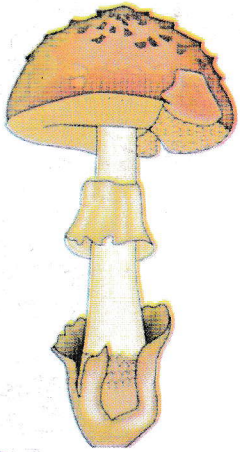
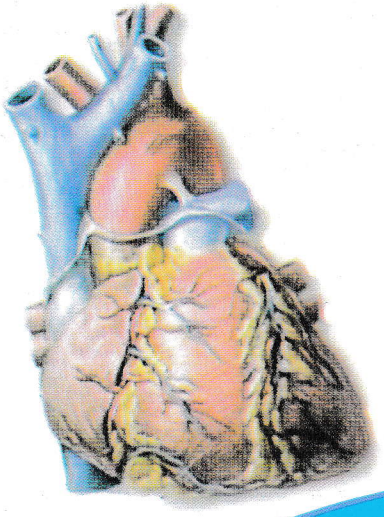
Module 3

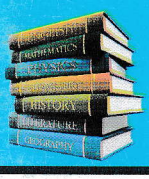
# BIOLOGY

## Stage I

# Analysing the Basics of Nutrition, Balance of Nature and Transportation of Materials in Living Things







Institute of Adult Education
Alternative Secondary Education Pathway

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## Stage I
## Analysing the Basics of Nutrition, Balance of Nature and Transportation of Materials in Living Things

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# Acknowledgements

This module is a product of the review process of Institute of Adult Education (IAE) secondary education modules produced in 2022 for Alternative Secondary Education Pathway (ASEP). The present modules have been updated to reflect the current Tanzania Institute of Education secondary education syllabi of 2010.

The Institute of Adult Education extends sincere thanks and gratitude to individuals who contributed in one way or another in accomplishing this task. The following staff of the IAE and non-staff specially deserve special appreciations and recognition for insightful and critical contributions in the review process of this module:

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# Contents

# About this module

This module has been produced by the Institute of Adult Education. All modules produced by the Institute of Adult Education are structured in the same way as outlined below.

## How this module is structured

### The module overview

The module overview gives you a general introduction to the module. Information contained in the module overview will help you determine:

- If the module is suitable for you,
- What you already need to know,
- What you can expect from the module,
- How much time you will need to invest to complete the module.

The overview also provides guidance on:

- Study skills,
- Where to get help,
- Unit assignments and assessments,
- Activity icons,
- Units.

We strongly recommend that you read the overview *carefully* before starting your study.

### The module content

The module is broken down into units. Each unit comprises:

- An introduction to the unit content,
- Unit outcomes,
- New terms,
- Core content of the unit with a variety of learning activities,
- Unit reflection,
- Unit assignments.

### Resources

For those interested in learning more on this subject, we provide you with a list of additional resources at the end of this module; these may be books, articles or web sites.

## Your comments

After completing this module we would appreciate it if you could take a few moments to give us your feedback on any aspect of this module. Your feedback might include comments on:

- Module content and structure,
- Module reading materials and resources,
- Unit assignments,
- Module assessments,
- Module duration,
- Module support (assigned tutors, technical help, etc.)

Your constructive feedback will help us to improve and enhance this module.

# Module overview

## Welcome to this module

Dear learner, Biology module 3 is about Analysing the Basics of Nutrition, Balance of Nature and Transportation of Materials in living things. This module comprises of three units. Unit 1 discusses Nutrition while unit 2 is about Balance of nature and unit 3 is about Transportation of materials in living things. I hope you will enjoy studying the module.

## General competence

By the end of this module, you should be able to evaluate roles of various physiological processes in animals and plants and develop positive attitude towards proper management of the environment.

## Study skills

As an out of school learner your approach to learning will be different to that from your school days: you will choose what you want to study, you will have professional and/or personal motivation for doing so and you will most likely be fitting your study activities around other professional or domestic responsibilities.

Essentially you will be taking control of your learning environment. As a consequence result, you will need to consider performance issues related to time management, goal setting, stress management, etc. Perhaps you will also need to learn about essay planning, coping with examinations and using the web as a learning tools.

Your most significant considerations will be time and space i.e. the time you dedicate to your learning and the environment in which you engage in that learning.

We recommend that you take time now before starting your self-study, to familiarize yourself with these issues. There are a number of excellent resources on the web. A few suggested links are:

- http://www.how-to-study.com/

The "How to study" web site is dedicated to study skills resources. You will find links to study preparation (a list of nine essentials for a good study place), taking notes, strategies for reading text books, using reference sources, test anxiety.

- http://www.ucc.vt.edu/stdysk/stdyhlp.html

This is the web site of the Virginia Tech, Division of Student Affairs. You will find links to time scheduling (including a "where does time go?" link), a study skill checklist, basic concentration techniques, control of the study environment, note taking, how to read essays for analysis, memory skills ("remembering").

- http://www.howtostudy.org/resources.php

Another "How to study" web site with useful links to time management, efficient reading, questioning/listening/observing skills, getting the most out of doing ("hands-on" learning), memory building, tips for staying motivated, developing a learning plan.

The above links are our suggestions to start with on your way. At the time of writing, these web links were active. If you want to look for more go to www.google.com and type "self-study basics", "self-study tips", "self-study skills" or similar.

## Need help?

Dear learner, in the course of your study, you may need help in various issues such as the location and how to get support from resource centres, clarification of various issues pertaining to your study materials (modules) and so on. If this happens, you are advised to ask for the help from your centre coordinator or facilitator, you can also visit the website of the Institute of Adult Education which is www.iae.ac.tz or ask for help by using phone no. +255 22 2150838.

## Module assessment

After each unit, you will be required to attempt one unit assignment. These are not meant for submission rather for reflection on what you have learned in the whole module. You will also be given tests and assignments for submission as you will be guided by your module facilitator. You will also sit for mock examinations to accomplish your continuous assessment.

# Getting around this module

## Margin icons

While working through this module you will notice the frequent use of margin icons. These icons serve to "signpost" a particular piece of text, a new task or change in activity; they have been included to help you to find your way around this module.

A complete icon set is shown below. We suggest that you familiarize yourself with the icons and their meaning before starting your study.

| | | | |
|---|---|---|---|
|  Activity |  Assessment |  Unit assignment |  Case study |
|  Discussion |  Group activity |  Help |  Note it! |
|  Outcomes |  Reading |  Reflection |  Study skills |
|  Summary |  Terminology |  Time |  Tip |
|  Computer-Based Learning |  Audio |  Video |  Feedback |
|  Objectives |  Basic Competence |  Answers to Assessments | |

# Unit 1

# Describing Feeding Processes in Living Organisms

## Introduction

Dear learner, welcome to unit 1 of Module 3 which is about Nutrition. The unit will help you understand much on necessary requirements for good health. In this unit, you will study the meaning of nutrition, their types and the importance of nutrition to both plants and animals. You will also learn the uses of food to organism especially you.

I hope this unit will make you more interested in Biology and also help you to solve different health problems related to nutrition. Have a nice study throughout the unit.

## Learning Outcomes

Upon completion of this unit you should be able to:

- Describe types of food nutrients and their importance to organisms;
- Design and carry out food test experiments;
- Describe the process of digestion;
- Demonstrate and carry out experiments on photosynthesis and food storage in plants; and
- Describe balanced diet, food processing, preservation; and storage.

## Concept of Nutrition

Dear learner, I hope you remember what you studied in Unit 1 of Module 1 of stage one. You studied about characteristics of living things. One of the characteristics is Nutrition. We said that, nutrition is the process by which organisms obtain food nutrients. More about how nutrition occurs will be discussed in this section. By the way, do you eat something either in the morning, afternoon or at night? Can you list down other organisms which also feed?

Obviously in the morning we normally take breakfast. We also take lunch in the afternoon and supper in the evening. Other organisms like cows, goats, sheep, zebra and giraffes feed on grasses as their food.

Plants such as grass, maize, banana trees, cypress and other trees absorb water and mineral salts from the soil. No single organism can remain alive in this world without eating. A combination of all these processes is what we call *nutrition*.

Nutrition is the process of getting nutrients and raw materials which are needed to maintain life in organisms. What we eat is known as food and contains food nutrients.

After learning about the concepts of nutrition, now let us study about the importance of nutrition and the types of nutrition.

**Importance of Nutrition**

Nutrition enables an organism to obtain nutrients required by the body for different body activities such as growth, respiration, repairing of worn out cells and protecting the body against diseases.

**Types of Nutrition**

There are two types of nutrition which are;

**1. Autotrophic Nutrition**

This is the type of nutrition where by organisms manufacture their own food from simple inorganic substances using carbon dioxide and water with the help of sunlight. Organisms which manufacture their own food are called Autotrophs. For Example: green plants, green algae, some bacteria and some protoctista.

**2. Heterotrophic Nutrition**

This is the mode of nutrition where by organisms obtain food nutrients by eating other organisms. Organisms which feed by this way are called Heterotrophs. For example: all animals, fungi, some bacteria and some protoctista.

Dear learner, if you have been investigative in your daily life, you could have noticed that heterotrophic nutrition occurs in three different ways. The following are the modes of heterotrophic nutrition.

a) **Holozoic mode of nutrition**. This is the mode of feeding whereby the organisms take in and digest complex food materials to obtain nutrients while egesting the indigestible food materials as faeces. Holozoic mode of nutrition can occur in different forms as follows;

(i) ***Herbivorous:*** It is the mode of feeding where by animals feed on plants. Examples of herbivores are cows, elephants, zebra and goats.

(ii) ***Carnivorous:*** It is a mode of feeding where by animals mostly eat meat or flesh of animals. They are sometimes called predators. Examples of carnivorous are lions, tigers and leopards.

(iii) ***Omnivorous:*** This is the mode of feeding where by animals feed on both plants and animals. Human beings and pigs are examples of Omnivores.

b) **Saprophytic mode of nutrition.** This is the mode of nutrition where by organisms feed on dead organic matter. Examples of saprophytes include mushroom and bacteria.

c) **Symbiotic mode of nutrition.** This is the mode of nutrition by which organisms of different species exist in nutritional relationship with each other. Symbiosis is the close relationship between two or more different species living together. This relationship can occur in different forms which are;

i. ***Mutualism***. This is a nutritional relationship in which the organisms of different species benefit each other by living together.

ii. ***Commensalism.*** This is a nutritional relationship in which two different species live together and one specie is benefiting from the relationship while the other is neither benefiting nor harmed.

iii. ***Parasitism***. This is the nutritional relationship in which two or more different species live together and one organism is benefiting while the other is harmed. A *parasite* is an organism that lives in or on the body of another organism (host) and obtains all its requirements from that host. Parasites that live inside the body of the hosts are called *Endoparasites* while those who are living to the outer surface of the host's body are termed as *Ectoparasites.*

# Nutrition in Mammals

## Human Nutrition

Dear learner, think of concrete blocks used to build a house. A concrete block is made up of particles of sand and cement bound together. A concrete block is like food you eat for your growth because without it a house cannot be built. Particles making up a block are like nutrients you get from food you eat. From this example, Can you now tell what a nutrient is?

*Nutrients are chemical substances needed by the body for growth, repair and maintenance.*

What is the difference between nutrient and food?

*Food is any substance eaten by organisms to provide the body with materials for growth, repair and energy.*

**Types of food nutrients**

There are about seven types of nutrients, namely:

i. Carbohydrates,
ii. Proteins,
iii. Lipids (fats and oils),
iv. Vitamins,
v. Mineral salts,
vi. Water,
vii. Roughage

Five of these nutrients which are carbohydrates, proteins, lipids, vitamins and roughages are organic compounds because they contain the elements of carbon, hydrogen and oxygen. The remaining nutrients which are minerals and water are inorganic compounds.

Dear learner, can you define and state properties and functions of each food nutrient listed above? For more information about types of nutrients please follow the discussion below:

**1. Carbohydrates**

Carbohydrates are substances made up of carbon, hydrogen and oxygen with a general formula $(CH_2O)n$.

Examples of carbohydrates are sugars, starch and cellulose.

Now let us classify carbohydrates.

**Classification of carbohydrates**

There are three types of carbohydrates which have been grouped according to their complexity. These are:

a. Monosaccharides
b. Disaccharides
c. Polysaccharides

**a) Monosaccharides (Reducing sugars)**

These are single molecules of sugars such as glucose and fructose. Both of them have a formula of $C_nH_{2n}O_n$. For example, simple glucose has a formula $C_6H_{12}0_6$. They are found in honey and most ripen fruits.

*Properties of Monosaccharides*

i. They are sweet
ii. They are readily soluble in water
iii. Reduce copper (II) ions in Benedict solution to insoluble copper (I) oxide.

*Function of Monosaccharides (reducing sugar)*

i. Source of energy i.e. provides energy to the body.

**b) Disaccharides**

Disaccharides are non-reducing sugars made up of two molecules of monosaccharides. Some examples are sucrose (sugar can), lactose (milk sugar), maltose (malt sugar). The chemical formula is $C_{12}H_{22}O_{11}$

*Properties of disaccharides*

i. They are sweet
ii. They are readily soluble in water
iii. They can be hydrolysed by enzyme or dilute hydrochloric acid

*Function of disaccharides*

i. They provide energy to the body.

**c) Polysaccharides**

Polysaccharides are carbohydrates made of long chains of molecules of sugars. "Poly" means many. Examples of polysaccharides are starch and cellulose.

*Properties of polysaccharides*

i. They are not sweet

ii. Insoluble in water or slightly soluble
iii. They are non reducing sugar
iv. Non – crystalline.

***Sources of starch***
Sources of starch include all cereals, yams, potatoes, cassava, maize, green bananas and beans.

***Functions of carbohydrates in the human body***
They are sources of energy (provide energy to the body).

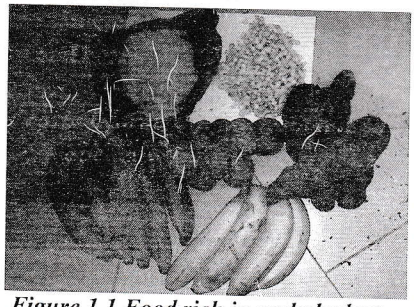

*Figure 1.1 Food rich in carbohydrates*

After you have studied about carbohydrates, let us now describe proteins as one of the food nutrients.

**2. Proteins**
Proteins are large molecules made up of chains of joined amino acids and contain the elements Carbon, Hydrogen, Oxygen and Nitrogen. Some contain phosphorus and sulphur.

Our bodies contain thousands of different proteins. All proteins are made only from about 20 different amino acids. Most amino acids are made in the body, but there are eight essential amino acids obtained in the food we eat. Proteins that contain all the eight essential amino acids are called **first class proteins.** These proteins are found in food that comes from animals such as meat, eggs and dairy products. Most plant proteins lack some of the essential amino acids and are called **"second class proteins"** e.g. beans, peas, soya beans.

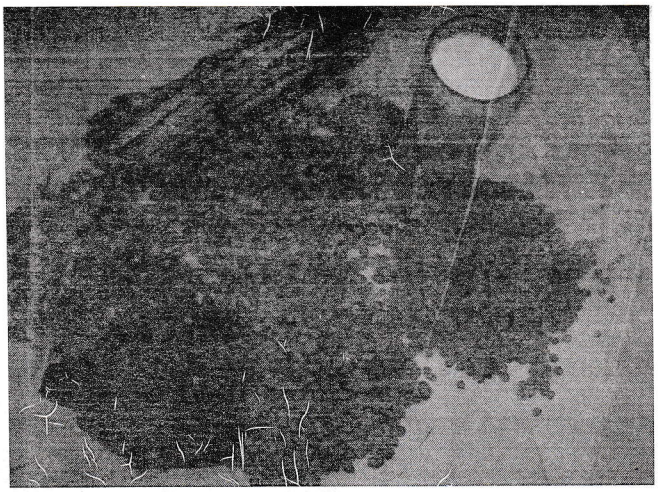

*Figure 1.2 Food rich in protein*

***Properties of proteins***

i. They are insoluble in water but soluble in dilute acids and alkali
ii. They are denatured at high temperatures, and
iii. They are sensitive to pH

***Biological importance of Protein***

i. Proteins build up and repair the worn out tissues of the body.
ii. They are used for making new protoplasm for growth and repair.
iii. Some act as enzymes, antibodies and hormones.
iv. They serve as source of energy only after the primary energy source (e.g. when carbohydrates and fats have been used up during starvation).

In addition to carbohydrates, can you please discuss other food nutrients which also provide us energy? Share with your friends.

**3. Lipids (Fats and oils)**

Fats and oils are collectively known as lipids. They are compounds made of carbon, hydrogen and oxygen but in comparison to carbohydrates they have less oxygen number. They are made up of fatty acids locked with glycerol joined by condensation process. Fats are solid lipids under room temperature while oils are liquids at room temperature.

*Natural sources of fats are* fish, animal fats and milk.

*Natural sources of oils* are soya beans, cotton seeds, sunflower, coconuts, cashew nuts and groundnuts.

***Properties of Lipids***

i. They are insoluble in water.
ii. They are less denser than water and therefore float on water.
iii. They are soluble in organic solvents such as ether, benzene, and chloroform.
iv. They can be emulsified or denatured by alkali (e.g. sodium bicarbonate).
v. They are poor conductors of heat.
vi. They are metabolically inactive.

**Biological importance of Lipids**

Lipids are important for several reasons:

i. They are a concentrated source of energy i.e. have high energy content compared to carbohydrates.
ii. Fats store other nutrients, such as vitamin A.
iii. Fats protect vital organs.
iv. They help keep our skin from drying out.
v. Lipids as a kind of fat are an important part of the cell membrane.
vi. Fats help to insulate the body against changes in environmental temperature.

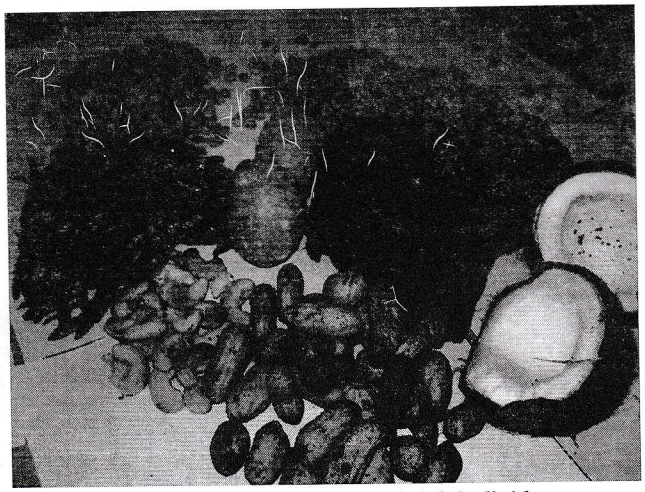

***Figure 1.3 Food rich in lipid***

Dear learner, we have already learnt about carbohydrates, proteins and lipids as food nutrients. Now let us continue with other categories of food nutrients.

**4. Vitamins**

These are food nutrients which protect us against diseases. Without them we may get several problems including night blindness, deformation of bones, bleeding of gums and anaemia.

***Characteristics of vitamins***

i. Vitamins are complex organic molecules that are needed by the body in very small amount.
ii. They do not contain energy.
iii. Most vitamins are enzyme helper, and play role in cellular reactions with the exception of vitamin D. Vitamins are not made by the body and therefore have to be obtained from the foods we eat.
iv. Vitamin D can also be made in the skin under direct morning sunlight. This synthesis involves the conversion of cholesterol to vitamin D by the help of sunlight.

**There are two main types of vitamins**

- **Water soluble:** These are vitamins that cannot be stored in the body. They should be included in a balanced diet every day. Example: vitamins B and C.
- **Fat–soluble:** They are vitamins that can be stored in the fatty tissue of our bodies, Examples; vitamins A, D, E and K.

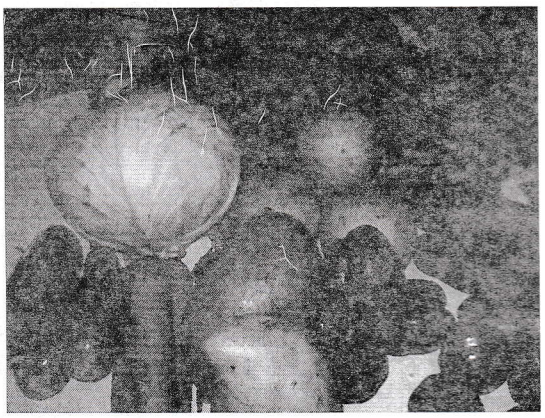

*Figure 1.4 Food rich in vitamins*

***Natural source of vitamins***

These are fresh fruits, vegetables, sun rays and meat.

***Properties of Vitamins***

i. Some vitamins are soluble in water while others are soluble in fats.
ii. Some vitamins can easily be destroyed by high temperatures e.g. vitamins $B_2$ and riboflavin.
iii. Vitamin C is easily destroyed by light.

I hope now you know what vitamins are. Let us now have a look in the table below for more details.

