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Open Educational Resources (OER) for Open Schooling

The Commonwealth of Learning (COL) Open Schools Initiative launched an Open Educational Resources (OER) Project to provide materials under the Creative Commons license agreement to support independent study in 17 specially selected secondary school subjects. Funded by the William and Flora Hewlett Foundation its aim is to broaden access to secondary education through the development of high quality Open Distance Learning (ODL) or self-study materials.

These specially selected OER subjects include:

1. Commerce 11
2. Coordinated Science 10 (Biology, Chemistry and Physics)
3. English 12
4. English Second Language 10
5. Entrepreneurship 10
6. Food & Nutrition
7. Geography 10
8. Geography 12
9. Human Social Biology 12
10. Life Science 10
11. Life Skills
12. Mathematics 11
13. Mathematics 12
14. Physical Science 10
15. Physical Science 12
16. Principles of Business
17. Spanish

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The *OER for Open Schooling Teachers' Guide* has been developed to guide teachers/instructors on how to use the Open Educational Resources (OER) in five of these courses.

1. English
2. Entrepreneurship
3. Geography
4. Life Science
5. Physical Science

The aim of this teachers' guide is to help all teachers/instructors make best use of the OER materials. This guide is generic, but focuses on Namibian examples.

Print-based versions are available on CD-ROM and can be downloaded from www.col.org/CourseMaterials. The CD-ROM contains the module and folders with additional resources, multimedia resources and/or teacher resources. Note that not all subjects have multimedia resources.

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The Commonwealth of Learning (COL) is an intergovernmental organisation created by Commonwealth Heads of Government to encourage the development and sharing of open learning and distance education knowledge, resources and technologies.

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Human Social Biology 12

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HSB Unit 1

Living Things

Introduction

Welcome to the first unit of the Human and Social Biology course. In this unit, you are going to learn about living things. Before getting into the details of the unit we could ask ourselves questions like;

- What are living things?
- What are those features that make living thing different from non-living things?
- Which living things affect human life?
- What makes life?

All these questions will help us understand this unit much better. Topic one of this unit will focus mainly on the first two questions and it deals with characteristics of living things. Topics 2 and 3 will focus on the third question and will be looking at some examples of living things that affect human health.

The last 2 topics will be on last question and we will learn about life’s building blocks. These building blocks are cells and they are included in this unit because all living things have cells. I hope you will enjoy the unit.

Time Frame

It is estimated that to complete studying this unit you will need between 13 to14 hours. Do not worry if you take longer in finishing this unit. Remember that we all have different abilities and hence we study at different paces.

You are encouraged to spend about 2 hours to answer the assignment in this unit. You will also need approximately 3 hours on the assessment at the end of the unit.

The total hours for completing the unit will thus be between 20 and 23 hours.

Upon completion of this unit you will be able to:

Outcomes

- *Describe* the characteristics of living things, disease causing organisms and organisms that do not cause diseases.
- *Describe* disease causing organisms and organisms that do not cause diseases.
- *Describe* cells; cell processes, specialisation and organisation

Teaching Approach:

The teaching and learning approach for this topic is learner centred and based on your previous knowledge and experience. This is meant to motivate you to explore information on your own or as a group at home and even in your study centre. You are encouraged to form study groups with other learners in your area to discuss the subject matter and assist each other in your studies. This will help you to do research and develop an interest and initiative to study. A number of activities have been included in the unit to help you interact with the learning material and you are encouraged to do all the activities in the unit. There are also some practical activities designed to have a greater emphasis on the understanding and application of scientific concepts and principles discussed in the unit to everyday life situations.

The unit itself is a challenge to us in the sense that it helps us understand ourselves. We are living things and we have to understand our bodies and we also have to understand things that affect our day to day living (particularly our health). We have in-text questions and activities with feedback to assist you as you work through the unit. The activities will facilitate your understanding of concepts of life as well as help you build skills, knowledge and practical applications. At the end of the unit there are assignment and assessment activities with feedback provided to help check your understanding of the unit content.

Terminology

Photosynthesis: Chemical process by which green plants take in carbon dioxide and water in the presence of sunlight to produce sugar.

Binary fission: A type of asexual reproduction occurring is some unicellular organisms in which a parent cell splits into two identical daughter cells.

Pathogenic bacteria: Bacteria that causes diseases.

Non-pathogenic Bacteria that does not cause disease.

bacteria:

Villi: Small finger-like projects in the small intestines that increase the surface area for absorption.

Stimulus: Something that causes a response in a living organism.

Online Resource

If you can get on the internet please utilize the resources at www.hippocampus.org. It is an excellent source of information for biology and the topics discussed in this unit. Here you will find:

- Presentations
- Simulations
- Videos
- Online Study Groups
- Links to Even More Information
- Textbook Correlations
- Online Courses

Topic 1: Characteristics of Living Things

Let us now start by asking ourselves the questions that we asked in the introduction; What are livings things? What are those features that make living things different from non-living things?

There are so many different things that are alive – human beings are just one of them. Can you think of any other living things? Write your ideas in this space. Some examples of living things include;…

You may have said that plants, animals, birds, fish and reptiles are living. This would be correct. So how do you know if something is alive? You know that a cow is alive, but a stone wall is not. It is not always so obvious whether something is alive or not – is a dried out seed or a virus particle living or non-living? To try to answer such questions biologists have made a list of the characteristics of living things. What would you put on that list? Write your ideas down in the space below. I know that something is alive if it is …

The characteristics of living things will follow after the objectives below.

Learning Objectives

At the end of the lesson you should be able to:

- List all characteristics of living things.
  Describe the characteristics of living lings

Characteristics of Living Things

You may have written that you know something is alive because it is breathing, growing or moving. These are all correct but there are other characteristics that help us to identify living things. Biologists have made a list of 7 characteristics of living things. All living things:

- feed
- grow
- reproduce
- move
- are sensetive
- respire
- excrete waste

You may have seen similar lists of characteristics of life using slightly different words. All of the 7 characteristics must be met for something to be called living.

Feeding

Feeding, as you know from personal experience, means taking in materials containing nutrients obtained from the environment. The materials are generally called food. Plants feed by taking in carbon dioxide from the atmosphere and water from the soil, which they use to make sugar during a process called photosynthesis. As plants take in water they also take in nutrients dissolved in it.

Animals on the other hand obtain ready-made food by eating other organisms such as plants and other animals. Feeding methods differ from one organism to the other. The intake of food is necessary to provide the organism with energy, materials for growth and to keep healthy by protecting it from diseases. Humans, like all other animals eat, that is why we always talk about breakfast, lunch and supper. Most of these will be covered in unit 2 which is on nutrition and diet.

Growth

Living things start life as tiny beings called eggs or seeds. As they feed and remain healthy they grow in size and mass as they get older. This increase in size is called growth. In fact as mentioned above, one of the reasons why organisms feed is for them to grow. Non-living things like stones do not feed and therefore do not grow.

Reproduction

Another feature of living things is that they have the ability to produce and give rise to young ones similar to them. This is called reproduction. Reproduction prevents living things from being extinct or dying off completely from the earth. If animals do not reproduce as quickly as they die they become extinct.

There is a large variety of ways in which living things reproduce. Small organisms like bacteria reproduce by splitting into two equal halves that develop into two independent individuals. More complex organisms like Man have specialized reproduction organs. These organs produce special reproductive cells from young ones which develop, more details of these will be covered in Unit 11 which has a section on reproduction.

Movement

Living things can change position and direction, this is known as movement. Plants move by changing the direction, for example, a plant can grow towards light. Animals can change their positions as well as direction. While movement of animals can be noticed as they move from one place to another it is not always easy to notice movement in plants. This is because most of the plant remains in the same position and only certain parts move. Roots move towards the moisture while the stem moves towards light. Plants movements are usually slow while animals move fast.

Sensitivity

Living things have the ability to detect or perceive changes in their surroundings and respond to them. This makes them take action for or against such changes. This character is referred to as sensitivity or irritability. So living things are sensitive or irritable to changes in their surroundings and they respond to them accordingly. Plants respond to stimuli very slowly and only with certain of their parts, animals on the other hand respond very quickly.

Man, as an animal has sense organs for detecting various stimuli in his or her surroundings. This will be covered in more detail in Unit 7. However let us do the following activity on human detection of stimuli.

Activity 1

Think of various stimuli Man is exposed to in his/her environment. List each stimulus you have thought about and against it state the sense organ that detects it. For example;

Light is a stimulus detected by the eyes

Feedback

You should have mentioned the following:

Sound detected by ears

Taste detected by the tongue

Heat and pressure detected by the skin

Smell detected by nose

Therefore Man has five sense organs which are specialized to detect specific stimuli.

So far we have learnt about five characteristics of living things, so let's continue and look at the last two, which are respiration and excretion.

Respiration

This is the ability of living things to produce energy. In fact it is a chemical reaction involving the burning of food materials inside the body cells. The result is that energy is produced and the cells are able to perform their processes.

Food + Oxygen → Energy + Carbon Dioxide + Water

You can see from the equation that respiration uses up food and oxygen to release energy carbon dioxide and water. Animals obtain the oxygen for respiration from the air, by breathing in. Plants obtain oxygen through pores called stomata and most of them are on the underside of plant leaves.

The energy produced is used for various activities like moving around and other processes that take place in the body. In animals carbon dioxide is excreted in breathed out air while in plants it is expelled through the stomata. All of these will be covered in more details in Unit 4 which is on the respiratory system.

Excretion

Another feature of living things is that they are able to remove waste products from their bodies and that is called excretion. Processes like respiration, movement, growth and others lead to the production of wastes, which the body must expel to the outside.

The excretory products are of no use to the organism and if allowed to accumulate they might be harmful. Examples of these products include carbon dioxide and urea in animals, which excreted by breathing and urinating respectively. Unit 10 of this course is on the Excretory System, so you will learn more about excretion in that unit.

Summary

For something to be classified as living, it has to have the following characteristics;

Feeding – for energy and increase in size

growth- start very small and end up very big

reproduction- give birth to young ones

movement – change position and direction

sensitivity – respond to changes in their surroundings

respiration – can produce their own energy

excretion – able to remove body waste

Only definitions and brief explanation of these life processes have been given in this unit. As you proceed with the other units you will learn more about these things. You will learn how organisms differ and the way some of the processes are carried out.

The next topic, topic 2 deals with organisms that affect human health. Before you move on to this topic, complete the end of topic Assignment 1. The assignment can be found at the end of the Unit. You should then compare your answers with those provided at the end of the assignment. We encourage you not to read the answers before doing the assignment so that you can gauge your understanding of the topic effectively.

Topic 2: Organisms Affecting Human Health

In the first topic we were looking at characteristics of living things in general. We were looking at things that show that there is life in an organism. Now in this topic we are going to look at organisms that affect life. We are going to focus on organisms that affect human health. Let us start by looking at good health.

Good health is when all the organs of the body are working properly. It means feeling well both in body and mind. Any abnormality or malfunctioning of the body is called a disease. I believe all of us had visited a doctor at one point in life after acquiring some disease. There are many different causes of a disease, such as micro-organisms getting into the body, faulty metabolism or inadequate diet.

In this lesson we will study organisms that cause diseases. Later on in Unit 14 we shall look at organisms that are useful to our lives. Organisms which enter the body of another organism and feed on its living tissue are called **parasites**. The organism in which the parasite enters into is called a **host**.

Parasites cause diseases to hosts by damaging their tissues or upsetting the normal functioning of the body. Parasites that cause diseases are called pathogens and examples of these are viruses, bacteria, worms, fungi and protozoa. We shall now study some of these parasites and later learn how some organisms such as insects spread these parasites.

Learning Objectives

At the end of the topic you should be able to;

- explain what a virus is
- describe the structure of a virus
- describe a bacterium and their types
- describe how bacterium grows in livings tissues
- outline the mode of reproduction in bacteria
- describe protozoa as unicellular organisms
- explain the structure of fungi

- briefly describe how fungi live and their mode of reproduction

Organisms that Cause Diseases to Humans

As already mentioned in the topic introduction we are going to look at organisms affecting human health. We shall focus mainly on organisms that cause diseases to humans particularly viruses, bacteria, protozoa and fungi. These organisms are normally referred to as microorganisms because they are relatively small in size. We shall look at the structure of each and how they reproduce. Let us start with viruses.

Viruses

Viruses and some other groups of tiny living things like bacteria, protozoa, some groups of fungi and algae are referred to as micro-organisms or microbes. This means that they are too small to be seen without the help of a microscope.

Viruses are the smallest of all the micro-organisms mentioned. In fact, they are so small that a row of one million of them will measure 5mm. The diameter of each is less than 0.0005mm. It is not clear whether viruses are living or non-living. Outside living tissue, they remain lifeless for years as crystals and as soon as they enter the host they come to life and begin to multiply. When viruses enter a host's cell they take over control of the cell and make the host cell produce new viruses using materials from the cell.

Structure of the virus

Viruses are very simple organisms, with no nucleus, cytoplasm or metabolic enzymes. We can't therefore call them cells. There is a wall around each virus, which is made up of protein. This wall encloses a coiled up strand of nucleic acid (that is DNA) as shown in the diagram below.

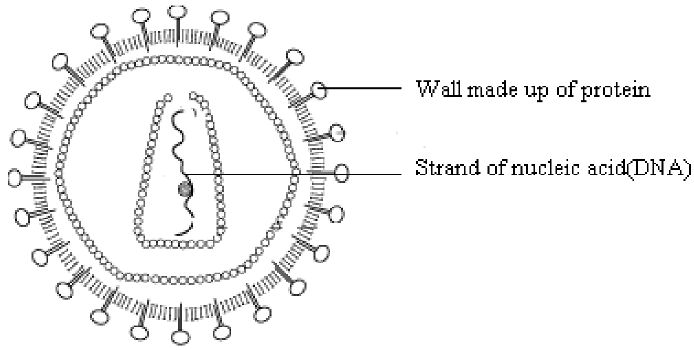

Figure 1: Structure of Viruses

You may want to know that DNA means. DNA means **deoxyribonucleic acid** and it is found in chromosomes. Chromosomes are made up of proteins and DNA. The DNA is a thread like chemical that contains chains of sugars and phosphates.

In cells that have a nucleus, the chromosomes are inside the nucleus. However, in a virus that has no nucleus, it is the DNA or RNA that performs the functions of a nucleus. RNA or ribonucleic acid is another chain of proteins found in cells.

Reproduction in a Virus

Viruses have a remarkable way of reproducing and it explains why they are so harmful. The materials for making new viruses come from inside the host cell. So the virus is a thief, robbing the host cell of its contents. Eventually the host cell bursts releasing new viruses, which attach more cells. The whole process takes about half an hour and you can imagine how many cells are destroyed in a day. A day to day example is that of common cold. A common cold virus attacks the cells that line the inside of a nose and the damage done on these cells makes the nose run. Each type of virus attacks certain cells in the body.

Can you think of other diseases that are caused by viruses? If you can then write them down in the space provided below.

____
____
____
____

I am sure that you have thought about AIDS. We always hear about AIDS and HIV(human immuno-defiency virus) in radios and we always read about these everywhere. Yes it is true that it is caused by a virus, that is Human Immuno-defiency Virus(HIV). Anyway there are many others and they include chicken pox, influenza, common cold, measles, rabies and polio. You will learn more about these diseases in unit 10 which is on Health and Diseases.

Bacteria

Bacteria (singular is bacterium) are also unicellular, that is, they consist of only one cell. They are much larger than viruses. A row of one million bacteria would be up to 0.5meters in length. Most bacteria are between 0.0005mm and 0.002mm long. No bacterium is longer than 0.01mm.

Structure of Bacteria

Each bacterium has a cell wall as shown in figure 2 below. Inside the cell wall there is some cytoplasm and a single genetic material or chromosome, which is a single strand of nucleic acid or DNA.

Bacteria have nuclei though they are not clearly defined. When the nuclear material has no membrane surrounding it, it is assumed that it not a nucleus.

However, the generic material (chromosome) can be identified as a group of strands within the cytoplasm and these are at the centre in the diagram below.

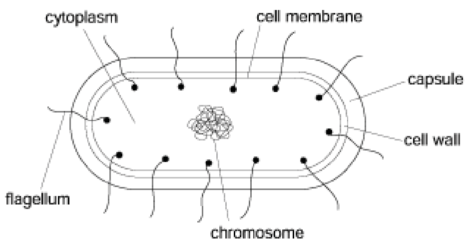

Figure 2: Bacterial cell

There are no vacuoles in the cytoplasm, which consists mainly of proteins, and may contain various types of granules, which store food, that is, they are food reserves.

On the outermost part of the bacterial cell there is a slime layer. It is sometimes also referred to as a **capsule**. This capsule covers the entire cell wall. Here you should bear in mind that it only present in some type of bacteria. The capsule consists of a slimy substance(at times it is referred to as a slime capsule), which makes it difficult for white blood cells in the human blood to engulf the type of bacterial cells that have the capsule.

Certain bacteria also have a long tail like structure called flagellum (many flagella). Bacteria use flagella to move from one point to another.

How Bacteria Reproduce

All bacteria reproduce by binary fission. This means they split into two identical parts. As shown in figure 3 below, we start with one cell, then the chromosomes in that cell duplicate and later the cell divides into two.

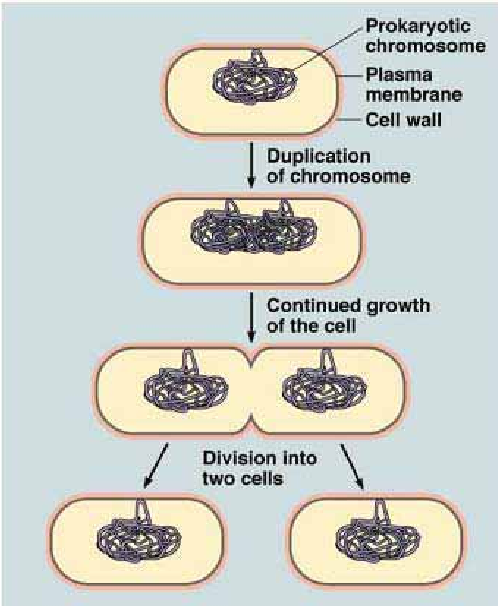

Figure 3: Binary Fission in bacteria

If good conditions are present, like warm temperatures, plenty of food and the ability to get rid of waste products, most bacteria can reproduce every 20 minutes.

This produces new bacteria at a very high rate and can result in millions of them being produced. This explains why diseases like boils, cholera and bacillary dysentery often develop very fast.

Types of Bacteria

There are two types of bacteria and these are the pathogenic ones and the non-pathogenic ones. The pathogenic ones are those that cause disease whilst the non-pathogenic ones are those which don't cause disease.

Lets us now look at types of bacteria starting with non-pathogenic ones.

Non pathogenic Bacteria

These live in water, soil or in decaying matter. In these conditions they feed by secreting enzymes onto the organic matter to digest it after which the digested food is absorbed through the cell wall.

The bacteria use this type of food for energy, growth and reproduction. This kind of feeding by the bacteria can be a nuisance when they attack our stored food. In nature it is a means of breaking down dead material (decomposition). This makes it possible for important chemicals to be recycled. Bacteria which cause decay are called Putrefying bacteria.

These bacteria do a good job of removing unwanted materials, which would otherwise accumulate around.

Activity 1

You may have studied the carbon and nitrogen cycle, which give examples of one of the positive roles of bacteria. Using your private reading and earlier learning in science, write in the space below other useful roles of bacteria

Feedback

You may have responded to the activity differently. But some of the responses are as follows.

The carbon and nitrogen cycle show how bacteria play a role in recycling nutrients. Some other useful kinds of bacteria are like those found in the digestive system of animals including man. Those produce vitamin B_{12} and K, which we need to keep healthy.

Bacteria are also important in the making of cheese, sour milk and brewing of alcohol and making of vinegar. So you can see that, bacteria may not only be non-pathogenic but can also be useful.

You have just learnt the usefulness of non-pathogenic bacteria. In the following section, we are going to learn about the pathogenic bacteria.

Pathogenic bacteria

These are the type of bacteria that cause diseases. Some of them only affect particular parts of the body, for example, the **bacillary dysentery** bacteria only attack the large intestine. Other bacteria can attack more than one organ of the body. Examples of pathogenic bacteria include those which cause **syphilis**, **gonorrhea**, **pneumonia** and many others. You will learn more about diseases in unit 10 of the course.

Another example of organisms that cause disease to humans is the Protozoa which follow in the next section.

Protozoa

These are very small unicellular organisms. They are considerably larger than bacteria viruses, and are visible without a microscope. The singular of protozoa is called a **protozoon**.

Can you remember what a unicellular organism is? What is it?

___

___

___

___

It is an organism which consists of one cell, that is, the body is made of only one cell.

Structure of a Protozoa

Each protozoon is covered by a cell membrane enclosing cytoplasm and a nucleus. The diagram below shows the structure of amoeba, which is an example of a protozoon.

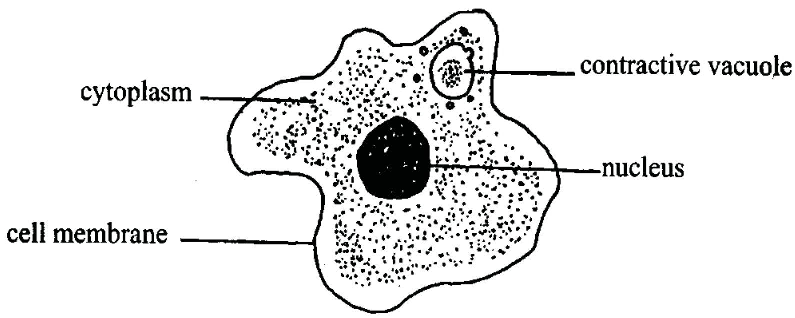

Figure 6: Amoeba

Within the cytoplasm there are fat droplets, food vacuoles and contractile vacuoles. Contraction vacuoles are used for elimination of water since most protozoa live in water and are likely to take in excess of it.

Protozoa have true nucleus, separated from the cytoplasm by a membrane (the Nuclear membrane). The nucleus occupies the almost fixed central position in the cell.

You have studied the structures of both the protozoa and bacteria. Before looking at where protozoa are found and how they feed can you now do the activity to refresh your memory.

Activity 2

What is the difference between protozoa and bacteria?

Feedback

The difference is that protozoa have a true nucleus. This is unlike bacteria, which do not have a true nucleus because it is not easy to identify.

Habitat and Feeding

Protozoa are found in a wide range of localities (habitats). They may live in fresh water, salty water, damp soils and even in dry sand. Protozoan pathogens also live in or on bodies of animals.

Do you remember what a pathogen is? Explain.

You should remember from the previous sections that a pathogen is a disease causing organism. What happens is that the protozoa feed by ingesting (taking in) small particles of food such as bacteria and other smaller beings. In case of disease causing protozoa like plasmodium, the malarial parasite, they absorb nutrients from their hosts and at times they destroy the body cells. As a result the host animal falls sick.

Reproduction in Protozoa

Most protozoa reproduce by binary fission. Do you still remember what this means? If so please not it down.

Do you remember that bacteria reproduce in the same way?

This process is very quick and very soon lots of protozoa have been formed. That is why a host infected with disease-causing protozoa like malaria parasite soon falls very sick. Now continue with activity 3 below.

Activity 3

In the space provided, summarise the process of binary fission by stating the steps that occur before the daughter cells are formed.

Step 1:

Steps 2:

Step 3:

Step 4:

Step 5: Two daughter that are identical are formed.

Feedback

Go to section 1.2 on reproduction of bacteria to check if you got the steps right.

There is another type of reproduction, which goes amongst protozoa. A few examples like plasmodium(the malarial parasite) form reproductive cells(gametes) and therefore reproduce sexually. These have rather complex methods of reproduction. However, plasmodium can also reproduce asexually as well. You will learn more about plasmodia when we deal with health and disease in Unit12 of the course.

Protozoa and Disease

As mentioned earlier on, not all protozoa cause diseases. Some types of protozoa like amoeba and paramecium are free living. There are others that live in rumens(stomachs) of cattle and are useful in the digestion of cellulose. Yet other types of amoeba live in human guts(alimentary canals) and cause amoebic dysentery.

Trypanosoma is a protozoa which cause disease in man (sleeping sickness) and we also have those that cause malaria for example plasmodium.

So far we have dealt with three of the organisms that cause diseases to human health, now let us look at the fourth one which are fungi.

Fungi

Most organisms in this group are multicellular. Yeast, however is a unicellular fungus.

Do you remember what multicellular means? It means having many cells. Fungi are plant like organisims that lack chlorophyll, and because of this, they depend on ready made food from green plants just like animals.

Structure of Fungi

Bodies of multi-cellular fungi are usually made up of fine branched and straight threads(filaments) called hypae (one is a hypha). Figure 7 below shows an example of a section of a fungal hypha.

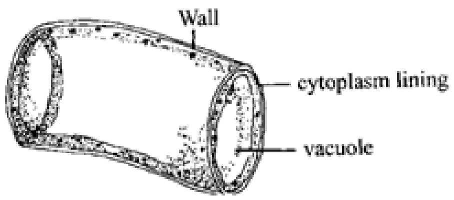

Figure 7: Section of fungal hypha

A collection of these filaments(threads) form a body of the fungus called a mycelium as shown in figure 8 below. In some fungi the threads (hypae) are divided into cells by cross walls but in others the walls are absent.

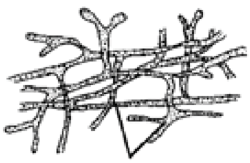

Figure 8: Body of a fungus

Hyphae may form a loose fluffy white mass(as the case in moulds, which form on rotting fruits or bread) or they may be closely woven together to form structures like mushrooms; toadstools and puffballs.

Feeding

Fungi live as parasites or as **saprophytes**. Most fungi are saprophytes, however, feeding by decomposing food and dead organisms. In that way, saprophytic organisms are free living, they don't act as parasites to other living things. Saprophytic organisms are very important in decaying substances so as to make possible re-cycling of matter.

Without decomposers bodies of animals that died centuries ago would still be on the ground.

Fungi and Disease

Many groups of fungi are parasitic, causing diseases mainly to plants, for example the mildews on pumpkins and smuts on sorghum. There are however, few parasitic fungi in animals, the common parasitic fungus that attach animals including humans is the ring worm.

As said above, ringworm is the most common fungal disease in animals. In human beings, the fungus attacks the skin and forms small circular patches. It attacks anywhere on the skin although growth on the scalp is the commonest infection. Another common type of ringworm is **Athletes Foot** in which the fungus grows between toes and on other soft parts of the foot. When moist accumulates due to sweat, the broken skin tissue rot and thus causing a bad smell. Ringworm is spread by contact.

Reproduction in Fungi

Many fungi reproduce asexually by means of small cells called spores. These spores are produced in great numbers and are so light that they are easily blown about by wind. The spores of common moulds are present everywhere in houses and the air as shown by the fact that food easily goes mouldy under warm damp conditions. Some fungi can reproduce sexually.

Summary

In this lesson, you learnt about organisms affecting human health. These include viruses, bacteria, protozoa and fungi, and all these organisms are relatively small in size and are mostly referred to as micro-organisms. You also learnt that some organisms are pathogenic and others are not. However all viruses are pathogenic. A pathogenic organism is the one which cause disease whilst a non-pathogenic one is that which does not cause disease that is, it is non infective.

In the next lesson we shall deal with slightly bigger organisms which include worms and insects.

As in topic 1, you should now complete Assignment 2 which is at the end of the unit.

Topic 3: Worms and Insects

In the previous lesson, we dealt with unicellular organisms which were very small in size, some of which can cause disease in different ways. In this lesson, we are going to learn about multi cellular organisms. Unlike the ones discussed in Topic 2 these are much larger in size. Within these two groups, there are members which can affect human health. We are going to start by discussing worms and then move onto insects.

Worms are multi cellular organisms. They reproduce both sexually and asexually. The term worm includes three main groups:-

1. Round worms: These have rounded (cylindrical) bodies and may live freely or as parasites. They are sometimes referred to as nematodes
2. Flatworms: As their name suggests all worms in this group have flat bodies.
3. Earth worms, marine and fresh water worms: These are found in the soil, sea water or fresh water and they are free living. A free living organism is a non-parasite organism.

For this lesson we will only study roundworms and flatworms. After dealing with worms, we will then take a look at insects.

Insects are also multi cellular organisms. We will study their parts and also how they reproduce. As a case study, the mosquito and the housefly will be discussed in details. These two are very common in our everyday lives especially during summer. Mosquitoes usually harass us at night in hot wet areas and houseflies also like visiting most of our kitchens and mostly our rubbish bins outside houses. I believe most us have had that experience. Let us enjoy the topic.

Learning Objectives

At the end of the lesson, you should be able to:

- Describe a round worm(e.g. hookworm) in terms of its lifecycle, and also how it reproduces
- Describe the life cycle of one flatworm, that is, schistoma
- Describe the structure of an insect
- List the different types of insects

- State how they reproduce
- Describe the lifecycle of a house fly and a mosquito.

Worms

As mentioned earlier on, we are only going to look at two types of worms, that is, roundworms and flatworms. Let us look at roundworms first.

Round worms

These are also called thread worms or nematodes. Their bodies are cylindrical and pointed at both ends. Their length vary from a few millimeters up to 300mm. most roundworms are not parasitic but are free living animals found in soil or water.

You might have come across a round worm when digging on moist soil or even in stagnant water. Other kinds of round worms are pathogens living in animals and plants and thus causing diseases like elephantiasis.

Do you know what elephantiasis is? It is a disease which causes inflammation and swelling of the limbs. The skin of people with this disease usually thickens.

Elephantiasis is common in tropical regions. An example of a parasite round worm which is common in Botswana is the hookworm.

This is a roundworm that parasites on man's small intestines. Hookworms feed and become adult in the small intestines. The name of this worm arises from the fact that it has hooks on its mouth region.

These are used to attach the worm onto the host's intestines. The hooks also cut through the villi to enable the worm to get access to the host's blood stream. This enables the worm to suck blood from the host.

(a) Structure of the hookworm

The hookworm is a small nematode, is only 1cm (10mm) long. Like all other roundworms its body is cylindrical and pointed at both ends as shown in the diagram below.

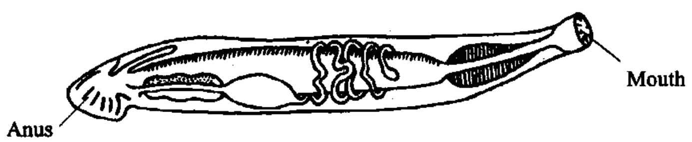

Figure 7: Hookworm

It reproduces by sexual means and the worm develops through larval stages that are also worm like. The larvae are small version of the adult hookworm.

(b) Life cycle of a hookworm

The lifecycle of the hookworm involves stages and these are the eggs, larvae and adult worms and these are labeled in bold in the diagram below. In between these stages, there are other stages which show either the egg, larvae or adult has moved from on area to the other. The stages are discussed below the diagram. Larvae are immature worm.

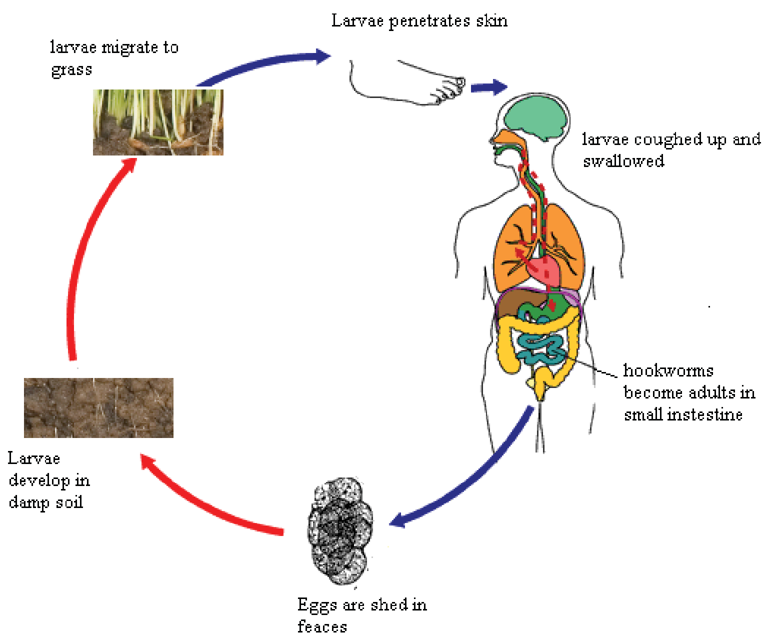

Figure 7: Life Cycle of a Hookworm.

1. This starts with an infected person passing out faeces which are infested with worm eggs. The infected person is referred to as host. This is because they have been accommodating the worms in their bodies.
2. Under favourable conditions like warm moist soil, eggs hatch into small larvae. These larvae feed on the faeces that were passed out with the eggs.
3. In 4-5 days, larvae mould and change into motile larvae which are made active and also attracted by warmth.

4. When an uninfected person places a naked foot on infected soil, larvae are attracted to it (by the heat) and as a result pierce the skin to enter the foot.
5. Larvae enter the blood system and go to the heart. From the heart they are transported to the lungs in the blood stream. In the lungs they pass the trachea to the back of the mouth where they get swallowed with food. They then pass through the stomach un-destroyed until they arrive in the small intestines.
6. In the small intestines, larvae attach themselves to the walls with hooks and feed on the blood of the host. They mature here, and develop into male and female worms.

Male and female worms copulate in the small intestine. The female lays eggs which eventually pass out with the human faeces to start the cycle again.

Let us now continue and look at the second type of worms which are flat worms.

Flatworms

They have flattened bodies and all members of this group are parasitic. They also have:

- Bodies that are protected by tough cuticle which is a waxy substance
- Means of attaching themselves onto the host.
- Produce many eggs because only few will find another host.
- An individual worm has both the female and male reproductive organs. This condition means the worms are referred to as hermaphrodites.

Examples of this group are tapeworms and blood flukes. We will study the blood fluke as an example from this group.

The following discussion of flatworms therefore, will be based on the Human blood fluke The other name for this parasite is Schistosoma and it causes a disease called schistosomaosis or bilhazia.

Three types of blood flukes exist. Their scientific names are:

(i) Schistosoma mansoni
(ii) Schistosoma japonica

The above mentioned blood flukes invade the blood vessels of the alimentary canal or the gut or the digestive system.

(iii)Schistosoma haematobium attack the blood vessels in the walls of the bladder.

(a) Structure of the blood fluke

The male fluke is larger than the female and it possesses a grove in which the female attach itself when mating as shown in Figure 8 below.

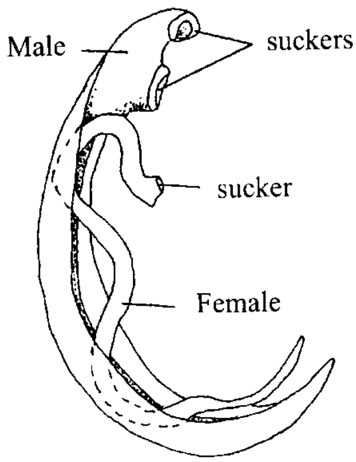

Figure 8: Human Blood fluke

Just like the round worms, the flukes have suckers which they use to attach themselves onto the host. The suckers are also used to suck nutrients from the host.

Blood flukes are small worms 10-20 mm long which live in the blood vessels of the host.

Let us now look at the lifecycle of schistosoma.

(b) Life cycle of schistosoma

The life cycle of the bilharzia worm involves two host organisms, Man as a primary host and an invertebrate as a secondary host.

An example of a secondary host can be the water snail. The life cycle and transmission of schistosoma is illustrated and explained below.

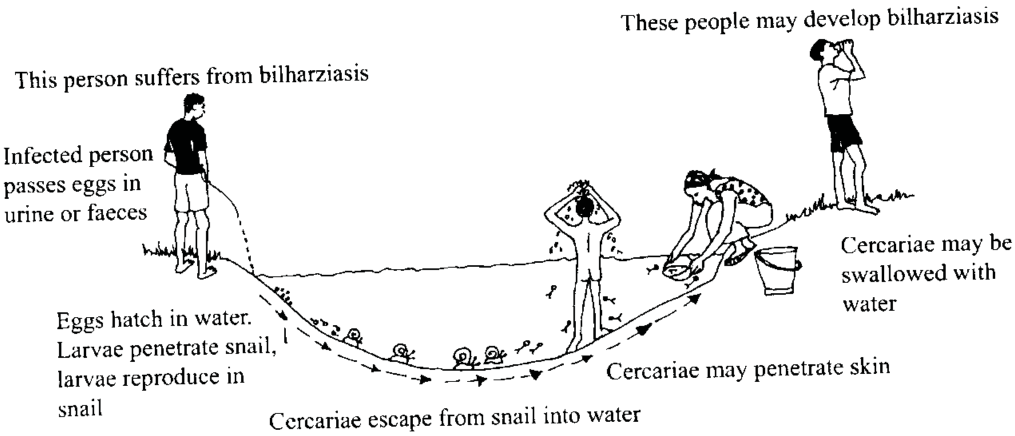

Figure: Transmission of Schistosoma

The parasite has a life cycle involving man and water snails as hosts.

1. Eggs are released into water when an infected man urinates or defaecates into or near water.
2. Eggs hatch into embryos which enter bodies of some types of water snails. The embryos cannot attack (infect) a person.
3. Embryos multiply asexually by binary fission in the snail and develop into forms with tails called Cercariae. Cercaria use their tails for movement in water.
4. Cercariae leave the snails and swim in water. If no host is found they die within 12 days swimming in water.
5. If a new host is found (a person) then cercariae enter through the skin that is, it penetrates his or her body when they get into contact with fluke infested water.
6. In the host's blood the worms grow and finally develop into adult flukes. These now settle in the blood vessels of the bladder or intestines.
7. The male and female flukes copulate and then release fertilized eggs into the blood stream.
8. The eggs (with their spores) bore through the blood vessels into the bladder or intestine and passed out in urine or faeces to start the life cycle.

The effect and control of the blood fluke and its primary host will be studied later in Unit 12. For now let us continue and look at insects.

Insects

Insects belong to a group called arthropods. This is a group of organisms that have jointed limbs. The group includes insects, crustaceans, spiders, millipedes and centipedes. Insects are supported and protected by a hard outer covering called an exoskeleton. Exo- means outside or external, so this is a kind of skeleton found outside the body flesh.

(a) Structure of an Insect

In insects, this skeleton is made of a substance called chitin, which is also covered by a layer of wax (together the wax and chitin are called cuticle). Very little water is lost from the insect by evaporation through the cuticle (wax is water proof).

The cuticle presents a problem as the insect grows. It soon becomes too small for its owner and as a result restricts its growth. The insects as a result have to moult (shed the cuticle off) several times before they reach adult sizes. When the cuticle is shed, a new one is formed. The insect grows when the new cuticle is soft and as it gradually hardens.

The body of an insect is divided into three parts, head, thorax and abdomen. The head bears a pair of sense organs (feelers) called antennae and the mouth parts for feeding. The thorax has three pairs of legs and a pair of wings.

While some insects are of help to us e.g. bees for making honey and pollinating flowers for the propagation of plants, others are a nuisance as pests e.g. locusts as well as vectors of disease e.g. mosquitoes, houseflies and tsetse flies. Being vectors means they transmit germs or disease-causing organisms. Insects do this either as mechanical carriers (like houseflies carrying germs in their body hairs) or as secondary hosts (mosquitoes may house plasmodium while it undergoes some developmental stages).

(b) Reproduction in Insects

Insects reproduce sexually, mainly by internal fertilization. The stages of growth by which a fertilized egg becomes an adult may be classified as:-

Incomplete metamorphosis like in locust, where by eggs hatch into nymphs which resemble their parents greatly and only few changes must occur to change them (the nymphs) into adults.

Complete metamorphosis like in houseflies, is where by the eggs hatch into completely different forms (different from the adults) which develop into yet other different stages.

To change to adults the bodies of these developmental stages (forms) must be completely destroyed and reorganized in shape and way of life.

Let us now study the mosquito and housefly and their life cycle. So as to understand the stages of development that occur in them.

1.1 Mosquitoes

Mosquitoes are found in most parts of the world. As adults they feed on plant juices. The females, however, need to suck blood of mammals and birds before producing eggs. It is these blood sucking female mosquitoes that are potential vectors (transmitters) for disease organisms.

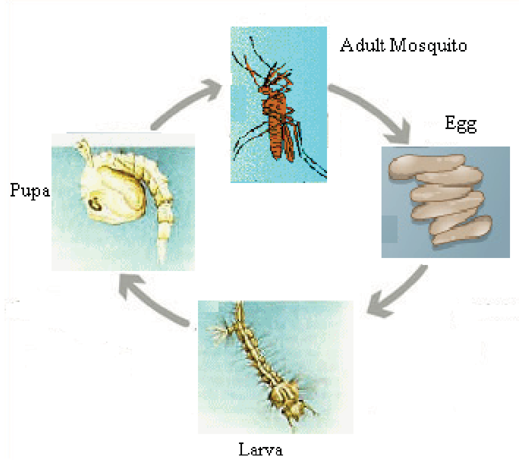

Figure 12 : Life cycle of anopheles mosquito

Eggs: These on the right in figure 12 above are laid in stagnant (not moving) water. They are boat shaped and each floats separately from the other.

Larvae: From the egg if you continue clockwise in the figure above you get larva. They hatch from the eggs. They are worm-like with bodies that are divided into head thorax and segmented abdomens.

Anopheles larvae breathe through spiracles (on the abdomen) which they bring into contact with the air by lying with their bodies parallel to the surface of the water.

Pupae: The next stage in the diagram if we continue clockwise is the pupa. The larva moult four times and become pupa. These have narrow curved abdomens and large rounded front ends representing the heads and thoraxes. Pupae breathe through respiratory trumpets which stick out from the surface of the thorax.

Adult (imago): This is the last stage in the cycle. During the pupal stage the body is reorganized and the pupal skin splits to release the mosquito. Adult mosquitoes live for about two weeks, resting during the day in dark curves (or under bushes) and feeding at night. Female adults feed on human blood to nourish their eggs. That is why female anopheles mosquitoes are transmitters of malaria.

Houseflies

Houseflies are widespread all over the world. Right from ancient times, people have associated the spread of diseases with houseflies. Houseflies have hairs covering all parts of their body. These hairs are able to hold small particles of dust and bacteria and these bacteria can be spread on food as houseflies walk over it.

Houseflies feed on decaying food or human faeces. It is actually from these sources that the housefly carries bacteria and other pathogenic organisms.

(a) Life Cycle of the Housefly

The housefly goes through a complete metamorphosis. During mating, the female fly receives large numbers of sperms into her body and these will fertilise the eggs. Flies look for decomposing organic matter such as faeces, a manure heap or dustbin to lay eggs on. Decaying matter provides a favourable temperature for incubating the eggs.

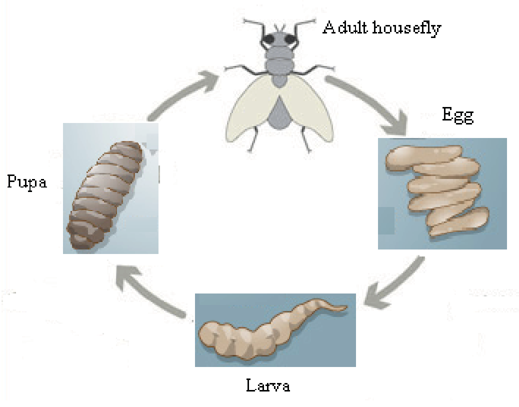

Figure 8: Life Cycle of the Housefly

Hatching occurs ten to seventy two hours after laying, depending on the temperature. Study carefully the above diagram taking note of events at various stages. We can control houseflies by breaking this life cycle one way or the or the other. Now do the activity below which is merely on controlling flies.

Activity 3

List all the possible ways in which you can protect food from houseflies

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Feedback

You should come up answers like;

Keep all unwrapped food in fly-proof containers such as refrigerators

Enclose all left- over food in fly proof dustbins.

Never leave faeces where human beings stay. Flush faeces and where this is possible burn or bury it.

In short what we are trying to do here is to try and destroy places where houseflies breed. They can breed anywhere, more especially on food that is not wrapped, on left-overs and on dirty areas like rubbish tips and manure heaps.

Summary

In this topic we have learned that:

1. Worms are three types i.e. round worms, flatworms and earth worms. Just as the name suggests, round worms are round in shape. Their examples include hookworms which are parasites on man's small intestines.
2. Flatworms are flat in appearance and they include the tape worm and the human blood fluke.
3. The human blood fluke or schistosoma cause the disease bilharzias, which is also called schistosomiasis.
4. Some insects are disease vectors. They belong to the group called arthropods. They reproduce sexually by internal fertilization.

5. Insects also go through different stages in their development from an egg into an adult. This is known as metamorphosis. Two common examples of insects in Botswana are the housefly, mosquito. These two are known vectors of diseases e.g. mosquitoes spread malaria.

   The life cycle of these two can be summarized as:
   Egg ⇨ larvae ⇨ pupa ⇨ adult
   The egg, larvae and pupa are totally different from the adult insect. Therefore they undergo complete metamorphosis.

   This brings us to the end of topic 3. The next topic, that is, topic 4 will be on cells. Remember to complete assignment 3 before you study the next topic.

Topic 4: Cells

Learners in the previous topics we have been talking about cells, uni-cellular and multi-cellular organisms without getting into details of what cells are. Now let us try and answer the following question;

What is a cell?

You must have thought, ”a cell is the basic unit that makes up living things.” This is definitely true. Cells are the basic blocks that make up living things. They can be compared to bricks that make a house. When a house is being built, bricks are placed adjacent to one another to produce a very big structure.

In living things, cells are also placed on top of each other and around each other to produce an organism.

Living things include both plants and animals and are made of cells. In this topic we are going to study both plants and animals cells and then compare the two. Later on in the topic we shall look at the structure of some of the cells in relation to their functions. I hope you will enjoy the topic.

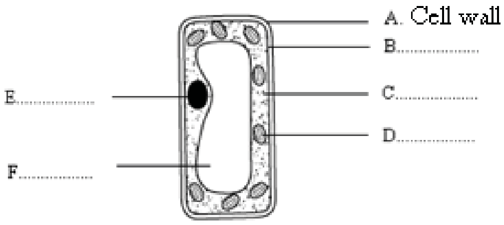
Learning Objectives

At the end of the lesson, you should be able to:

- Describe the structure of the plant and animal cells
- Explain the differences between a plant and an animal cell
- State the functions of the parts of a cell
- Define a tissue, organ and organ system

Plant cell

Let us start by looking at the diagram below that shows the structure of a plant cell. The different parts have been labeled with alphabets ranging from A to F. I would like you to study the diagram carefully before moving on to the next section. The part that follows immediately after the diagram will help you label the missing parts. We hope that will help you remember the parts easily next time.



You should have noticed that next to the alphabets, there are blank spaces. As you read through this section, fill in the spaces with the names of the parts.

