TRANSPORT OF MATERIAL

Transportation Of The Materials refers to the movement of materials into the organisms or from one part of the organism to another. It can also be the movement of materials from the organism to the environment. Organisms require a transport system to carry out various life processes that include nutrition, respiration, excretion, coordination, growth and development.

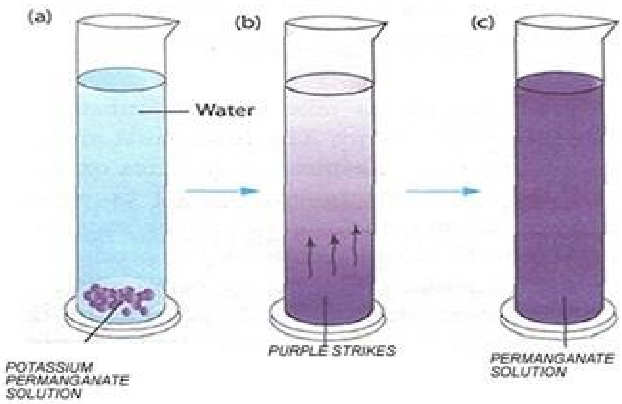
For example, during nutrition, organisms take in food substances that they need to provide them with energy. The food must also be transported to all parts of the organism. Respiration requires oxygen, which must be taken in from the environment. During excretion, waste materials from the organism are transported to the excretory organs and removed from the body. Growth requires the production and transportation of growth hormones to the growing parts of the organism. Movement and locomotion are made possible by the transportation of impulses to the relevant organs. Reproduction requires the movement of gametes (sex cells) or the transportation of genetic material. Sensitivity is made possible by the transportation of messages about the presence of a certain thing in the environment.

Ways of Transportation of Materials

- **Active transport**; where the cell has to use energy to move materials across the cell membrane.
- **Passive transport**; which occurs spontaneously without the need of energy to transport materials through the cell membrane. Processes like diffusion, osmosis and mass flow involve passive transport.

Diffusion

Diffusion is the movement of particles from an area of high concentration to one of low concentration. A difference in the concentration of a substance between two regions is known as **a concentration gradient**. Diffusion causes particles to move from the area of high concentration to a low concentration area. This process continues until the particles are distributed evenly throughout the liquid. Figure below shows the diffusion of potassium permanganate in water.



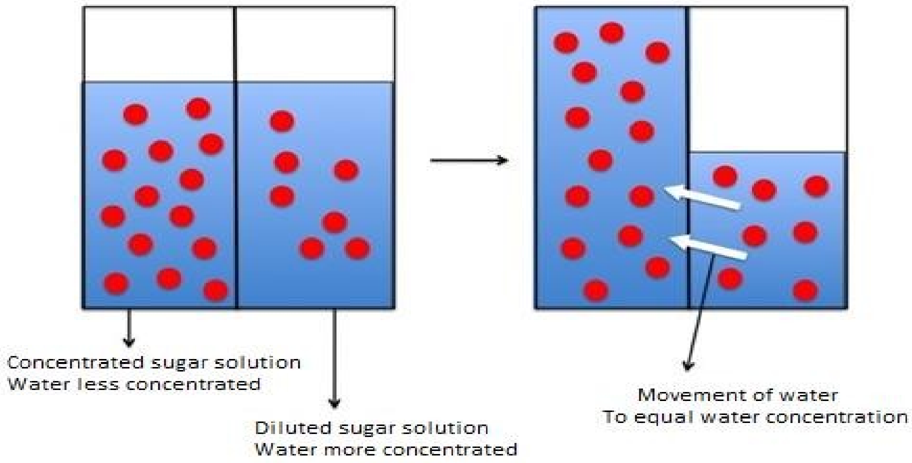
FACTORS AFFECTING RATE OF DIFFUTION

- **Concentration gradient**: high diffusion rate with higher concentration and vice versa
- **Surface area to volume ratio:** the higher it faster the diffusion rate.
- **Distance over which diffusion takes place**: example a thin layer of cells increases diffusion rate

Osmosis

Osmosis defined as the process by which water move from a weak solution into a strong through a semi-permeable membrane. The semi permeable membrane is only permeable to some solutes (dissolved substances).

For osmosis to take place there must be two separated solutions by a semi-permeable membrane. One solution should have greater water and a lesser quantity of solute than other solution. This solution is hypotonic, it has a lower water potential. The second should have a lesser volume of water and volume of solute than the other solution. This solution is hypertonic, meaning it has greater water potential. Two solutions have the same water potential are said to be isotonic



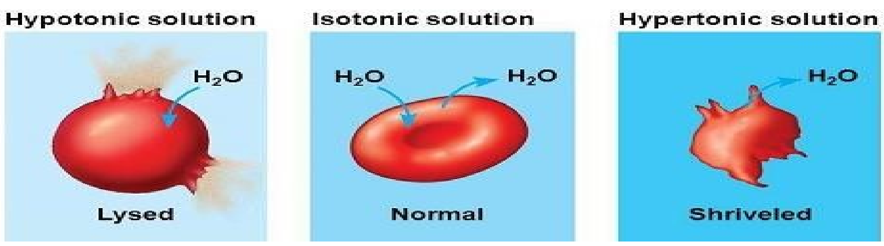
Effects of osmosis in living organisms

Osmosis and animal cells

When an animal cell is put in a hypotonic solution, it absorbs water. If it remains in the solution for a long time, it absorbs excess amounts of water. A cell that does not have a mechanism for removing the excess water bursts due to the excessive internal pressure. When an animal cell is placed in a hypertonic solution, it loses water. If it remains in the solution for a long time, it loses a lot of water, shrinks and shrivels.

These effects of osmosis on animal cells can be observed in red blood cells. Under normal conditions, the osmotic pressure of red blood cells is equal to that of the blood plasma, i.e. they are isotonic. Thus, there is equal movement of water in and out of the cells. This helps to maintain the disc shape of these cells.

When red blood cells are put in a hypotonic solution, they absorb water, causing the cell volume to increase. Excessive amounts of water cause **hemolysis (bursting).** When red blood cells are put in a hypertonic solution, they lose water, leading to shriveling of the cell. This is referred to **crenation**



Osmosis is important for the reabsorption water in the colon and the kidneys. This help to maintain the body's water balance.

