DEPARTMENT OF EDUCATION

# GRADE 11

# BIOLOGY

# MODULE 3


# TRANSPORT SYSTEM

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# GRADE 11

# BIOLOGY

# MODULE 3

# TRANSPORT SYSTEM

**IN THIS MODULE YOU WILL LEARN ABOUT:**

**11.3.1: TRANSPORT SYSTEM IN PLANTS**

**11.3.2: TRANSPORT SYSTEM IN ANIMALS**

**Acknowledgements**

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**DIANA TEIT AKIS**
PRINCIPAL

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## SECRETARY'S MESSAGE

Achieving a better future by individual students and their families, communities or the nation as a whole, depends on the kind of curriculum and the way it is delivered.

This course is a part of the new Flexible, Open and Distance Education curriculum. The learning outcomes are student-centred and allows for them to be demonstrated and assessed.

It maintains the rationale, goals, aims and principles of the national curriculum and identifies the knowledge, skills, attitudes and values that students should achieve.

This is a provision by Flexible, Open and Distance Education as an alternative pathway of formal education.

The course promotes Papua New Guinea values and beliefs which are found in our Constitution, Government Policies and Reports. It is developed in line with the National Education Plan (2005 - 2014) and addresses an increase in the number of school leavers affected by the lack of access into secondary and higher educational institutions.

Flexible, Open and Distance Education curriculum is guided by the Department of Education's Mission which is fivefold:

- To facilitate and promote the integral development of every individual
- To develop and encourage an education system satisfies the requirements of Papua New Guinea and its people
- To establish, preserve and improve standards of education throughout Papua New Guinea
- To make the benefits of such education available as widely as possible to all of the people
- To make the education accessible to the poor and physically, mentally and socially handicapped as well as to those who are educationally disadvantaged.

The college is enhanced to provide alternative and comparable pathways for students and adults to complete their education through a one system, many pathways and same outcomes.

It is our vision that Papua New Guineans' harness all appropriate and affordable technologies to pursue this program.

I commend all those teachers, curriculum writers, university lecturers and many others who have contributed in developing this course.

**UKE KOMBRA, PhD**
Secretary for Education

# MODULE 11.3 TRANSPORT SYSTEM

**Introduction**

All plants need water. The wilted leaves recover when water is added to the soil, which means water has been conducted upward into the leaves. For photosynthesis, leaves need water. Likewise, the food produced in the leaves is transported to the other parts of the plant including the stem, roots, flowers, fruits and the leaves. All this transportation is the function of conducting tissues.

Similarly, in animals, the food placed in the **gut** is carried to all parts of the body. Oxygen absorbed in the lungs is transported to every cell of the body. The carbon dioxide produced, is carried to the lungs for elimination. The poisonous body waste is transported to the kidneys for elimination in urine and so on. All such functions are the outcome of a transport system.

## Learning Outcomes

**After going through this module, you are expected to:**

- explain the need for a system of transport in plants and animals.
- list and explain mechanism for movement of molecules such as diffusion, osmosis and active transport.
- explain the structure and function of xylem and phloem in plants.
- explain the structure and function of the human heart.
- describe the composition of blood.
- differentiate between arteries, veins and capillaries.
- identify the diseases and the causes of diseases of the heart and
- state the function of the lymphatic system.

## Time Frame

Suggested allotment time: **6 weeks**

If you set an average of three (3) hours per day, you should be able to complete the module comfortably by the end of the assigned week. Try to do all the learning activities and compare your answers with the ones provided at the end of the module. If you do not get a particular activity right in the first attempt, you should not get discouraged, but instead, go back and attempt it again. If you still do not get it right after several attempts, then you should seek help from your friend or even your tutor.

**DO NOT LEAVE ANY QUESTION UNANSWERED**

## Terminology

| | |
|---|---|
| **Active transport** | A form of transport of substances that brings ions from roots to plants. |
| **Agglutination** | The process of clumping together of red blood cells. |
| **Cellulose** | Carbohydrate that forms and gives strength to plant cell wall. |
| **Concentration gradient** | An unequal distribution of ions across the cell membrane in the process of diffusion. |
| **Conducting tissues** | A tube which allows the flow of nutrients in the plants. |
| **Diffusion** | is the movement particles or molecules from a region of their higher concentration to a region of their lower concentration. |
| **Evaporation** | The process of a liquid changing to gas. |
| **Globulin** | Antibodies that support the defensive role of blood. |
| **Gut** | The internal organs of an animal. |
| **Haemoglobin** | A special type of protein that gives blood red in appearance and it contains iron which enables the blood to transport oxygen. |
| **Humidity** | The amount of moisture in the air. |
| **Lignin** | A hard substance that is deposited vascular vessels. |
| **Lumen** | The part of a tubular organ. |
| **Molecule** | The smallest particle in a chemical element or compound. |
| **Osmosis** | The movement of water molecules from a region, having more water molecules to a region, having less water molecules when separated by a semi - permeable membrane. |
| **Permeability** | The quality of allowing liquids or gases to pass through. |
| **Saturated** | Unable to absorb or dissolve anymore substance at a given temperature and pressure. |

| | |
|---|---|
| **Sieve tube** | A tube consisting of an end to end series of a thin-walled living plant cells. |
| **Transpiration** | The loss of water vapour mainly from the stomata of the leaves. |
| **Wilting** | The loss of strength in tissue when water is insufficient. |
| **Tissue system** | A tissue or a group of tissues which performs similar functions irrespective of their location on the basis of division of labor. |
| **Vascular tissue system** | Made up of xylem and phloem (with or without cambium) or sometimes either xylem or phloem only. |

### 11.3.1 Transport System in Plants

Transporting materials inside an organism is one of the principal characteristics of all living things. Plants have to transport water and minerals from the soil to the leaves, and must also get food from the leaves to where it is needed or stored.

**Transport in Flowering plants**

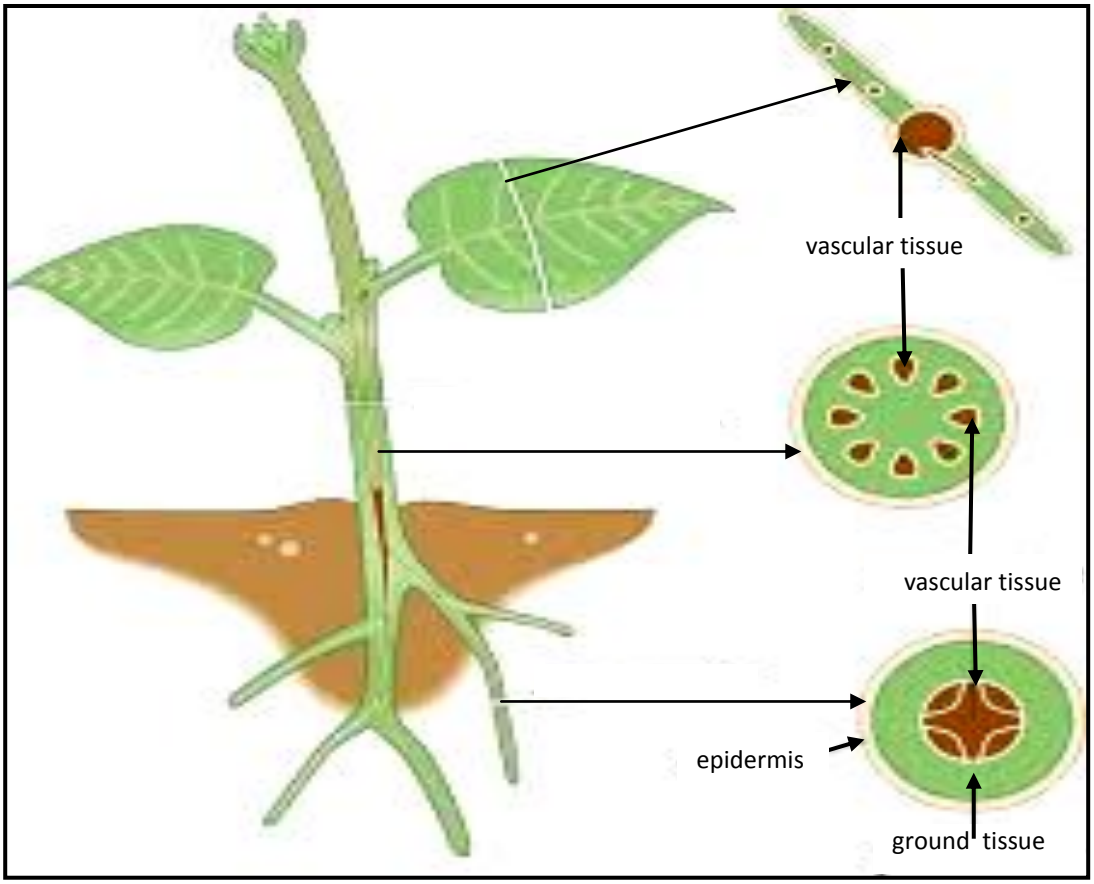
Plants have two conducting tissues for the transportation of substances that are found in groups, called **vascular bundles**.

**What are vascular bundles?**
These are strands of tissue that carry water and nutrients within the plant. It consists of **xylem** on the inside and **phloem** on the outside, separated by a layer of **cambium** which consists of a group of cells that can divide and differentiate to form new xylem and phloem when the plant grows.

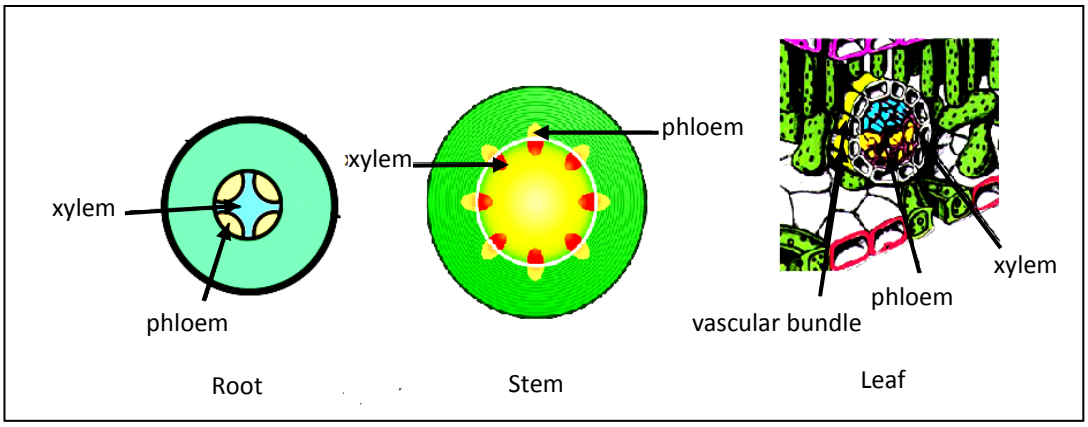
**Where can we find the xylem and phloem?**
The position of these bundles varies in different parts of the plant as shown in the diagrams on the next page.

In a leaf, for example, the phloem is usually found closer in the lower surface. Xylem vessels are tough and strong so the vascular bundles are in the center of the root to resist forces that could pull the plant out of the ground.

The stem has to resist compression (squashing) and bending forces caused by the plant's weight and the wind. The vascular bundles are arranged near the edge of the stem with the phloem on the outside and the xylem on the inside as shown in the diagram on the previous page. We have looked at the position of the vascular in bundles in plants.




Parts of the plant showing the xylem and phloem



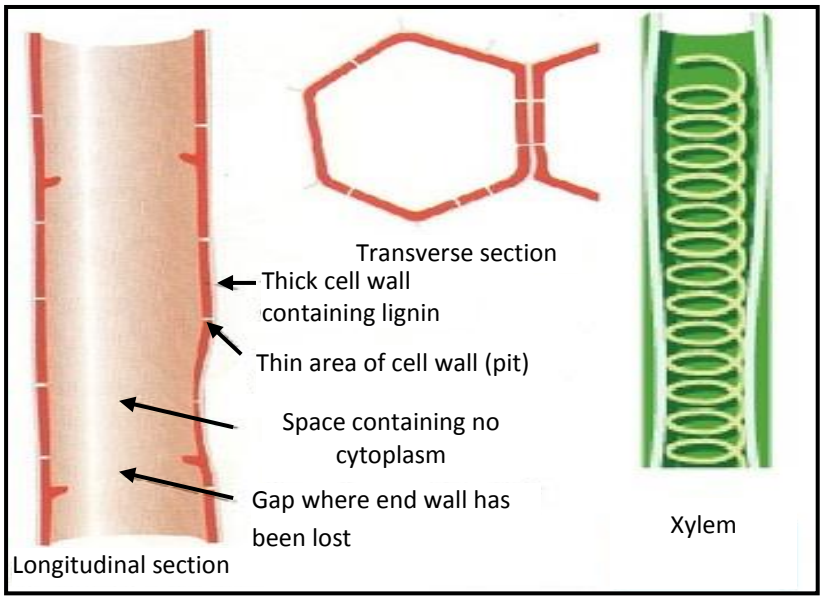

Cross section of root, stem and leaf showing the location of xylem and phloem

What are **xylem** and **phloem** and how do they look like? Now let us study their structures and functions.