Part A has been done for you. It is called the cell wall. The cell wall is the outer most layer found in plant cells. It holds the internal parts of a cell together thereby providing protection. This layer consists of a compound called cellulose which actually toughens the cell wall, thereby helping it to achieve its function of protecting the cell.

Another part of the cell is called the cell membrane. This structure is labeled B on your diagram. You should now write the word cell membrane next to the letter B on your diagram. Do you have any idea about the function of this part?

If you do not, then don't worry as I will provide it for you. The function of this part is to control the movement of substances into and out of the cell. The cell membrane can actually allow some substances, such as water to pass through it.

But it can also prevent the passage or movement of some substances, such as starch molecules through it. This property has resulted in this membrane sometimes being referred to as a semi permeable membrane.

What is a semi permeable membrane? It is a membrane that allows certain substances to pass through it and at the same time denying others passage.

It is selective with respective to the substances it allows to pass through. This is probably the reason why it is sometimes referred to as a selective permeable membrane or partially permeable membrane.

Part C is called the cytoplasm. This is the site where most of the chemical reactions of living things take place. It is a jelly like watery liquid which contains a large number of the smaller parts of the cell called organelles. Student what are organelles? Organelles are small parts or organs of the cell.

Examples of organelles include the mitochondrion. This is the organelle where respiration takes place. Chloroplast structure D (on the diagram) is also an organelle found in plants. Chloroplast contains a pigment called chlorophyll.

Do you have any idea of what the function of this pigment is?

I will give you a hint. It plays a very important role in photosynthesis.

What is it?

You should have said, they are responsible for trapping sunlight energy to use during photosynthesis. The sun provides the energy that the plants need to manufacture carbohydrates using carbon dioxide and water.

Structure E is called the nucleus. It is sometimes referred to as the heart of the cell. Do you have any idea why this is so? Well it is because it controls all the activities of the cell. A lot of chemical reactions take place in the cell. These reactions include respiration and photosynthesis. All these reactions are controlled by the nucleus.

Another part found in the plant cells is the vacuole, labeled F on your diagram.

This is found in the centre of the cell and it contains a watery liquid called cell sap.

The vacuole takes up a large volume of the cell and is separated from the cytoplasm by a thin membrane. The function of the part is that it acts as a storage place for plant foods such as sugars and salts dissolved in water.

Another very important function of the vacuole is to create some pressure on the cell wall and thus keeping it rigid or firm.

I hope you have now attached names to the blank spaces next to the alphabets. Let us check to see whether you got the labels correct.

A – cell wall

B – cell membrane

C – cytoplasm

D – chloroplast

E – nucleus

F – vacuole

If there is any you got wrong please do your corrections.

Let us now look at an animal cell.

Animal Cell

This cell has been labeled for you.

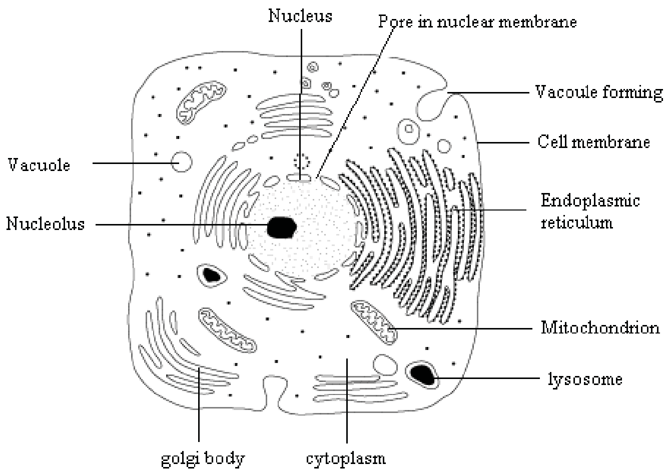


Figure 2: Animal cell

Do you see any similarities between this cell and the plant cell we discussed earlier on in section 1.0?

Activity 1

From what is described on the plant cell figure 1, and the diagram of an animal cell in figure 2, state below what you observe as similarities between an animal and a plant cell.

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Feedback

You should have mentioned that they have a cell membrane, cytoplasm and a nucleus. The animal cell also has a mitochondrion which is an organelle.

I would like you to name the function of this organelle.

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Feedback

Mitochondria (one is a mitochondrion) are organelles used to produce energy in cells they are more prominent in animal cells, probably because animals are more active than plants and therefore need more energy.

The parts which are also found in an animal cell have the same function as those found in plants.

Activity 2

Can you now recall and state the functions of the following parts?

Nucleus

Cytoplasm

Mitochondrion

Feedback

Once again you can check your answers by going back to the section on a plant cell.

Comparison between a plant and animal cell

If you further compare these cells, you might notice that there are certain differences which exist amongst the two.

Activity 3

Study figures 1 and 2 again and note down the features that are present in one and not in the other. These features are the differences between the two types of cells.

Feedback

One obvious difference, you would have noted, is that the animal cell does not have a cell wall.

This is only found in plant cells. Other parts which are not present in animal cells include the chloroplast and vacuole

The next table summarizes the similarities and differences that exist among these cells. We have discussed all of them in the above section.

Table 1: comparison of a plant and an animal cell

Similarities	
Plant Cell	**Animal Cell**
Has a cell membrane Cytoplasm present Nucleus present Mitochondrion present	Has a cell membrane Cytoplasm present Nucleus present Mitochondrion present
Differences	
Plant Cell	**Animal Cell**
Has cell wall Has vacuole Chloroplasts present	No cell wall No vacuole No chloroplasts

Plants and animals consist of millions of cells. Each cell has a specific role to play in the body of the organism. We have noted three major differences between animal and plant cells. There are also other differences within these groups as different cells are adapted to their functions within organisms.

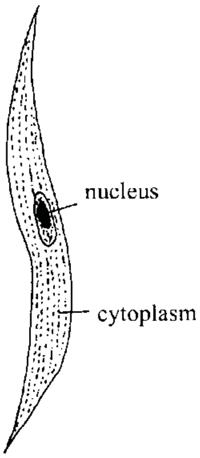
Let us now continue and look at the structure of cells and why they have that particular role.

The structure of Cells in Relation to their Functions

Both plant and animal cells have the structure that suits their functions. This section deals with the structure of selected plant and animal cells to show you how the shape of cells is related to the work they do in the organism.

Structure and functions of selected animal cells

The shape of animal cells makes them able to perform their functions for the well being of the organism. For example the muscle cells are structured in such a way that they are able to contract and relax just like a rubber band. This is probably why their cells are thin and long as the diagram below shows.



A Muscle Cell

Activity 4

Within the bloodstream there are also cells. Can you name any cell found within the blood?

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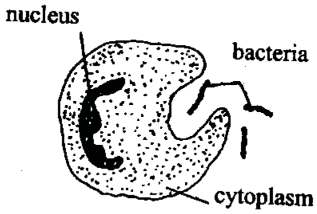
Feedback

If you couldn't think of any, don't worry as I will help you.

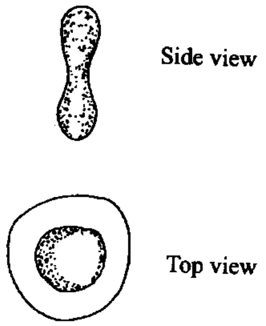
The cells that make up blood include red blood cells and white blood cells.

What are the functions of these cells? Well, the white blood cells provide the body with defense against invasion by pathogenic or disease causing organisms. These cells are able to change their shape so as to encircle and engulf the pathogen as shown in the diagram below.



A white blood cell engulfing a pathogen

The red blood cells on the other hand are responsible for transporting oxygen throughout the body. All these cells have been structured in such a way that they are able to achieve their function. Unlike other cells, the red blood cells have a biconcave shape (as shown below). This shape provides them with a large surface area to volume ratio for maximum absorption of oxygen

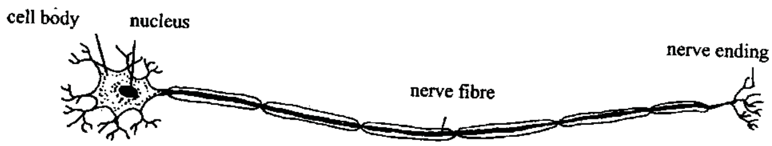


A red blood cell

Another feature of red blood cells is that they are pliable that is they can easily change shape. This characteristic makes it possible for them to squeeze through very small spaces such as those of blood capillaries.

There is another type of cell in animals known as nerve cells. These cells are responsible for transmitting impulses or messages from the sense organs/receptor organs to the nervous system and from the nervous system to the effectors or organs where a response is going to be undertaken.

Nerve cells are well adapted to carry out their functions. For example, they are long and thin. This enables them to transmit messages over long distances within the body.



A nerve cell

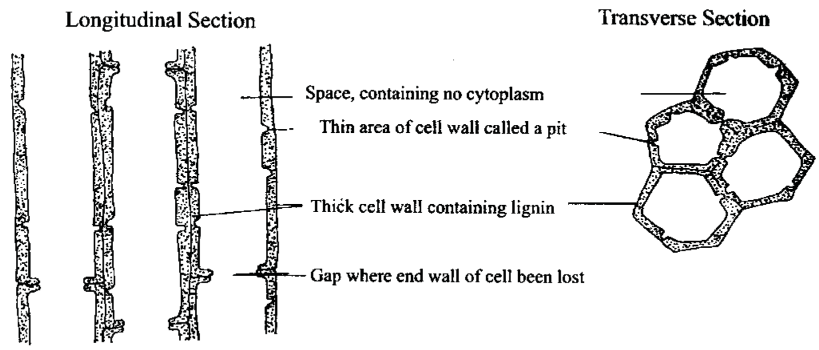
The fact that the structure of a cell is related to its function is known as cell specialization. That is to say, each animal and plant cell is specialized to play a particular role in that organism.

We have seen how the shapes or structure of selected animal cells match their functions. In the next section we are going to see that the same applies to plant cells.

The Structure and Function of Selected Plant Cells

It is not only animals who have specialized cells, even plants do have such types of cells. An example can be "xylem cells". Their function is to transport water and mineral salts from the soil to all parts of the plant.

Let us now look at how these are structured.



Xylem cells

What do you notice about the cells? Can you see that they have lost their cross walls? Well, the loss of cross walls has resulted in the xylem forming a cylindrical tube running from the roots to the aerial parts of the plant. Figure 15 above shows how tubes look like. The left hand side, i.e. the longitudinal section shows how the cells look like if viewed from the side vertically. The transverse section shows the cross section of the cells if viewed from above. Remember that these cells are cylindrical. This facilitates an uninterrupted flow of water through these vessels. The walls of the xylem cells have a compound called lignin. Lignification actually toughened the cells as a result they can withstand the pressure of water passing through them.

We have been looking at the structure and the functions of cells and in the following section we will look at how cells are grouped in living organisms.

Cellular Organisation in Living Things.

Cells of a particular type are usually grouped together to form a tissue. For example xylem tissue, muscle tissue, etc. xylem tissue consists of xylem cells whilst muscle tissue consists of muscle cells.

Organisms with many cells in their bodies are more effective and efficient because jobs are shared by the cells. This is called division of labour and work in living things proceeds very fast because of this. A situation like this can be compared to work in a clothing factory, where some people fit in buttons while others sew on zips and yet others iron and pack the finished garments. There is also a room for specialization. This is opposed to a situation where each cell does every activity for itself, it takes a long time and there is no room for specialization.

You can imagine if only one xylem cell was to transport water from the soil. Many parts of the plant would definitely remain without water.

A tissue can therefore be defined as a group of cells which are similar in shape and size and perform the same function.

Different tissues occur in a living organism. Several tissues may be grouped together forming a functional unit called an organ. Examples of organs in plants include roots, stem and leaves whilst in human beings, the lungs, kidneys, etc are examples of organs. These organs perform clear functions and are made of different types of cells and tissues.

Activity 5

Think of your body and identify three organs and their functions. These organs are also made of different tissue. For each organ, identify two tissues and complete the table.

Organ	**Function**	**Two tissues**

Feedback

You should have mentioned some of the following organs;

Organ	Function	Two Tissues
Heart	Pumps blood around the body	Muscle
		Fat
Skin	Covers and protects internal and external body parts	Germinative
		Granular
Stomach	Breakdown and absorption of food	Muscle
		Fat

There are many organs in the body you could have mentioned. From the above, I mentioned the lungs and kidneys. Of course there are many more like eyes, nose, ear, arms, legs, intestines, brain and so on. You can see that your answer may be right although it does not appear here. Confirm by reading books in the reference list.

I can't mention all the functions here since I don't know which organs you identified. But I hope that you identified the organs and their functions. Tissues in those organs are many. You have the muscle, nerves, blood and bone tissues. Please check in the reference books if any other tissue you mentioned is correct.

Do you think that organs within the body can work independently of one another?

Definitely not! Organs work with one another to carry out specific life processes. When they do work with one another, they form an organ system.

An example of such a system can be the reproductive system. The organs that make such a system say in females are womb, vagina, uterus and others.

What about the organs that make up the male reproductive system?

You should have mentioned the testicles, penis, cowper's gland and others. You will learn more about these systems in unit 10 which is on Reproduction and the Continuity of Life.

Summary

We have now come to the end of the topic. At this stage you should be able to label animal and plant cells, describe their similarities and their differences. Their similarities include the following: they both have cell membrane, cytoplasm, nucleus and mitochondrion. On the other hand the plant cell has a cell wall, a vacuole and some chloroplasts which an animal cell does not have.

We also looked at the structures of some plant and animals to show that the shape of a cell is related to the work that the cell performs in the organism.

We also learned that a group of cells performing the same functions is called tissue. Furthermore a group of tissues may be grouped together to form a functional unit called an organ.

Let us now continue and look at the last topic in the unit which looks at what is happening within cells. But before you do so, you know that you should do the end of topic assignment as you have done in all the other units.

Topic 5: Cell Processes

In the previous topic, you learnt about the different parts of a cell and their functions. However there is one part which I feel we should go over again and that is the cell membrane. We said this part has a very important function.

Do you remember its function?

As you may remember, it controls movement of substances into and out of the cell. In fact, this is what we are going to learn about in this topic. There are three processes involved in such a movement and they are diffusion, osmosis and active transport.

I hope you will enjoy the topic.

Learning Objectives

At the end of the lesson, you should be able to:

- Define diffusion
- Define osmosis
- Describe the effect of osmosis on both plants and animal tissue
- Conduct experiments using solutions of varying concentrations to demonstrate osmosis
- Explain what active transport is

Learning Resources

These resource materials are needed for the lesson:

1. Purple crystal or any crystal that can dissolve in water. An example of such a crystal would be sweet aid or cool aid.
2. Petri dish or saucer or just a clear glass plate
3. Water

Lets kick start our lesson by looking at diffusion.

Diffusion

This is the movement of molecules of gases or even liquids from regions of high concentration to where they are less concentrated. The end result is that the molecules will be evenly distributed. As mentioned earlier on, diffusion takes place on both the liquids and gases. This is to say particles of both gases and liquids can diffuse.

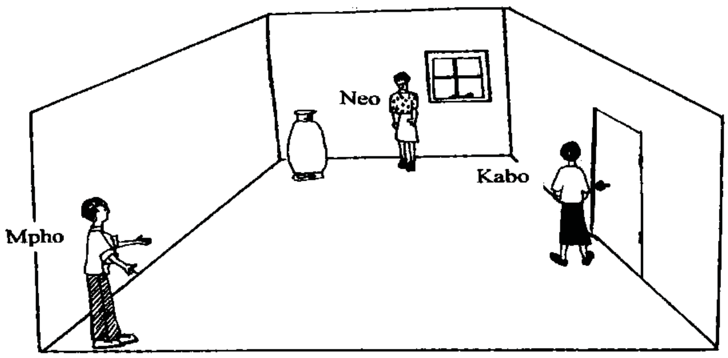
Think about what happens if one sprays a perfume at one corner of the room. Very soon the perfume can be smelt all over the room. This illustrates the point that the perfume molecules (gas molecules) had moved from the region where they were more concentrated to where they were not present at all. Perfume molecules were concentrated where the perfume was sprayed and after some time they were spread evenly around the room. That is the reason why you smelt the perfume even though you did not go to the corner where it was sprayed.

Now let us think about what is happening in the next activity.

Activity 1

Kabo, Neo and Mpho are inside a room with closed windows and door as shown below.

A gas cylinder is placed at one corner of the room and its tap is turned on.



Amongst the three who will smell the gas fumes first? And Why?

____

____

____

Feedback

Obviously Neo will smell the gas first. This is because she is closer to the source where the molecules are in high concentration.

After Neo who is next and why?

____

____

____

Feedback

Definitely Kabo will be the next. This is because the molecules are moving further away from the source to where they are they are least concentrated.

Ultimately the gas molecules will start moving towards Mpho. The movement of gas molecules will continue until there is an even distribution of gas molecules in the room. For this activity make sure that you do not have fire near the room because it can be very dangerous. The gas catches the fire easily and you might end up causing a lot of damage.

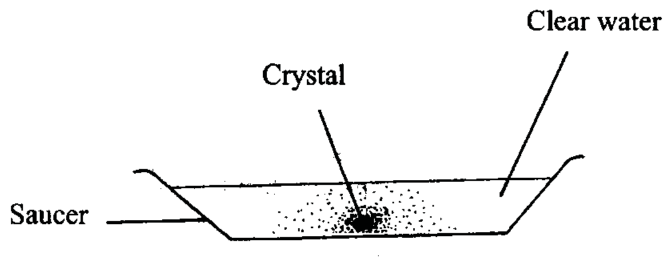
This is an example of diffusion in gas. The next experiment illustrates diffusion in liquids.

Activity 2

You will need the following apparatus:

- A purple crystal
- A petri dish or a saucer
- A glass of water

Procedure: Fill the saucer with water up to the surface. Then put the crystals into the saucer. It should be placed in the middle of the container, as shown below.



The crystal should be carefully placed into the water, that is, try by all means not to stir the water. It can be placed using a pair of forceps or even a pair of scissors.

Observe and note down what happens to the crystal after 10 minutes, after 1 hour and then after 24 hours.

Observations

10 minutes____________________________________

1 hour ____________________________________

24 hours ____________________________________

Explain your observations

____
____
____
____
____

Feedback

After 10 minutes the purple colour will have spread away from the point where the crystal was placed.

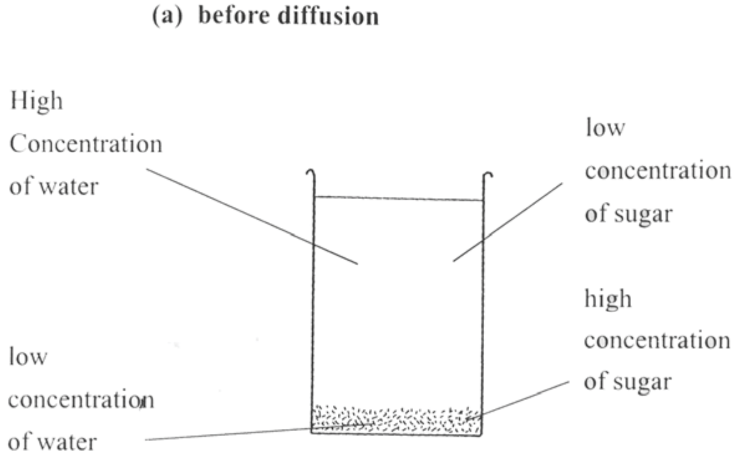
After 1 hour the crystals will have spread further away from their original point.

When 24 hours has passed, the purple colour of the crystal will have completely covered the water.

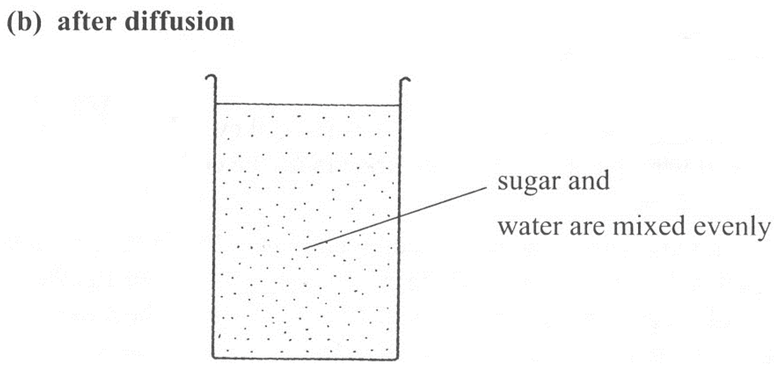
The above observations happened because the crystal molecules were diffusing from the point where they were originally at a higher concentration to where they were at a lower concentration or not present at all. This ultimately resulted in an even distribution of the crystal molecule throughout the saucer.

The next example further illustrates diffusion.

Dineo added 3 tablespoons of sugar into an empty glass. She then gently added about 200 millilitres of water into the glass. Diagram (a) shows how the mixture at the beginning, the sugar and the water are still separated with the sugar at the bottom and the water above. The mixture was then left sometime, say a day.



After 24 hours, the sugar and water molecules had already mixed as sown in the diagram below.



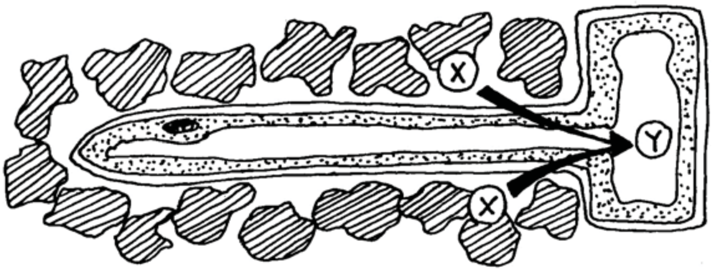
So while water molecules move towards the sugar at the bottom, sugar molecules move towards the water. The molecules move from high to low concentration until they are evenly mixed.

Diffusion of gases is faster than diffusion in liquids because there are larger spaces between the fast moving molecules of a gas. It is by diffusion that useful substances like oxygen diffuse into a cell and waste substances like carbon dioxide diffuse out of cell.

There is a special type of diffusion that takes place in living things that is called osmosis and this is what is going to be discussed in the next section.

Osmosis

Osmosis is the movement of substances from high concentration to low concentration through a semi-permeable membrane. It is a type of diffusion but this time the particles go through a selectively permeable or semi-permeable membrane. Only those particles that are small like particles of water can diffuse. In the previous section, we mentioned the cell membrane and said because it is selectively permeable it controls what goes in and what comes out of a cell.



Osmosis in Cells

In the figure above X represents water molecules and Y is the cell cytoplasm. The water is moving from the soil where it is highly concentrated into the cell where it is low in concentration.

Each cell in living things is surrounded by a cell membrane. Inside the cell there are many different molecules. If you think of the cell membrane as a bag and the molecules inside the cell as groceries, it should help you to understand how the molecules are contained in a cell membrane. The distinguishing factor between osmosis and diffusion is that in osmosis substances pass through a semi-permeable membrane whilst in diffusion there is just free movement of particles of any size.

Do you still remember which part of the cell is semi-permeable? It is important that you answer this question before going onto the next section. If you do not remember go back to Topic 4, and go over section 1.0 again.

Let us now continue and look the last part that deals with movement of particles in cells and that is by active transport.

Active Transport

Did you notice anything common between osmosis and diffusion?

____

____

____

Well in both processes there is movement of particles from high to low concentration until there is an even distribution.

There is another transport (movement) that exists in living things. In this type of movement particles move from points of low concentration to that with high concentration. This movement is said to be against a concentration gradient. For this to happen, energy has to be used. In osmosis and diffusion movement is along a concentration gradient.

This movement of molecules from an area where they are few to an area where they are many is called active transport. An example of where this happens is in the roots of a plant. If you pull out a plant from the soil and observe the roots of that plant you will notice that the roots of that plant have got some hairs in them. Those are meant to absorb mineral salts from the soil. Mineral salts are normally present in the soil in very low quantities and under normal circumstances (by osmosis) these minerals salts are supposed to move from the plant into the soil. But then the root hairs take up the mineral salts from the area of low concentration to the area of high concentration, that is, against the concentration gradient. What this means then is that you need a lot of energy for this to happen, and therefore active transportation can only take place in living things. If a cell dies it can't produce energy and therefore active transport stops.

Summary

In this topic you learnt about some of the processes that take place in living cells. These are diffusion, osmosis and active transport. All of them are responsible for the movement of substances in and out of the cells.

Osmosis and diffusion are similar in that they involve the movement of substances from areas of high concentration to areas of low concentration, that is, along the concentration gradient. They also do not require energy to happen.

Osmosis is sometimes referred to as a special type of diffusion. Their difference is that in osmosis the substances or particles move across a semi-permeable membrane whilst in diffusion molecules move freely.

Active transport on the other hand involves movement of particles from areas of low concentration to areas of high concentration. Unlike osmosis and diffusion, it is an energy requiring process.

The end of topic assignment can be found in the end of the unit. Complete it and check your answers against the ones provided as we have advised earlier.

Unit Summary

Summary

In this unit you learned how living things feed, grow, move, sense, reproduce, excrete and respire. We also learnt about organisms that affect human health and these include viruses, bacteria, protozoa and fungi. These organisms can either be pathogenic or non-pathogenic. Worms and insects were also covered.

In the last parts of the unit we looked at the building blocks of life and cells. We looked at both plant and animal cells. We also looked at processes that take place in cells and these are diffusion, osmosis and active transport. All of them are responsible for the movement of substances in and out of cells.

Remember that this is the first unit of the course and most of the concepts covered will be dealt with in more detail in the units that follow. As already mentioned in the teaching and learning approach, we have an assignment with some answers at the end which are for you to check your own understanding of the unit. Please be honest with yourself do assignment then check the when you finish. I hope you have enjoyed the unit.

Assignment

Assignment

Topic 1 Assignment

1. Is a plant a living thing? [1 mark]

2. Give **two** reasons for your answer in (1) above [4 marks]
   (a)
   (b)

3. Name **two** life processes in a plant [2 marks]
   (a)
   (b)

4. Living things carry out seven important life processes. Certain things that are not alive also carry out some of these life processes. Cars, for example, move and excrete

(a) Explain why it is reasonable to think that cars excrete [2 marks]

(b) Name **two** other processes which cars carry out that are like life processes. [2 marks]

(c) Explain why the two processes you chose in part (b) are like life processes. [2 marks]

(d) How will you convince somebody that cars are not living. [2 marks]

5. List and explain any five characteristics of living things that you did not mention in the above questions [15 marks]

   (a)

   (b)

____

(c)____

____

(d)____

____

(e)____

____

Each correct answer is 3 marks. One mark awarded for the characteristic and two marks awarded for the explanation.

Total[30 marks]

Topic 2 Assignment

1. Explain why viruses are sometimes considered as non-living? [2 marks]

   ____

2. (i) Viruses live as ______________________________ in their hosts. [1 mark]

   (ii) What does the term "host" mean? [2 marks]

   ____
   ____

3. Compare reproduction in bacteria, fungi and viruses. [3 marks]

   ____
   ____
   ____
   ____

4. Under favourable conditions, a bacterium divides into two every 20 minutes. Starting with a single bacterium, how many bacteria would this rate of division produce in one hour. [4 marks]

   ____
   ____
   ____
   ____

5. There are two types of bacteria. One is pathogenic and the other is non pathogenic. Non-pathogenic bacteria can be helpful to

man. State three ways in which this type of bacteria can be helpful to man. [3 marks]

____
____
____
____

TOTAL[15Marks]

Topic 3 Assignment

1. (a) Name the disease spread by schistosoma [2 mark]

____

(b) Name the two hosts of schistosoma [2 marks]

____
____

(c) Describe how humans are infected with this disease? [3 marks]

____
____
____
____
____

2. (a) Complete the following life cycle of a mosquito [2 mark]

Egg ⇨ ____ ⇨ pupa ⇨ ______

3. How can knowledge of the above cycle help in the control of the disease? [2 marks]

____
____
____
____

4. Give two functions of the hooks on the mouth part of a hookworm [2 marks]

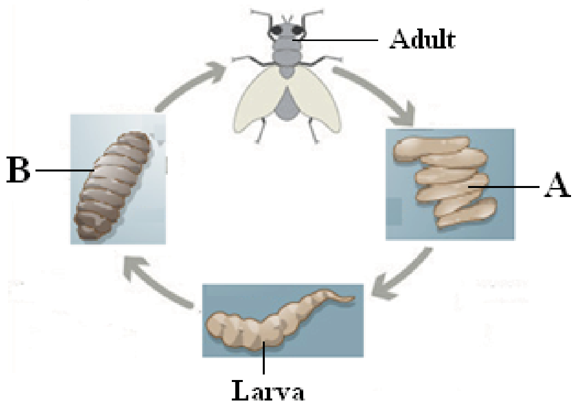
____
____
____

5. Differentiate between complete metamorphosis and incomplete metamorphosis. [3 marks]

____
____
____
____

6. Discuss the ways in which house flies can be kept away from food. [5 marks]

7. (a) Complete the following diagram which shows the life cycle of a housefly. [2 marks]



A ____

B ____

(b) How can the knowledge of its life cycle be used to control the above vector. [2 marks]

Total [25 marks]

Topic 4 Assignment

1. What is a cell? [1 mark]

2. (a) State three differences between a plant and an animal cell. [3 marks]

(c) State three similarities between a plant and animal cell. [3 marks]

3. Define the following and give one example of each. Each correct answer caries two marks. One for the definition and the other mark for the example. [8 marks]

(a) Cell:____

____

(b) Tissue:____

____

(c) Organ:____

____

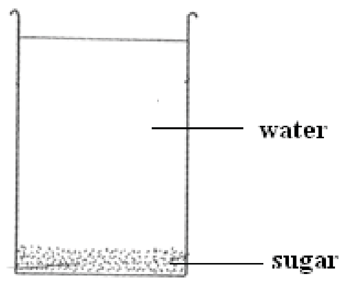
(d) System:_______________________________________

____

Total [15 marks]

Topic 5 Assignment

1. Look at the diagram below:



(a) Where can you find a high concentration of sugar molecules? [2 marks]

____

(b) What will eventually happen to the sugar molecules? [1 marks]

____

(c) Explain why you stir a cup of coffee after putting in the lump of sugar? [1 marks]

(d) What would happen if you put a drop of ink into a jar of water? [2 marks]

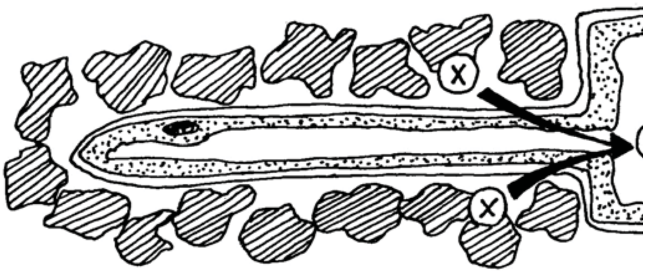
2. Would diffusion of a liquid be faster or slower than diffusion of a gas? [1 marks]

Explain your answer. [1 marks]

3. Name **one** useful substance which diffuses into a cell. [2 marks]

4. What is the difference between an impermeable and selectively permeable membrane? [2 marks]

5. The arrows in the next diagram shows the movement of water into a root hair cell from **x** to **y**.



(a) State the process happening in the root. [1 mark]

(b) What could be the main cause of the movement of water into the cell? Explain in detail. [2 marks]

Total [15 marks]

Answers for Assignments

Assignment 1 Answers

1. Yes

2. Plants do the following; they excrete, they are sensitive, they move, grow, reproduce, feed and respire

3. Any two of the above mentioned processes

4.

   (a) They are able to remove carbon dioxide and water, from the engine, which are waste products of fuel combustion
   (b) Combustion of fuel detects changes

   (c) Combustion of fuel is comparable to respiration since the process produces energy. Detection changes in the environment is similar to sensitivity

   (d) They do not reproduce and grow

5. Refer to text, sections 1.1 to 1.7

Assignment 2 Answers

1. They show no signs of life outside a host

2. (i) Parasites

   (ii) Organism which provides nourishment and shelter to a parasite

3. Bacteria produce asexually by binary fission whilst some fungi produce sexually and other asexually. Viruses on the other hand produce asexually.

4.

Time Minutes	No of Bacteria
0	1
20	2
40	4
60	8

The number of bacteria will be 8 after one hour

5. Bacteria can be used for the following:

    - Sewage treatment
    - Food production e.g sour milk
    - Production of vitamins K and B12 in human intestines

Assignment 3 Answers

1. (a) Bilharzia

    (b) Snail and humans

    © through bathing or drinking water contaminated with the fluke

2. Larva

3. This can help in that one can know the stage at which the parasite is prone to methods of controlling it. That they know the stage at which the parasite is vulnerable. Control method.

4. Cuts through the skin for blood to be sucked. Attachment of parasite onto host.

5. Complete metamorphosis results in a rapid transformation from the larval to the adult form whilst in incomplete metamorphosis the changes are minimal

6. By covering the food. Another way is to use insecticides and repellents to kill flies. Safe disposal of refuse can also help since they provide breeding grounds for flies.

7. (a) A – Pupa B – Eggs

    (c) The answer has the same sense as in 3 above

Assignment 4 Answers

1. Basic unit of life

2. (a) Plant cell has a large vacuole, chloroplasts and cell wall, which and animal cell does not have

    (b) They both have a nucleus, cell membrane and cytoplasm

3. (a) Unit of life, eg red blood cell

    (b)Tissue: group of cell performing one function e.g epithelial tissue, muscle tissue
    © Organ: is a group of tissues performing a broad function e.g

heart
(d)System: A group of organs performing many functions e.g digestive system

Assignment 5 Answers

1. (a) At the bottom of the glass

   (b) They will be evenly distributed in the container

   ©To make the sugar diffuse faster into the water

   (d)The ink will diffuse into the water until its molecules are evenly distributed

2. Diffusion of gases is faster because there are bigger paces between the gas molecules. These spaces make movement much easier and faster

3. Oxygen or food

4. An impermeable membrane allows no particles to pass through whilst the other allows some but not all particles to pass through

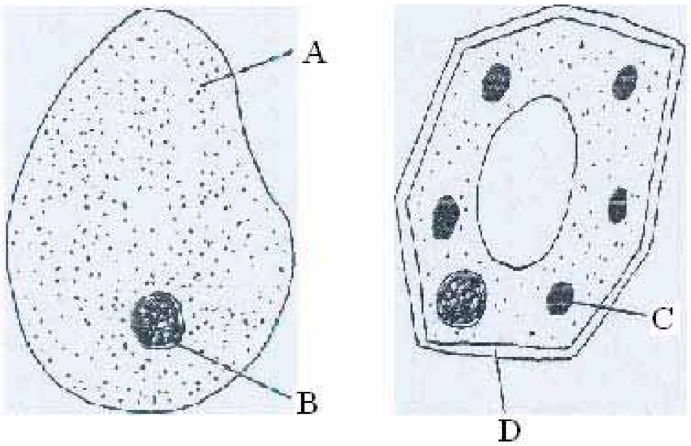
5. (a) Osmosis

   (b)The concentration of sugar and salts at Y is higher than at X, while the concentration of water at X is higher than at Y. Then water moves from X (in the soil) where it is high, into the cell at Y, where it is low.

Assessment

Assessment

1. Which labeled structure A, B, C and on the diagrams below contains large amounts of DNA?



2. Which one of the following organisms exists as parasites only?
   A. Bacteria
   B. Fungi
   C. Protozoa
   D. Viruses

Questions 3, 4 and 5 refer to the cell structures listed below.

1. cell membrane
2. cellulose cell wall
3. cytoplasm
4. vacuole
5. chloroplast

3. **Which two** structures appear only in plants?

   A. 1 and 2
   B. 1 and 3
   C. 1 and 5
   D. 2 and 4

4. In a plant cell, which two are selectively permeable therefore allowing water and small solute molecules to pass into the cell?

A. I and 2
B. I and 3
C. 2 and 3
D. 2 and 4

5. ___________ contain(s) the pigment chlorophyll, which traps sunlight.

A. 1
B. 1 and 4
C. 4
D. 1 and 5

6. Structure ________ is found in both plant and bacterial cells but not in animal cells.

A. 1
B. 2
C. 3
D. 2 and 3

7. Which one of the following gives the correct sequence in the lifecycle of a housefly?

A.	egg	adult	pupa	larva
B.	egg	larvae	adult	pupa
C.	egg	larvae	pupa	adult
D.	egg	pupa	adult	larvae

8. Hookworm is spread by

A. snails
B. food
C. rats
D. water

9. Excretion, irritability and movement are characteristics of

A all animals and plants
B animals only
C animals and some plants
D plants only

10. Draining stagnant water is one method of controlling one of these insects, which one is it?

A. Mosquito

B. Housefly

C. Cockroach

D. Bees

11. Humans may be infected with schistosoma by

A. Eating meat from an infected cow

B. living food uncovered

C. bitten by anopheles mosquito

D. walking barefooted on infected soils

12.Which of the following exists only as parasite?

A. Houseflies

B. Virus

C. Bacteria

D. Protozoa

13. Which of the following groups contains the smallest organisms?

A. Algae

B. Bacteria

C. Fungi

D. Insects

14. Which structure controls the activities of the cell?

A Mitochondrion

B Nucleus

C Ribosome

B Cell membrane

15. All living organisms are made up of

A. One or more cells

B. Tissues

C. Organs

D. Organ systems

16. What will happen to cells if they are left in distilled water?
    A. Water moves into them by osmosis
    B. They die
    C. They become plasmolysed
    D. The cells become soft

17. ___________ do not have a nucleus.

    A. Bacteria

    B. Fungi

    C. Viruses

    D. Protozoa

18. What is the main physical difference between round worms and flat worms?

    A. Round worms are parasites whilst flat worms are not

    B. Round are round whilst the other one is flat in shape

    C. Flatworms are parasites whilst roundworms are not

    D. Roundworms are intestinal parasites whilst flat worms are blood vessel parasites.

19. Snail are vectors of which pathogen?
    A. Malaria parasite
    B. Cholera
    C. Plasmodium
    D. Schistosoma

20. Which of the following is a tissue

    A. Eye

    B. Ear

    C. Muscle

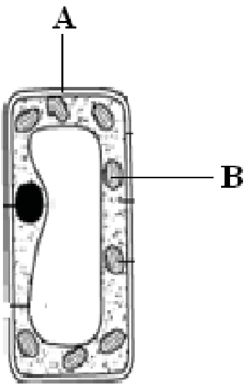
    D. Lungs

[20 Marks]

Section B

Answer all questions on the spaces provided.

1. The digram below shows a typical plant cell.



(a) Name the part labeled A ____________________ [1 mark]

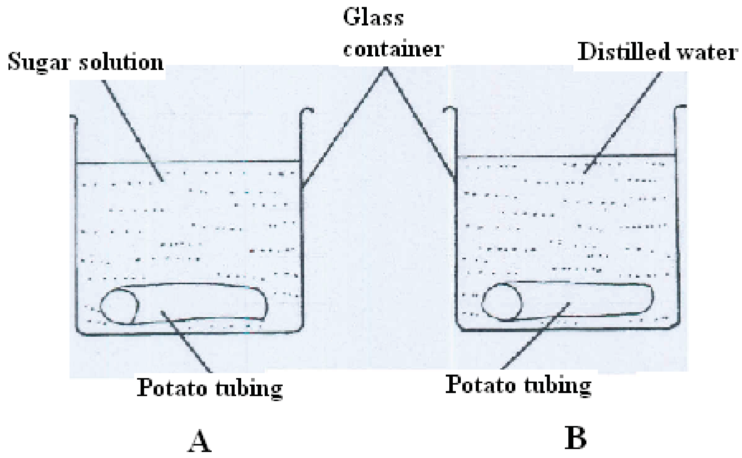
(b) What is the function of the part labeled B. [2 marks]

____

____

____

(c) Two experiments were set up as shown below to investigate osmosis.



In which setup did the potato tubing increase in size? Explain why?

____

____

____

____

____

____

____

2. (a) Explain fully what is meant by the term osmosis. [2 marks]

(b) Kabo and Neo investigated how the mass of the potato tubings changed when in different concentrations of sugar solutions. Some of the tubings were boiled first. The slices were first weighed and then placed in solutions of varying sugar concentration for 25 minutes. They were then weighed again. Suggest three ways in which the experiment can be improved. [2 marks]

(c) In the experiment Kabo and Neo calculated the percentage mass gain or loss of the potatoes. Why was this better than simply using the actual mass gain or loss. [3 marks]

3. Plant cells have two structures, which are not found in animal cells. These are cell wall and chloroplasts.

(a) What is the main function of cell wall in plants? [2 marks]

(b) What problems would animals have if their cells had a tough cell wall? [1 mark]

(c) What is the main function of chloroplasts in a plant cell? [2 marks]

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Contents

HSB Unit 2

Nutrition and Diet

Introduction

Welcome to unit two of the Human and Social Biology course. In Unit 1 you learned that one of the characteristics of living things is feeding. Living things feed in order to get energy to carry out life processes which makes them different from non-living things. On the other hand plants, unlike other living things, are able to produce their own food by utilizing energy from the sun. This energy is then passed on to other living things when the plants are consumed. The energy stored in any type of food that one eats can be traced back to plants and ultimately to the sun. There are other nutrients that form part of the nutrition needed by living things. These have important roles to play in living things.

In this unit we shall be looking at a special type of feeding which is based around the fact that everything needs to consume energy to carry out work and to remain healthy. Nutrition can be defined as the provision that allows an organism to assimilate food and use it for growth, work and health. There is a strong relationship between health and diet, good food leads to good health and this will be covered in more detail in Unit 12 when we look at health and diseases. In this unit we will look at nutrition in general, that is sources of nutrients, their types, and uses.

This unit consists of three main topics: photosynthesis and the carbon cycle; classification of nutrients; and sources of nutrients. Photosynthesis is a process in which green plants manufacture food from carbon dioxide and water. The carbon cycle illustrates the significance of the circulation of the carbon element in the form of carbon dioxide between the earth, living organisms, and the air. Do not worry if you don't understand this now as this will be discussed in more detail further in the unit. It is also very important to note that food production is not only done through plants but also by microorganisms, such as in an industrial process called biotechnology which you will study in Unit 14. Examples of food produced by biotechnology are yoghurt, cheese, bread, wine, beer and so on. These are food items that you are always buying and eating, aren't you? You will definitely enjoy this topic very much.

Time Frame

It is estimated that to complete studying this unit you will need between 10 to15 hours. Do not worry if you take longer in finishing this unit. Remember that we all have different abilities and hence we study at different paces.

You are encouraged to spend about 2 hours to answer the assignment in this unit. You will also need approximately 3 hours on the assessment at the end of the unit.

The total hours for completing the unit will thus be between 15 and 20 hours.

Teaching and Learning Approach

The teaching and learning approach for this topic is learner centred and based on your previous knowledge and experiences. This is meant to motivate you to explore information on your own or as a group at home and even in your study centre. You are encouraged to form study groups with other learners in your area to discuss the subject matter and assist each other in your studies. This will help you to do research and develop initiative and interest in studying. A number of activities have been included in the unit to help you interact with the learning material and you are encouraged to do all the activities in the unit. There are also some practical activities designed to improve understanding and application of scientific concepts for everyday life situations.

The unit as we have seen above is on nutrition and diet and this forms part of our day to day living. We should know what type of food to eat and when to eat it as this has a direct impact on our health. We have in-text questions and activities with feedback to assist you as you work through the unit. The activities will facilitate your understanding of concepts of life as well as help you build skills, knowledge and practical applications. At the end of the unit there are assignment and assessment activities with feedback provided to help check your understanding of the content.

Upon completion of this unit you will be able to:

Outcomes

- *Explain* how green plants produce their own food.
- *Describe* how human beings depend on plants for food.
- *Describe* how carbon is recycled.
- *Describe* the major sources and uses of nutrients.
- *Explain* the importance of a balanced diet.

Terminology

Carbon Cycle: Circulation of the carbon element between the earth and the atmosphere.

Chloroplasts: These are green-coloured organelles found within the plant cell that contains chlorophyll.

Peristalsis: Is the movement of food along the oesophagus caused by the alternate contraction of the circular and longitudinal muscles.

Combustion: The act of burning a substance e.g. coal

Fossilization: Process through which dead remains of organisms change into fossils and fossil fuels over time (i.e. usually it takes millions of years for that to happen).

Fossil Fuels: These are substances that release heat energy when burnt e.g. coal, natural gas, crude oil.

Photosynthesis: Is a process through which green plants produce their own food.

Online Resource

If you can get on the internet please utilize the resources at www.hippocampus.org. It is an excellent source of information for biology and the topics discussed in this unit. Here you will find:

- Presentations
- Simulations
- Videos
- Online Study Groups
- Links to Even More Information
- Textbook Correlations
- Online Courses

Topic 1: Photosynthesis and the Carbon Cycle

In this section you will learn about photosynthesis and how it results in food production for which human beings and other living organisms are directly or indirectly dependent.

Human beings obtain their food from plant products and from animals which feed on plants. All food substances, be it, energy giving foods or body building materials, are made by plants. Among other things human beings eat seeds of plants, fruits, leaves, roots, as well as milk, beef, butter, and cheese, which come from cattle that eat plants (grass). Whatever item human beings eat, therefore, can be traced back to green plants. On the basis of this, plants are sometimes referred to as producers.

The carbon cycle plays a significant role in the production of food. All living things need carbon to make proteins, carbohydrates and fats. This carbon can be transferred between organisms and the environment by a series of processes, e.g. respiration, photosynthesis, decay and combustion.

Learning Objectives

After completing the work in this topic you will be able to:

- Explain how green plants make their own food.
- Define Photosynthesis.
- State the word and scientific equation for photosynthesis.
- Describe how living things depend on photosynthesis for food.
- Describe the carbon cycle.

Photosynthesis

In unit 1, we learnt the characteristics that show that something is living. Living things feed, grow, reproduce, move, sense, respire and excrete. Feeding is very important as it provides energy for all these processes to happen. Think about what you ate the yesterday. How much of it came from plants?

Most of the food that we eat comes directly from plants e.g. maize meal, cornflakes, sorghum, rice, potatoes and so on. Others like meat come from animals that have eaten plants. Living green plants carry out the process of photosynthesis that forms the discussion in this section.

What is photosynthesis?

Green plants are able to make their own food from simple raw materials around them by a process called photosynthesis. The light from the sun is very important in this process as it provides energy for this to happen. This term is divided into two parts; that is "**photo**" and "**synthesis". Photo** – means light and **synthesis** means putting together.

There are four things that are needed for photosynthesis to happen:

- **Light energy**- usually from the **sun** is used to convert carbon dioxide and water into glucose.
- **Chlorophyll** – The **green pigment** that is found in **chloroplasts** and which makes leaves look **green**. Chlorophyll absorbs the energy in **sunlight** and uses it to combine carbon dioxide **(CO_2)** and **water** to produce **glucose**. Oxygen is simply a by- product.
- **Carbon dioxide** – carbon dioxide enters the leaf of plant by diffusion through the stomata.
- **Water –** comes from the soil up the stem through the xylem vessels and into the leaf.