Osmosis and plant cells

In an **isotonic solution**, plant cells neither lose nor gain water. In hypotonic solution cells absorb water, causing the cell membrane to push against the cell wall. The cell is to be turgid. It does not burst because membrane exerts pressure on the cell wall restricts additional intake of water. Turgid plants to maintain their shape.

In a hypertonic solution, plant cells lose water this causes the vacuole to shrink and their cell membrane to pull away from wall, making the cell flaccid. Such a **cell is to be plasmolyzed** and the process **plasmolysis.** If a plasmolyzed cell is placed in a hypotonic solution, it absorbs water and becomes turgid.

Osmosis is important for the absorption of water by plant roots. Opening and closing of stomata also depend on osmosis. When guard cells absorb water the stomata open and when they lose water the stomata close.

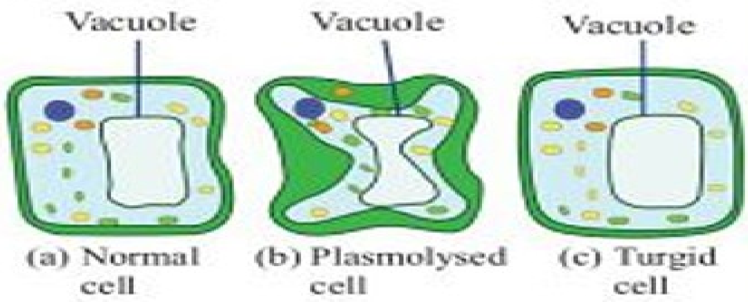


Figure 8.6: Effect of osmosis on a plant cell

Osmosis and unicellular organisms

Unicellular organisms that live in fresh water, for example amoeba and euglena, are hypertonic to surrounding so water enters the organisms by osmosis. These organisms have a contractile vacuole. The contractile vacuole collects the excess water and removes it from the cell. This prevents the cells from bursting

Mass Flow

Mass flow is the bulk movement of substances from one region to another due to the difference in pressure between the two regions. Mass flow occurs within a cell or along a vessel. Examples of systems where mass flow occurs are:

- The circulatory system (flow of blood) in animals.
- The lymphatic system (flow of lymph) in animals.

Transport of manufactured food material in plants from the site of manufacture (mostly leaves) to the point of use (all plant parts) through the phloem. This process is called **translocation.**

TRANSPORTATION IN MAMMALS

Mammals are complex multicellular organisms. Their bodies are made up of numerous cells and tissues. Hence, diffusion alone is not enough to ensure efficient carrying out of life processes.

Mammals therefore have an elaborate transport system called the circulatory system. The circulatory system is made up of the heart, the blood and the blood vessels**.**

The Mammalian Heart

An example of the mammalian heart is the human heart. The human heart is approximately the size of a clenched fist. It is located in the chest cavity between the two lungs.

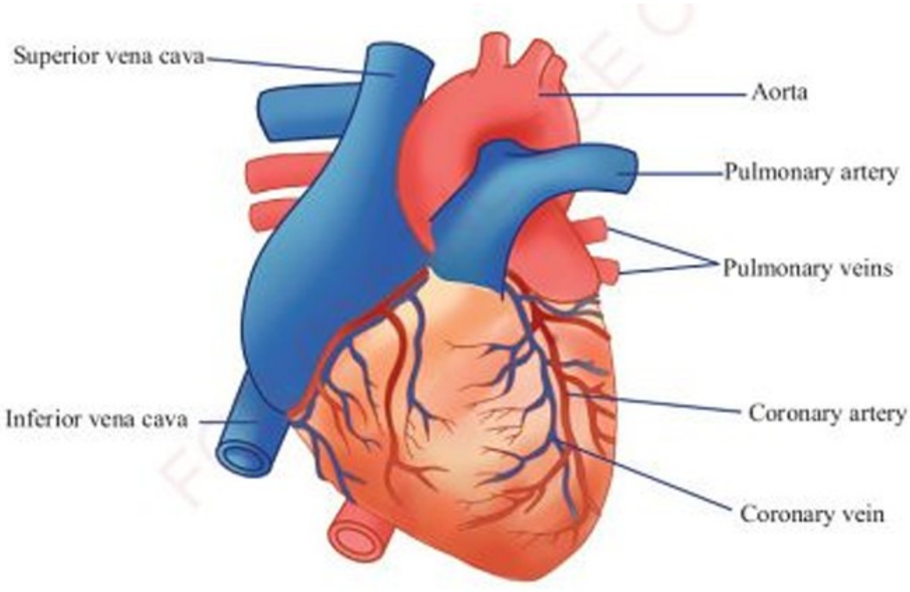


Figure 9.1: External structure of the mammalian heart

The external structure of the mammalian heart

The mammalian heart is broader at the top and narrower at the bottom. It is enclosed by a double layer of tough inelastic membranes called the **pericardium**. The membranes prevent the heart from over-expanding when it is beating very fast. The pericardium also secretes a fluid called **pericardial fluid**. This fluid enables the membranes to move smoothly against each other.

The wall of the heart is made up of the **cardiac muscles**. Cardiac muscle is never fatigued (tired). It works continuously as long as a person is alive. This type of muscle is found only in the heart.