**Structure of xylem**

**Xylem** is one of the tissues that make up the vascular bundles that is sometimes called wood. Xylem vessels consist of dead cells. It consists mainly of hollow vessels, stretching from the roots to the leaves. They have a thick, strengthened cellulose cell wall with a hollow **lumen.**

The end walls of the cells have disappeared, so a long, open tube is formed with no cross walls separating them, these results to a hollow lumen that is continuous. The walls of the xylem vessel contain holes called pits where water enters through. At maturity, the xylem vessel is a dead structure. The cells that make up the xylem have lost their nucleus and cytoplasm and become "wood".




Longitudinal and transverse sections of xylem

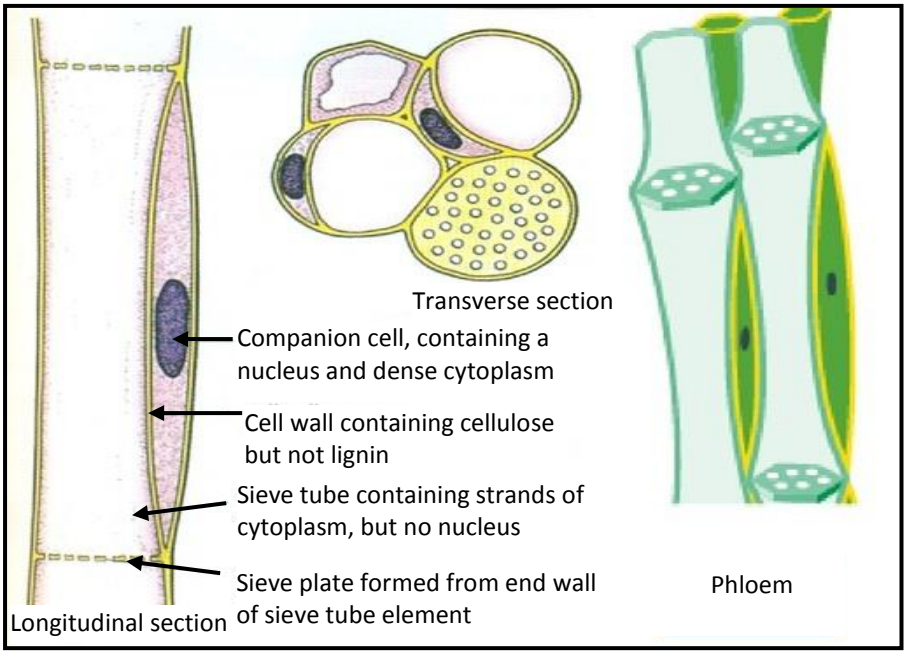
**What are the functions of xylem?**

1. To conduct water and dissolved mineral salts from the roots to the stem and eventually to the leaves. The xylem is well adapted to transport and dissolve mineral salts because it has a **continuous lumen** without any cell end- walls or protoplasm to prevent the flow of water.
2. It can provide mechanical support for the plants .Xylem vessels are reinforced by a hard substance called **lignin** that is deposited on the vessels. It is this material that prevents the collapse of xylem.

**Structure of phloem**

The other type of vessel that makes up the vascular bundle is the **phloem**. Phloem tissue is made of columns of living cells. It usually consists of **sieve tubes** which are consisting of a single column of elongated, thin walled living cells, called **sieve tube cells**.

**Sieve tube cell** is a long tube that runs alongside the xylem tissue. They are made of long narrow tubes with perforated sieve plates along the thin length that contains a cytoplasm but no nucleus. Its activities are controlled by a companion cell next to it which has a nucleus and a rich cytoplasm that nourishes and keeps them alive.




Longitudinal and transverse sections of phloem

**What are the functions of phloem?**

The function of the phloem tissue is to transport food nutrients such as glucose and amino acids from the leaves and to all other cells of the plant, this is called **translocation**.

The transport of manufactured foods occurs through the cytoplasm of the sieve tube cells and across the perforated sieve plates by diffusion and active transport.

The structure of the phloem allows it to be adapted for its role in the transport of food in the following ways:

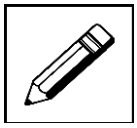
- The sieve tube cells are perforated to enable food substances to pass through them to be transported to various parts of the plant.
- The sieve tube cells are accompanied by companion cells that keep them alive for the transport of food substances, in addition to directly aiding the transport of food substances.

We have already described and identified the structures and functions of the xylem and phloem. Now, let us revise what we have learnt so far by comparing their characteristics and functions and complete the Learning Activity 1.

**CHARACTERISTICS AND FUNCTIONS OF XYLEM AND PHLOEM**

| Parts of Vascular Bundles | Characteristics | Functions |
|---|---|---|
| Xylem | • Conductive cells at maturity<br>• Thick cell walls arranged end to end to form empty passages<br>• Forms "wood" of mature plant | • Transport of water and minerals from roots to leaves<br>• Mechanical support of plant |
| Phloem | • Conductive cells living at maturity<br>• Sieve cells elongated: arranged end to end for conduction<br>• Companion cells help nourish sieve tube cells and assist in translocation | • Transport of organic materials up and down the plant body called translocation |

It is now time for you to complete Learning Activity 1 on the next page. Remember, learning activities are not sent in for assessment. However, this learning activity will help you complete Assignment 3 (which you will send in for assessment)



## Learning Activity 1

**40 minutes**

**Answer the following questions.**

1. What are vascular bundles?

   _____
   _____

2. What are the constituents of the vascular bundle?

   _____
   _____

3. What are the functions of the xylem?

   _____
   _____

4. How is the xylem adapted to its functions?

   _____
   _____

5. What is the function of the phloem?

   _____
   _____

6. How is the phloem adapted to its function?

   _____
   _____

Thank you for completing your Learning Activity 1. Check your work. Answers are at the end of this module.

---

**Transport of Water and Mineral salts**

**How do plants absorb water from soil?**

1. **Uptake of water**

   Plants absorb water from the soil through their tiny root hairs by **osmosis.** The soil solution usually has a higher water potential, than the cell sap in the vacuole of the root hair cell. Since there is **water potential gradient**, water enters the root hairs by osmosis. Inside the root, water passes from one cell to another by osmosis. This process continues until the water reaches the **xylem vessels.**

**Osmosis is the movement of water molecules from a region having more water molecules to a region, having less water molecules when separated by a semi - permeable membrane**.

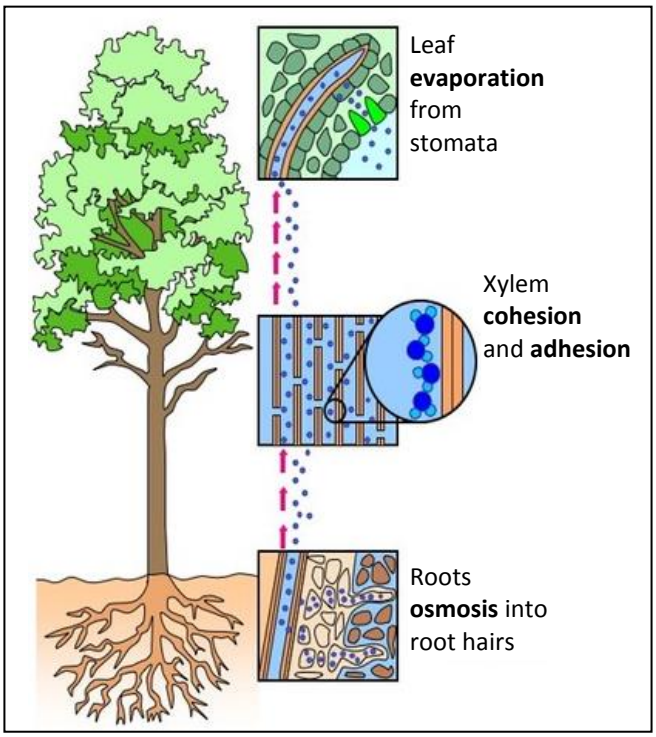
How do plants absorb mineral salts from the soil?

2. **Uptake of mineral salts**

Plants absorb mineral salts in the form of **ions** dissolved in the soil water, through the root hairs. This may take place via **diffusion**.

When there is a lower concentration of ions in the soil, than the root hairs, the ions do not diffuse into the **root hairs**. It involves the movement of ions against a **concentration gradient,** and to do this, the root hairs require energy. This process is called **active transport**.

From the root hair, the mineral salt ions move inwards through the root cells by diffusion until they reach the **xylem**.

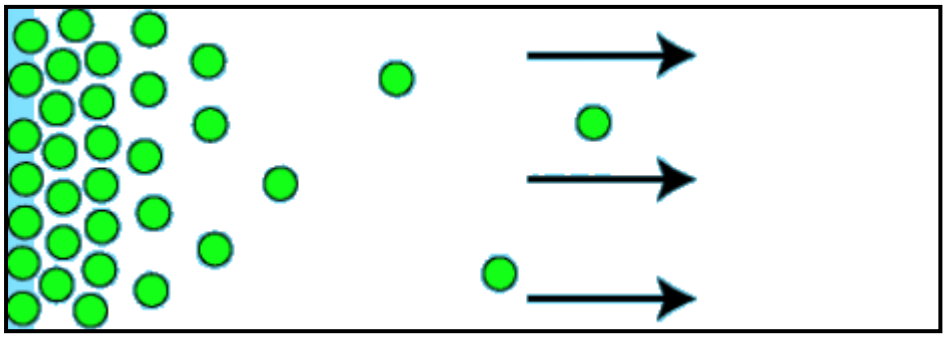



Transpiration stream

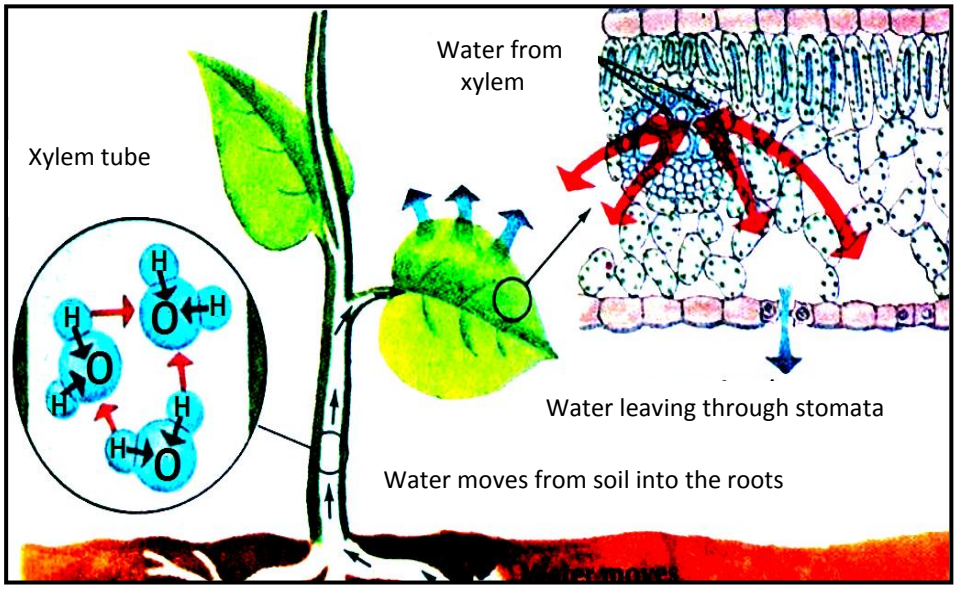
**Active transport is the movement of molecules (against concentration gradient) from a region of lower concentration, to a region of higher concentration. Energy is needed or required in active transport**.

Owing to the semi - permeability of the root hair cell plasma membrane, sugar and starch will not be able to move out of the sap and into the solution in the soil. However, it does allow dissolved mineral salts in the soil to pass into the sap of the root hair by diffusion. As such, **in conditions where there is higher concentration of dissolved mineral salts in the soil compared to the solution in the root hair, the mineral salts will move into the sap by diffusion.**

Diffusion of mineral salts from the soil to the root hairs



**High concentration** ⟶ **Low concentration**




**Diffusion is the movement of particles or molecules from a region of their higher concentration to a region of their lower concentration.**

In conditions when there is a low concentration of mineral salts in the soil, the root hair cell is able to absorb the mineral salts in the soil, against the concentration gradient by active transport, (that is the use of energy to transport a solute up a concentration gradient from a less concentrated solution to a more concentrated solution.

For example, when there are more potassium ions in the soil compared to the root hair sap, the ions would move in by **diffusion**. If there are less potassium ions in the soil compared to the root hair sap, the ions will be taken in by **active transport**.