What really happens in photosynthesis is that the light energy is used to convert carbon dioxide and water into glucose. Oxygen is then made as a waste product. This can be summarized by the following word and symbol equations:

- **Word equation**

$$\text{Carbon dioxide} + \text{Water} \xrightarrow{\text{Light energy}} \text{Glucose} + \text{Oxygen}$$

❖ **Symbol equation**

$$6CO_2 + 6H_2O \xrightarrow{\text{Light energy}} C_6H_{12}O_6 + 6O_2$$

The formula equation illustrates the short forms of chemicals involved as well as their balanced elemental number of atoms i.e. six molecules of carbon dioxide plus six molecules of water produce one molecule of sugar plus six molecules of oxygen. Chemicals on the left side of the equation: carbon dioxide and water, are called **reactants.** Those on the right side of the equation (i.e. glucose and oxygen) are **products.** All this can be illustrated in the diagram below.

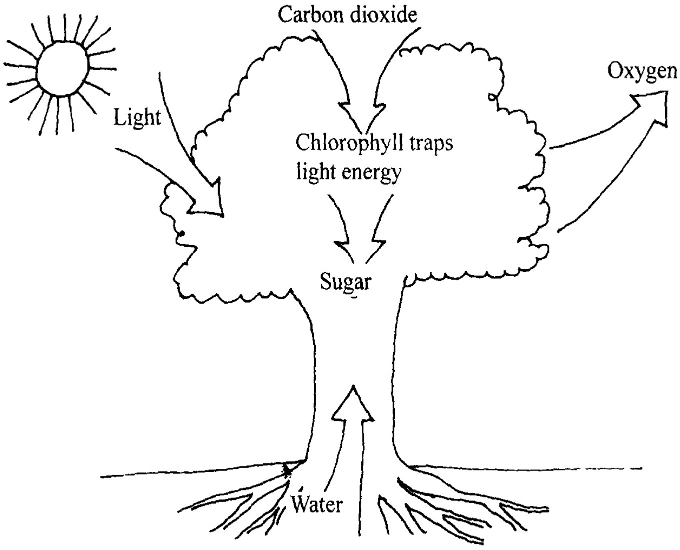

Figure 1: Photosynthesis in plants

The above diagram also sums up what happens in the plant, during the process of photosynthesis. Most photosynthesis takes place in the leaves of plants and the energy used in the process comes from the sun. The green substance in plant leaves called **chlorophyll** absorbs this energy. This energy is used to change water and carbon dioxide into sugar (glucose) and oxygen. Water and carbon dioxide are said to be raw materials for photosynthesis.

On the basis of the above discussions, we can define photosynthesis **as the production of carbohydrates by green plants using light energy from the sun to synthesize carbon dioxide and water.** Photosynthesis takes place in the **leaves** of all **green plants**. The carbohydrate produced is glucose. In the next section we shall look at how the products of photosynthesis are useful to living things.

Dependence of living things on photosynthesis

You will now look at how the glucose produced during photosynthesis can be used by living things. Also the oxygen produced is vital for the process of respiration which will be briefly discussed under the carbon cycle later and in more detail in Unit 4: The Respiratory System.

Green plants make use of some of the glucose (sugar) produced during photosynthesis. The glucose can be used by the plant in respiration to release energy. The energy, in turn, can be used to build large molecules from smaller ones:

- Sugars can be converted into insoluble **starch** and stored in the roots;
- Sugars can be changed into **cellulose** which forms new cell walls;
- Sugars can combine with nitrates and other nutrients to form **amino acids** which then can be used to build **proteins** for plant growth;
- Sugars can be converted into lipids (fats and oils) in seeds.

Green plants are sometimes referred to as primary producers. Do you know why?

Well it is because all living things depend on photosynthesis either directly or indirectly for nutrition and remember that plants are capable of photosynthesizing (as are some algae).

Plants obtain the energy they need to make food from the sun. Man and other animals depend on plants and plant products for food. This means that man and other animals are indirectly dependent on energy from the sun.

Let us now do a short activity to check our understanding of the discussing above.

1. What chemical does photosynthesis use to trap sunlight?

2. Which factors are needed for photosynthesis to take place?

3. Which gas is given off during photosynthesis?

4. What structures within leaf cells contain chlorophyll?

5. How does carbon dioxide get into the cells of a leaf?

6. After photosynthesis, what is glucose stored as in a leaf?

ACTIVITY 1

FEEDBACK:

I hope you found the activity fairly easy since we have just discussed all these matters. You should have given the following answers;

1) *chlorophyll*

2) carbon dioxide, water, chlorophyll and light energy
3) oxygen

4) chloroplasts

5) through diffusion via the stomata

6) starch

Before the activity we said that plants get their energy directly from the sun now imagine what would happen if the **sun** was to cease to exist?

- Green plants would die since they depend on sunlight to make their own food by photosynthesis.

- Plant eaters (herbivores) would die since they depend on plants.
- Flesh eaters would die since they eat other animals.
- Decomposers (organisms that feed by breaking down dead plants and animals) would eventually die from lack of food.

This means that all living things depend on photosynthesis directly or indirectly.

Below are a few examples of the dependence of living things on photosynthesis:

(a) Sun $\rightarrow$ green plants $\rightarrow$ cow $\rightarrow$ man

(b) Mophane tree $\rightarrow$ mophane worm $\rightarrow$ man

In all examples given, all food substances for man (and all the energy he needs) are traced back to plants.

Remember, from the equations and the discussions above, that there are two products of photosynthesis. We have been dealing with the sugar and the other product is oxygen which is released into the atmosphere as a waste product. All living organisms, plants and animals take in this gas during a process called respiration – to release energy for life.

Even if livings things are constantly taking in water, oxygen, minerals, and carbon dioxide, these materials never get used up completely because just as they are absorbed for use in some processes, other processes return them. In other words, there is a balance in nature in which losses **equal** replacements and materials are hence recycled again and again.

In nature materials move in cycles (they circulate). Let us look at the recycling of carbon as an example.

The Carbon Cycle

During the day plants absorb carbon dioxide as the raw material for photosynthesis. The carbon, which makes up the carbon dioxide, is incorporated at first into carbohydrates such as sugar or starch, and then into cellulose of cell walls and proteins and other organic compounds found in living organisms.

When animals eat the plants the organic plant matter is digested, absorbed and built into compounds making animal tissues. Thus carbon atoms from the plant become an integral part of the animal, but plants never run out of carbon dioxide because it is constantly replaced during the processes of respiration, decay, and combustion.

Respiration

All living things take in oxygen and food and release carbon dioxide and energy in the process called respiration. Respiration is virtually the opposite of photosynthesis and will be covered in more detail in unit 4.

Plants are eaten by herbivores, which also use the food and release more carbon dioxide. The same thing happens when herbivores are eaten by carnivores, energy and carbon dioxide are produced as a result of respiration.

Decay

After death, the bodies of organisms decompose (decay) and are absorbed by bacteria and fungi (decomposers). The bacteria feed on the dead organic matter and use it to produce energy and carbon dioxide during respiration.

Combustion

Combustion or burning of carbon compounds results in the release of carbon dioxide. Examples of carbon compounds include wood, coal, natural gas and petroleum oil. Minus the wood, these are fossil fuels which have been formed from the remains of dead plants and animals that lived millions of years ago. The process is called **fossilization.**

You have learned from the above that in the carbon cycle there are several processes which produce carbon dioxide. These processes include respiration and combustion. There is only one process, which traps carbon dioxide from the atmosphere, however, and that is photosynthesis.

The key processes that happen in living things especially plants, in the carbon cycle, are photosynthesis and respiration.

However these processes do have their differences and similarities.

Activity 2

Can you think of any similarities between these two processes (photosynthesis and respiration)?

If you do, can you list them on the space below:

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FEEDBACK:

I hope you got most of the answers correct and the table below highlights the differences between photosynthesis and respiration. The column on the left shows what happens in photosynthesis and that on the right shows what happens in respiration.

Photosynthesis	***Respiration***
1. Needs carbon dioxide but releases oxygen as a by-product.	*Needs oxygen but releases carbon dioxide as a waste.*
2. Food (glucose) is produced.	*Energy is produced.*
3.Take place in the green parts of plants e.g. leaves.	*Takes place in all living cells of the plant and the animal.*
4. Uses energy from the sun.	*Uses food produced through photosynthesis.*

What happens in the carbon is very interesting. An atom of carbon which is today in a molecule of carbon dioxide in the air, may tomorrow be in a molecule of cellulose in the cell wall of some plant, e.g. grass. When a cow eats the plant, the carbon atom may become one of the many in a protein molecule in a cow's muscle.

When the protein molecule is used for respiration the carbon will enter the air again as carbon dioxide. No new carbon atoms are created but they are recycled from one molecule into another.

The diagram below summarises the carbon cycle as explained above.

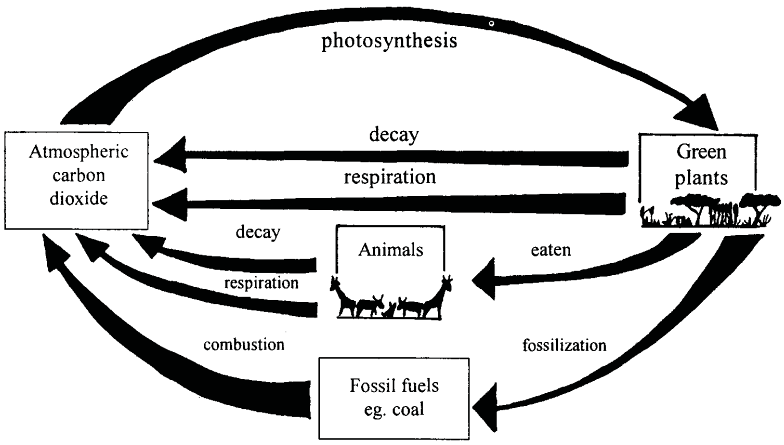

Figure2: The Carbon Cycle

The same kind of recycling applies to nearly all elements on Earth as it does on carbon. A large proportion of the atoms, which make up our bodies (as human beings) were at one time an integral part of many other organisms. Such atoms become part of the human body as we eat meat from animals like goats, cows, pigs etc, and also as one eats vegetables, fruits, fish and other foods.

Summary

In this topic you have learnt that, carbon dioxide reacts with water in the presence of sunlight energy (absorbed by chlorophyll) in order for plants to produce carbohydrates and oxygen. This process is called photosynthesis. It is very important because without it food production will not take place.

All living things depend on this process for food. For instance, green plants can use the carbohydrates they produce as soon as it is produced, if it is immediately needed for respiration. On the other hand, animals can eat the green plants containing carbohydrates or eat other animals that eat green plants for energy.

During photosynthesis carbon dioxide is one of the materials needed for food production. Plants obtain carbon dioxide from the atmosphere or the air. Carbon atoms enter the green plants through openings called stomata. These openings are found on leaves. When photosynthesis is taking place the carbon atoms from carbon dioxide are converted to carbohydrates which build up the plant tissues.

When animals eat plants, the carbon atoms in plants are transferred to their tissues and animals recycle the carbon back to the atmosphere when they respire or die and decay. Similarly, plants that are not eaten by animals will release carbon dioxide back into the atmosphere through death and decay, respiration and combustion.

When plants and animals are alive they carry out the process of respiration in order to get energy that is used for the activities of living things. When both plants and animals die, their bodies are decomposed by bacteria and in doing so, the carbon atoms in their tissues escape back into the atmosphere.

When green plants die and decompose, under extreme pressure, for a period of more than one million years they turn into substances called fossils fuels such as crude oil, natural gas and coal. When fossil fuels combust they produce energy and they release carbon dioxide back to the air.

You have now completed topic 1 and are ready to do the topic assignment which can be found at the end of the unit in the assignment section. Once you have completed the assignment, compare your answers with those provided after the assignment. If any of your answers are incorrect revise the relevant section(s). If you got all the answers correct, congratulations! You are now ready to study Topic 2.

Topic 2: Classification of Nutrients

As we have seen in Topic 1, plants have the ability to trap light energy from the sun and use it to make food which they store within themselves. Animals such as humans can then have access to this food when they eat the plant. The food you eat consists mainly of substances called carbohydrates. The plant produces these during photosynthesis. Meat forms the staple food in Botswana. Meat contains two substances called proteins and fats.

In this unit we will discuss carbohydrates, proteins, and fats in detail. We will also consider the role of vitamins and minerals which are a necessary part of our diet.

Some people, not only in Botswana, eat the wrong type of food or sometimes they cannot even get enough food. In most cases this is because they do not know what to eat.

In this unit, we are also going to discuss what you should eat and what you should not eat in order to stay healthy.

Learning Objectives

By the end of this topic, you will be able to;

- List the major types of nutrients.
- State the sources and uses of nutrients in the human body.
- Describe and carry out the benedicts test for reducing sugars, the iodine test for starch, the Biuret test for proteins and the grease spot test for fats.
- List the principal sources of vitamins C and D, and of the elements calcium and iron.
- List the uses of vitamins A, B and D.
- List the uses of calcium ions in the formation of bones and teeth, in blood clotting, and in muscular contraction.
- State the use of iron in the formation of haemoglobin and relate iron deficiency to anaemia.
- Outline the uses of water and fibre in the body.

Topic Resources

There are some practical tests described in this topic. You are encouraged wherever possible to do these experiments yourself. The science tutor at your nearest study centre will be able to tell you what arrangements have been made to give you access to the science facilities.

To do the tests described in the topic, you will need the following:

- Bunsen burner
- Iodine solution
- Benedicts solution
- Copper sulphate solution
- Sodium hydroxide solution
- Water
- 6 test tubes
- White tile
- Beaker or any container to prepare hot water
- Food samples, just a small amount will do, say a table spoon of each.

NB. The above mentioned apparatus should be made available by your science tutor in your respective study centres. Ensure that arrangements are done such that you indeed carry out the experimental activity. Your tutor will guide you through the experiments and you must also learn how the tests are done and what test results to expect.

Classification of Nutrients

Have you ever sat down and thought about the kind of chemical substances that can be found say in a meal which has foodstuffs such as porridge, chicken, spinach, tomatoes and onions?

Well, a careful analysis of this meal will show that it contains the following substances;

- Carbohydrates
- Fats and oils
- Proteins
- Minerals
- Vitamins

We will now look at each one of them in details. All of these are important to our bodies and are needed in different quantities. Let us discuss these one by one.

Carbohydrates

Carbohydrates are a group of nutrients containing the elements carbon and hydrogen. They include all types of sugars like sucrose which we drink in tea and sugars found in fruits and milk. They also include starches and cellulose that cannot be digested by human enzymes. They are found in vegetables and are valued as roughage. They provide fibre, which is important in digestion and the prevention of constipation.

(A) Sources of Carbohydrates

Foods which contain carbohydrates are mostly obtained from plants. The most common carbohydrates are sugars and starches. Sweet fruits, honey, and jams are examples of sugar foods. Examples of starchy foods are bread, millet, maize, and rice.

I mentioned honey amongst the foods that contain carbohydrates, yet I have been telling you that carbohydrates are obtained from plants. In the activity below, I want you to note your views about this and to list foodstuff with carbohydrates.

ACTIVITY 1

1. Can you think of any reason why honey is included among foodstuffs which contain carbohydrates?

Hint; this has to do with the way that honey is made. Write the reason below.

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2. Can you think of any foodstuffs, which contain carbohydrates? If so, then list them down.

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FEEDBACK

Q1*: Honey is produced from a substance called nectar. This is a sweet liquid found in plant flowers. Bees extract the liquid and use it to make honey. Therefore, the sources of honey are essentially plants.*

Q2*: The list is endless and it includes samp, mealie rice, sorghum, potatoes, etc.You should realize that foods containing carbohydrates are mostly derived from plants. They are referred to mostly as plants derivatives because they are produced from plants.*

Let us now continue and look at the functions of carbohydrates.

(B) Functions of Carbohydrates

Carbohydrates have two main functions and these are;

They are sources of energy

Carbohydrates are the chief sources of energy and as a result they are sometimes called the "Fuel of Life". The energy is released during respiration. The body converts most carbohydrates into glucose (the simple form of carbohydrates) before they are used for energy production.

They are Food Reserves

Carbohydrates are also important as food reserves. Many plants store large quantities of starch. In animals, the main carbohydrate food reserve is glycogen, which is stored in the liver and muscles. The fact that you are an animal means that if you eat more, the excess is converted into glycogen and stored in your liver and muscles.

We are now through with the section that deals with carbohydrates, in the next section we will discuss fats and oils.

Fats and Oils

The other name for fats and oils is **lipids.** Like carbohydrates, they are also made of two elements, hydrogen and oxygen. Do you know the difference between fats and oils? The difference is simple; it is that fats are solids and oils are liquids at room temperature.

(a) Sources of Lipids (fats and oils)

Fats occur in both plants and animals. This means that we have animal fats and plants fats. Butter, lard, and dripping are all animal fats. These fats are solids at room temperature. Plants fats are normally liquids at room temperature such as sunflower oil, corn oil. Margarine consist mainly of vegetable oils but they have been processed into a solid.

(b) Uses of Fats

Fats have two main functions and these are:

- **Provision of energy** They are used during respiration to produce energy. Fats are used usually when all carbohydrates have been used up.
- **As a storage of compounds** in animals

We must have all skinned or at least seen an organism that has been skinned. Now if you were to look under the skin of a freshly skinned goat or sheep, you will notice some fat deposits. In fact, as you skin the goat some of the fat tends to stick to the meat or the main body. Have you ever wondered why this is the case? Please do the activity below that allows you to give your views before we continue.

ACTIVITY 2

Why is fat deposited under the skin? Please write your answer down in the space below.

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***FEEDBACK**:*

You should have written something like;

The fat stored under the skin, helps keep the body warm as well as serving as an energy store

It is also used in the formation of cell membranes and as a solvent for vitamins A and D

That brings us to the end of the section on fats and oils, the next section deals with proteins.

Proteins

Proteins consist of small units called amino acids. They are made of the elements hydrogen, oxygen, nitrogen and some amino acids contain sulphur.

(a) Sources of Proteins

Unlike carbohydrates which have many different types of sugars, there are two types of proteins and these are animal proteins and plant proteins. You can obtain plant proteins from plant products like beans and cereals such as maize. Animal proteins on the other hand come from animal products and they include meat products, milk products, and even chicken products. The flesh of all the animals eaten by humans contains proteins.

(b)Functions of Proteins

Proteins have very important roles to play in the human body and they include:

- Repair and if possible replacement of damaged tissues in the body.
- Proteins form the main structures of the body. We therefore need proteins for growth and body building.
- Manufacturing enzymes. Enzymes are substances which speed up reactions in cells.
- In addition, proteins give us a certain amount of energy. This can only take place if there has been a shortage of carbohydrates and fats in the food we eat.

There is also a shortage of proteins in the world today. Do you have any idea why it is so?

Well, this is because most of the food which contains proteins comes from animals. Animals are expensive to keep and they may require feeding and housing. The whole animal cannot be used for food but only certain parts. One animal will probably produce 2 or 3 offspring, which in turn can be used for food.

ACTIVITY 3

Write down foodstuffs which contain proteins below.

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FEEDBACK: the list is quite long and it includes all foodstuffs obtained from animals like meat, eggs, fish etc. Leguminous plants are also rich in proteins, so plant food stuffs like beans, and soya beans are also rich in proteins. If you have mentioned these or similar foodstuffs you are probably right.

There are many scientific ways of finding out which food types they have. We will later look at how this can be done, for now let us continue and look at mineral salts.

Mineral Salts

These are the simplest elements found in almost all kinds of foods but the quantity and type of mineral present varies from one source of food to another. Some of them give the blood its correct composition while others are components of important structures such as bones and teeth. Others help to control the chemical reactions in the body. Lack of these minerals causes deficiency diseases.

The following table shows the most important minerals and their food sources, functions and deficiency symptoms.

Table1. Mineral Elements and their Ffunctions

Name of Element	Food Sources	Function of Element	Deficiency Symptoms
Calcium	Milk, cheese, green vegetables	-formation of bone and teeth -proper muscle action and blood clotting	- poor bone and teeth development -frequent muscle cramps
Iron	Spinach, yeast, milk, dried fruit, pumpkin leaves	-formation of haemoglobin in the red blood cells.	-causes anaemia
Iodine	Sea fish, iodized salt, cheese	-formation of a hormone called thyroxine	-mental and physical retardation in children -causes goiter in adults
Phosphorus	Milk, meat, eggs	-strengthens bone and teeth. -important for protein synthesis in cell formation	-poor bone development

In this section, we are going deal with calcium and iron only as they are the most critical mineral elements in the normal functioning of the body notwithstanding that other mineral elements are also important.

Calcium is needed for the hardening of our bones and teeth. When a baby is born, the bones are soft. To become hard they must take up calcium salts. These salts are calcium phosphate and carbonate and the process is called calcification. Calcium can be obtained from foods such as milk, cheese, and fish. If a child does not eat enough calcium his bones remain soft and become deformed, especially the legs since they carry the whole body. This condition is known as rickets and it is shown in the diagram below.

Fig3: A Victim of Rickets

Calcium is also needed for making muscles contract. It also helps blood to clot when you cut yourself.

Iron is present in haemoglobin - the red pigment in blood. Haemoglobin carries oxygen through the body in red blood cells. Iron occurs in a number of foods, especially liver and kidneys. Small amounts occur in drinking water and we get quite a lot from metal utensils used in cooking.

Shortage of iron results in the blood containing too little haemoglobin. This result in a deficiency disease **called anaemia.** The oxygen carrying capacity of the blood is cut down resulting in tiredness and lack of energy. People who are anaemic may need to take iron tablets. An expectant mother should take particular care to eat foods rich in iron, otherwise the developing baby may use most of the iron in her blood and she may become anaemic.

Now let us pause a bit and check what we have learned from **Table 1** above by doing the activity that follows

Activity 5

Kagiso visited his friend Basadi at Gabane. When he got there, he found Basadi's grandmother preparing lunch. She was intending to serve them a meal consisting of samp, spinach, liver and soup. The soup was prepared using tomatoes, onions and carrots with a little bit of salt. Which food amongst the ingredients used contained the following?

(a) Vitamins C (b) Vitamin D (c) Calcium (d) Iron

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FEEDBACK:

You should have come up with the following answers:

(a) *Vitamin C- spinach, onions, tomatoes and carrots*

(b) *Vitamin D- liver*

(c) *Calcium- spinach*

(d) *Iron-liver*

If you did not get some of the answers correct, go back to the table and review.

Let us continue with the next section which is on vitamins.

Vitamins

Vitamins are a group of organic substances that are needed in a diet. In Topic 1 you have learned what an organic substance is. What is it? I am sure that you remembered that they are substances that are produced by living cells, so vitamins are organic substances since they are made in living tissues. Each has a specific job to do but the overall function of vitamins is to help control the chemical reactions taking place in the body. Each one occurs in particular kinds of food. If any of them are missing from the diet, a person may become ill and possibly die if deficient for extended periods of time. Vitamins are described by letters such as A, B, and C. For vitamins to do their job, they must be in solution. Some of them dissolve in water. This is why we need water and fats in our diet.

Now let us use the table below to look at some of the important vitamins in detail.

Table 2: Vitamin Sources, Functions and Deficiency

Name of vitamin	**Source of vitamin**	**Function of vitamin**	**Deficiency effect**
A	Milk, butter, fresh green vegetables, carrots	Needed for; healthy skin and good vision in dim light	Poor vision ery well in dim light and possible **night blindness**
C	Oranges, grapefruit, lemons, fresh green vegetables	Needed for; Healthy skin and blood vessels	The gums and nose bleed. There is bleeding inside the body and healing occurs slowly. Can lead to a deficiency disease called **scurvy**
D	Milk, butter, eggs, fish, liver	Needed for; strong bones and teeth	The bones become soft and bend or break easily. Can lead to a deficiency disease called **rickets**

Let's now look at Vitamins A, C, and D in detail. Vitamin A is important for sight, Vitamin C for healthy blood vessels and for healing, and lastly Vitamin D is necessary for strong bones.

(a) Vitamin A

This vitamin is obtained from milk, butter, eggs and vegetables. It is essential for good eyesight. Any lack of this vitamin causes difficulty in seeing in dim light (night blindness). If the deficiency is severe, blindness can easily develop due to the cornea becoming opaque. Lack of vitamin A is one of the most common causes of blindness in the world today.

(b) Vitamin C

This vitamin keeps our epithelia (thin walled cell membranes) in a healthy state. It is abundant in green vegetables such as spinach, and citrus fruits such as oranges and lemon. It is also abundant in the liver of livestock. Lack of vitamin C causes **scurvy**. The symptoms of scurvy are a lowered resistance to bacterial invasion, wounds failing to heal quickly and weak teeth easily decay. Sores and blisters appear in the mouth.

(c) Vitamin D

When a child grows, its bones become hard by taking up calcium salts. For this to happen vitamin D is needed. It promotes the absorption of calcium in the small intestines. If the child does not get enough vitamin D, he or she will develop **rickets.** The body itself can make a certain amount of Vitamin D. It is made in the skin provided sunlight is present. In a sunny climate, an adult can get all the vitamin D the body needs by exposure to sunlight. This vitamin helps the build up of calcium and phosphorus into bone tissue by facilitating the absorption of these minerals from the gut.

Apart from the three vitamins that we have looked at above there are other nutrients that are needed in our bodies. These include water and dietary fibre or roughage. Let us start with water.

Water

Water is a very essential daily requirement. All chemical reactions in our body tissues take place in solution. We take in water by mainly drinking. However, there is plenty of water in most solid foods. Lettuce, or cabbage contains 90% water, and bread contains about 40% water. Human beings normally need to drink about a litre of liquid every day. About two thirds of the human body is composed of water, which has many uses or functions. These are the uses of water in the human body:

- It takes part in the many chemical reactions occurring in the body.
- It is also a solvent and medium for transport as in blood.
- It is a component of the cytoplasm of cells which you have learnt about in unit 1 when dealing with parts of a cell.
- It is a reagent in the digestion (hydrolysis) of food.

Water is not a food, but without it a person would die in a few days. Water cannot be stored in the body. When water is lost from the body through sweating, diarrhea, and urine it should be replaced.

Dietary Fibre (roughage)

Fibre consists mainly of plant cell walls, which cannot be digested by human enzymes but are digested by bacteria in the colon. These walls form what is called cellulose. Fibre is found in fruits (such as mangoes and bananas), vegetables (such as rape and cabbage) and grasses (maize cobs and oats). Fibre is important in maintaining a healthy digestive system. It adds bulk to food and enables the muscles of the alimentary canal to grip it and keep it moving by peristalsis which you will learn more about in unit 3. Fibre stimulates peristalsis and helps to keep faeces soft. Lack of fibre will cause constipation (this is the hardening of faeces making it difficult or very painful for them to move out).

We have been looking at vitamins and other nutrients that are useful in our bodies, but how do we know which nutrients are found in the different types of food? In the next section we shall look at food tests that enable us to know the nutrients in food types.

Food Tests

Most food stuffs have been analyzed to find out the type and quantities of nutrients they contain.This information is very important among nutritionists when they advise people on the diet they should take. The analysis takes the form of food tests which is the subject of this section.

You might have noticed that food packages always have a list of substances that they contain. These substances are called ingredients. Let's take full cream milk to demonstrate this point. The brand we will be looking at is Nespray. Nespray has the following ingredients: butter fat, proteins, carbohydrates, lactose, minerals and moisture. It is very easy to find out the ingredients in any food package. This is done by simple tests called food tests. Each type of nutrients has its own test. We are going to look at the tests for starch, called reducing sugar, proteins and fats as these are very important for our bodies.

Reducing Sugar (glucose) Test

The chemical or reagent to be used for this food test is Benedict's solution. Benedict's solution is made of copper sulphate, which is blue in colour. The solution is reduced to copper oxide, which is brick red or orange during the test. Glucose is called a reducing sugar because of its action on Benedict's solution.

Let us first look at the resources that we need.

Resources:
To test for reducing sugars you will need the following:

- Benedict's solution
- Food samples (Rice Meat, Porridge, Egg, Raisins and Apple juice)
- 6 test tubes labeled according to food samples
- Bunsen burner
- Beaker

Procedure

When doing this test, please do not mix the food samples and follow the procedure below:

1. Crush a piece of food into small pieces and pour about $2cm^3$ of it into a test tube. Do this for all the food samples and make sure the food is in the correct test tubes.

2. Pour about $2cm^3$ of Benedict's solution into each test tube and shake.

3. Boil some water in a beaker over a Bunsen burner.

4. Put the test tubes in the beaker of water and leave it for two to three minutes.

5. Observe the changes and record you findings in the table below.

TEST TUBE	FOOD SAMPLE	RESULT	CONCLUSION
1	RICE		
2	MEAT		
3	PORRIDGE		
4	EGG		
5	RAISINS		
6	APPLE JUICE		

If the food sample contains sugar, the samples will change from blue to one of the following colors; green, yellow, orange or brick red. A sample which changes to brick red has more sugar, followed by the orange one and then yellow. The one which turns green has the least amount of sugar.

Starch or Iodine Test

The procedure for the starch test is very simple. You do not need any test tubes or water bath. You only need the following.

Resources:

- Iodine solution
- White tiles
- Food samples (Rice, Meat, Porridge, Egg, Butter)

Procedure:

The procedure is follows:

- Obtain a small quantity of the food and place it on a clean tile. The food can be in liquid or solid form.
- With a dropper, add 2 or 3 drops of iodine solution to each food samples.
- Record your observations and conclusions on the table below.

TEST TUBE	FOOD SAMPLE	RESULT	CONCLUSION
1	RICE		
2	MEAT		
3	PORRIDGE		
4	EGG		
5	RAISINS		
6	APPLE JUICE		

If a blue black color develops, starch is present and if it remains brown then starch is absent.

Let us now look at a test for proteins.

Test for Proteins (Biuret test)

The Biuret test involves two reagents and these are sodium hydroxide and copper sulphate. For this test you will need the following resources.

Resources:

- Biuret
- Sodium hydroxide

- Copper sulphate
- 5 test tubes
- Food samples (Rice, Meat, Porridge, Egg and Butter)

Procedure

The procedure is very simple and is as follows:

- Crush the food into fine powder, if it is not in liquid form, and then add a little water to make a suspension.
- Pour about $5cm^3$ of this suspension into the test tube.
- Add about 2-3 drops of sodium hydroxide.
- Add about 2-3 drops of copper sulphate using a dropper and then shake.
- Record results and conclusions in the table below.

Test tube	**food sample**	**Results**	**Conclusion**
1	Rice		
2	Meat		
3	Porridge		
4	Egg		
5	Butter		

If the solution goes purple, proteins are present.

The last food test that we are going to do on this topic is the test for fats and it is discussed in the next section.

Test for Fats (the grease spot test)

For this experiment, you will need a filter paper or any plain white paper and some samples of food.

Resources:

- Filter paper or plain paper
- Food samples (Distilled water, Butter, Orange squash and Ultra milk)

NB Distilled water can be prepared by boiling water in a container and then allowing it to cool.

Procedure

You should rub some of the food onto the paper. Apply the above test to the food samples mentioned above and record your observations and conclusions in the table below.

Sample	**Observation**	**Conclusion**
Distilled water		
Butter		
Orange squash		
Ultra milk		

If a translucent mark appears on the paper then the food contains fat. A translucent mark is one that allows light to pass through but is not transparent like glass.

Summary

In this topic you have learned about the five classes of nutrients that include carbohydrates, fats, proteins, vitamins and mineral salts. You have also learnt that food tests are experiments that help us to find out the presence of different nutrients in food. For instance, to find out the presence of glucose or reducing sugar, the Benedict's solution is used. After the reaction with the food, it would turn orange or brick red if glucose is present. The starch test is done using iodine solution. If the food sample reacts with Iodine by turning blue or black it shows the presence of starch in the food sample. To find out the presence of protein, two chemicals are added to a food sample. These chemicals are sodium hydroxide solution and copper sulphate solution. After sometime if the food sample turns purple it shows the presence of proteins. The other name for this protein test is Biuret test. To test for the presence of fats you do what is known as the grease spot test. You simply put or smear a food sample on a piece of white paper and remove it after sometime. If the food sample leaves some oil marks on the paper it shows the presence of fat in the food.

You have also learned that Vitamins and minerals are needed for cellular functioning and good health.

Water and fibre are also some examples of very important components of foods that you learned about. For instance, water helps in the formation of blood plasma and some body fluids; it also cools the body and dissolves nutrients. A lack of water in the body leads to dehydration.

Fibre or roughage helps in adding bulk to food that we eat.This helps the walls of the alimentary canal by providing them with something to grab as they squeeze down the food in a process called peristalsis. Lack of fibre in the diet may lead to constipation.

As in the previous topic, it is now time to complete the end of topic assignment. You should follow the same procedure as in Topic 1 to check your answers and take remedial action if any of your answers are incorrect. Once you have done this you can move on to Topic 3.

Topic 3: Nutritional Value of Food

In the previous topic, we dealt with major nutrients that are needed by human beings. Some of the areas we covered included the sources of these nutrients and their uses in the body.

Different people like different types of food. Some people are vegetarians, that is, they eat only food which consists of plant products. Their reasons for this are quite varied and depend on the individual concerned. In Botswana, beef including its products, is a staple food in most households. This is despite the fact that they might have access to our own traditional vegetables.

In this topic we are going to look at the nutritional value of common types of food. We will also look at the importance of having a balanced diet. If we do not plan our food choices properly we stand the chance of developing malnutrition diseases. This is because some nutrients may not be present in the diet. All the same, if we take in more food than the body requires we make the body prone to diseases like obesity and coronary/cardiovascular or heart related diseases. Though it is not easy to control our diet, it is advisable that we try by all means to balance our diets.

Learning Objectives

After completing the work in this topic you will be able to:

- Describe the nutritional value of foods obtained from animals and plants.
- Define a balanced diet.
- Describe malnutrition.
- Explain why diet especially energy intake should be related to age and physical activity of an individual.
- List the food and drinks consumed in one week and the major nutrients they contain.

Food and Energy Content

We need energy to move, grow, mend our tissues when they are damaged, and just to keep ourselves alive. We get energy from our food and the energy contained in food can be expressed in kilojoules (kJ). As mentioned in the previous topic, almost all the packaged food and drinks that we buy from the shops have a table somewhere with the heading NUTRITION INFORMATION. That gives the amount of energy present in the food, the amount of proteins, carbohydrates, sugars and the amounts of other essential nutrients available in the food. You can get into the kitchen right now, grab a box of cornflakes or a can of coke, look at it and you will get the information. That information is very important for us to plan our diet.

Use the information below, which gives the amount of energy contained in 10g of each food type (carbohydrates, fats and proteins), to do the activity that follows.

10 g of carbohydrates = 170 kj

10 g of fats = 390 kJ

10g of proteins = 180 kj

ACTIVITY 1

1. Which food type contains the greatest amount of energy?

2. Lesego and Tiro are friends. One time on a Sunday, they went out for a walk. Lesego bought herself an ice cream and yoghurt. Tiro preferred to have two cans of coke. Among the two, who had something which contains more energy? Give reasons for your answer.

FEEDBACK:

1. *It is obviously fats. This is because, in comparison, 10grams of fat contains more than twice the energy contained in an equal amount of protein and carbohydrates.*

2. *Lesego bought things containing more energy than Tiro. This is because yoghurt is a dairy product, so it contains fats. It also contains sugar, which is a carbohydrate. Ice cream on the other hand also contains sugar and some may even contain milk, which does have fats. A combination of these two will therefore contain more energy than coke. Coke contains carbohydrates only and does not contain fats which provide additional energy.*

The nutritional value obtained from animals (meat, fish, egg, milk) is different from foods obtained from plants (roots, tubers, seeds and fruits). The table below shows the values for common foods obtained from plants and animals.

Table 1: Nutritional values of plant and animal foods

(Note that the remainder of the quantity is water)

Types of food (100g amounts)	Proteins(g)	Fat (g)	Carbohydrate(g)	Kilojoules
Beef	19	13	0	827
Mutton	15.7	27.7	0	1325
Goat	18.7	9.4	0	690
Chicken	20.2	12.6	0	848
Ox liver	16	7.8	0	539
Fresh fish	16.4	5	0	313
Canned fish	22	24	0	1312
Fresh eggs(2-3 eggs)	12.4	11.7	0.9	681
Milk	3.5	3.5	5	272
Cheese	25	31	2	1618
Dried beans	22	2.1	61.6	1442
Ground nuts	25.6	43.3	23.4	2282
Maize	9.5	4.3	72.9	1488
Rice	7.1	1.1	78	1500
Wheat	10.7	1.1	75.5	1546
Bread	8.4	1.0	49	439
Sweet potatoes	1.3	0.4	27.3	489
Sugar cane			100	1670
Butter	0.6	81	0.4	2993

Analysis can be carried out to find out how much each food substance is present in different foods.

This information is valuable because it tells us its nutritional is useful. For example, maize contains a lot of carbohydrates and is a good energy provider. Meat contains a lot of proteins which makes it good for growth and body building. For packaged food, as already mentioned, most of this information is provided on the container. In the next section we will try and focus on the amount of energy required by the body in a day.

Daily Energy Requirements

Imagine someone lying in bed doing nothing. Does someone in such an inactive state need energy?

Yes, even in such an inactive state energy is needed to breathe, make the heart beat; drive all the chemical reactions which keeps us alive. The rate at which these processes take place is called “basal metabolic rate”, and it refers to the rate at which energy is used by an organism at complete rest.

Roughly an average person needs about 7000 kilojoules of energy per day. However this varies from one individual to another. There is a balance between the food we eat and the energy we use. The amount of food needed depends on different things such as age, sex and occupation. An adult needs more energy than a baby mainly because of the size of the body, the larger the body the more energy you will need. A man will need more food than a woman because men are generally stronger and more muscular than women. A sportsperson needs more food than a person reading a book because he/she burns a lot of energy whilst exercising. The diagram below illustrates this and also gives you some more examples.

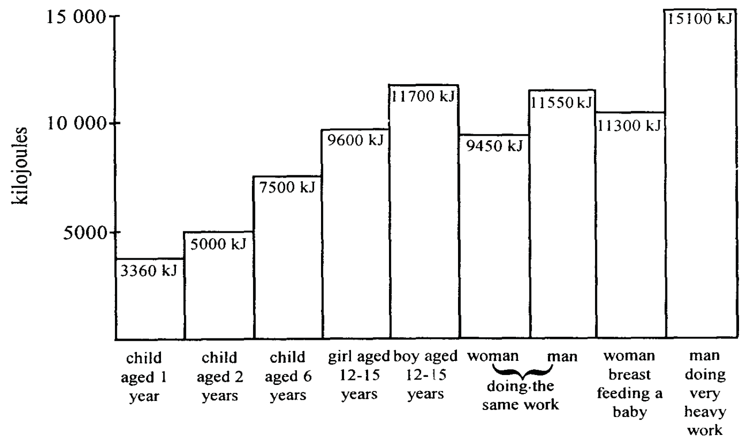


Fig 5: Energy Used on a Daily Basis

The graph shows the amount of energy used in a day by people of different ages and also people of the same age but different occupations. As discussed above, when a man and a woman are doing the same work the man will still need more energy. We can also see that a man doing very heavy work will need even more energy.

Let us now do the activity below which will help you try and determine your daily energy needs.

ACTIVITY 2

(a) From what you have learned in section 1.2, decide what your daily energy requirements are and explain why.

____

____

____

____

____

(b) Use table 2 to decide what type of food and how much you would need to eat each day to provide.

____

____

____

FEEDBACK: At BOCODOL, we do have many Learners of different age groups and occupations. Some of them take this HSB course. I don't know what response they gave. However, if you look at Fig. 5 and locate your age range and occupation you will get an estimate of what your daily energy requirements should be. Then from Table 1, you can choose the type and amount of food combination you can eat daily in order to get your estimated energy needs. You can ask your tutor and/or discuss with other learners if you can't follow this procedure.

We have now come to the end of our section on Food and Energy Content and will now continue and look at a Balanced Diet.

Balanced Diet

A balanced diet is the type and amount of food supplying sufficient quality and quantity of proteins, carbohydrates, fats, vitamins, minerals, fibre and energy to sustain a healthy life. These nutrients are needed for the following reasons;

Carbohydrates: source of energy.

Proteins: source of materials for growth and repair.

Fats: source of energy and contain fat soluble vitamins.

Vitamins: required in small amounts to keep you healthy.

Mineral salts: required for teeth, bones and muscles.

Fibre: required to help your intestines function correctly.

It is important to eat the correct amounts of nutrients in the right proportions. We also need to understand our bodies, that is, as a person you should know what your body needs the most and also consider the work that you do each and every day when you plan your diet. If you are tired most of the time, you should know that you lack energy so eat more carbohydrates. If you do not heal easily then you lack vitamins, if you feel you are not strong enough eat more minerals and so on. The important thing is to make sure that you eat what your body needs, do not eat too much of anything or too little of anything as this can cause diseases that will be discussed in the next section.

However there are some special cases, such as for babies, that are summarized in the table below. This is where life begins so we have to plan for the baby.

Table 2: Special Food Requirements For Infants, Adolescents, Expectant (Pregnant) Women And Lactating Mother

PERSON	ADDITIONAL NUTRIENTS	IMPORTANCE
Infants	Protein	For a very rapid growth period
	Protein, calcium, Vitamin D, Phosphates	For growth of bones and teeth
Adolescents	Protein, calcium, Vitamin D, Phosphates	For a very rapid growth period
	Carbohydrate	Energy requirements increase during this active age
Expectant mother	Protein	For growth of the body
	calcium, Vitamin D, Phosphates	For growth of baby bones
	Carbohydrates	Extra energy for carrying the baby
Lactating mother	As for expectant mothers, although the quantity need further increasing for milk production	

The table above shows the food requirements from when the baby is still in the mother's womb up to a point when he or she is an adolescent. For others some of the suggested weekly intake of food is shown in the table below.

Table 3: ShowsSuggested Weekly Intake Of Food And Drinks That Could Make A Balanced Diet.

Groups of food value	Examples of food	Sources	Nutrient
1. energy	Porridge (	Sorghum,	Fat, protein,

giving food	**hard and soft), butter**	**maize, milk**	**carbohydrate**
2. body building food	**Milk, meat**	**Cows, chicken, pigs, sheep, cattle and goats**	**Protein, calcium and carbohydrate**
3. protective food	**Cabbage, spinach and oranges**	**Garden or vegetable shops**	**Vitamins**
	Liver, fish	**Livestock, dams and rivers**	**Iron, protein, iodine, protein**

Water is very important, as it has been said earlier. Sources of water include; fruits, soft drinks, juices, and underground as well as surface sources of water. Scientifically it has been discovered that most of the common headaches that people experience are a sign of dehydration. In addition to supplying water, juice drinks also supply us with vitamins.

As already mentioned earlier a balanced diet is needed for energy, growth and good health, if your diet does not contain the required nutrients, you may suffer from malnutrition which is discussed in the next section.

Malnutrition

A person who has a poor diet may suffer from malnutrition. Malnutrition arises from three aspects of nutrition and these are:

1. Lack of enough food leading to starvation and death.
2. Lack of a balanced diet with major nutrients missing in the diet.
3. Over eating or eating too much of particular nutrients that the body does not need.

When an individual experiences any of the three above, he/she develops signs that show that there is a problem in the nutritional status of that individual. There are three corresponding signs of nutritional problems and these are;

1. Marasmus
2. Kwashiorkor

3. Obesity

These nutritional problems are described below according to the order listed above.

Marasmus
This is a nutrient deficiency associated with the general shortage of food substances particularly those that gives us energy. Due to problems in the society, like drought and general lack of adequate food leading to starvation, the daily intake of food is low. The body becomes wasted away as the nutrients from the body tissues, like muscles and bones are mobilized to do essential body processes like breathing and blood circulation. As a result the individual is reduced to a skeleton. The little girl in Figure 6 is suffering from general starvation (marasmus).

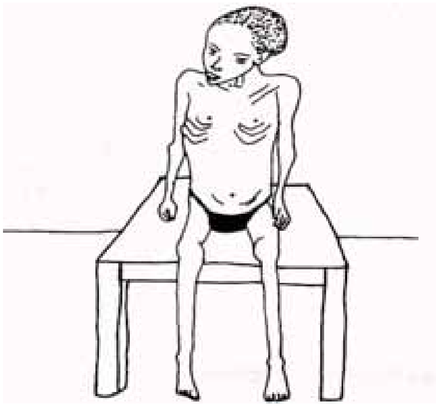


Figure 6: A Victim of Marasmus

As you can see from the diagram above there is no flesh on the child's body. You can actually see a skeleton, that is, you can count the ribs of the child and even see each and every bone of the child.

Kwashiokor
Most people in the world do not have enough money to buy protein foods such as meat and fish. These people sometimes suffer from **KWASHIOKOR.** Do you have any idea of what kwashiorkor is?

Well, it is a deficiency disease that arises from lack of proteins in the diet. This is common amongst children.

Can you think of any reason why this disease is common amongst children? If you can, please write them down in the space below.

Some people tend to stop breast feeding their babies at a very tender age. They then start to feed the baby carbohydrate rich food. Although the child may get enough energy, starchy foods are relatively low in proteins. This is unlike breast milk that contains sufficient balanced nutrients for a developing child.
As already mentioned in the previous section, proteins are needed for growth and repair. Therefore, are needed more by children as they are still growing, so the disease is common amongst children.

Children who have this disease develop the following symptoms that you can see in Figure 7 below;

- They have a bulging stomach
- They are often small as compared to their counterparts who are nourished
- Their skin and hair are pale

FIGURE 7: Shows Kwashiorkor Victim

C) Obesity

What happens when we eat too much food? Some people eat too much of the kind of food their body does not need in large amounts. Thesepeople are often unhealthy because they are overweight, figure 8 below shows an example of an overweight person. Although they eat enough food, they may not get enough minerals and vitamins to stay healthy.

Figure 8: An Overweight (obese) Person

Suppose a person eats more food than it is needed for producing enough energy, most of it is turned into fat stored under the skin. The result is that the body weight increases and the person run the risk of becoming fat (obese). Obesity is caused when a person's energy input is higher than the energy output. Overweight people do not live as long as people of normal weight. An overweight person has a greater chance of having a stroke or heart attack. There are many other illnesses that are also associated with overweight.

Let us now close the topic by giving examples of other malnutrition diseases, these are shown in the table below;

Table 3: Shows Deficiency Diseases and Their Causes

Name of deficiency/ Malnutrition disease	**Cause**
1. night blindness or poor	It is caused by lack of vitamin

night vision	A
2. Beri Beri	Lack of vitamin B?
3. Pellagra	Lack of vitamin B2
4. Rickets	Lack of calcium
5.Scurvy	Lack of vitamin C
6.Anaemia	Lack of Iron
7.Goitre	Lack of Iodine
8.Marasmus	Lack of Carbohydrates
9. Kwashiorkor	Lack of proteins

Summary

In this topic you have learnt about the different kinds of food nutrients, their different sources and nutritional values. For instance bean seeds are a source of proteins and iron while oranges are a source of vitamin C. All the cereals are sources of carbohydrates and vitamin B. Margarine, butter and meat are some sources of fat.