The wall of the heart has three layers:

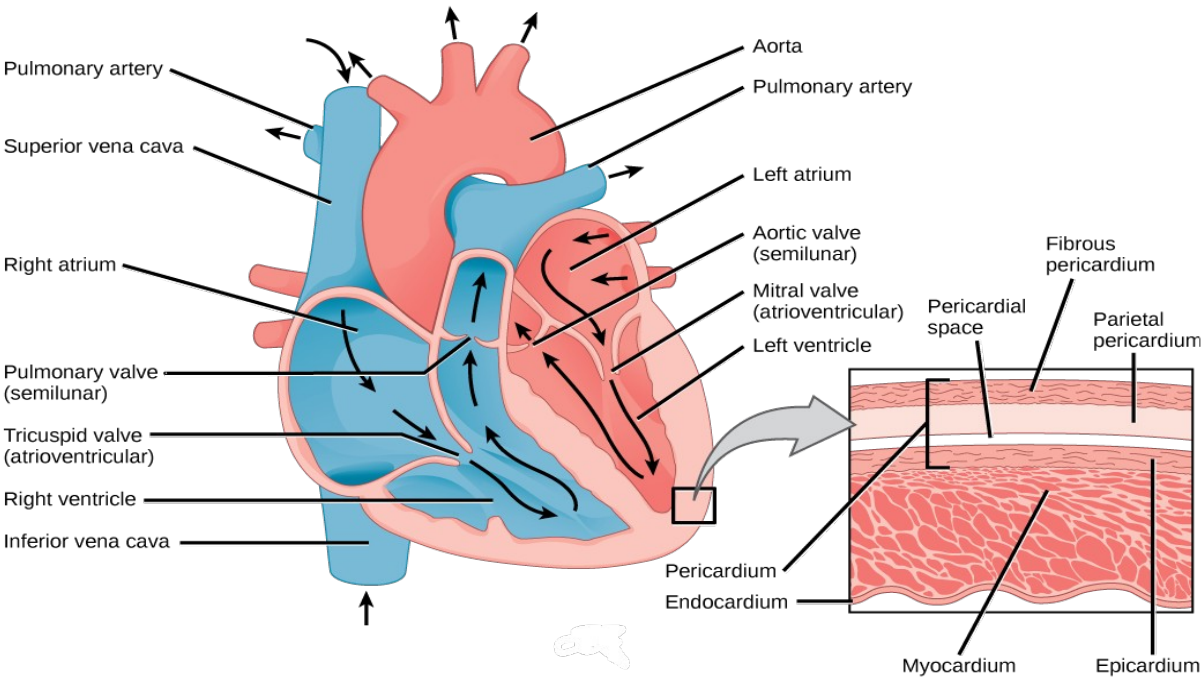
- **The epicardium** is the outer protective layer.
- **The myocardium** is the middle layer.
- **The endocardium** is the inner most layer. This layer is continuous with the lining of the blood vessels attached to the heart.

The coronary artery supplies the heart with oxygenated blood. The coronary vein carries blood containing waste materials away from the heart.

The vena cava and **pulmonary vein** bring blood from the rest of the body to the heart. The aorta and pulmonary artery transport blood from the heart to the rest of the body.

The vena cava and **pulmonary vein** bring blood from the rest of the body to the heart. The aorta and pulmonary artery transport blood from the heart to the rest of the body.

A Diagram Show the Internal Structure Of The Mammalian Heart



The heart has four chamber right auricle, right ventricle, left auricle and left ventricle. The auricles are also called atria (singular: atrium). The walls of the ventricles are thicker than those of the auricles. This is because the ventricles pump blood to a greater distance than the auricles.

Auricles pump blood to the ventricles. Ventricles pump blood to all other parts of the body. The left ventricle is thicker than the right ventricle because the right ventricle pumps blood to the lungs while the left ventricle pumps blood to the rest of the body.

The heart has several valves. Valves have flaps that ensure that blood flows in one direction only. **The tricuspid** valve is found between the right auricle and right ventricle. The **bicuspid valve** is found between the left auricle and left ventricle. Semi lunar valves are located at the bases of the pulmonary artery and aorta to prevent blood from flowing back into the ventricles.

Note: Valves close when blood tries to flow back.

The left and right sides of the heart are separated by the **septum**. The septum is a thick muscular wall that prevents mixing of oxygenated and deoxygenated blood.

The flow of blood through the heart;

The vena cava brings **deoxygenated** blood to the heart. Deoxygenated blood contains low amounts of oxygen**.** The vena cava has two branches:

- **The superior vena cava** which transports deoxygenated blood from the upper parts of the body such as head, neck and upper limbs.
- **The inferior vena cava** which transports deoxygenated blood from the lower parts of body such as the lower limbs, kidney, liver, stomach and intestines.

The inferior vena cava and the superior vena cava unite to form the **vena cava**; the vena cava is connected to the right auricle. When the **right auricle** relaxes, it fills up with deoxygenated blood from the vena cava. There is increased pressure in the right auricle when the muscles contract. This pushes the blood trough the tricuspid valve. The muscles of the right ventricles relax and it fills up with blood. The tricuspid valve closes to prevent blood from owing back into the right auricle. When the **right ventricle** is full, the increased pressure causes the muscles to contract and the **Semi lunar valve** in the pulmonary artery to open. The blood flows into lie pulmonary artery and the bicuspid valve closes prevent back flow of blood.

The pulmonary artery transports blood to the lungs. Blood absorbs more oxygen in the lungs, and thus becomes oxygenated. Oxygenated blood flows to the heart through the pulmonary vein. This vein is connected to the left auricle. When the **left auricle** relaxes, the **semi lunar valve** opens and blood from the pulmonary vein flows in. Pressure increases in the **left auricle** as it fills up with blood. The pressure causes the muscles of the auricle to contract and pump blood through the **bicuspid valve** into the left ventricle.

The muscles of the left ventricle contract, allowing blood to flow in. The bicuspid valve closes to prevent blood from flowing back into the left auricle. Pressure builds up in the left ventricle as blood flows in.

The muscles of the left ventricle contract, pumping blood through the semi lunar valve into the aorta. The aorta branches into smaller arteries that transport blood to all parts of the body. The heart beats in such a way that when the auricles contract, the ventricles relax and vice versa.

In the right atrium, there is a small patch of muscle called the **sinoatrial node** (SAN). This node acts as a pacemaker, setting the time and rate of cardiac muscle contraction.

How heart is adapted to its functions?