**Table 1.1 Source, Function and Deficiency of vitamins**

| Vitamins | Source | Functions | Deficiency | Excess |
|---|---|---|---|---|
| Vitamin A (Retinol) | Butter, Fish-liver oils, liver, eggs, carrots, milk and some vegetables especially spinach | -Control normal epithelia structure and growth.<br>-Formation of vision pigment, rhodopsin for night vision | - Poor right vision or night blindness | - Stored in the Liver<br>- Become toxic when stored in large amount e.g. children<br>- Lead to bone fractures later in life when is greater than recommended<br>- In pregnant woman, lead to great risk of birth defects |
| Vitamin $B_1$ (Thiamine) | Meat, yeast, liver kidney, heart. enriched bread and breakfast cereals | Coenzyme in cellular respiration | - Beriberi failure,<br>- Weak and painful muscle<br>- Mental disturbance | Water soluble and any excess easily excreted |
| Vitamin $B_2$ (Riboflavin) | Liver, eggs, cheese, milk, enriched bread and cereals | Used in cellular respiration, growth and general body functioning | Damage to eyes mouth and genitals | Water soluble and any excess easily excreted |
| Vitamin $B_3$ (Niacin/Nico tinic acid) | Meat, yeast, milk, enriched bread and cereals | Essential components of the enzymes | Pellagra. (Producing skin lesions) | Brief illness, but macein is very soluble and any excess is quickly excreted |
| Vitamin $B_{12}$ | Liver, eggs, | Essential | Pernicious | Not identified |

| | | | | |
|---|---|---|---|---|
| | milk | components of the enzymes. | anaemia | |
| Folic acid (Folacin) B complex | Green leafy vegetables | Formation of red blood cells (capsules) | Anaemia birth | Water soluble and easily excreted |
| Vitamin C (ascorbic acid) | Citrus, fruits green peppers, tomatoes | -Coenzyme in the synthesis of collagen<br>-Metabolism of connective tissues.<br>-Production of strong skin | - Scurvy, skin and gums becomes weak and bleeds<br>- Wounds fail to heal.<br>- Connective tissue fibres fail to form<br>- Anaemia<br>- Heart failure | No harm |
| Vitamin D | Synthesized when ultraviolet light strikes the skin also found in fish liver oil and butter | - Rickets, in children.<br>-Osteomalacia (softening of the bones) in adults | Rickets-bone deformation in youngs. | - In infants causing excess calcimine deposit and mental retardation |
| Vitamins E (Tocopherol) | Egg yolk, salad, green vegetable, oils and milk | Acts as a reducing agent in cells | - Causes sterility in both males and females | Toxic in infants |
| Vitamin K. | Spinach and other green leafy vegetables | Blood clotting factors | Slow clotting blood | Toxic in infants |

After studying about the roles of vitamins to our health, let us look at the roles mineral salts play in our body.

**5. Mineral Salts**

Minerals are inorganic substances required for normal functioning of the body. We obtain minerals from the food we eat. Our bodies cannot store minerals so it must be included regularly in the diet.
Some minerals come from plants after being absorbed from the soil. Other minerals can be obtained by eating animal products or other foods.

**Minerals can be categorized into two groups**

i. **Macro-elements;** e.g. calcium, phosphorus (phosphate), sulphur, iron, potassium, sodium, chlorine, magnesium and iron. These elements are needed in large amount.
ii. **Micro (trace) elements;** include fluorine, zinc, copper, iodine, manganese, chromium and cobalt. These elements are needed in small amounts.

**Table 1.2: The role of essential elements**

| Element | Function | Deficiency | Food Sources |
|---|---|---|---|
| Calcium (Ca) | Formation of bones and teeth, nerve and muscle actions | Brittle teeth and bones | Milk product, fish, eggs, beans and groundnuts |
| Chlorine (Cl) | Formation of an acidic stomach medium | Poor digestion of protein. | Table salt |
| Magnesium (Mg) | Muscle contraction, Formation of bones and teeth | Failure of muscle contraction. Poor bones and teeth formation | Green vegetables |
| Potassium (K) | Growth, nerve and muscle actions, corrects composition of lymph and blood | Retarded growth Failure of muscle contractions. | Green vegetable, fish |
| Sodium (Na) | Osmoregulation and transmission of nerve impulses | Muscle cramp | Table salts |
| Phosphorous (P) | Formation of bones and teeth and ATP | Rickets, poor health | Milk products and meat. |
| Iron (Fe) | Formation of the red cell pigment (haemoglobin) | Anaemia | Liver, unpolished cereals |
| Iodine (I) | Formation of the hormone thyroxine | Goitre | Vegetable, Fish and ground water |

**6. Roughage**

Roughage is indigestible food materials e.g. cellulose.

**Source of roughage**

Vegetables and fruits are good sources of roughage.

*Figure 1.5: Food rich in roughage*

**Importance of roughage**

Roughage stimulates muscles of the alimentary canal thus encourages peristaltic movements (peristalsis). When roughage is missing from the diet a person suffers from constipation.

7. **Water**

Water is a liquid composed of the elements hydrogen and oxygen. It is one of the simplest form of the essential nutrients and also the most important. It constitutes about 70% of the total body weight. Organisms would die from lack of water. Water is constantly being lost from the body. About 3 to 5 litres of water is lost from our bodies everyday through sweat, urine and exhaled air. Most water is replaced in our bodies by drinking liquids and from the food we eat.

**Functions of water in the body**

(i) It is a biological solvent
(ii) It is a medium for transport of materials
(iii) It regulates temperature (has cooling effect)

**Balanced diet**

We have learnt about the feeding in organisms. Do you remember different food substances and nutrients required for proper body growth and development? How much should we take (eat)? Is that amount correct to all ages and sex? Is the type of food given to children equivalent to that given to adults, sick or expectant mothers? All these questions and others will be answered in this section.

*A balanced diet is one which provides the body with all types of food nutrients in proper proportions.*

**Components of a balanced diet**

A balanced diet must contain:

(i) Carbohydrates.
(ii) Lipids (fats or oils).
(iii) Proteins.
(iv) Vitamins.
(v) Mineral salts.
(vi) Roughage.
(vii) Water.

**Importance of balanced diet**

In order for the body to function properly, it needs all types of food nutrients in the right quantities and proportions.

If cells are supplied with certain types of food only, an organism is likely .to suffer from certain diseases which are the result of deficiency or lack of other nutritional substances. These diseases are called **nutritional deficiency diseases**.

The balanced diet is not uniform to every group. It differs from group to group.

**Balanced diet to different groups of people**

The need for a balanced diet differs according to age, sex, activity, state of the body and environment. When a person is still growing, he/she requires more protein foods than a grown up one. A more active person uses more energy than a less active person. An active person therefore, requires more energy giving food stuffs. A pregnant woman requires more food than a non-pregnant one. The extra food is required by the developing embryo.

**a) Nutritional needs of infants (aged 0 – 5 months old)**

After birth, the mother must provide the baby with food by feeding it with breast milk. Breast milk is the best balanced diet for the newly born baby. The breast milk contains proteins, fat, carbohydrates, vitamins, minerals and water in the right proportions and is therefore a balanced diet.

**b) Nutritional needs of infants (aged 6 – 12 months)**

As an infant grows, its energy requirements also increase gradually (its nutritional needs also increase gradually). At this age breast feeding should continue to be the main food supply, but gradually additional weaning foods should be given to the baby. They include porridge, mashed potato, vegetable and fruit juices.

**c) Nutritional needs of children (aged 1 – 5 years)**
Breast feeding should be continued for at least two years. The child should be fed adequately on food substance which contains enough carbohydrates, proteins, vitamins and mineral salts to ensure that the child gets the daily necessary food nutrients to avoid malnutrition.

**d) Nutritional needs of children (aged 5 – 10 years)**
At this age group, children grow rapidly and are very active. Therefore they need enough quantities of protein, carbohydrates, lipids, vitamins and mineral salts. A balanced diet is essential to protect them from deficiency diseases.

**e) Nutritional needs of expectant and lactating mothers**
A pregnant woman requires more food than a non-pregnant one. The extra food is required by the developing embryo. Pregnant women need extra food containing proteins, carbohydrates, lipids and mineral salts such as calcium, iron and phosphates. They are needed in order to maintain constant breast milk production. These nutrients will also be used for general body health and energy needs. Protein is required for building the body of the embryo. Therefore, food substances recommended for diet include: meat, eggs, liver, green vegetables, fruits, fish and milk.

**f) Nutritional needs of the sick**
Sick people need a balanced diet for quick recovery. Food rich in proteins, vitamins will enable the sick person's body repair damaged cells and fight infections.

**g) Nutritional needs of the elders (aged)**
The elderly people need special balanced diet in order to provide their bodies with energy and resistance to diseases.

**h) Nutritional needs of sedentary workers**
Sedentary workers are people who sit in one place for a long time while performing their daily duties. These people need balanced diets which contain less carbohydrates and lipids but with high protein contents. They also need to exercise regularly.

**i) Nutritional needs of people who use extra energy**
People who use extra energy need a well-planned balanced diet with more carbohydrates to provide them with energy.

Suggest balanced diet for the following groups of people: pregnant mother, infants, lactating mother, your grandparent, sedentary worker and a sick person. What differences do you observe in the meals? Why?

Visit some villages including your village and observe peoples' health. I hope that you may see children and even adults who seem to have nutritional problems. Some children have large stomach, very thin legs and arms. Some adults have huge fat body and so on.

The following session is about "malnutrition". You will learn more about causes of various problems stated above.

Too much or too little of anything is harmful. This is also applied to food intake. Too much intake of food or too little intake leads to poor health, a condition known as **malnutrition.**

**Malnutrition**

Malnutrition is a condition resulting from failure to live on a balanced diet. It is caused by either:

- Not getting a balanced diet or,
- Eating too much food i.e. overfeeding or, and
- Eating too little food i.e. underfeeding.

Diseases caused in the body as a result of malnutrition are called *nutritional deficiency diseases*.

*Some examples*: Kwashiorkor, marasmus, goitre, beriberi, pellagra, scurvy, night blindness and rickets.

**1. Kwashiorkor**

It is a nutritional deficiency disease in young children caused by lack of protein in the diet. It is common in children aged between 1 – 5 years.

It usually occurs when the baby is suddenly deprived of its mother's milk and is put on a weaning diet which is deficient in protein.

Suggest balanced diet for the following groups of people: pregnant mother, infants, lactating mother, your grandparent, sedentary worker and a sick person. What differences do you observe in the meals? Why?

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*Figure 1.6: A child suffering from Kwashiokor*

***Symptoms of Kwashiokor***

i. Protruding stomach (swollen abdomen).
ii. Swollen lower parts of limbs (oedema). This is caused by the accumulation of body fluids in those parts.
iii. Skin becomes dry and cracks easily.
iv. Loss of appetite and usually develops diarrhoea.
v. The child becomes weak, dormant and easily upset.
vi. Loss of weight.
vii. The child looks pale and anaemic.
viii. The child becomes unhappy.

***Effects***

It can lead to death.

***Prevention***

Feeding children properly and breastfeeding should be supplemented with food stuffs rich in protein.

***2. Marasmus***

It is caused by lack of enough food or failure of the body to absorb and utilize the food taken. The body may fail to absorb food taken because of illness such as diarrhoea and tuberculosis. It is common in children aged one year.

*Figure 1.7: A child suffering from Marasmus*

***Symptoms***

i. Wrinkled skin.
ii. Stunted growth.
iii. Tendency of crying continuously.
iv. Underweight by 60% or more for its age body becomes thin.
v. Tendency of eating a lot of food when it is available

***Effects***

Poor mental development and poor resistance to diseases.

***Prevention***

The child should be given enough food in form of balanced diet.

***3. Obesity***

This is a condition which develops when a person eats too much high energy food (carbohydrates and lipids) and does not do enough exercise or hard work. In this case, the total amount of food that such a person eats is more than what is required for normal body health. The extra food eaten is stored as fat under the skin around intestines, heart and kidneys. The person becomes overweight or obese.

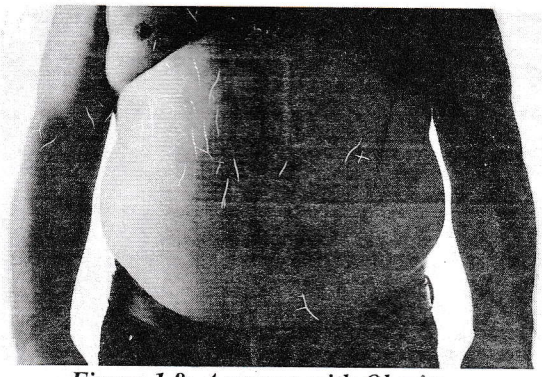


*Figure 1.8: A person with Obesity*

***Symptoms***

The body becomes extremely big with hanging stomach.

***Effects***

The person suffering from obesity may have flat feet, heart diseases, high blood pressure, abdominal hernias, diabetes and stones in the gall bladder.

***Prevention of Obesity***

i. Physical exercises
ii. Reduce food nutrients such as carbohydrates, fats (especially animal fats)

***Note:***

The relationship between body health and weight is calculated by using Body Mass Index (BMI). BMI informs about the existing relationship between the estimated body fat and the risks of diseases or condition associated. BMI helps to establish the health status of a person so as to know whether she/he is at unhealthy or healthy weight. The following formula is used in calculating BMI;

$$BMI = \frac{\textit{Body mass (in kilograms)}}{\textit{Person's weight (in metres}^2\textit{)}}$$

For example, The BIM of a person with weight of 40kg and height of 1.82metres can be calculated as follows;

$$BMA = \frac{40}{3.3124} = 12.07$$

Table 1.3 below shows the BMI ranges which can guide on how different values of BMI are used to interpret the condition of the body.

**Table 1.3 BMI Interpretation**

| BMI | Health status |
|---|---|
| Below 20 | Under weight |
| 20 – 25 | Advisable range |
| 25 -30 | Over weight |
| 30 – 35 | Obese |
| Above 35 | Very obese |

### 3. Rickets

Rickets is a condition characterized by softening of the bones of the child resulting to fracture and deformity.

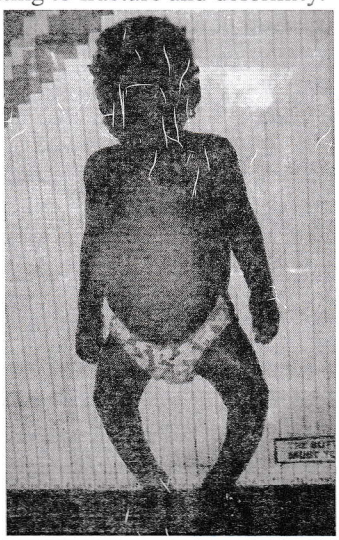


*Figure 1.9: A child with Rickets*

***Causes***

Rickets is caused by the lack of vitamin D, phosphorous and Calcium in the body.

***Symptoms***

i. Formation of bow legs due to soft bones
ii. Pain in bones.
iii. Dental problem associated with weak teeth or delayed formation of teeth.
iv. Stunted growth.

v. Experiencing muscle cramp.

***Prevention***

i. To increase intake of diets containing vitamin D, Phosphorous and calcium.
ii. Exposure to moderate amount of sunlight

***5. Anorexia Nervosa (slimmer's disease)***

Anorexia nervosa is a deliberate starvation for becoming slim. Anorexia is associated mainly with young women often at the beginning of adolescence. It commonly starts as a result of dieting. Gradually it becomes more exaggerated and the woman eats less and less until the fear of putting on weight becomes an obsession.

***Symptoms***

i. Low body weight.
ii. Soft down hairs.
iii. Extremely thin body.

***Effects***

i. Wasting away of body tissues.
ii. Cause constipation.
iii. Lower blood pressure.
iv. Teeth decay.
v. Cause low immunity leading to susceptible infections.
vi. Minerals and vitamins deficiency affecting metabolic processes.

**Factors that Cause Malnutrition in Tanzania**

In developing countries like Tanzania, malnutrition cases are caused by a number of factors such as:

**i) Ignorance**

Most of the people in Tanzania are ignorant. They don't know the importance of balanced diet in mothers and growing children's health. They also don't know the types of food to be eaten by the children and mothers. They usually eat unbalanced diet.

**ii) Poverty**

Most people in Tanzania are poor; as a result, they can not get foods rich in balanced diet.

**iii) Tribal customs**

Certain tribal customs prevent children and women from eating certain types of foods. For example, in some societies pregnant women are not allowed to eat eggs.

**iv) Religious taboos**
Certain religions prohibit certain types of foods due to religious beliefs e.g. Muslims are not allowed to eat pork.

**v) Drinking behaviour**
Spending too much money on alcoholic drinking instead of buying foods for the family may lead to malnutrition.

**vi) Early death of one or both parents**
The death of one or both parents may cause the children lack important services like food nutrients.

**Methods that can Eradicate Malnutrition in Tanzania**
(i) Education: Educate people on the importance of balanced diet.
(ii) Change the drinking behaviour: Luxurious life styles should be balanced by going hand in hand with provision of balanced diet to the children.
(iii) Males should involve themselves in the provision of food production for the families. The provision of food in many cultures is the responsibility of women. Men need to be educated and become fully involved in the provision of food. Their involvement will also facilitate elimination of taboos and practices like those denying expectant mothers and children to eat food like eggs, liver, kidneys, heart, etc.

## Digestive System in Human

Dear learner, take in any food such as rice, meat, etc. Relax for about four hours. Then go for a long call to the toilet. Try to observe your waste. It is not exactly similar to the food you ate? If not, what has changed it in the way it is? How have those changes been brought about? Can you explain how these changes are brought about from the mouth to the anus?

The above information brings you to what is called digestion.

Dear learner, before proceeding familiarize yourself with the following terms which are commonly used when studying about digestion.

***Ingestion:*** The process of taking food substances into the mouth.
***Digestion:*** The process by which food substances are broken down into simple, soluble substances in the form that can be absorbed and utilized by the body.

***Absorption:*** The process by which soluble food products are taken up in the blood stream.

***Assimilation:*** The process by which the absorbed food is incorporate into the body cell.

***Egestion:*** The removal of undigested material from the body through anus.

***Digestive system:*** A tube passing through the body from the mouth to the anus. It is actually a long hollow tube called the ***Digestive tract/Alimentary Canal.*** It starts from the mouth and runs to the anus.

***Enzymes:*** These are organic substances which increase the rate of chemical reaction in living organisms. They speed up the rate of chemical reactions which break down or build up certain substances.

Observe the alimentary canal of a rabbit, hare, goat or sheep when dissected. Draw and label diagrams to show the parts of the alimentary tract and its associated structures. Compare your structure with Fig 1.10.

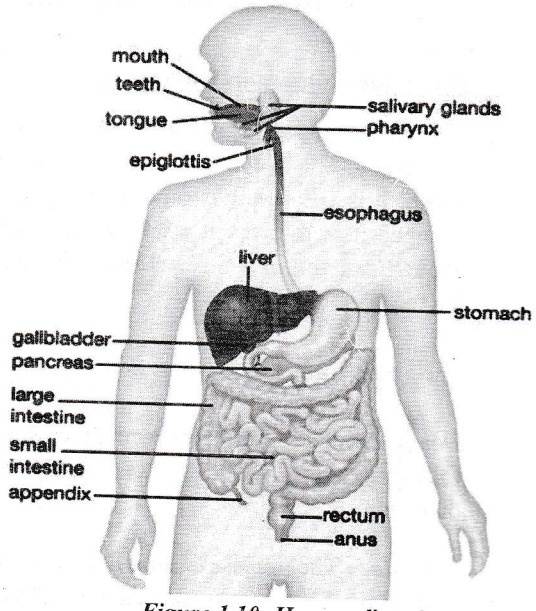



*Figure 1.10: Human digestive system*

The digestive system begins with the mouth, followed by pharynx, oesophagus, stomach, duodenum, small intestine, large intestine, rectum and ends with the anus.
Several major organs (accessory organs) along the digestive tract aid digestion. They include salivary glands, the pancreas, and the liver. They add their secretions to the digestion system, but are not part of the digestive tract/alimentary canal.
Three activities are involved in the digestive process:

i. Mechanical digestive or mastication,
ii. Chemical digestion, and
iii. Absorption.

**Enzymes**

Enzymes are macro-molecules which are made up by proteins produced by living cells. They act as organic catalysts and play a key role in the control of cell metabolism.

***Properties of enzymes***

i. They are effective in small amounts and a small amount of enzyme can catalyse a large amount of substrate.
ii. They are usually specific in their actions due to the specific shape of their active sites, e.g. maltase acts on maltose only; pepsin on protein and Lipase on lipids only.
iii. They are sensitive to temperature and work best at an optimum temperatures. They are denatured by excessive heat and inactivated by low temperatures.
iv. They are sensitive to pH. A particular enzyme is active within a narrow range of pH and has an optimum pH at which it works best.

Let us now discuss how digestion takes place starting from the mouth.

**Mouth/Buccal cavity**

Dear learner, take the mirror and observe your mouth. While observing it, take in some food. What is happening with your jaws, teeth and tongue while chewing? After this activity, let us continue to describe how digestion takes place.

Digestion begins in the mouth where food is cut and ground by teeth. This makes food easier to dissolve and affords a greater surface area for various enzymes to act upon. This process of breaking large food particles into small particles using teeth is called **mechanical digestion** or **mastication.**

While in the mouth, enzymes secreted by salivary glands are added to the food. This initiates chemical digestion. Saliva contains **salivary amylase** enzymes that initiate the digestion of starch which is converted into maltose. Saliva also contains mucus which acts as a lubricant.

Mucus also binds the food together into a mass called **bolus**. During swallowing, the bolus is pushed into the oesophagus, the tubular channel that leads to the stomach.

**Swallowing**

Dear learner, again pickup the mirror and observe what changes occur in your gut as you are swallowing food. Do you see successive waves?

During the swallowing process, openings to the respiratory trachea and nasal passage are automatically closed by epiglottis to ensure that food is kept out of these places. In spite of your best efforts, you cannot breathe while swallowing. The walls of the oesophagus contain muscles that contract in successive waves. Contraction of circular and longitudinal muscles of the oesophagus to form successive waves is called *peristalsis*. Contractions of the muscles move the bolus to a valve called **cardiac sphincter** where the oesophagus joins the stomach. The sphincter allows food to pass into the stomach but usually not letting it move back into the oesophagus. Peristalsis enables a person to swallow food while standing on her/his head. Gravitational force has no effect on peristalsis.