Studies have shown that although diffusion plays a part in the absorption of mineral salts, the mineral salts are mainly brought in by active transport.
The root hair is most suitable for the transport of water and mineral salts into the roots because of the following structural adaptations:

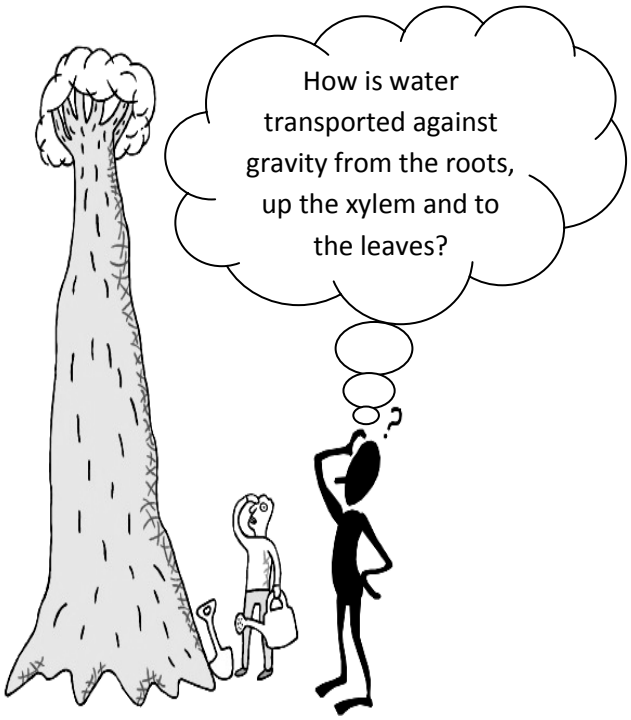
- The root hair cell is **elongated** and **narrow.** This increases the surface area to volume ratio for the absorption of water and mineral salts.
- The root hair cell sap is rich in **sugars, amino acids and mineral salts.** This makes it more **concentrated** than the soil solution, allowing water to move in by osmosis. In addition, the **partially permeable plasma membrane** of the root hair cell prevents the leaking out of the sugar, amino acids and mineral salts.
- The root hair is a **living cell**. This allows it to **generate energy from cellular respiration to be used for active transport of minerals.**

**Moving water up the stem**
How does water move up the stem?
There are three forces that move the water upward:

1. **Root pressure** is a force that pushes water up the xylem (produced by the continuous movement of water through the root cells)

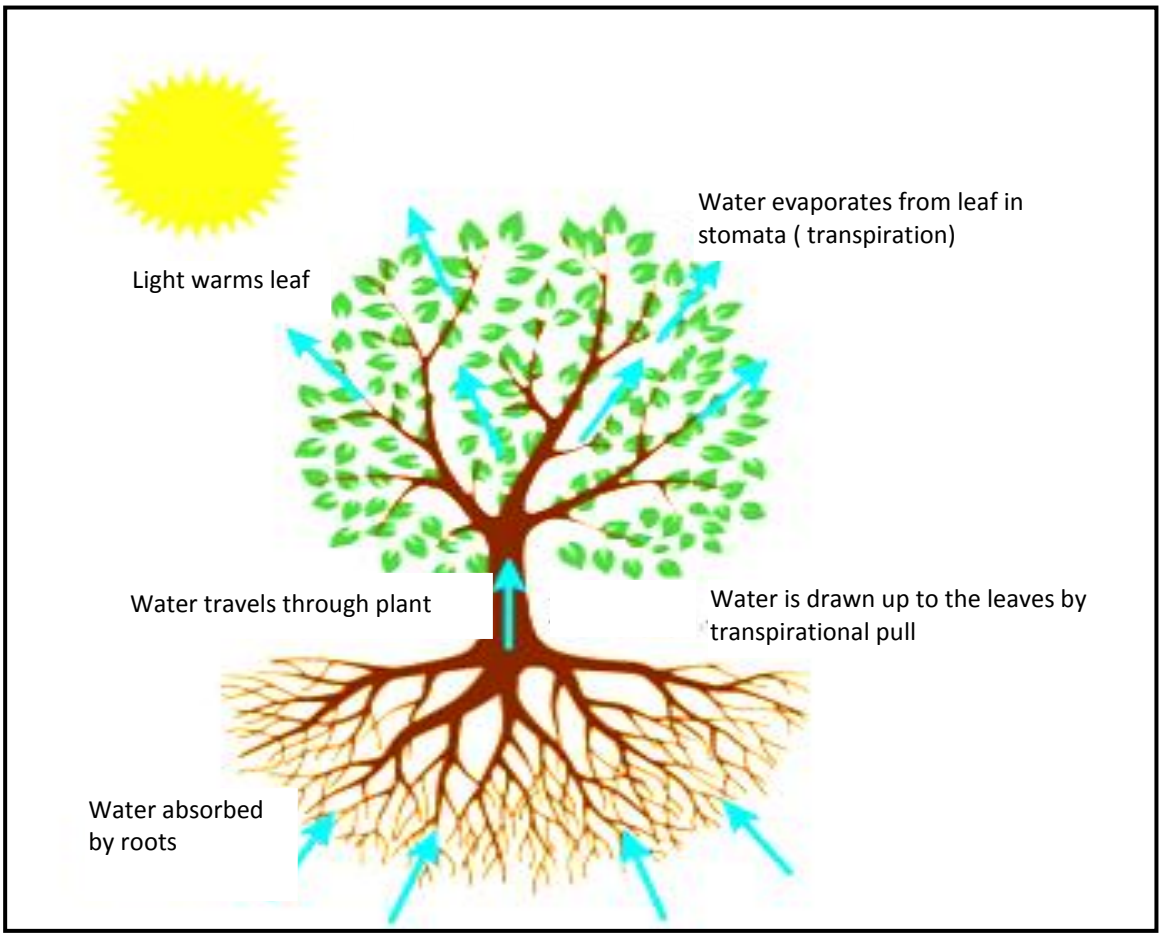
2. **Capillary action** is a force that pushes water up the narrow xylem vessels

3. **Transpiration pull** is a force that pulls water up the xylem (produced by evaporation of water from the leaves). It is a force that helps to transport water and ions from the roots to the leaves.




**How does this pulling force come about?**
Plants absorb large amount of water. However, they make use of only a small portion of that water.

A large portion of water is lost by evaporation through the stomata of the leaves. The evaporation of water from a plant is called transpiration. As water evaporates from the leaves during transpiration, a pulling force called the **transpiration pull** is formed.

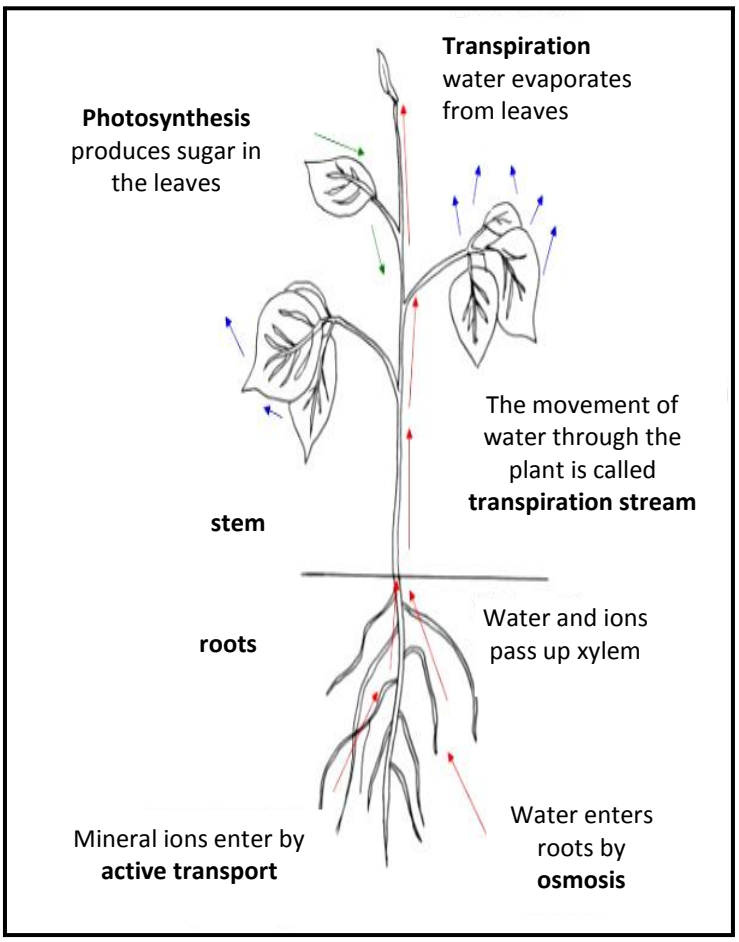



Transpiration in plants

**Transpiration is the loss of water vapour mainly from the stomata of the leaves.**

**Transpiration stream** is the uninterrupted passage of water from the soil to the air in plants. Water passes from the soil to the root by osmosis. The next stage is that water passing to the xylem vessels and then the water moves up the xylem vessels to the leaves

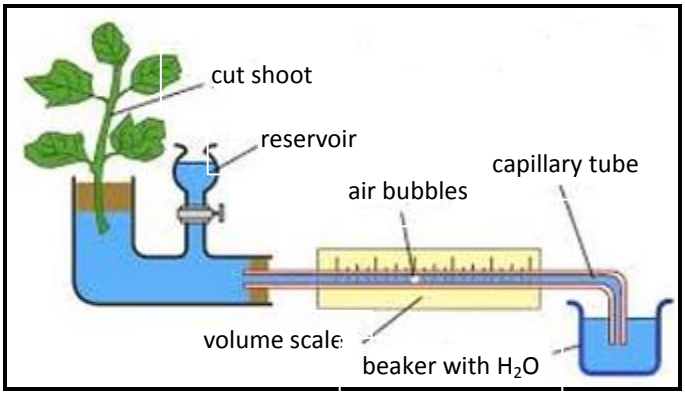
Soil → root hair → xylem vessel → leaves → air




Summary diagram of transpiration stream

**Factors affecting the rate of transpiration**

1. **Light**
   It stimulates the stomata to open, allowing gas exchange for photosynthesis, and as a side effect, it increases transpiration since the stomata pores is open. However, the absence of light and the closure of stomata, transpiration will decrease.
2. **Humidity**
   It affects the water potential gradient between inside and the outside of a leaf. When humidity of the surrounding air is low, the gradient increases and more water is transpired. High humidity decreases the rate of transpiration.
3. **Temperature**
   High temperature increases the rate of evaporation of water, and increasing the rate of transpiration. However, at low temperature, the rate of evaporation decreases as well as transpiration.
4. **Air Movement / Wind**
   Wind blows away saturated air from around the stomata, replacing it with drier air, therefore increasing the water potential gradient and increasing transpiration. If the air does not move away, then the transpiration rate will decrease.




**Potometer an instrument used to measure the rate of transpiration**

It is now time for you to complete Learning Activity 2. Remember, learning activities are not sent in for assessment. However, this learning activity will help you complete Assignment 3 (which you will send in for assessment)

---

## Learning Activity 2

**40 minutes**

**Briefly answer the following questions.**

A. By which process does each of the following take place?

i) Mineral ions entering root hair _____

ii) Mineral ions moving through roots _____

iii) Water entering root hairs _____

iv) Water moving through root cells _____

B. What is transpiration?

_____

_____

C. Why is transpiration important in plants?

_____

_____ _____

Thank you for completing your Learning Activity 2. Check your work. Answers are at the end of this module.