Adaptations of Heart to Its Functions

1. The heart is divided into 4 chambers to carry a large volume of blood and avoid mixing of oxygenated and deoxygenated blood.
2. The heart is divided into two by the atrioventricular septum; that prevent mixing of oxygenated blood and deoxygenated blood The walls of the left ventricle are thicker than those of the right ventricles, to generate more pressure to pump blood over longer distance to the rest of the body.
3. It has cardiac muscles which are myogenic, (does not need nervous stimulation) for pumping of blood.
4. Heart has tricuspid and bicuspid valves are held by tendons which prevents the valves from turning inside out during ventricular contractions.
5. Semi lunar valve at the base of the aorta and pulmonary artery; prevents back flow of blood to the ventricles once it has been pumped out
6. It has tricuspid and bicuspid valves between articles and ventricles which prevents back flow of blood into the right and left ventricles respectively.
7. The heart is connected to the coronary artery which supplies food and oxygen to the cardiac muscles for the pumping action.
8. The heart is connected to the coronary artery which supplies food and oxygen to the cardiac muscles for the pumping action.
9. The heart is connected to the coronary artery which supplies food and oxygen to the cardiac muscles for the pumping action.
10. The Sino Atrial Node (S.A.N), the pacemaker region which initiate the wave of contraction leading into contraction and relaxation of muscles;

11. The atrioventricular node, in the heart spreads out waves of contraction throughout the heart creating the heart beat

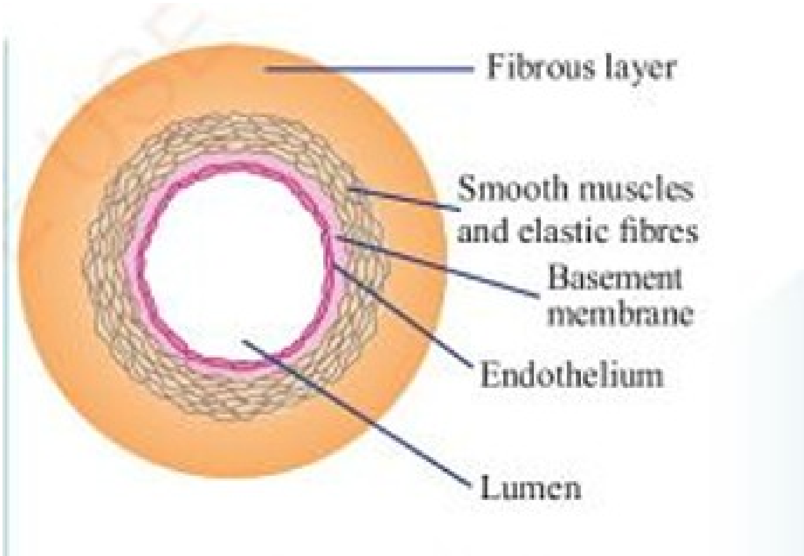
Blood vessels

Mammals have three types of blood vessels: arteries, veins and capillaries.

Arteries

Arteries are thick-walled, muscular and elastic vessels that transport blood from the heart to all parts of the body. All arteries transport oxygenated blood, except the pulmonary artery which transports deoxygenated blood from the heart to the lungs.

Cross-sectional Diagram of Artery



The **endothelium** is the innermost layer of the artery. It has only one layer of cells. The endothelium surrounds the **lumen** (the central tube of the vessel). The lumen of an artery is narrow and smooth so that it can transport blood at high pressure.

The muscular layer is made of smooth muscle and elastic fibres. Smooth muscle is arranged in circles round the endothelium. This layer makes it possible for the artery to contract and relax for the efficient movement of blood.

The outermost layer is the fibrous layer made of connective tissues such as ***collagen***. The fibres are arranged parallel to the length of the vessel. They enable the artery to withstand the pressure caused by the blood coming from the heart.

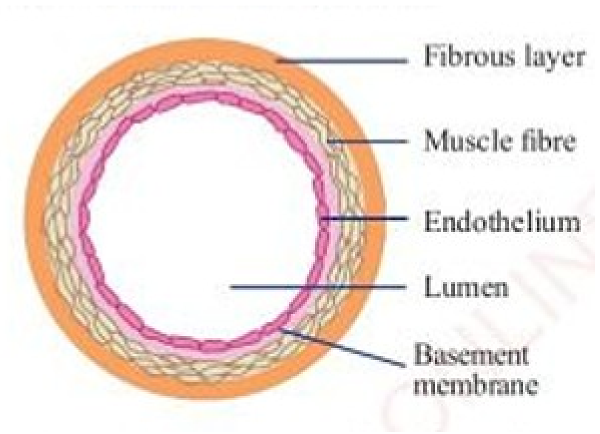
When the ventricles contract, the arteries relax to allow blood to flow from the heart into them. Conversely, when the ventricles relax, the arteries contract, pushing the blood forward. This rhythmic contraction and relaxation of the arteries is what we feel as a pulse.

Pulse rate is the number of pulses per minute. The pulse rate reflects the heartbeat. An adult human's heart beats at an average of **72 times a minute**. However, this can increase or decrease due to physical activity, emotional state or health factors.Arteries branch to form **arterioles.** Arterioles in turn branch to form **capillaries**. Capillaries are joined at the other end by v**enules** which join to form **veins**.

Veins

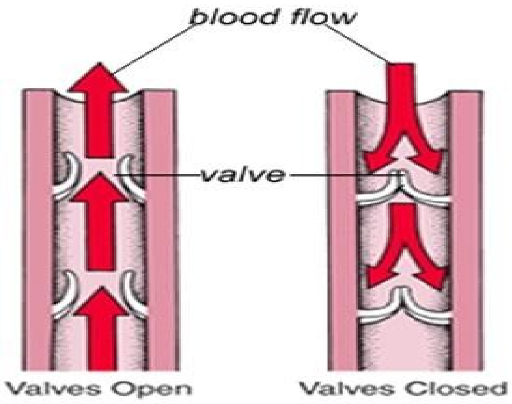
Veins are vessels that transport blood to the heart from all parts of the body. All veins transport deoxygenated blood except the pulmonary vein. The pulmonary vein transports oxygenated blood from the lungs to the heart

Cross-sectional Diagram of Vein



Veins have a larger lumen and less muscular walls compared to arteries. This is because the blood in the veins flows at low pressure.

Vein have valves at regular intervals. The valves prevent the back flow of blood.

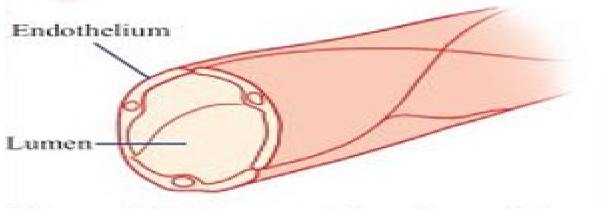


The muscles next to the veins squeeze the veins and help to force blood to flow towards the heart. The contraction of the ribs during breathing also helps to squeeze some veins and keep blood flowing.

