a minute. The normal range of heart rate is 60 – 100 beats in a minute.

### 9.7.6 Evaluate The Role Of Cardiovascular Health In Determining Heart Rate Response And Recovery Time After Exercise

It is necessary to keep the heart rate within the normal range. The decreasing heart rate is a result of slow heartbeat, which leads to bradycardia. In this condition, the heart rate is too slow (or below 60 beats per minute). This slow heart rate reduces amount of blood and oxygen to vital organs of body causing shortness of breath, dropping of blood pressure, extreme fatigue etc.

On the other hand, when a heart beats very fast (more than 100 beats per minute), this condition is called tachycardia. Due to this rapid heart rate, the function of heart becomes very hard. It means that the heart does not have enough time to fill with blood and enough blood is pumped forward.

A healthy, well-conditioned heart has a stronger muscle and larger chambers, allowing it to pump more blood per beat. In fit individuals, the heart rate increases more gradually during exercise because the heart can meet the muscles' increased oxygen demand with fewer beats. In contrast, a less healthy cardiovascular system must beat much faster to compensate for lower efficiency.

HRR is the speed at which the heart returns to its resting rate after physical exertion. It is a powerful non-invasive marker of cardiovascular fitness. A standard measure of good cardiovascular health is a drop of 18 beats per minute (bpm) or more within the first minute of stopping exercise. Faster recovery indicates a robust parasympathetic nervous system that can quickly reactivate to calm the heart after the stress of exercise.

## 9.8 Cardiovascular Disorders

### 9.8.1 Differentiate Between Arteriosclerosis And Atherosclerosis

#### **Atherosclerosis (ATH):**

ATH is a disorder in which bad fats (i.e. low-density lipoprotein or LDL and cholesterol) get deposited in blood vessels internal layer. Accumulation of fats leads to gradual narrowing of lumen of blood vessel. Narrow lumen leads to gradual compromise of blood supply to target organs, and leads to myocardial infarction and stroke.

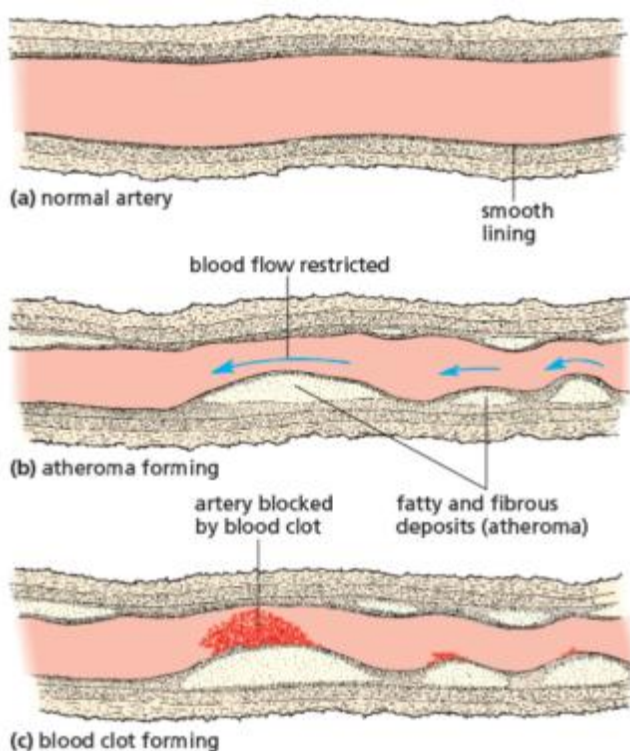
#### **Arteriosclerosis:**

It is a process in which arteries loss their elasticity due to some pathological process or simply by aging. Loss of elasticity leads to high blood pressure which may eventually lead to vascular hemorrhage.

### 9.8.2 Describe That Plaque Buildup Narrows The Coronary Arteries And Restricts Blood Flow To The Heart

Deposits of a fatty substance, called atheroma, are laid down in patches in the lining of the large and medium arteries. This happens to everyone and the number and size of the patches increase with age. However, until one of them blocks an important artery the effects are not noticed. The patches may join up to make a bigger area, which reduces the internal diameter of the vessel.