**It is now time for you to complete Assignment 3 in your Assessment Book 3 before going on to the next topic.**

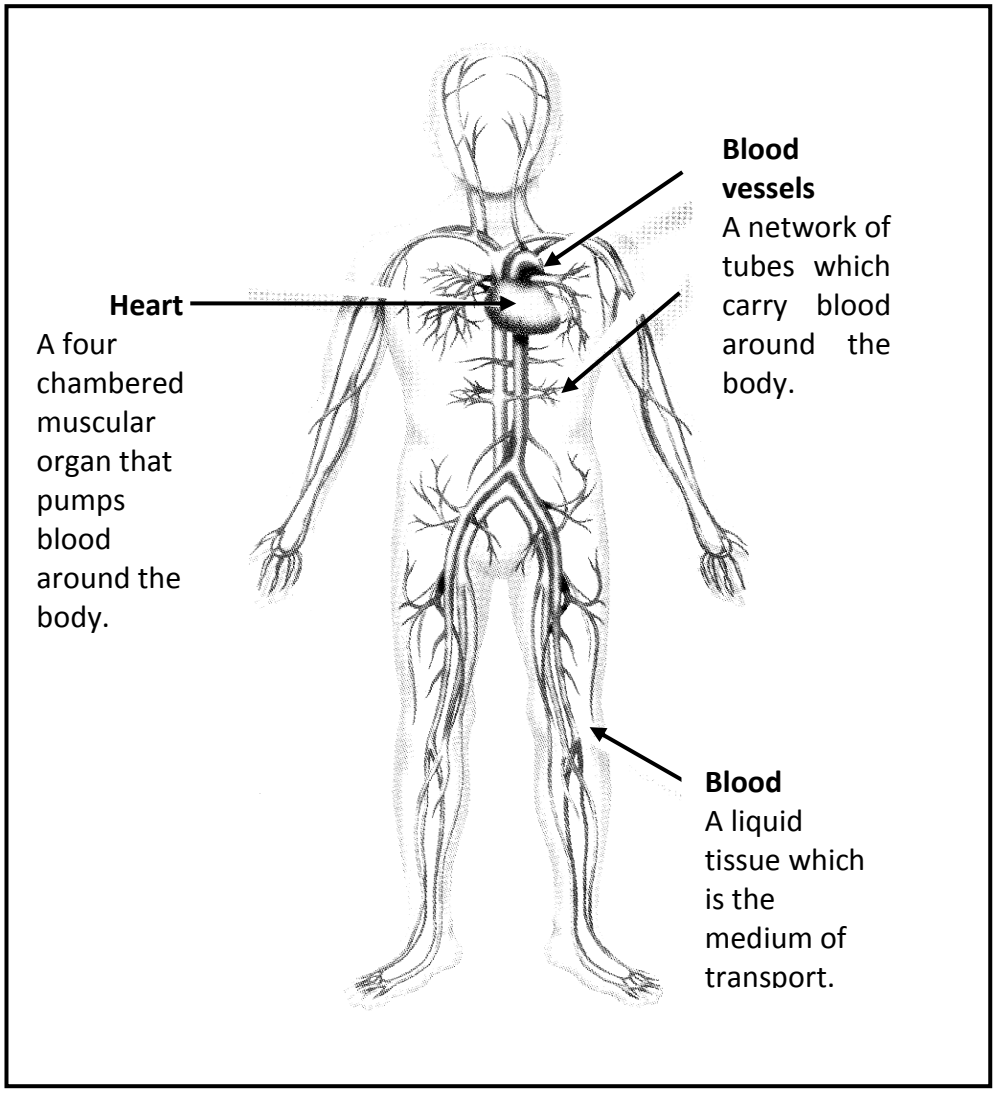
### 11.3.2 Transport System in Animals

In the body of most animals, substances are transported from one part of the body to another through blood. Thus, blood is the "tissue for transport" and circulates throughout the body. Circulatory system consists of organs, which make blood circulate throughout the body. Blood transports nutrients, respiratory gases, hormones and waste materials from one part of the body to another.

**Transport System in Human Body**

What does the circulatory system made up of?

**COMPONENTS OF THE CIRCULATORY SYSTEM**




The circulatory system is made up of the heart, the blood vessels and the blood as shown in the diagram.

**Why do we need a circulatory system?**

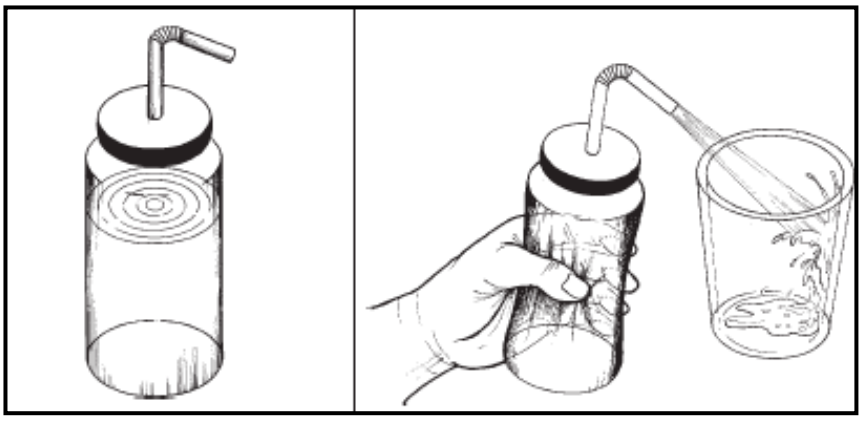
In an Amoeba, its entire body is in contact with its surroundings. So, diffusion is enough to help transport materials in and out of this one–celled organism. Simple unicellular organisms do not require a circulatory system, as all of their parts are very near to the plasma membrane. Humans are large multi–cellular organisms, and so need transport system called **"the circulatory system",** to efficiently supply all our tissues and muscles the needed nutrients.

It is now time for you to complete Learning Activity 3. Remember, learning activities are not sent in for assessment. However, this learning activity will help you complete Summative Test 3 (which you will send in for assessment)

## Learning Activity 3

**20 minutes**

You will need a plastic bottle with straw for this activity. If you cannot find one, just use your imagination. The picture below can help you visualize what will happen.



Plastic bottle with straw and water

1. Fill the bottle with water. Then, fill a small empty cup with water from the bottle.
2. Determine how long it takes you to fill the cup. Then, return the water to the bottle.
3. Fill the cup again with water but this time, do it faster.

**Briefly answer the following questions**

A. What action did you make in order to let the water out of the bottle?

_____

_____

B. What did you do in order to fill the cup faster?

_____

_____

Thank you for completing your Learning Activity 3. Check your work. Answers are at the end of this module

---

**Components of the Circulatory System**

1. **Heart**

The heart is the most important organ of the circulatory system. Do you know what your heart looks like? Clench your fist and look at it. That's approximately the same size as your heart. Your heart is a pear-shaped organ that lies between your lungs. It is slightly tilted to the left.

Consider the following facts:

- The heart pumps approximately 70 times a minute. In this period, it is able to pump around 5 liters of blood. That is about 100,800 times each day.
- When you are exercising rigorously and your body cells need a higher rate of blood flow to obtain more oxygen, nutrients and food, the heart pumps more rapidly to force more blood around your body faster. The heart will pump up to 200 times per minute to move 40 liters of blood around your body if it has to.

**Parts of the heart**

How does the heart carry out its function as a pump?

If we look at a section of the heart on the next page, we will see four **chambers** and four **valves.** The two upper chambers are called atria (singular **atrium)** and the two lower chambers are called **ventricles.**

**The chambers**

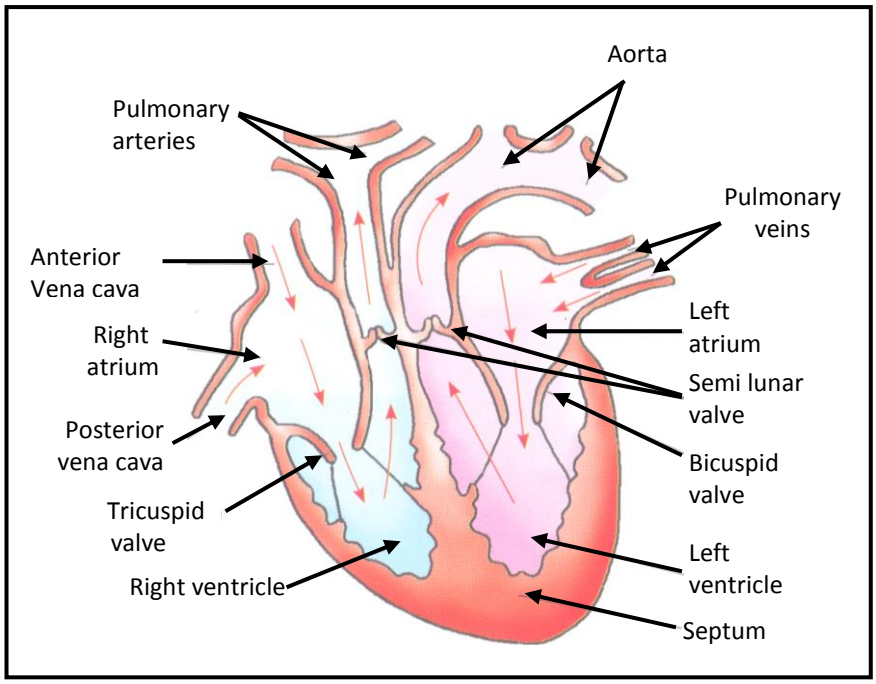
The heart is divided in half down the middle by a thick wall. The right side pumps blood to the lungs. The left side pumps blood to all parts of the body. So the heart is really two pumps working side by side.

Each pump has a top chamber and it is called **atrium** – this receives blood from the **veins**. The lower chamber on each side is the **ventricle,** which pumps blood out of the heart through the **arteries.**

**The Heart**

**The human heart: It is about the size of a closed fist. It weighs about 300g. It is made up of a special cardiac muscle which contract and relax. It pumps throughout a lifetime, at about 70 times a minute**

Look at the picture below. It shows the major parts of the heart.




Parts of the human heart

There are four chambers of the heart. The **right ventricle** has thinner walls than **left ventricle,** as it only needs to pump blood to the nearby lungs. The **right atrium and left atrium** have thinner walls as they only need to push blood to the ventricles. **Left ventricle** has thick muscular wall as it pumps blood around the body.

Between the atrium and the ventricle on each side are the valves. **Valves** are tough flaps of tissue that are joined to the ventricle wall. There are two types of the heart valves, namely **tricuspid valve** on the right side of the heart and the **bicuspid valve** on the left side of the heart.

A muscular wall called **septum** completely separates the left side of the heart from the right side of the heart. This prevents the mixing of **oxygenated blood** in the **left chambers** with **deoxygenated blood** in the **right chambers.** The major blood vessels connect to the chambers of the heart like the **anterior vena cava** and **posterior vena cava** carry blood to the right atrium.

**Pulmonary arteries** connect the heart with the lungs as part of the pulmonary system. It carries blood from the right ventricle to the lungs.

**Pulmonary veins** carry blood from the lungs to the left atrium and the **aorta** carries oxygen rich blood away from the heart, from the left ventricle to the systemic circulation.

**Try it out:**

During each heartbeat, there is a rush of blood along the arteries. You can feel this as a pulse on your wrist, neck or in front of your ears. By taking your pulse, you can find out how fast your heart is beating.

Gently place three fingers either on your wrist or neck. Take your pulse by counting the number of beats in one minute. This is your heart rate. Compare your heart rate when you are resting with that, after you have jogged on the spot for two minutes.

The rate at which the heart beats can be determined by taking the pulse.

A. To take your pulse, place the middle and index fingers of one hand on the wrist of the other hand.

Move your fingers slightly until you feel a throbbing point.

B. Count the number of beats in 15 seconds. Multiply this number by 4. The value you will get is the number of times your heart beats per minute. For example, if you counted 17 beats in 15 seconds and multiplied this by 4, this means that your heart beats 68 beats per minute.

C. Sit quietly on a chair. Take your pulse.

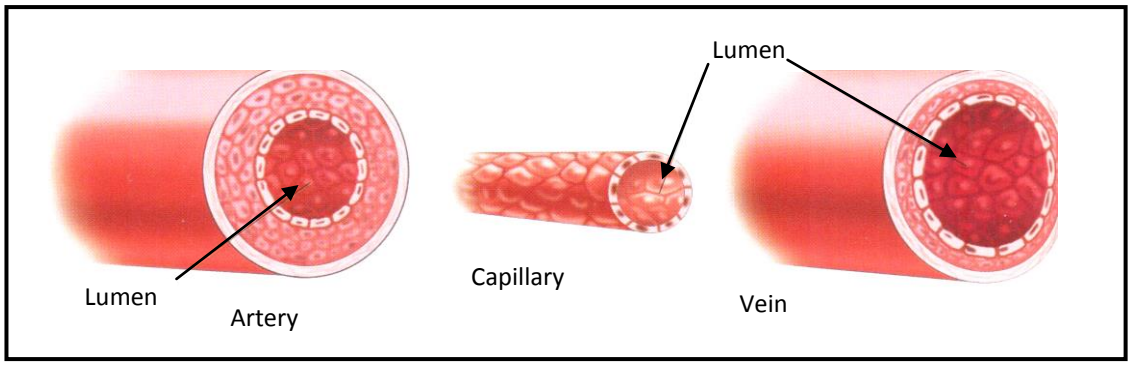
D. Walk briskly around the room for around one minute. Then immediately take your pulse.

What did you notice? Is it faster or slower than the one you took previously? Why do you think your heart rate changed?