A balanced diet can be defined as a diet sufficient in all food nutrients (proteins, fat, vitamins, fibre, carbohydrates and water) in their right quantities, quality and energy to sustain a healthy life. Lack of a particular nutrient in the diet will lead to a deficiency disease. For instance, lack of vitamin D will lead to rickets. Lack of proteins will lead to kwashiorkor while lack of carbohydrates leads to Marasmus.

If more carbohydrates or fats are eaten than the body requires, a condition called obesity develops. This condition makes the affected individual overweight. Moreover, people who are obese easily suffer from coronary or heart related diseases like atherosclerosis or coronary thrombosis, heart attack and high blood pressure.

You have come to the end of Topic 3. It is now time to complete the end of topic assignment which is at the end of this unit. Again you should follow the procedure outlined in the previous topics to check your answers and revise the relevant section where necessary.

The unit summary that follows reminds you of what you discussed in all three topics of this unit.

Unit Summary

Summary

In this unit you learned that green plants are able to make their own food (carbohydrates) in the presence of sunlight energy, carbon dioxide, water, and chlorophyll through a process called photosynthesis. All living things depend on this process for food.

When animals eat plants, the carbon atoms in plants are transferred to their tissues and animals recycle the carbon back to the atmosphere when they respire or die and decay.

When plants and animals live they always carry out the process of respiration in order to get energy that is used for living. When both plants and animals die, their bodies are decomposed by bacteria and by so doing, the carbon atoms in their tissues escape back into the atmosphere.

When green plants die and decompose for a period of more than one million years they can potentially (given the correct conditions) turn into substances called fossils fuels such as crude oil, natural gas, and coal. When fossil fuels combust they produce energy and they release carbon dioxide back into the air.

We also discussed in this unit the five classes of nutrients: carbohydrates, fats, proteins, vitamins and mineral salts.

We conducted experiments to find out the presence of different nutrients in food. For instance, to find out the presence of glucose or reducing sugar Benedict's solution is used. After the reaction with the food, Benedict's solution would turn orange or brick red if glucose is present. The Starch test, on the other hand, is done using iodine solution. If the food sample reacts with iodine by turning blueish-black, it shows the presence of starch in the food sample. To find out the presence of protein two chemicals are added to a food sample. These chemicals are sodium hydroxide solution and copper sulphate solution. If after some time the food sample turns purple it shows the presence of proteins. This protein test is called the Biuret test. To test for the presence of fats you do what is known as the grease spot test. You simply put or smear a food sample on a piece of white paper and remove it after sometime. If the food sample leaves some oil marks on the paper it shows the presence of fat in the food.

We also learned that vitamins and minerals are needed for cellular functioning and good health and that water and fibre are also some examples of very important components of foods. For instance water helps in the formation of blood plasma and some body fluids; it also cools the body and dissolves nutrients.

Fibre or roughage helps in adding bulk to food that we eat, this helps the walls of the alimentary canal by providing them with something to grab

as they squeeze down the food by peristalsis. Lack of fibre in the diet may lead to constipation.

In Topic 3 we learnt about nutritional values of different food substances. We also learnt about the importance of different nutrients in our bodies, including the importance of having a balanced diet. We finished the topic and the unit by looking at malnutrition and diseases associated with it, mainly marasmus, kwashiorkor, and obesity.

Congratulations! You have finished unit 2. You can now complete the assessment which is at the end of the unit and submit it for marking to your institution or learning centre.

Assignment

Assignment

Topic 1 Assignment

Write your answers in the space provided.

1. List three processes by which carbon dioxide is produced.

____

____

____

[3 marks]

2. What processes in nature uses up carbon dioxide?

____

____

____

[3 marks]

3. What percentage of air is carbon dioxide?

____

[1 mark]

4. Define fossilization

____

____

[2 marks]

5. What is chlorophyll and what is its function?

____

____

[2 marks]

6. How does a green plant make carbohydrates?

____

____

____

____

[4 marks]

7. Describe differences between photosynthesis and respiration.

____

____

____

____

[4 marks]

Topic 2 Assignment

Write two reasons in the space provided near each question.

1. Give **two** reasons why we need food. [2 marks]
2. State the important classes of nutrients. [3 marks]
3. Name three examples of foods, which contain starch.

[3marks]

4. Why does a pregnant woman need to have more protein?

[1 marks]

5. What is the difference between fat and oil?

[4 marks]

6. Which reagent will you use to test for glucose?

[1 mark]

7. Name three foods which are rich in vitamin C.

[3 marks]

8. Which two vitamins are found in milk?

[2 marks]

9. Why does a person need itamin D?

[2marks]

10. Which mineral is needed for making red blood cells?

[1 mark]

11. What is calcium used for?

[1 mark]

12. State the steps you will take to test a sample of food for protein.

[7 marks]

Topic 3 Assignment

1. Name the food substances that make up a balanced diet.

[5 marks]

2. Define balanced diet.

[2 marks]

3. Each person needs a different amount of food energy. Why is this so?

[3 marks]

4. What type of food is missing from the diet of a child suffering from kwashiorkor?

[1 mark]

5. What are the advantages of breast milk compared to bottle-feeding?

[3marks]

6. List examples of food and drink together with their nutrient values you have consumed in one week.

[6 marks]

Total = [20 marks]

Answers to Assignment 1

1. (a)by respiration(b) through decay (c) through combustion

2. The process of photosynthesis.

3. 0.03% to 0.04%

4. The process in which fossil fuels are formed. For instance, when dead plants, and animals decompose for a period over millions years.

5. The green substance in plants is chlorophyll.

Chlorophyll absorbs energy from the sun in the process of photosynthesis.

6. Through photosynthesis as shown below.

$$\text{Carbon dioxide + water} \xrightarrow[\textbf{Chlorophyll}]{\textbf{Sunlight energy}} \text{glucose + oxygen}$$

7. They are both chemical reactions, which take place in plants and animals. However, photosynthesis takes place in plants only.

Answers to Assignment 2

1. (a) for growth (b) to keep warm

2. (a) carbohydrates (b) proteins (c) fats and oils (d) vitamins (e) roughage and oils

3. (a) maize (b) sorghum (c) millet (d) rice, rice

4. For the development of the embryo

5. A fat is a solid at room temperature while oil is a liquid at room temperature.

6. Benedict's solution

7. (a) Oranges

(b) Lemons

(c) Guavas etc

8. (a) Vitamins (b) Vitamin D

9. To prevent the diseases like rickets from attacking and also for healthy bones and teeth.

10. Iron

11. For strong bones and teeth, muscle contraction and also for

blood clotting.

12. ---Crush the food into fine powder if it is not solid

---- Add a little water to make a suspension

----- Pour about 2 cubic centimeters into a clear glass container or test tube

----- Add a little sodium hydroxide till the solution clears

------ Add copper sulphate solution and then shake

Answers to Assignment 3

1. (a) carbohydrates (b) proteins (c) fats and oils (d) vitamins

(e) minerals

2. A diet, which includes all the nutrients in the right proportion.

3. It depends upon age, sex, and occupation.

4. proteins

5. (a) Gives good relations between mother and child.

(b) Contains antibodies to prevent the child from certain diseases.

(c) It is cheaper and available at all times.

(d) It is at the correct temperature.

6. Food and drink consumed in one week include:-

(a) **Examples of food**		**Nutrients contained**
-Rice	:	starch
-Meat	:	protein and iron
-Cabbage	:	roughage and Vitamin C

(b) **Examples of Drink**		**Nutrients contained**
- Milk	:	protein, fat, carbohydrates and calcium
- Juice drink	:	Vitamin A &C
- Mageu drink	:	carbohydrates and Vitamin B

Assessment

Assessment

Instructions to Learners

1. Answer all questions in Section A and B.
2. Each question in Section A carries one mark.
3. Answer Section B in the space provided against each question.
4. You may take two hours to do this assignment.

Section A [20 Marks]

Write the correct letter in the box.

1. Which one of the process does **not** serve to return carbon dioxide to the atmosphere?

A. Photosynthesis
B. Respiration
C. Industrial combustion
D. Decomposition of humus

2. Which of the following gases is used as a raw material in photosynthesis?

A. Carbon dioxide
B. Nitrogen
C. Oxygen
D. Water vapour

3. How does the carbon in green plants get transferred to animal tissues?

A. Animal respiration
B. Animal consumption of plants
C. Fossilization
D. When both plants and animals die and decay

4. Which of the foods is rich in a nutrient, which reduces the risk of anaemia?

A. Citrus fruit
B. Fish
C. Liver

D. Milk

5. The following are procedures for testing solid food for the presence of proteins.

1. Add 3 drops of copper sulphate solution
2. Add $3cm^3$ of water
3. Chop food into smaller pieces
4. Add 3 drops of sodium hydroxide solution

What is the correct order for carrying out this test?

A. 1 → 2 → 3 → 4
B. 3 → 2 → 4 → 1
C. 3 → 4 → 1 → 2
D. 4 → 1 → 2 → 3

5. In a food test, what is the final colour for the presence of proteins?

A. blue –black
B. black-red
C. purple
D. white

6. By which process do saprophytes like fungi and bacteria obtain their energy?

A. Photosynthesis
B. Respiration
C. Decay
D. Combustion

7. Mention any **three** common ways by which both plants and animals put carbon dioxide back into the atmosphere.

A. Respiration, death and decay
B. Combustion, fossilization and photosynthesis
C. Fossilization, photosynthesis and respiration
D. Death, decay and combustion

8. The results of testing a liquid food showed a positive iodine test for starch and a negative Benedict's test for glucose.
What colours would have been seen at the end of these tests?

Iodine test	Benedict's test
A. Blue-black	Blue
B. Blue-black	Red

C. Brown	Blue
D. Brown	Red

9. Which two minerals in the diet are most important for bone growth?

A. Calcium and Iodine
B. Calcium and Iron
C. Calcium and Phosphorus
D. Phosphorus and Iron

10. The table below shows the carbohydrate and fat content of portions of foods. Which food portion lacks a major source of energy for living things

Food portion	Carbohydrate(g)	Fat(g)
A	0	16
B	6	16
C	26	10
D	20	14

11. The element iodine is necessary in the diet because it:

A. protects the teeth from decay
B. prevents goitre
C. is needed to make adrenaline
D. is a constituent of red blood cells

12. What is the main function of roughage in the human diet?

A. to provide vitamins
B. to provide extra energy
C. to provide mineral salts
D. to stimulate peristalsis

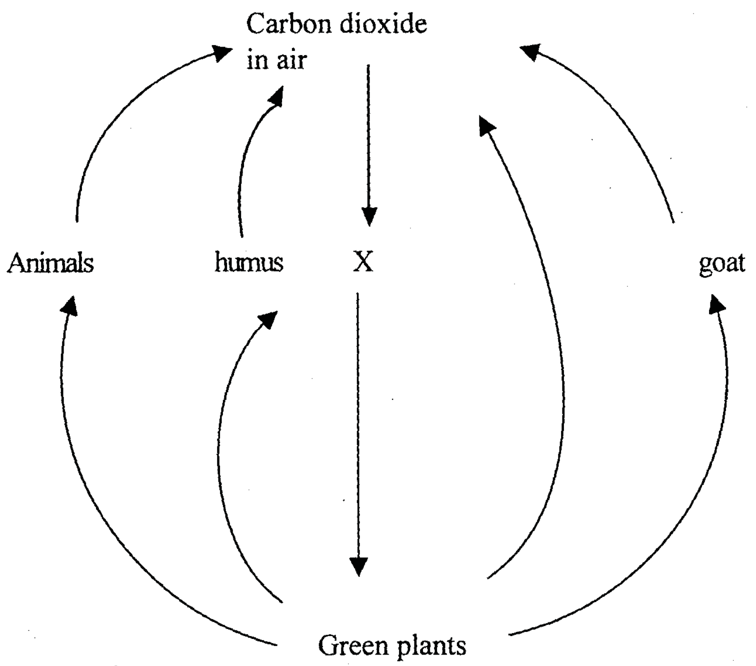
13. Which reagent is used to test for proteins in food samples?

A. Benedict's solution
B. Biuret solution
C. Ethanol
D. Iodine solution

14. Which of the following traps light energy for photosynthesis to take place?

A. Carbohydrate
B. Carbon dioxide
C. Cellulose
D. Chlorophyll

15. The diagram shows the carbon cycle



What does X represent?

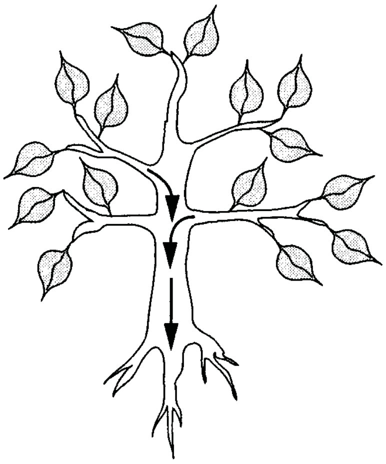
A. Animal respiration
B. Combustion
C. Decomposition
D. Photosynthesis

16. Which energy change occurs during the process of photosynthesis?

A. Chemical energy $\longrightarrow$ heat energy
B. Chemical energy $\longrightarrow$ light energy
C. Heat energy $\longrightarrow$ chemical energy
D. Light energy $\longrightarrow$ chemical energy

17. Which substance moves in the direction shown by the arrows in

the plant?



A. Sugar
B. nitrate (ion)
C. oxygen
D. water

18. What is Respiration?

A. loss of water from the leaves
B. manufacture of food in the leaves
C. movement of water in xylem
D. release of energy from food

19. Kwashiorkor is a deficiency disease resulting from lack of:

A. Fats
B. Proteins
C. Carbohydrates
D. Vitamins

20. Which equation represents the chemical reaction that takes place during respiration?

A. carbon dioxide + oxygen $\longrightarrow$ glucose + water
B. carbon dioxide + water $\longrightarrow$ glucose + oxygen

C. glucose + oxygen → carbon dioxide + water
D. glucose + water → carbon dioxide + oxygen

Section B

Question 1

(a) Describe the process of photosynthesis using the following terms. **Chlorophyll, oxygen, chemical energy, water, light energy, glucose, and carbon dioxide.** **[4 marks]**

____
____
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(b) Write word equation for the process of photosynthesis.
[2 marks]

____
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(c) Fig. 1 shows the diagram of the carbon cycle

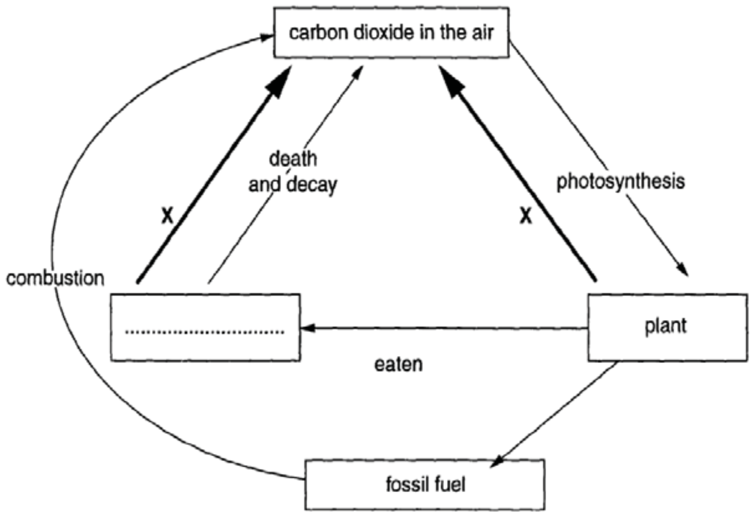


Fig. 1

(i) Complete the carbon cycle by filling in the empty box
[1]

(ii) Name the process **at the X**

____ [1]

(iii) Write the word equation for the process **X** [2]

____

____

____

(iii) Mention any three ways by which plants replace carbon dioxide into the atmosphere. [3]

____

____

(iv) Explain how carbon dioxide in the atmosphere becomes part of animal tissues. [3]

____

____

____

Question 2

Table 1 shows nutritional information for two foods, **X** and **Y.**

Table 1

Food X

Energy	334.0kj	1562.5kj
Protein	5.1g	7.0g
Iron	1.45mg	15.0mg
Dietary fibre	5.3g	3.0g
Carbohydrates	_	34.0g
Fats	_	0.7g

(a) With reference to table 1

(i) Name the nutrient in **Y** that contributes to high energy content;

____ [1]

(ii) Name the substance that contributes most to body mass, which is lacking in both foods;

____[1]

(iii) State which of the two foods should be recommended to an anaemic person;

____[1]

(b) Define a balanced diet

____ [1]

(i) Why is protein needed in the diet?
[2]

(ii) Why is fibre thought to be important?
[2]

(iii) Suggest the health risks of an excessive intake of carbohydrates and fats.

Question 3

The three major nutrients are carbohydrates (sugars and starches), lipids (fats and oils) and proteins. Carbohydrates and lipids contain carbon, hydrogen and oxygen.

(a) Name the additional element in all proteins.

____ [1]

(b) Table 2 shows the results of some tests carried out on three foods,

A, B, and C.

Table 2

Test	Food **A**	Food **B**	Food **C**
Add Biuret solution	Violet solution	Violet solution	Blue solution
Boil with Benedict's solution	Blue solution	Blue solution	Red solution
Add iodine solution	Brown colour	Brown colour	Black colour
Rub on to paper, dry	No clear spot	Clear spot	No clear spot

Using the information in table 2, state the food or foods that contain protein____

Protein and lipid____

Only carbohydrate ___________________________________ [3]

1. Name the food substances that makes up a balanced diet (5 marks)
2. Each person needs a different amount of food energy. Why is this so? (3 marks)
3. What type of food is missing in the diet of a child suffering from kwashiorkor? (1 mark)
4. What are the advantages of breast milk compared to bottled milk? (3 marks)
5. List examples of food and drink together with their nutrient values you have consumed in one week (6 marks)

Contents

HSB Unit 3

Digestion and Absorption of Food

Introduction

Unit 3 is more or less a continuation of units 1 and 2. In unit 1 you learned that one of the characteristics of living things is feeding. You learned that it is through feeding that living things obtain energy that drives all other life processes, like breathing, moving, and doing work. In order to feed living things there must be a source for various types of food. In unit 2 you discussed various types of food, their sources and use in the body of living things. You also learned that there are several types of food, each with a specific value for the body of living things, including humans. You will recall that there is food which gives you energy, food which encourages growth, and there is food which maintains health. These two units lay a foundation for unit 3 which mainly deals with how the body of humans, as living things, is adapted to process the food we eat before it can be used in the life processes you learned in unit 1.

Hence in this unit you are going to learn that something must be done on the complex food materials the living things eat before it can be used by the body to supply energy, to grow, repair and maintain health. This something to be done on food is called **digestion**. You are certainly aware that most food materials like meat, sorghum, and rice are solid complex materials, but to be used to supply energy and other needs, these food materials have to enter the blood and cells of animals. A piece of meat or a lump of maize meal is too big to enter the blood or cells. Therefore those solid chunks of food have to be reduced to soluble forms that are able to enter the blood. You should now appreciate the importance of digestion as a means to life. Without a proper functioning digestive system, for example during times of stomach illness, humans cannot convert food, even if it is abundant, into forms that would supply energy to drive other life processes.

What is digestion?

You may recall from your junior certificate, and even primary certificate studies that: **Digestion is the process by which food is broken down into small particles**. For food to pass into the blood stream and to cells where it is needed to supply energy and other needs, it has to be broken down into its smallest constituents. These constituents are the ones able to penetrate blood capillaries and float in the blood and enter body cells. You will learn more about blood and its importance in unit 4.

***Do you remember all the classes of food you learnt about in Unit 2**?*

If you don't, then please go back to unit 2 which deals with these foods. We are now going to deal with how they are digested; so it is better if you have an understanding of what they are composed of.

We will begin unit 3 by learning about different types of teeth, their structure and how they help in the breakdown of food. We will then discuss the two types of digestion. These are physical digestion and chemical digestion. Physical digestion results in a change in the physical appearance of food. The food is just crushed into smaller solid particles by the teeth and the tongue softens it with saliva.

Chemical digestion results in a complete change in the chemical constitution or chemical make-up of the food. This is achieved by chemicals called enzymes. We are going to find out about enzymes and how they help in the chemical breakdown of food. After we have learned about these two different processes of breaking down food, we are going to learn about the digestive system, that is, its structure and function and the absorption and use of the products of digestion.

Finally, we shall learn how the blood sugar is kept constant within limits that are healthy for the body. We shall also learn the condition called **diabetes** that results from the failure of the body to control blood sugar.

This order of sequencing learning, that is, beginning with teeth, then physical and chemical digestion and finally to regulation of blood sugar follows the natural steps of how digestion takes place.

Time Frame

It is estimated that to complete studying this unit you will need between 15 to 20 hours. Do not worry if you take longer in finishing this unit. Remember that we all have different abilities and hence we study at different paces.

You are encouraged to spend about 2 hours to answer the assignment in this unit. You will also need approximately 3 hours on the assessment at the end of the unit.

The total hours for completing the unit will thus be between 20 and 25 hours.

Outcomes

At the end of the unit, you should be able to:

- *Explain* the types, structure, functions and possible defects of teeth.
- *Explain* the importance of oral hygiene.
- *Describe* the process of chewing and explain the need for chewing.
- *Explain* the nature and properties of enzymes.
- *Discuss* the effect of pH, temperature and other factors on enzyme activity.
- *State* the structure and function of the parts of the digestive system.
- *Describe* ingestion, digestion, absorption and assimilation of food.
- *Explain* defecation, diarrhoea and constipation.
- *Explain* the body mechanism for controlling blood sugar and how poor blood sugar control leads to the condition called diabetes.

Teaching and Learning Approach

The approach used in this unit is the teaching has been made interactive with learning. There are activities and feedback throughout the study material. Doing activities instead of just reading only is meant to engage you into active learning.

Conversation is evident in this unit and this is meant to create dialogue and invite you to think about some issues or to check and verify what has been presented. Conversation is also used when giving you activities and feedback. Activities are meant to make you an active learner by engaging you in recalling and thinking about what you learned previously. Feedback is meant to alert you on the issues you should consider when answering a question or give you a hint to stimulate your thoughts towards a correct answer. You are welcome to disagree with me, but before you reject what or how I have presented something you need to consult other learners and your tutor at the study centre or at the next tutorial session; so that you are on the side of the majority.

In preparing this material I assumed that you have achieved some level of earlier learning in the biology of the human body. I am certain that junior certificate and even primary school syllabi have topics on teeth, the digestive system, enzymes and so on. This assumption is meant to encourage you to draw on your earlier learning instead of boring you by repeating what you already know. It is also to remove from you the idea that this course is something completely new and therefore difficult. This is not the case because you are already familiar with food and digestion. What might be new to you is well explained and linked to your past learning and personal experience with digestion. The most interesting thing about this course and unit 3 in particular, is that you are learning about yourself as a human; what takes place inside your own body and within the society you live. You surely have a lot of personal knowledge and experiences to take from!

I have also used a test yourself approach in which there is a self-assessment exercise at the end of each topic. When you have completed studying a topic, turn to the Assignment section, towards the end of the unit, and do the exercise for that topic. After answering the questions in the exercise, turn to the feedback section next to the exercises and compare your answers with those provided. As a self-disciplined learner I suggest this: Study the topic, revise it and after that attempt the exercise. Compare your answers with mine at the end of the unit. Resist the temptation to look for answers in the text as you answer the questions! Finally check in the text to verify the answers you are in doubt of.

Apart from training your self-discipline, this approach allows you to constantly evaluate yourself in preparation for the assessment exercise (which you write at the end of the unit and for any final examination you might sit at the end of the whole HSB course). The assessment is a tutor marked assessment that consists of questions from the whole unit.

Unlike the exercises appearing in the assignment section, which covers the learning that took place within a topic, there is only one assessment that covers the learning that took place in the whole unit. Therefore preparation to answer it is slightly different from that suggested for assignment exercises. The suggested approach is to revise the unit cover to cover before attempting to answer the assessment exercise so that you have no temptation to check answers in the text. After answering, you will follow the procedures laid down by your institution to dispatch the answered assessment to the tutor for marking. The tutor will award marks and give you general feedback on your performance and answers to the specific questions in the assessment exercise. I have suggested answers as a part of the feedback to the assessment exercise.

In terms of time, I estimate that you will need the following time to complete the various topics and their assignments; **Topic 1,** 4 hours; **Topic 2,** 2 hours; **Topic 3,** 5 hours; **Topic 4,** 3 hours and **Assessment** 1 hour. You will therefore take about 15 hours to complete the unit.

Unit 3 needs no special resources to achieve its outcomes and the ODL context I am teaching. Common home materials, appliances and equipment like mirrors, soap, cooking oil are stated in the topic under which they are used. These resources are mentioned because they can enrich your understanding, but to avoid disadvantaging learners in contexts that may not afford them, the teaching is such that they are not a mandatory precondition to learning. So, try to get these resources and use them if you can, but if you can't get them, don't worry because you can learn from the examples given.

Terminology

Digestion: Break down and absorption of food materials.

Enzymes: Chemicals that make the breakdown of food faster.

Alimentary canal: A system of tubes along which digestion takes place; also known as gastro-intestinal tract (GIT).

Wisdom tooth: The last molar at the back of both sides of the jaws.

Dental plaque: A layer of bacteria and food debris on the tooth.

Tartar: A black layer of hardened plaque on the tooth.

Active site: Part of an enzyme where a substrate binds before it is broken into products.

Denature: Alterthe natural form of a protein by heat.

Accessory organs: Secretory organs associated with digestion which release digestive juices into the alimentary canal.

Mastication: The act of chewing.

Sphincter: Rings of muscles that allow food to move forward.

Compound gland: A gland which secretes some of its contents inside cells and others outside the cells.

Appendicitis: Inflammation of the appendix as a result of infection.

Online Resource

If you can get on the internet please utilize the resources at www.hippocampus.org. It is an excellent source of information for biology and the topics discussed in this unit. Here you will find:

- Presentations
- Simulations
- Videos
- Online Study Groups
- Links to Even More Information
- Textbook Correlations
- Online Courses

Topic 1: Teeth and the Breakdown of Food

Introduction

Welcome to topic 1 which is dealing with issues we are very familiar with; teeth and food. How many meals in a day do nutritionists normally recommend for healthy living? Think about this question, but if I remember correctly, they say that a normal person needs breakfast, lunch and supper. If you notice at home or at work, teeth are always occupied in between those recommended meals. The fact that some people can be munching chewing gum every now and then makes teeth one of the busiest parts of the body.

As mentioned in introduction to this unit, for the body to use foods like rice, meat, maize meal and others, they have to be converted to soluble forms that the body can absorb. Teeth are the first part of the digestive system to break down food. The type of digestion that is done by the teeth is physical digestion, which takes place in the mouth.

Can you remember what physical digestion is?

Write down the meaning in your notebook.

You are likely to have stated that: Physical digestion also called mechanical digestion is the breakdown of food into smaller particles, which **results in a change in the physical or outward appearance of the food.** If you have not written something like that in the bold sentence above, then make a correction. In physical digestion the teeth crush and grind the food into smaller particles. The food is also made soft when the tongue mixes it with the saliva.

Since the teeth are the main structures for physical digestion, this topic will address issues regarding the types, structure, possible defects of teeth, and how we can maintain a healthy mouth and healthy teeth.

Learning Objectives

At the end of the topic, you should be able to:

- state the types of teeth and their functions
- identify parts of a tooth from a diagram, and state their functions
- state how chewing affects food
- explain the need for chewing
- describe the cause of dental decay
- describe the care for the teeth and mouth.

Types of Teeth

You have teeth. Don't you? Open your mouth in front of a mirror and write down what you can see. You would have noticed that there are some white hard bones-resembling structures that look like small nicely shaped stones. Other parts of the mouth are fleshy, pink in colour and prone to bleeding if scratched, but those white structures are hard and scratch-resistant. You are looking at your white teeth. You can also look at the teeth of your friend or a family member to compare with yours.

One of the characteristics of mammals is that they have different types of teeth. I am sure you know what type of animals mammals are and that you must have seen the teeth of different mammals in your life experience or in earlier studies of science. The common mammals you should know by now are yourself; a human being, a goat, a cow and a dog to name a few. For those who might not be familiar with these mammals, observe those that are available in your environment. Any animal that gives birth to its young ones alive, and can feed them on the milk it produces is a mammal; observe it.

What can you say about their sets of teeth? Are they similar?

If you cannot answer this question, don't worry. We are all guilty of not observing certain things that we have come into contact with most of our lives. So on the basis of this I would like you to do this activity. Use your notebook to write down your thoughts. Feedback to this activity and others elsewhere in the unit is given in italics below the activity.

Activity 1.1: [Take 10 minutes]

1. Request your friend to observe his/her teeth. You could also open your mouth and observe your teeth in a mirror. In either case note down the types of teeth and the shapes you have observed. You could just look at their shapes and the way they are positioned in the mouth.
2. Try some means of obtaining a goat's skull or head, like when a goat is slaughtered at home. In either case observe the kind of teeth it has and how they are positioned in the mouth.
3. Look at the teeth of a dog next time it opens its mouth like when panting or barking, and note their shapes and sizes.
4. Try to count the total number of teeth in each of the three animals.

If you have done the activity, you would have realised that different mammals have different sets of teeth. The front teeth are shaped differently from those on the sides and those at the back of the mouth. The total number of teeth is also different among the three animals. We shall learn about the number of teeth later in this topic.

For this activity use mammals that are available in your situation.

Can you think of the reason why animals have different types of teeth?

Write down your thoughts before reading. Well, it is because mammals eat different types of food. Some eat raw hard or tough food while others eat soft and often processed food. We say that the teeth are adapted to suit the type of food the animal eats.

The shape of the individual tooth, however, is suited to its role in the mouth. Did you know that the shape and position of each tooth in the mouth determines what it does on the food? You can check this out by doing the following activity.

Activity 1.2: [Take 7 minutes]

Get a fruit like an apple or banana and try to observe the following actions of teeth.

1. Bite off a normal-sized piece. Which position are the teeth that bite off?
2. Try to chew the piece using the front teeth. How does it feel?
3. Now direct the piece or bite off a new piece and let it go where the chewing is comfortable. Which position are the teeth that give comfortable chewing?
4. What conclusion can you draw about the shape and position of individual tooth and its action on food?

Although we shall come back to the function of teeth later in the topic, from the activity you should notice that the front teeth have the shape and position suitable for biting. Since the teeth of the upper jaw overlap those of the lower jaw, you could have noticed that chewing action is awkward. On the other hand if you bite off a piece it will, as if subconsciously, move to the side and back teeth. These teeth have flat tops and those of the upper jaw fit well on top of those in the lower jaw, making the chewing and grinding actions comfortable. In conclusion, teeth at the front are suited for biting food. Those at the sides of the jaws are suited for chewing food.

Let us find out more about our teeth, that is, human teeth. Observe your teeth again using a mirror. Count the number of teeth you can see and compare the figure with that you found in Activity 1.1. You can also ask members of your family to observe and count their teeth.

Figure 1: Distribution of teeth in a human mouth

Royalty free clipart: retrieved 8 July 2010 on http:www.clker.com/clipart-10400.html

How many teeth are there in a human mouth?

You may have observed that the number of teeth increases as an infant grows to adulthood. The number of teeth therefore depends on the stage of growth. One of the exciting events in the growth of an infant is the appearance of the first teeth. Please, find out from relatives, neighbours and from human biology books, on average at what age do the first teeth appear, how many there are and in which jaw do they first appear?

You would have found out from the above sources that a human has 28 teeth at about18 years of age increasing to 32 at full adulthood. Figure 1 above shows an open mouth with a full set of 32 teeth. Humans grow their first set of teeth when they are about 4 months old. Normally two small teeth appear in the front part of the lower jaw, and soon followed by another two in the upper jaw. The first set of teeth in infants is called **milk teeth** and these teeth are temporary. At a certain age, say around 6 to 7 years, milk teeth start to fall off and are gradually replaced by bigger and firmer teeth. These are permanent, and are known as **permanent** teeth.

On average, by the age of 14 years, 28 of the permanent teeth should have appeared in humans. Four more teeth called **"wisdom"** teeth are added in the late teens or early twenties. When one loses permanent teeth, they are lost forever! That is why it is important to protect our teeth.

How many different shapes of teeth do you have?

You may use the mirror again or Figure 1 above to answer this question. Also observe the shape and position of each type in the two jaws.

Generally, the shape and number of teeth in the mouth of any mammal is given by what is called a **dental formula**. This is simply a representation of each shape of teeth according to the position it occupies in the lower and upper jaws of a mammal.

Thus, in humans the number of teeth can be worked out as:

Name of teeth	I	C	PM	M	Total
Upper jaw	4	2	4	6	= 16
Lower jaw	4	2	4	6	= 16
Total	**8**	**4**	**8**	**12**	**= 32**

I= Incisors, C= Canines, P = Pre-molars and M= Molars

Formula is: 2 (2/2, 1/1, 2/2,3/3) = 16x2 = 32

In Activity 1.1, I asked you to observe the number of teeth in a goat and a dog; you can calculate the total number of teeth in the two mammals using the following formulae. Compare the number you found with the number you get by using the formula.

In an adult dog

You have this distribution: I- 3/3 C - 1/1 P- 4/4 M- 2/3 = 21x2= 42

Formula is: 2(3/3, 1/1, 4/4, 2/3) = 42

In an adult goat

You have this distribution: I-0/3 C-0/1 P-3/3 M-2/3 = 16 x 2 = 32

Formula is: 2(0/3, 0/1, 3/3, 3/3) = 32

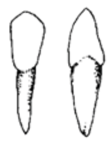
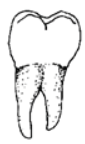
I hope you have observed that the shape and size of the teeth and their positions differ from a mammal to mammal. Why do you think it is so?

In a natural setting a human often eats cooked food; a goat grazes on hard vegetable materials while a dog eats bony and meaty material. It is important to note that the hardness of the food the animal eats determines the shape, size and position of the teeth in its mouth.

Let me bring you back to the human who is the subject of the course. I am doing so by inviting you to check whether the summary below (Table 1) of the various types of human teeth and their role in physical digestion of food is correct.

Table 1: A summary of human teeth and their functions

Type of teeth	Description	Function	Number

Incisor 	long, thin, sharp-edged, one root	cutting, gnawing, holding, biting food	8
Canine 	conical, pointed, one long root	tearing, piercing food	4
Pre-molar 	large, flat, rough-edged surface, two roots	grinding and chewing	8
Molar 	largest, flat, rough-edged surface, three roots	grinding and chewing	12

Let's remember what we have learned about teeth so far by doing the following activity.

Activity 1.3: [Take 5 minutes]

1. How many premolars does an adult human have?
2. What is the name given to the last molar tooth in humans?
3. How does the canine look like and what is it used for?
4. How do we call the front teeth and what are they used for?
5. Why are the canines large in animals like dogs and lions?

If you have thoroughly studied the relevant sections of the topic you should have no problem of responding to these questions. Try several times to answer them without referring to the text. Then when you feel you are defeated read the relevant section and find the answer. Question

5 requires you to be familiar with the type of food various animals eat. You can also find some answers in Table 1.

Now that we know the types and number of teeth, let's now look at the internal structure of the tooth.

Structure of the Tooth

I believe this is not the first time for you to encounter Figure 2: Internal structure of the tooth. Junior Certificate and even Primary School Science teach something about teeth. I guess this is a revision that should not take much of your time.

But, do you expect the different types of teeth we have just learned about to also have different internal parts (structure)? That is what we are going to find out in this section. In finding out we shall use Figure 2, which you should study and as you read the text that follow it, you will be expected to continuously go back to Figure 2 and write the words against the letters representing the internal parts of a tooth.

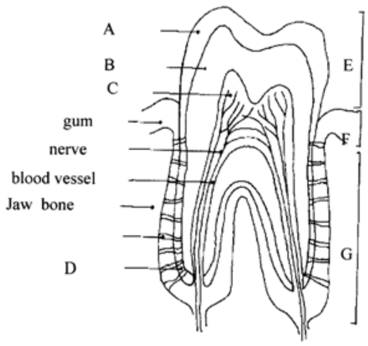


Figure 2: Internal structure of the tooth *[Source: BOCODOL Unit 3, 2002]*

When you look at the outside appearance of a normal tooth you will notice that it has a white cover. This part is the **enamel**. It can be seen appearing on top of the red or grey part called **gum**. Label A the enamel on Figure 2. Enamel covers the exposed part of the tooth and makes a hard biting surface. It is a non-living substance containing the mineral calcium. It is very hard and resistant to decay and wear.

The next one, labelled B, is a thick layer of hard bone-like material. It is softer than the enamel. It is called the **dentine**. The dentine is a living tissue, which contains living bone cells. Now write the word dentine next to the letter B on Figure 2.

The next one is a soft connective tissue, part C, in the centre of the tooth. This is covered by the dentine and it is called the **pulp cavity**. It contains blood vessels, nerve fibres and pain-**sensory receptors**. The blood vessels transport materials to and from the cells in this tissue. Now label the part C. Don't forget that you have to do this for all the parts marked with letters on the diagram.

Part D is a bone-like substance called the **cement**. It fixes the tooth into the jaw bone, similar to the way concrete is used to fix a pole into the ground.

Part E is the visible part of the tooth. It is the white portion outside the gum. Label E **crown.** This is the part of the tooth you see when a person smiles.

The next is the **neck** of the tooth. It is the space between the crown and the root. Label F neck.

Label G **root**. It is the bottom most portion of the tooth. It is the part that is fixed into the jaw bone.

I now invite you to check Table 2 and verify whether the summary of the parts of the human tooth and their descriptions is correct. Once again the letters have been placed next to the words. You should check on Figure 2 to see whether you have slotted the right words next to the letters.

Table 2: Summary of the Parts of a Human Tooth

Part of tooth	Description
A: Enamel	The white, hard material which makes up the crown that protects inner parts of the tooth.
B: Dentine	Thick layer of hard living bonny material.
C: Pulp cavity	Space inside the tooth containing blood capillaries and nerves held together by connective tissues.
D: Cement	Hard, bonny material that hold the tooth into the jaw bone.
E: Crown	Visible part of the tooth outside the gum.
F: Neck	Space between the cement and the crown.
G: Root	Part of the tooth that is imbedded in the jaw bone.

We have described the structure and function of the parts of the tooth. In the next section we shall learn the role of teeth in the digestion of food.

Teeth in the Digestion of Food

In Section 2, we learned how teeth are adapted to the food an animal eats.

We also learned how the structure of each tooth is suited to its role in physical digestion. Now from your experience, how do humans take in food? How do you compare this with how other animals take in food? Give a thought to these questions before you read on.

As mentioned earlier the process of physical digestion begins in the mouth where the food is first chewed and crushed by the teeth and then mixed with saliva. We all chew food before swallowing it. Even babies who have not yet developed teeth do attempt to chew food.

Have you ever wondered why we chew food? Why can't we just swallow it?

From the questions posed in the first paragraph above, chewing is very important in the human's physical digestion. Humans are the only animals whose food intake is controlled. Most other animals will gobble as big chunks of food as their teeth are able to cut and their throats are able to swallow. Humans have forks, knives and spoons, which enable them to cut chunks of food they are able to comfortably chew thoroughly and swallow. They also have the patience to chew and grind the food before attempting to swallow.

Therefore chewing in humans is an important feature of physical digestion because it breaks down the food into small pieces, which can easily be swallowed.

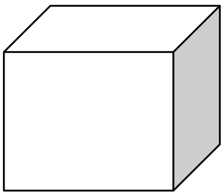
Another importance of chewing is that the small particles of food it creates increase the surface area for **enzymes** to work on the food. The smaller the food particles are, the greater the surface area to volume ratio which favours speedy enzyme action on food.

Did you know that a rat has a bigger surface area to volume ratio than an elephant? Yes, it is true! If you divided the surface area with the volume of each and every mammal, the rat and the bat, the smallest of them all, would compete for the first position as having the highest ratios.

If you find difficulty in believing this claim, do the following activity to prove it.

Activity 1.4: {Take 5 minutes}

Calculate the surface area to volume ratio of box A (the rat) with 2 cm long equal sides, and box B (the elephant) with 20 cm long equal sides.



Box A (Rat = Small food particle) Box B (Elephant = Big chunk of food)

I am sure from your junior secondary, even standard 7 mathematics you are able to calculate the area and volume of a cube. You can also work out the ratio of surface area to volume. So, I suggest you try the activity before you read the feedback below.

	Box A	***Box B***
Surface area	$= 4(2\ cm \times 2\ cm)$	$= 4(20\ cm \times 20\ cm)$
	$= 16\ cm^2$	$= 1600\ cm^2$
Volume	$= 2cm \times 2cm \times 2cm$	$= 20cm \times 20cm \times 20cm$
	$= 8\ cm^3$	$= 8000\ cm^3$
Area: Volume	$= 16cm^2/8cm^3$	$= 1600cm^2/8000cm^3$
	$= 2$	$= 0.2$

Since the sides of the cubes are equal and it has 4 sides:

Area = 4(side x side)

The volume (V) also will be:
V = side x side x side

A ratio is how many times a quantity goes into another. In this case, how many times can the area of the cube go into its volume? You find this by: area divided by volume: Area/Volume

You can see that the area to volume ratio (2) of box A (the rat) representing small particles of food is 10 times bigger than that (0.2) of box B (the elephant) representing a big chunk of food. In general bigger objects have a smaller surface area compared to their volume.

These boxes are an example, but if you are able to determine the area and volume of a rat and an elephant and use the above calculation method you would arrive at the same conclusion as for the above boxes.

So what can you say about the effect of chewing on food in humans? I hope you have observed that in physical digestion, chewing reduces the particle size of food, thus giving them a higher surface area to volume ratio than the chunk of food we bite. Since enzymes attack food particles from the surface, this condition favours the speed with which enzymes break down food. We will deal with chemical digestion by enzymes in topic 2.

Our discussion on the structure of the mouth and teeth and how they are suited for digestion shows how important these organs are to our health. The role of the mouth in capturing and manipulating food with the tongue, and the role of teeth in physical digestion have confirmed their importance to healthy human life. In the next section we will discuss how to keep these two important parts of our body healthy.

Oral Hygiene

Do you brush your teeth or at least wash your mouth? How many times a day do you do that? These may sound trivial questions, but if you have noted the important roles teeth and the mouth play in physical digestion, keeping healthy these two parts of the body becomes a serious concern. They are the entrance to the entire digestive system and the first to perform part of the process of digestion.

What other roles do you think the teeth and mouth play? Think about this question before you continue.

Generally our teeth are very important to our well being. Apart from capturing and chewing food the presence of teeth in our mouth improves our appearance, and makes us speak more clearly. People who lost, even a few of their teeth, their looks and speech become distorted. Diseased teeth make our mouth foul smelling which offends those we speak to or who come close to us. It is therefore very important that we keep our mouth and teeth healthy.

Now, from the discussion we have had so far under section 4.0, can you say what 'oral hygiene' is? Write your answer on a paper before you proceed. I hope you have noticed that the heading is made of two words. **oral** is a word meaning **'something to do with the mouth cavity'**. **hygiene** is a word meaning **'a set of principles or practices aimed towards health'**. Combining the meanings of the two words **oral hygiene** in this context can be defined as 'the **practices of caring for teeth and mouth so as to keep them healthy'**. If we don't take proper care of them, they will develop diseases which are referred to as **dental diseases.** In the following part of this section we are going to learn health problems that arise from poor oral hygiene.

Have you ever spent one day without brushing teeth or washing the mouth? How does the mouth feel, and what do you find on the surface of and between the teeth? Try this experiment for curiosity's sake and you will get the answers to the questions! Don't clean your mouth and teeth for at least 24 hours and check how your mouth smells and what is on the surface and between the teeth. I am sure from your observation you will realise the importance of oral hygiene.

The truth is that our mouth is inhabited by millions of microorganisms, including bacteria and fungi. From your earlier learning especially in unit

1 of this course and your experience, I am sure you know that these two organisms are agents of most human diseases. Teeth diseases like **gingivitis** are a result of bacterial action; mouth diseases like **oral thrush** are a result of fungal action. These microorganisms are constantly multiplying inside the mouth using food debris and dead skin of the mouth lining as a source of nutrients. If not interrupted by cleaning teeth and washing the mouth, they lead to oral diseases described below.

We are going to learn about the following common diseases of teeth and gums:

- Gingivitis
- Periodontitis
- Dental caries
- Dental fluorosis

The first two are diseases that initially affect the gums and are called **periodontal** or gum diseases. As we learnt in figure 2, the gum is the red or grey part in the mouth from which the teeth appear to emerge, and surrounds the teeth. The term periodontal means **'around the tooth'.** The two diseases attack the gum around the tooth and if untreated eventually attack the tooth itself. As mentioned above, the millions of bacteria in our mouth are constantly building up a sticky colourless or yellow layer on the surface of our teeth and gums. This layer is called **dental plaque**. If the plaque is allowed to build up as a result of poor cleanliness of our teeth and mouth, the activities of bacteria in the plaque lead to the diseases listed above.

We are now going to learn how each of them causes problems to the teeth and mouth.

Gingivitis

Have you ever seen your or someone's gum looking a bit swollen and more red than a normal gum? If the gum you saw had these features, then you can suspect gingivitis. Be alert next time and look!

Gingivitis is a mild disease of the gums that is curable. It is caused by inadequate oral hygiene. The bacteria that have built up in the plaque irritate the gums and cause infection. Inflammation that results from the body's defences makes the gums red, swollen and bleed easily.

Since gingivitis does not cause discomfort, it is advisable to look for the above signs and seek medical help; otherwise it will progress into a severe form called **periodontitis.**

Periodontitis

What is the nature of this disease then? As mentioned above, periodontitis is an advanced form of untreated gingivitis (Fig. 3). The plaque grows under the gum line **(A),** and toxins secreted by bacterial activities stimulate a chronic inflammation response in which tissues and bones supporting the teeth are destroyed **(B).** Gums separate from the teeth forming spaces between, in which more bacteria enter and cause more damage. As these empty spaces (known as **pockets (C)**) go deeper into the jaw bone), the jaw bone level is reduced in thickness **(D),** and the teeth become loose and may have to be extracted by a dentist. At times the teeth may be so loose that they can easily fall off when biting a slightly hard material.

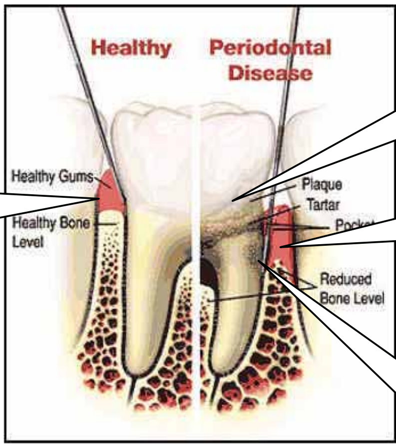


Figure 3: Damage by periodontitis

As you interact with people, observe their teeth, sometimes you might see the signs of these diseases mentioned above.