The surface of a patch of fatty deposit can become rough, causing a blood clot to form. The coronary artery supplies the muscles of the ventricles with blood. If this gets blocked it starves the muscles of oxygenated blood and the heart may stop beating. This is a severe heart attack. A blood clot might form anywhere in the arterial system. However, its effects in the coronary artery and in parts of the brain are the most severe.



### 9.8.3 Describe Causes And Symptoms Of Angina Pectoris And Myocardial Infarction

In the early stages of coronary heart disease, the atheroma may partially block the coronary artery and reduce the blood supply to the heart. This can lead to a pain in the chest that happens during exercise or hard work. This is a warning to the person that he or she is at risk and should take safety measures to avoid a heart attack.

Causes of myocardial infarction (Heart Attack) and Angina Pectoris (Chest Pain) can be divided into non-modifiable factors (which we cannot change) and modifiable factors (which we can change).

Non-modifiable factors	Modifiable factors
Sex (More in males)	Stationary life (no exercise)
Age ( More in old age)	Smoking and High fat diet
Race (More in blacks)	Stress
Family history	Heavy alcohol consumption

### 9.8.4 Describe The Preventive Measures For Coronary Heart Diseases

1. Dietary Changes: Adopt a diet rich in fruits, vegetables, whole grains, and lean proteins (fish and legumes).
2. Regular Exercise: Aim for at least 150 minutes of moderate-intensity aerobic activity (like brisk walking or swimming) or 75 minutes of vigorous activity per week.
3. Aspirin: Low-dose aspirin (75–100 mg daily) acts as a blood thinner to prevent clots and reduce the risk of heart attacks.
4. Angioplasty (PCI): A minimally invasive procedure where a balloon is inflated inside a narrowed artery to widen it. Often, a small mesh tube called a stent is permanently placed to keep the artery open.
5. Coronary Artery Bypass Grafting (CABG): A major surgery used for severe blockages. Surgeons use a healthy blood vessel from another part of the body (like the leg or chest) to create a detour, or "bypass," around the blocked section of the coronary artery.

### 9.8.5 Analyze Lifestyle Factors That Contribute To Coronary Heart Diseases

1. Diet: An unbalanced diet with too much animal fat and too many calories can lead to obesity. Being overweight puts extra strain on the heart and makes it more difficult for the person to exercise. Sometimes fats can form a deposit in arteries, restricting the flow of blood through them. The deposits can also cause blood clots, which can result in a heart attack.
2. Smoking: Statistical studies suggest that smokers are two to three times more likely to die from a heart attack than non-smokers of a similar age.
3. Lack of exercise: Heart muscle loses its tone and becomes less efficient at pumping blood when we do not exercise. Lack of exercise results in slower blood flow. This may allow atheroma to form in the arterial lining, although there is not much direct evidence for this.

## 9.9 Immune System

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### 9.9.1 Define The Terms

1. Pathogen: A pathogen is any biological agent that causes disease or illness to its host e.g. bacteria, viruses, fungi, and parasites. They function by invading the body, multiplying, and interfering with normal physiological processes.
2. Antigen: An antigen is a protein or polysaccharide found on the surface of a pathogen that immune system recognizes as "foreign". Antigens act like molecular ID tags that trigger an immune response when detected by WBCs.

3. **Antibody:** An antibody (also known as an immunoglobulin) is a Y-shaped protein produced by specialized white blood cells called B-lymphocytes. Their primary role is to identify and neutralize pathogens by binding specifically to their matching antigens, much like a lock and key. This binding can physically block the pathogen or "flag" it for destruction by other immune cells.

### 9.9.2 List The Main Components Of The Immune System

### 9.9.3 Describe Function Of Each Component In Defending The Body Against Pathogens

#### **White Blood Cells (Leukocytes)**

These are the primary soldiers of the immune system. They circulate in the blood and lymphatic vessels to monitor for pathogens. They are produced in bone marrow.

1. **Phagocytes:** These cells (like neutrophils and macrophages) "eat" and digest invading organisms.
2. **Lymphocytes:** These are more specialized.
  - a. **B cells:** Produce antibodies to target specific bacteria and viruses.
  - b. **T cells:** Destroy infected or cancerous cells directly and coordinate the overall immune response.