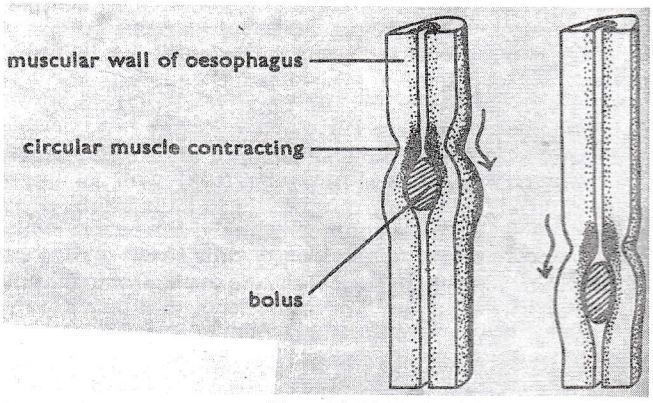



*Figure 1.11 Peristalsis*

**Stomach**

As you take in food, it reaches a time when you get satisfied. So if someone invites you to eat at the same time, you say my stomach is full. However, about four hours later you again feel hungry and your stomach is no longer full and you need to eat.

*How are such changes brought about?*

**Adaptations and Function of the Stomach**

i. The stomach walls are made of layers of muscles that contract in opposite direction to mixing food, a process known as *churning.*

ii. It has two sphincters. The cardiac sphincter prevents back flow of food to the oesophagus while pyloric sphincter holds the food in the stomach for digestion before allowing it to pass to the duodenum.

iii. The inner walls of the stomach have gastric glands for secretion gastric juice which has the following components;

- ***Pepsinogen:***
  This is an inactive form of pepsin. It is converted by Hydrochloric acid into pepsin which digests protein into peptides. Pespin is not secreted in its active form because it can digest the walls of the stomach when the food is absent.

- ***Hydrochloric acid:***
  - It provides acidic medium which is the suitable pH for function of pepsin.
  - It converts inactive pepsinogen into the active form pespsin.
  - It kills the bacteria that enter in the stomach with food.
  - It helps in the breakdown of food in stomach into tiny particles.

- ***Renin:***
  It helps in coagulation of milk, a form which can be acted by pepsin.

- ***Water:***
  It provides a medium for chemical digestion to take place.

- ***Mucus:***
  It covers the stomach walls preventing it from being corroded

***Note;*** Vitamins, water and drugs like alcohol are absorbed in the stomach.

After about 3-4 hours of mechanical and chemical digestion in the stomach, food is reduced to a soft pulp called **chyme**. Chyme is a thick liquid made up of partially digested proteins and starch, vitamins, minerals, water, acids and undigested foods.
At this point, the **pyloric sphincter valve** between the stomach and small intestine opens, allowing small amount of chyme bit by bit to pass into the upper part of small intestine called **duodenum**.

**The Small Intestines**
The small intestine is a long tube about 7m, with a diameter of 2.5cm. It is smaller than the large intestine. The small intestine consists of two parts:

i. **Duodenum;** the first part joining the stomach.
ii. **Ileum;** second and longest part of the alimentary canal.

As chyme is pushed through the pyloric sphincter, it enters the **duodenum.** This stimulates secretion of digestive juices from two different accessory organs, the liver and pancreas which join the duodenum via bile duct and pancreatic duct respectively.

***Bile juice:*** this contains salt, sodium hydrogen carbonate which neutralizes the acidic chyme into alkaline for proper functioning of the enzymes in the duodenum. Also, it breaks down lipids into fat droplets, a process known as *emulsification.*

***Pancreatic juice:*** this is composed of;
- Pancreatic amylase which hydrolyses the remaining starch into maltose;
- Pancreatic lipase which digests fat droplets into fatty acids and glycerol; and
- Trypsin; digest the remaining protein into peptides.

**Ileum**
The lining of the ileum secretes intestinal juice which contains the following enzymes to complete digestion;
- Maltase; Digests maltose into glucose molecules,
- Sucrase; Converts sucrose into glucose and fructose,
- Lactase; converts lactose into glucose and galactose,
- Peptidase; Converts peptide into amino acids, and
- Lipase; Converts fatty droplets into glycerol and fatty acids,

**Absorption of food in the small intestine (ileum)**

Dear learner, it is wonderful to learn that, what you eat is less than what you give out through the anus (defecation). Where do other food substances go? The next session will answer it.

Once the food has been digested, it needs to be absorbed into the blood so that it can be transported all over the body for use. Most nutrients are absorbed into the circulatory system through the cells that line the small intestine (ileum).

The ileum has several features which contribute to its efficiency in absorption. These features are as follows;

(i) The ileum is long. This ensures maximum absorption of the end products of digestion.

(ii) The internal surface of the ileum is lined with finger like projections called villi (singular villus). These villi increase the surface area for absorption.

(iii) The inner layer of the ileum is thin. This decreases the distance through which food is passed into the transport system.

(iv) Each villus is provided with a network of blood capillaries and a lymphatic vessel called lacteal. These vessels transports absorbed food.

(v) The internal lining of ileum is folded to form ridges. These slow down the movement of food along the ileum, hence ensure the complete absorption of the digested food materials.

*Dear learner, how do villi work?*

The internal surface of the intestine is lined with finger-like projections called **villi**. The cells covering the villus, in turn have extensions on their cell membranes called **microvilli**. Villi and microvilli increase the surface area of the lining of the small intestine, making absorption more efficient. Nutrients are absorbed through **capillaries** and tiny lymph vessels are called **lacteals** in the villi. Blood capillaries absorb the glucose, amino acids, vitamins, water and mineral salts. Lacteals absorb fatty acids and glycerol.

The liver neutralizes many toxic substances in the blood and removes excess glucose by converting it to glycogen for storage. The filtered blood then carries the nutrients to all parts of the body. The tiny lymph vessels called **lacteals** absorb fatty acids and glycerol which are carried through the lymph vessels and eventually to the bloodstream through lymphatic vessels near the heart.

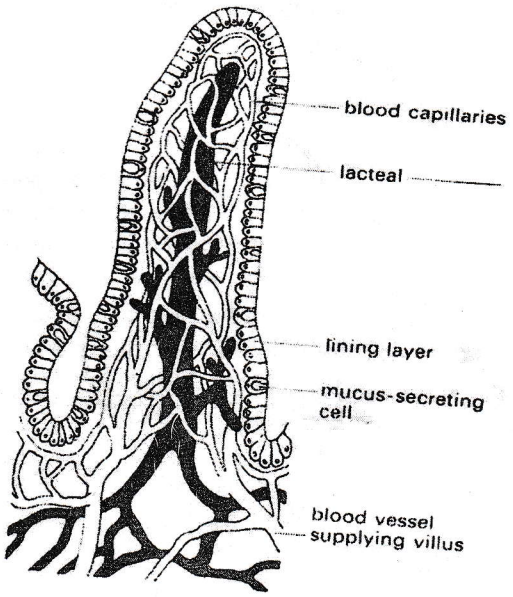



**Figure 1.12 Structure of villus**

**Large intestine**

Undigested food materials leave the small intestine through a valve and enter the **large intestine or colon**. The colon is the final organ of digestion.

An organ called the **appendix** is located near the junction of the small and large intestine. The Appendix is a finger-shaped pouch, which does not serve any known function. If the appendix becomes infected by bacteria, this results in appendicitis. Under this situation the appendix must be removed.

The large intestine is about 6 cm wide and 1.5 m long. It absorbs water from the material remaining in the digestive tract. Water-soluble vitamins are absorbed along with the water e.g. Vitamin K. When most of the water has been removed from the undigested material, a solid waste matter called faeces remains. **Peristalsis** propels the faeces through the large intestine and into the **rectum**, the last few inches of the large intestine. Faeces collected in the rectum are eliminated through the **anus.**

Dear learner, I hope now you are aware about how digestion in human being takes place. The discussion that follows will be on how digestion in ruminant organisms takes place.

**The Ruminant Digestive System**

Ruminant comprises herbivorous organisms that ingest food, chew and swallow it, thereafter returns it to the mouth for further chewing. This swallowed food is called *Chewing cud. Ex*amples of ruminants are goats, zebra, cow, gazelle, sheep and the like.

Unlike non ruminant organisms, ruminant organisms have four stomach chambers which are rumen, reticum, omasum and abomasum. Both have alimentary canal with mouth, pharynx, esophagus, duodenum, ileum, caecum, colon, appendix, rectum and anus.

***Rumen*** receives food from the mouth for the first time, immediately bacteria start to act on cellulose present in plants. This softens the chewing cud and digests into more simple form for further digestion.

As the food leaves the rumen, it is more soft and very green in colour. The food is then returned to the mouth and chewed again after which it is passed directly to ***reticulum*** which appears like honeycomb. In this part the food is mixed with water becoming more watery, less green, less coarse and smelly.

The cud is returned to the mouth, chewed again and passed to the ***omasum*** as very fine particles with little water. The omasum looks like pages of the book. From here, the food is passed directly to the abomasum which is the true stomach of ruminant organisms. The abomasum secrete gastric juice for protein digestion and killing microorganisms swallowed with food.

Dear learner, human digestive system is quite different from ruminant digestive system as shown in Table 1.4 below.

**Table 1.4: Differences between Human Digestive System and Ruminant Digestive System**

| Human Digestive System | Ruminant Digestive System |
|---|---|
| i. Have one stomach chamber | Have four stomach chambers |
| ii. They have incisors and canine in their upper jaw | Incisors and canine are replaced by horny pad |
| iii. Diastema is absent in their lower jaw | Diastema present in their lower jaw |
| iv. Do not regurgitate food swallowed | Regurgitate food swallowed for further chewing |
| v. Do not have bacteria for cellulose digestion | Have bacteria for cellulose digestion |

Dear learner, bear in mind that your alimentary canal can sometimes be affected by certain disorders and diseases. The following session discusses some common disorders and diseases that occur in our digestive system.

## Common Disorders and Diseases of the Human Digestive System

### 1. Dental Caries

This refers to as teeth decay caused by bacteria attack. It occurs when bacterial living in the mouth digest the carbohydrate food remains on teeth turning them into acids. The combinations of bacteria, acids, food debris and saliva form *plaque* which stick to the teeth. The acid in the plaque erode the white surface of the teeth called enamel. This creates holes in the teeth, a condition called dental caries.

***Symptoms of Dental Caries***

i. Toothache after eating sweet, cold or hot food.
ii. Formation of holes in teeth.
iii. Swelling around the tooth.
iv. Headache.
v. Bad odour in the mouth.

***Contol Measures for Dental Caries***

i. Brushing teeth regularly.
ii. Damaged teeth can be filled with pulp of artificial enamel.
iii. Reduce intake of sugary food.
iv. Avoid eating very hot or cold food.

**2. Heart Burn**

It is a burning sensation occurring in the esophagus due to excessive secretion of hydrochloric acid in the stomach that tend to outflow in the exposed surfaces of the esophagus. The burning or painful sensation can be felt just below the breast bone.

***Symptoms of Heartburn***

i. Burning feeling in the chest which occurs after eating.
ii. Bitter test in the mouth.
iii. Pains increase when laying down or bending over.
iv. Difficult swallowing of food.

***Prevention and treatments of heart burn***

i. Avoid acidic food that cause heartburn.
ii. Avoid tobacco and beverages like alcohol and caffeine.
iii. Eat reasonable amount of food.
iv. Wear clothes that are loose around the stomach.
v. When sleeping, use pillow to raise up your head.
vi. Drink a lot of water to neutralize the acid in the stomach.

**3. Stomach Ulcers**

This is a disorder associated with the formation of sore in the lining of the stomach. It is caused by the corrosion of the stomach lining due to the action of hydrochloric acid and digestive enzymes. The sores can also be caused by the action of bacteria known as *Helicobacter pylori.* The condition of ulcers can be worsened by the state of emotional stress.

***Symptoms of Stomach Ulcers***

i. Burning sensation in the stomach just below the breast bone.
ii. Nausea and vomiting.
iii. General body tiredness and weakness.
iv. Experiencing blood in vomit and stool.

***Prevention and Treatment of Stomach Ulcers***

i. Avoid consumption of acid containing food.
ii. Avoid alcohol, tobacco, smoking, caffeine.
iii. Use medication which can prevent action of bacteria causing ulcers.

**4. Constipation**

This is the giving out of hard stool due to the excessive absorption of water in the colon leading to difficult egestion.

***Causes***

i. Not drinking enough fluids.
ii. Inadequate intake of fibres in diets.

iii. The habit of ignoring to go for the long call.
iv. Old age and pregnancy.

***Signs and Symptoms of Constipation***

i. Difficult egestion because of hard stool that are difficult or painful to pass.
ii. Stiff muscles in the bowel for three to four days.
iii. Feeling like you did not completely empty the stool from the rectum.

***Prevention and Control of Constipation***

i. Take enough fibres in meals.
ii. Drink enough fluids.
iii. Do exercise regularly.
iv. Go for a long call when you feel it.
v. Use medication to soften the stool.

**5. Flatulence**

This is a disorder due to the accumulation of gases in the stomach. It can be resulted from eating foods which produce gas in the stomach such as beans, cabbage, onion, milk, breads and fat foods. Flatulence can also be caused by swallowing air and poor absorption of carbohydrates in the gut.

***Signs and Symptoms***

i. Stomachache.
ii. Increased frequency of passing wind or "farting".
iii. Belching frequently.
iv. Accumulation of gas in the digestive tract.

***Prevention and Control of Flatulence***

i. Avoid taking food that are known to cause flatulence.
ii. Minimize the intake of lipid foods.
iii. Avoid eating too much food.
iv. Avoid going to bed immediately after meal as it can facilitate movement of gases from the stomach to the intestines.
v. Though cooking of food for easy digestion.

## Nutrition in Plants

Dear learner, the next part is about plant nutrition. Have you ever seen a plant eating food? If not, how do plants obtain their food? For more details, join the discussion below.

*How plants make food?*

Plants get food by manufacturing it from simple inorganic substances like carbon dioxide and water into complex organic compounds i.e. (glucose) in the presence of **sunlight** and **chlorophyll**. This process is called **photosynthesis**.

Plants like animals need food as well as other substances for their health growth. I hope you still remember the differences between plants and animals especially in the case of nutrition. Can you provide those differences? What materials do plants need to make their own food?

**Mineral elements**

Mineral elements are inorganic substances which occur naturally and absorbed by the plant for its normal growth and development. Depending on their necessity, mineral elements are categorized into two major groups which are;

a) **Macro elements**

These are mineral elements required by plants in large amount. Examples are: Sulphur, Magnesium, Potassium, Nitrogen, Phosphorus and Calcium.

b) **Micro elements**

These are mineral elements required by the plants in small quantities. Examples are: Boron, Copper, Manganese, Iron, Chlorine, Zinc and Molybdenum.

**Table 1.5: The role of essential Macro-elements in plant nutrition**

| Element | Function | Signs of Deficiency | Effects of excess |
|---|---|---|---|
| Sulphur | Formation of protein in the protoplasm | a) Yellow leaves<br>b) Stem becomes slender | Premature aging of plant |
| Phosphorus | a) Formation of nucleic proteins and co-enzymes<br>b) Nuclear division<br>c) Acting as buffer in the cell sap | a) Small leaves that drop early<br>b) A reddish colour in the stem and leaves | Deficiency of zinc and iron |

| | | | |
|---|---|---|---|
| Nitrogen | a) Protein synthesis<br>b) Synthesis of nitrogen bases and chlorophyll | a) Extremely stunted growth with very small leaves<br>b) Yellowing of leaves | The plant become very succulent, hence easy to fall down |
| Calcium | a) Health growth and cell wall formation<br>b) Neutralizing certain organic acids<br>c) Activating certain enzymes | a) Weak, stunted growth<br>b) Poor root development | Limit absorption of micro elements |
| Magnesium | a) Formation of chlorophyll<br>b) Activation of enzymes | a) Poor growth<br>b) Yellowish of leaves | Slows growth rate.<br>Hinders photosynthesis process |
| Potassium | a) Cell formation<br>b) Regulation of certain cell activities | a) Very poor growth<br>b) Discolouration of the leaves<br>c) Rolling of leaves | Hinders absorption of calcium and magnesium |

**Table 1.6: The role of essential Micro-elements in plant nutrition**

| Element | Function | Signs of deficiency | Effects of excess |
|---|---|---|---|
| Boron | a) Assist in production of sugar and starch<br>b) Facilitates absorption of water by cells | a) Delayed growth in plant tips<br>b) Hollow stem and malformed fruits | a) Dropping of leaves<br>b) Burning of leaves |
| Iron | a) Formation of the chlorophyll<br>b) Transportation of oxygen | a) Poor growth<br>b) Yellowish of leaves | Formation of brown spots on leaves |

| | | | |
|---|---|---|---|
| Copper | Production plant protein | a) Wilting of leaves<br>b) Hinders growth in plant tips<br>c) Folding of leaves | Hinders growth |
| Chlorine | Facilitates plant metabolism | a) Wilting of leaves<br>b) Poor development of roots | Folding in edges of leaves |
| Manganese | a) Speeds up enzyme activity<br>b) Used in chlorophyll formation | a) Leaves turns to yellow<br>b) Formation of grey or white spots on leaves | a) Hinders absorption of iron<br>b) Formation of brown spots on the leaves |
| Zinc | Improves growth of the plants | a) Leaves becomes yellow around veins<br>b) Formation of purple spots on leaves<br>c) Deformed leaves | a) Hinders absorption of iron.<br>b) Leaves become pale green |

**Experiment to Investigate the Roles of Essential Mineral Elements in Plant Nutrition**

**Aim:** To investigate the effects of mineral elements on plants

**Materials**

Small pots or tins, maize seeds, fertilizers, Note book and a pen.

**Procedure**

- Prepare 3 pots or tins ready for planting seeds
- Plant seeds in all pots/tins
- Put different amount of fertilizer in your pots/tins as follows;
- Never put any fertilizer in the first pot/tin,
- Put recommended amount of fertilizer in the second pot/tin,
- Put large amount of fertilizer into third pot/tin than recommended,
- Provide equal amount of water in each pot/tin every morning and evening,
- Observe and record the results on the progress of the plants in all pots/tins, and
- Discuss the findings with your friends.

Let us discuss the process of photosynthesis in details.

## Photosynthesis

Photosynthesis is a process occurring in green plants by which chlorophyll molecules trap sunlight energy and transfer it into chemical energy, which is stored in molecules of carbohydrate. The process can also occur in some bacteria and protoctista like green algae.

It is a process by which green plants manufacture organic substances such as starch from simple inorganic substances (water and carbon dioxide) in the presence of sunlight and chlorophyll.

**Raw materials for photosynthesis**

Water and carbon dioxide are raw materials for photosynthesis.

Water provides hydrogen atoms which reduce carbon dioxide to form carbohydrates.

**Conditions Necessary for Photosynthesis**

i. ***Chlorophyll:*** This traps sunlight energy.

ii. ***Light:*** breaks water molecules to form hydrogen atom and Hydroxyl group; hydroxyl groups (OH) recombine to produce water and oxygen. The process of breaking water molecules by light is called photolysis. Light also excites electrons in chlorophyll molecule.

***iii. Carbon dioxide;*** combines with water molecule to form glucose.

***iv. Water;*** releases oxygen gas in the atmosphere and combines with carbon dioxide to form glucose.

**Products of photosynthesis**

i. Glucose.
ii. Water.
iii. Oxygen.

Water and oxygen are by-products (waste materials) of photosynthesis.
Equation of photosynthesis can be represented as follows:

$$\text{Carbon dioxide + water} \xrightarrow[\text{Chlorophyll}]{\text{Light}} \text{glucose + water + oxygen}$$

$$6CO_2 + 12H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light}} C_6H_{12}O_6 + 6H_2O + 6O_2$$

**Structure of the leaf in relation to photosynthesis**

Plants manufacture their own food through the process of photosynthesis. In this process, the structure of the leaf offers maximum advantage for this process. Figures 1.13 and 1.14 show the internal and external parts (structures) of the leaf respectively.

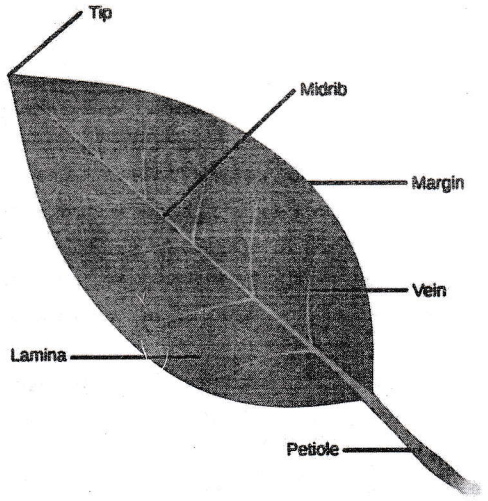



*Figure 1.13 External structure of the leaf*

**Adaptive features of a leaf to photosynthesis**

***Petiole;*** is the leaf stalk that attach to the branch or stem while directing the leaf to the sun.
***Lamina;*** this is the broad surface area of the leaf for maximum absorption of sunlight.

***Midrib and veins;*** have xylem and phloem for transportation of materials in the leaf. Xylem transports water and dissolved mineral salts into the leaf while Phloem transport manufactured food from the area of synthesis to the area where it is needed.