Dental Caries

This is a disease you might have seen especially among toddlers (small children). You could have seen that the milk teeth have been eaten away or pitted with black holes.

This disease is also known as **tooth decay** or **tooth cavities**. Caries form through interaction of acid-forming bacteria and presence of fermentable carbohydrates in the mouth. Many factors including the nature of one's teeth and saliva and other diseases of the body, like diabetes, enhance dental caries. The disease can develop on both the root and crown of the tooth. It affects people of all ages.

When some types of bacteria in the dental plaque ferment sugars, acids are produced. These acids begin to dissolve the enamel and dentine forming black holes called caries in the teeth. As mentioned above among toddlers all the teeth may be affected probably because kids like to eat sugary materials like sweets.

Dental caries appear as patches of brown discolouration that has no pattern. Also dental caries attack between the teeth and along the gum line where the tooth brush does not reach and food debris collect and attract bacteria that produce acids. The teeth are normally eaten away leaving big visible brown to black holes or remaining as short stubs.

In adults, dental caries can develop progressively until the bacteria reach the root and cause abscess (Fig. 4).The excruciating pain that results called **toothache** leaves no alternative but to extract the tooth. Where possible, to avoid damage to the jaw bone and the gum, the tooth should be extracted by a dentist rather than by anybody daring to extract it.

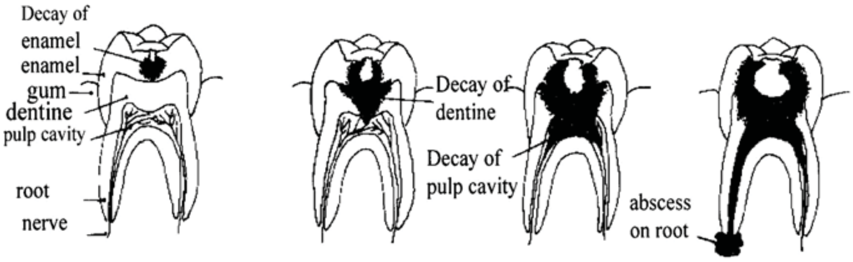


Fig.4: The progression of tooth decay (dental caries) *[Source: BOCODOL Workbook 3, 2002].*

You notice that the diseases discussed earlier, that is, gingivitis and periodontitis are first stages towards dental caries. As you learned, they affect the tissue surrounding the tooth, and if there is no treatment the acids produced by bacteria dissolves enamel and create holes through which bacteria reach the pulp cavity and abscess. By this time the individual is affected by dental caries (tooth decay) and cannot save his/her tooth. It has to be extracted. It is advisable to visit a dentist before the bacteria reach the pulp cavity. Normally dentists use some hard materials to seal off the holes and prevent entry by bacteria.

Fluorosis

In interacting with people you could have seen some with white or brown patches on the surface of their teeth. That is a case of **fluorosis**. Dental caries we have just learnt about is different from this other disease of teeth called **dental fluorosis,** because fluorosis is not caused by bacteria. Dental fluorosis is caused by ingesting the chemical fluorine in amounts that exceed recommended limits. Young children are mostly affected when they are developing both the milk teeth and the permanent teeth. Although fluoride is important in the formation of tooth enamel, too much fluorine interferes with the deposition of enamel resulting in white to yellow and brown or even black patches on the surface of the tooth.

Excess fluorine can be ingested in drinking water if it has not been treated to recommended healthy fluorine levels. Toddlers can ingest excess fluoride when they swallow foam from fluoride toothpastes and fluoride mouthwashes when they are cleaning their teeth since these materials are sweet-tasting. To prevent this from happening, toddlers require supervision when cleaning their teeth, particularly to limit the size of toothpaste and amount of mouthwash they use.

Excess fluorine affects teeth when enamel is being formed during the formation of milk teeth and permanent teeth. Excess fluorine has no effect on established teeth of adults.

Activity 1.5 below will help you revise what you have learned thus far. I would like to suggest you attempt the activity when you have completely mastered the facts for the topic.

Activity 1.5: [Take 7 minutes]

1. Write down the parts of a tooth in order starting from outside of the tooth.
2. What important property does the enamel have?
3. What danger do kids who swallow much tooth paste when brushing teeth are likely to face?
4. At what age does dental caries affect humans?
5. What do you understand by oral hygiene?

For the answers to the questions, you should refer to the relevant sections in the topic. Question 3 requires you to know the content of toothpastes that may affect the health of kids' teeth.

Earlier in this topic we emphasised the importance of teeth in physical digestion. We also learned that teeth are important in speaking clearly and general looks of a human. Without teeth, even a few, important aspects of humanness are lost; like a nice smile, clean breathe and a clear speech and singing.

We have, however, learned that there are diseases that affect teeth, especially if one neglects to clean them and in fact to clean the whole of the mouth cavity. The following subsection looks into ways the teeth and mouth must be kept clean and healthy.

How to Take Care of Our Teeth and Mouth

Have you asked yourself so far why we are using "how to take care of our teeth", and not "how to clean our teeth"? What is the difference between taking care of teeth and cleaning teeth? Think about it, and you will get the answers as you proceed with this subsection.

One of the oral hygiene practices is cleaning the mouth and teeth regularly in order to avoid dental disease and bad breathe. The following are recommended practices for proper oral hygiene. May be you practice some of them by now. Next time try those you find new but helpful.

Flossing

This could be new to you. It is new because the commonest way of cleaning teeth is by brushing and using tooth picks. People in rural areas, who don't have tooth brushes, can use a chewed and softened piece of wood, to brush the surface of their teeth and pick food debris between teeth. Flossing technique of cleaning teeth may be found among few urban dwellers.

What is flossing? Dental floss is a thin silk thread used to dislodge food debris packed between teeth. It can also be used to scrub off plaque on the surface of the teeth. Flossing for interdental cleaning is recommended once a day especially at night before going to sleep. It helps to prevent receding and bleeding gums, gum diseases, and cavities between the teeth. Receding gum is the gum that is getting detached from the teeth, leaving the roots visible.

Tongue Cleaning

Cleaning the tongue by brushing it or scrubbing it by something clean is an essential part of daily oral hygiene. Cleaning removes the white/yellow coating of bacteria, fungi and dead cells on the surface of the tongue. The practice prevents bad breathe and diseases of teeth and gums.

Gum Care

Massaging the gum with a toothbrush bristles is a recommended oral health practice. It helps prevent receding gums, gum diseases and cavities between teeth.

Use of a Mouth Wash

Have you used these? Try them; they are available in pharmacies and supermarkets. Fluoride mouthwashes containing an anti-bacterial agent is recommended for oral hygiene. In fact it is recommended to be used after brushing with fluoride toothpaste. It alone may be ineffective because it cannot dislodge food debris between teeth and gum line or remove the sticky plaque on the surface of teeth, but it leaves a feeling of freshness and good breathe.

Teeth Cleaning

Dentists recommend that teeth should be professionally cleaned twice a year. Professional cleaning involves tooth scaling and tooth polishing to remove hard plaque called **tartar.** Tartar is plague that has hardened and turned black; and has to be removed through professional cleaning.

Between cleanings by a dentist, regular and proper personal cleaning of teeth is recommended to prevent build up of new plaques and tartar.

Interdental Brushing

Can you say what the term interdental means? Give it a try before reading on. By far the most common practice in oral care is the brushing of teeth. In most families it is done almost instinctively. Now that interdental brushes are on the market, dentists recommend interdental brushing to flossing because it carries less risk of damage to dental tissues. Interdental brushes have stiff bristles that are able to penetrate between teeth and to scrub plaque along the gum line. Next time you visit a shop selling tooth brushes ask the attendants to show you one, and buy it.

While brushing is the most popular method of oral hygiene, it has to be done with proper technique, and use a recommended toothpaste if one is available to avoid dental problems. It may also require the additional use of fluoride mouthwash to obtain maximum protection.

Figure 5 is a pictorial representation of the best and effective way of brushing your teeth.

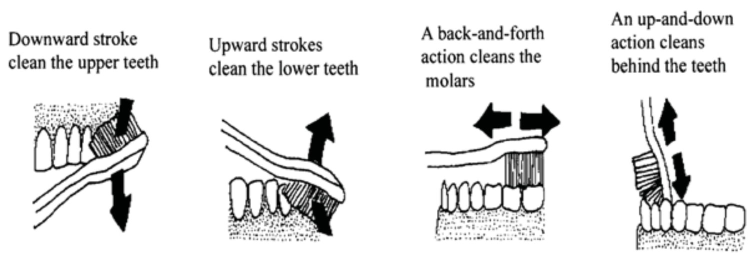


Figure 5: Technique of brushing teeth *[Source: BOCODOL Workbook 3, 2002]*

What techniques do you use to brush your teeth? The procedures for proper brushing shown in Figure 5 can be described as follows:

- Place the bristles of the brush pointing to the junction of the teeth and gums at an angle of about 45^o degrees to the teeth
- Vibrate the brush in a circular motion gently but firmly around the

necks of the teeth and between them

- Brush the side of the teeth which is facing inside the mouth
- Brush the biting surfaces with a backward and forward rubbing movement.

Note: It is more important to clean everywhere on the teeth and mouth thoroughly than to worry about a particular method. The method described above works for most people.

Safe Food and Drink

I think you have now found out the difference between taking care of teeth and cleaning teeth. This subsection has nothing to do with cleaning; it talks of how to keep teeth and mouth healthy through nutrition. Remember Unit 2 covered various aspects of proper nutrition.

Foods that support healthy muscles and bones also help teeth and gums. Bread and cereals are rich in vitamin B while fruits and vegetables contain vitamin C; the two vitamins contribute to healthy gum tissue. Meat, fish, and poultry contain magnesium and zinc for healthy teeth.

Sugars are commonly associated with dental cavities. Table sugar (sucrose) and sugars present in fruit juices are the major culprits. The more frequent sugary food or drink is taken in, the more the pH of the mouth becomes acidic. The low pH favours the activity of bacteria which leads to demineralisation of the teeth and formation of cavities. Also acids contained in fruit juice like orange, vinegar and other soft drinks lower the pH of the oral cavity causing the demineralisation of enamel. Are you familiar with the word demineralisation? Find out more about it before reading on; however, I will tell you that it is made of two words. The prefix 'de' means to take away or to decrease in amount or value. The word "mineralisation" means to add or to deposit minerals on to the tooth. So, demineralisation of teeth simply means that minerals forming the tooth are removed from it, which of course makes it weak.

It is generally advised that the consumption of sugary foodstuffs and drinks be limited. If such materials are ingested then more frequent brushing or flossing is required to prevent build up of acid-producing bacteria.

Exercising Safe Personal Habits

What habits do you think can expose the teeth and mouth to unhealthy conditions? Well, I will tell you these ones. Habits like smoking lead to unhealthy teeth and mouth. Tobacco contains nicotine and tar which tend to stain the teeth. Tobacco smoke also creates an environment in which bacteria which damage teeth and gums thrive. Other habits like excessive intake of alcohol expose the individual to accidents and fights which may lead to teeth being knocked out or jaws broken.

You can add a few more of your own you have thought of. Finally, you can see that caring for teeth is wider than cleaning teeth. It involves practices that are not necessarily cleaning like proper nutrition and good personal conduct. Cleaning, is in fact one of the ways of caring for teeth. To make you internalise this important section of keeping the mouth and teeth healthy, check your understanding of it by doing the activity below.

Activity 1.6: [Take 10 minutes]

1. Explain why the use of interdental brushes is recommended.
2. Give **two** differences between dental caries and dental fluorosis
3. Explain other practices of caring for teeth that do not involve cleaning.
4. What are periodontal diseases and name some of them.

You need to have understood the content of section 4.0 on which these questions are based. Then you should have answered the questions without difficulty. Attempt the activity and if you have difficulty check the answers in the text. question 1 and 2 deal with the cleaning of teeth; and any effective cleaning is expected to dislodge food debris between teeth and along the gum line and to remove plaque from the surface of teeth. questions 2 and 4 deal with dental diseases and their differences normally is based on their causes or agents and their symptoms. If you think along these lines your answers will be correct.

You can also ask other learners how they approached the activity; and in the next tutorial session ask the tutor to respond to the way you and your fellow learners have approached the activity.

This brings us to the end of topic 1. Let's us now briefly look at what we have been learning.

Summary

In this topic, we learnt about the teeth. Teeth help in the physical digestion of food. This is by breaking down food into smaller pieces to increase the surface area for chemical digestion and by enabling swallowing. There are four different types of teeth which have different functions. For example: we use our incisors to grip and cut the food we eat, canines pierce and tear meat whilst the premolars and molars crush and grind the food that we eat.

Despite the fact that we have four different types of teeth, they all have the same internal structure. The parts are the enamel, dentine, pulp cavity, cement, crown, neck and the root. Cement glues the root of the tooth into the jaw bone.

We also learnt that if we don't practice oral hygiene, we are likely to develop some dental diseases. These diseases include dental decay and gum diseases. We should eat the right types of food and avoid sugary types of foods and drinks. Another way is by cleaning our teeth everyday especially after meals. Also safe personal habits like not smoking, avoiding excessive alcohol intake and inclination to fighting can prevent accidents and other dangers that would render our jaws broken or teeth knocked out.

Thank you for completing this topic. Can you now do Exercise 1 at the end of this unit? Remember to follow my suggestions; that you study; and even revise the topic thoroughly before you do the exercise. Try the exercise several times. Don’t check your answers from the text as you answer the questions.

Check the feedback to exercise 1 and compare it with your responses. Refer to the text to verify your answers and those given in the feedback.

After completing the exercise and verifying your answer, you will now be ready to begin Topic 2 which is about enzymes.

Topic 2: Enzymes

Introduction

In topic1, we learned about physical digestion of food by the teeth. As we went through the topic, we mentioned that physical digestion prepares the food for chemical digestion. Now this is what we are going to learn in this topic.

Have you felt that after a delicious meal that your tummy is full? Have you felt again that after 2 to 3 hours your tummy is empty and you wish had something to eat again? What do you think has happened to the food that filled the tummy? I hope your response is that, that emptiness is a result of something having dissolved some of the food that was filling the tummy. What is it that is capable of dissolving food in the tummy? The answer is that, there are chemicals in the digestive system which break down food. As you might remember in Topic 1 you learned that apart from physical digestion, there is chemical digestion. Chemical digestion is made possible by the presence of chemical substances in our digestive system called **enzymes.**

Enzymes are proteins, which act as biological catalysts in living things. Catalysts are substances which speed up chemical processes. In living things these processes include digestion, respiration and formation of proteins. Enzymes enable these chemical processes to proceed more easily and faster than they would without enzymes. In this topic, we are only going to deal with enzymes that play a role in digestion, that is, **digestive enzymes.**

Learning Objectives

At the end of the topic, you should be able to:

- define enzymes
- list and explain the properties of enzymes
- state and describe the effect of temperature and pH on enzyme activity
- list the groups of enzymes and the type of food they digest.

Digestive Enzymes

We have learned in the introduction to this topic, that enzymes are biological catalysts which are important in speeding up body processes. Depending on the type of process they participate in, enzymes can be categorised into two types. There are those that are found inside cells and also exert their influence inside the cells. These are known as **intra-cellular** enzymes. The word **intra** means inside or within.

The other type is the **extra-cellular** enzymes. The word **extra** means outside something. These enzymes occur outside the cells and exert their actions outside. They normally act on materials that are inside body cavities or body tubes like intestines. Very good examples of these are the digestive enzymes; we are going to learn about.

If you were asked what digestive enzymes are, what would you say?

You may read the introduction to the topic if you find a problem in saying that digestive enzymes are chemicals that are responsible for the chemical break down of food.

But then which food are we referring to here? Is it a vitamin or is it a mineral?

From unit 2, you learned the various types of food nutrients as carbohydrates, proteins, lipids, water, vitamins and mineral salts. The question above is; do the last two need to be released from their food sources?

The answer is that it is definitely neither a vitamin nor a mineral. These cannot be broken down into any smaller substances. Then, if it is not these two we have just mentioned which ones are they? From the knowledge you got in unit 2, you can say that the rest of the food nutrients need to be chemically digested to be released from the bulky food humans eat.

Now, which food types are digested by enzymes?

The clue I give you is that each group of enzymes is named after the name of the food nutrient it acts on. Thus, you have the enzyme groups named as:

- Carbohydrases
- Lipases
- Proteases.

Find out if you can match enzymes with the food they digest by doing the activity below.

Activity 2.1: [Take 2 minutes]

From the clues I have given you, link each food nutrient to the enzyme that acts on it.

Enzyme	Food nutrients
Carbohydrases act on	
Lipases act on	
Proteases act on	

This must have been as easy as ABC! Carbohydrases act on carbohydrates, lipases act on lipids and proteases act on proteins.

The term **lipid** means both fats and oils. Do you know the difference between fats and oils? Well, in unit 2 you should have learned that fats are generally solids while oils are generally liquids at room temperature. Lipids of animal origin are generally solids at room temperature. Examples are the fats we see on meat or in the milk of a cow, sheep, pig and other mammals. Most lipids of plant origin tend to remain liquid at room temperature, like sunflower, cotton or olive oil.

Coming back to enzymes; within the groups of enzymes you have learned in the above section, there are individual enzymes that are secreted in a particular part of the digestive system to act on particular particles of food. We will take carbohydrases as an example. The other name for these enzymes is **amylases**. Examples of carbohydrases include **salivary amylase** (also called **ptyalin**) which is found in the salivary glands in the mouth, and **pancreatic amylase** which is secreted into the duodenum by the pancreas. We are going to deal with these enzymes in later parts of the unit, as we study digestion in the alimentary canal or gut. For now let's look at the properties of enzymes.

Properties of Enzymes

Nature has given various things peculiar properties or characteristics that make them able to do their job. Enzymes are no exception, for they have six important properties, which affect their activities. These properties are:

- **They are made of proteins**: This is one of the reasons why we need proteins in our diet. Most chemicals that have a role to play in the body processes are proteins. The shape of each protein makes it act the way it does. Each enzyme also as a protein has a specific shape that makes it act on a specific type of food nutrient.

- **They are specific in their action:** This means that each enzyme controls one particular reaction. For example, the enzyme responsible for digesting carbohydrates will only play that role. It will not take part in the digestion of fats or proteins.

- **They can be used over and over again:** This is because they are not altered or destroyed by the reaction in which they take part.

- **They are destroyed by heat:** This is because, as mentioned earlier, enzymes are proteins and are denatured by heat. For example if you boil an egg, even for one minute, the contents which are proteins in liquid form are irreversibly changed to a solid. Most human enzymes will stop working when the body temperature rises above 45^{o}C, which means death.

- **Enzymes are sensitive to pH:** Every enzyme has a pH range over which it is able to work. Some enzymes such as **pepsin** work in very acidic conditions in the stomach whereas intestinal enzymes like **trypsin** work best in alkaline conditions. This is again due to the protein nature of enzymes. Most enzymes will be destroyed when they react with other chemicals found in a pH environment that is not suitable to them.

You will now learn how the above properties influence how enzymes act on food nutients.

How Enzymes Work

A substance on which an enzyme acts is called a **substrate**. For example, if you have an enzyme that acts on proteins then we call proteins the substrate of that enzyme. Alternatively, if an enzyme works on starch, then starch is its substrate. The new substance formed as a result of the reaction is called a **product.**

Let us now do one example of an enzyme controlled reaction. We will use a carbohydrate called starch and an enzyme found in the saliva. We called this enzyme salivary amylase, in earlier sections.

In this case **starch is the substrate**, and the enzyme is **salivary amylase**. This enzyme breaks down starch into smaller pieces called **maltose**. So, **maltose is the product**. This is illustrated below.

Salivary amylase

Starch		Maltose
(substrate)	**enzyme**	**(product)**

As you know from junior certificate and other studies, molecules are constantly moving and bumping into each other. Now follow enzyme action as described in Figure 1. When a substrate molecule (A) bumps into a molecule of the right enzyme (B), it gets attached on the surface of the enzyme molecule at C. The shape of the enzyme molecule is such that it has parts at C on which the substrate easily gets held up. These parts on the enzyme molecule where the substrate is held are called the **active sites** of the enzyme (Figure 1).

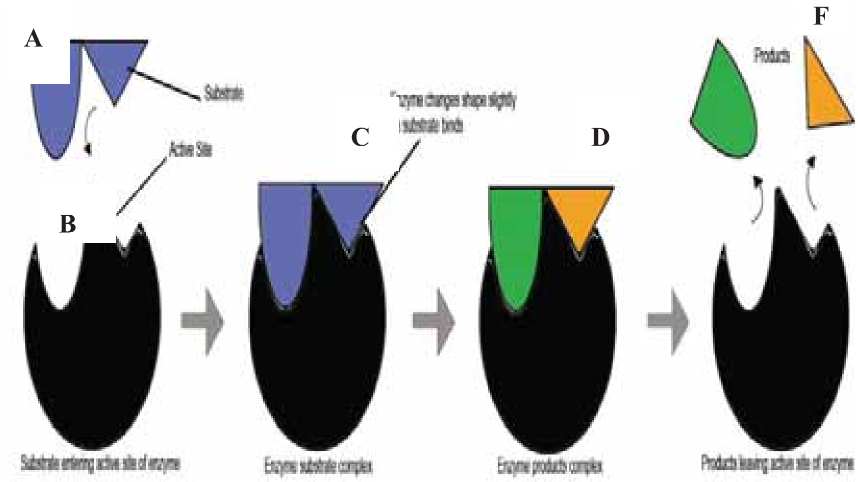


Fig. 1: Enzyme action on a substrate *[Drawn by BOCODOL)*

After the enzyme and the substrate have attached onto one another (D), the reaction then takes place at the active site, and the substrate breaks up to release the products (E). In each situation, the active site is set free to bind other substrates which in turn are broken into products.

The enzyme loses its ability to act on substrates when the shape of its active sites is distorted so that the substrate no longer fits into them. As you learned earlier, the destortion can be due to inappropriate temperature, pH level and presence of chemicals such as poisons

When you have finished studying the relevant sections, try to do the following activity. The purpose of the activity is to find out if you have so far grasped the facts about enzymes.

Activity 2.2: [Take 6 minutes]

1. What does the words “intra” and “extra” mean as used in this topic.
2. Differentiate the terms “enzyme”, “substrate” and “product”.
3. Name the enzyme found in saliva and the food it acts on.
4. List any **four** properties of an enzyme.
5. Name the part on an enzyme that enables it to do its work.

Verify your answers by going over the relevant sections of the topic. You can also ask your tutor or fellow learners. For question 5, you have to be aware that the work of enzymes in digestion is to split a complex substrate into simple products. Remember to note that how the shape of an enzyme enables it to achieve this.

In this topic we learned that enzymes are living chemicals that have properties of proteins. Hence like all living things, the condition in which they work influences their activities. Several factors influence the activity of enzymes and these will be discussed in the next section.

Factors Affecting Enzyme Activity

The major factors affecting enzyme activity are temperature and pH, since they are the conditions that are likely to change in the human body. But other factors like chemicals we swallow such as medicines and poisons or toxins from bacterial infection when we fall sick may inhibit activity of enzymes.

Temperature

From your earlier learning in science, what would you say temperature is? If you thought that temperature is how much cold or hot something is; you are correct. In general a rise in temperature increases the rate of most chemical reactions, and a fall in temperature reduces the rate. If for example the temperature at which an enzyme controlled reaction is taking place is very low, the reaction would proceed at a very low rate.

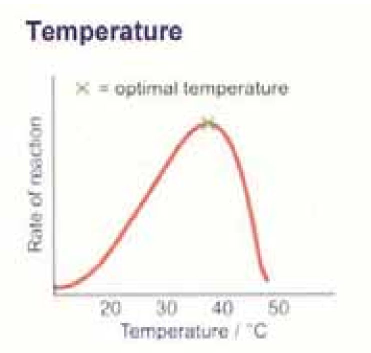


Fig. 2: Effect of temperature on enzyme activity

Now if you increase the temperature, the reaction will increase. This will happen until you reach a point where the reaction would stop increasing, and begin to decline. The temperature at which enzyme activity is the highest is called the **optimum temperature,** see Figure 2. Any temperature below or above the optimum temperature makes the enzyme act slowly.

The highest temperature at which enzymes are able to work in humans is around 40 ^{o}C above this temperature the enzyme may be destroyed and cease to work. We say that the enzyme is **denatured** by heat, and as a living chemical, it is killed.

This is one of the reasons why organisms are killed by prolonged exposure to high temperatures. The enzymes in their cells are denatured and their activities proceed too slowly to maintain life or stop completely.

pH

Once again remind yourself of the meaning of pH. Write it down in your notebook. If you doubt your definition of pH, check under Terminology at the beginning of the unit. As you might remember, enzymes work within a narrow range of pH values. That is, enzymes work best at a particular level of acidity or alkalinity (pH). Acidic or alkaline conditions change the chemical properties of most enzymes which are not suited to work under particular pH conditions. Some work best at a pH of 2 (acidic), others work in alkaline medium, that is, around pH 8-9, some others at neutral (pH7) e.g. salivary amylase in the mouth works best at or near a neutral pH. This also can be shown on the following graph (Figure 3). As mentioned earlier, in an unsuitable pH condition, the enzyme reacts with other substances that might distort the active sites or compete with the substrate for the active sites.

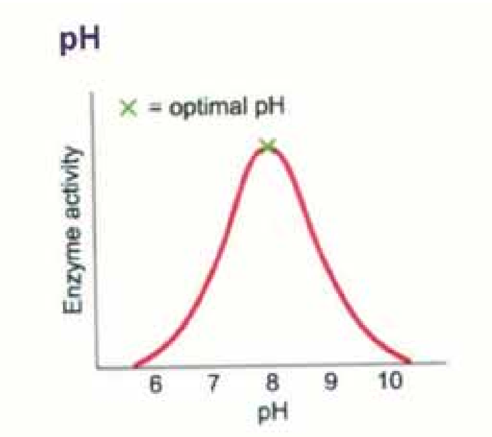


Figure 3: Effect of pH on enzyme activity

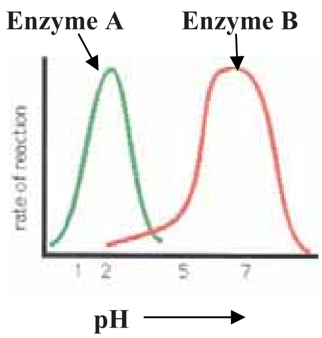
Other Factors Affecting Enzyme Action

This is only to mention that apart from temperature and pH there are other factors that influence how enzymes work. For example, chemical inhibitors like drugs and poisons influence how enzymes work, and may even prevent enzymes from working. Also the relative concentration of enzyme and substrate can affect the speed of enzyme action, whereby too much substrate will occupy the active sites on the enzyme, and reduce the speed of breaking down the substrate.

Do activity 2.3 to check your understanding of how enzymes work.

Activity 2.3: [Take 7 minutes]

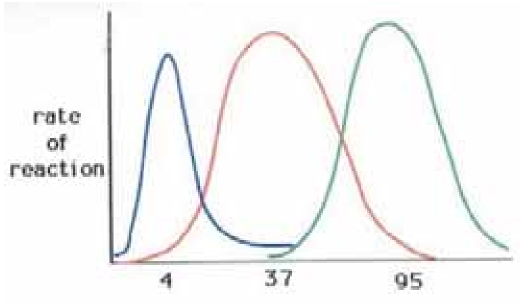
1. In an experiment the rate of reaction of two enzymes was plotted against the pH. Study the graphs and answer the questions below it.



(a) In which part of the digestive system are you likely to find enzyme B?
(b) Name **one** enzyme that can have the same rate of reaction as enzyme A.

2 Enzyme activity was determined on three organisms that live in different habitats. Study the graphs and answer the questions.

Organism X Organism Y Organism Z



Temperature°C →

(a) In which habitat are you likely to find organism X?
(b) Which of the three organisms is likely to be Man?
(c) What sort of habitat is suitable for organism Z?

3. List any other **two** factors that may affect enzyme activity.

The activity is based on what is taught in the sections that deal with conditions that may affect activities of enzymes. Graphs mainly test whether you are able to interpret the data. Try the activity after you have studied the facts and figures given in the topic. In questions 1 and 2, the conditions favouring the highest enzyme activity are the ones that favour the survival of the organism in the given condition. For example in Question 1 (a) Enzyme B has optimum activity at about pH 7 or neutral pH. Where in the digestive system do you find about neutral pH, and what enzyme do you find there? Think of the mouth for example. Apply the same reasoning to Q1 (b). Which enzyme that operate at an optimum acidic pH of 2, and where do you find such conditions in the digestive system? Think of the stomach. In Q2 (a) Organism X has the enzyme optimum at 4°C. This implies that the organism is adapted to very cold conditions like on the summit of high mountains or near the earth's poles. Apply the same reasoning to Q 2(c) where the organism has an amazing optimum enzyme activity at 95°C. What habitats have such hot conditions? For Q 2(b) organism has its optimum temperature of 37°C, and Man has a constant temperature of around 37°C regardless of the environmental temperature. Of the three, Organism Z is likely to be Man. You may also discuss the activity with your tutor and other learners.

Summary

In this topic you have learned that enzymes are biological catalysts which speed up reactions in the body. Digestive enzymes have points called binding sites on their structure. It is at these points (binding sites) that the substrate gets attached and reacts with the enzyme to break up into products.

There are certain conditions, which affect the activity of enzymes. These include temperature, pH and presence of inhibitors, to mention some.

Enzymes work best within certain range of temperatures. When you increase the temperature in an enzyme-controlled reaction, the rate of reaction also increases until a certain temperature is reached. The temperature at which an enzyme works best is called the optimum temperature.

Enzymes also work within a narrow range of pH values. As already defined, pH is how acidic or alkaline a liquid is. Each enzyme also has an optimum pH. Some have acidic optimum pH values; others have neutral pH values whilst others have alkaline optimum pH values.

Apart from temperature and pH, chemical inhibitors such as medicines and poisons interfere with enzyme action, whereas high concentration of substrate relative to enzyme can reduce the speed of enzyme action.

When all these conditions are favourable, enzymes will have the highest activity. When conditions are unfavourable, enzyme activity is low and may even stop, mainly because the active sites become deformed and the substrate can't attach itself or because other substances out-compete the substrate for the active sites.

This is the end of the topic. You can now do exercise 2 at the end of this unit. Remember my suggestion at the beginning in the teaching and learning approach section of the unit that as a self-disciplined learner you should study the topic, revise it and after that attempt the exercise. Thereafter you can compare your answers with the feedback to exercise 2 at the end of the unit. You should then be ready to move on to topic 3: The digestive system.

Topic 3: The Digestive System

Introduction

Have you ever stayed without eating, say for two days? If you have never, just imagine how you would feel in the stomach and in the whole body. The reality is that living cells throughout the human body need a constant supply of food nutrients for energy, growth, and repair of damaged cells. As mentioned earlier in topic 1, the foods we eat like rice, meat are a complex assembly of smaller units. For the body to use such foods, they have to be disassembled or split into their smallest components that are able to penetrate the wall of the small intestine into the body fluids for transportation to all living cells. The digestive system is responsible for disassembling food and absorption of the components. Digestion is of two types. There is physical digestion which we have already said takes place in the mouth and chemical digestion which takes place partially in the mouth and in the rest of the digestive system. As already explained in the previous topic, chemical digestion is achieved through the action of enzymes.

In this topic we are going to learn about the site where all chemical digestion takes place; that is the **alimentary canal**. This is a long muscular tube running from the mouth to the anus, and coiled round so that it can neatly fit into the abdominal cavity. The other names that are sometimes used to refer to this canal are the **gastro-intestinal tract** or the **digestive system** when the accessory organs are included.

Learning Objectives

At the end of the topic you should be able to:

- identify from a drawing, the structures and functions of the main parts of the digestive system
- outline the functions of the pancreas and the liver in digestion
- state the functions of amylases, proteases, and lipases
- state the main site for the digestion of proteins, starch and lipids
- describe the need for the fat to be emulsified
- describe the absorption of the products of digestion
- state the function of colon
- state what happens to the products of digestion
- explain defecation, constipation and diarrhoea.

The Digestive System and the Process of Digestion

The structure of the digestive system is shown in figure 1. The system consists of two components, namely the canal through which food passes and the glandular organs that are found along it called **accessory organs;** these organs are the salivary glands, the liver and the pancreas. The accessory organs secrete enzymes that are essential in the process of digestion. We shall learn about accessory organs as parts of the digestive system and in the context of the process of digestion.

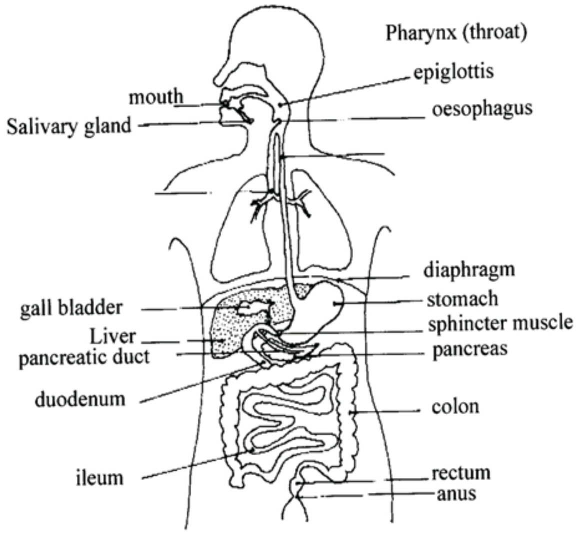


Figure 1: The Structure of the Digestive System *[Source: BOCODOL, Workbook 3, 2002]*

As mentioned in the introduction to this topic, the process of digestion involves gradual breakdown (disassembling) of complex food materials into their simplest components as the food moves along the digestive tract. Inside each organ are special structures and digestive juices which break down food into simpler components. The organ breaks the ingested food into much simpler components for the next organ to act upon until the simplest components are finally reached and are absorbed into the blood or **lymphatic** systems.

Study figure 1 above carefully. This is very important because in the next sections, we will discuss the structure and the roles of each of the parts that make up the system. Broadly the functions of the digestive system are the following in that order:

1. ingestion	2. propulsion
3. digestion	4. absorption
5. assimilation	6. egestion

Let's now look at how these functions happen in the appropriate parts of the digestive system.

The Mouth

The mouth, as we have noted in topic 1, is the entry point of food into the digestive system. So the first function of the mouth is the **ingestion** of food. Figure 2 shows the structure of the mouth that enables it to carry out this important function.

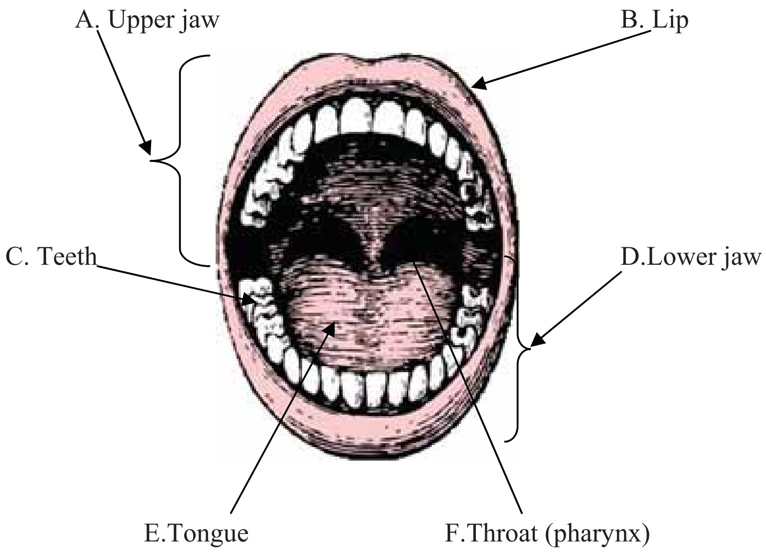


Figure 2: The Structure of the Mouth *[Source: Refer page 8 of this Unit]*

The mouth is made of two jaws; the upper jaw, A (the **maxilla)** and the lower jaw D (the **mandible**). The jaws are housed in fleshy muscular cheeks which end in lips **(C)** at the front. The jaws and cheeks provide a temporary room for the food during **mastication** (chewing). The lower jaw is hinged to the upper jaw in such a way that it can open substantially wide enough to capture big chunks of food. The way the upper jaw is hinged to the lower jaw and the muscles which operate it, together with the **tongue (E)**, enable both jaws to manipulate food whilst it is in the mouth.

As already learned in topic 1, each jaw is equipped with teeth **(B)** of various shapes and sizes designed to capture and chew most types of food humans eat. The mouth is also equipped with a muscular organ, the tongue, which plays an important role in digestion. It turns the food in the mouth, mixing it with saliva, and pushing the bolus of food into the throat or pharynx **(F).**

Other important structures for digestion are the **salivary glands** present under the tongue and in the cheeks. The glands produce a digestive juice called **saliva** containing an enzyme which plays a role in the digestion of starchy foods.

Having learned the structure of the mouth, let's see how digestion takes place in it.

Digestion in the Mouth

Spare a moment and recall when you were having a meal, how the mouth received and treated food or next time you are having a meal, pay attention to how the mouth treats food.

Food is captured by the teeth that are adapted to cut. For example a soft food like a ripe banana; what teeth will cut off a piece? What about hard food like meat on bone or a maize cob? I hope you observed that for a banana, the fruit is positioned between the front teeth (incisors) which cut off a piece. For meat on bone a maize cob or sugarcane, the food is positioned between the side teeth, especially the incisors, and a piece is chewed off.

The piece is then directed to the side teeth and masticated (chewed) and physically broken down into smaller pieces. Because the food material is physically crushed, this is called **physical/mechanical digestion.** As the food is chewed it is softened by the saliva. The tongue helps to mix the food with saliva to soften it. The tongue rolls up the softened small pieces of food into a round ball or **bolus** and pushes it into the **throat** or **pharynx**. This is the first stage of digestion called ingestion or taking in of food.

As pointed out above, saliva is made in the salivary glands, and it contains two substances that are helpful in digestion. The two are:

(i) an enzyme called **salivary amylase** (also called **ptyalin)**which splits some of the starch into simpler starch particles called **maltose**. You by now know that, digestion by enzymes involves chemical splitting of complex food materials into simpler ones, and that is why it is called **chemical digestion.**

$$\text{Complex starch} \xrightarrow{\text{Salivary amylase}} \text{Maltose}$$

(ii) a slimy substance called **mucin** which helps to soften the food and make it slippery. Next time you observe food which has been chewed you will notice that it has a slimy consistency when you touch it. Being slimy makes the food able to smoothly slide down the gullet (oesophagus) when we swallow. Next time you eat starchy food like bread, attempt to swallow before you thoroughly chew and mix it with saliva. You are likely to feel the food getting stuck in the throat and choking you!

From the mouth, food is pushed into the next chamber at the back of the mouth called pharynx or throat.

The Pharynx

If you look at figure 2, you can see that the phyranx is a space or cavity at the back of the mouth. The space within the mouth and pharynx where the food is manipulated before swallowing is called buccal cavity. There is no digestion taking place in the phyranx itself; in fact the food stays there momentarily. It is a cross-road into which the food passage or oesophagus, and the air passage, the windpipe or **trachea** open. A flap of a muscle called **epiglottis** at the top of the voice box (**larynx**) closes the windpipe when we swallow something (food or drink). This prevents some of what we are swallowing from entering the windpipe and choking us. Notice next time you swallow something, breathing stops momentarily for the duration of swallowing.

As mentioned above, the food passage or oesophagus is the next part which opens into the phyranx. Let's learn what happens in it.

The Oesophagus

Do you think the food is dropped through the oesophagus into the stomach as if it were a stone? Recall what happens when you swallow food. I hope you have realised that food is not dropped like a stone. It is rather propelled by the gentle pushing and pulling action of the muscles of the oesophagus. This special mechanism is called **peristalsis**. Because of peristalisis one is able to swallow even in upsisde down position. Try it! It is the mechanism that propels food along the whole length of the alimentary canal. Let's see how the oeasophagus is suited for peristalisis.

The structure of the oesophagus

The oesophagus is a muscular tube about 20 cm long. At rest and during chewing the passage is closed off by a ring of muscles called **upper oesophageal sphincter** at the top near the pharynx, and **lower oesophageal sphincter** at the bottom near the stomach. These sphincters (or valves) prevent food from going back in the direction it came from.

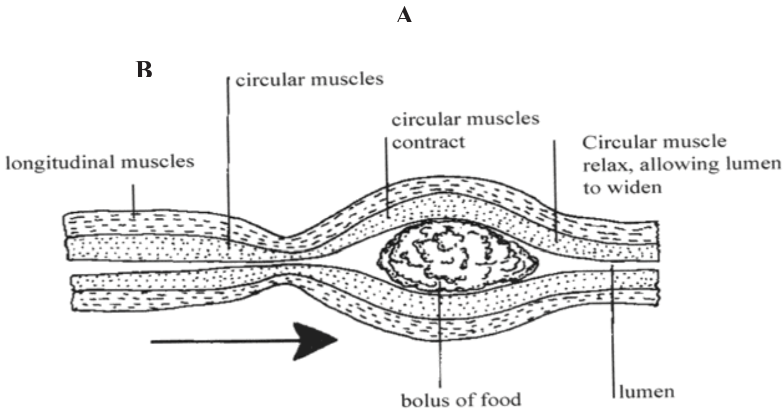


Figure 3: The Structure of the Oesophagus *[Source: BOCODOL, Workbook 2, 2001]*

The wall of the oesophagus, like the whole of the digestive tract is made up of two sets of muscles, the circular muscles **(A)** which run around the food passage, and the longitudinal muscles **(B)** which run lengthwise along the food passage (Figure 3). These are the muscles responsible for peristalis along the whole length of the alimentary canal. Let's learn the part the oeasophagus palys in digestion.

The role of the oesophagus in digestion

The role of oesophagus like the whole of the walls of the digestive tract is to propel food from the mouth into the stomach by the action of peristalsis. The contraction and relaxation of the muscles propels the bolus of food through the passage by a wave of forward squeezing and pushing as you can see in Figure 3.

Next time you see a snake swallowing its prey like a rat or a frog, you will see a wave of relaxation and contraction as the prey moves along the length of the snake. You can also see the same movement by looking at the Adam's apple region (front part of the neck below the chin), of a fellow learner or yourself in a mirror. You will see the up and down movement of this region as you swallow something, even your saliva.

As pointed out earlier, peristalsis does not only take place in the oesophagus, but also in the whole of the alimentary canal. It is responsible for the **propulsion** of food through the canal. Do you understand the term propulsion? Find out from other learners and books what it means. You can also get the meaning from the explanation of peristalisis in the above sections of this topic.

Since peristalsis is achieved by the action of muscles it will occur best when you have plenty of fibre in your diet. When peristalsis stops happening, you get constipation. This is because the food you have swallowed is not moving. The reason why it is not moving is because of the muscles of the alimentary canal which can only function when there is dietary fibre in your food. Food lacking in fibre like over refined grains sticks on the wall of the intestines. Fibre provides a sort of grip on the wall of the canal so that muscles are able to push the food forward.

Have you ever seen a vehicle stuck in mud? The wheels keep rotating at one place because the soft mud cannot provide firm grip for the wheels to move in either direction. How do you normally provide grip for the wheels to drive out of the mud? You will see people putting stones, branches of trees, wooden planks and other rough materials. In the same way the roughness of dietary fibre makes the food have a firm grip on the wall of the alimentary canal and is then able to move forward. Attempt this activity to check how much you understand about the digestive system so far.

Activity 3.1: [Take 7 minutes]

1. What is the main function of the digestive system?
2. What is the function of the tongue?
3. What is ingestion?
4. Name the enzyme found in the mouth and the food it acts on.
5. What is the function of epiglottis?
6. What are the other names for "throat" and "windpipe"?
7. Explain how peristalsis occurs.

You should have no problem with this activity which requires that you recall some facts. After attempting to answer the questions verify your answers by reading relevant sections. For Question 7 you should emphasise the role of the smooth muscles of the alimentary canal and the importance of fibre

In the following section you will learn what happens to the food as it enters and leaves the stomach.

The Stomach

As mentioned above the oesophagus empties its content into the stomach through the lower oesophageal sphincter, also known as **cardiac sphincter**. The sphincter prevents the stomach contents from flowing back into the oesophagus and mouth. However, some conditions may render the cardiac sphincter open and the acidic stomach contents to rush into the mouth. These conditions are called **heartburn** and **gastro-oesophageal reflux disease** (GERD).You might have suffered from heartburn at one occassion. This is a burning sensation in the chest, often with bitter-tasting hot liquid coming into the mouth. That is heartburn.

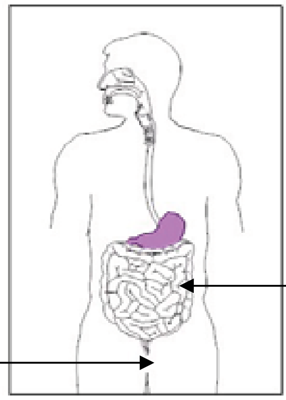


Figure 4: Position of the stomach *[ECTVE Module 2, 2008]*

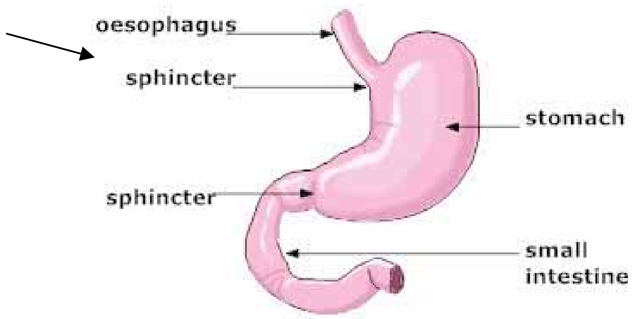
The Structure of the Stomach

You can feel the position of the stomach in your body, especially after a good meal. The stomach is like a J-shaped bag lying below the chest cavity and in the upper part of the abdominal cavity (Figure 4). The inside surface of the stomach is folded and offers a large surface area for digestion. The stomach walls also consist of cells called **gastric cells**. This is the reason why they are sometimes referred to as **gastric walls.**

We learned that the wall of the alimentary canal is made of circular and longitudinal types of muscles. The stomach has a third additional type, the **oblique** muscle. This muscle brings about the churning effect on the food, thereby turning it over and mixing it with **gastric juice**, in a way a concrete mixer mixes sand, cement and water to make concrete. The food may stay there for some time undergoing digestion.

As already pointed out, rings of thick muscles control the entry and exit of materials into and out of the stomach, like the way the **lower** oesophageal sphincter (A) in Figure 5 controls entry of food from the oesophagus, so does the **pyloric sphincter** (B) controls the exit of **chyme** into the duodenum.

In the following section you will learn what happens to food whilst in the stomach.



Digestion in the Stomach

Has it ever happened to you that when you saw a plate of delicious food, just seeing, saliva seemed to power into your mouth? This is called salivating and commonly occurs when one sees, say roasted meat.