2. **The blood vessels**

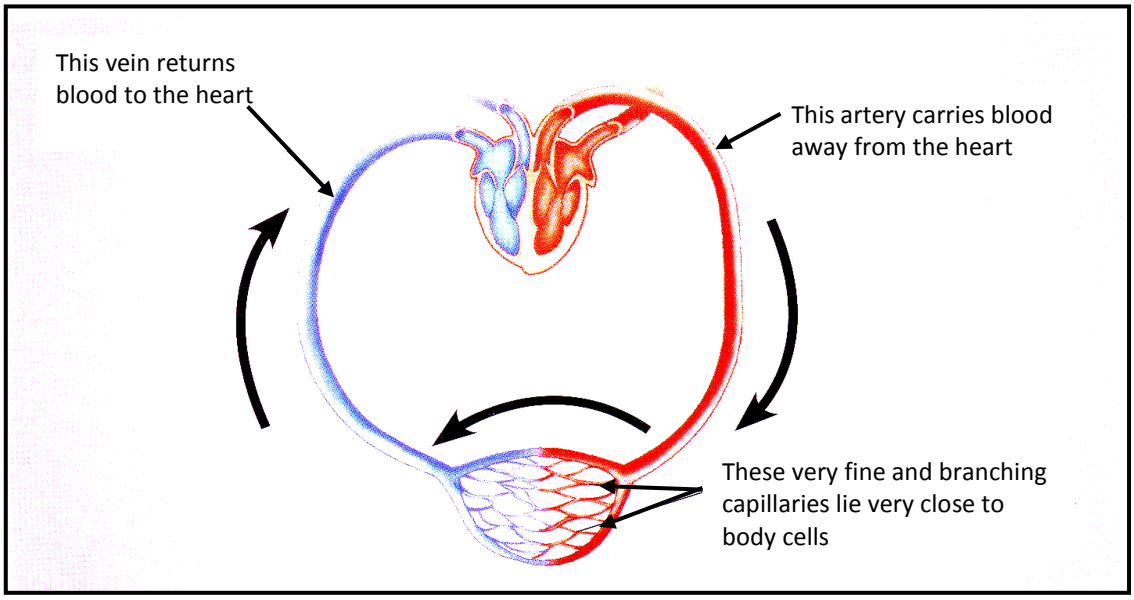
**Blood vessels** form a network of tubes to bring blood around the body. There are three types of blood vessels. They are the arteries, veins and capillaries. Study the diagrams below and on the next page.

Let us compare the three types of blood vessels.




**COMPARISON OF THE THREE TYPES OF BLOOD VESSELS**

| Basis of Comparison | Artery | Capillary | Vein |
|---|---|---|---|
| **Structure** | • Thick wall containing more muscle cells and elastic fibers<br>• Small and narrow lumen<br>• Valves absent | • Very thin wall made of one layer of cells<br>• Very small lumen<br>• Valves absent | • Thin wall containing fewer muscle cells and elastic fibers<br>• Large and wide lumen<br>• Valves present along its walls |
| **Function** | • Carries blood away from the heart | • Carries blood to body cells<br>• Allows exchange of materials between blood and body cells | • Returns blood to the heart |
| **Blood flow** | • Very fast, in spurts<br>• High pressure<br>• Sustained by the elasticity of its muscular wall and pumping heart | • Slow, smooth<br>• Pressure has a value between that of an artery and a vein | • Slow, smooth<br>• Low pressure<br>• Sustained by contraction of body muscles like in arms and legs |




Three types of blood vessels

## 3. The blood

When you have wounded yourself, blood comes out. Sometimes blood keeps on flowing because it continuously flows in your body. You need to stop the flow of blood.

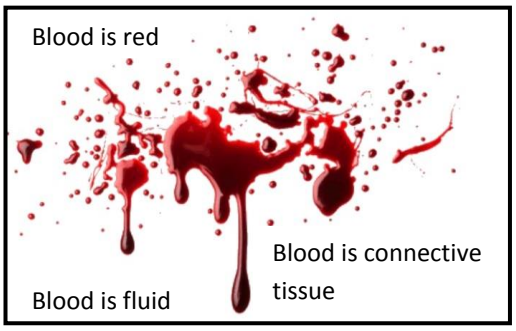
What does blood do in your body? Blood is called the fluid of life. Without blood, human life would not be possible. The sight of blood might make a lot of people feel sick or scared, but you should not be afraid of blood. This is the fluid needed by every cell in your body in order to live.

### What is blood?

Blood is the red fluid circulated throughout the body by the circulatory system.

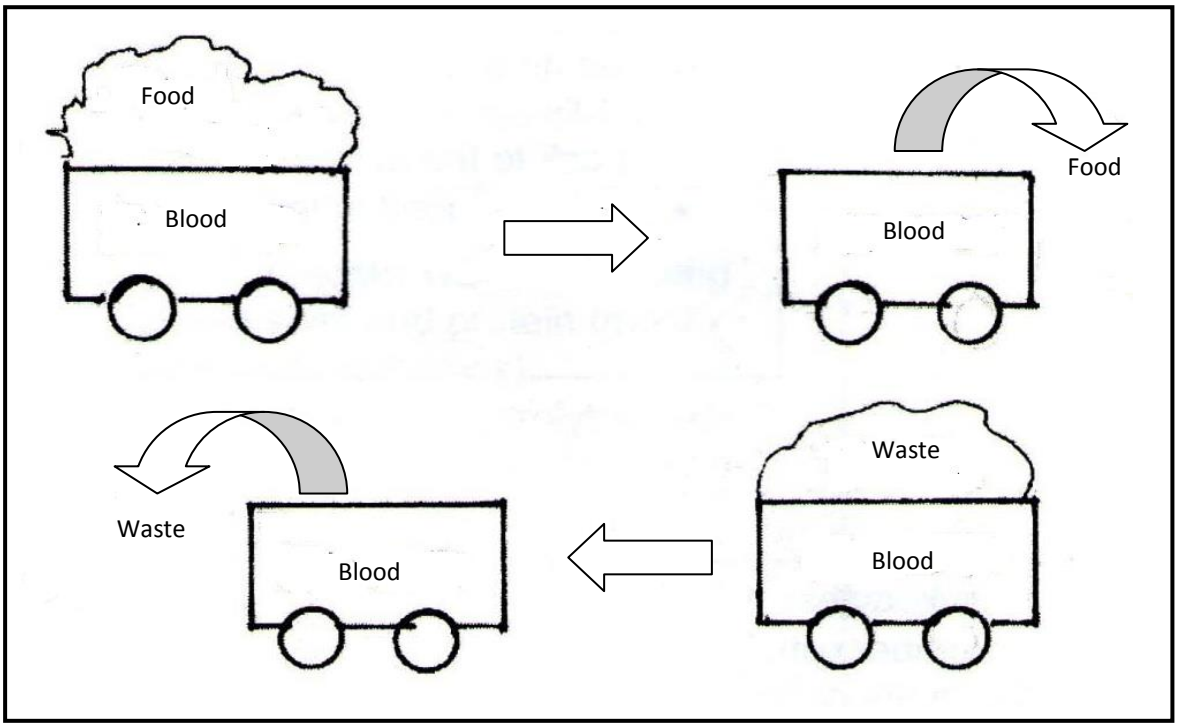
In human beings, blood is considered a connective tissue. It is a connective tissue because it is produced by the bone marrow inside bones, which are connective tissues.

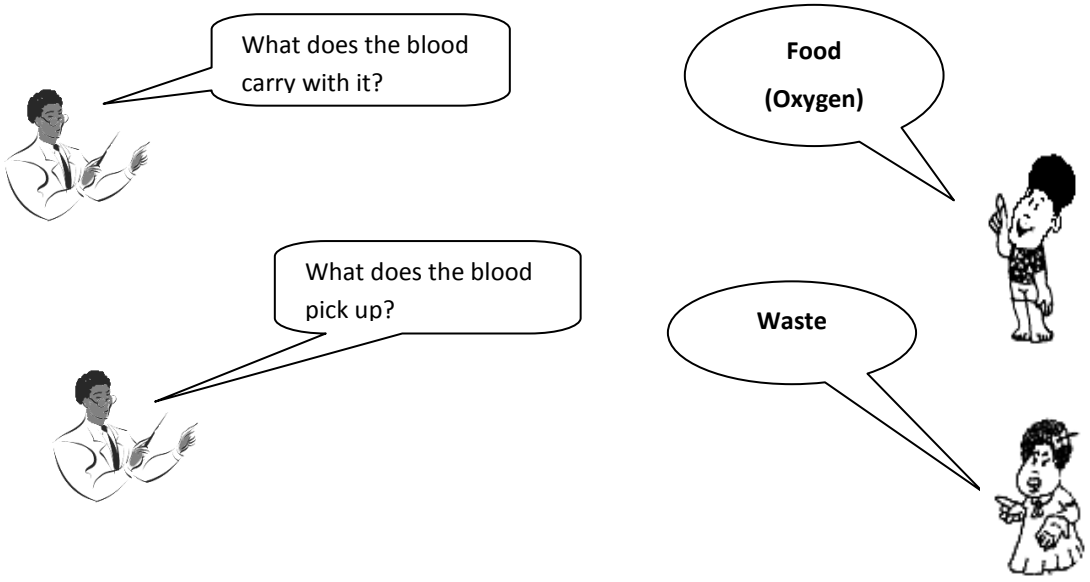
However, compared to other connective tissues, like ligaments and cartilages, blood is liquid. This enables blood to have special properties that other connective tissues do not have.




Blood drop on wall tattooo

Study the diagram below.



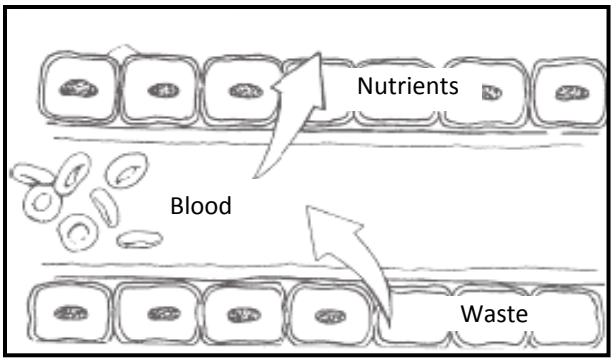




**Blood contains substances needed by the body to maintain normal cell function**

The lives of all the cells in your body depend on the jobs done by your circulatory system. The blood exchanges nutrients and water with all the cells found in the body.

In the diagram on the right, nutrients carried by the blood pass through blood vessels and go to the cells of the body.

Conversely, waste products from these cells enter through the blood vessels to be transported out of the body.




Body cells

**Blood** is a life sustaining fluid. It transports many different substances such as **oxygen, digested food and waste products such as carbon dioxide.**

What is blood made up of?

Blood consists of 55% **Plasma**, a pale yellow fluid,
4% **Red Blood Cells,**
1% **White Blood Cells and Platelets**

An adult's body contains about 6 liters of blood

Let us take a look at the components of a human blood.

**A.** **Plasma** is the material carrier. It is a pale yellow liquid mostly water and contains several dissolved substances which is carried around the body.

Some functions of plasma are:

i. It carries useful substances such as **digested food** from the small intestine to the other parts of the body.
ii. It transports chemicals such as **hormones** and **antibodies** from where they are produced, to the parts of the body that need them.
iii. It transports soluble protein like **fibrinogen** which helps in the **clotting of blood.**
iv. It transports excretory **waste products** from the body tissue to where they will be removed from the body. For example, **urea** to **the kidney** and **carbon dioxide** to the **lungs.**

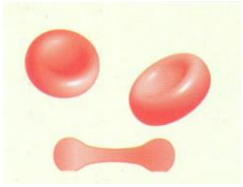
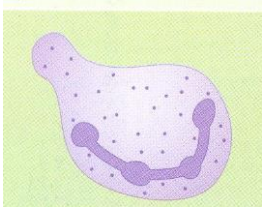
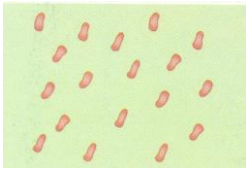
**Test yourself:**

1. Lina has a big wound. After a few seconds, it stops bleeding. Can you tell why?
2. What will happen if your body lacks red blood cells?
3. Why people die if they lose too much blood?

**B. The blood cells**

The blood with its plasma consists of three types of blood cells. The table on the next page shows the structures and functions of each cell.

**STRUCTURES AND FUNCTIONS OF THREE BLOOD CELLS**

| Blood Cells | Structure | Function |
|---|---|---|
| **Red Blood Cell** (Erythrocyte) the oxygen carrier  | • Biconcave and have no nucleus<br>• Each cell contains hemoglobin, the pigment that makes blood appear red. | • Transport oxygen from lungs to all respiring tissues.<br>• Prepare carbon dioxide for transport from all respiring tissues to lungs. |
| **White Blood Cell** (Phagocyte and Lymphocytes) the germ killers  | • Colorless and have a nucleus<br>• Larger in size but less numerous than red blood cells.<br>• They are made in the bone marrow. | Two types of white blood cells They kill in different ways<br>a. **Phagocytes** kill bacteria by **engulfing** and **digesting** them and the process is called **phagocytosis.**<br>b. **Lymphocytes** kill bacteria by producing chemicals called **antibodies** that either kills bacteria or make poisonous substance really harmless. |
| **Platelet** the blood clotter  | • Bits and pieces of broken down cytoplasm from a certain bone marrow cells.<br>• They have no nucleus | • Cell fragments involve in blood clotting. They help in the clotting of the blood that prevents excessive loss of blood |

**Blood group and blood transfusion**

You must have heard that blood has to be arranged for a person undergoing a surgery (operation) or in a case of accident. This arrangement is to replace blood lost from the patient. It is called blood transfusion.