**The Internal Structure of the Leaf**
The Internal Structures of the leaf viewed under a Microscope is shown in figure 1.14

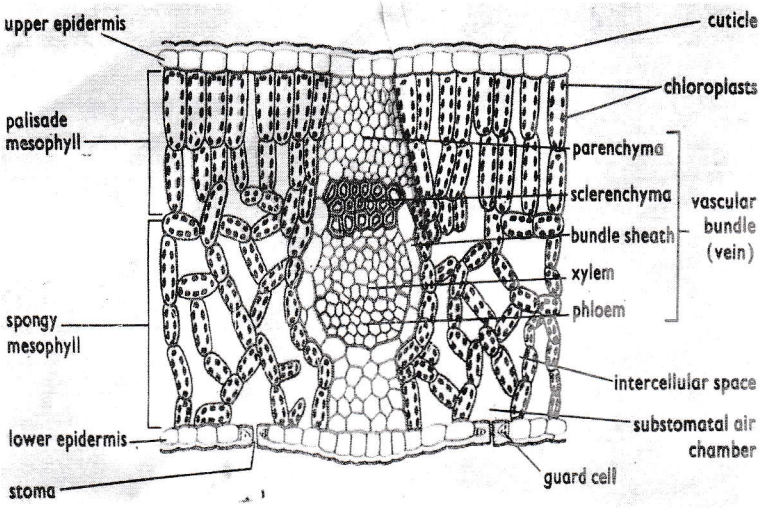



*Figure 1.14 Internal structure of a leaf*

**Cuticle**

This is the transparent upper layer of the leaf made of wax which acts as water proof. Cuticle allows light to pass to the inner parts of the leaf. It also protects the leaf from mechanical damage of the leaf due to the action of pests.

**Epidermis**

The next layer from the cuticle is the epidermis. This is a one cell thick found in both lower and upper part of the leaf. It contains the pores called stomata on both sides of the leaf.

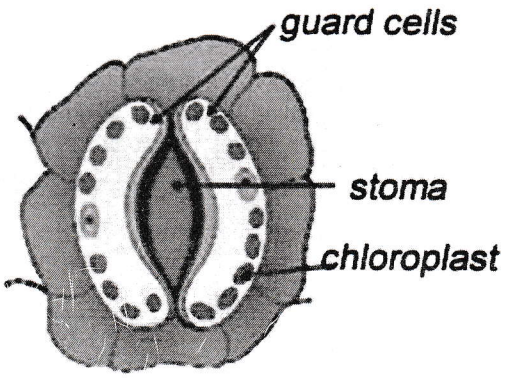



*Figure 1.15: Stomata and Guard cells*

**Stomata**

Stoma is a hole in the epidermis of the leaf surrounded by guard cells. It allows oxygen and carbon dioxide to diffuse in and out of the leaf.

**Vascular bundles**

This is a general term which is used to describe transporting tissues of the plant which are xylem and phloem.

***Xylem:*** These are tubes through which water and mineral salts move into the leaf from the roots.

***Phloem:*** Are tubes through which manufactured food materials move from the leaf to other parts of the plant.

**Mesophyll**

These are palisade and Spongy mesophyll layers. The palisade mesophyll are made up of elongated cells. It has high concentration of mesophyll for maximum absorption of light.

Spongy mesophyll is made up of loose and scattered cells to allow gaseous exchange to take place.

**The Process of Photosynthesis**

Photosynthesis occurs in a specialized organelle called chloroplast. It is a unique feature in all autotrophs. The chloroplast contains green pigments called chlorophyll which functions is trapping energy from the sunlight.

Carbon dioxide enters the leaf through stomata. Water is brought into the leaf from the stem through midrib and veins. Absorbed light energy, makes the carbon dioxide and water to combine forming glucose and oxygen.

Glucose formed is utilized by the plant for food while oxygen is given out as by product. The excess amount of glucose produced is converted into starch in the various parts of the plant including roots, fruits and leaves.

**Experiment 1**

**Aim**: To investigate the presence of starch in a photosynthesizing leaf.

**Apparatus**

- Bunsen burner.
- Beaker or test tube.
- Tripod stand/charcoal stove.
- Wire gauze.
- Water bath.
- Small shallow dish, white tile.
- Dropper.
- Match box/source of heat.

**Chemicals**

- Ethanol (an alcohol), and iodine solution.
- Water.

**Specimen**

- Two green leaves.

**Procedure**

Do the following to complete the experiment:

- Take two green leaves that one has been exposed to sunlight for a few hours (at least 8 hours) and the other in a dark.
- Boil them in water, in order to break the cell walls and membranes so that iodine solution can penetrate easily.
- Place the leaves in a beaker or test tube containing alcohol. Put the test tube in a water bath so the chlorophyll can be dissolved and extracted. Chlorophyll is soluble in alcohol.
- Rinse the leaves with hot water. The hot water will help to remove any excess chlorophyll and soften it.
- Spread the leaves in a shallow dish and pour a few drops of iodine solution over the leaves.
- Leave them for a few minutes. Then observe what the changes do you see? What do you say about those changes?

**Observations**

Blue black patches were formed on the leaf exposed to sunlight whereas the one from the dark shows pale brown colour of iodine.
On applying iodine solution observe areas turn blue-black, then draw diagrams showing the pattern of changes.

**Conclusion**

Blue black indicates the presence of starch. Therefore, a leaf exposed in the light manufactures glucose which is stored in form of starch during photosynthesis. In the dark no photosynthesis took place, so no starch produced.

Now, continue with the second and third experiments

**Experiment 2**

**Aim:** To show that carbon dioxide is necessary during photosynthesis.

**Materials:** Potted Plant, Conical flask, Caustic soda, Split cork, white tile and iodine solution.

**Procedure**

- Take the leaf attached to a potted plant
- Pass the petiole of the leaf blade through a split cork.
- Enclose the leaf blade in a flask containing some caustic soda solution. Caustic soda solution is used to absorb all carbon dioxide from the enclosed air in the flask.
- Tight the flask at the neck to prevent any air entering the flask.
- Set up an experiment early in the morning and expose to bright sunlight for some time.
- Remove the leaf after six hours from the flask and detach from the parent plant.
- Then, test for starch and observe the changes.

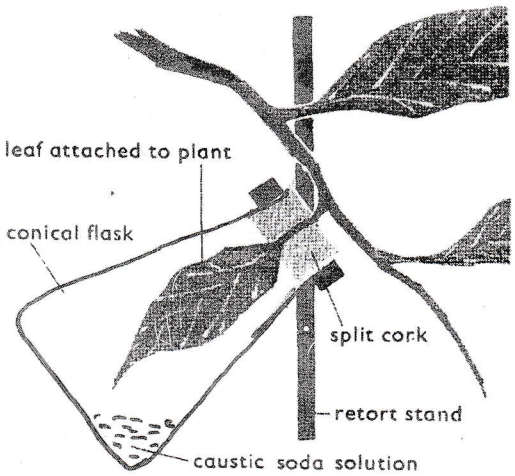



*Figure 1.16: Experiment to show that $CO_2$ is necessary for photosynthesis*

**Observation**

The leaf which was placed in the flask containing caustic soda retains the colour of iodine. The free one has turned into blue black colour.

**Conclusion**

The absence of starch in the flasked leaf shows that carbon dioxide is necessary for photosynthesis.

**Experiment 3**

**Aim:** To show that chlorophyll is necessary for photosynthesis.

**Procedure**

Take a fresh variegated leaf from a plant. Draw and label the green and yellow or white parts. Follow the same procedure for testing starch in a leaf, then test the leaf for starch.

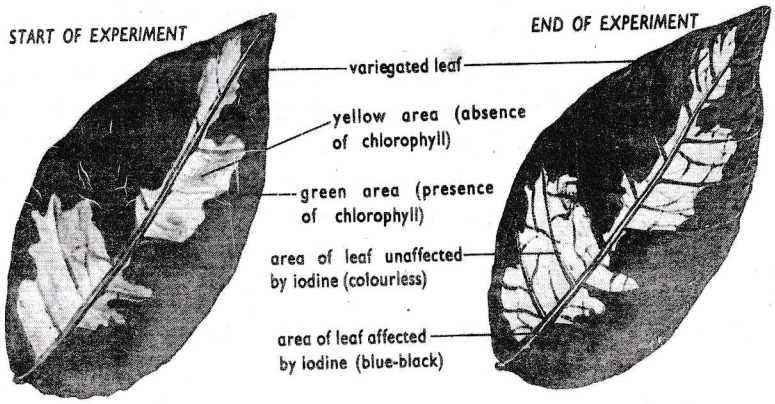



*Figure 1.17: Experiment to show that chlorophyll is necessary for photosynthesis*

**Note:** *variegated leaf* is that which has green and non-green parts.

**Observation**

- Those parts with green colour turned blue black with iodine solution.
- White parts retaine the colour of iodine, meaning that such parts do not contain starch.
- Starch formation cannot take place in any part of the leaf where there is no chlorophyll.

**Conclusion**

Chlorophyll is necessary for photosynthesis.

### Importance of Photosynthesis

***i. Food production***

All organic food consumed by animals is the by-product of photosynthesis.

***ii. Oxygen production***

Oxygen is a by-product of photosynthesis. It is used by most organisms during respiration.

***iii. Energy conversion***

All the energy used in the life processes comes from the sun through photosynthesis. Light energy is converted to chemical energy which is stored in organic food substance.

***iv. Reducing carbon dioxide gas from the air***

High level of carbon dioxide is harmful to the lives of other organisms. Therefore, when plants absorb carbon dioxide to effect photosynthesis, minimize the risks that can be brought by the increased concentration of carbon dioxide in the atmosphere. Example, Global warming

## Properties of Food Substances

Dear learner, I hope that you still remember about carbohydrates, proteins, lipids, vitamins, mineral salts, roughage and water. However, it is somehow difficult to know type of nutrients available in food unless we test that food sample.

Let us see how to test the food sample in the laboratory.

**Table 1.8: Identification of Food Substances (Food Test)**

| Test for | Procedure | Observations | Inference |
|---|---|---|---|
| Starch | Add $2cm^3$ of starch solution to a test tube or depression of a spotting tile. Then add a 2 drops of iodine solution. | A blue black coloration appears in the mixture | Starch present. |
| | | Retains the brown colour of iodine. | Starch absent. |

| Test for | Procedure | Observations | Inference |
|---|---|---|---|
| Reducing sugars | Add $2cm^3$ of a solution of reducing sugar to a test-tube, and $2cm^3$ of Benedict's solution, then boil for 3 minutes. | The mixture changes from blue to green, yellow and finally to orange. | Reducing sugar present |
| | | If the mixture remains blue colour of Benedict's solution. | Reducing sugar absent. |
| Reducing sugars | Add $2cm^3$ of a solution of reducing sugar to a test-tube and $2cm^3$ of Benedict's solution, then, boil for 3 minutes. | The mixture changes from blue to green, yellow and finally to orange. | Reducing sugar present |
| | | If the mixture remains blue colour of Benedict's solution. | Reducing sugar absent. |
| Non-reducing sugars | Add $2cm^3$ of sucrose solution to a test tube, add $1cm^3$ dilute hydrochloric acid to break it into reducing sugars, then boil. Cool it. Add $1cm^3$ Sodium Hydroxide (NaOH) for neutralization. Then, carry out Benedict test. | The solutions turn green, yellow, orange and finally brick red precipitate. | Non-Reducing sugar present. |
| | | If the mixture retains the blue colour of the reagent (Benedict's solution). | Non-Reducing sugar absent. |
| Lipids e.g. oil | ***Sudan III test*** Add $2cm^3$ oil to $2cm^3$ of water in a test tube. Add few drops of Sudan III solution and shake vigorously. Leave it to settle for a 5 minutes. | A red-stained oil layer separates on the surface of the water then the water remains uncoloured. | Lipid (oil) is present. |
| | | Retained the colour is formed on the surface. | Lipid or oil, is absent. |
| | ***Emulsion test:*** Rub a small amount of lipid on a white paper. | The rubbed area becomes translucent. | Lipid present. |
| | | Not translucent | Lipid absent |
| Protein | ***Burette test*** Add $2cm^3$ of protein solution to a | A purple/violet colour develops | Protein present. |

| Test for | Procedure | Observations | Inference |
|---|---|---|---|
| | test-tube. Add $2cm^3$ of Sodium Hydroxide solution. Add 3 drops of 1% Copper (II) Sulphate solution and shake after each drop. | No colour change | Protein absent. |

**Note:** Remember to use past tenses when writing food test report. Never use commanding language like 'add", "put" instead use words like "was added". See example table 1.9.

**Table 1.9: Food test report**

| Test for | Procedure | Observation | Inference |
|---|---|---|---|
| Starch | $2cm^3$ of solution C in a test tube, 2 drops of Iodine solution was added then shaken. | The mixture turned into blue black | Starch was present. |

Before proceeding further, complete the following activity:

Make a request to your nearby secondary school having a laboratory with apparatus used for food test. Make a solution containing extracts from onion bulb, Irish potatoes and egg white. Carry out food taste, tabulate your work, and compare your results with those shown in the table above.

**Storage Organs in Plants**

Dear learner, imagine you have a job whereby you are paid a salary every month. Possibly you do not spend all your salary buying various things. Now, where do you keep the remaining balance?

Plants are also clever like you; they keep their excess food in different storage areas. In this section you are going to learn how this takes place in plants.

**Types of storage organs in plants**

Plants can store food in leaves, seeds and fruits, stems and roots.

**a) Food storage in leaves**

Leaves become modified to store food. Such modified leaves are called bulbs e.g. onions. These leaves store glucose.

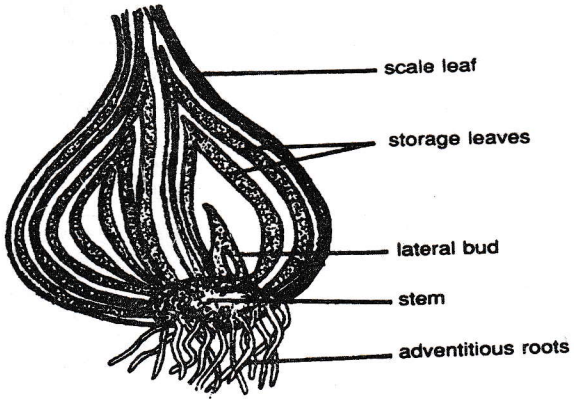



*Figure 1.18: Bulb of onion*

**b) Food storage in fruits and seeds**

Fruits and seeds are also storage organs in plants. Food stored in seeds is used during germination before the growing embryonic plant produces its leaves. Examples of seeds are peas, beans, maize, rice and wheat. Fresh fruits store sugars e.g. fructose in mangoes, tomato, pineapples and ripe banana.

**c) Storage in stems**

According to their modifications some stems are used as storage organs in plants. Stem tubers, are swollen ends of underground stems (rhizomes) which store starch.

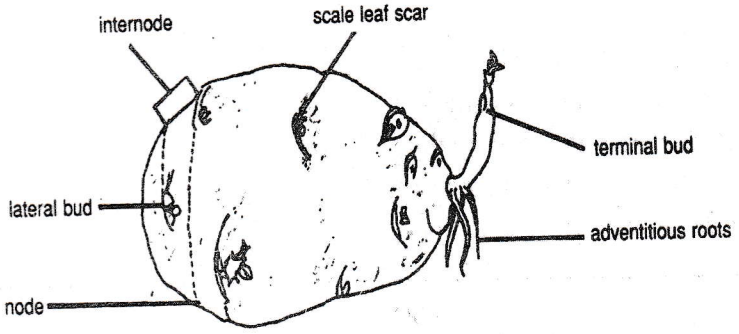



*Figure 1.19: Irish potato tuber*

***Corm:*** A short swollen underground stem storing starch e.g. cocoyam, anthericum.

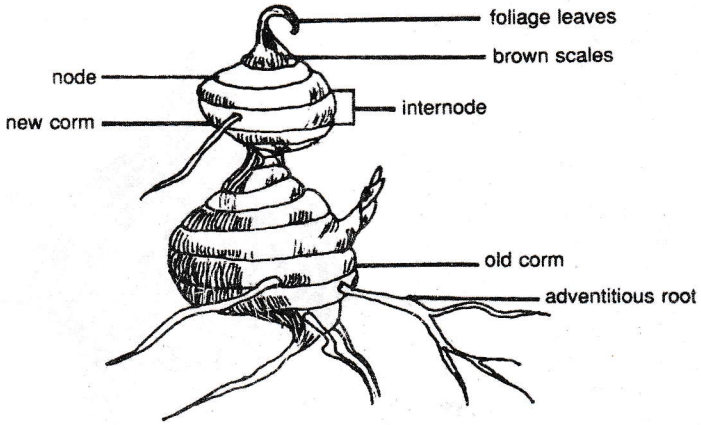



*Figure 1.20: Corm of anthericum*

***Sugar cane:*** Is the stem found above the ground level. It stores food in the form of sucrose.

**d) Food storage in roots**

The roots become swollen with food reserve e.g. root tubers are swollen ends of the roots storing starch e.g. sweet potatoes and cassava.

The tap root (main root) of carrots and beetroot are swollen with reducing sugars (glucose).

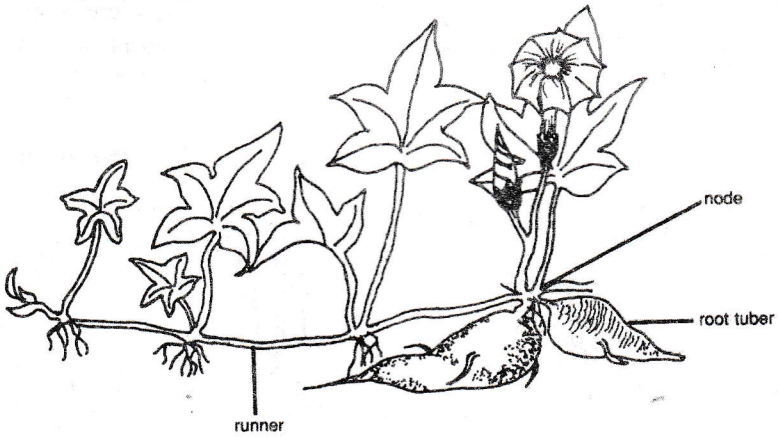



*Figure 1.21: Root tuber of sweet potato*

## Food processing, preservation and Storage

While plants store excess food within themselves, humans have designed some ways/methods of processing, preserving and storing food for future use. Can you list them?

### Food processing

*Processed food* is any food that has been treated in some way to make it more appetizing, more edible or to preserve it from decaying. It involves activities such as picking, sorting and washing.

### Food Processing Techniques

The following are common ways of processing food;

i. *Cooking:* involves boiling, frying, steaming and baking.
ii. *Fermentation:* Making alcohol from Carbohydrates such grapes, banana.
iii. *Peeling:* removing outer layer in some foods e.g. potatoes, cassava.
iv. *Liquification:* extracting juices from fruits e.g. mangoes, oranges and pineapple.
*v.* *Chopping/ Slicing:* cut into small pieces eg. potatoes, cassava, banana.

### Food Preservation

This is an advanced method of food processing that use the means of preventing food from getting spoiled or going bad. These methods can be modern or traditional ones.

### *Traditional Methods of Food Processing and Preservation*

i. ***Curing***
This is addition of a substance that can absorb water to the food in order to prevent the growth of microorganisms. Curing is mostly done in animal flesh. Examples of curing substances include salt, sugar and vinegar.
ii. **Drying in the sun**
This method intends to remove moisture in the food. It can be used to preserve maize, coffee, cloves, beans and paddy.
*iii.* ***Smoking***
This method intends to remove moisture in the food to prevent the growth of microorganisms. The foods like cereals, meat and fish can be dried by using this method.
*iv.* ***Cooking***
This technique can be done by boiling, steaming, roasting and

baking in hot ash. Apart from softening and increasing flavour of the food, some cooking methods help to distort the growth medium of microorganisms.

v. ***Salting***
This is the application of salt on food which helps to absorb moisture and kill microorganisms. E.g. meat, fish

vi. ***Fermentation***
This is the process of changing sugar into alcohol. Example, milk can be fermented into yoghurt, mangoes, cucumber, and lemon into vinegar.

***Modern Methods of Food Processing and Preservation***

i. ***Pasteurization***
This method is the application of very high temperature within a short time in order to kill microorganisms and increase shelf life. The process maintains nutrient content and flavour of the food. E.g. milk and fruit juice.

ii. ***Canning or bottling***
The method involves heating food preserved in air tight containers. The food is packed into containers or bottles and air is removed to create the vacuum. The container is sealed and then heated to kill microorganisms. Examples of the foods that can be treated using this method include tomatoes, beef and fruit juices.

iii. ***Using additives***
In this method some edible chemicals are added to the food in order to prevent the growth of microorganisms. It is done in fish and meat. Examples of chemicals used in this method include vinegar, sodium chloride and sodium b nzoate.

iv. ***Irradiation***
This method involves the use of rays of energy to stop any growth of microorganisms. Examples of the food that can be preserved through this method are onions, potatoes and beans. The method makes food last longer.

**Food Storage**

*Food storage* refers to method used to keep reserves of food in an appropriate place for future use. Food storage can be done under small scale or large scale. It can be done using traditional or modern ways.

***Traditional Ways of Food Storage***

***i. Storage in granaries and Pits***

Granaries are small hut raised above the ground by using stones or pieces of wood. They have one opening at the side or top used to fill in the cereals to be stored. This method prevents the cereals from being attacked by insects, rodents and birds.

On the other hand, Pits are used to store raw crops such as potatoes, cassava, yams and carrots. It is done by digging a hole in the ground which is then filled with the foods to be stored and covered with sand.

***ii. Storage in Pots and Tins***

Cereals are stored in pots and tins and covered with a tight lid to prevent oxygen from entering. This method keeps away microorganisms to allow storage of food for months.

***Advantages of Traditional Methods of Food Storage, Processing and Preservation***

i. The method maintains nutrients in the food.
ii. The method does not use harmful chemicals.
iii. It requires simple technology, hence minimizes cost.
iv. It is a simple method that can be done by any one.