Similarly, triggered by the presence or even expectation of food, the gastric walls secrete the acidic gastric juice into the stomach cavity. The muscular walls of the stomach squeeze and churn the food, mixing it with gastric juice, the enzymes and hydrochloric acid it contains.

What do you think is the function of gastric juice?

Well, it has several functions:

- Being a liquid it softens the food further to form a semi-solid mass, which makes it easier for the food to move through the stomach and along the intestines without much friction. The semi-solid material as it leaves the stomach is called **chyme**.
- It contains a digestive enzyme, which breaks complex proteins into less complex pieces called **peptides.** That enzyme is called **pepsin.**

$$\text{Proteins} \xrightarrow{\text{Pepsin (in gastric juice)}} \text{Peptides}$$

- In babies where the main diet is milk, the gastric juice contains an enzyme called **rennin** which coagulates protein (**casein**) in the milk. The protein forms small solids which are easily attacked by protein splitting enzymes in the small intestines.

- The strong hydrochloric acid in the gastric juice kills harmful microbes that might have been ingested with food.

Before you continue with the next section, test the undestanding you sofar on digestion by doing the activity below.

Activity 3.2: [Take 5 minutes]

1. For this question, you should use your previous knowledge on enzymes to do it. Look at the above enzyme action. Amongst the three substances appearing in it, which one is the

(i) substrate? ______________________________

(ii) product? ______________________________

(iii) enzyme? ______________________________

2. What is the function of the pharynx in digestion?

3. What makes the content of the stomach acidic?

5. Describe the structure of the stomach.

6. What are the functions of the stomach?

You will recall that in the stomach pepsin (enzyme) will split protein (substrate) to less complex peptides (products) before the food in its semi-solid form called ***chyme*** *passes into the intestines. Other questions are also easy. If you do not remember, refer to the relevant section of the topic. Question 3 refers to those components of the stomach that make it able to do its job.*

The next parts of the digestive system you are going to learn about are the intestines.

Intestines

Intestines are the longest part of the digestive system ranging up to 8 – 8.5 metres in length. There are two types of intestine, the large and the small intestine. Figure 6 shows the constituent parts and relative positions of the two intestines.

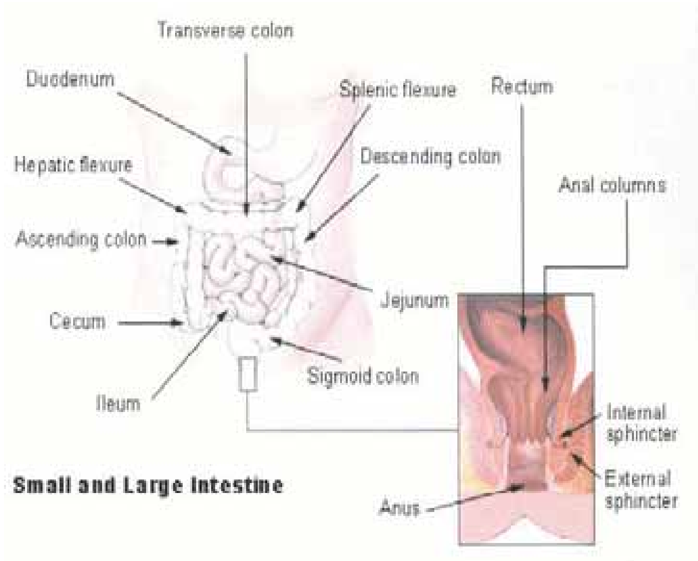


Figure 6: Position and parts of large and small intestines (anus and rectum open to show internal structure)

[retrieved 04/05/09 at *http://www.daviddarling_info/encyclopidia/L/large_intestine.html*]

We shall discuss intestines beginning with the small intestine because it is the one next to the stomach.

The Small Intestine

When food leaves the stomach, it goes into the small intestine which is the longest part of the alimentary canal, stretching between the stomach and the large intestines. In this part all chemical digestion and absorption of food take place.

Structure of the small intestine

The small intestine is a narrow tube measuring 6 - 7 metres long and 2.5 - 3 centimetres in diameter. It consists of three structurally and functionally distinct parts, although there is no clear line of demarcation between them. Each part fades imperceptibly into the next. From the stomach, they are the **duodenum**, **jejunum** and **ileum,** see Figure 7. These are the sites where final digestion of fats, proteins and carbohydrates take place with concomitant absorption of the products of digestion (glucose, amino acids, fatty acids and glycerol).

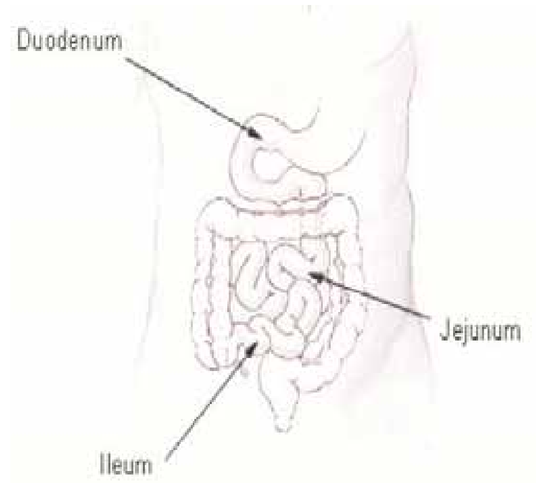


Figure 7: Position of the parts of the small intestine.
[retrieved 05/06/09 at *http://en.wikipedia.org/wiki/Small_intestine]*

Duodenum

This is the first and the shortest part of the small intestine. It can also be called **front-intestine** or **anterior gut**. In humans, the duodenum is a hollow tube about 25 - 30 cm (10 - 12 in) long linking the stomach to jejunum. Though short, most of the chemical digestion takes place in the duodenum. The head of the pancreas lies within the C-shaped loop of the duodenum. Two organs, gall bladder and pancreas empty their secretions into the duodenum through the **common duct.**

Jejunum

This is the part also known as **middle intestine** or **mid-gut** that follows the duodenum, and in humans it is 2.5 metres long. The internal surface of jejunum has many folds and these folds are covered with finger-like projections called **villi.** The villi are in turn covered with microscopic **micro-villi.** There are more folds in jejunum than in ileum and the villi in jejunum are longer than those in the ileum, see the structure of the wall of jejunum and ileum in Figure 8. All these features make the jejunum an important site for absorption of the products of digestion because of the large surface area they provide.

Ileum

Also called **posterior intestine** or **hind-gut**, ileum is the final section of the small intestine stretching to the **caecum** of the large intestine. In humans the ileum is 2 - 4 metres in length.

Like the jejunum, the internal surface of ileum has many folds on which there are numerous villi. The surface of each villus has even a greater number of micro-villi. This suggests that ileum is involved in the final absorption of the products of digestion.

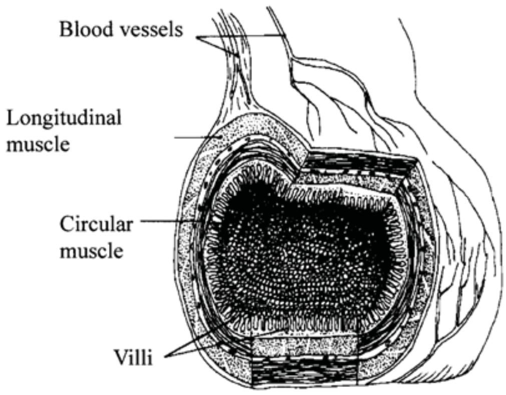


Figure 8: The structure of the wall of jejunum and ileum *[Source: BOCODOL*

Wokbook 3, 2001]

The ileum and jejunum are identified by some differences, for example ileum has more fat deposit, is paler in colour and has a smaller diameter than the jejunum.

The Large Intestine

The material that has not been digested enters the large intestine through a valve (sphincter) that separates ileum and the caecum of the large intestine. By this time digestible materials have been broken down and the products of digestion absorbed. The function of the large intestine is to absorb water and solidify the faecal matter so that it passes out of the anus in a slightly hardened form.

The structure

The large intestine is wider in diameter than the small intestine and is 1.5 metres long. It lies along the lengths and breadth of the abdominal cavity. It stretches from the junction of its caecum with ileum (called **ileocaecal valve**) to the anus. Figure 9 shows its position in relation to some other organs. The large intestine is made of three main parts, the caecum, colon and rectum; some of these parts have distinct components, refer to Figure 6 above.

The wall of the large intestine is made of the smooth muscles found in other parts of the digestive tract, but the inner surface has no villi, implying that there is no absorption of food taking place in it.

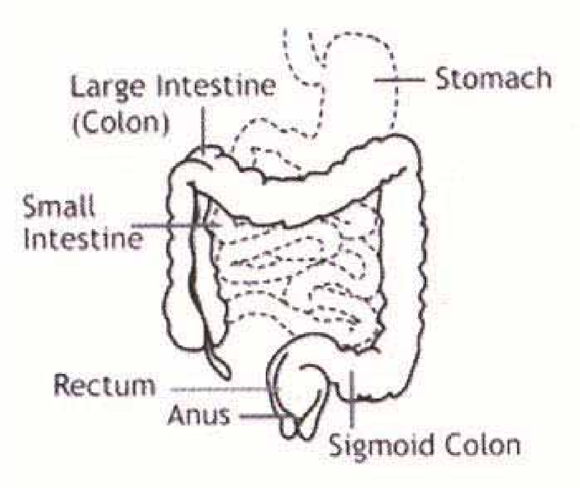


Figure 9: The position of the large intestine relative to small intestine and the stomach [retrieved 04/05/09 at *http://en.wikipedia.org/wiki/Large_intestine*]

Let's learn more about the parts of the large intestines and their components.

The Caecum

Caecum is a Greek word meaning 'blind'. So, caecum is a blind-sac like pouch at the beginning of the large intestine. It is called blind because it is closed. It is like a *cal de sac* on a road, where you have no way out except to go back where you came from (Figure 10).

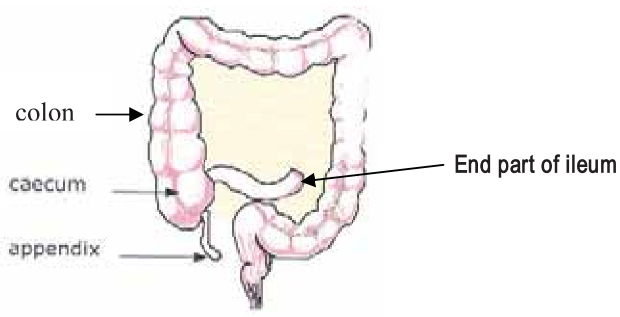


Figure 10: The caecum and associated parts *[Source: [FCTVE Module 2, 2008]*

At the bottom end of the caecum is a finger-like structure called **appendix.** Both caecum and appendix contain some micro-organisms which breakdown some of the indigestible plant materials that have resisted enzyme digestion in the small intestines. These two structures are well-developed in animals like cows and rabbits which depend on raw plant materials as the main diet.

In some cases the appendix gets infected by harmful bacteria causing a very painful condition called **appendicitis.** The appendix is then cut off, and apart from the scar left by the operation, the person lives as if nothing happened; implying that its function in the body is very insignificant.

The Colon

The colon is the longest part of the large intestine. In fact the caecum and rectum are short enlarged portions of the colon. The colon loops the entire wall of the abdominal cavity. The liver and spleen where each loop (flexure) is positioned describe that part of the colon; refer to Figure 6 and 11.

Thus, the **ascending colon** goes up the right side of the abdominal cavity from the level of the right pelvis and curves near the liver (**hepatic flexure**). The **transverse colon** lies across the top of the abdominal cavity below the stomach. Then it curves downwards near the spleen (**splenic flexure)** into the **descending colon** that lies on the left side of the abdominal cavity. This part of the colon holds most of the material to be eliminated such as some remaining water, inorganic salts, dead cells, micro-organisms and undigested materials.

The **sigmoid colon** is the S-shaped portion of the colon between descending colon and rectum. Like the rectum it holds the faecal materials coming from the descending colon.

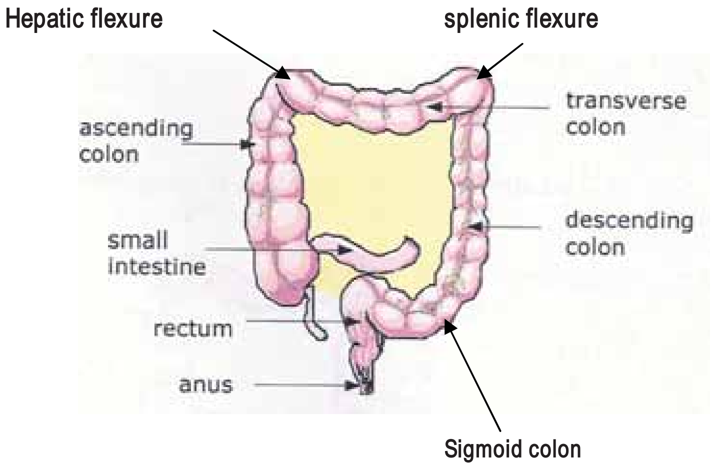


Figure 11: Parts of the colon *[Source: [FCTVE Module 2, 2008]*

The next part of the colon is the rectum that we are going to learn about.

The Rectum

This is an enlarged lower end of the colon whose function is to store faeces before it is eliminated through the anus. All materials from the descending colon accumulate in the rectum and are expelled at intervals. This process of expulsion is called **egestion** or **defecation**.

The Anus

The anus is the lower opening of the digestive system. It is guarded by a pair of tough sphincter muscles, one on the inside and the other on the outside, see Figure 6.

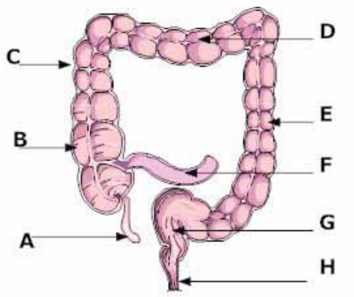
We learnt that most processes in digestion are involuntary, meaning that you don't have to be conscious of them to happen. Under normal health condition, however, egestion/defecation is voluntary. A person can exercise control over this process, that is, whether it happens or not, to a reasonable extent.

Before you go to the next section which is new, test yourself about the intestines by doing the following activity.

Activity 3.3: [Take 10 minutes]

1. What are the digestive processes that take place in the small intestine?

2. Explain the function of the villi.
3. On the diagram, name the parts of the large intestine A-E



Source: *[FCTVE Module 2, 2008]*

4. What are the names of the organs labeled F – H?
5. What is the function of the appendix?
6. What does the rectum do?

Information to this activity is captured under the small and large intestines. After you have exhausted your attempt to label or answer the questions refer to relevant sections and diagrams.

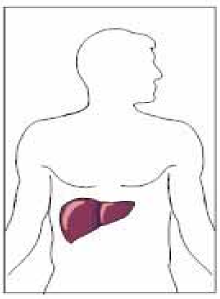
I hope you remember that in the introduction to this topic (Topic 3), I mentioned that the digestive system consists of the alimentary canal and accessory organs. Now that you have completed learning about the alimentary canal, prepare to learn about these important organs.

Accessory Organs

In the mouth and at the beginning of the small intestines are organs which are associated with digestion. These organs act as glands which secrete juices containing digestive substances. The organs are the salivary glands, the liver and the pancreas. The liver and the pancreas secrete their juices into the duodenum while salivary glands secrete into the mouth. The juices or secretions are mixed with the food by the churning action of the intestinal muscles as it passes along the small intestines.

Let us now look at the structure of these organs. We will start with the liver.

The Liver



The liver is the human body's largest organ after the skin, weighing over a kilogramme. It is positioned top-left side of the abdomenal cavity below the diaphragm (Figure 12). It has many functions in the body, but we shall concentrate on those functions relating to digestion.

Figure 12: The position of the liver *[FCTVE Module 2, 2008]*

The structure of the liver

The liver consists of the left (A) and right (B) lobes. The tissues of the liver make greenish-yellow bitter-tasting liquid called **bile,** which drains through a network of tubes called **ducts (C)** and is temporarily stored in a balloon-like structure called the **gall bladder** (D) (see Figure 13). A tube called **main duct** (E) from the gall bladder joins the **pancreatic duct** at the head of the pancreas to form the **common duct,** just before it enters the duodenum (see Figure 14 under the section on pancreas). The secretions from the two organs enter the duodenum for digestion as a mixture of bile and **pancreatic juice.**

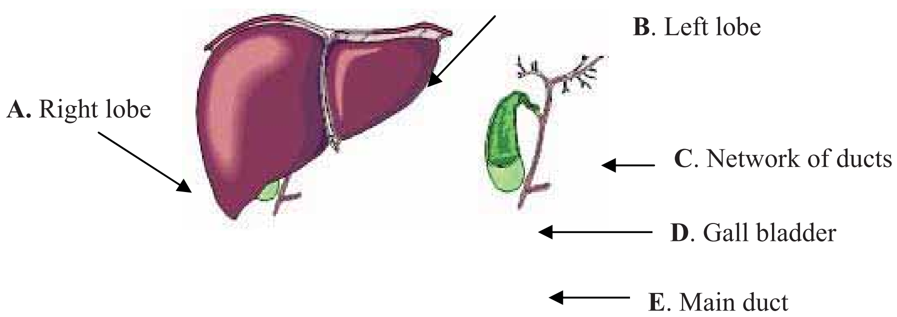


Figure 13: The liver and gall bladder *[FCTVE Module 2, 2008]*

Next, you can now learn about another accessory organ, the pancreas.

The Pancreas

The pancreas is called a **compound gland** because it exercises both **exocrine** and **endocrine** functions. Do you know what these terms mean? Endocrine glands pass their secretions into the blood system while exocrine glands like salivary glands pass their secretions into a passage or a cavity. The pancreas does both, hence its description as a compound gland. Since we are interested in digestion, we shall concentrate on the exocrine function of the pancreas.

Structure of the Pancreas

The pancreas is a fish-shaped organ about 15 cm long. It is spongy in texture and greyish in colour. Its big end **A** (the head), refer to Figure 14, is linked to the C-shaped loop of the duodenum while the thin end **B** (the tail) extends into the abdominal cavity. Some tissues of the pancreas make digestive enzymes which are secreted as **pancreatic juice.** A net-work of ducts (tubes) drains the juice into a main duct, the **pancreatic duct**. As mentioned earlier, the pancreatic duct joins the **common duct C** linked to the gall bladder, just before it empties its content into the duodenum.

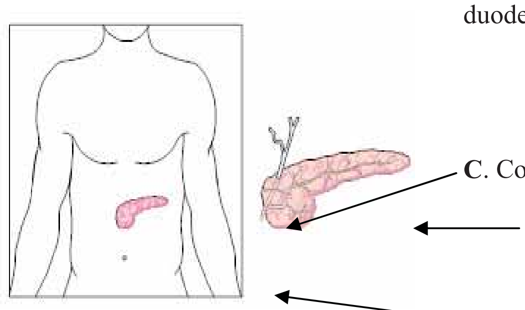


Figure 14: Position of the Pancreas *[FCTVE Module 2, 2008]*

Let us look at the role these organs whose structure we have described above, have in the process of digestion.

Chemical Digestion in Intestines

As the chyme from the stomach passes through the pyloric sphincter into the duodenum it is very acidic. Since all intestinal enzymes work best under slightly alkaline conditions (pH 8-9), it is necessary to raise the chyme pH to this level. The bile has this important function because it consists of **bile salts** that are alkaline. In addition, the pancreatic juice contains alkaline chemicals (bicarbonates) which also have the effect of raising pH of the content of the duodenum.

Unlike the pancreatic juice, the bile does not contain enzymes. However, the bile salts are able to physically breakdown large drops of fats into very small droplets. Therefore, the action of bile salts creates small fat droplets, which offer a large surface area for digestion by fat-splitting enzymes, the lipases. The action of the bile on fats can be summarised as:

Bile salts

Large fat drops $\longrightarrow$ Very small fat droplets

This action is known as **emulsification**. Since the salts responsible for the action are in the bile they are referred to as **bile salts.**

Once the suitable pH (8-9) is created and the fat has been emulsified, it is time for enzymes to act.

The pancreatic juice contains most enzymes such as amylases, lipases and proteases. In fact most digestion takes place in the duodenum as already mentioned. Any type of food will have a specific enzyme to deal with it in the pancreatic juice.

What you have to remember is that the food materials have to be disassembled into the primary units they are made of. Thus, an enzyme will do its part and pass the rest of the splitting job to the next enzyme.

Let's look at the action of pancreatic enzymes.

The Pancreatic Amylases

Just like salivary amylase you learned about in Topic 2, this type of enzymes work in neutral to alkaline conditions. They continue splitting the complex starch that has escaped digestion in the mouth to maltose and any maltose formed to glucose.

Starch (escaped from mouth) $\xrightarrow{\text{Pancreatic amylases}}$ Maltose

Maltose (formed in mouth) $\xrightarrow{\text{Pancreatic amylases}}$ Glucose

This process will continue into jejunum and ileum until all the digestible starches (carbohydrates) are converted to glucose. Any food that escapes digestion in one organ of the intestine is dealt with in the next organ. Only hard indigestible form of carbohydrates, like hard vegetable matter called **cellulose,** will pass into the large intestine.

Pancreatic Lipases

This group of enzymes is responsible for the disassembling of fats into their smallest components. From previous units and topics, you should be in a position to say what the components of fats are. What are they?

Lipases break down lipids into their smallest components, which are fatty acids and glycerol. The body can absorb and utilise fat in our diet only in the form of fatty acids and glycogen.

The splitting of fats by lipases can be summarised as follows.

$$\text{Lipids} \xrightarrow{\text{Pancreatic lipases}} \text{Fatty acids and glycerol}$$

There are **intestinal lipases** that are secreted by some cells in the walls of intestines. These are ready to deal with the fat that could have escaped digestion by pancreatic lipases in the duodenum.

Still remember the difference between fats and oils and how they are collectively called?

The action of lipases is made easier by the fact that the fat has already been emulsified into droplets by the bile salts.

Pancreatic Proteases

These are types of enzymes which act on proteins**.** We have just discussed the chemical digestion of fats and carbohydrates into their basic components.

Now what do you think are the functions of proteases in digestion?

Anyway, they are responsible for the final splitting of proteins into their simplest components. Do you still remember the components of proteins?

You remember that pepsin split complex proteins into less complex peptides in the stomach. Proteases in the small intestines will continue to split proteins that could have escaped pepsin action and at the same time keep splitting peptides into much simpler products. The simplest final product of splitting proteins and peptides is **amino acids**. The body is only able to absorb and use proteins when they are in the form of amino acids.

The action of proteases is summarised as follows.

In the stomach

$$\text{Complex proteins} \xrightarrow{\text{Pepsin (in acidic gastric juice)}} \text{Peptides}$$

In the small intestines

$$\text{Proteins (escaped pepsin digestion)} \xrightarrow{\text{Proteases (in alkaline pancreatic juice)}} \text{Amino acids}$$

$$\text{Peptides (from pepsin digestion)} \xrightarrow{\text{Proteases (in alkaline pancreatic juice)}} \text{Amino acids}$$

You have come very far in learning about the digestive system; do the following actity to your understanding so far.

Activity 3.4: [Take 5 minutes]

1. What liquid is made in the liver that is used in digestion?
2. What is the function of the liquid in (1) above?
3. What is the function of the gall bladder?
4. Why is the pancreas known as a 'compound gland'?
5. Name the liquid produced by the pancreas for digestion.
6. Name the tube carrying the liquids produced by both the liver and the pancreas.
7. In which part of the digestive system does the tube in (6) empty its contents?
8. What is chemical digestion?
9. What is emulsification?
10. For each type of enzyme secreted by the pancreas, name the substrate and the products.

This is another recall activity which you should attempt after thoroughly studying the relevant sections. For question 10, you may recall that the pancreatic juice contains several enzymes which act on different food substrates. If you encounter any challenge after checking your answer against the information provided in this topic, discuss with your tutor or other learners.

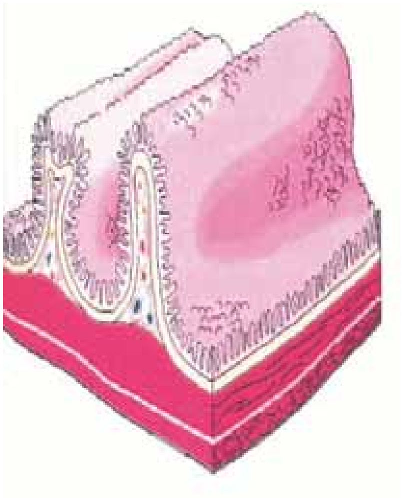
Study the next section which deals with how the products of digestion are continuously absorbed as they are formed.

Absorption of the Products of Digestion

The smallest components of digested food are absorbed into the body fluids. As you will learn in Unit 5, the main body fluids are blood and a colourless fluid called **lymph**. These are the fluids that transport various materials including food within the body. In case of food, it is transported to places in the body where it may be used immediately or stored for future use.

How is digested food absorbed?

As we learnt earlier, the structure of jejunum and ileum is suited for the absorption of the products of digestion. You learned that their length and the presence of villi and microvilli combine to offer a large surface for the absorption of the products of digestion. Some authorities compare the size of the surface for absorption the small intestine provides to the size of a tennis court. Hope you have seen or can imagine how large a tennis court is!



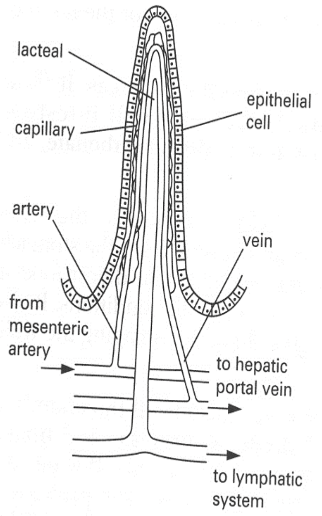


Figure 15: (a) The folded wall of small intestine with villi (Source: *[FCTVE Module 2, 2008]* **(b) the structure of one villus** *[Source: BOCODOL, Workbook 3, 2001]*

Now, as the digested food passes along the jejunum and ileum it brushes against the villi and then amino acid and glucose molecules penetrate the thin walls of the villi into the numerous blood capillaries surrounding the inside of each villus. This efficient transportation system for the products of digestion is another important adaptation of the small intestines to the process of digestion. It ensures that products are quickly taken away to give room to others being formed.

Once in the blood stream, the products are transported to cells and tissues where the molecules are to be used immediately or converted into forms that can be stored for future use.

Fatty acids and glycerol are not absorbed into the blood. As Figure 15 shows, inside each villus there is structure called **lacteal** in which fatty acids and glycerol are absorbed. The lacteals join to form lymph ducts that empty the absorbed fatty acids and glycerol into the main lymphatic system which carries them into a vein at the base of the neck. They then leave the lymphatic system and join the blood circulation.

Water is alsonh a product that is absorbed as explained in the following sub-section.

Absorption of Water

As you now know, food is mixed with digestive juices as it moves along the digestives system. Water is the largest component of the digestive juices; other components like salts and enzymes occur in relatively small amount. Because of this, food in the digestive system is in a semi-solid form with water.

As we learned earlier, not all the food is digested. There are some components of food which are not digestible. For example, part of the plant material called **cellulose** is the fibre that cannot be digested. So such indigestible material passes into the large intestines along with the water. Water is a very essential substance, which our body needs, and so it has to be absorbed into the blood stream. The process of absorbing water takes palce along the length of the colon. Depending on the healthy condition of the digestive system, water is absorbed so that the material that passes out of the colon through the anus is often semi-solid to solid **faeces**. In the last subsections of this topic, we will learn about some abnormalities of the digestive system which can make an individual pass out very hard or very watery faeces.

Use the following activity to find out how much you still understand on the sbsorption of digested food.

Activity 3.5: [Take 10 minutes]

1. What are the products of digestion that are absorbed into the body systems?
2. In which parts of the digestive system are these products absorbed?
3. Explain **four** characteristics which make the parts in (2) above suited for absorption of the products of digestion.
4. What is the function of (a) capillaries (b) lacteal?
5. Which part of the digestive system absorbs water?
6. What do you think faeces are composed of?

Try the activity without referring to the text. These are simple facts that *you should easily remember and answer the questions. When you have tried several times to remember, check in relevant sections of the topics and find the answers. You may countercheck with your tutor or another learner if you are in doubt of the answers you give.*

You will learn from the following section about the final end of the journey for the food a human has, a few hours earlier, ingested through the mouth

The Fate of the Products of Digestion

A few hours before, the ingested food took a journey from the mouth and travelled through a long twisting tube. In the tube it underwent complete transformation from a solid complex material, like a chunk of meat, into microscopic molecules called glucose, amino acids, fatty acids and glycerol. So the food is reaching its journey's end? What happens to these microscopic molecules? Let's start with glucose.

Glucose

As you learned in unit 1, living things have another characteristic apart from feeding. This is a characteristic called respiration; by which animals including humans convert glucose into energy. The process of respiration is taught in unit 4. It involves complex enzyme-contolled reactions that ultimately convert glucose into energy.

Thus, during respiration inside the cells, glucose is used to produce energy, carbon dioxide and water. You should have learned about this in your junior certificate course. This energy is used to drive the many chemical processes in cells and tissues. An example of such a process is the contraction of muscles when running or lifting a load. These two are energy requiring processes and the glucose that has been absorbed is used to provide that energy. If there is more glucose than the body requires immediately, the liver converts it to a storage compound called **glycogen**. Remember that this compound is only found in animals and not plants. If there is a supply of glucose that exceeds the storage capacity of the liver, glucose is converted into glycogen in the muscles and stored there.

When an individual consumes a lot of carbohydrates, more glucose can be produced beyond the storage capacity of the liver and muscles. In such a case excess glucose is converted to fat and stored in body tissues that store fat. Remember how we call those tissues? Check in the following section.

When there is need for glucose, the glycogen in the muscles and liver can always be converted to glucose to supply energy. First liver glycogen is used, followed by muscle glycogen. If no supply of glucose from the diet is forthcoming, then the fat is mobilised from storage tissues and re-converted to glucose and used as energy source. The next section teaches more about fats.

Fatty Acids and Glycerol

These two products of fat digestion eventually recombine to make fats which are used to make cell membranes and other structures of cells. Excess fats that are not needed for immediate use are transported to storage tissues known as **adipose tissues**. In the storage tissues, fatty acids and glycerol are once again recombined to form lipids which are then stored for future use. Adipose tissues are found around the abdomen, the buttocks, under the skin and around organs like kidneys.

During starvation, fats are mobilised from their storage tissues and used to produce energy since energy from dietary carbohydrates is in short supply. As a result the human body loses condition and the person is said to be **emaciated (skinny)**. Fats produce 2.5 times the energy produced from the same weight of glucose. This means that, fat is a concentrated form of energy.

The next subsection deals with another product of digestion, amino acids.

Amino Acids

These are absorbed by cells and reassembled to make proteins. Some of them are used for the formation of cell membranes, others for making the nucleus and its contents, and still some are components of enzymes which control and co-ordinate chemical activities within the cells and the whole body. These amino acid-dependent processes are associated with growth, repair of damaged tissues, and maintenance of the well being of a person.

At times an individual eats too much protein foods, like eating a plate full of meat, and the amount of amino acids produced are beyond the body demand for amino acids. Unfortunately amino acids cannot be stored for future use. Then the liver converts excess amino acids that are not needed for the above mentioned processes to other non-protein substances the body needs. This liver function is known as **deamination,** and the nitrogenous wastes that result are excreted in urine via the kidneys.

When learning about intestines, we concluded that digestion and absorption of usable nutrients are completed in the small intestine, and that solid undigestible materials go into the colon. The three sub-sections below deal with the expulsion of those solid residues of digestion and the problems associated with it.

Defecation

This is another characteristic of living things that you may have encountered in unit 1. Unit 1 talks of excretion as a characteristic of living things. The term excretion describes the way a living organism must get rid of wastes, whether liquids or solids. Defecation therefore is the excretion of solid wastes. This term (defecation) means the same as 'egestion' which is commonly used in biology books. The term describes the action of living things, including humans, to pass out some of the residues of what they ate.

As already pointed out, some components of the food we eat, like cellulose in the vegetable material, resist digestion. Although they cannot be digested they are still an important part of our diet. The undigested cellulose or **roughage** is the bulk (the volume of solid materials) that the muscles of the alimentary canal need to be able to push food along.

Roughage and other undigested materials in the ileum move into the **colon** from where they are expelled from the body through the anus. This action of removing this undigested waste is called **egestion or defecation.**

As a result of disease or nature of food an individual eats, defecation process can have some problems. Learn about these problems in the following two sections.

Constipation

This is one of the abnormalities of the digestive system I promised to tell you about. Sometimes the faeces move very slowly along the large intestine, with the result that more water is absorbed from them than usual and they become dry, and hard. The sufferer takes too long to visit the toilet. When he/she finally goes there, it becomes painful to pass out such hard material. At times gases accumulate in the digestive tract causing the abdomen to swell with rumbling noises inside because of the gases. This condition is called **constipation.** Have you ever experienced this proble?

Constipation may arise from not going to the toilet when you are supposed to; like when one is on a bus or any situation where there is no toilet nearby, and you have to be patient for a long time. The prolonged 'hold up' makes water absorption to proceed for too long making the faeces hard or gases to accumulate and the stomach to swell. Constipation is also caused by eating over-refined foods which do not contain fibre. As already mentioned in earlier sections, fibre provides grip on the wall of intestines. It also increases the bulk of material in the large intestine stretching its wall. This stimulates the muscles to contract, pushing the faeces along and keeps them moving until they are expelled. Consipation also may be caused by disease infection.

Medications called **laxatives** are often used to relieve constipation by encouraging movement of materials in the intestines and finally to defecate.

Another problem of defecation is diarrhoea discussed below.

Diarrhoea

The opposite of constipation is **diarrhoea**. It is another common abnormality of the digestive system people call a 'running tummy'. You may have experienced this condition since it is common.

Diarrhoea results from the failure of the colon to absorb water from the faeces. It is generally caused by an infection in the digestive system. This condition is characterised by frequent visits to the toilet and passing out watery faeces.

At times prolonged diarrhoea leads to excessive loss of water leading to **dehydration**. In diseases like cholera, water loss may be so severe that the affected individual dies in a very short time.

There are medications used to stop diarrhoea by killing organisms that are damaging the lining of the alimentary canal. This allows the food to stay in the intestines long enough for adequate absorption of water to occur. But you need to visit a doctor who is professionally qualified to determine the cause and to give the medication that targets the cause.

Now that we have come to the end of topic 3, do the following activity to check your understanding of its concluding sub-sections.

Activity 3.6: [Take 5 minutes]

1. The table below asks you about the final destination and use of the final products of digestion. Complete it.

Product of digestion	Use in the body	Where it goes in the body
Glucose		
Amino acids		
Fatty acids and glycerol		

2. Explain the causes, signs and control of:

(a) constipation (b) diarrhoea.

The activity is straightforward since it requires you to recall what you learnt in the topic. Attempt to do it without going back to the text and see how you perform. You can attempt twice or three times and then locate the answers by going over the relevant sections of Topic 3.

Summary

In this topic we learned that for food to be fully utilised by the body, it has to be split into its simplest components. This process of splitting the food is called digestion. There are two types of digestion. These are chemical digestion and physical digestion. Physical digestion of food is done by the teeth. It breaks down food into smaller particles. This makes it easier for chemical digestion to take place later in the process.

Chemical digestion is carried out by enzymes. Enzymes are catalysts which speed up the digestion process and other processes inside cells. Chemical digestion results in a change in the chemical arrangement of the food. For example starch is chemically digested into glucose, proteins are digested into amino acids and fats are broken down into fatty acids and glycerol. Each enzyme is responsible for the digestion of only one type of food or substrate. For example: amylases are responsible for starch, proteases are for protein digestion and lipases are for fat digestion. The activity of enzymes changes food from a more complex state to the simplest form that the body is able to absorb and use.

We also learned that after food has been digested, the products are absorbed through the wall of the small intestine. The small intestine is well adapted to this process because it is over 6 metres long; the inner wall is folded and bears millions of villi and micro-villi. All these structural adaptations provide a large surface area for maximum absorption of the products of digestion. The wall of the villi and micro-villi is one cell thick and has a net-work of capillaries and lymph vessels. These structures facilitate ease of diffusion and quick transportation of the products of digestion to other parts of the body where they are to be utilised or stored.

The absorbed products of digestion are used as follows:

- Glucose is used in respiration for producing energy. Excess is converted to glycogen and stored in the liver and muscles. Extra glucose above liver and muscle storage is converted to fat. Glycogen and fat can be converted back to glucose and used in respiration when there is a shortage of glucose in the blood.

- Fatty acids and glycerol are essential in the formation of cell membranes. Excess of these is reassembled into fat and stored in adipose tissues. They are also used for providing energy, especially under situations of starvation or heavy muscular activity.

- Amino acids are used for making proteins. Some of them are utilised in the formation of cell membranes and enzymes. Excess amino acids cannot be stored, instead the liver converts them into non-protein substances the body needs.

- Most water is absorbed in the colon and passed into the blood stream so that residues of digestion pass out of the anus in a semi-solid to solid form.

Undigested material has to be removed from the body. This takes place through a process called egestion also known as defecation.

We have come to the end of the topic. Do Exercise 3 at the end of this unit.

Then check the feedback to Exercise 3 at the very end of the unit and make corrections as necessary.

You can then go ahead and study the last topic, topic 4 of Unit 3.

Topic 4: Regulation of Blood Sugar

Introduction

In topic 3 we learned that glucose is one of the products of digestion which is absorbed in the blood. Another name for blood glucose is actually **blood sugar**. As you learned in topic 3, glucose may be used immediately to provide energy and excess is stored for future use. That is, the amount of sugar in the blood is maintained within constant range for good body health.

As you will learn later in this course all the factors that sustain a healthy body, such as body temperature, pH (acidity/alkalinity), water and of course blood sugar, must be kept within a normal constant range of amounts. The mechanism of doing so is called **homeostasis**. This term refers to the maintenance of a constant healthy environment inside the body. Those factors I have mentioned above are kept constant within limits or range that makes a person feel and act healthily. You will learn about homeostasis in unit 9.

In this topic we are going to learn about homeostasis as it applies to blood sugar only. By constant environment we mean that the amount of blood sugar is kept the same within certain limits or range. That is, as mentioned above, there is a certain range within which sugar in the blood is healthy, and above or below that range it is unhealthy. We are going to learn about the organs and mechanisms responsible for maintaining blood sugar within those healthy limits.

Learning Objectives

At the end of the topic, you should be able to:

- explain the role insulin plays in regulating blood sugar
- explain the role glucagon plays in the control of blood sugar
- explain diabetes; its cause, effect and control.

Organs Responsible for Controlling Blood Sugar

Introduction

You might be familiar with news media like radio, television and newspaper reports that such cases like excessive body weight (called obesity); diabetes and hypertension are increasing in the world. While these cases used to be conditions in adults, children are also, reportedly, increasingly being affected. All these conditions and others not mentioned here are linked to how the human body is able to control its blood sugar.

In the same way that the body has organs responsible for the breakdown and absorption of food, it also has organs and mechanisms by which it controls the blood sugar level. Can you guess which organs are responsible for this function? Think about this question before you read on.

Well, I hope you thought of the pancreas and the liver. In topic 3 we learned that the pancreas is a compound gland. Do you remember why? I said that the pancreas serves both as an **exocrine** gland by secreting digestive enzymes into the duodenum, and at the same time acts as an

endocrine gland by secreting substances called **hormones** in the blood. Some of these substances control the use of blood sugar in the body. The liver is also an important organ in the body, in which chemical reactions that regulate the supply and use of absorbed food, including blood sugar, take place. Let us learn more about how the two organs are responsible for the control of blood sugar.

The Pancreas and the Liver

In topic 3, we learnt about these organs in connection with digestion. You may wish to check more information about the pancreas there .The glucose found in the blood (blood sugar) was originally absorbed from the small intestines or mobilised from the storage organs like the liver and muscles. You should remember that carbohydrates are digested to glucose in the alimentary canal. It follows that soon after a big meal rich in carbohydrates the blood is carrying a large amount of sugar (glucose).

The amount of glucose in the blood, however, needs to be carefully regulated for good health. Too little glucose in the blood, a condition known as **hypoglycemia,** can result in the brain cells not functioning properly leading to a coma, and possibly death. Too much glucose in the blood, a condition known as **hyperglycemia,** is also undesirable. Do you notice a difference between the two terminologies? Yes, there is a difference. One starts with **hypo** and the other with **hyper**. The prefix **hypo** means below; hence hypoglycemia means a body condition that is a result of sugar levels that are below normal. Similarly, the prefix **hyper** means above; hence hyperglycemia is a body condition resulting from blood sugar levels that are above normal.

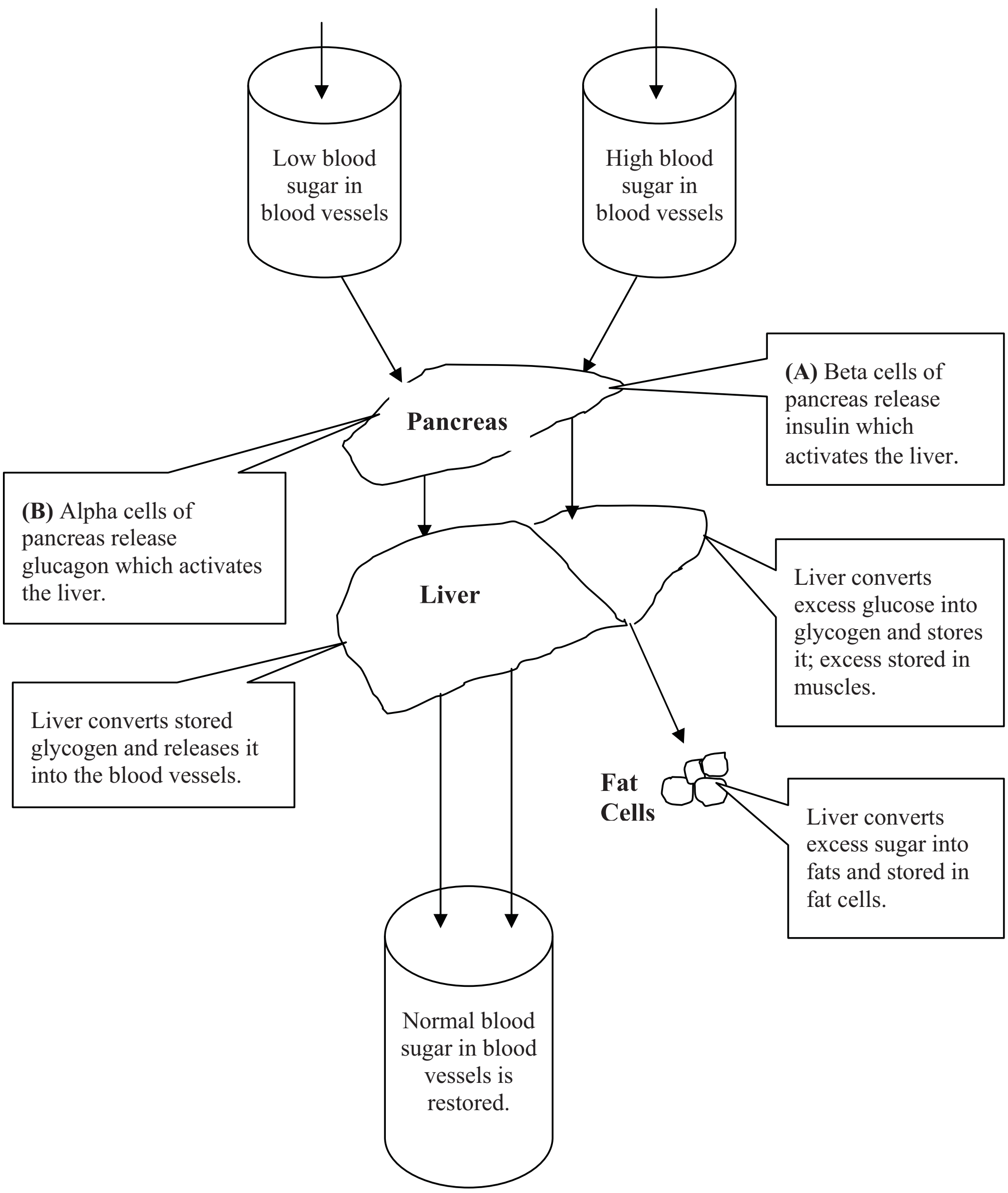


Figure 1: The pancreas and the liver in the control of blood sugar

High blood sugar (hyperglycemia) can lead to a situation where water in and around the cells moves into the blood. The end result would be that the cells would be denied water, that is, become **dehydrated** (water removed)**,** shrink and lose the ability to perform their functions properly.

The pancreas is the central organ in the control of blood glucose levels. It works in conjunction with the liver. The pancreas regulates blood sugar by secreting two substances called **hormones; insulin** and **glucagon** into the blood.

I believe you must have met the term hormone during your earlier studies of human biology. You might have learnt that hormones are chemical messengers produced by some body tissues, called glands, and sent to activate some other parts of the body. You will learn more about hormones in detail in unit 8.

The two hormones, insulin and glucagon, the pancreas secretes act in opposite ways. That is, while insulin lowers **(A)** the blood sugar, glucagon raises **(B)** it as is shown diagrammatically in figure 1, and explained in the sections that follow, and in Figures 2 and 3, for each of the two hormones.

Mechanism for Controlling Blood Sugar

I hope by now you are aware that the brain controls most of the well being of an individual. In fact an individual is still alive until he/she is certified brain dead! Like all life processes the brain ultimately is the controller of blood sugar. It is the brain that triggers off the secretion of the hormones insulin and glucagon by the pancreas. Thus, the partner organs with the brain, in the control of blood sugar are the pancreas which secrets the hormones and the liver which carries out the conversion processes of the soluble blood sugar into insoluble glycogen and fat. The following sections explain how each hormone works to lower or raise the level of blood sugar.

Insulin action in the lowering of blood sugar level

You might have heard of people suffering from high blood sugar. These people have a condition where blood sugar rises above the normal level. At times these people must always have a bottle containing the hormone insulin so that they can inject themselves with it to lower the sugar level. This is insulin made in laboratories and sold in a pharmacy.

Insulin therefore, has the effect of lowering sugar level when it goes high. How does it happen? See figure2 below; after a meal rich in sugar, the blood sugar level rises after absorption from the intestines (Stage 1). The brain detects that blood sugar level has exceeded the normal level for good health (Stage 2), which is 85 mg of glucose per 100 ml of blood. It instructs the cells within the pancreas called the **islets of Langerhans** to produce natural **insulin** (Stage 3). The cells in the islet of Langerhans which secret insulin are known as **beta** type of cells. The insulin circulates in the blood to the liver where it stimulates the liver cells to extract excess glucose from the blood. The excess glucose above the 85 mg level is converted to **glycogen** and stored in the liver (Stage 4). The liver can only store about 100 grams of glycogen. Another amount can be stored as **muscle glycogen** in the muscles. The muscles also have limited capacity for storing glycogen. When these two stores (liver and muscles) are filled and there is still more glucose in the blood, the liver will then convert it to fats for long term storage in the fat cells.