Capillaries

Capillaries are the smallest blood vessels. They are narrow and have walls that are one cell thick. Capillaries are in direct contact with the tissues of the body. They form a network for the efficient diffusion of substances. Their thin walls maximize the rate of diffusion.

Diagram Show Cross-section of capillary



The thin walls of the capillaries enable oxygen and nutrients to diffuse from the blood to the cells, carbon dioxide and other waste products to diffuse from the cells into the blood and white blood cells to reach sites of infection. Capillaries join to form venules (small veins) which join to form veins.

Differences between arteries, veins and capillaries. *Table below gives a summary of the structural and functional differences between arteries, veins and capillaries.*

Comparison of Structure and Function of Arteries, Veins and Capillaries

Features	**Arteries**	**Veins**	**Capillaries**
Lumen	Have narrow smooth lumens	Have wide irregular lumens	Have narrow smooth lumens
Wall Thickness	Have thick muscular walls	Have thin, less muscular walls	Have one cell thick walls
Valves	Lack valves except where they are connected to the heart	Have valves at regular intervals	Lack valves
Blood Pressure	Transport blood at high pressure	Transport blood at low pressure	Transport blood at low pressure
Direction of Blood Flow	Transport blood away from the heart	Transport blood towards the heart	Transport blood within the tissues
Type of Blood	Transport oxygenated blood, except the pulmonary artery	Transport deoxygenated blood, except the pulmonary vein	Transport either oxygenated or deoxygenated blood
Flow Characteristics	Contract and relax to create a pulse	Blood flows smoothly	Blood flows smoothly

Blood is a specialized fluid tissue found in humans and other vertebrates. It is composed of four main components: plasma, red blood cells, white blood cells, and platelets. The primary function of blood is to transport oxygen gas and nutrients throughout the body. Additionally, it helps in removing waste products, transporting hormones, and forming blood clots to prevent excessive loss of blood in case of injury. Blood also plays a crucial role in the immune response to infections. An adult human typically has about 4 to 6 liters of blood, and its pH is approximately 7.4

Plasma

Plasma is a pale-yellow fluid. Approximately 55% of the blood is plasma. Plasma is mostly made up of water but it also has dissolved substances such as food nutrients, metabolic wastes, oxygen, proteins and mineral ions. These solutes make up 8% of the plasma while water makes up 92%.

The major functions of plasma are the transportation of:

- nutrients from the digestive system to the whole body
- red blood cells containing oxygen to the tissues
- wastes such as carbon dioxide and urea to the excretory organs
- white blood cells and antibodies to sites of infection
- hormones to the target organs
- mineral ions such as sodium, potassium and chlorides
- Platelets to sites of bleeding.

Plasma is also important for distributing heat to all parts of the body, regulating the pH of body fluids and it is where the exchange of nutrients and waste products takes place in the body.

Red blood cells

Normal red blood cell

Another name for the red blood cells is **erythrocytes**. They are red, round biconcave cells with no nucleus. One milliliter of blood has approximately 5 to 6 million red blood cells Red blood cells are formed in the bone marrow. Their lifespan is about 120 days. The liver and the spleen destroy old red blood cells and release **haemoglobin** for the formation of new cells. **Haemoglobin** is the red pigment in erythrocytes. It has a high affinity for oxygen.

The function of red blood cells is to transport oxygen and carbon dioxide. The adaptation red blood cells that make them suited for this function are the presence of haemoglobin, their large numbers, biconcave shape and the lack of nucleus which increases the total surface area of gaseous exchange.

Transportation of oxygen

In the lungs (where there is a high concentration of oxygen), haemoglobin combines with oxygen to form oxyhaemoglobin. This is an unstable compound which releases oxygen when it reaches tissues that have a low concentration of oxygen. The formation of oxyhaemoglobin and release oxygen and haemoglobin can be shown using the following equation.

$$\text{Haemoglobin} + \text{oxygen} \longrightarrow \text{Oxyhaemoglobin}$$

Oxygen diffuses out of the red blood cells, through the capillary walls to the tissues.

Transportation of carbon dioxide

In the red blood cells, carbon dioxide combines with haemoglobin to form carbominohaemoglobin. This compound is transported to the lungs where carbon dioxide is released and expelled from body.

White blood cells

These cells have irregular shape with nuclei. They are also called ***leukocytes.*** They help the body to fight against diseases and infections. 1mls of blood has approximately 5,000 to 10,000 white blood cells. They are produced in the white bone marrow and in the lymph nodes.

The function of white blood cells is to protect body against infection. They perform this function by:

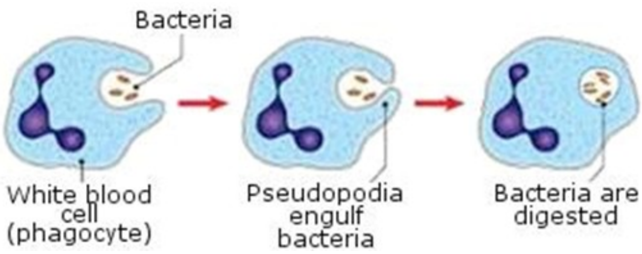
Phagocytosis in a white blood cell

1. Engulfing and destroying pathogens (a process called phagocytosis).

2. Producing substances that neutralize toxins produced by pathogens.

3. Causing clumping together of foreign materials in the body.

4. Killing infected body cells.

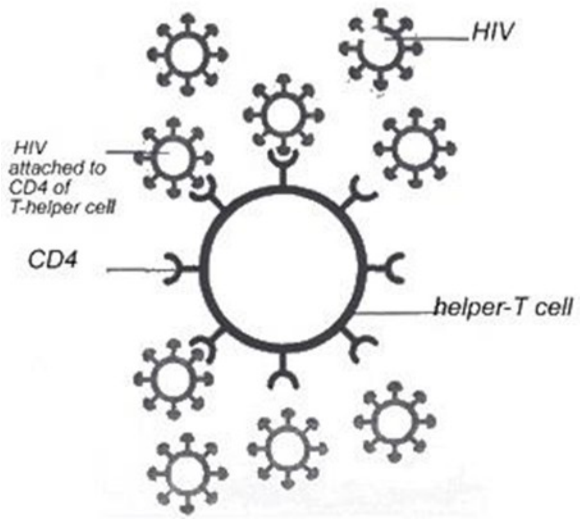


The effect of HIV on white blood cells

The Human Immunodeficiency Virus (HIV) attacks a type of white blood cells called helper-T cells. These cells are essential for body immunity. When they encounter an antigen, the helper-T cells divide themselves to form new cells. This increases the number of cells available to fight the infection. After the infection, some cells remain as memory cells to activate an immune response if the infection happens again, in addition helper-T cells activate other cells in the immune system.