**Blood transfusion** is the transfer of blood from a donor to the recipient. It is only successful when the blood of the donor and the recipient match. Unmatched blood transfusion causes **agglutination** which means the clumping of red blood cells together**.**

**Two components of red blood cells**

**Agglutinogen**

A type of polysaccharide (sugar) present in the walls of red blood cells.

**Agglutinin**

A globulin antibody present in the plasma. In each person, the agglutinins in the plasma are complimentary to the agglutinogens in the red blood cells. The complimentary agglutinins are named **A and B** respectively.

Thus, a person with blood type **A** will have **agglutinogen A** on his red blood cells and **agglutinin B** in his plasma. A person with blood type **B** will have **agglutinogen B** and **agglutinin A**. A person with blood type **AB** will have **both A and B agglutinogen** and **no agglutinins**. A person with blood type **O** will have **no agglutinogen** but have **both A and B agglutinins.**


Blood donor | Pocket of blood | Blood bank collects, tests, types and stores blood donations used for blood transfusion

**SUMMARY OF FOUR BLOOD GROUPS AND THE SUBSTANCE PRESENT IN IT**

| BLOOD GROUP | Agglutinogen in red blood cells | Agglutinin in the Plasma |
|---|---|---|
| A | A | B |
| B | B | A |
| AB | A and B | none |
| O | none | A and B |

**What are the different blood groups?**

Blood of all human beings belong to one of the four blood groups named A, B, AB and O. The blood group is inherited from parents.

## FOUR BLOOD GROUPS

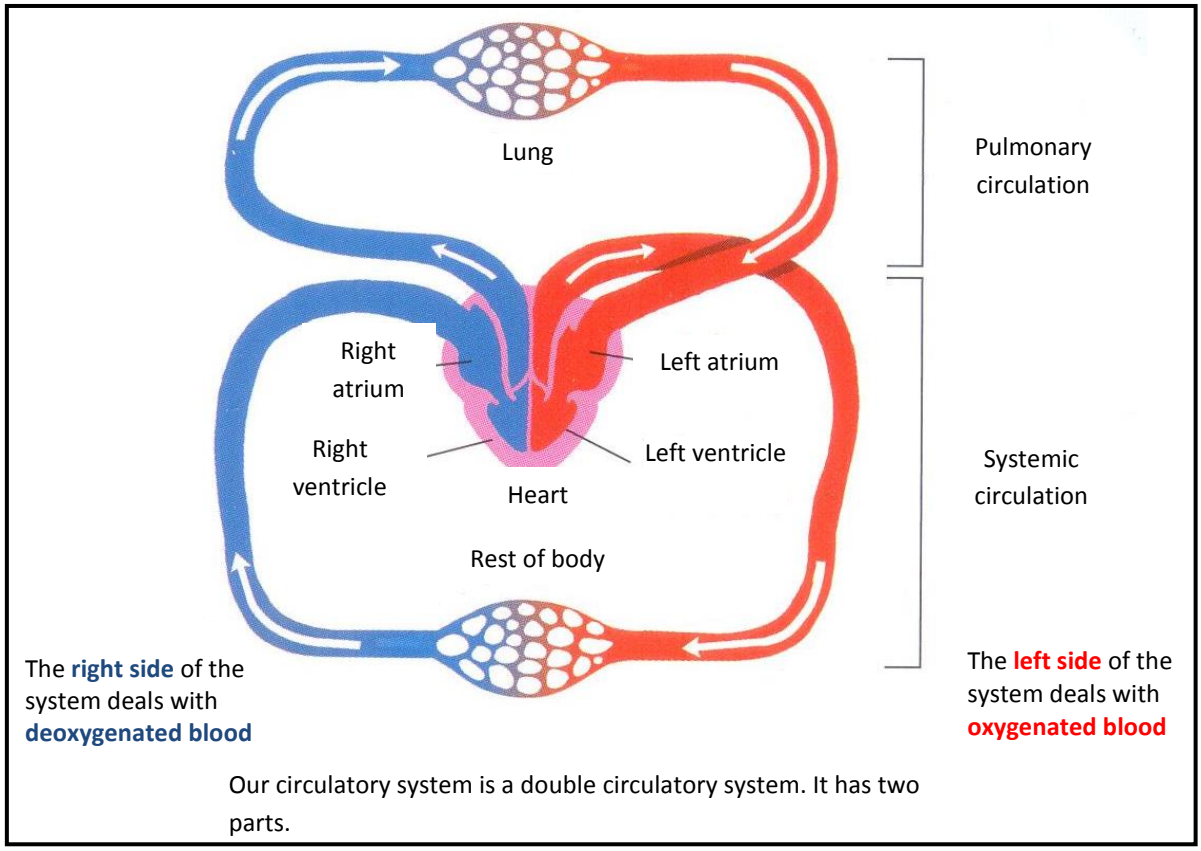
| BLOOD GROUP | Can Donate Blood to | Can receive Blood from Blood Group |
|---|---|---|
| A | A, AB | A, O |
| B | B, AB | B, O |
| AB | AB | A, B, AB, O |
| O | A, B, AB & O | O |

You must have noticed from the table above that a person with blood group O can donate blood to all blood groups. So, blood group **O** is called the **universal donor**. Blood group **AB** can receive blood from all blood groups**.** So, blood group **AB** is called a **universal recipient.**

### Human Blood Circulation

**How blood circulates in the human body?**

To get all the way round, blood has to go through the heart twice which is called **double circulation.** Double circulation is necessary to maintain the blood pressure required to maintain the circulation of blood around the body. It is also an efficient transport system, as there is no mixing of oxygenated and deoxygenated blood.




Double circulation

**The double circulation**

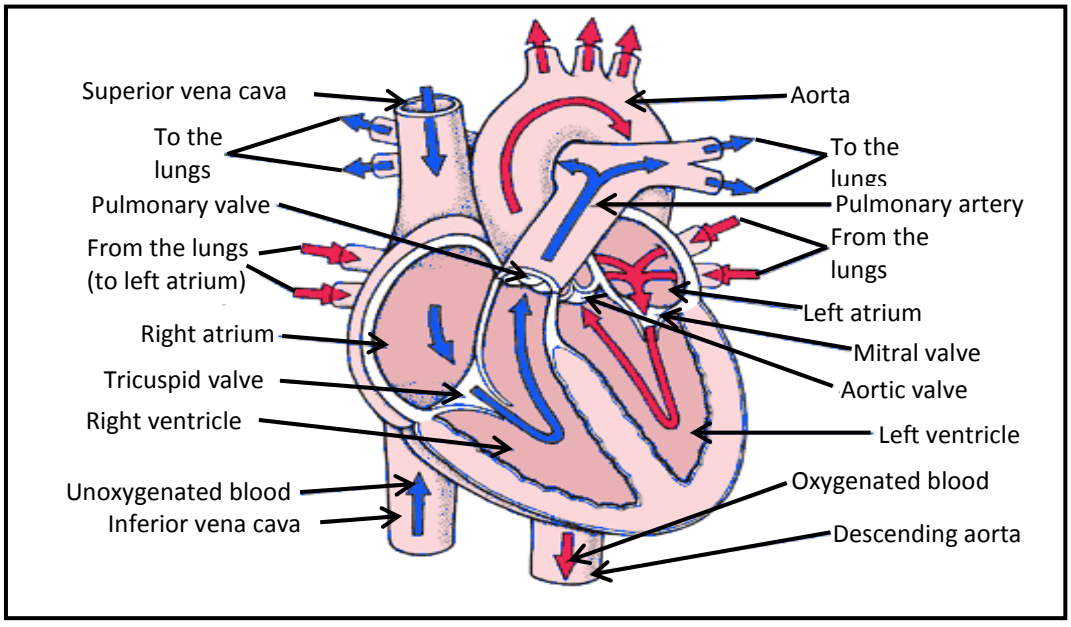
1. **Pulmonary circulation**
   - The circulation linking the lungs to the heart.
   - Right ventricle pumps deoxygenated blood to the lungs.
   - Blood pick up its oxygen in the lungs and give off its carbon dioxide
   - Freshly oxygenated blood flows into the heart's left half.
2. **Systemic circulation**
   - The circulation lining the heart to the rest of the body (except the lungs).
   - Blood from the heart is sent to the tissues to deliver oxygen through the arteries and to pick up carbon dioxide.
   - The blood returns back to the heart through the veins.

**How does blood flow through the heart?**

The right and left sides of the heart work together. The pattern described below is repeated over and over, causing blood to flow continuously to the heart, lungs, and body.

**A. Right side of the heart**

1. Blood enters the right side of the heart through two large veins. The superior vena cava and the inferior vena cava .The **superior vena cava** collects oxygen-poor blood from the upper half of the body. The **inferior vena cava** collects blood from the lower half of the body. Blood leaves the superior vena cava and the inferior vena cava and enters the **right atrium**.
2. As the atrium contracts, blood flows from your right atrium into your **right ventricle** through the open **tricuspid valve**. When the ventricle is full, the tricuspid valve closes. This prevents blood from flowing backward into the right atrium while the ventricle contracts.




Parts of the heart with the directions of blood flow through its chambers

3. When the RV contracts, blood is pumped through the pulmonary valve into the pulmonary artery and into the lungs, where it picks up oxygen.

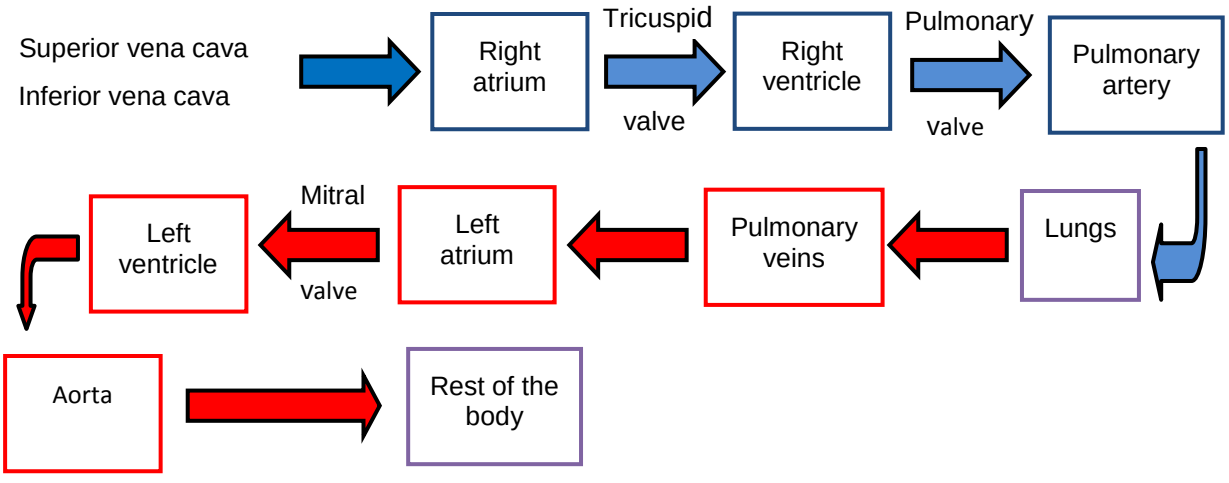
> **Why does it happen this way?**
> Because blood returning from the body is relatively poor in oxygen. It needs to be full of oxygen before being returned to the body. So the right side of the heart pumps blood to the lungs first to pick up oxygen before going to the left side of the heart, where it is returned to the body full of oxygen.

**B. Left side of the heart**

1. Blood now returns to the heart from the lungs by way of the **pulmonary veins**. The pulmonary veins empty oxygen-rich blood from the lungs into the **left atrium**.
2. When the left atrium contracts, blood travels through the **mitral valve** and into the **left ventricle.**
3. The **left ventricle** is a very important chamber that pumps blood through the aortic valve and into the aorta.
4. The **aorta** (the main artery of the body) receives all the blood that the heart has pumped out and distributes it to the rest of the body.

> The **left ventricle** has a thicker muscle than any other heart chamber, because it must pump blood to the rest of the body against much higher pressure in the general circulation (blood pressure).

Here is a recap of what we just discussed. Blood from the body flows to the:




Pathway of blood flow through the heart

**How does blood flow through your lungs?**

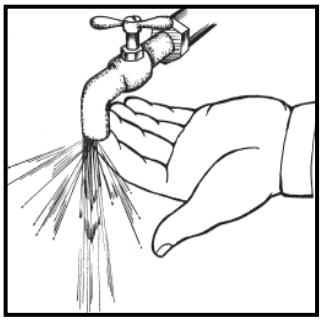
Once blood travels through the pulmonary valve, it enters your lungs. This is called the **pulmonary circulation**. Blood travels to the pulmonary arteries from your pulmonary valve and eventually to tiny capillary vessels in the lungs.