In a healthy person insulin will continue to activate the fat cells to take up more and more blood sugar and store it as fat regardless of the amount of sugar from digested food. As a result the individuals gains weight without having abnormal sugar levels. You may remind yourself the parts of the body where fat is stored by reading appropriate sections of Topic 3.

As the amount of glucose in the bloodstream reduces, the rate at which the pancreas secretes insulin is also reduced. This slows down the removal of glucose from the blood until the healthy limit mentioned above, is reached (Stage 5).

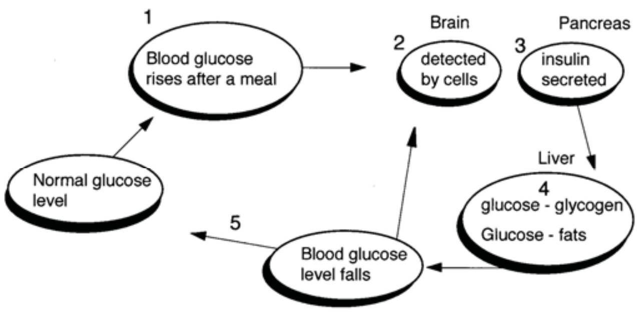


Figure 2: Insulin Action in Controlling Blood Sugar

Glucagon Action in Raising Blood Sugar Level

Did you know that glycogen is an immediate source of glucose occurring in animals only and not plants? Yes, under the influence of the other pancreatic hormone, glucagon, it readily converts to glucose when the blood sugar level falls below 85mg/100ml. How does it happen?

Look at figure 3; after a long time without a meal or after a heavy muscular exercise, the blood glucose falls below normal level (Stage 1). The brain will detect that the blood sugar is lower than normal (Stage 2). This is communicated to the **alpha** cells of the islets of Langerhans in the pancreas. The alpha type of cells will begin to secrete a hormone called **glucagon** (Stage 3). Glucagon circulates in the blood to the liver where it stimulates it to start breaking down glycogen into glucose (Stage 4). Glucagon also acts on other parts of the body like on muscles and fat cells to instruct them to release glucose until the normal blood glucose level is reached (Stage 5).

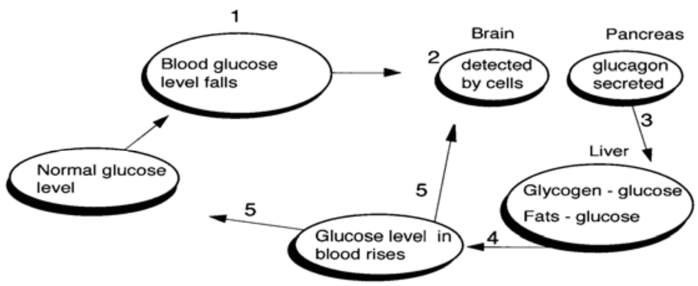


Figure 3: Glucagon Action in Controlling Blood Sugar

As the blood glucose level returns to normal, this is detected by the brain which commands the pancreas to reduce or stop the secretion of glucagon. In that way the blood sugar is maintained within limits necessary for healthy living. Once the liver and muscle glycogen have been broken down to provide glucose, stored fat is next broken down and converted into glucose by the liver cells. This happens during prolonged fasting or starvation.

It is time to test yourself on how the body maintains blood sugar levels.

Activity 4.1: [Take 5 minutes]

1. What is the meaning of the following terms?
   (a) Endocrine gland
   (b) Exocrine gland
2. What is another name for blood sugar?
3. Name the **two** hormones responsible for controlling blood sugar.
4. Where do the hormones come from?
5. Which organ of the body that ultimately detects that blood sugar is

high or low?

You must have found these questions easy as you can remember them from the sections of Topic 4. The organ of the body that detects most things in the body is the brain which then trigers the release of chemical messengers called hormones from certain organs called glands. Endocrine glands release the hormones in the blood while exocrines release their contents into body cavities.

I hope you noted from the above section that poorly controlled blood sugar leads to poor health. In the following section you will learn the commonest ill health associated with uncontrollable blood sugar.

Diabetes

Diabetes is a health condition that is increasingly becoming common in the whole world. You might even be familiar with people who are suffering from it.

When the body can’t regulate the amount of blood glucose, the person is said to be suffering from diabetes. I am sure you have heard of people who are believed to have sugar diabetes, or you might even have met them. There are two types of diabetes that affect people.

Type 1 Diabetes

This type occurs when an individual does not produce enough insulin. It happens when the immune system of the person attacks and destroys the beta cells of the pancreas. Do you remember that these cells are the ones that produce insulin? The pancreas then produces little or no insulin. As a result, after a meal rich in sugar, there is not enough insulin to convert excess glucose into glycogen. The level of the glucose will rise to a point where the kidneys begin to secrete glucose into the urine because the excess glucose can't be reabsorbed and used or stored.

If the kidney can't reabsorb the glucose, then this has an effect on its ability to absorb water. The end result is that, the body loses more water as urine. This is the reason why most people with diabetes are often very thirsty and drink large amounts of water, which they also lose fast through urination.

Type 1 Diabetes develops most often in children and young adults and its symptoms show up over a short period. How can we help people with Type 1 diabetes? A person with Type 1 Diabetes must take insulin daily in order to live. Insulin is usually injected into the person at interval and dosage the doctor recommended. Insulin must always be available and taken as recommended.

Type 2 Diabetes

This is another type of diabetes, where the individual continues to produce insulin but its quantity fails to adequately stimulate the liver cells to convert glucose to glycogen. This condition is called **insulin resistance**. Consequently, the blood glucose level rises, producing the same affects as in Type 1 Diabetes, that is, an increased water intake due to thirst and frequent urination.

This is the most common type affecting the majority of people. It is normally associated with old age, overweight and lack of exercise. It starts gradually with the pancreas secreting enough insulin, which fails to control blood sugar. Eventually insulin production stops resulting into symptoms similar to those of Type 1 Diabetes. The individual may have to take insulin to live.

In the following sub-section you will learn about the symptoms or signs that will tell you that a person is beginning to suffer from diabetes.

Symptoms of Diabetes

Thirst is not the only sign of diabetes, other signs include:

- Frequent urination, the individual passes out water often. This is what brings thirst, and the person has to drink more water to replace that being lost.
- Extreme hunger, the individual feels hungry and tends to eat often. This is mainly because of the low blood sugar which informs the brain that the individual needs to eat and boost the blood sugar level, even when the person has been eating a short while ago.
- Unexplained weight loss. Normally weight gain is a result of converting sugar into fat, but since the sugar taken in is lost through urination, the individual can’t gain weight.
- Feeling tired. Because of low blood sugar which is constantly lost, there is no sugar to generate energy, as a result the person feels tired and unable to energy demanding activities.
- Blurred vision, the individual can’t see objects clearly. In some case the individual may go blind.
- Frequent infections, bacteria and fungi multiply easily. The person is get affected by diseases causing organisms like fungi and bacteria. Immunity seems to be compromised by diabetes.

- Swollen and inflamed gums - gums may bleed easily. Also bacteria and fungi in the mouth tend to multiply even with good oral hygiene, and cause gum diseases which lead to bleeding.
- Twitching hands and feet; uncontrollable shaking of hands & feet. This occurs because of hypoglycemia (low blood sugar). You could have noticed this in yourself when you are very hungry. It is worse for a diabetic person because of a constant low level of blood sugar.

If diabetes is not detected early or is left uncontrolled, it can result into many healthy complications like heart attacks, strokes, kidney failure, blindness and limb amputations.

In the following sub-section you will learner about factors that make a person to be easily affected by diabetes.

Who is likely to develop Type 2 diabetes?

- Age 45 and older – adults above this age might be affected. The insulin secreting cells in the pancreas can lose function with age.
- Overweight individuals – we learned that obesity can cause it. People whose weight is much higher than their weight are said to be obese and tend to suffer from diabetes.
- Individuals with family history of diabetes – diabetes is thought to be a genetic condition that runs through the family. That is, if your parent suffers from diabetes, you are likely to suffer from it.
- Certain races or tribes tend to suffer more than others – e.g. black race might suffer than white race.
- Individuals with a high blood pressure. People with high blood pressure take drugs that eventually lead to diabetes.
- High level of bad cholesterol and /or triglycerides. Consumption of animal fats which contain cholesterol and triglycerides will eventually cause heart diseases and diabetes. Food of plant origin contain less of these materials and are less likely to cause diabetes
- Lack of exercise – work that does not involve muscular action. When a person does not do exercises most of the blood sugar, which is normally burned to produce energy, is converted to fat. The individual becomes overweight and is likely to suffer from diabetes.
- History of heart or blood vessel disease: As mentioned above, people who have heart and blood vessel diseases, take drugs

which may lead to diabetes.

The next sub-section will address the way you can prevent and control diabetes.

Prevention and Control of Diabetes

This will depend on the type of diabetes affecting an individual.

- With type 1 diabetes, the individual must take insulin daily as we observed above.
- With type 2 diabetes, the following behavioural changes have to be adopted.
  - one has to change lifestyle especially eating habits and having regular exercises
  - diet with plenty of fruits and vegetables is recommended
  - there are diabetes medications that must be taken as regularly as the doctor recommended.

Now that you have completed the effect of uncontrollable sugar levels you can do the following activity.

Activity 4.2: [Take 5 minutes]

1. What name is given to the condition when the body cannot maintain its normal blood sugar levels?
2. Give **five** signs that an individual has the condition you named in (1) above.
3. What characteristics that may cause an individual to develop the condition you named in (1) above.
4. Give **two** ways that individuals can use to control the condition in (1) above.

All the answers are related to diabetes condition discussed in Section 3.0. Read the section before you attempt the activity and then verify your answers by checking where relevant concepts are explained. You may also discuss the questions with your fellow learners.

Summary

In this topic, we learned about the control of blood sugar by the pancreas and the liver. We have also learned that diabetes is the condition that results from the failure of those two organs to control blood sugar.

The pancreas regulates the amount of sugar in the blood by producing a hormone called insulin. Insulin controls the conversion of blood glucose into glycogen. This is when there is lots of glucose in the blood like after a meal rich in carbohydrates. When there is less blood sugar, the pancreas stops producing insulin and produces another hormone called glucagon. This hormone has the opposite function to that of insulin because it causes the breakdown of glycogen into glucose, which is then released into the blood.

Lack or low production of the hormone insulin results in a condition called sugar diabetes. Once detected by medical tests, diabetes can be controlled through the change of lifestyle, especially a healthy diet and regular exercises, and by taking medications as the doctor prescribed.

You have now come to the end of Unit 3, and you can now try exercise 4 at the end of the unit.

Then compare your answers with those suggested in the Feedback at the end of the unit.

Unit Summary

Summary

In this unit you learned about the process of digestion. In **Topic 1**, you learned that teeth help in digestion by breaking down food into smaller pieces to increase the surface area for chemical digestion and to enable swallowing. There are four different types of teeth which have different functions. For example: we use our incisors to grip and cut the food we eat, canines pierce and tear meat whilst the premolars and molars crush and grind the food that we eat.

All types of teeth have the same internal structure namely, the enamel, dentine, pulp cavity, cement, crown, neck and the root. Cement glues the root of the tooth into the jaw bone.

You also learnt that if we don't practice oral hygiene, we are likely to develop some dental diseases. Some of these diseases are dental caries and gum diseases. It is therefore necessary to practice oral hygiene. This is achieved by avoiding sugary types of foods and drinks. Another way is by keeping our teeth clean by proper brushing everyday especially after meals.

In **Topic 2** we learned that enzymes are biological catalysts which speed up reactions in the body. Digestive enzymes work in the alimentary canal under suitable conditions. These conditions include normal body temperature, appropriate pH and absence of chemical inhibitors. Enzymes work best when these conditions are optimum and their activity decrease on both sides of the optimum. Each enzyme has a particular optimum condition and is specific to the substrate it acts on.

We then moved on to **Topic3** to explain that the human digestive system is a complex series of **organs** and **glands** that processes food. In order to use the food we eat, the enzymes have to disassemble it into its smallest components that can be transported around the body to where those components are used or stored. The residues from the process of digestion are expelled through the process called egestion or defecation.

Most of the digestive organs (like the stomach and intestines) are tube-like and hold the food as it makes its way through the body. The digestive system is essentially a long, twisting tube that runs from the mouth to the anus, plus a few other organs (like the liver and pancreas) that produce or store digestive chemicals.

The start of the process - the mouth: The digestive process begins in the mouth. The mouth is adapted for the ingestion of food because it is a spacious cavity capable of holding sizable chunks of food; it is equipped with teeth, the tongue and the salivary glands. Food is partly broken down by the process of chewing using teeth (**mechanical** digestion) and by the action of salivary enzymes (**chemical** digestion). These enzymes are produced by the salivary glands and break down carbohydrates into smaller molecules.

On the way to the stomach - the oesophagus: After being chewed and swallowed, the food enters the oesophagus. This is a long tube that runs from the mouth to the top of the stomach. It uses rhythmic, wave-like muscle movements (called **peristalsis**) to force food from the throat into the stomach. This muscle movement gives us the ability to eat or drink even when we're positioned upside-down.

In the stomach - the stomach: is a muscular sack-like J-shaped organ that churns the food and mixes with a very strongly acid liquid (gastric juice). Food in the stomach that is partly digested and mixed with stomach acids is called **chyme**.

In the small intestine - After being digested in the stomach, the food enters the **duodenum**, the first part of the small intestine. In the duodenum, bile (produced in the liver and stored in the gall bladder), enzymes from the **pancreas** and other digestive enzymes produced in the small intestine help in the breakdown of food (disassembling).

In the large intestine - after passing through the small intestine, food passes into the large intestine. Here, some of the water and chemicals like sodium are removed from the food. The bacteria in the large intestine help in the digestion process. The first part of the large intestine is called the **caecum** (the appendix is connected to the caecum). Food then travels upward in **the ascending colon**. The food travels across the abdomen in the **transverse colon**, goes down the other side of the body in the **descending colon**, and into the **rectum**. The rectum temporarily stores faeces before it is expelled.

At the end of the process - the anus: solid wastes that are stored in the rectum are passed out at intervals through the anus. The anus is equipped with tough muscles on the inside and outside, such that under normal condition defecation is a voluntary action; that is, an individual is conscious of it.

We also learned that after the food has been digested, the products are absorbed through the walls of the small intestines. The intestines are well adapted to this process because they are long; the inner wall is folded and bears millions of villi and microvilli.All these structural adaptations provide a large surface area for maximum absorption of the products of digestion.

The wall of the villi is one cell thick and has a net-work of capillaries and lymph vessels. These structures facilitate ease of diffusion and quick transportation of the products to other parts of the body where they are to be utilised or stored. The absorbed substances are used or stored in various parts of the body.

In **Topic 4** you learned about the role of the pancreas and the liver in the regulation of blood sugar. The pancreas secretes two important hormones: insulin which lowers blood sugar from higher than its upper limit to normal limits, and glucagon which raises blood sugar when it is lower than its lower limit. The liver is the one responsible for converting the soluble blood sugar into the insoluble glycogen and fat under the influence of insulin. It also reverses this process under the influence of glucagon when blood glucose is lower than the lowest normal limit.

In topic 4, we also learnt that uncontrollable blood sugar leads to the condition called diabetes. Symptoms of diabetes include thirsty, hunger, frequent urination, infections and may lead to heart diseases, limb amputations and kidney failure among others. Individuals have characteristics which render them vulnerable to diabetes; such as old age (above 45), parental genes, inactive lifestyle, poor diet and overweight among others. Diabetes is a chronic condition once it strikes. It can be prevented and managed by regular exercises, a diet rich in vegetables and fruits, and taking medication as prescribed by a doctor.

Congratulations! You have now reached the end of unit 3 on the human digestive system. I hope that you have found it interesting. It is a good idea to look again at the learning objectives of each topic of this unit and make sure that you have achieved all of them. When you are happy that you fully understand the digestive system, then you should do the unit assessment test at the very end of the unit.

References and Recommended Books

As an OER, it is recommended that tutors and other in-house subject matter experts, select reference materials and some recommended books for this unit. These in-house specialists will certainly be familiar with the various contexts under which learning will be taking place, and hence able to provide reliable information on how learners can access further reading.

References Used in Unit 3

BOCODOL (2002). *Workbook 3: The Digestive System*. BOCODOL, Botswana

Francistown College of Technical and Vocational Education (FCTVE) (2008). *Module 2: The Human Body.* BTEP Certificate in Beauty Therapy, Distance Learning Materials, FCTVE, Botswana.

WWW references are given within the text where they are cited or as sources near the illustrations they refer to.

Assignment

Assignment

After completing and revising each topic, do the self-check exercise for that topic below. Then compare your answers with mine at the end of the unit. Start now with exercise 1 for Topic 1.

Topic 1: Exercise 1

1. Name the **four** types of teeth in humans. [4 marks]
2. How many teeth are there in an adult human? [1 mark]
3. The hardest part of a human tooth is the --? [2 marks]
4. The words "tearing" and "chewing" have been used several times in Topic 1. Say exactly what you think each word means.

   Tearing: [4 marks]

   Chewing: [2 marks]
5. What is dental decay? [2 marks]
6. What causes toothache? [2 marks]
7. Write any **five** preventive measures of tooth decay. [5marks]

Total = [22 Marks]

I hope you did well in Topic 1. After revising Topic 2, do Exercise 2 which is based on it. Remember to compare your answers with those in the feedback at the end of this unit, and verifying where you have a doubt by reading the relevant section in the topic.

Topic 2: Exercise 2

1. What is an enzyme? [2 marks]
2. Name **one** example of an enzyme. [1 mark]
3. (a) Mention **four** properties of enzymes. [4 marks]
4. The following reaction shows the action of the enzyme pepsin on a protein.

   $$\text{Protein} \xrightarrow{\text{Pepsin}} \text{Peptides}$$

   (a) Amongst the three substances, which one is the

   (i) substrate? (ii) product? [2 marks]

   (b) Define the following words: [4 marks]

(i) substrate (ii) product

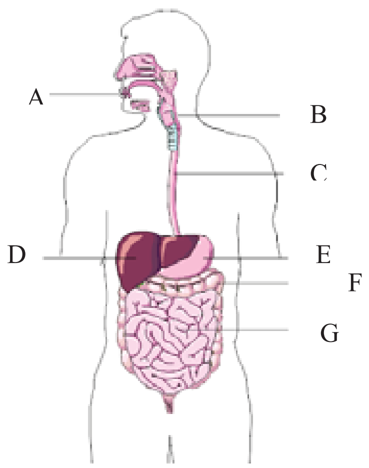
(iii) optimum pH (iv) optimum temperature

5. List the group of enzymes that will digest (i) meat (ii) rice (iii) ice cream. **Total = [20 Marks]**

I am sure you are finding these exercises interesting, especially if you attempt to answer them after revising the topic. Now try exercise 3 after revising topic 3. It is a rather long topic, and has many questions. It may need a reasonable amount of time to revise and do the exercise. Wish you good luck!

Topic 3: Exercise 3

1. (a) Which digestive juice is made by the lining of the stomach? [1 mark]
   (b) Name the components of this juice. [2 marks]
   (c) What is the pH of the stomach contents? What causes this pH? [2 marks]
2. (a) What is digestion? [1 mark]
   (b) Which type of food is made up of:
      (i) glucose molecules? [2 marks]
      (ii) fatty acids and glycerol [1mark]
      (iii) What is a protein molecule made of?
3. Define the following words [6 marks]
   (a) Ingestion
   (b) Peristalsis
   (c) Emulsification
4. Identify and name the parts A to G on the diagram. [7 marks]



5. (a) State the site where final digestion takes place? [1 mark]

   (b) Name **two** substances that are digested there and the enzymes responsible for their digestion. [4 marks]

6. (a) State the kinds of foods that are absorbed into the blood capillaries of the small intestines. [3 marks]

   (b) (i) Name **two** materials that pass into the large intestine from the small intestines. [2 marks]

   (ii) State the functions of the colon? [2 marks]

7. Explain how the small intestine is adapted to the absorption of the products of digestion. [4 marks]

8. Discuss the fate of the fatty acids and glycerol, and the amino acids that have been absorbed into the blood stream after digestion. [8 marks]

9. Explain the difference between assimilation and absorption. [4 marks]

10. Explain how the conditions (i) constipation and (ii) diarrheoa occur and how each is controlled. [4 marks]

Total = [50 Marks]

Try Exercise 4 as well after revising the topic which is the final in the unit. By the end of the exercise you will have gained the experience for answering the Unit Assessment which is marked by your Tutor.

Topic 4: Exercise 4

1. (a) Name the hormones involved in the control of blood sugar. [2 marks]

   (b) Name the organ that produces these hormones. [1 mark]

2. Explain the role of the liver in the control of blood sugar. [5 marks]

3. What cells that store the excess sugar that cannot be stored by the liver and muscles. Name at least **two** parts of the body where these cells are found. [3 marks]

4. (a) What is sugar diabetes? [2 marks]

   (b) If a person who has sugar diabetes eats a meal which has lots of carbohydrates, what will happen to their blood sugar levels? [1 mark]

5. (a) If Tshepho, who is a healthy person, goes without food for two days; what will happen to her blood sugar level? [1 mark]

   (b) Suppose Tshepho was suffering from sugar diabetes, what would happen to her blood sugar level and why? [3 marks]

6. Explain why very low blood sugar levels can be dangerous to health? **[20 Marks]**

Answers to Exercises

Exercise 1

1. Incisors, canines, premolars and molars.
2. 32
3. Enamel, calcium
4. Tearing – cutting off the food from non-food materials before grinding it into smaller pieces which can then be swallowed. An example is removing meat from bone or maize grains from a cob using teeth.

   Chewing - crushing and grinding the food into smaller pieces.

   The two actions are important functions of teeth because they reduce the particle size of food which makes it easy to swallow. It also prepares the food for chemicals digestion because the small particles created expose a large surface area to enzymes which digest the food.
5. Rotting of the teeth due to acids produced by bacteria.
6. Toothache is a pain resulting from the rotting of a tooth caused by the bacteria that have penetrated it and reached the sensitive nerves in the pulp cavity. It starts from the food residues that accumulate after eating without cleaning the teeth. The bacteria convert the sugary part of the residues into acids. The acids dissolve the protective tooth enamel and attack the soft inner parts. Bacteria and the acids they produce eventually reach the sensitive nerves in the pulp cavity and cause rotting and pain, hence toothache.
7. Enamel, dentine, pulp cavity, neck, cement, crown, root
8. Regular brushing of teeth, avoiding sugary foods between meals, regular visits to a dentist, eating healthy diets, cleaning the tongue and any other practice described in Topic 1.

Exercise 2

1. An enzyme is a biological catalyst, which speeds up chemical reactions in the body of a person.
2. Amylase, pepsin, trypsin etc (any correct enzyme)
3. Explaining that

   - enzymes are proteins which explains one of the needs for proteins in the diet
   - enzymes are denatured: being proteins they are denatured

(destroyed) by high temperatures

- As catalysts they speed up reactions but they don't change or get destroyed
- They work only at a specific pH
- They are specific and take part in only one reaction and on a particular substrate. (Any correct property)

4. (a) (i) Protein is the substrate

(ii) Peptides are the products

(b) (i) A substrate is a material upon which an enzyme works.

(ii) A product is a material produced from the activity of an enzyme on a substrate.

(iii Optimum pH is the pH at which an enzyme functions best.

(iv) Optimum temperature is the temperature at which an enzyme functions best.

5. (i) Proteases will digest meat.
(ii) Amylases/carbohydrases will digest rice.
(iii) Ice cream will be digested by lipases.

Exercise 3

1. (a) Gastric juice

(b) Hydrochloric acid and pepsin and in babies renin.

(c) It is acidic (pH 2) because of the hydrochloric acid which is secreted by the gastric cells.

2. (a) Digestion is the breakdown of food into simplest components.

(b) (i) Starch

(ii) Fats

(iii) Amino acids

3. (a) Taking in something through the mouth.

(b) Waves of muscular contraction and relaxation, which pushes food through the alimentary canal.

(c) The breakdown of large drops of fats into smaller droplets by bile salts.

4. A = teeth; B = Pharynx (throat); C = oesophagus gullet); D = liver; E = small intestines; F = large intestines; G = small intestines

5. (a) Small intestines

(b) • Maltose digested by intestinal amylases/carbohydrases
- Lipids digested by intestinal lipases
- Peptides digested by intestinal proteases.

6. (a) Glucose, Amino acids, Fatty acids and glycerol

   (b) (i) Water and undigested material

   (ii) The water is reabsorbed into the blood stream whilst the undigested material is going to form faeces and as a result pass out during defecation.

7. The length of the small intestine and the numerous villi and microvilli provide a large surface area for maximum absorption of digested materials. The thin wall of the villi allows fast absorption of products. The network of capillaries and lacteals ensures quick transportation of the products of digestion. This gives room for more products.

8. Glucose is used to provide energy during respiration. Excess is converted by the liver into glycogen and then stored in the liver and muscles. Still excess is converted to fats and stored.

   Amino acids are reassembled by the cells to form proteins which are needed by the body. Some of them will be used in the formation of cell membranes and others for making enzymes.

9. Absorption is the diffusion of digested material through the wall of the small intestine into the blood from the alimentary canal whereas assimilation is taking digested food from the blood, and incorporating it into the body cells and tissues. The food becomes a part of the human body.

10. (i) Constipation occurs when peristalsis is too slow and there is too much absorption of water from the faeces. The result is that there is difficult in passing out faeces and gases which tend to build up in the alimentary canal and cause swelling. The faeces become hard and difficult to pass out.

    There are substances called laxatives which can be taken to allow the materials to slide down the system and are passed out. It can be prevented by always eating food that is rich in fibre. Go to the toilet as soon as it becomes necessary, rather than ‘holding up’ and going at a later time; this will prevent constipation.

    (ii) Diarrhoea occurs as a result of a stomach upset due to bad food or infection of the alimentary canal. The person visits the toilet very frequently and passes out liquid faeces. This leads to water loss and dehydration of the body cells and in some infections like cholera, it may lead to death in a matter of hours.

The immediate action to take is to drink as much water as possible to replace that being lost and to seek medical attention quickly. There are drugs used to stop diarrhoea and to kill the cause of infection, but these must be prescribed by a doctor who is likely to know what has caused the diarrhoea.

Exercise 4

1. (a) insulin and glucagon

   (b) pancreas produces the two hormones

2 The brain detects the sugar level in the blood and instructs the pancreas to produce insulin. The liver responds to insulin converting excess blood sugar into glycogen. Initial glycogen is stored in the liver itself and more glycogen can be stored in the muscles. Insulin also activates liver cells to convert extra glucose, above the liver and muscle storage, into fat which is stored in fat cells.

   When the blood sugar level falls below 85mg/100ml blood, the liver responds to glucagon from the pancreas to raise the level by converting glycogen to glucose. Glucagon also activates muscles and fat cells to convert their storages into glucose, when dietary glucose is in short supply. Thus, the liver is important because its response to insulin and glucagon to either mobilise or demobilise glucose, maintains the blood sugar within healthy limits.

3. Fat cells store dietary fat and fat that is converted from excess blood sugar. The fat cells are found around the belly, under the skin, at the buttocks and around internal organs like kidneys.

4. (a) Sugar diabetes is a condition when the body is unable to maintain blood sugar within healthy limits.

   (b) The blood sugar level will rise above normal limits, leading to the loss of sugar and water through frequent urination.

5. (a) Her blood sugar level will remain normal because glycogen will be converted to glucose to replenish the glucose used up; even fat may be mobilised to produce energy.

   (b) Her blood sugar will fall below normal because she has no control of the blood sugar. She will have to eat something otherwise she will feel very hungry, thirsty and weak.

6. Very low blood sugar is dangerous because blood sugar is the immediate source of energy for all body processes. If the sugar is low, then vital processes like breathing and elimination of wastes

will proceed slowly or even stop leading to coma and death.

Assessment

Assessment

Instructions to Learners

1. Answer **all** questions.
2. Each question in Section A carries one mark.
3. You may take one hour to do the assignment.
4. Use A4 paper to write the assignment.

Section A: Multiple choice questions **[10 Marks]**

1. The process of absorption of food in mammals is best described as the:

   A. taking of food into the mouth.

   B. breaking down of food into small particles.

   C. passage of insoluble food from the anus to the outside.

   D. passage of soluble food from the gut into the blood stream.

2. During digestion fat is broken down into

   A. fatty acids and amino acids

   B. fatty acids and glycerol

   C. amino acids and glycerol

   D. glucose and glycerol

3. The gall bladder stores and discharges a product which

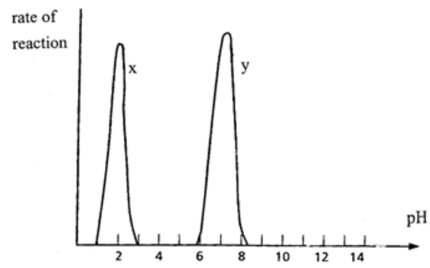
   A. is called urine

   B. digests protein foods

   C. makes the digestion of fat easier

   D. breaks protein into smaller pieces

Questions 5, 6 and 7 are based on the diagram below.



4. At which pH does enzyme X work best?

   A. 2 B. 8 C. 11 C. 13

5. In which part of the digestive system would the enzyme X work best?

   A. Stomach B. Mouth

   C. Small intestine D. Large intestine

6. In which organ of the human digestive system would enzyme Y work best?

   A. Mouth B. Stomach

   C. Large intestine D. Small intestine

7. Tooth decay is **not** caused by the following.

   A. The accumulation of plaque on the teeth

   B. Acids produced by bacteria from food residues in the mouth

   C. Worms developing from food residues in the mouth

   D. Improper cleaning of the mouth

8. Which of the following is **not true** about enzymes?

   A. They are all proteins

   B. They are affected by extremely high temperature

   C. Each enzyme has its own pH at which it functions best

   D. One enzyme can breakdown several kinds of food

9. Absorption of products of digestion takes place only in the

   A. stomach. C. small intestines.

   B. large intestines. D. colon.

10. Which one of the following features make the small intestine adapted for absorption of digested food?

A. Having a large diameter

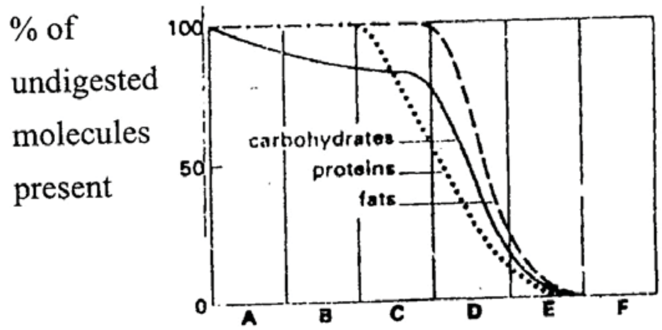
B. Presence of enzymes

C. A great length

D. Being white in colour

Section B: Short answer questions [10 Marks]

The diagram below shows the extent to which carbohydrates, proteins and fats are digested as the food passes through the alimentary canal of a person. The letters (A to F) represent successive parts of the alimentary canal.



Source: BOCODOL, Assignment 2001

1. (a) Name parts B and C. [2marks]

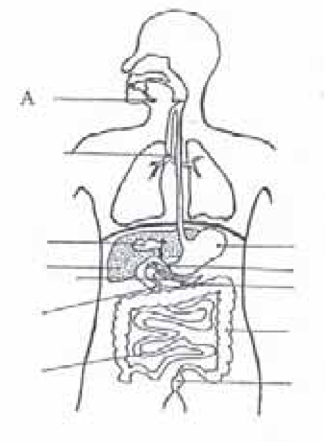
   (b) What brings about the start of digestion of carbohydrates in part A of the system? [1 mark]

   (c) Explain why the percentage of undigested protein suddenly decreases in part C of the canal. [2 marks]

   (d) In which part of the canal (A to F) does most digestion occur? [1 marks]

   (e) In which part of the canal (A to F) would lipase be present and on which type of food would it act? [2 marks

Study the diagram below and answer the questions that follow.



Source: BOCODOL-Workbook 3, 2001

2. Write the letter against the arrow corresponding to the phrase describing the correct function of the part shown by each arrow. Some letters may be used more than once. The first one has been done for you as an example.

A: where salivary amylase is produced (done for you).

B: where most water is absorbed.

C: where bile is stored.

D: where villi are found.

E: where the last stage of carbohydrate digestion takes place.

F: where faeces are stored before egestion.

G: where glucose is converted to glycogen for storage.

H: where protein digestion begins.

I: where pancreatic juice is secreted.

J: where gastric juice is secreted.

3. (a) How does bile help in the digestion of fats? [2 marks]

(b) (i) Which enzyme digests fats [1 mark]

(ii) Where is the enzyme in (i) secreted and what does it digest fat to? [2 marks]

(iii) How does the enzyme in (i) differ from bile? [2 marks]

4. (a) Molar and premolar teeth are concerned with the breakdown of food into smaller pieces.

(i) Explain how this breakdown is achieve. [2 marks]

(ii) Why is this breakdown of food important for the process of digestion? [2 marks]

(b) Tooth decay is very common in human beings. Explain why this is so. [6 marks]

5. Explain the following issues of blood sugar.

(a) Mechanisms by which blood sugar is maintained within healthy limits. [5 marks]

(b) The nature of diabetes, its symptoms and control. [5 marks]

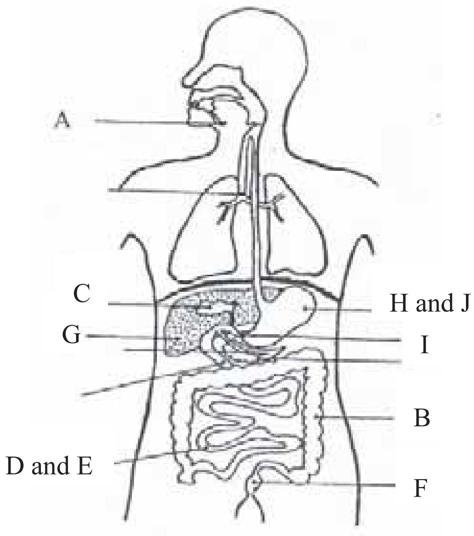
Answers to Assessment Questions

Section A: Multiple Choice Questions

1. D
2. B
3. C
4. A
5. B
6. B
7. C
8. D
9. C
10. C

Section B: Short Answer Questions

1. (a) B is oesophagus and C is the stomach
   (b) The amylase in the saliva
   (c) The protein digesting enzyme pepsin starts to work on proteins.
   (d) In part D (small intestines) where the percent of undigested food is reduced for all food types, indicated by the slope of the curves.
   (e) Lipase will be present in part D. It will digest fats.
2.



3. (a) The bile emulsifies fats. It breaks big fat drops into small droplets which have a large surface area for digestion.

   (b) (i) lipase

   (ii) Pancreatic lipase is secreted from the pancreas and intestinal lipase is secreted from the walls of the small intestines. It breaks fats into fatty acids and glycerol.

   (i) Bile does not contain enzyme. Its function is to break up the big fat drops into smaller ones. On the other hand lipase is an enzyme. It chemically disassembles fat into its primary component units, the fatty acids and the glycerol.

4. (a) (i) Molars and premolars breakdown food physically by a grinding action. The biting surface is ragged with rough and sharp projections which crush and grind the food materials to small particles.

   (ii) The breakdown is important because it increases the surface area for enzymes to work on the food. Since enzymes attack food from the outside the particle, the larger the surface area the greater the number of enzyme molecules that attack each particle, and in so doing speed up the chemical reaction.

   (b) Food particles left in the mouth after eating are fermented by some acid forming bacteria. These acids dissolve the hard protective enamel and then the bacteria are able to penetrate and attack the soft dentine and pulp cavity leading to tooth decay.

   To avoid tooth decay and eventual loss of teeth it is important to keep the mouth and teeth clean. This is done through the cleaning of the gum, the tongue, teeth and between teeth. Brushing with suitable fluoride toothpaste is the most common way of keeping our mouth clean. You can also use fluoride mouthwash to rinse the mouth after brushing. Mouthwashes contain anti-bacterial agents which protect the mouth, from tooth decay-causing bacteria.

5. (a) Blood sugar level is maintained within healthy limits by means of two hormones, insulin and glucagon secreted by the pancreas. The two have opposing actions.

   After a rise in blood glucose the pancreas produces insulin which instructs the liver to convert excess glucose into insoluble glycogen. If there is more glucose in the blood than what the liver can store the rest is stored as glycogen in the muscles and any other excess is stored in fat cells as fat.

The brain detects changes in blood sugar level, and when sugar falls below the lower limit of 85mg/100ml of blood, the pancreas secrets glucagon which instructs the liver to convert glycogen into glucose. This is done until the normal blood sugar level is reached, and the secretion of glucagon is stopped. In this way the insulin and glucagon actions maintain the sugar level within healthy limits.

(b) Diabetes is a health condition when the body cannot regulate the use of blood sugar. This happens because the pancreas cannot produce enough insulin or none at all. Too low or too high blood sugar is unhealthy and it can lead to death.

The signs of diabetes include thirsty, frequent urination, extreme hunger etc. It is controlled by medicines, taking insulin, exercise, reducing body weight and other measures listed in Topic 4 of Unit 3 of your Human and Social Biology course.

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Contents

HSB Unit 4

Respiratory System

Introduction

Welcome to unit 4 of human and social biology. In the previous three units we have learned about living things, nutrition and diet, and digestion and absorption of food. In this unit we will learn about the exchange of gases between human beings and their environment. This is also referred to as breathing. This unit builds on the earlier ones and requires you to draw back on what you learnt. For example, it deals with how some products of unit 3 are utilised and moved around in the body. Turn back to unit 3 to remind yourself of these.

The unit will also make us realise how the body uses gases with the body's cells. This will be dealt with under a process which is not new to you, known as respiration. There are two major topics in this unit and they are: (i) Breathing and Gaseous Exchange, and (ii) Respiration.

Under the topic breathing and gaseous exchange, we will describe how breathing happens, where it takes place, why it takes place and how it is affected by physical activity. We will also learn about the differences between the gases that are taken in and out- or inhaled and exhaled air. Under respiration we will learn how this process results in the release of energy required for different activities that take place in the body. This is an important process for the body and it cannot take place without oxygen, one of the gases in the atmosphere. So, we will explore how breathing is a necessary process for respiration to take place. This unit will require us to recall the process of diffusion that we learnt in unit 1, Living Things, as it is the process by which gases are moved from the lungs to the blood so that they may be transported to body cells. If you can't recall the definition, please make sure you go back to your Unit 1 notes to refresh your memory before you start this Unit.

You must have learned from Junior Secondary, and also realized from daily experience, that humans always breathe. This can be seen by the inward and outward, or up and down movement of the chest. This happens when the lungs become bigger and smaller as air moves in and out of the lungs. Breathing is so important such that a person who is prevented from breathing for a few minutes may die. We will therefore also learn how artificial breathing or, mouth-to-mouth respiration may be done, so that we may be in positions to save lives. To grasp the information better, we will need to recall what we learnt under Unit 2 on Photosynthesis and the carbon cycle. This information will help us appreciate the importance of carbon dioxide in nature by showing how it is exchanged in the environment. You will get to see that respiration is the reverse of photosynthesis.

By the end of this unit you should be able to:

Outcomes

- Describe the parts of the respiratory system and explain how each is involved in breathing.
- Explain changes that occur during breathing.
- Describe gaseous exchange.
- Differentiate between inspired and expired air.
- Demonstrate the effects of physical activity on breathing.
- Describe respiration.
- Apply the skills of mouth of mouth resuscitation.

Teaching and Learning Approach:

The information in this unit is presented in an interactive manner that engages and challenges you in discussions, asks you questions and invites you to reflect on issues as well as to share your experiences and views.

There are also activities to engage you in the learning process. There are seven varied activities ranging from responding to questions to taking part in practical activities. These different activities will help you understand concepts discussed better and enable you to experience or interact with the content presented. The practical activities are meant to also assist you in the application of the concepts taught to everyday life situations. You are requested to undertake all the activities before reviewing the feedback provided on the activity. The feedback provided is usually in the form of responses to questions, but in some cases it directs you to other sections of the topic or unit to recall information. This is meant to help you build new information on already existing information and to make connections between topics.

The emphasis is on learner centeredness so as to enable you to develop the skill of exploring knowledge on your own. You are encouraged to have a problem solving attitude, which just means that you should do the best to find ways of addressing challenges you might encounter with any part of the unit. You can talk to teachers or other learners in the formal school system, or fellow colleagues who can be contacted through study centres. These learner centred approaches also enable you to build on to your own experiences, thus making learning more meaningful and easier.

You are required to have a study plan that entails regular study times and visits to a study centre or satellite centre near you, as well as the community or local library and/or library of your nearest Junior Secondary School.

Resources:

You will need the following resources to conduct some of the activities:

- Colourful pens/ markers
- Empty mayonnaise bottles
- Candles and Matches
- Watch
- Skipping rope
- Cards

Time Frame

It is estimated that to complete studying this unit you will need between 5 to10 hours. Do not worry if you take longer in finishing this unit. Remember that we all have different abilities and hence we study at different paces.

You are encouraged to spend about 2 hours to answer the assignment in this unit. You will also need approximately 3 hours on the assessment at the end of the unit.

The total hours for completing the unit will thus be between 10 and 15 hours.

Terminology

Alveoli: Balloon like air sacs found at the end of each bronchiole.

Anaerobic respiration: The breakdown of food to release energy in the absence of oxygen.

Bronchi: Two short tubes that break up from the windpipe once it gets into the lungs. These are also known as the bronchial tubes.

Bronchioles: Many branches of the bronchi that are found inside the lungs.

Gaseous exchange: The exchange of gases between the body and the environment as well as within the lungs and the blood. It is part of the process in respiration in which oxygen is absorbed into the body from the environment and carbon dioxide is released.

Residual air volume: Air which cannot be expelled no matter how hard you breathe out.

Trachea: The windpipe which is a long tube that takes air in and out of the body via the mouth or the nose.

Online Resource

If you can get on the internet please utilize the resources at www.hippocampus.org. It is an excellent source of information for biology and the topics discussed in this unit. Here you will find:

- Presentations
- Simulations
- Videos
- Online Study Groups
- Links to Even More Information
- Textbook Correlations
- Online Courses

Topics

There are two topics in this Unit:

- Breathing and Gaseous exchange
- Respiration

The topics have been arranged in this way because it is necessary to first explore the process of breathing before we learn how to utilize the gases in the process of respiration. This is because in the first topic we will begin to appreciate the different gases exchanged between humans and the environment and then explore how exactly these gases are used in the second topic.

Topic 1: Breathing and Gaseous Exchange

Stop everything you are doing and take notice of what is happening to your chest. What do you notice? You may have realised that your chest is moving up and down. This movement shows the process of breathing, or the taking in and out of gases. This process takes place due to the respiratory system which starts with the mouth or nose and ends with the air sacs found in the lungs. Compare the role of the mouth here with that of the one mentioned in unit 3, topic 1, digestion. The roles are completely different even if both deal with taking in something and passing it down to the other body parts. In digestion, the mouth was for taking food in and cutting it into small pieces before passing it down the oesophagus. Now here, the mouth takes in gases and passes them down other body parts and not the oesophagus- we will discuss these parts in this topic.

The respiratory system is important in that it allows for oxygen to be taken to all body cells where the process of respiration takes place. It also allows for carbon dioxide to be taken away from the body cells and out of the body. This is why it is said that the respiratory system deals with breathing and the gaseous exchange. In this topic we will learn how the different parts of the respiratory system are involved in breathing and gaseous exchange.

We will also compare the compositions of the gases that are exchanged during breathing. The gases are known as inspired and expired air. It is important to learn about the composition of these so as to understand that more oxygen is taken in than is taken out, which will give us an indication that the body uses oxygen.

Learning Objectives

At the end of the topic you should be able to:

- Identify the different parts of the respiratory system.
- Explain the function of parts of the respiratory system.
- Explain the process of breathing.
- Describe gaseous exchange.
- Identify where gaseous exchange takes place.
- Describe how the alveolus is adapted for its function.
- Compare inspired air and expired air.
- Explain the effects of physical activity on the rate of breathing.
- Give reasons why breathing rate changes during breathing.

The Respiratory System

We mentioned that we will be learning about the parts through which gases are taken after they leave the mouth. Remember how we said that the chest is always moving. Can you say any of the parts you know that are inside the chest and are involved in the taking in of gases after the mouth?

The diagram below, Figure 1, (The Respiratory System) shows the different parts of the respiratory system but has left out the two parts through which gases are taken in and out of the body, can you identify the two parts on the diagram below?

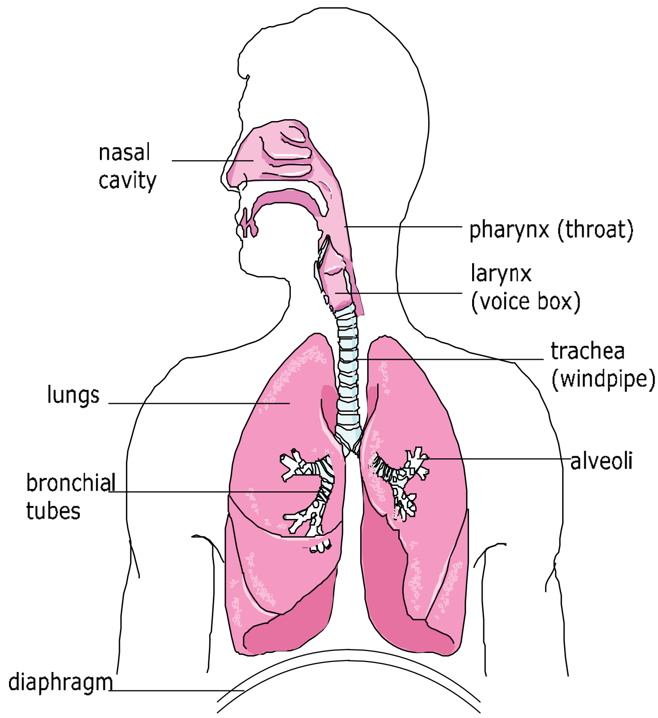

Figure 1: The Respiratory System

Yes, the two parts left out are the nose and the mouth. We can breathe in either through our mouths or our noses. However, it is said that it is more advantageous to breathe in through the nose. Do you know why it is so? It is because when we breathe in through the nose, hair in the nose traps some of the dust particles and prevents them from going into the lungs. Have you noticed that if you blow your nose after playing in the sand the mucus coming out will be brownish in colour? This is because the mucus and the hairs in the nose will have trapped dust particles.

We will now look at the functions of the different parts indicated on Figure 1 above, including the nose and the mouth which have been left out in the diagram as we have already noted above. Please ensure that you look up each part that is mentioned on the diagram above before you study what it does. This will help you to place the position in the body with the function. Remember that the diagram is similar to what the inside of your body looks like so knowing these parts will be like knowing yourself better.