***Disadvantages of Traditional Methods of Food Storage, Processing and Preservation***

i. The food can not last longer.
ii. The method cannot be applied to a large scale food storage.
iii. Not all foods can be processed, preserved and stored by this method.

**Modern Ways of Food Storage**

i. *Refrigeration*

It is the method used to keep away microorganisms by lowering the temperature up to $3^0C$ of the instrument or room used to store food. Examples of the foods that can be refrigerated include milk, fruits, meat, fishes and vegetables.

ii. *Freezing*

It involves keeping the food at very low temperature to stop growth of microorganisms. Examples of the food that can be treated by this method include meat and fish.

***Advantages of Modern Methods of Food Storage, Processing and Preservation***

i. Foods can last longer even a year.
ii. Almost all types of food can be stored using this method.
iii. It can accommodate large quantities of food because of high technology used.

***Disadvantages of Modern Methods of Food Storage, Processing and Preservation***

i. The method can lower the nutritional value of food.
ii. It needs high skilled people to apply the method.
iii. It involves use of chemicals which can be harmful to consumers.
iv. The method is limited to some areas with electric supply.

Most of the methods mentioned above are daily used in our society. Let us now compare the methods of food preservation

**Table 1.10: Comparison between modern and traditional methods of food preservation**

| Traditional method | Modern method |
|---|---|
| Less expensive. | More expensive. |
| Less effective | More effective (enable food to be stored for a long time. |
| Can be used anywhere. | Some of them are used in areas with electricity. |
| Do not require advanced technology, hence everybody can use. | It requires advanced technology. |

**Importance of Food Processing, preservation and Storage**

i. They prolong the life of food.
ii. The methods make the food more appetizing and edible.
iii. It prevents wastage of food.
iv. It helps to save money by economizing the resources.
v. It prevents spoilage of food.

vi. It maintains quality of food.

vii. It eliminates toxic and harmful microorganisms from the food.

viii. It makes the food available in all seasons of the year.

ix. It enables long distance transportation of delicate and perishable foods such as meet, fruits and vegetables.

## Unit Reflection

1. Dear learner, have you discovered areas of difficulties in this unit? What are they?
2. Why do you think it is important to study this unit?
3. How can you apply the knowledge gained in this unit to help your society improve their nutritional status using food available in their locality?

## Unit Assignment

1. What do you understand by the following terms:
   (a) Peristalsis
   (b) Absorption
   (c) Macro-elements
   (d) Micro-elements
   (e) Digestion

2. Briefly explain five features which make ileum able to absorb food nutrients efficiently.

3. (a) What do you understand by the term "balanced diet".
   (b) Explain the causes, symptoms and preventive measures of Kwashiorkor.

4. Briefly explain factors which cause malnutrition in Tanzania and ways of eradicating it.

5. In a class experiment Form II students performed the following investigations:
   - A green potted plant was kept in sunlight for six hours.
   - A health leaf was detached from the plant and boiled in water for a few minutes.
   - The leaf was transferred from boiling water to beaker containing ethanol.
   - The beaker containing ethanol and the leaf was then put into a water bath and ethanol was allowed to boil for about five minutes.
   - The leaf was removed from ethanol and dipped in boiling water and then spread on a white tile.
   - Iodine solution was added onto the leaf.

   (a) What was the aim of the above experiment .....
   (b) Why was it necessary to:
   (i) Expose the green plant in sunlight for 6 hours?
   .....
   (ii) Boil the leaf in water? .....
   (iii) Boil the leaf in ethanol? .....
   (iv) Use a water bath? .....
   (c) What were the expected results at the end of the experiment?

6. What do you think will be the effect on human life if plants fail to carry out photosynthesis?

# Unit 2

# Demonstrating Balance of Nature

## Introduction

In the previous unit, you learnt about nutrition in living organisms. You saw the way food are manufactured and utilized in living things. In this unit you are going to learn about balance of nature. Here, we are going to look at the ways in which organisms interact amongst themselves and with their environment. Let us now join this discussion which will give you a clear picture concerning the unit.

## Learning outcomes

Upon completion of this unit you should be able to:

- Describe biotic and abiotic components of the environment;
- Identify ways in which organisms interact with non-living components of the environment (biotic and abiotic interacting ways); and
- Diagrammatically construct a food chain and food web.

## The Natural Environment

Dear learner, the world is full of organisms. They all need food for growth and development. Food is either being synthesized by organisms themselves or obtained from other organisms. This means that life depends on living and non-living components found in the community. This session will give you relationship among organisms themselves or with the environment in which they live especially abiotic component e.g. water, soil, minerals, etc.

Make an observation of your surroundings and list different living things you see. Give reasons why they are there? How do each get food? Does each organism get enough food?

Organisms live in areas which supply what they need for their growth and development. That means there must be enough food, space, conducive temperature and pressure. In short, organisms live in the environment which suffices their needs. The place where organisms are found is known as *habitat*. This offers the natural environment to organisms.

*What is environment?*

*Environment* is all surrounding things/conditions which influences or affects the development of living things.
Environment is composed of both biotic (living part) i.e. flora (plants) and fauna (animals) and abiotic (non – living part)

**Importance of the Natural Environment**

The natural environment is important in the following ways;

i. It provides food required by all living organisms to survive
ii. It provides shelter and security to living organisms
iii. It provides a conducive place for the organisms to reproduce to maintain their generations
iv. It's a place where living and non-living organisms interact

Let us look at the common terms which you might come across when studying this unit.

- **Ecology** is the study of the interaction between living things and their environment.
- **Population** is the total number of same species living in a given environment.
- **Community** is the population of different species in a given area.
- **Habitat** is a part of the environment with a specific set of condition that supports the life of an organism.
- **Ecosystem is** the self-supporting system composed of primary producers, various consumers, decomposers and the environment. Examples of ecosystem are garden, forest, pond, iver, Grassland, lake, mountain and national park.

**Components of the Ecosystem**

i. Abiotic factors/components
ii. Biotic factors/components

1. **Abiotic components** are the non living components of the environment. It comprises all the non-living things like the rocks,

soil, water and other factors like climate and weather. The following are the factors making abiotic components;

***a) Climatic factors;*** include the factors such as temperature, light, wind and water.

*Temperature:* this is the degree of coldness and hotness that is influenced by sunlight. The amount of temperature of a place influences the type of organisms that can live in that particular area.

*Light:* main source of light is sun. Life is very important for various physiological activities taking place in living organisms such as photosynthesis, plants growth, opening and closing of stomata.

*Wind:* this is the moving air. Wind influence evaporation of water from water bodies and formation of rainfall, transpiration and seed dispersal.

*Water:* save as habitat of aquatic organisms. It is a universal solvent which support life of all living organisms. Evaporation of water contributes in rain formation. It therefore influences dispersal of living organisms in the environment.

**b) *Soil factors;*** these are factors such as soil texture, soil pH, and soil composition.
*Soil texture:* this determines the size of soil particles. Depending on soil texture, there are three types of soil which are sand soil, clay soil and loam soil. The nature of soil texture determines the type of plant or species that can live in the area.

*Soil composition:* this includes factors like mineral matters, microorganisms, water and air. These components determine the fertility of the soil, hence distribution of plants and other species.

*Soil pH:* this is the measure of acidity and alkalinity of a soil. pH value of the soil affect the growth of plants and other organisms. Some organisms can live well in alkaline condition while others can live well in acidic conditions.

*c)* **Aquatic factors;** these are factors such as salinity or wave actions.

*Salinity:* this is the amount of salt present in water bodies. Some organism die when introduced to saline water while others live successfully in such environment. E.g. Mangrove tree live in saline water.

*Wave action:* this cause movement of water in large water bodies caused by wind movements. Wave action can cause migration of aquatic organisms to other parts of the water body, hence affecting distribution of living organisms. It also erodes sediments from the shorelines of the water body creating breeding area for fish.

**d) Geological factors;** these are factors such as altitude, geological substratum and slopes.

*Altitude:* this is the height above the sea level. Altitude determines distribution of living organisms in the environment. For example, at higher altitude which is characterized by low temperature, pressure and oxygen concentration, there is less number of organisms compared to regions at low altitude.

*Geological substratum:* refers to the nature of the soil that determines the composition of the soil due to their disintegration. The nature of the soil formed can favors growth of some species while eliminating others.

*Slope:* this refers to the steepness of gentleness of the land. In very steep land, there is high rate of soil erosion which affects soil fertility for growth of species of plants. Therefore, there is high number of organisms in gentle slope than in steep slope.

2. **Biotic components:** are the living components of the environment. It comprises all the plants, animals and decomposers living in the environment. Biotic factors influence the life of other organisms in a population. It includes the availability of food and competition for basic needs.

**Food Availability**

Living organisms can only survive in the presence of food. This can be achieved either by synthesizing or feeding from another organism.

***Prey-Predator Relationship***

*Predator:* this is an organism that kills and eats another organism. For example, lion, leopard and cat.

*Prey:* this is an organism that is killed and eaten by a predator. For example, goat, zebra and cow.

# Interactions of Organism in their Environment

As you have learnt *that, ecosystem* is the unit consisting living things (plants and animals) and non-living organisms interacting together in their environment.
Generally in an ecosystem, biotic factors interact with abiotic factors in many ways. For example, green plants absorb water from the soil for photosynthesis. Oxygen is given out and carbon dioxide from atmosphere is absorbed by plants. High temperature affects enzymes' functioning. Plants also interact with the soil by absorbing all essential nutrients from it. Man feeds on ready made food like all other heterotrophs.

Therefore, some organisms feed on grass only while others feed on both animals and plants. These environmental interactions lead into balancing of nature.

## Food Chain and Food Web

Food chain and web show how food and energy are passed between species.

**Food Chain**
A food chain is a linear feeding relationship where by one organism is a source of food of the next in the sequence. In other way, food chain is the sequence of organisms, through which energy may flow in an ecosystem.

The food chain always starts with producers and ends with decomposers. Usually the bacteria and fungi decompose dead organisms and provide materials to be used by producers.
Example of food chain:

Grass ⟶ grasshopper ⟶ Lizard ⟶ Snake ⟶ Hawk ⟶ Fungi

In a food chain, energy and nutrients are passed from one organism to another. Food chains rarely contain more than six species because amount of energy passed on diminishes at each stage, or trophic level.

In a food chain, an animal passes only about 10 percent of the energy it receives. The rest is used up in maintaining its body, or in movement, or it escapes as heat. The amount of available energy

decrease at every trophic level, and each level supports fewer individuals than the one before.

**Food web**

A community of living things may contain hundreds or even thousands of different species. Each species is usually involved in several different food chains. Therefore, different food chains often interconnect or intertwine to form a large network, called a **food web**. Even in a small ecosystem, such as a pond, food webs can be extremely complicated. The different types of organisms with equal or similar feeding, occurring in one same level or occupy same position is known as *trophic level*.

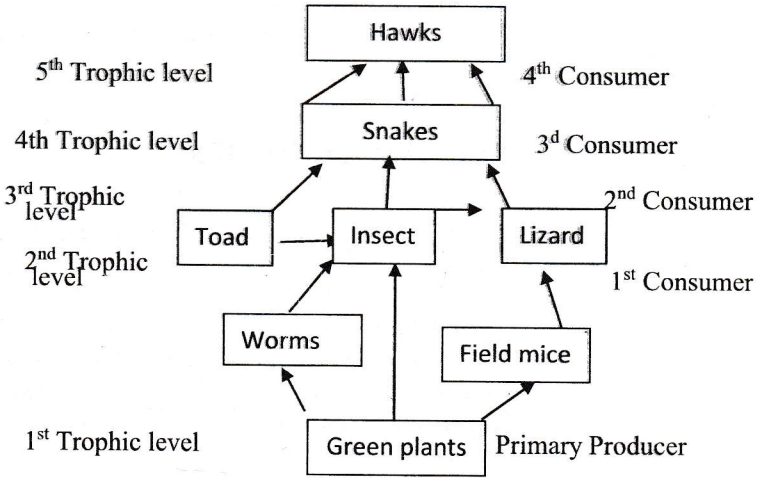



***Figure 2.1: Food web***

**Trophic Level**

In food chain, each species occupies a certain position in the chain. This position is called a trophic level. For example, owls eat mice, so if a food chain contains an owl and a mouse, the owls will be at a higher level. The number of **trophic levels** is the same as the number of species in the food chain. The same species may occupy different trophic levels in different food chains.

**Producer**

A producer is an autotrophy, which means that it can make its own food. Producers form the first trophic level of a food chain, because

they make the food that supports the other species in the chain. Green plants, and some kinds of bacteria, are the most important producers. They harness the sun's energy to make food by photosynthesis. A few species of bacteria make food by chemosynthesis, which uses the energy in chemicals. These organisms (green plants, bacteria) are called **primary producers**, because they produce food to be used by higher trophic levels.

**Consumers**

Consumers are heterotrophs, or living things that cannot make food for themselves. They survive by taking in food that has been made by other living things. A food chain contains several kinds of consumers of which each occupies a different trophic level.

- Primary consumers eat producers,
- Secondary consumers eat primary consumers,
- Tertiary consumer eat secondary consumers, and
- Quaternary consumers eat tertiary consumers.

Therefore, there is a tendency of eating and being eaten by others.

**Decomposers**

Decomposers or saprophytes are vital part of food webs. During the process of decay, they break down the organic compounds in dead remains and release their raw materials, such as carbon dioxide, back into the environment. Bacteria and fungi are the most important decomposers.

**Predator/prey**

A predator is carnivorous. This means, it lives by eating other animals, which are known as its prey. The term predator usually refers to animals that catch and kill. Most predators are larger than their prey; they have special adaptations to help them find and catch their food. These include good vision, a keen sense of smell, or strong legs for rapid movement. Prey also has special adaptations to help them survive the attack of their predators. In the absence of predators, species quickly increases in numbers. Eventually, a shortage of resources forces the population to level out. If a predator is introduced, the numbers of its prey fall. Both populations soon decrease, but in nature, the prey rarely dies out altogether.

**Significance of food chain and food web**

Is the food chain and food web important to our life? How?

- ➢ They facilitate energy flow in the environment.
- ➢ The interdependence of organisms in food chain or food web

helps to maintain the balance of populations of organisms in ecosystem.

*Before Proceeding do the following reflections.*

## Unit Reflection

1. Do you think this unit is important to our life? How?
2. Can you apply the knowledge you obtained in this unit to your surroundings? Where? And how?

## Unit Assignment

*Answer the following questions and put the work in your portfolio:*

1. (a) What do you understand by the term environment?
   (b) Write an account of various human activities which contribute to environmental degradation.
2. Explain how organisms interact amongst themselves and their environment.
   a) Construct a diagram of food web by using the following organisms: grass, shrub, zebra, gazelle, wildebeest, lion, hyena, fungi and bacteria.
   b) From the food web constructed in part (a) above, draw five food chains.
3. Explain the meaning of the following terms and give two examples of each:
   (i) Producers.
   (ii) Consumers.
   (ii) Decomposers.

# Unit 3

# Describing Transportation of Materials in Living Organisms

## Introduction

Dear learner, it is my hope that you enjoyed studying the previous unit on Balance of Nature. Welcome to the next unit which is about "Describing Transportation of Materials in Living Organisms".

In this unit you will learn how different materials are made to reach all parts of the body of an organism. You will learn on the movements of materials in plants including water, mineral salts and food. Movement of food nutrients in animals (human in particular) will also be covered. Please get ready for it.

## Learning Outcomes

Upon completion of this unit you should be able to:

- Describe transport, and mechanism of absorption and movement of water, minerals, salts and produced food in plants
- Describe the components, functions and disorders of the circulatory system in human,
- Identify blood groups and blood transfusion, and
- Explain roles and disorders of lymphatic system in human.

## General Concepts of Transport of Materials

Dear learner, in unit 1 you learnt about nutrition in plants and in animals. In plants, the manufactured food needs either to be used or stored if in excess. It will reach where it is required to go through transportation. In animals such as human beings, the digested food is absorbed in the small intestine (ileum). From the ileum it is again transported to different parts of the body for either use or storage. Wastes also need to be transported out of the body for effective functioning of body cells.

Transportation in organisms is responsible for movement of organic food or inorganic substances from one part of the body to another e.g. nutrients from intestines to the cells or manufactured food in leaves to other parts of a plant, mineral salts from the soil to the leaves and other parts of plant. Transportation in plants is also

known as translocation or conduction. Transportation ensures that cells are supplied with all useful materials like nutrients and water. Non – useful e.g. end products of metabolism are also removed through transport. Unicellular organisms get what they need from their environment across their membranes. Wastes are also excreted through their membranes. The need of medium of transport (e.g. water/blood) is very essential in both unicellular and multicellular organisms.

**Importance of transportation in Living things**

i. To enable adequate supply of respiratory substrate and sufficient oxygen to cells to ensure efficient release of energy for its own purpose.
ii. To transport nutrients from site of intake to a region where they can be synthesized into the requirement of the organism. Example; transportation of water and mineral salts from soil to leaves.
iii. To transport waste products from cells to excretory organs. *Example*, transportation of urea from liver to kidney, transportation of carbon dioxide from respiring cells to lungs.
iv. Transportation of substances (e.g. amino acid and mineral salts) required for building new cells to the region of active cell division.
v. Transportation of synthesized food (e.g. sugar) from leaves to roots for storage.
vi. Transportation of hormones from area of secretion to area of their target organs.

Now, welcome to the discussion on different methods important in transportation of materials in organisms. Be relaxed, and take note for the points you think will be helpful to you for better understanding.

## Diffusion, Osmosis and Mass Flow

Transportation of materials in organisms involves diffusion, osmosis and mass flow in higher multicellular organisms. In unicellular organisms like amoeba, transportation is by diffusion and osmosis.

**a) Diffusion**

Dear learner, before explaining the concept of diffusion do the following experiment and observe what takes place in that experiment.

**Experiment 1: To demonstrate diffusion**

Take a glass of water and pour a drop of fresh milk using tea spoon. What happens to the drop of milk? Give reasons? Can you give the name of this process?

Carefully compare your observation with figure 3.1, the diffusion of potassium permanganate crystal in a container.

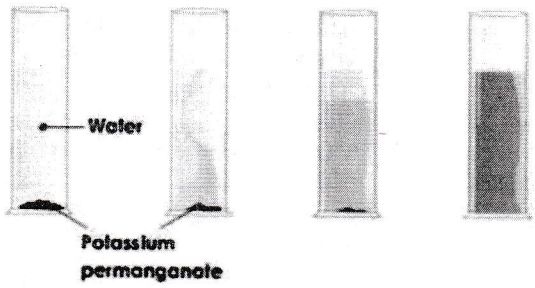



***Figure 3.1: Simple diffusion***

*Dear learner diffusion is a process whereby soluble molecules or ions move freely from where there are high concentrations to where they are low concentration. That is free movement of molecules from high concentration to lower concentration down a concentration gradient.*

If you observe carefully experiment 1 above, when you pour drop of milk in water, you will discover that the particles of milk drop spread freely in the water. This means that those particles of milk were "many" concentrated in the drop and move to where there were no particles. Diffusion takes place in liquids as in above example, in gases e.g. ammonia and in solids e.g. potassium permanganate.

**Factors Affecting the Rate of Diffusion**

The following are the factors affecting the rate of diffusion;

i. ***Concentration gradient:*** this is influenced by the difference in concentration between two regions. Therefore, when there is very big difference in concentration between two regions it maximizes the rate of diffusion.

ii. ***Surface area to volume Ratio:*** when the surface area of the cell increase, the amount of substances diffusing into the cell increases as well. The opposite of this is also true.

iii. ***Diffusion distance:*** when diffusion occurs across the membrane, the thinner the membrane the faster the rate of

diffusion, and the thicker the membrane the lower the rate of diffusion.

**b) Osmosis**

*This is a process whereby solvent molecules i.e. water molecules move across a selective membrane. In other way, osmosis is the movement of water molecules from a region of their high concentration to a region of their low concentration through a selective or semi- permeable membrane.* From this definition, we can say that, there are three types of solution;

- ***Hypotonic solution:*** is the type of solution with lower concentration of solutes than others.
- ***Hypertonic solution:*** is the type of solution with higher concentration of solutes than others.
- ***Isotonic solution:*** this is a solution with same concentration of solutes with another solution.

Now study the diagram in Figure 3.2 where you can learn more about Osmosis.

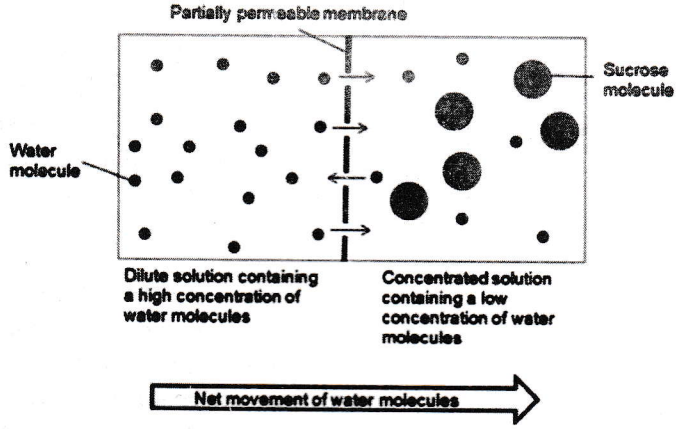



*Figure 3.2: Theoretical explanation of osmosis*

***Note;*** Osmosis takes place mainly in living tissues.

**Experiment 2: To demonstrate osmosis**

*Materials:* Take two large Irish potatoes, knife, salt, water and trough of water or plate.

***Procedures***

- Peel both potatoes.
- Boil one potato and leave another unboiled.
- Cut each into two equal halves.
- Scoop one half of the boiled and unboiled potatoes to make a hole in each half.
- Prepare your trough with water.
- Label your specimen as follows:
  A. Unboiled potato with salt or sugar.
  B. Unboiled potato without salt or sugar.
  C. Boiled potato with salt or sugar.
  D. Boiled potato without salt or sugar.
- Carefully place them in a trough of water.