Oxygen travels from the tiny air sacs in the lungs, through the walls of the capillaries, into the blood. At the same time, carbon dioxide, a waste product of metabolism, passes from the blood into the air sacs. Carbon dioxide leaves the body when you exhale. Once the blood is oxygenated, it travels back to the left atrium through the pulmonary veins.

**Disorders related to the circulatory system**

Go to the kitchen sink in your house. Turn on the tap so that water flows smoothly. Then cover half the opening of the tap with your finger.

What do you notice about the pressure or force of the water coming out of the tap?



Think of the tap as a blood vessel. When it is clogged (usually with fatty deposits) the pressure of the blood increases. This causes blood to rush downward because it is forcing itself through a small opening.

This pressure is too much for the tissues of the body. Sooner or later, damage can occur. Blood pressure also increases when there is an increase in the pumping action of the heart.

In the example, this is similar to attaching a pump to the water pipe. Even if the blood vessel is wide enough, if the heart is pumping too strongly, high blood pressure still occurs, leading to organ damage.

A stressful life can increase the pumping action of the heart.

This is the reason why relaxation is important as shown in the diagram on the right.

**Diseases of the Heart and the Circulatory System**

1. **Coronary Artery Disease (CAD),** is also known as **Coronary Heart Disease** which occurs when the artery that supplies blood to the heart muscle **(coronary arteries)** become hardened and narrowed. This happens because of the building up of fat deposits called **plaque** on the inner wall or lining of the arteries.

   Blood flow to the heart is reduced as plague narrows the coronary arteries. This decreases the oxygen supply to the heart muscle. CAD may be caused by blood clots in the coronary artery called **coronary thrombosis.**

2. **Anaemia** is a common disease that occurs when there is no enough iron in a person's diet. When hemoglobin level falls below a certain point, it makes a person look pale and inactive. Iron in the diet helps remove anemia.

   **Anaemia** occurs when the concentration of red blood cells or haemoglobin in the body falls from the normal level. There are many types of anaemia, but the most common is iron deficiency anaemia. This is caused by the lack of iron in the diet, which is needed in the production of haemoglobin.

   Ms. Alice is thin and pale. She often feels tired and breathless. Her heart rate is also rapid. When she consulted a doctor, she found out that she has anaemia.

3. **Haemophilia** is a disease in which a person cannot make the chemical needed to heal wounds. It is also passed on by parents to children.

4. **Leukemia**

   Nena is 10 years old. Lately, she has grown pale and weak. She also bleeds and bruises easily. She also often suffers from bouts of fever and chills. She throws up a lot and complains of headaches. When her parents brought her to a doctor, they found out that she has leukemia.

   **Leukemia** is a blood cancer. The bone marrow makes excessive white blood cells at the cost of red blood cells. Leukemia is a type of cancer that affects the bone marrow. The bone marrow is the spongy center of the bone that produces blood cells. In a leukemia patient, the process of blood cell production gets out of control. The marrow produces too many immature blood cells, that are abnormally shaped and cannot perform their usual duties. This explains why the disease is called **leukemia**, which means **white blood.**

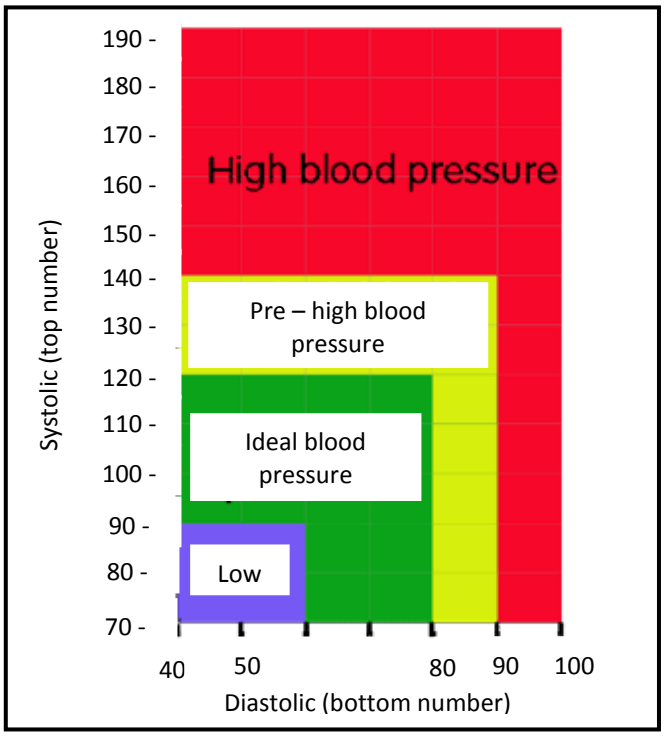
   As these abnormal cells multiply and crowd the bone marrow, they tend to interfere with the production of other blood cells. When they move into the body, they collect in different places, causing swelling and pain.

5. **Hypertension** is a high blood pressure and leads to headache, dizziness and fatigue. Normal blood pressure is 120/180. High blood pressure is caused also by anxiety. Proper diet, exercise, medicines and tension free mind helps to cure high blood pressure.


**Sphygmomanometer** is an instrument use to measure blood pressure

Using this blood pressure chart:

To work out what your blood pressure readings mean, just find your top number (systolic) on the left side of the blood pressure chart and read across, and your bottom number (diastolic) on the bottom of the blood pressure chart. Where the two meet is your blood pressure.




Blood pressure chart

**What blood pressure readings mean?**
As you can see from the blood pressure chart, o**nly one of the numbers has to be higher or lower than it should be** to count as either high blood pressure or low blood pressure:

- **90 over 60 (90/60) or less:** You may have low blood pressure.
- **More than 90 over 60 (90/60) and less than 120 over 80 (120/80):** Your blood pressure reading is ideal and healthy. Follow a healthy lifestyle to keep it at this level.
- **More than 120 over 80 and less than 140 over 90 (120/80-140/90):** You have a normal blood pressure reading but it is a little higher than it should be, and you should try to lower it. Make healthy changes to your lifestyle.
- **140 over 90 (140/90) or higher (over a number of weeks):**
  You may have high blood pressure (hypertension).Change your lifestyle - see your doctor or nurse and take any medicines they may give you. More on high blood pressure

**So: If your**

- **Top number is 140 or more** - then you may have **high blood pressure,** regardless of your bottom number.
- **Bottom number is 90 or more** - then you may have high blood pressure, regardless of your top number.
- **Top number is 90 or less** - then you may have low blood pressure, regardless of your bottom number.
- **Bottom number is 60 or less** - then you may have low blood pressure, regardless of your top number.

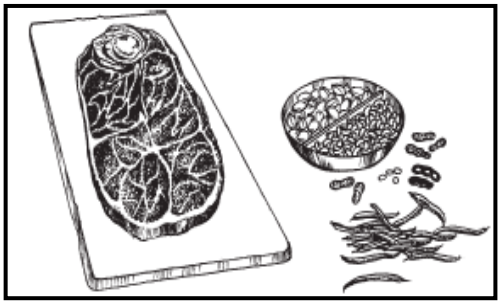
6. **Heart attack or coronary thrombosis** happens when the blood clot and blocks the flow of the blood. The person suffers great chest pain and the heart may stop beating.

**How do we take care of our circulatory system?**

To maintain a healthy circulatory system, we need to practice the following habits.

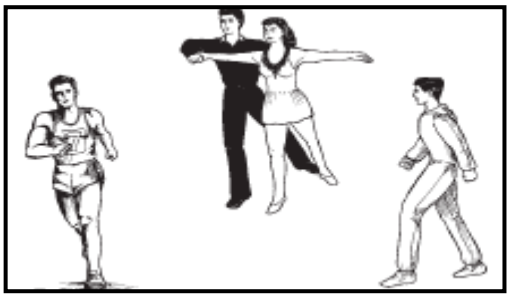
- Eat low-fat and calorie foods to avoid fat deposits from clogging your blood vessels. Eating vegetables, fruits, nuts, grains and rice can help prevent high blood pressure and other diseases of the circulatory system.
- Avoid too much salt in your diet as well, because too much salt increases the risk of heart disease
- Eating foods rich in iron such as red meat, beans and nuts help prevent iron deficiency anaemia.

Low – fat calorie foods



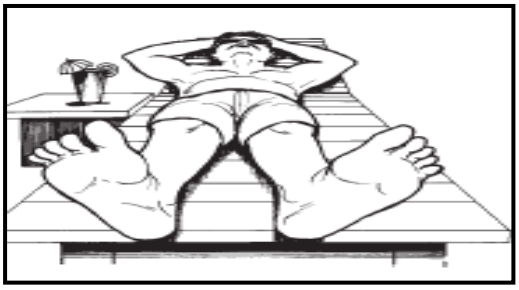
Foods rich in iron

Avoid smoking and drinking too much alcohol. Smoking increases your risk of having high blood pressure and heart attacks



Exercise regularly. Exercise makes your heart stronger. Exercises such as running, dancing and brisk walking are good for the heart when done correctly.

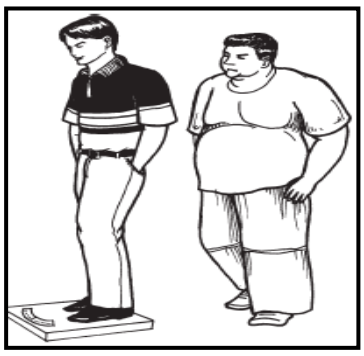
Always maintain proper hygiene. Infections can affect the circulatory system, too



Learn to relax.
Stress puts more work in your heart.

Be aware of throat infections, especially among children. These could develop into rheumatic heart disease. Seek medical attention immediately

Have your blood pressure checked regularly.



Maintain your ideal body weight. Obesity will make you prone to hypertension and other heart problems.

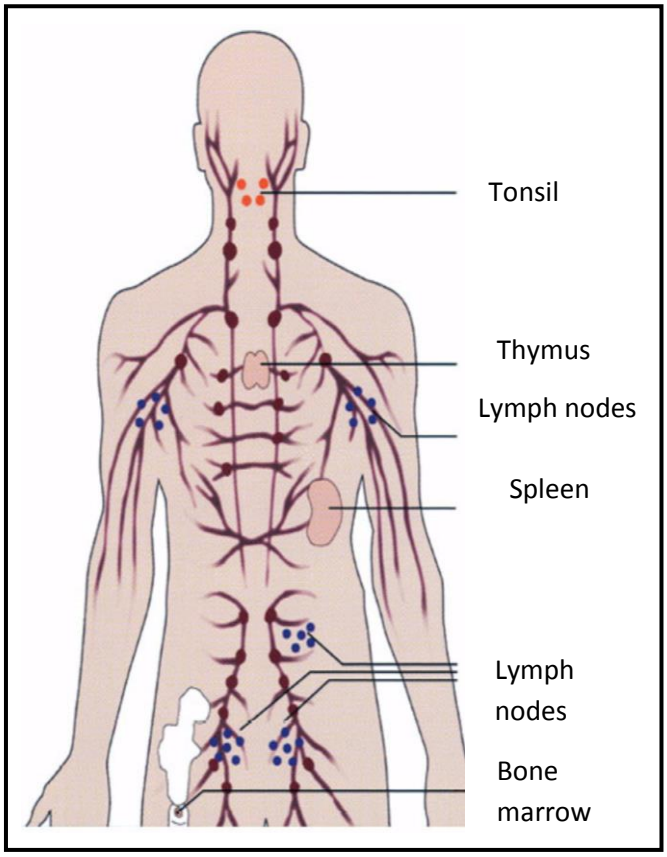
**The Lymphatic System**

The primary function of the lymphatic system is to transport lymph, a clear, colorless fluid containing white blood cells that helps get rid of toxins, waste and other unwanted materials.

It drains and filters fluid that helps to form tissues and produce **lymphocytes**, the body's defense process. (Collect poisons and produces antibodies)

Lymphatic comes from the Latin word **lymphaticus**, meaning **connected to water,** as lymph is clear.

The lymphatic system is a network of tissues and organs that primarily consists of:




The Lymphatic System

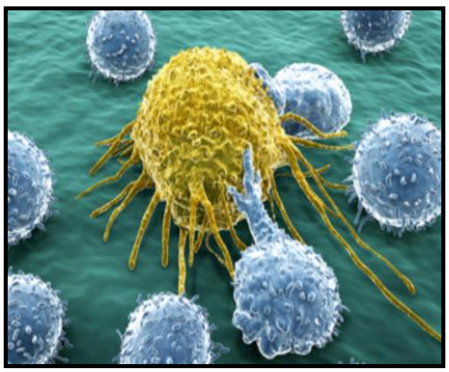
1. **Lymph vessels** - carry lymph

   - The lymph system is made up of a network of lymphatic vessels that carries lymph a clear watery fluid that contains protein molecules salts and other substances through the body and towards the heart. The lymph system affects every cell and organ in our body.