HIV has a protein envelope that can only bind to its receptor called CD4 found on the cell membrane of the helper-T cell. When it enters the human body, HIV fuses its protein envelope with the CD4 then enters the cell. Once inside the cell, the virus becomes part of the helper-T cell and replicates together with it as it undergoes division. This increases the amount of HIV in the blood. The HIV destroys helper-T cells resulting in the reduction of the number of helper-T cells and reducing the CD4 count.

Diagram HIV attacking T-helper



HIV destroys helper-T cells in the following ways:

1. It reproduces inside the helper-T cell, and then ruptures the cell's membrane and the new viruses are released.

2. It alters the helper T-cells so that when it responds to an infection, it kills itself instead of dividing to form new cells.

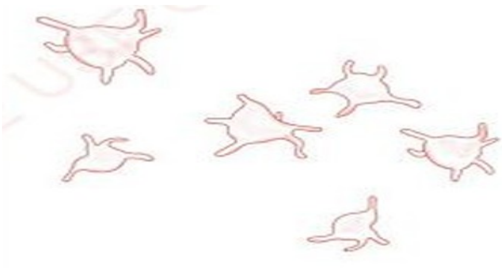
3. It marks helper-T cells as targets for destruction by other cells in the immune system.

4. It causes the fusion of many helper-T cells to form a giant' cell. Such a cell can survive but it cannot perform normal helper-T cell functions.

Thus, HIV lowers the body's immunity significantly making it vulnerable to opportunistic infections.

Platelets

Platelets are also called thrombocytes. They are fragments of cells produced in the bone marrow. One milliliter of blood contains about 250 000 to 400 000 platelets. They play an important role in the clotting process.



Blood platelets

The clotting processes

Platelets at the site of an injury produce **thromboplastin** which starts off the clotting process. Thromboplastin, with the help of vitamin K and calcium neutralizes **heparin**, an anticoagulant in blood. Heparin converts **prothrombin** (which is an inactive plasma protein) to **thrombin** (an active plasma protein).

Thrombin catalyzes the conversion of soluble **fibrinogen** to insoluble **fibrin**. Fibrin forms a network of fibres that traps debris and blood cells. The result is a clot at the site of the wound preventing further loss of blood.

Blood Groups and Blood Transfusion

Grouping of human blood is done using the ABO system and the Rhesus factor.

The ABO system

The ABO system of grouping blood depends on two things. First is the presence or absence of antigen A or antigen B on the membranes of the red blood cells. Second is the presence of antibody A or antibody B in the blood plasma.

A person cannot have a certain antigen membrane of the red blood cell and also have the corresponding antibody in the plasma. For example, you cannot have both antigen **A** antibody **a**. This would cause agglutination clumping together of red blood cell. Agglutination can cause fatal

Blood groups according to ABO system

Blood group	Antigen on the membrane of the red blood cell	Antibody in the plasma
A	A	b
B	B	A
AB	A and B	None
O	None	a and b

Rhesus factor

This factor is named after the Rhesus monkey in which it was first observed. When the rhesus factor is present on the red blood cell membrane, a person is said to be rhesus positive. This is abbreviated as

Rh+. If it is absent, the person is rhesus negative this is abbreviated as Rh-. Thus, a person's blood is said to be A+ if it is blood group A and has the Rhesus factor or A- if it is blood group A but lacks the Rhesus factor. There is also B+ or B-, O+ or 0- and AB+ or AB-blood groups.

If a rhesus negative woman marries a rhesus positive man, their children are highly likely to be rhesus positive. During the last months of pregnancy, the rhesus antigen from the foetus passes into the mother's blood. This causes the mother's body to produce antibodies which destroy some of the foetus's red blood cells. This destruction is minimal in the first child but in the children that follow, a lot of destruction could take place, killing the foetus. This is called haemolytic disease of the newborn ***or erythroblastosis*** foetalis. To prevent this, the mother is treated with anti-rhesus globulin. This prevents her body from forming antibodies against the rhesus antigen.

Blood transfusion

Blood transfusion is the transfer of blood from one person (the donor) to another (the recipient). It is necessary to replace blood when the recipient has a blood disorder or has lost a lot of blood due to surgery or an accident.

In order for blood transfusion to be successful, the blood of the donor and that of the recipient must mix without agglutination. When this happens, the blood is said to be compatible. If the blood is incompatible, agglutination occurs.

Blood compatibility depends on the blood groups of the donor and the recipient. For example, if a person of blood group A receives blood from a person of blood group B, the recipients' body produces antibodies against antigen B. This is because the antigen is seen as foreign material.

Individuals with blood group AB are called universal recipients. They can receive blood from people of any blood group. However, they can only donate blood to someone with blood group AB. Those with blood group O are universal donors. They can donate blood to people of all blood groups. On the other hand, they can only receive blood from someone with blood group O.

The following is a compatibility table for the different blood groups.

Donor's blood group	**Recipient's blood group**			
	A	B	AB	O
A	✓	✕	✓	✕
B	✕	✓	✓	✕
AB	✕	✕	✓	✕
O	✓	✓	✓	✓

Key:

- ✓ - *Means compatible*
- ✕ - *Means incompatible.*

If blood from a rhesus positive person is transfused to a rhesus negative person, the recipient produces rhesus antibodies. If such a transfusion is done a second time, massive agglutination can occur. This can lead to loss of life.