**Observation**

- Water rises only in A

*Carefully compare your results with those in figure 3.1*

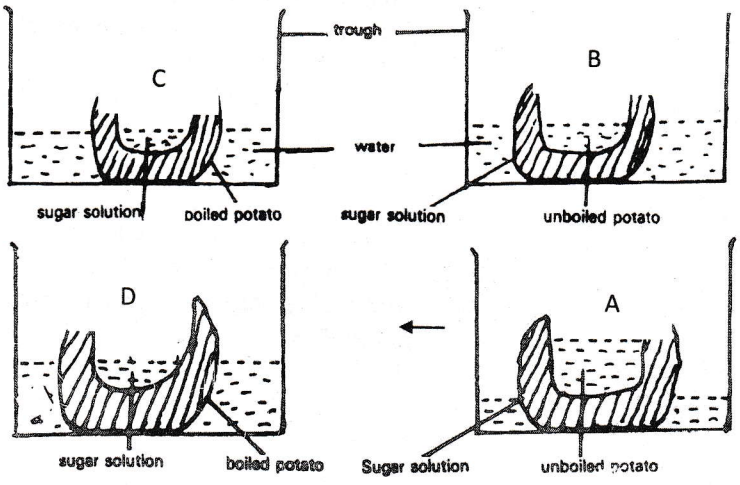



***Figure 3.3: Osmosis in living materials***

**Conclusion**

- Water rises only in A because of differences in concentration and the potato being a living tissue. (C has salt like A but no rise of water because it is not living (boiled).

- The tissues are killed on being boiled (high temperature)
- Therefore osmosis takes place in living tissues.
- Experiment B is a control experiment.

***Control experiment***
This is an experiment containing all conditions necessary except the condition under test.

**Effects of Osmosis in Living Things**

***Osmosis and Anima Cell***
When animal cell is placed in hypotonic solution it tends to absorb water. Therefore, if the cell will be left in that solution for a long time, it will absorb excess water to the extent of bursting, the process called ***Haemolysis.*** The bursting is because the animal cell has mechanism of removing excess water and it has no cell wall protecting its cell.

In other way, when an animal cell is placed in hypertonic solution it tends to loose water from its cell. If the cell will be left for long time, it will lose a lot of water and shrink a process called ***Crenation.***

***Osmosis and Plant Cell***
When a plant cell is placed in hypotonic solution it tends to absorb water. Therefore, if the cell will be left in that solution for a long time, it will absorb excess water and become turgid, the process called ***Turgidity.*** Bursting do not occur in plants cells because of the presence of cell wall which is stiff and rigid to prevent bursting.

Again, when the plant cell is placed in hypertonic solution it tends to loose water from its cell. If the cell will be left for long time, it will lose a lot of water and become flaccid, a process called ***Plasmolysis.***

*Turgidity*

**Experiment 3: To Demonstrate Turgidity and Flaccidity of the Cell**

Take 2 small pieces of about 2cm of a stalk of a young bean seedling, 2 plates, water and salt at home.

Do the following:

- Dissolve salt in one plate,
- Label specimens as;
  A. Plate without salt
  B. Plate with salt
- Cut about a ¼ of a bean stalks at one ends
- Carefully put the stalks in each plate
- Observe the results after one hour what happens in those specimens? Can you give reasons? Explain what are the roles of these material movements?

*Compare your observation with the diagrams in Figure 3.4.*

When a cell is placed into a solution of lower concentration of water than its cell sap, water moves into the cell until the cell can no longer absorb any more water. The cell is said to be full or *turgid*. Turgidity is a condition where a cell cannot absorb any more water from its surrounding.

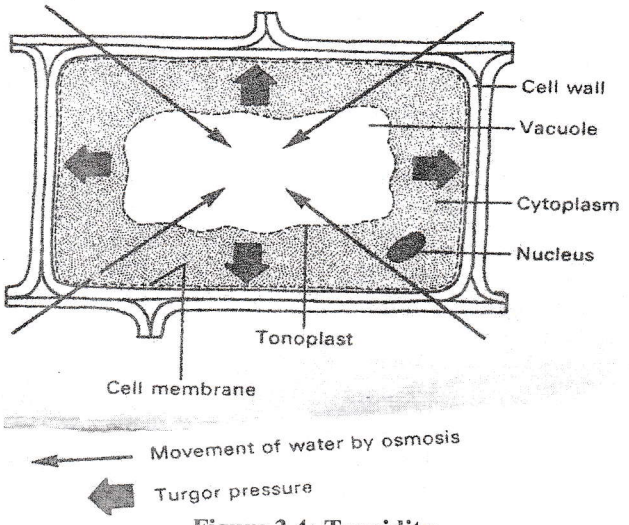
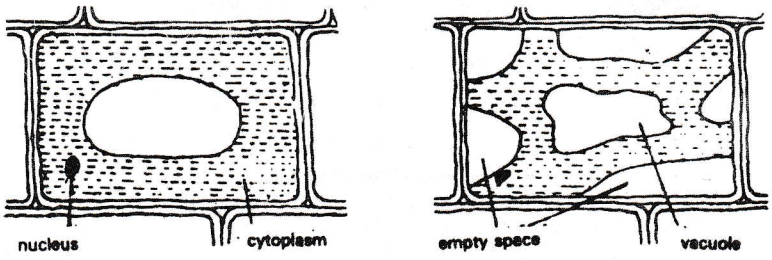



**Figure 3.4: Turgidity**

*Plasmolysis*

When a cell is placed into a solution of higher concentration than its cell sap, water will move from the cell into the solution. The cell

membrane will collapse and the cell becomes limp. This state is known as *plasmolysis*. Plasmolysis is the loss of water by cells to the surroundings. See Figure 3.5.




**(a) Before plasmolyis** **(b) After plasmolysis**

***Figure 3.5: A plant cell showing plasmolysis process***

***Osmosis in Unicellular Organisms***

Small aquatic organisms like amoeba and euglena have the challenge of gaining water from their environment because of having hypertonic cells. These organisms have contractile vacuole which enables them to remove excess water from their cell, hence prevent bursting.

**c) Mass Flow**

*Mass flow is the movement of fluids within a cell or along a vessel or tube without passing through a membrane.*

In larger organisms the speed at which materials are transported around the body by osmosis and diffusion is very low compared to materials that are needed. This is why mass flow is very important in large organism because it facilitates the speed of transportation of large quantities of materials which travel at greater distances.

In many animals mass flow is demonstrated in their circulatory and lymphatic systems. Food and gases are transported by mass flow through vessels from the region of entry to the point where they are absorbed by the cells. In plants, mass flow is responsible for the transport of water and mineral salts. These travel from the roots through the stem and the branches to the leaves in xylem vessels.

**Table 3.1: Differences between Diffusion, Osmosis and Mass Flow**

| Characteristics | Diffusion | Osmosis | Mass flow |
|---|---|---|---|
| Materials transported. | Gas and liquid. | Water. | Solids, liquids and gases. |
| Transportation medium. | None. | Semi permeable membrane. | Vessels or cytoplasm. |
| Cause of movement. | Diffusion gradient. | Osmotic pressure. | Pressure differences. |

***Application of Diffusion, Osmosis and Mass Flow in Living Things***

These processes enable materials to be transported from one part of the body to another and between cells. They enable the following;

i. Gaseous exchange in lungs of animals and leaves of plants.
ii. Absorption of digested food in the stomach, and intestine.
iii. Excretion, removal of water materials from the cell.
iv. Absorption of nutrients and water by plant roots.
v. Transportation of materials in in circulatory system and digestive system.

## Transportation of Materials in Animals

Dear learner, this section deals with how materials are transported in living organisms particularly human being.

### The Mammalian Heart

Dear learner I hope you have come across a slaughtered bird like hen or duck in your life. Did you observe the internal organs including the heart? How does that heart look like? Obviously, if you really observed it critically you might found that the heart of that bird looks like that displayed in figure 3.6. Is it true?

Dear learner, the structure of a bird is similar to that of other mammals including you. For more details about human heart join our discussion that follow. We are starting by observing critically figure 3.6

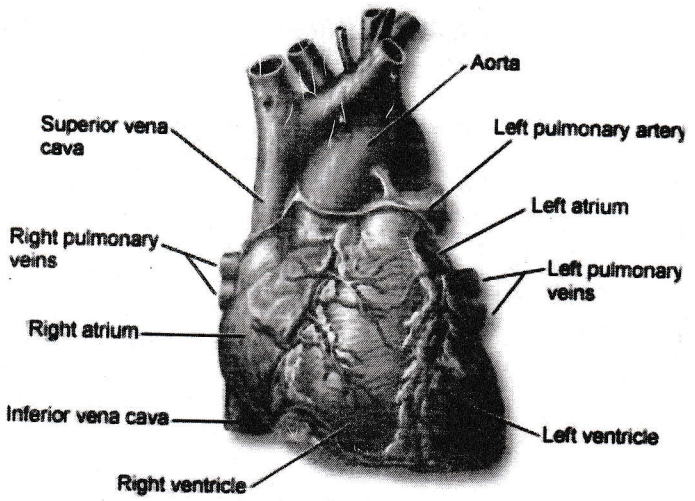



*Figure 3.6: External structure of the human heart*

In the human body the heart is situated slightly to the left of the middle of the thorax behind the breastbone (**sternum**). It is enclosed by a sac known as the pericardium and is surrounded by the lungs. It has the same size with someone's clenched fist. It consists of four chambers, the two upper ***atria*** and the two lower ***ventricles***.

A thick muscular wall (**septum**) divides the right atria and right ventricle from the left atria and left ventricle preventing oxygenated blood from mixing with deoxygenated blood. Valves between the atria and ventricles maintain coordinated unidirectional flow of blood from the upper atria to the lower ventricles. The ventricles are the parts of the heart that pump blood to the whole body or to the lungs. They have thicker walls than the atria, and the contraction of the ventricle wall is much more important to move blood to the whole body.

*The heart is the muscular pumping organ made up of cardiac muscles, a specialized tissue which is capable of rhythmical contraction and relaxation over a long period without becoming fatigue.* The muscle is richly supplied with blood vessels and also contains connective tissue which gives strength and helps to prevent muscle tearing.

The mammalian heart is made up of two thin walled **atria** (auricles) which are elastic and distend as blood enters them. The left atrium

receives oxygenated blood from the pulmonary vein while the right atrium receives deoxygenated blood from the vena cava.

When full, the atria contract together, forcing the blood in them into their respective **ventricles**. The right ventricle then pumps blood to the lungs for oxygenation. Since there is a shorter distance between the lungs and the heart, the right ventricle does not need much force to pump the blood hence has less muscular wall than the left ventricle which pumps blood to all parts of the body.

To prevent backflow of blood into the atria, the ventricles have valves between the atria and ventricles. On the right side of the heart, these comprise three cup-shaped flaps called **tricuspid valves.** On the left side of the heart, only two cup- shaped flaps are present and these are called **bicuspid valves.**

Blood leaving the ventricle is prevented from returning by the pocket valves present in the **aorta, (***Semi lunar valves/pulmonary valves***)** and the **pulmonary artery** which closes when the ventricles relax.

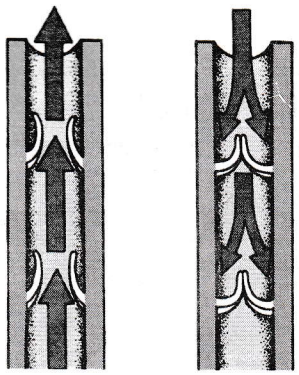



***Figure 3.7: Action of valves in a vein***

Lower your left arm for 3 seconds to make the blood vessels prominent. Using your left hand finger, press the vessels towards the palm of the lowered hand. Note the swellings of the blood vessel. Repeat the exercise in a reverse direction. What has happened? And why did it happen?

Dear learner, the palm swelling occurred when the blood vessel was pressed towards it. Pressing the blood vessel towards palm of the lowered hand resulted into swelling. The swelling indicates presence of valves in the blood vessel.

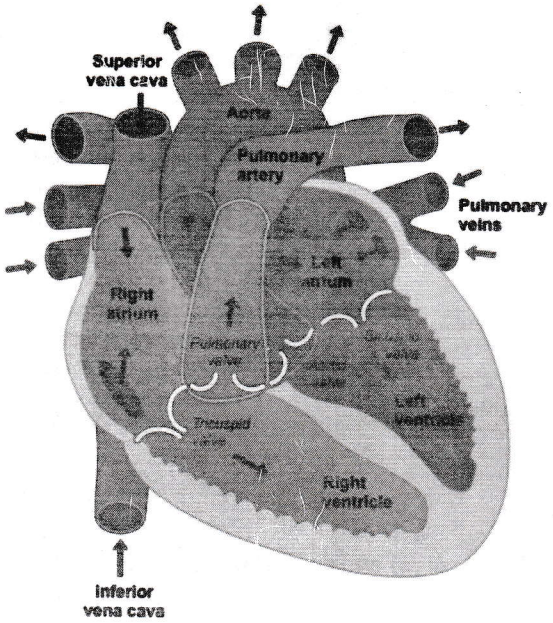



*Figure 3.8: The internal structure of the human heart*

**Table 3.2: Adaptations of the Heart to its Functions**

| Adaptive features | Function |
|---|---|
| i. Have muscular walls | Contract to pump blood |
| ii. Have cardiac muscles | Contract and relax continuously to pump blood as they cannot fatigue. |
| iii. Valves | Ensure unidirectional flow of blood/Prevent backflow of blood. |
| iv. Septum | Separates oxygenated from deoxygenated blood in the two sides of the heart |
| v. It is connected with large blood vessels | Helps in transporting oxygenated blood from the heart to all parts of the body and transporting deoxygenated blood from all parts of the body to the heart. |
| vi. Sino atrial node | Determine time and rate of contraction of cardiac muscles |
| vii. Coronary artery and Coronary vein | Coronary artery supply oxygenated blood to the heart muscles while Coronary vein carry deoxygenated blood away from the heart muscles. |

**Blood Vessels**

Most blood vessels are tubular of varying size from 1cm to 0.001 mm in diameter. They always carry blood in one direction only. Mammals have main three types of blood vessels; arteries, veins and capillaries.

**a) Arteries**

***Features of arteries***

i. Have thick-elastic walls. They are fairly wide but the cavity in which the blood passes is narrow. Arteries are branched into arterioles which finally end up in capillaries which are very small.
ii. With exception of pulmonary artery, all arteries carry oxygenated blood.
iii. They carry blood away from the heart.
iv. Arteries are situated deeper in the body.
v. Arteries are pink in colour.
vi. Have no valves.
vii. Have small lumen.

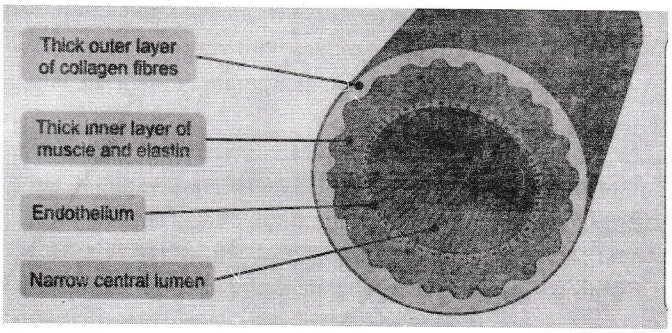



*Figure 3.9: An artery*

**b) Capillaries**

These are tiny vessels of only one cell thick. Because of this thinness, they have small pores in which some fluid can squeeze out. Also some white cells squeeze out of the capillaries. Most of squeezed out substances return to the blood. Blood in capillaries is at very high pressure at the junction of arteriole. Fluid squeezed out is tissue fluid.

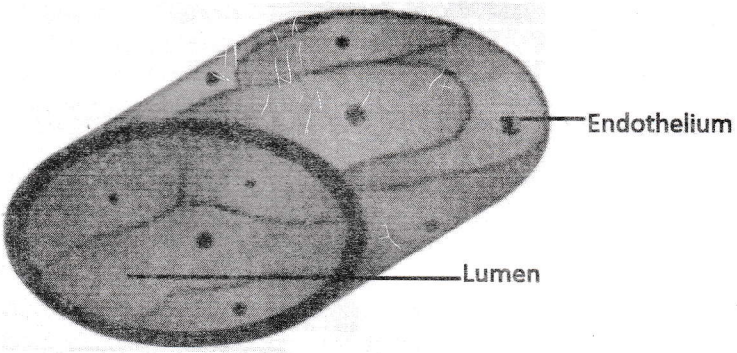



*Figure 3.10: Structure of the capillary*

**c) Veins**

These are less muscular. They carry blood from capillary and carry it back to the heart.

- They carry blood towards the heart/away from the body
- All carry deoxygenated blood except pulmonary vein.
- They are reddish in colour
- They are more superficially situated
- Most veins have valves to prevent back flow as blood in them moves with very low pressure
- Have large lumen.

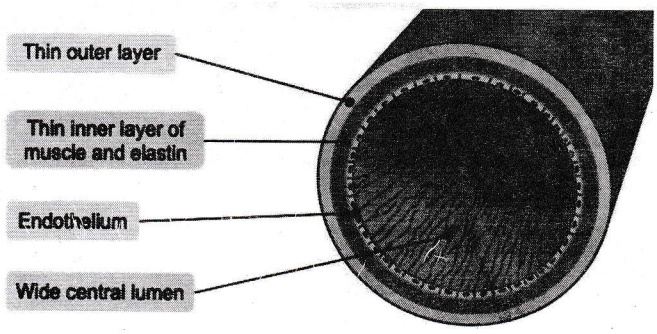



*Figure 3.11: The structure of the vein*

Dear learner, before you proceed further, do the following activity.

1. What are the functions of arteries, capillaries and veins?
2. Give at least four differences between arteries and veins.

## The blood

Blood is a tissue which is a medium of transportation in most animals. Blood consists of blood cells in an aqueous solution. It is a tissue which connects all parts of the body. Human body contains about 5.5 litres of blood.

**Blood Components**

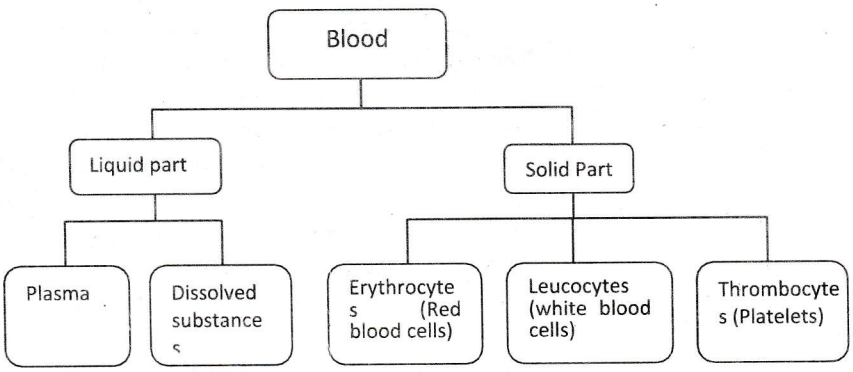



***Figure 3.12: Blood components***

Let us now discuss the components of the blood in details.

**a) Erythrocytes [Red Blood Cells]**

These are minute biconcave discs with spongy cytoplasm in an elastic membrane. They have no nucleus. They contain red pigment called haemoglobin which is used to transport oxygen. They are manufactured in the red bone marrow of short bones i.e. in the ribs and vertebrae. Haemoglobin is a protein with iron.

Erythrocytes have life span of about four months after which they break down or decompose in the liver and spleen. Bulky irons are stored in these organs, especially the spleen. Bile is also produced during the decomposition of these red blood cells.

**Functions of Erythrocytes:**

*1.* **Oxygen transportation**

At high concentration of oxygen in the lungs, the haemoglobin combines with oxygen to form an unstable compound, the *oxyhaemoglobin* is released to body parts where there is low concentration of oxygen e.g. muscles.

$Hb + O_2 \longrightarrow$ HbO unstable compound

HbO + Muscles $\longrightarrow$ muscle Hb + $O_2$ from the muscle, oxygen is released and captured by cells

*N. B Lack of iron results in anaemia*

***2. Transportation of Carbon dioxide***

At high concentration of carbon dioxide in the body muscles, the haemoglobin combines with carbon dioxide to form an unstable compound, the *carbaminohaemoglobin* is released in the lungs where there is high concentration of oxygen.

***NB;*** *carbon monoxide is a poisonous gas produced from burning charcoal and car exhausts. When inhaled, the red blood cells combine faster with it than oxygen. At higher level, carbon monoxide crowds out oxygen. This in turn, cause damage of tissues and organs such as brain, hence, it may lead to death.*

**Leucocytes [White Blood Cells]**

These are very few compared to red cells. To every 6000 red blood cells there is only one white blood cell. They are manufactured in the white bone marrow found in long bones. Also lymph nodes manufacture white blood cells. White blood cells have nucleus.

*There are two types of white blood cells:*

**Phagocytes:** These are non-granular and with non-lobed nucleus. E.g. Monocytes are phagocytic and ingest bacteria therefore defends the body.

**Lymphocytes** They contain lobed nucleus and granular cytoplasm. They produce ant toxins/ ant poison and antibodies for body defence. All together they defend the body.