#### **Antibodies (Immunoglobulins)**

They circulate in the blood and recognize specific antigens on the surface of pathogens. Once bound to a pathogen, they can disable it directly or "tag" it so that phagocytes can find and destroy it more easily.

#### **Lymph Nodes**

These small, bean-shaped structures act as filtering stations for the lymphatic system. As lymph fluid drains from tissues, it passes through these nodes, which trap bacteria, viruses, and other foreign substances. They are packed with white blood cells. When an infection is detected, these cells multiply rapidly, which is why your "glands" (lymph nodes) often feel swollen when you are sick.

### 9.9.4 List The Components of First Second And Third Line Of Defense

#### **First Line of Defense: Physical and Chemical Barriers**

1. **Nasal Hair:** Physical filter that trap dust and microbes before they enter deeper into respiratory system.
2. **Ear Wax:** Physical filter that trap dust and microbes before they enter deeper into the ear canal.
3. **Tears:** Contain enzymes (lysozyme) that can break down the cell walls of certain bacteria.
4. **Cilia:** Microscopic hairs in the pharynx that sweep trapped pathogens toward the throat to be coughed out or swallowed.
5. **Skin:** A tough, waterproof layer that acts as a primary physical shield.
6. **Mucous Membranes:** Sticky linings in respiratory and digestive tracts that trap inhaled or ingested germs.
7. **Stomach Acid:** Highly acidic environment that kills most bacteria on food.

#### **Second Line of Defense: The Innate Immune Response**

1. **Phagocytic Cells:** Specialized white blood cells that eat and digest any foreign invaders they encounter.
2. **Inflammation:** Increases blood flow to infected area, bring more WBCs and cause redness, heat, swelling.
3. **Fever:** A controlled increase in body temperature that can slow the reproduction of pathogens.

#### **Third Line of Defense: The Adaptive Immune Response**

1. **B-Lymphocytes:** Produce specific antibodies that act like smart bombs to neutralize specific pathogens.
2. **T-Lymphocytes:** Coordinate entire immune response, attack and destroy virus infected or cancerous cells.
3. **Antibodies:** Special Y-shaped proteins that bind to antigens of specific pathogen to flag it for destruction.

### 9.9.5 Differentiate Between Innate/ Non-Specific And Adaptive/Specific Immunity

Feature	Innate Immunity (1 <sup>st</sup> & 2 <sup>nd</sup> Line)	Adaptive Immunity (3 <sup>rd</sup> Line)
Cell Types	Phagocytes (Macrophages, Neutrophils) Physical barriers like skin/cilia.	B Cells (B-lymphocytes) T Cells (T-lymphocytes)
Role	Immediate clean-up crew to prevent and contain infections.	Eradicates specific pathogens Provides long-term protection.
Response	Works within seconds to hours of exposure.	Takes days or weeks to fully activate
Memory	No Memory: The response is exactly the same every time it encounters the same pathogen.	Immunological Memory: Remembers the pathogen; if it returns, the body reacts almost instantly and more strongly.
Specificity	Treats all invaders (bacteria, viruses, dust) the same way using general patterns.	Recognize unique antigens and create antibodies for that exact strain.

### 9.9.6 Describe That Phagocytic Cell Ingest And Destroy Pathogens As Part Of The Second Line Of Defense

Phagocytosis is the primary process used by phagocytic cells to ingest and destroy invaders. The phagocytic cell moves toward a pathogen by following chemical signals (chemotaxis). Cells' membrane wraps around the pathogen, pulling it inside into a sac called a phagosome. The phagosome fuses with a lysosome, which contains powerful enzymes and acids that break the pathogen apart. Harmless remains are expelled from cell. Each cell type has a specific role in this non-specific response:

1. **Neutrophils:** These are the first responders. They are the most abundant white blood cell and arrive quickly at an infection site to begin eating bacteria.
2. **Macrophages:** These cells are larger and more powerful. They can ingest a high volume of pathogens and also help clean up dead neutrophils and cellular debris.
3. **Dendritic Cells:** These act as messengers. After ingesting a pathogen, they travel to the lymph nodes to show pieces of antigens to the third line of defense, triggering a more specific immune response.
4. **Natural Killer (NK) Cells:** They scan body cells for signs of infection or cancer and force them to self-destruct (apoptosis) by releasing lethal proteins.