Precautions taken during transfusion

- Blood from the donor must be checked for compatibility with blood from the recipient in terms of both ABO blood group and Rhesus factor in order to avoid agglutination.

- The donor's blood must be screened to ensure that it does not have pathogens that can cause diseases such as HIV and AIDS, syphilis and hepatitis B.
- Donated blood is stored in special bags and an anticoagulant is added to prevent it from coagulating.
- Donated blood is kept in a refrigerator for a maximum of 21 days. After that it expires and should not be used.
- Transfusion should be done only when extremely necessary.

Advantages of blood transfusion

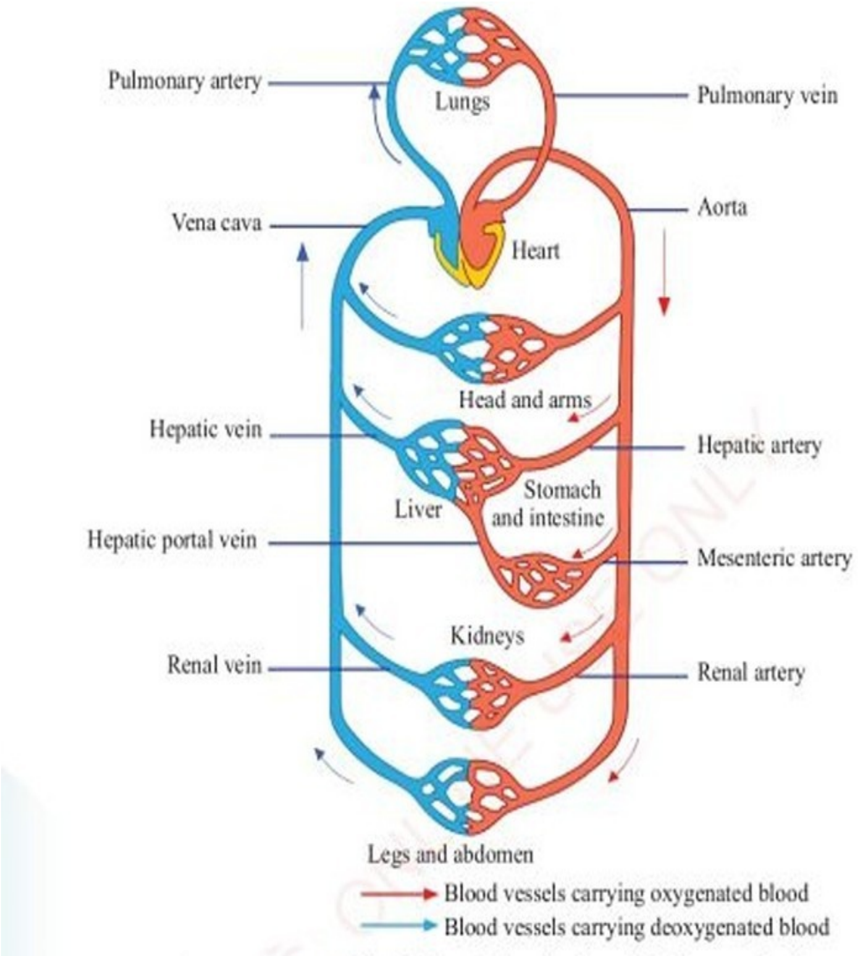
- It ensures rapid replacement of blood lost from the body, for example during surgery or due to an accident.
- Blood transfusion is used to treat diseases such as sickle-cell anemia

Disadvantages of blood transfusion

- There are no exact blood matches. Blood is a complex tissue that contains many different.
- One person's blood cannot be exactly the same as another's. Hence, there are chances of developing a reaction to transfused blood.
- Transfused blood may not always be 100% free of infections.

Blood circulation in human being

Blood circulation is the movement of blood from the heart to all part of the body and back to the heart. Human being exhibits **double circulation** where by the blood passes through the heart twice for each complete circulation. Double circulation includes ***pulmonary circulation*** and ***systemic circulation.***



Blood circulation in the whole human body

Double circulation in human being

- In other less complex organisms like the fish, blood goes through the heart only once; this is known as **single circulation.**

Pulmonary circulation

- • During pulmonary circulation, deoxygenated blood is brought to the heart through the vena cava. This blood is emptied into the right auricle. The right auricle pumps blood to the right ventricle. When the right ventricle contracts, it pumps blood to the lungs through the pulmonary artery.
- • In the lungs, the blood is oxygenated. It then flows back to the heart through the pulmonary vein. The movement of blood between the heart and the lungs is called the pulmonary cycle.

Systemic circulation

- In systemic circulation, the pulmonary vein transports blood to the left auricle. The left auricle then pumps the blood into the left ventricle. The left ventricle has strong muscles that pump blood to all parts of the body through the aorta.

- tyhAfter the tissues have derived their requirements from the blood, it flows back to the heart through the vena cava. This movement of blood between the heart and the various parts of the body is called the systemic cycle.