Beside the lymph, this complex system contains lymphatic capillaries, lymph vessels and lymph nodes.

2. **Lymph nodes** - filters lymph fluid of bacteria and foreign material and produces lymphocytes and lymph

3. **Spleen** – is the largest lymphatic organ located on the left side of the body just above the kidney. It destroys old red blood cells. Spleen is the largest lymphatic organ, contains white blood cells that fight infection and disease.



Lymphocytes attack a cancer cell

Some bacteria or viruses that enter the body are collected by the lymph and passes on to the lymph nodes where they are filtered out and destroyed.

4. **Thymus** – stores immature lymphocytes and prepares them to become active cells. It is located in the chest just above the heart.

5. **Tonsils** – are large clusters of lymphatic cells found in the pharynx

The **tonsils, spleen** and **thymus** are all parts of the lymphatic system.

**Importance of Lymphatic System**

- It is one of the most vital systems which is essential for good health and is closely related to the circulatory system and part of the immune system.
- It is an extensive drainage network that helps keep bodily fluid levels in balance and defends the body against infections.
- It is our body's filtering system and it helps remove toxins, wastes, excess fluids, and infection from all tissues in our body through proper flow and drainage.
- This is one of the jobs of the lymphatic system: **to detect, filter and remove bacteria and other foreign invaders from our body.**

It is now time for you to complete Learning Activity 4. Remember, learning activities are not sent in for assessment. However, this learning activity will help you complete Summative Test 3 (which you will send in for assessment).

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## Learning Activity 4

**40 minutes**

**Briefly answer the following questions**.

1. What are the components of the circulatory system?

   _____

   _____

2. Briefly describe the function of the:

   a. Red blood cell

   _____

   _____

b. White blood cell

_____

_____

c. Blood platelets

_____

_____

3. What are the four chambers of the heart?

_____

_____

4. What are the different blood vessels and their functions?

_____

_____

_____

5. Name at least 3 coronary heart diseases.

_____

_____

_____

6. What is the main function of the Lymphatic system?

_____

_____

Thank you for completing your Learning Activity 4. Check your work. Answers are at the end of this module.

**NOW REVISE WELL USING THE MAIN POINTS ON THE NEXT PAGE**

## SUMMARY

You will now revise this module before doing **SUMMATIVE TEST 3**. Here are the main points to help you revise. Refer back to module topics if you need more information.

- In plants, the transport system consists of vascular bundles.
- Vascular bundles are strands of tissue that carry water and nutrients within the plant, consisting of xylem on the inside and phloem on the outside, separated by a layer of cambium.
- The cambium consists of a group of cells that can divide and differentiate to form a new xylem and phloem when the plant grows.
- Xylem transports water and dissolved mineral salts, as well as to provide mechanical support for the plant. The xylem is reinforced with a hard substance called lignin.
- Phloem transports manufactured food substances, such as sugars and amino acids from the leaves to the other parts of the plants.
- Vascular bundles are arranged in a ring in dicotyledonous stem and scattered in monocotyledonous stems.
- The pith and cortex are food storage regions in the stem.
- The movement of water through a plant is as follows:
    a. Water enters the root hairs from the soil by osmosis
    b. It moves to through the root cells by osmosis to the root xylem
    c. The great amount of water absorption occurs in the zone of maturation in the root tip.
    d. It moves up to the stem and leaves from the roots, through the xylem by root pressure, capillary action and transpiration pull
- The root hair cells are adapted to absorb water and mineral salts.
- Mineral salts are absorbed as dissolved ions by the roots via diffusion and active transport.
- Transpiration is the loss of water in the form of water vapor from the leaves, especially through the stomata, as a consequence of gaseous exchange.
- During transpiration, water is pulled up the xylem from the roots to the leaves.
- The rate of transpiration is affected by light, temperature, humidity, air movements /wind
- Wilting is the loss of turgidity in plant tissue, where the intake of water is insufficient to replace that lost by transpiration or other means, causing a deflation of plant cells.
- The translocation is the transport of manufactured food, in the form of sugars, from the leaves to the rest of the plant in the phloem.
- Blood transport chemicals around the body.
- Blood is made up of red blood cells, white blood cells and blood platelets.
- Blood travels round the body through blood vessels such as arteries, veins and capillaries.
- The heart is a double pump. Each side has a chamber called atrium and ventricle
- The right side of the heart receives and pumps deoxygenated blood. The left side of the heart receives and pumps oxygenated blood. This is called double circulation.
- Every human being belongs to a blood group: A, B, AB or O.

- The circulatory system is prone to many diseases. Among these diseases in the Circulatory system are anemia, hemophilia, leukemia, hypertension and heart attack.
- You can take care of your circulatory system by: eating low-fat, low-calorie, low-salt, high-iron foods; avoiding smoking and drinking too much alcohol, finding time to relax and exercise, having your blood pressure checked regularly, seeking medical attention at once in case of throat infections, maintaining proper hygiene, and maintaining your normal weight.
- Lymphatic system detects, filters and removes bacteria and other foreign invaders from our body.

---

**NOW DO SUMMATIVE TEST 3 IN YOUR ASSESSMENT BOOK AND SEND IN TO THE PROVINCIAL COORDINATOR FOR MARKING.**

## Answers to Learning Activities 1 - 4

### Learning Activity 1

1. Vascular bundles are strands of tissue that carry water and nutrients within the plant

2. Vascular bundles are made up of Xylem and Phloem

3. Xylem conducts water and dissolved mineral salts from the roots to the stem and leaves and it also provides support for the plants.

4. Xylem consists of a hollow vessels stretching from roots to leaves.

5. Phloem transport manufactured food (sugar and amino acids) from the leaves to the other parts of the plants.

6. Phloem consist of sieve tubes cells to enable food substances to pass through them to be transported to the different parts of the plant

---

### Learning Activity 2

A. i) Diffusion
   ii) Osmosis
   iii) Diffusion
   iv) Osmosis

B. Transpiration is the evaporation of water vapor from plant leaves through the stomata. Plants absorb large amount of water. However, they make use only a small portion of water.

C. Transpiration is important because it can keep the plant turgid or firm or it cause wilting of plants.

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### Learning Activity 3

A. In order for the water to pass from the plastic bottle to the empty cup, you had to squeeze the bottle.

B. In order to fill the cup faster, you had to squeeze the bottle even harder. The action that you did can be likened to the action of the heart, which continuously pumps blood throughout the body. Indeed, the heart is the most hardworking organ of the body.

**Learning Activity 4**

1. The components of the circulatory system are: Heart, Blood and Blood vessels

2. a. Red blood cell – transport oxygen
   b. White blood cell – engulf and digest bacteria and other organisms and produce antibodies which kill bacteria
   c. Blood platelets - help in the process of blood clotting

3. Right atrium, Right ventricle, Left atrium and Left ventricle

4. Artery – carries blood away from the heart
   Vein – carries blood back to the heart
   Capillary – allows exchange of materials between blood and body cells

5. Any of the following: Anemia, Hemophilia, Leukemia, Hypertension and Heart attack

6. Lymphatic system detects, filters and removes bacteria and other foreign invaders from our body.

## REFERENCES

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# FODE PROVINCIAL CENTRES CONTACTS

| PC NO. | FODE PROVINCIAL CENTRE | ADDRESS | PHONE/FAX | CUG PHONE (COORDINATOR) | CUG PHONE (SENIOR CLERK) |
|---|---|---|---|---|---|
| 1 | ALOTAU | P. O. Box 822, Alotau | 6411343/6419195 | 72228130 | 72229051 |
| 2 | BUKA | P. O. Box 154, Buka | 9739838 | 72228108 | 72229073 |
| 3 | CENTRAL | C/- FODE HQ | 3419228 | 72228110 | 72229050 |
| 4 | DARU | P. O. Box 68, Daru | 6459033 | 72228146 | 72229047 |
| 5 | GOROKA | P. O. Box 990, Goroka | 5322085/5322321 | 72228116 | 72229054 |
| 6 | HELA | P. O. Box 63, Tari | 73197115 | 72228141 | 72229083 |
| 7 | JIWAKA | c/- FODE Hagen | | 72228143 | 72229085 |
| 8 | KAVIENG | P. O. Box 284, Kavieng | 9842183 | 72228136 | 72229069 |
| 9 | KEREMA | P. O. Box 86, Kerema | 6481303 | 72228124 | 72229049 |
| 10 | KIMBE | P. O. Box 328, Kimbe | 9835110 | 72228150 | 72229065 |
| 11 | KUNDIAWA | P. O. Box 95, Kundiawa | 5351612 | 72228144 | 72229056 |
| 12 | LAE | P. O. Box 4969, Lae | 4725508/4721162 | 72228132 | 72229064 |
| 13 | MADANG | P. O. Box 2071, Madang | 4222418 | 72228126 | 72229063 |
| 14 | MANUS | P. O. Box 41, Lorengau | 9709251 | 72228128 | 72229080 |
| 15 | MENDI | P. O. Box 237, Mendi | 5491264/72895095 | 72228142 | 72229053 |
| 16 | MT HAGEN | P. O. Box 418, Mt. Hagen | 5421194/5423332 | 72228148 | 72229057 |
| 17 | NCD | C/- FODE HQ | 3230299 ext 26 | 72228134 | 72229081 |
| 18 | POPONDETTA | P. O. Box 71, Popondetta | 6297160/6297678 | 72228138 | 72229052 |
| 19 | RABAUL | P. O. Box 83, Kokopo | 9400314 | 72228118 | 72229067 |
| 20 | VANIMO | P. O. Box 38, Vanimo | 4571175/4571438 | 72228140 | 72229060 |
| 21 | WABAG | P. O. Box 259, Wabag | 5471114 | 72228120 | 72229082 |
| 22 | WEWAK | P. O. Box 583, Wewak | 4562231/4561114 | 72228122 | 72229062 |

# FODE SUBJECTS AND COURSE PROGRAMMES

| GRADE LEVELS | SUBJECTS/COURSES |
|---|---|
| Grades 7 and 8 | 1. English |
| | 2. Mathematics |
| | 3. Personal Development |
| | 4. Social Science |
| | 5. Science |
| | 6. Making a Living |
| Grades 9 and 10 | 1. English |
| | 2. Mathematics |
| | 3. Personal Development |
| | 4. Science |
| | 5. Social Science |
| | 6. Business Studies |
| | 7. Design and Technology- Computing |
| Grades 11 and 12 | 1. English – Applied English/Language& Literature |
| | 2. Mathematics – General/Advance |
| | 3. Science – Biology/Chemistry/Physics |
| | 4. Social Science – History/Geography/Economics |
| | 5. Personal Development |
| | 6. Business Studies |
| | 7. Information & Communication Technology |

**REMEMBER:**

- For Grades 7 and 8, you are required to do all six (6) subjects.
- For Grades 9 and 10, you must complete five (5) subjects and one (1) optional to be certified. Business Studies and Design & Technology – Computing are optional.
- For Grades 11 and 12, you are required to complete seven (7) out of thirteen (13) subjects to be certified.

Your Provincial Coordinator or Supervisor will give you more information regarding each subject and

**Notes:** You must seek advice from your Provincial Coordinator regarding the recommended courses in each stream. Options should be discussed carefully before choosing the stream when enrolling into Grade 11. FODE will certify for the successful completion of seven subjects in Grade 12.

| GRADES 11 & 12 COURSE PROGRAMMES | | | |
|---|---|---|---|
| **No** | **Science** | **Humanities** | **Business** |
| 1 | Applied English | Language & Literature | Language & Literature/Applied English |
| 2 | Mathematics -General/Advance | Mathematics -General/Advance | Mathematics –General/Advance |
| 3 | Personal Development | Personal Development | Personal Development |
| 4 | Biology | Biology/Physics/Chemistry | Biology/Physics/Chemistry |
| 5 | Chemistry/ Physics | Geography | Economics/Geography/History |
| 6 | Geography/History/Economics | History / Economics | Business Studies |
| 7 | ICT | ICT | ICT |

| CERTIFICATE IN MATRICULATION STUDIES | | |
|---|---|---|
| **No** | **Compulsory Courses** | **Optional Courses** |
| 1 | English 1 | **Science Stream:** Biology, Chemistry, Physics |
| 2 | English 2 | **Social Science Stream:** Geography, Intro to Economics and Asia and the Modern World |
| 3 | Mathematics 1 | |
| 4 | Mathematics 2 | |
| 5 | History of Science & Technology | |

**REMEMBER:**

You must successfully complete 8 courses: 5 compulsory and 3 optional.