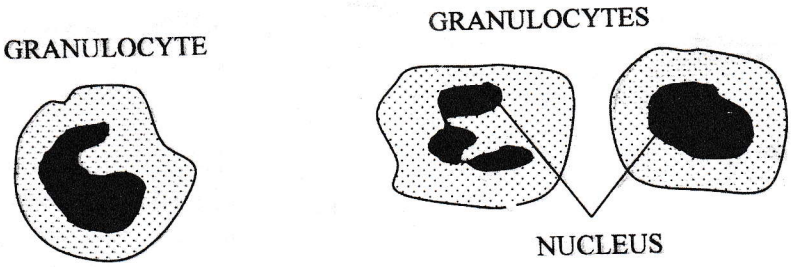



**Figure 3.12: White blood cells**

**Effect of HIV on white blood cells**

Dear learner, it is clear now you are aware about HIV which causes AIDS. Where do these viruses live in human body?

Dear learner, the Human Immunodeficiency virus (HIV) once entering in the body of a human being affects the immune system. It replicates in a particular type of white blood cell called T4 cells. The virus destroys these cells.

The T4 cells also are called helper T cells because they help other T cells called killer T cell which fights against 'invaders' (pathogens) such as bacteria. Losing T4 cell means that an individual's immune system breaks down and the person become weak and vulnerable to a variety of diseases.

**b) Thrombocytes or blood platelets**

Have you ever cut yourself with a knife, razor blade, bush knife or any other sharp object? What happened after sometimes? Does the blood get out?

Platelets are tiny irregular, square or star-shaped structures which are non-nucleated. They are formed in red bone marrow. They are found in mammals only.

***Function***

Platelets promote blood clotting by producing a factor *"thromboplastins"* which convert soluble protein fibrinogen into insoluble fibrin which form a mash over a cut open vessel.

**Mechanism of blood clotting**

When a vessel is cut open, the wall of the vessel produces enzyme **thrombokinase** which together with thromboplastins produce a factor which converts unreactive proteins prothrombin and

fibrinogen into reactive thrombin and fibrin. These form an insoluble mash fibrin. In the presence of Ca+ ions, this mash is cemented and form hard red scabs which completely prevent bleeding.

Vitamin K is very important for effective process. It initiates the process to take place or produces suitable environment. Failure of blood to clot results in haemophilic diseases, where the individual bleeds continuously, finally will lead to death.

**c) Plasma**

Plasma is the liquid part of blood which is 90% water. The remaining part is of dissolved and suspended substances. Most important compounds are sodium chloride, sodium bicarbonate, glucose, amino acids and proteins including albumin, fibrinogen, and the globulin, antibodies, hormones, urea and other nitrogenous compounds.

The compositions of plasma are very precise and are regulated by the liver and kidney so that within a very narrow limits, the living cells are soaked in a liquid of unvarying composition.

*Is blood important to our life?*

Let us now explain about the functions of blood in our bodies.

## The circulatory system

Dear learner, the human circulatory system consists of the heart which acts as a pump, and the blood vessels in which the blood flows. Arteries carry blood away from the heart. Veins carry blood towards the heart. Capillaries are very thin vessels and form the interface between arteries and veins. They are the actual sites of exchange of oxygen and nutrients between the blood and body fluid. The human circulatory system is a **double circulatory system**.

**The Double Circulation System in Humans**

Double circulation refers to the process whereby blood flows twice through the heart before being taken to other body parts. The "double circulation" system of blood flow in the human body is divided into ***the pulmonary circulation and the systemic circulation.***

**(i) Pulmonary circulation**

The right ventricle pumps deoxygenated blood into the pulmonary arteries. These arteries bring the blood to the lungs, where it passes through a capillary network close to air-filled alveoli. This enables the release of carbon dioxide and the acquisition of oxygen from the air. The oxygenated blood returns to the left atrium of the heart via the pulmonary veins.

**(ii) Systemic circulation**

From the left atrium the blood moves to the left ventricle, which pumps it into the **aorta.** Aorta distributes the blood to all parts of the body. The progressively thinner arteries ends in capillary beds, where nutrients and oxygen are exchanged with the surrounding tissues. The capillaries turn into veins which return the deoxygenated blood to the right atrium of the heart through the **superior and inferior vena cava.** From there the blood moves into the right ventricle and pulmonary circulation is resumed. See Figure 3.14.

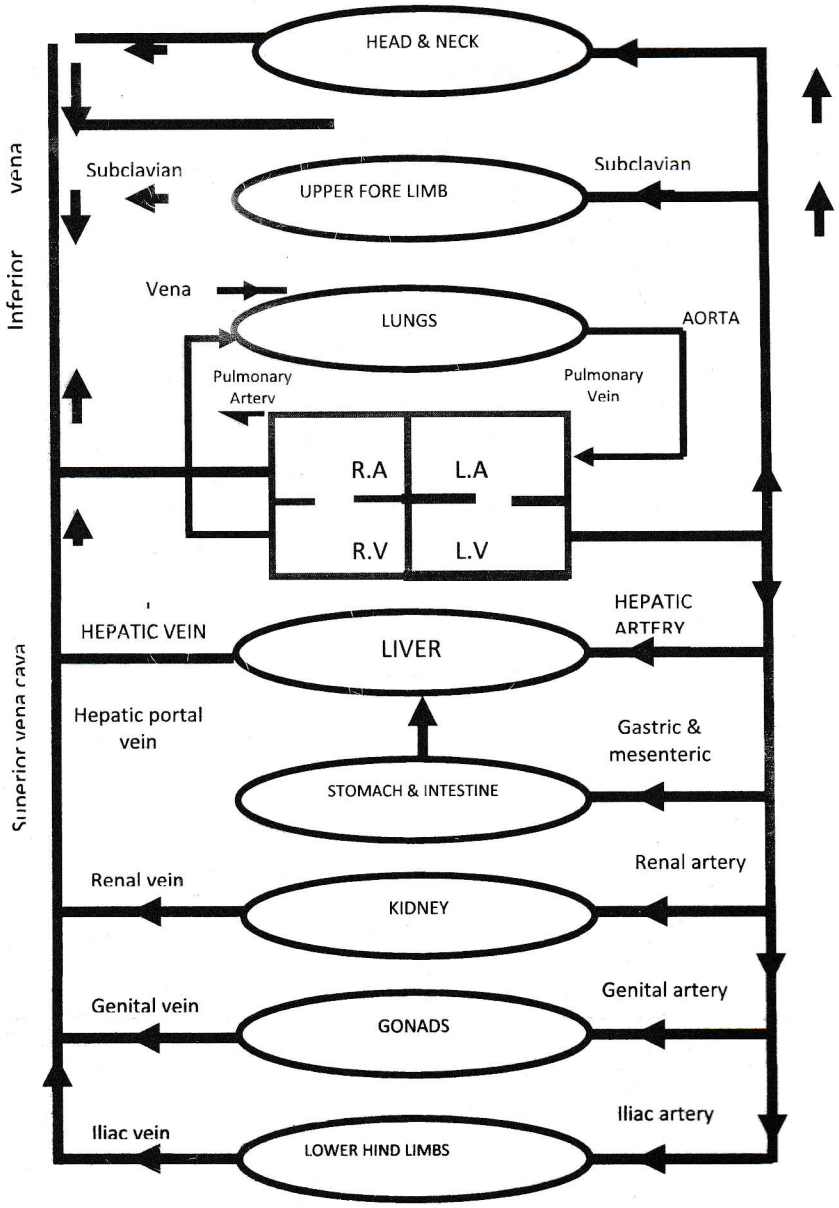



**Figure 3.14: General plan of the mammalian circulatory system**

## The Heart Beat

Dear learner, every beat of the heart involves a sequence of events called the ***cardiac cycle.*** This consists of three major stages: the ***atrial systole***, the ***ventricular systole***, and the ***complete cardiac diastole.***

The atrial systole consists of the contraction of the atria and the corresponding influx of blood into the ventricles. Once the blood has fully left the atria, the ***atrioventricular valves***, which are situated between the atria and ventricular chambers close. This prevents any backflow into the atria. It is the sound of the valves closing which produces the familiar beating sounds of the heart.

The ventricular systole consists of the contraction of the ventricles and flow of blood into the ***circulatory system.*** Again, once all the blood has left, the *pulmonary* and *aortic semilunar valves* close. Finally complete cardiac **diastole** involves the relaxation of the atria and ventricles in preparation for new blood to enter the heart.

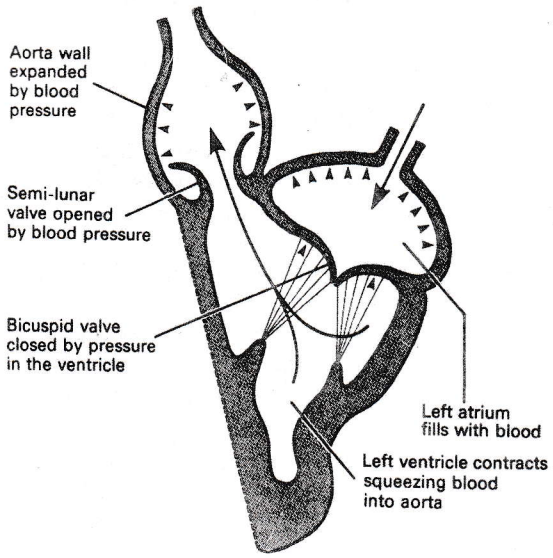



*Figure 3.15: A ventricle contracts (systole)*

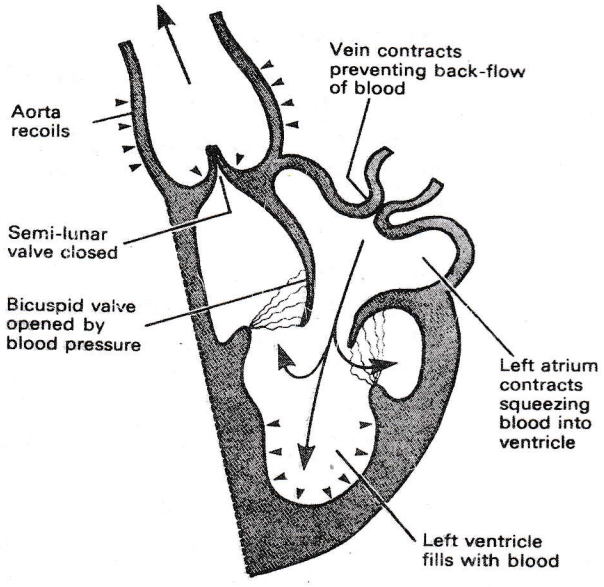



*Figure 3.16: Ventricle relaxes (diastole)*

**Importance of Blood Circulation System**

Dear learner, the aim of blood circulation is to ensure that cells are supplied with fresh oxygen and food immediately as required, and that there is no accumulation of end products of body metabolism especially those which are poisonous e.g. carbon dioxide and nitrogenous wastes. Generally, the blood circulation has the following functions:

i. Transportation of oxygen to body cells and carbon dioxide to the lungs.
ii. Formation of clot (blood clotting).
iii. Prevention of infection.
iv. Transportation of nitrogenous wastes from liver to kidney for excretion.
v. Distribution of hormones.
vi. Distribution of heat and temperature control.
vii. Transportation of digested food together with mineral salts.

**Diseases and disorders of the circulatory system**

Dear learner, I believe you are now aware about circulatory system. Circulatory system might not function well, if it is affected by diseases.

The following are disorders and diseases of circulatory system:

**1. High blood pressure (hypertension)**

Blood pressure (BP) is measured by taking two readings and recording them as fraction. The upper figure represents the pressure of blood created by the contraction of the left ventricle.

The lower figure (the diastolic pressure) represents the pressure of blood when the left ventricle relaxes. It is usually measured in mm Hg (Mercury). The normal blood pressure of a health body is 120/80 mmHg.

High blood pressure is caused by the following:-

i. ***Over eating:*** which cause fatty deposits of cholesterol to build up inside blood vessels. This leads to narrowing of the blood vessels which restrict the normal flow of blood.

ii. ***Stress:*** this is caused by increased rate of heartbeat which results in more blood being pumped from the heart, hence high blood pressure.

***Symptoms of High Blood Pressure***

i. Feeling dizzy.
ii. Noises in the ear.
iii. Severe headache.

***Effects of high blood pressure***

High blood pressure may cause the bursting of blood vessels. The bursting of blood vessels may happen to the vital organs such as brain.

***Prevention and Control***

i. High blood pressure can be treated by medication
ii. Doing physical exercise
iii. Minimizing fat in diets
i. Maintaining recommended body weight
ii. Reduce stress.

**2. Leukaemia**

Have you ever seen a person with Leukaemia? What are the observable symptoms shown by such a person? Compare your answers with the information given.

Leukaemia is a condition resulting in over production of any one type of white blood cell that cause the suppression of the production of other blood cells.

The excessive amounts of white blood cells produced infiltrated various organs such as the spleen and the liver, causing a reduction in the function and efficiency of these organs. This infiltration also caused the enlargement of the liver and the spleen.

**Here are some of the symptoms of Leukaemia:**

i. A tendency to bleed easily.
ii. Higher contents of white blood cells in blood sample.
iii. Extreme weakness.
iv. Anaemia due to lack of red blood cells.
v. Infections of the mouth or throat accompanied by fever.

***Prevention and Control***

Leukaemia is a type of blood cancer so it is difficult to control. A patient suffering from leukaemia need frequent blood transfusions. It can be treated with radiotherapy and chemotherapy to destroy the abnormal cell.

**3. Sickle-cell anaemia**

The term anaemia refers to condition in which the amount of haemoglobin or the number of red blood cell in a specific volume of blood is below normal.

What factors do you think can cause reduction in the number of red blood cells or a reduction in the amount of haemoglobin in the red cells? Several factors can cause red blood cell reduction or reduction in the amount of haemoglobin, which are:-

i. Lack of iron.
ii. Hookworm infection.
iii. Destruction of red blood cells by the malaria parasite (plasmodium).

***Symptoms of Sickle-cell anaemia***

i. Muscle fatigue.
ii. Shortness of breath during physical exercise.
iii. Headache.
iv. Abdominal pain.
v. Dark coloured urine.

***Effect of Sickle-cell anaemia***

Reduction in the oxygen carrying capacity of the blood.

Sickle-cell anaemia is a genetic disorder which results in the production of abnormal haemoglobin and the shape of the red blood cells becoming distorted to sickle shaped/half moon.
Sickle cell anaemia is an inherited disorder and it is difficult to control. People carrying the defective gene should be advised not to have children to avoid the risk of passing these hereditary material.

**4. Arteriosclerosis**

This is the stiffness/rigidity of the arteries due to the deposition of fats around the walls of arteries causing a decrease in size of lumen of arteries. This results into difficulties in blood circulation leading to *hypertension.*

***Causes of Arteriosclerosis***

i. Too much alcohol consumption.
ii. Smoking.
iii. Excessive intake of fats in diets.
iv. Lack of physical exercise.
v. Old age.

***Symptoms of Arteriosclerosis***

i. Feeling dizzy.
ii. Noises in the ear.
iii. Severe headache.

***Effects of Arteriosclerosis***

i. Inflammation in the blood vessels.
ii. Blockage of the lumen of artery.

**The blood pressure**

Blood moves through the arteries, arterioles, and capillaries because of the force created by the contraction of the ventricles.

***Blood pressure in the arteries***

The surge of blood that occurs at each contraction is transmitted through the elastic walls of the entire arterial system where it can be detected as the **pulse**. Even during the brief interval when the heart is relaxed called **diastole,** there is still pressure in the arteries. When the heart contracts called **systole,** the pressure increases.

Blood pressure is expressed in two numbers, example, $\frac{120}{80}$, the denominator is the pressure during systole while the numerator is the pressure at diastole.

The unit of measurement is the **torr**, in this example, the pressure is equivalent to that produced by a column of mercury 120 mm high.

Although blood pressure can vary greatly in an individual, continual high pressure especially diastolic pressure may be the symptom or cause of a variety of illness. The medical term for high blood pressure is **hypertension**.

Visit any nearby dispensary, measure and record your blood pressure in your diary for one week. Then, ask your nurse or doctor if your BP is normal or not; the name of BP machine: and how variation of BP is formed and the signs of high and low BP. Remember to write the points and put in your portfolio.

**Blood Groups and Blood Transfusion**

Dear learner, do you know your blood group? What is your blood group? If you don't know your blood group make sure you test it. This section illustrates the types of blood groups and blood transfusion.

Blood groups are genetic, like the colour of a person's eyes. There are four major blood groups: A, B, AB and O.

Blood groups are based on red blood cell antigens, which are proteins on the cell surface that are recognized by a person's immune system. If an antigen is identified as "non-self" by the immune system, the cell is targeted for destruction by antibodies.

Group A has one type of antigen (A), Group B has a different type (B), Group AB has both A and B antigens, and Group O does not have either antigen.

These blood groups are further divided by whether or not an antigen called the Rh factor is present on the person's blood cells. If it is present, that person's blood is Rh positive (+); if not, the blood is Rh negative (-). Combining Rh factor with the four major blood types results in eight different main blood types (for example, AB-). In addition, there are minor blood groups.

An individual of a certain blood type will develop antibodies against the antigens that they don't have. For example, a Blood Group A individual has no B antigens on their red blood cells; therefore, this person's white blood cells will make antibodies against the B antigen (anti-B) that will be present in their plasma

As we have seen, blood groups are formed as a result of combination of an antigen found in cells and antibody in the plasma. There are two antigens namely; antigen A and antigen B. Also there are two antibodies (agglutinin) namely **a** and **b.** For a blood group to be formed, there must be a pairing between antigens and antibodies in order to avoid agglutination to occur. See Table 3.3.

**Table 3.3: Blood groups**

| Blood Group | Antigens on RBCs | Antibodies in Serum |
|---|---|---|
| A | A | b |
| B | B | a |
| AB | A and B | Neither |
| O | Neither | a and b |

**Blood Transfusion**

This is the art of giving blood to a person in demand (Recipient) i.e. sick person. The person who gives blood is called the donor. In transfusion donors antigen(s) are considered most important so as to avoid reactions with antibodies of the recipient.

**Table 3.4: Simple Blood Transfusion Recipient's blood group**

| Donor's blood group | A | B | AB | O |
|---|---|---|---|---|
| A | √ | X | √ | X |
| B | X | √ | √ | X |
| AB | X | X | √ | X |
| O | √ | √ | √ | √ |

Note:

- √ transfusion possible
- X transfusion impossible

A person with Blood group O can donate blood to all other blood groups. Blood group is called *universal donor*. While a person

with Blood group AB can receive blood from all other blood groups. So blood group AB termed as *universal recipient.*

During blood transfusion, it has been found that not necessarily a person with group A can give blood to group A person and person with blood group B can donate blood to a person with blood group B because agglutination. Agglutination may occur even if groups are the same because of the presence of Rhesus factors (Rh factors). The person may have either positive Rhesus factor or negative Rhesus factor and not both. Therefore there is blood group $A^+$ & $A^-$, $B^+$ & $B^-$, $AB^+$ & $AB^-$, $O^+$ and $O^-$

***Rh factor in Marriages***

Rh factor has effect on marriage especially when father is $Rh^+$ and mother $Rh^-$. If the foetus inherits father's blood, mother's blood will fight antigen D. Couples of this type may have only one child but the successive pregnancies will be destroyed by the already produced antibodies in the mothers' blood. To prevent this, the mother is injected with anti-Rh antibodies after her first delivery.

**Advantages of blood transfusion**

i. It saves the life of the sick people
ii. Used to treat diseases such as sickle cell anaemia

**Disadvantage of blood transfusion**

i. If the blood is not properly screened it may cause death (due to agglutination) or transmission of diseases (AIDS, Hepatitis B)
ii. There is no exact match of blood due to difference in chemical constituents

Therefore there is a need to be very careful when transfusing blood to the recipient.

**Precautions to be taken during Blood Transfusion**

i. Check the compatibility between donor's blood and recipient's blood
ii. The blood must be screened thoroughly before transfused
iii. The blood to be transfused must be treated by anticoagulant and stored in special bag
iv. Check for expiring date because maximum day for blood to stored is twenty one days
v. Must be done only when necessary.

## The Lymphatic System

The lymphatic system consists of widely distributed lymph capillaries which are found in all tissues of the body. These capillaries merge to form lymph vessels which possess valves and whose structure is similar to that of veins. The fluid within these vessels (lymph) is therefore carried in one direction only namely away from the tissues. The lymph vessels from the right side of the head and thorax and the right arm combine to for the **right lymphatic duct,** which drain into the right subclavian vein near the heart. The lymph vessels from the rest of the body form the thoracic duct which drains into the left subclavian vein.

Along the lymph vessels are series of **lymph nodes**. These contain a population of phagocytic cells, e.g. Lymphocytes which remove bacteria and other foreign material from the lymph. During infection, these nodes frequently swell. Lymph nodes are the site of lymphocyte production.

The movement of lymph through the lymphatic system is achieved in three ways:

- ***Hydrostatic pressure;*** the pressure of tissue fluid leaving the arterioles helps push the lymph along the lymph system.

- ***Muscle contraction;*** the contraction of skeletal muscles compresses the lymph vessels, exerting pressure on the lymph within them. The valves in the vessel ensure that this pressure pushes the lymph in the direction of the heart.

- ***Inspiratory movements;*** on breathing in, pressure in the thorax is decreased. This helps to draw lymph towards the vessels in the thorax.

### Lymph

***Lymph*** is a milky liquid derived from the tissue fluid. It contains lymphocytes and rich in fats obtained from the lacteals of the small intestine. These fats might damage red blood cells and so are carried separately, until they are later added to the general circulation in safe quantities.

Fluid which diffuses out of blood capillaries and enter spaces between cells nourishes body cells. It lacks blood protein but rich in

white blood cells. It is carried in the body through lymphatic system. Lymph returns to the blood system through left subclavian vein near the heart.