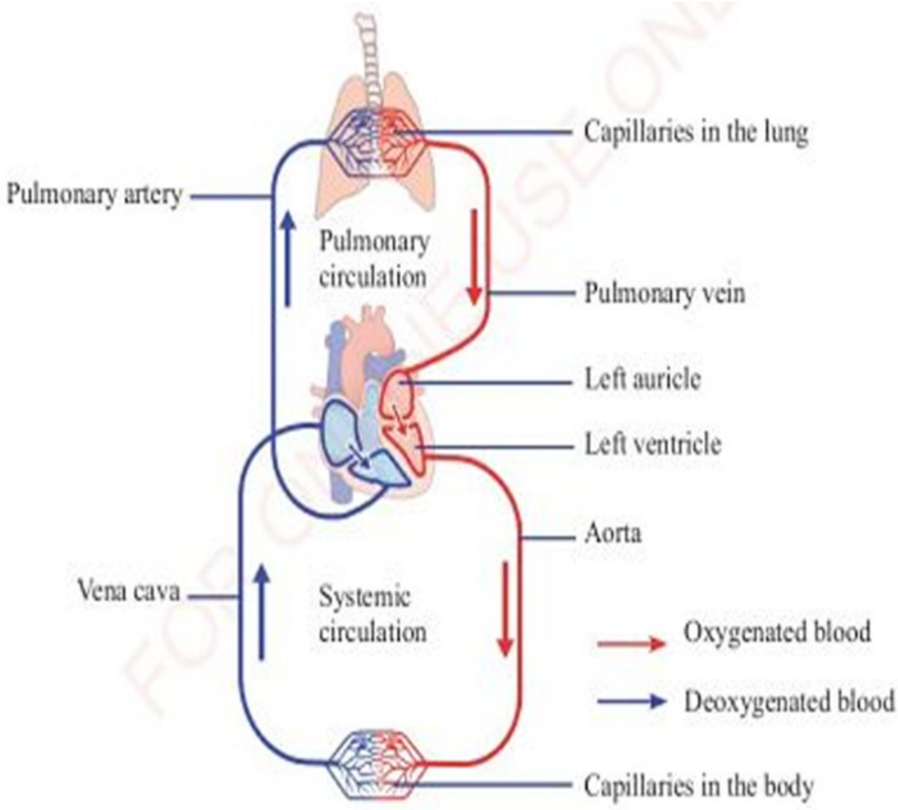


Figure 9.14: Double circulation in human beings

Formation of tissue fluid

The aorta is the largest artery in the body. It branches into smaller arteries, which in turn branch into even smaller vessels called arterioles. Arterioles branch into capillaries which are in contact with the tissue of the body. The capillaries have tiny pores that allow some components of blood to filter into the tissues.

At the arterial end of the capillary, there is high blood pressure. This forces fluid out through the any pores in the capillaries

The fluid is composed of water, oxygen, hormones and nutrients. This fluid bathes the cells. It is called tissue fluid or interstitial fluid.

The substances in this fluid diffuse into the cells through the cell membrane. In addition, the waste products from the cells diffuse into the tissue fluid. These wastes include carbon dioxide, minerals, heat and nitrogenous wastes.

At the venous end of the capillary, blood pressure is low; water potential is also low. The pressure of the tissue fluid is higher. This forces the tissue fluid back into the capillaries.

Diffusion also helps in the re-entry of tissue fluid to the capillary. However, some tissue fluid remains within the cells. This later enters the lymphatic system to form **lymph**.

The capillaries join to form venules. Venules join to form veins. The veins transport blood back to the heart. Veins in the lower part of the body unite to form the inferior vena cava while veins in the upper part of the body unite to form the superior vena cava. These two large veins join to form the vena cava which transports blood to the right auricle of the heart.

Importance of blood circulation

1. It enables the transportation of cell requirements such as oxygen and nutrients to all the body tissues.

2. It ensures that waste products from the cells are removed in order to prevent accumulation. Accumulation of waste products is harmful to the body.

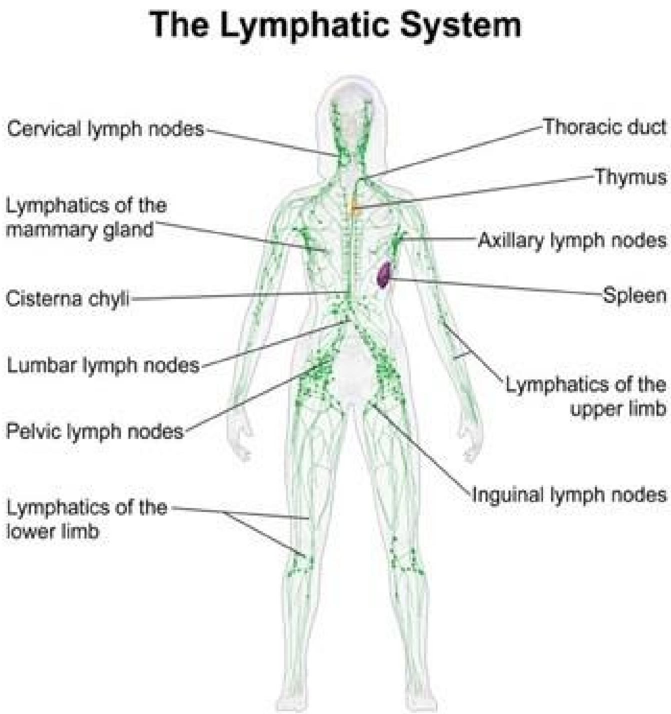
3. Blood circulation is important for the regulation of body temperature. Body heat is transported to all parts of the body through this system.

4. Blood circulation also transports hormones from the organs that produce them to the organs where they are needed. For example, insulin from the pancreas is a hormone necessary for the regulation of blood sugar levels

Lymphatic System

The lymphatic system closely resembles the blood circulatory system. It consists of lymph, lymph vessels through which lymph travels, and lymphoid organs and tissues such as **thymus**, **adenoids**, **tonsils**, **lymph nodes** and **spleen**.

Lymphatic system connects with the blood circulatory system at the **superior vena cava**



After cells get their requirements from tissue fluid, not all the fluid flows back into the capillaries, Part of it flows into **lymph vessels**. Once in these vessels, the fluid is called **lymph**.

Lymph is a pale-yellow fluid. It has the same components as tissue fluid, but more fatty substances.

Lymph vessels unite to form larger vessels called **lymph ducts**. There are two main lymphatic ducts; **the right lymphatic duct** empties into the right **subclavian vein** while **the left lymphatic duct** drains into the left **subclavian vein.** The two veins join to form the superior vena cava. In this way, the contents of lymph enter the blood circulation system

Formation of lymph

Lymphatic ducts form nodule-like structures called **lymph nodes**. These nodes are found in the abdomen, groin, armpits and neck. Lymph nodes are important sites for the production of white blood cells. They also filter out foreign materials such as bacteria and dead tissue before they enter the bloodstream.

Importance of the lymphatic system

1. Lymph nodes produce lymphocytes (white blood cells) which help the body to fight diseases.

2. Lacteals enable absorption of fatty acids after digestion.

3. It provides a way of getting tissue fluid back to the circulatory system.

4. The spleen destroys worn out red blood cells.

5. The spleen, the adenoids and the tonsils produce antibodies which help in fighting disease-causing microorganisms.