### 9.9.7 Describe

#### Production Of Antibodies By B-Cells To Neutralize Pathogens

Each B-cell has a specific receptor for a single antigen. When it encounters its matching antigen on a pathogen, the B-cell is activated. The activated B-cell divides rapidly to produce thousands of plasma cells. These plasma cells secrete millions of antibodies (Y-shaped proteins) into the bloodstream. Antibodies neutralize pathogens by binding to them, which can:

- Block the pathogen from entering healthy cells.
- Clump pathogens together (agglutination) so they can't move.
- Tag them as a target for destruction.

#### Role Of Phagocytosis In Eliminating Pathogens

While antibodies flag and disable pathogens, they do not usually destroy them directly. This is where phagocytes (like macrophages and neutrophils) come back into play. Phagocytes have receptors that easily grab onto the tail end of an antibody. Antibodies coat a pathogen which makes it much easier for a phagocyte to find, ingest, and digest via phagocytosis.

### **Importance of Memory Cells for Long-Term Immunity**

During the first encounter with a new pathogen, the body takes several days to create enough antibodies. However, not all B-cells and T-cells become active fighters. Some cells differentiate into Memory B-cells and Memory T-cells, which remain in the body for years or even a lifetime. If the same pathogen enters the body again, these memory cells recognize it instantly. They trigger a massive and rapid production of antibodies often so fast that the pathogen is destroyed before you even feel symptoms. This is the biological basis for immunity.

### 9.9.8 Describe

#### **Vaccines Work To Stimulate The Immune System**

Vaccines contain antigens, which are weakened, killed, or fragmented parts of a pathogen that tell cells how to make a harmless piece of the pathogen. The immune system identifies these antigens as foreign substances that do not belong in the body. B-lymphocytes respond by producing antibodies designed specifically to attach to and neutralize that particular pathogen. T-lymphocytes are also activated to destroy any cells that might be infected and to coordinate the overall immune response

#### **Vaccines Provide Protection Against Specific Diseases**

After the initial threat is cleared, the body retains memory B and T cells. These cells keep a record of specific germs. If exposed to the actual disease in the future, these memory cells recognize it immediately and flood the system with antibodies before the pathogen can act.

### 9.9.10 Explain The Steps Involved In The Process Of Blood Clotting

#### **Step 1: Vascular Spasm (Vasoconstriction)**

When a blood vessel is injured, the smooth muscle in its walls immediately contracts. This vasoconstriction reduces the diameter of the vessel, significantly slowing blood flow to the area and minimizing blood loss.

#### **Step 2: Platelet Plug Formation**

Platelets in the blood respond to the exposed collagen fibers of the damaged vessel wall. Platelets stick to the exposed collagen. Once attached, platelets change shape and release chemical signals (like ADP and thromboxane). These chemicals attract more platelets to the site, which stick to each other to create a temporary, loose seal called a platelet plug.

#### **Step 3: The Coagulation Cascade (Clot Formation)**

To turn the fragile platelet into a sturdy clot, the body initiates a complex series of chemical reactions involving clotting factors (proteins in the plasma). The cascade leads to the production of an enzyme called prothrombinase. Prothrombinase converts the inactive protein prothrombin into the active enzyme thrombin. Thrombin then converts soluble fibrinogen into insoluble fibrin threads. These threads weave through the platelet plug, trapping red blood cells and creating a stable, solid blood clot.

#### **Step 4: Clot Retraction and Repair**

Contractile proteins within the platelets (actin and myosin) pull on the fibrin threads, squeezing out serum and shrinking the clot. This pulls the torn edges of the blood vessel closer together. Platelets release growth factors that stimulate smooth muscle and connective tissue cells (fibroblasts) to divide and rebuild the vessel wall. Eventually, an enzyme called plasmin dissolves the clot once the tissue is healed.