**Importance of the lymphatic system**

i. Lymph nodes in the lymphatic system lymphocytes which assist the body to fight against disease
ii. Facilitate fat absorption in lacteal after digestion
iii. It is a means of returning tissue fluids into circulatory system

**Disorders of the lymphatic system**

Several factors may upset the normal formation and flow of lymph. The following are disorders of lymphatic system:

**1. Oedema**

The lymphatic system may be able to handle the increased lymph production successfully. As a result lymph accumulates on the tissue. This condition is known as Oedema. Oedema of this type can be controlled by reducing the blood pressure, either by dieting or by medication.

**2. Elephantiasis**

This disease is caused by filarial worms which block the lymph vessels causing accumulation of lymph resulting into swelling of the arms and legs. The worms are transmitted by a mosquito known as culex from infecting person to uninfected person.

If a person is infected with filarial worms, some of the lymph vessels will be blocked by the parasites. As a result of the blockage, the lymph vessels will be damaged and drainage becomes inefficient. This may cause the legs or aims to become enlarged by oedema, the condition known as elephantiasis.

***Preventive measures***

Destroying breeding sites of mosquitoes

**3. Lymphoma**

This is a cancer of lymphatic system which attack the lymph nodes which are used to secrete against infections in the body. Lymphoma can also affect spleen, thymus gland and bone marrows.

***Symptoms***

i. Inflammation of lymph nodes.
ii. Tiredness in muscles.
iii. Fever and severe weight loss.
iv. Itching.

***Treatment***

i. Use chemotherapy or radiations.
ii. Bone marrow transplant.

**4. Tonsillitis**

This is a bacterial or viral disease that cause swelling or inflammation of tonsils.

***Symptoms of Tonsillitis***

i. Tonsils become red and swollen.
ii. Sores in throat.
iii. Chill and muscle ache.

***Treatment of Tonsillitis***

i. Take enough fluids.
ii. Have enough rest.
iii. Medical treatment in case of severe illness.

## Transportation of Materials in Plants

*How do you think the transport of water and mineral salts in plants is possible?*

Dear learner, can you tell how plants make their own food? Can you suggest the way food from leaves and water from the soil is carried to different parts?

Plants require water and mineral salts for their metabolic processes like photosynthesis. They absorb water and mineral salts from the soil through their root hairs, and transport them in a mass flow to the leaves. Plants also transport manufactured foods in a mass flow from the leaves to different parts of the plant e.g. storage organs. Plants have developed a vascular tissue for the transportation of these substances.

### The vascular Tissues

Think about plants, what are the structures that help plants to carry food, water and minerals?

The vascular tissues are the transporting tissue in plants. They are made up of **xylem** and **phloem.**

Xylem vessels transport water and dissolved mineral salts through the plant from the roots to the leaves (an upward mass flow movement). **Phloem** transports manufactured food from area of synthesis to other parts of the plants for storage or utilization

**Vascular bundles in monocots and dicots**

Collect the monocot and dicot roots, stems, leaves and flowers from your surroundings. With a razor blade cut the transverse section of the stems and root and observe the arrangement of vascular bundles under the light microscope. Then compare your observations with the diagrams in figure 3.17, 3.18, 3.19 and 3.20.

**Arrangement and distribution of vascular tissue in monocotyledon and dicotyledon plants**

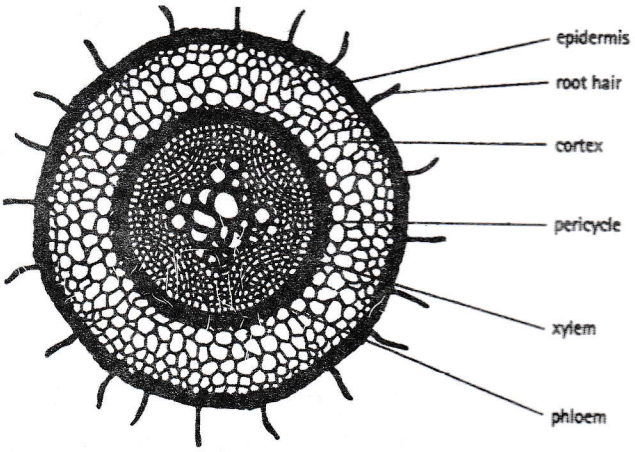



*Figure 3.17: Diagram of dicot root in transverse section*

**The piliferous layer ( epidermis)**

The piliferous layer bears root hairs which are a single layer of cells that lacks cuticle for easy absorption of water and mineral salts from the soil.

**Cortex:** thin walled cells and air spaces among the cells.
**Endodermis:** the inner most layer of the cortex and is single cell thick.

**Pericycle:** single layer of walls from which roots arise.

**Vascular bundles:** phloem alternate with xylem.

**Pith:** obliterated as xylem occupies the centre.

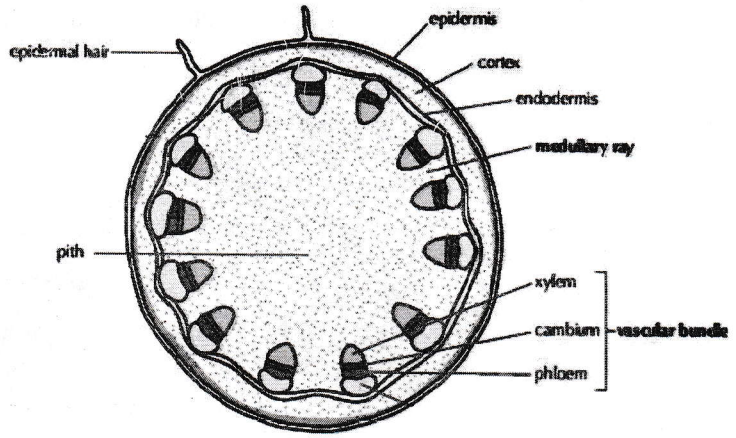



*Figure 3.18: Dicot stem in transverse section e.g. bean, sunflower*

- **Epidermis:** forms the outer layer and is covered with cuticle.
- **Cortex:** lies just below the epidermis with cellular air spaces among the cells.
- **Endodermis:** the innermost layer of cortex.
- **Vascular bundles**: have been arranged in a ring around the pith.
- **Cambium:** present between xylem and phloem in each bundle for secondary growth.
- **Pith:** occupies the central part of the stem.

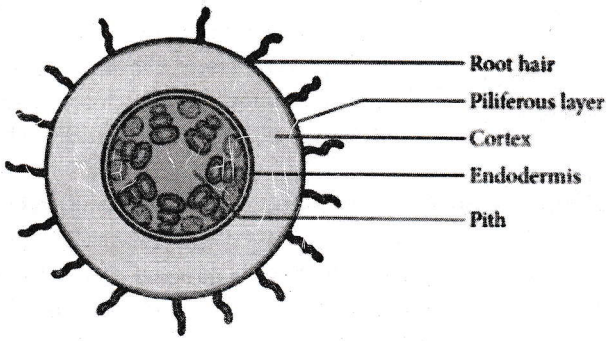



*Figure 3.19: Monocot root in transverse section*

- **Piliferous layer:** the outer most layer bear root hairs.
- **Cortex:** of the walled cells and intercellular spaces
- **Endodermis:** the inner most layer of cortex

- **Pericycle:** source of roots.
- **Vascular bundles**: are radially arranged in a ring and they alternate.
- **Pith:** is present.
- No cambium.

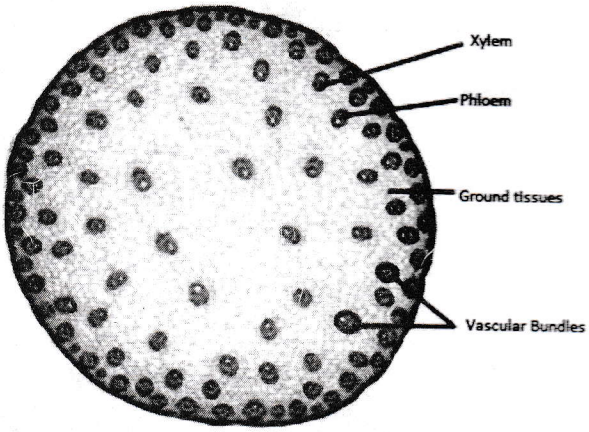



*Figure 3.20: Monocot stem in transverse section e.g. maize stem*

- **Epidermis:** layer with a thick cuticle on its outer surface.
- **Ground tissue:** thin walled cells. Intercellular spaces occur among these cells.
- **Vascular bundles**: are scattered in the ground tissue.
- There is no pith and cambium.
- Small and numerous vascular bundles near the periphery and become larger and fewer towards the centre.

After you have learnt the structures responsible for transport in plants, let us now see the mechanism of water and mineral salt absorption in plants.

**Mechanism of absorption of water and dissolved mineral salts**

Did you learn how water enters the plant body during photosynthesis? Did you also learn that water used during photosynthesis is absorbed by roots?

To answer such questions I welcome you to this section by which you will learn the mechanisms of absorption of water.

The absorption of soil water is done by the root hairs which occur just behind the tip/apex. Each root hair is an outgrowth of the

piliferous cells. It is elongated and thin to increase surface area for the absorption. It also lacks cuticle for easy absorption. The root hairs are actually in contact with the soil water on one side and with the cortex cells on the other side.

Water moves from the soil into the root hairs by osmosis along a water gradient because the root hair sap contains sugars and other solutes and is more concentrated (has less water) than soil water.
From the root hairs, water moves across the cortex of the root to the xylem vessels by osmosis.

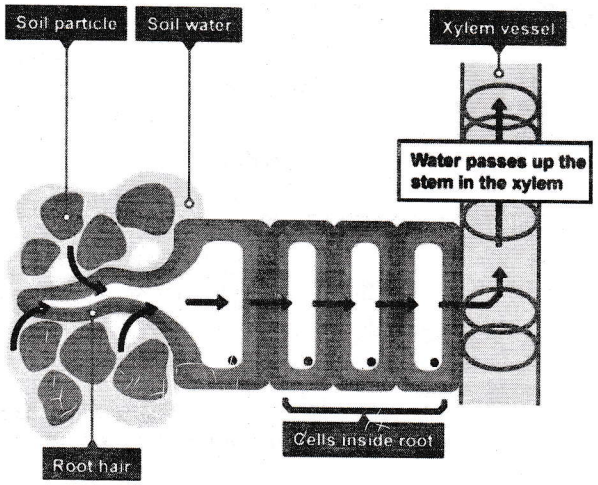



*Figure 3.21: Water movement from the root hair to the xylem*

**Path:** Water from root hair moves to xylem vessels. Within the xylem vessels water is transported upwards to reach the leaves where it is used during photosynthesis and the excess of it is transpired into the atmosphere.

**Forces which maintain continuous water flow within xylem**

i. ***Root pressure;*** This is a force generated in the roots due to accumulation of water that moves through the cell vacuoles.
ii. ***Transpiration pull;*** (*sunction pressure or mechanical pull*). This is the drawing of water from the lower parts of the plants and from the soil as a result of the pulling effect from above as, water is lost by evaporation to the atmosphere through the stomata.
iii. ***Capillarity;*** Is the force which raises water in the narrow xylem vessel tubes against the force of gravity. It enables water to reach the leaves in very tall trees.

**Absorption of mineral salts**

Mineral salts are absorbed in dissolved form by the root hairs and other young parts of the roots.

The absorption may involve diffusion which occurs when the internal amount of mineral salts is less than the external amount. Most mineral salts absorbed, are already at a higher amount inside the cells than outside, and therefore are actively absorbed using energy.

**Experiment to Investigate Forces that Cause Raising of Water in Plants**

**Aim:** Demonstrate Root Pressure in Plants

**Materials:** Potted plant, Bush knife

**Procedure**

- Completely cut the stem using a bush knife
- Observe and record what happens to the remaining part of the stem/stump.
- Discuss the findings with your friends.

**Question**

- What is the biological term that can be used to describe the process observed?

**Experiment:** To investigate forces that cause raising of water in plants

**Aim:** To demonstrate Capillarity in plants

**Materials:** 3 Glass tubes of different diameters, beaker, and coloured water and retort stand

**Procedure**

- Pour coloured water in the beaker
- Put glass tubes in water, make sure they are not touching the bottom of the beaker
- By using retort stand, clamp the tubes in order to hold them in place. Set your apparatus as shown in figure 3.22
-

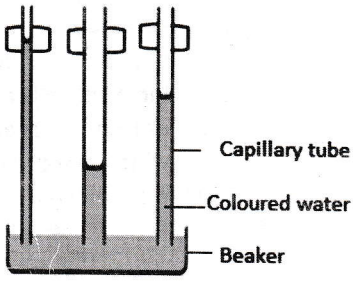



*Figure 3.22: Set up to demonstrate Capillarity*

**Question**

- Observe how water rises in the glass tube, then compare the levels of water in the tubes. What can you comment?
- Discuss the findings with your friends.

**Transpiration in plants**

Do you know that water reaches the leaves via vascular tissues? Does all water absorbed by the roots in a plant remain the cells constantly or some are lost in a form of vapour? To know the solution of these problems study the section below about transpiration.

The bulk of water moving through a plant, about 99% evaporates from the surfaces of the cells inside the leaves and escapes from the leaves as water vapour through stomata. The evaporation of water

from the cells of leaves is known as *transpiration*. This is the process by which plants lose water by evaporation through the leaves. From your experience and the knowledge you have, are there advantages and disadvantages of transpiration in plants?

**Types of Transpiration**

There are main three types of transpiration as follows;

i. ***Stomatal transpiration;*** this occurs through the stomata available on the surfaces of the leaf.

*ii.* ***Cuticular transpiration;*** occurs through leaves' cuticle

*iii.* ***Lenticular transpiration;*** occurs through lenticels of the plant. Lenticels are pores found in the root and bark of the plant stem.

**Significance of transpiration**

***Advantages***

i. The evaporation of water from leaf cells (transpiration) makes a continuous movement of soil water into plants (transpiration stream) possible. The constant supply of water to plants makes the plant cells always be turgid and active.

ii. Transpiration also helps to absorb and distribute mineral salts which move along with water throughout the plant.

iii. Transpiration also brings **cooling effect** on plants when the excess heat of the leaf cells is used to evaporate the excess water. If these were to remain in the cells they could harm them e.g. denaturation/destroy of enzymes.

***Disadvantages***

i. High rates of transpiration and water deficit cause wilting. In extreme case, may cause death of the plants.

ii. Water deficit also inhibits metabolic processes within the plants e.g. synthesis of protein or photosynthesis may stop altogether.

iii. Transpiration also leads to drying of the soil as it loses its water to the transpiring plants.

**Factors affecting the rate of transpiration**

I believe so far you have realized that transpiration process is affected by a number of factors as discussed below:

The rate at which water vapour is lost by a plant depends on several factors which may be internal/Plant factors or external/environmental factors.

**a) Plant Factors**

***i. The size of the stomata***

The larger the size of stomata pore the higher the rate of transpiration. In the other hand, the smaller size of stomatal pore greatly minimize transpiration rate.

***ii. The size of the leaf***

Plants with broad leaves have large number of stomata compared to those with thin leaves. Greater number of stomata increases the rate of transpiration.

***iii. Leaf cuticle***

A thick cuticle prevent water loss by transpiration while thin cuticle make loss of water by transpiration easier.

***iv. Position of Stomata***

Leaves of many plants have stomata only on the under surface, transpiration rate is low in these plants compared to those with stomata on both sides.

***v. Sunken stomata***

Some plants mostly Xerophytic plants have sunken stomata. This adaptation increase the distance through which the water vapour diffuses before it enters the atmosphere, in so doing transpiration rate is lessened.

b) ***Environmental Factors***

***i. Humidity***

The rate of transpiration is higher when the atmosphere is dry compared to the water content in the leaves. The rate falls when the atmosphere is saturated with water molecules (high water content).

***ii. Temperature***

The rate of transpiration is lowered when the atmospheric temperature is low as there will be high contents of water molecules in the atmosphere. At high atmospheric temperatures, transpiration rates become higher due to increase in capacity for the atmospheric air to hold water molecules from the leaves.

***iii. Light***

Leaves absorb light energy from the sun for photosynthesis. Some of the light energy increases the internal temperature of the mesophyll cells in the leaves. The increased temperature causes water vapour to diffuse out much faster than at normal temperatures.

**iv. Wind**

When air is still, the air surrounding transpiring leaves become saturated with water molecules, hence low rate of transpiration.

When the air surrounding the leaves of a plant is in motion (moving), it carries away water molecules. The remaining dry air is able to receive water molecules from the transpiring plants; therefore the rate of transpiration becomes high.

**v. Soil water content**

The amount of water available to the plant also determines the amount of water lost by transpiration. When the amount of soil water is low, less water is absorbed by the plant, guard cells become flaccid and close up the stomata, thus inhibiting transpiration.

When there is excess soil water, plants absorb more water, guard cells become turgid, causing opening of stomata and therefore, increases the rate of transpiration.

## Unit Reflection

1. What were the most important points you noted when learning through the unit?
2. Which parts do you think were clear and well understood?
3. Have you noted the parts you think were not clear to you?
4. Find help from nearby experienced person and make several revisions, so that you understand well.

## Unit Assignment

*After the completion of this unit, do the following questions to test yourself if you have understood the unit then put the work into your portfolio.*

1. (a) Give the differences between osmosis and diffusion.
   (b) Explain what would happen to the following cells if they were transferred from their normal conditions into dilute water.
   (i) A red blood cell.
   (ii) A plant parenchyma.

2. (i) Explain the meaning of "Transpiration pull"
   (ii) Transpiration is said to be both, beneficial and harmful to plants. Justify.
3. Briefly describe the differences between arteries and veins
4. (a) Explain the meaning of the following terms;
   (i) Turgidity.
   (ii) Plasmolysis.
   (b) Explain why an animal cell would burst if placed in a hypotonic solution while a plant cell would not.

5. Why blood group AB is known as universal recipient?

6. Explain the way water and mineral salts are absorbed by the plant roots.

7. Explain why is not advised for a person to sleep in poorly ventilated room with charcoal burner?

8. a) Xylem and phloem are collectively known as.....

   b) State the role of xylem and phloem.

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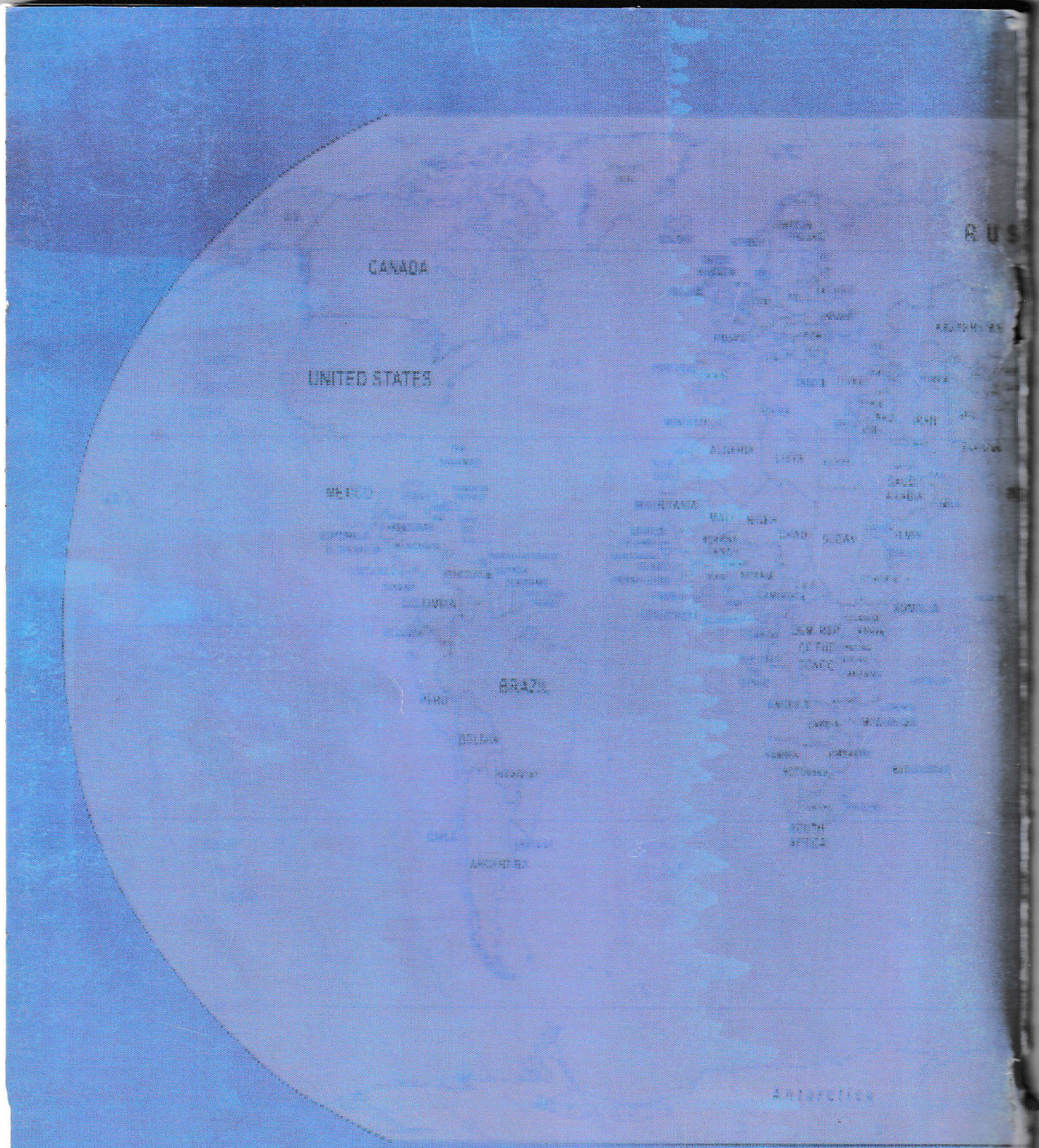


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