Nose

The inside of the nose has hairs. The hairs help to trap dust particles to prevent them from going in. This is because dust may damage the inner parts of the respiratory system, so the dust must be stopped from going in. As air moves deep into the nose, it is moistened and warmed up. This is to ensure that air reaching the lungs is not cold and dry.

Mouth

The mouth can also be used for taking air in and out. It is especially used when one has a blocked nose due to flu.

Throat

The throat is called the pharynx. The throat is at the back part of the mouth. Refer to the diagram above to locate it. When we swallow, food goes through the throat before it reaches the oesophagus. When we breathe in, air passes through the throat before it reaches the voice box, also known as the larynx.

Voice box

The voice box is a short pipe-like structure made of rings of cartilage. In men, some of the cartilage rings protrudes outwards to form the Adam's apple. When we breathe in, air moving from the voice box goes to the windpipe.

Windpipe

The voice box and the windpipe make a continuous pipe. The windpipe is also known as the trachea. It is a straight pipe of about 12 centimeters long in adults. The trachea is kept open by rings of cartilage that surrounds its wall. The trachea is the tube that then divides into two smaller tubes which have the same structure as the trachea.

Bronchial tubes

After the windpipe has entered the chest, it splits into two short tubes - the bronchi (singular- bronchus). One bronchus takes air to and from the left lung, whereas the other bronchus takes air to and from the right lung. The bronchi also divide up into smaller branches which are called bronchioles.

Bronchiole

Within each lung, the bronchus divides into many branches called bronchioles. The bronchioles get narrow towards the ends. Their walls are not covered by rings of cartilage. Instead, they contain smooth muscle, which allows them to widen or get narrow

Alveoli

At the end of the bronchioles are little, thin walled, pouch-like, balloon like air sacs called alveoli. Can you guess what the singular for one of these air sacs is called? A single air sac is called an alveolus. Each alveolus has a dense network of blood capillaries. There are millions of alveoli in each lung.

There is one part of the above diagram that we did not cover, this is the diaphragm. We will discuss it soon.

You will now do an activity to check your understanding of the parts of a respiratory system. For this you will have to once again apply information learnt earlier. However, now we will now compare our body parts to something well known to us.

Activity 1

For this activity- you are required to recall what a tree looks like as well as its structures.

1. If we were to use a tree to represent the respiratory system, write what you think the following parts of the tree would represent, the first has been done for you.

Stem-------------------------Trachea

Main branches--------------

Smaller branches-----------

Leaves-------------------------

2. Explain the similarities between the parts of the tree and those of the respiratory system.

Feedback:

1. The matching between the tree and the respiratory system are:

Stem-------------------------Trachea

Main branches----------- Bronchi

Smaller branches-------- Bronchioles

Leaves---------------------- Alveoli

2. Similarities between the parts are that:

Stem and Trachea- They both have firm rings that hold them up. They have room to allow for movement of substances.

Main Branches and Bronchi- They both branch from the main stem and branch out into smaller branches which are similar to it in structure. They also have room to allow for movement of substances.

Smaller Branches and Bronchioles- They are both smaller branches which lead to structures where gaseous exchange takes place. Leaves are found at the end of the tree branches whilst alveoli are found at the end of the bronchioles.

Leaves and Alveoli- They both have thin walls and provide a large surface area that allows for gaseous exchange to take place. To verify what this means, please look for a tree with wide leaves and study it- this will help you understand better.

Breathing

We have briefly touched on breathing and dealt with it at the Junior Secondary level. We are now going to go into detail about it. Please remember all that has been said as it will make it easier to understand this important process that every living organism must do in order to survive.

Breathing is a process whereby air is taken in and out of the lungs. When we breathe in, air moves into the lungs and the opposite happens when we breathe out. The air goes through the parts of the respiratory system we discussed above before it reaches the lungs. Do you remember the different parts? If you don’t, turn back to the diagram of the respiratory system. Once air reaches the lungs, it gets into the blood stream for it to be carried to all body parts. You will discuss this in the next unit.

In this section we will discuss breathing in detail by explaining how parts like the diaphragm and ribs, which we did not discuss in the above section dealing with parts of respiratory, are involved as well as how air moves in and out of the capillaries found around the alveoli or air sacs.

Breathing takes place when the muscles change the size of your lungs. Place your hand on your chest again and breathe in and out- check what is happening as you do that. When you breathe in or inhale, the muscles make your lungs to get bigger. When you breathe out or exhale, the muscles make your lungs to become smaller. I hope you were somehow able to notice that when you placed your hand on your chest. These muscles are found in the diaphragm and ribs; we will look at these in detail later. The reasons for making the lungs bigger are so that pressure within the lungs may decrease so as to allow air to enter and the opposite happens when the lungs become smaller. We will now analyse the process of breathing and the organs it involves by using the figure 2 below.

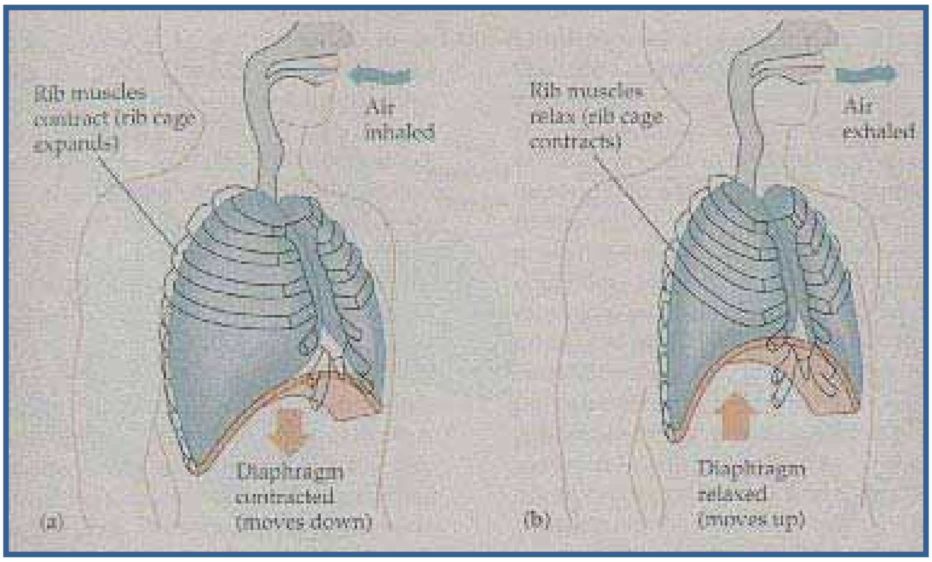

Figure 2: The process of breathing

Look at the diagrams in figure 2 above. You should be able to use the arrows next to the mouths on both figures a) and b) to identify which diagram shows breathing in and breathing out?

What can you notice about the muscles of the ribs and the diaphragm in both figures 2a) and b)?

If you said that the muscles have to contract during breathing in and relax during breathing out, then you are right. Do you know what these muscles of the ribs are called?

They are called **intercostal muscles**.

The lungs contain no muscle fibres and are made to expand and contract by movements of the ribs and diaphragm. The diaphragm is a sheet of tissue which separates the thorax from the abdomen. It is domed slightly upwards when it is relaxed and flattens when it is contracting. In Figure 3 you can see the difference in the shape of the diaphragm during inhalation and exhalation. The ribs are moved by the intercostals muscles which run from one rib to the next. The contraction of the intercostal muscles makes the ribs to move upward and outward resulting in the space in the chest increasing. Can you guess what happens when the intercostal muscles relax? Yes, the opposite thing happens in that the move is downwards and inwards making the space inside the chest to decrease.

The movement of air into and out of the lungs is called ventilation. Ventilation helps to renew the supply of oxygen and to remove surplus carbon dioxide. This is important for the process of respiration that we will learn about in the next topic.

We will now review how the lungs fit into the rib cage and learn how they are affected by the contraction and relaxation of the above mentioned muscles.

The lungs are enclosed in the thorax or chest area within the rib cage; see Figure 3 below on size of lungs during breathing. This can also be seen on Figure 2 though it is not that visible. To see this look at how it shows the expansion of the rib cage on 2 a) and the opposite on 2 b).

Do you know why the lungs are enclosed in the rib cage for protection? This is because they are very delicate. Find out which other organs are protected in the rib cage. You will learn about this in Unit 6 under Functions of the Skeletal system.

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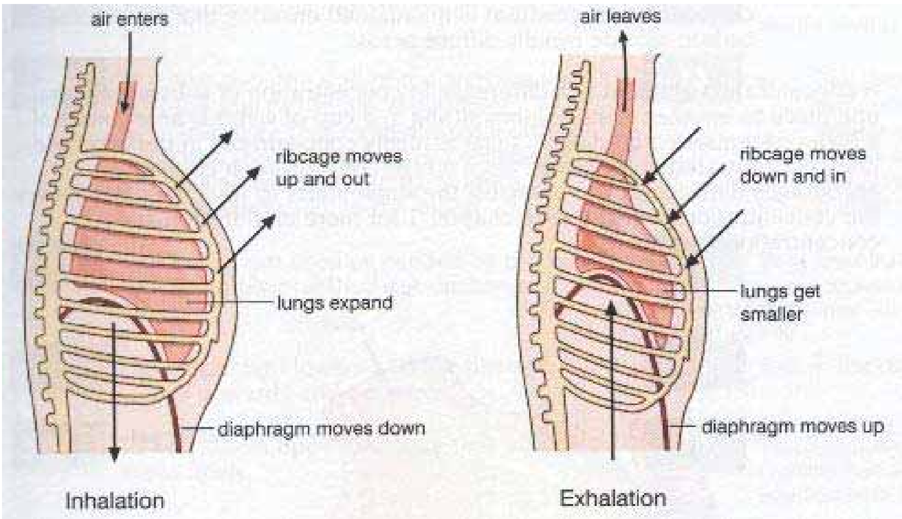

2 a) **2b)**

Figure 3: Lung size during Inhalation and Exhalation

Can you see the difference in the sizes of the lungs during inhalation and exhalation? Remember earlier we said that the increase in size allows pressure to drop so that air may enter and that the increase in pressure forces air out. The lungs have a spongy texture and can be expanded and compressed by movements of the thorax resulting in the drop or increase in pressure that allows for air to be sucked in or blown out.

Can you also see from the above picture that the diaphragm is involved in the increasing and decreasing of the size of the lungs? To see this, look closely at the arrows above the ‘inhalation’ and ‘exhalation’ labels on both diagrams.

You will now perform an activity to experience the up and down movement of the chest and not only just the increasing in volume.

Activity 2

Put your hand on your chest and breathe in deeply. What happens to your chest? Does your chest move outwards and upwards?

Now, while your hand is still on your chest, breathe out deeply. What happens to your chest, does it move inwards and downwards? Why do you think this happens?

Feedback:

You should have realized that the changes that happen on the chest are that it moves outwards and upwards when you breathe in and that they move inwards and downwards when you breathe out. This is due to the contraction and relaxation of the muscles of the ribs and diaphragm as they increase and decrease the size of the lungs.

You will now do an activity to recall how the different parts are involved in breathing. Please remember to do the activity before checking the feedback.

Activity 3

The table below shows the ribs, diaphragm, and lungs. Complete the table by filling in the missing sections to indicate what happens to these organs during inhalation and exhalation.

	Inhalation	**Exhalation**
Diaphragm		
Intercostals muscles of ribs		
Lungs		

Feedback:

The way the organs are involved during inhalation and exhalation is shown below:

	Inhalation	**Exhalation**
Diaphragm	Diaphragm muscles	Diaphragm muscles

	contract and pull it down	relax and it returns to its dome shape
Intercostals muscles of ribs	Contract and pull the rib cage upwards and outwards	Relax, allowing the ribs to move downwards
Lungs	Lungs expand so that air can be pulled in.	Lungs return to their original size so that air is pushed out.

We have been learning mostly about the different parts that are involved in breathing. We will now discuss an important aspect of breathing that results in the exchanging of gases between humans and their environment. Can you guess what that section is?

Gaseous Exchange in the Lungs

Can you guess what the term **gaseous exchange** means? Analyse each word and you will get the meaning.

I hope that you said something like it is when animals and plants exchange gases between themselves and the environment. Yes, it is how humans get the oxygen they need; oxygen is obtained from the air by means of the lungs when we breathe in. In the lungs, the oxygen dissolves in the blood and is carried to the tissues by the circulatory system, you will learn about this system in detail in the next unit. Carbon dioxide is also carried from the tissues to the lungs by this circulatory system. The movement of the gases between the lungs and the circulatory system is also known as gaseous exchange. This is because they exchange the gases oxygen and carbon dioxide.

For oxygen to reach the lungs it would have gone through all the parts discussed in the section on the parts of the respiratory system. Refer to this section to remind yourself of these parts and their functions.

In this sub-topic, we will now learn how the different parts of the respiratory system are adapted for the process of breathing. This entails looking at the inner parts in detail. However, we will only look at parts that have structures that have been modified to improve the exchange of gases. These structures include things similar to what we learnt about under the topic on cells in Unit 1.These are the wall size of the cells, how they are lined, and so on. Please refer back to that section of Unit 1.

The epithelium that lines the inside of the trachea, bronchi and bronchioles consists of ciliated cells. There are also cells which secrete mucus. The mucus forms a thin film over the internal lining. Dust particles and bacteria become trapped in the sticky mucus film and the mucus is carried upwards, away from the lungs, by the flicking movements of the cilia. In this way, harmful particles are prevented from reaching the alveoli.

The alveoli have thin elastic walls, formed from a single-cell layer of epithelium. Beneath the epithelium is a dense network of capillaries, see Figure 4 below. The capillaries branch out from the blood vessels that bring in oxygenated blood and form those that then take out deoxygenated blood away from the lungs. Can you guess why the walls of the alveoli are only one cell thick? It is for allowing gases to diffuse across them easily. I hope you can interpret how the gases will move from the process of diffusion you discussed under Unit 1 Topic 5.

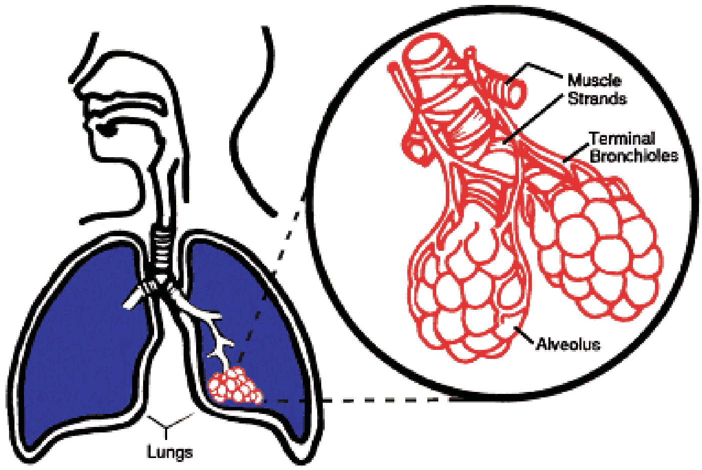

Figure 4: Gaseous exchange at the alveolus

In the earlier section of this topic we learnt that when we breathe in, air moves from the nasal cavity to the throat, to the trachea, to the bronchus, to the bronchioles and eventually to the alveolus.

How many alveoli do you think we have in our lungs?

We have more than 250 million alveoli in our lungs. Each alveolus is surrounded by a dense network of blood capillaries. Let us study the diagram of the alveolus as drawn below.

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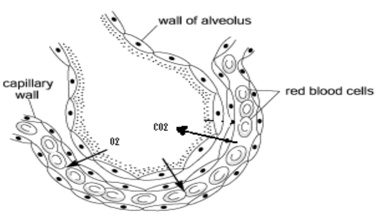


Figure 5: The Alveolus

What can you infer about the movement of air during breathing in and breathing out from the above diagram? It shows that when we breathe in, air moves into the alveolus. In the alveolus, oxygen diffuses into the nearby blood capillaries, and carbon dioxide diffuses from the blood capillaries into the alveolus. In other words, there is exchange of gases between the alveolus and the blood capillaries, because oxygen moves from the alveolus into the capillaries and carbon dioxide moves from the blood capillaries into the alveolus.

Inspired and Expired air

Remember that previously we talked about how gaseous exchange is the taking in of oxygen and the removal of carbon dioxide. We also mentioned inhaled and exhaled air which can also be called inspired and expired air. Well, the lungs only take up a small amount of the oxygen in the atmosphere - 21 %. The rest of the air we breathe in is made up of other gases, which are not really needed in the body but are just taken in because they are present in the atmosphere. The information of the contents of inhaled and exhaled air is shown in the table below. You will also discuss an activity conducted by two friends who wanted to show these differences. The activity is meant to make you appreciate these differences better.

Table 1. Differences between Inhaled air and Exhaled air

	Inhaled air	Exhaled air
Oxygen gas	21%	16%
Carbon dioxide gas	0.03%	4%
Water vapour	Variable	More
Temperature	Variable	Warmer

Activity4: Showing that Inhaled and Exhaled Air are Different

Tshiamo and Kabelo wanted to prove that inhaled air is different from exhaled air so they performed the following activity. Please review the activity and conduct a similar one to see what results you will get.

What they needed:

They took two empty bottles of mayonnaise that have lids, two candles, a coloured pen, box of matches and a watch.

What they did:

- They marked the bottles of mayonnaise with an **I** and an **E**.
- Tshiamo then opened the bottle marked I, placed a lit candle into it and then closed it. He breathed out in the bottle marked **E**, placed a lit candle into it and then closed it.
- Tshiamo explained to Kabelo that the **I** indicated that the air contained in the bottle was inhaled air, whilst **E** indicated that the air in the bottle was exhaled air.
- The candles were left in the bottles until they went out.
- They noted which one had burned for longer.

Before they did the experiment above, Tshiamo had asked Kabelo which candle would go out first between the one in bottle **I** and the one in bottle **E**. What do you think he said? What would you have said?

Feedback:

Kabelo had said he thought that the one in bottle **E** would go out first.

After the experiment Tshiamo said he was right and explained that this is because the candle in bottle **E** did not have enough oxygen because exhaled air has less oxygen content than inhaled air. He explained that the air in bottle **I** is similar to what we breathe in.

You will now do another activity that checks your understanding of the above content.

Answer the following questions to the best of your ability.

Activity 5

1. Why is there less oxygen in exhaled air than in inhaled air?
2. Why is there more carbon dioxide in exhaled air than in inhaled air?

Clue: Which gas does the body need between oxygen and carbon dioxide? Remember what you learnt at the Junior Secondary level.

Feedback:

1. There is less oxygen in exhaled air because the oxygen taken is used in the cells of the body.
2. There is more carbon dioxide in exhaled air because the processes in the cells produce it and it has to be taken out of the body.

We will now learn about the lung capacity so that we may understand better how physical activity or exercise affects the rate of breathing. This will be dealt with in detail in the next section on effects of physical activity on breathing.

Lung capacity

Can you now deduce what lung capacity is from the words? It is said to be the total volume of air the lungs can hold when fully inflated (filled with air). It is said to be about five litres in an adult. However, in quiet breathing, when asleep or at rest, you normally exchange only 500 cm3, or half a litre. This amount is said to be the **tidal volume**. During exercise you can take in and expel an extra three litres of air; why do you think this is so?

I hope you said that it is because we take in more oxygen; you will appreciate this better in the next topic. From the above text I hope you can realise that it means that there is a **residual volume** of one and half litres which cannot be expelled no matter how hard you breathe out. This air is always in the lungs.

The Effects of Physical Activity on the Rate of Breathing

Can you remember what we discussed under breathing and inspired and expired air? You should remember that we said that breathing is when gases are taken in and out of the lungs and that the difference between inspired air and expired air is mostly the amounts of oxygen and carbon dioxide involved.

The number of times you breathe in and out a minute is called your breathing rate. How do you think you can determine your breathing rate? Find a way of determining your breathing rate. To do this you must place your hand again on the chest, but this time use a watch to record the number of times you breathe in during a minute. Remember to press hard on your chest so you can feel it move.

At rest, you normally inhale and exhale about 16 times per minute. During physical activity, such as exercises, the breathing rate may rise to between 20 and 30 breaths per minute. Why do you think this so?

I hope you said that the rate and depth of breathing increases. Why do you think this is necessary?

Again, I hope you said that the increased rate and depth of breathing during exercise, allows more oxygen to be dissolved in the blood. This will help supply the active muscles with more oxygen to burn food for energy. The extra carbon dioxide, which the muscles also put into the blood, will also be removed by the faster and deeper breathing that occurs during and after the exercise.

This will become clearer after we have performed the activity below.

Activity 1.6: Checking the effects of exercise on the breathing rate

Kabelo had read somewhere that all physical activities result in an increased breathing rate and he wanted to prove it. Kabelo asked his friend Tshiamo to help him check if this was true. Again you are requested to review the experiment and conduct a similar one.

What they needed:

A skipping rope and a watch with a minute hand.

What they did:

Kabelo asked Tshiamo to time a minute whilst he counted the number of times he breathed in and out. He then recorded it as 18 breaths per minute. Kabelo then skipped rope for two minutes and immediately took his breathing rate again. This time it was at 27 breaths per minute.

What conclusion can you make from the results above? In your conclusion answer the following questions:

1. Describe why the breathing rate increases during exercise.

2. Explain what you think happens to the ribs and the diaphragm during breathing after one has undertaken physical activity.

Feedback:

The conclusion that can be made is that indeed the breathing rate increases when one is doing physical activity. The reason for this is that more gases may be taken into and out of the body.

1. This helps to bring in more oxygen needed to burn food for the release of energy in the muscles. It also helps to remove carbon dioxide at a faster rate.

2. The ribs move up more whilst the diaphragm moves down more so that the lungs become much bigger. This helps to take up more oxygen.

In the next topic we will begin to appreciate more how the body uses oxygen to burn food so as to release energy. This will be dealt with in the process of respiration.

Summary:

We have discussed how the different respiratory parts are structured so that the exchange of gases happens easily and smoothly. We also looked at the differences between the gases inhaled and exhaled during the process of breathing. This is necessary so that we can compare the contents of the different gases. It also helps to give us a better understanding of which gases are required by the body for it to perform better. This information will become very important in our next topic on the process of respiration.

We also discussed the importance of the capillaries in enabling the transfer of gases from the lungs to the rest of the body cells and vice versa; we covered this when we looked at the blood supply around the alveoli.

We also discussed how physical activity affects breathing. It is important to understand how the body adjusts breathing so as to allow for a better exchange of gases between the human body and the atmosphere during physical activity.

Key points to remember are that physical activity makes the breathing rate to increase so that more oxygen can be taken in and carbon dioxide taken out quickly. It is also important to remember that the alveoli are numerous with thin walls and a dense network of capillaries, which help in the blood transporting both oxygen and carbon dioxide around the body.

You have completed topic 1 and are now ready to do the end of topic exercise. This can be found at the end of the unit. Once you have completed the exercise, compare your answers with the ones provided. If all your answers are correct, move on to topic 2. If some of your answers were incorrect, review the relevant sections before moving on to topic 2.

Topic 2: Respiration

In topic 1 we have been learning about how the human body takes in oxygen and takes out carbon dioxide. We did this by recognising the different parts of the respiratory system, seeing how they allow for this gaseous exchange, as well as the differences in inhalation and exhalation resulting in taking in the gases and the release of these gases. We also discussed the breathing rate and how it changes during physical activity so that more oxygen is taken and carbon dioxide released.

In this last topic we will discuss how the oxygen is utilized and how carbon dioxide given off as a by-product. You will have to recall especially the topic on gaseous exchange.

This means that we will be describing the process of respiration. This is a process that releases energy for different processes such as movement, growth and reproduction. The energy is released from the food human beings eat, and oxygen is needed for this process. Recall how we said that you will need your past information on photosynthesis. You will need to recall especially the equation.

We will also discuss the process of mouth-to-mouth resuscitation as a vital one for saving lives. This is a process also known as artificial respiration, or breathing, as it takes an outside force to make one to start breathing again.

Learning Objectives:

At the end of the lesson, you should be able to:

- Define respiration.
- State the word equation for respiration.
- List activities where energy is required.
- Describe the skills of mouth to mouth resuscitation.
- Apply the skills of mouth to mouth resuscitation.

Definition of Respiration

You know what respiration is because we dealt with it when we discussed living things in Unit 1, as well as in Unit 2 under the comparison of photosynthesis and respiration. So what do you think respiration is? Write your answer below.

____

____

Feedback

It is definitely the release of heat energy from food, which takes place in all living cells. This means that humans take in energy in the food they eat. This energy has to be transferred into a useful form to power movement, growth, or to keep the body warm. Energy is also needed to drive chemical reactions that take place in the body such as making new cells.

Every living cell requires energy. This is because there are chemical reactions which take place in these cells, and for these reactions to happen, energy has to be made available. Respiration provides this energy.

We will now discuss the process of respiration in detail.

Process of Respiration

Let us now review the process of respiration in detail. Respiration is a carefully coordinated series of chemical reactions that take place in the cells of living organisms, resulting in the breakdown of organic food substances with the release of energy. It happens in all plant and animal cells. Most living things need oxygen for this process. You will recall that in topic 1 we said that when you exercise, breathing happens faster and deeper so that we can take in more oxygen and release carbon dioxide faster. Do you think that respiration also happens faster to release more energy?

Yes, respiration also takes place faster, which is why carbon dioxide also has to be taken out at a faster rate. What really happens is that the muscle cells of the body need more energy to contract and relax and therefore they respire more. For this to happen, oxygen and dissolved food that have reached the muscles react together to release the needed energy. In other words, food is burnt in the presence of oxygen to release. This is the exact opposite of what happens during photosynthesis.

Apart from what we have just mentioned, can you think of anything else the energy is needed for? Living things require heat energy to also carry out the life processes we discussed in Unit 1. These processes include movement, reproduction, sensitivity, growth and even feeding.

We mentioned growth. Do you have any idea why it is mentioned?

Well, it is because for growth to take place in humans, the cells have to divide and increase in numbers. Cell division is an energy requiring process. This is similar to reproduction, which is said to also need energy. The sending of electrical impulses by nerve cells also needs energy. Please think of other examples of activities that need energy, refer to your notes of Unit 1.

During respiration, dissolved food is used up. In fact, it is mostly glucose which is used to provide the energy. The glucose reacts with oxygen to produce energy and two other products, which are carbon dioxide and water. The right word to use for this reaction is oxidation. So we can say that glucose is oxidised to produce heat energy. This is similar to the burning in the presence of oxygen that we mentioned earlier. Can you guess why the words burning are used?

It is because respiration releases energy, needs oxygen, and produces carbon dioxide and water. Although some of the energy is released as heat, cells do not catch fire. This is because as said above, respiration is a series of carefully controlled chemical reactions.

The chemical reaction of respiration can be summarised as:

Glucose + Oxygen ----------------------→ Energy + Carbon dioxide + Water

Can you see that it is the exact opposite of the one for Photosynthesis?

The above equation simply means that glucose reacts with oxygen to produce energy, carbon dioxide and water. Glucose and oxygen are the reactants in the chemical reaction whilst energy, carbon dioxide and water are produced thus they are called products.

The above is an example of a word equation. This is because words are used to represent the substances involved in the reaction. Chemical symbols can also be used to represent the substances involved in this reaction.

Before we do the chemical equation for respiration, let us first come up with the chemical symbols of the reactants and products of this reaction.

The chemical symbol for glucose is C6H12 O6, oxygen is O2, carbon dioxide is CO2, and water is H2O. The chemical equation is therefore:

C6H12O6 + 6O2 ----------------------→ Heat Energy + 6CO2 + 6H2O

This means exactly the same as the word equation given above. It shows the reactants (glucose and oxygen) on the left and the products (energy, carbon dioxide and water) on the right side of the arrow.

Do you know that some organisms can release energy without oxygen? Examples are yeast cells and bacteria, and their type of energy is known as anaerobic respiration. There are times when anaerobic respiration happens in the muscles of an active person. Find out when and why this happens.

Mouth to Mouth Resuscitation

By now you must be convinced that breathing is one of the most important processes for one to stay alive. It is said that if one stays without oxygen for long they may die or become brain dead, which will eventually lead to death. There are things that can be done to a person that cannot breathe by themselves, and one of them is mouth-to-mouth resuscitation, which is also known as the "kiss of life". In this topic we will explain this important process.

If a person has an accident that leads to them being unconscious, they stop breathing, this may lead to them dying. However, to stop the person from dying, artificial respiration can be performed. This must be carried out as soon as possible, otherwise, the brain cells may be damaged so badly by the lack of oxygen that they never recover. This may happen within a few minutes after the person stops breathing, so speed is essential.

One way of performing artificial respiration is by doing mouth-to-mouth resuscitation. We will discuss how this may be done. To perform this, you first lay the person on his or her back. You then check to ensure that the windpipe is not blocked. The next step is to take a deep breath in, and breathe out into their mouths. You shouldn't fear that your exhaled air has carbon dioxide, remember from the previous lesson that the amounts are not that much and that the oxygen in the exhaled air is enough to keep that person alive.

Another way of providing artificial respiration is by means of a resuscitator. This is a machine that has a tube used to force oxygen into the lungs of a patient and then sucks it out. A system of valves ensures that fresh air is sent to the lungs each time. An unconscious person can be kept alive for many weeks or even months on a machine like this. Sometimes the brain recovers sufficiently for the person to start breathing again.

Stages or Steps in Mouth-to-Mouth Resuscitation

Check the scene and the person carefully. If the person is unconscious, call 911 or the local emergency number. If not breathing do the following:

1. Pinch the nostrils shut with the fingers of one hand, then tilt the head back and push the lower jaw forward so their chin juts out. This will force the tongue forward and open the air passages.

2. Take a deep breath, then open your mouth and seal your lips against the person's mouth. Breathe out firmly, but gently, into the person's mouth and so into his lungs.

3. Lift your mouth off, and then turn your head so as to look at the person's chest. If you have been successful you will see that it has risen and is now falling as air comes out of the lungs.

4. Repeat steps 2 and 3 above giving one slow breath every 5 seconds. If breaths do not go in, re-tilt the head and reattempt breaths. The person's colour should improve, and eventually he or she should start breathing by themselves.

You will now do a simple activity that will enable you to be a better helper.

Activity 1

Use the steps above to create your own small colourful card on how to perform mouth-to-mouth resuscitation. Visit the nearest clinic or health post to talk to a nurse or a first aid worker about mouth-to-mouth resuscitation.

Cross check the steps provided by the nurse or first aid worker with the ones on your small card and make any necessary corrections. You should carry this card with you at all times.

Summary:

We have discussed the process of respiration to see how it utilizes the oxygen and releases the carbon dioxide when we learnt about gaseous exchange. Key to note is the fact that the main reason why respiration takes place is so that energy may be made available for the body. The energy is in fact used for many different processes taking place in the body. We also outlined the steps involved in mouth-to-mouth resuscitation, and designed our own portable information cards on these steps. This is important in that we all become familiar with these steps so that we can assist people in cases of emergencies and save lives.

Now that you have finished the second topic, it is time to do the End of Topic Exercise 2, which you will find at the end of this unit. As in the previous topic, complete the exercise and then compare your answers with the ones provided. If there are any incorrect answers revise the relevant section/s and then read the Unit Summary and get ready for the last activity of the unit by completing the Tutor Marked Assignment.

Unit Summary

Summary

In this unit you learned that air passes through several parts of the body for it to reach the alveoli where gaseous exchange takes place. We also learnt how the alveoli are adapted for this process of gaseous exchange. It is important to remember that one of the ways the alveoli are adapted for this process is the fact that they have a dense supply of capillaries that enable oxygen and carbon dioxide to move in and out of the blood.

Most importantly in this unit, we also looked at how we breathe and how inspired and expired are different. It is important to learn about these processes because they help the body to take in oxygen that is needed for an important process of respiration and they also help to take out carbon dioxide which is released as a waste product. We also discussed the important processes of respiration and mouth-to-mouth resuscitation looking at how they are necessary to ensure life.

The last activity of this unit is to complete the tutor marked assignment which can be found after all the end of topic exercises. This activity, as its name suggests, has to be sent in to your tutor for marking.

You will find the tutor marked assignment in the last section of this this unit, the assessment section.

Unit Assignment

Assignment

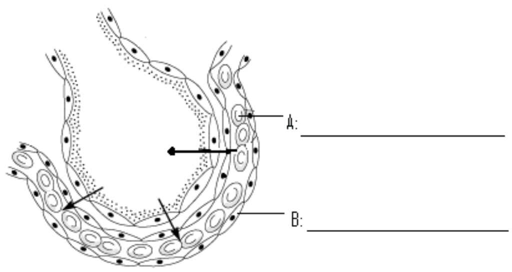
Topic 1 Exercise

1. Define gaseous exchange in terms of oxygen and carbon dioxide. [2 marks]

2. In which part of the lungs does gaseous exchange occur?

   [1 mark]

3. a) Label the parts indicated below. [2 marks]



b) Describe what the arrows into and out of the alveoli indicate on the diagram above.

[2 marks]

4. Outline three ways in which the alveolus is adapted for gaseous exchange. [3 marks]

5. Describe four differences between the air we breathe in and the air we breathe out. [4 marks]

6. Explain what would happen to your breathing rate if you were to engage in a physical activity. Give reasons for why this happens. [3 marks]

Topic 2 Exercise

1. Outline four steps involved in mouth-to-mouth resuscitation.

   [8 marks]

2. a) Write the word equation for the process of respiration.

   [3 marks]

---

   b) List two ways in which the body uses energy.

   [2 marks]

Responses to Assignments:

Topic 1 Exercise

1. Oxygen is taken into the lungs and carbon dioxide is taken out.
2. Alveoli.
3. a) A- Red blood cell, B- Capillary wall.

   b) Arrow pointing out-Carbon dioxide entering the alveoli from the body;

   Arrow pointing in- Oxygen leaving the alveoli to enter the blood.
4. Thin wall for easy passage; Has a large surface area; Is surrounded by many capillaries.
5. Air breathed out is warmer; has lots of Carbon dioxide, it has lower oxygen and more moisture.

   Inhaled air is cooler, has lower carbon dioxide, more oxygen and less moisture.
6. The breathing rate increases and becomes deep so that more oxygen may be taken in and carbon dioxide taken out. This helps to speed up the process of respiration that releases energy needed by the body.

Topic 2 Exercise

1. Pinch the nostrils shut with the fingers of one hand, then tilt the head back and push the lower jaw forward so their chin juts out. This will force the tongue forward and open the air passages.

Take a deep breath, then open your mouth and seal your lips against the person’s mouth. Breathe out firmly but gently into the person’s mouth and so into his lungs.

Lift your mouth off, and then turn your head so as to look at the person’s chest. If you have been successful you will see that it has risen and is now falling as air comes out of the lungs.

Repeat steps 3 and 4 above giving one slow breath every 5 seconds. If breaths do not go in, re-tilt head and reattempt breaths. The person's colour should improve and eventually he or she should start breathing by themselves.

2. **a)** Glucose + Oxygen -----------------------→ Energy + Carbon dioxide + Water

b) Movement of organisms, reproduction, cell division, growth etc..

Assessment

Assessment

1. Explain what you think the importance of breathing is.
   [2 marks]

   ____

2. State two advantages of breathing in through the nose.
   [2 marks]

   ____

3. a) Outline what happens to the muscles in the rib cage when a person breathes in. [3 marks]

   ____

   ____

   b) Outline what happens to the rib cage when one breathes out. [3 marks]

   ____

   ____

4. Relate the effect of vigorous physical exercise to the rate and depth of breathing?
   [2 marks]

   ____

5. Define vital volume?
   [1 mark]

   ____

6. Describe gaseous exchange in terms of oxygen and carbon dioxide. [2 marks]

   ____

   ____

7. State two ways in which the alveolus is adapted for gaseous exchange. [2 marks]

   ____

   ____

8. Make comparison between the air we breathe in and the air we

breathe out. [3 marks]

____

____

9. (a) What is respiration [2 marks]

____

____

(b) Write down both the word and chemical equations for respiration. [4 marks]

____

____

10. Describe the four steps involved in mouth to mouth resuscitation. [4 marks]

i. ____

ii.____

iii. ____

iv. ____

Total = [30 Marks]

Answers to TMAs

1. Breathing enables gaseous exchange that is, movement of oxygen into the lungs and to the cells and the removal of carbon dioxide from the cells through the lungs.
2. Air is cleansed by the cilia as it passes through the nose.

   More air enters the lungs than if it was through the mouth.
3. a) Intercostal muscles contract and pull the ribcage downwards.

   Diaphragm also contracts and moves downwards.

   Volume of the lungs increases and the air pressure decreases and air moves into the lungs.

B) Intercostal muscles relax and pulls the ribcage downwards.

   Diaphragm also relaxes and becomes dome shaped.

   Volume of the lungs decreases and the air pressure also increases and air moves out of the lungs.

4. Increases the rate and depth of breathing.
5. Maximum amount of air one can breathe in or out per minute.
6. Movement of oxygen into the lungs and carbon dioxide out of the lungs
7. Any of the following:

   thin walls for easy passage of gases.

   has a large surface area.

   surrounded by many capillaries.
8. Air breathed out is warmer, has lots of carbon dioxide, has lower oxygen and more moisture.

   Air breathed in is cooler, has lower carbon dioxide and moisture and more oxygen.
9. (a) Respiration is the release of energy form glucose.

   (b) The chemical reaction of respiration:

   i. Word

   Glucose +Oxygen -------------→ Energy + Carbon dioxide + Water

   ii. Chemical

   $C_6H_{12}O_6 + 6O_2$ --------------→ Heat Energy + $6CO_2$ + $6H_2O$
10. (i) Pinch the nostrils shut and tilt the victims head back.

(ii) Seal your lips against he person 's mouth to breathe into their lungs.

(iii) lift your mouth off and observe to see if the chest is moving to show breathing.

(iv) Repeat steps 2 and 3 at a steady rate.

Contents

HSB Unit 5

The Circulatory System

Introduction

The circulatory system is a system responsible for blood circulation around an animal body. It is the third of the systems that you will study in this course. Remember that in unit 1, a system was defined as a group of different organs that work together to perform one or more functions. In unit 3 you learned about the digestive system, and in unit 4 you learned about the respiratory system. The other systems that you will study later are the skeletal, nervous, endocrine and excretory systems which will be discussed in units 6, 7, 8 and 10 respectively.

In our discussion of the respiratory system in unit 4 you learned how carbon dioxide leaves the blood and enters the lungs to be breathed out. You also learned how oxygen diffuses from the lungs into the blood to be transported to different body cells. All this forms part of the blood functions that we will discuss in topic 1 of this unit. We will go on to learn about the structure of the heart and how it pumps blood around the body. This is covered in topic 2. In the last topic we look at the blood vessels in which this blood flows and how they form a network to bring blood close to every cell in the body. Remember what you learned about digestion and absorption of food in unit 3; food is brought to the cells by this network of blood vessels.

This unit is, thus, divided into three topics in which we will learn about the different sections of the circulatory system.

Teaching Approach

The teaching approach used in this unit is learner centered. It is meant to encourage you to find information on your own as well as come up with your own ways of studying. This will motivate you to carry on with your studies and to apply the skills acquired in your everyday life. Take note that what you learned at lower levels e.g. Junior Certificate and what you experience on a daily basis will also form a base for our teaching and learning approach. We will, thus, strive to build on your previous knowledge as we gradually introduce new concepts. This is meant to assist you to understand the subject matter better. Most of the units in this course are related, so you will now and then be referred to a unit you did before.

The unit has eight different activities and in text questions. These are meant to help you check how much you have understood, help you recall what you learnt in the previous units as well as in other topics of this unit, and experiment on some of the content (e.g. you may be asked to locate your pulse points and to count your pulse rate). You may carry out the experiment with a group of friends, and then compare your pulse rates. Please note that now and then you will be asked to work with your friends or to ask your parents at home about how to do some things. These activities and discussions aim to encourage you to get varied points of views on the issues discussed in this course and arrive at an informed decision.

At the end of every topic of this unit, there is an assignment that will further test your understanding of the topic content. You can do the assignment and discuss the answers which are provided at the end of the unit with your friends. This you can do at the learning centres if you are not very far from them. At the end of the unit there is an assessment test which you have to do and mail to your local college of distance learning for marking.

Time Frame

It is estimated that to complete studying this unit you will need between 10 to 15 hours. Do not worry if you take longer in finishing this unit. Remember that we all have different abilities and hence we study at different paces.

You are encouraged to spend about 2 hours to answer the assignment in this unit. You will also need approximately 3 hours on the assessment at the end of the unit.

The total hours for completing the unit will thus be between 15 and 20 hours.

Outcomes

Upon completion of this unit you will be able to:

- *Describe* the components of blood and their functions.
- *Explain* the role and structure of the mammalian circulatory system.

Terminology

Haemoglobin: red pigment found in red blood cells which is responsible for transportation of oxygen.

Pathogen: microorganisms that cause diseases.

Biconcave shape: shaped like a concave lens on both/two sides. E.g. red blood cell.

Lumen: opening (bore) at the center of a blood vessel through which blood moves.

Endothelium: smooth inner lining of a blood vessel.

Resources

You will need a watch or any type of watch.

Online Resource

If you can get on the internet please utilize the resources at www.hippocampus.org. It is an excellent source of information for biology and the topics discussed in this unit. Here you will find:

- Presentations
- Simulations
- Videos
- Online Study Groups
- Links to Even More Information
- Textbook Correlations
- Online Courses

Topic 1: Composition and Function of Blood

In this topic you will learn about the composition of blood and the functions of the different components of blood.

At your age, you definitely have bled before. Have you ever wondered what makes up the blood that comes from you?

You will get to know that blood which looks like a simple liquid to the naked eye is actually a tissue made of different cells. These cells float in liquid called plasma. Blood consists of four main components, and these are the liquid plasma, red blood cells, white blood cells and platelets. These can only be seen under a microscope.

Unfortunately for you, you may not be able to see them under a microscope. You will however see them in diagrams and will get to know about their functions.

Learning Objectives

At the end of this topic, you should be able to:

- Identify red blood cells and different white blood cells from diagrams.
- State the origin of red blood cells, white blood cells and platelets.
- State the function of red blood cells, white blood cells, platelets and plasma.

Composition of Blood

Before we go through this section, please do the short activity below. This will help you recall what you did at junior secondary school about composition of blood.

Activity 1

In the list below, underline the four main components of blood:
Glucose, white blood cells, virus, plasma, heat, red blood cells, platelets, genes

Now read the passage below to find the correct answers.

Blood is a tissue, and it's made of four main components, red blood cells, white blood cells, platelets and plasma. The general functions of blood are to transport materials around the body, to distribute heat around the body and to protect the body against infection. These functions are carried out by the different components of blood therefore that is why we are now going to discuss in detail the different components of blood and their functions.

Feedback:
You should have underlined white blood cells, plasma, red blood cells and platelets.

This can easily be picked by reading through the above passage.

Now that we have some idea of the four components of blood, we are ready to move on to discuss the functions of each of these components. The next four subsections of this topic discuss the functions of each of the four blood components in the following order: red blood cells, white blood cells, platelets and plasma. We start the discussion with the red blood cells because they are the most common. You may have been told at junior secondary that these are the cells that give blood its red colour!

Red Blood Cells

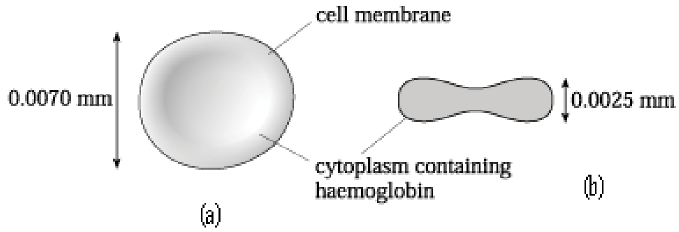


Figure 1: Red Blood Cells (a = top view, b = side view) (Cambridge International Examinations Science Diagrams for Examiners)

How many red blood cells do you think you have in your blood? Remember these cells are so small we can't see with our naked eyes. Just a drop of blood contains millions of them.

Red blood cells are produced in the red bone marrow found in the bones of the ribs and the backbone.

Functions of Red Blood Cells

In the first unit, you covered the function of red blood cells under cell specialization. Recall what you learned and write the function in the space below:

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……………………………………………………………………………

You must have correctly written it as **transportation of oxygen around the body**.

This is their special function (remember they are specialized cells). These cells therefore have some special features that enable them to perform this special function.

Look at **Fig. 1** and see if you can find any features that make it easy for these cells to perform their function. Write any special features you notice on the space below before I help you.

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One special feature of these cells is that their cytoplasm contains a red pigment called **haemoglobin**. This pigment readily reacts with oxygen to form an unstable compound known as **oxy – haemoglobin**. Oxygen is then transported in this form around the body. We shall look at how this happens in detail later.

Now look again at **Fig. 1**. Can you notice the distinct shape of the cell? It is disc shaped, and it looks as if it has been pressed at the center on either side. We refer to this shape as *disc and biconcave.*

This feature is very important in the function of red blood cells as it increases their surface area for more reaction between oxygen and haemoglobin, and therefore transportation of more oxygen. Do you still remember what you learned about surface area in unit 3? Remember the example of the rat and elephant you were given? Ahaa!, that very concept applies to red blood cells, because like the rat, a white blood cell has a great surface area to volume ratio.

Another feature of red blood cells is that unlike most cells, they do not have a nucleus. This means they have more space to contain more haemoglobin, and can therefore carry more oxygen.

<u>How red blood cells transport oxygen</u>

"In the lungs, the oxygen dissolves in the blood and is carried to the tissues by the circulatory system, you will learn about this system in detail in the next unit."

Do you remember this sentence? It comes from unit 4 and below we look at how this oxygen gets into the blood to be carried to the different tissues.

When blood passes through the lungs, the haemoglobin in the red blood cells readily react with oxygen to form the unstable compound **oxy – haemoglobin**. The weak bond between oxygen and haemoglobin breaks when blood reaches the tissues, where the concentration of oxygen is lower than in the lungs. The oxygen diffuses into the tissues while haemoglobin remains in the red blood cells. Remember that in unit 4 you learned that the oxygen reacts with glucose to generate energy! This is how the oxygen is used in the tissues to ensure that its concentration here is lower than in the lungs.

We will now discuss the white blood cells and you will notice the difference between them and the red blood cells.

White Blood Cells

At your age, you have fallen ill many times. I guess if I ask you how many times you have recovered without visiting your family doctor or taking any medication it will be difficult to come up with the number.

On all those occasions, you recovered because of your white blood cells. These cells are responsible for fighting any infection that happens to the body. They are able to reach all areas of infection. White blood cells are able to squeeze out of blood capillaries, and can therefore reach infected areas outside blood vessels. There are different types of white blood cells, namely phagocytes, monocytes and lymphocytes, see figure 2. White blood cells are produced in the white bone marrow found in the bones of the limbs. Although all these cells fight infection, the way they do it is different.

You can compare this to an army which fights the enemy using tanks, helicopters and foot soldiers.

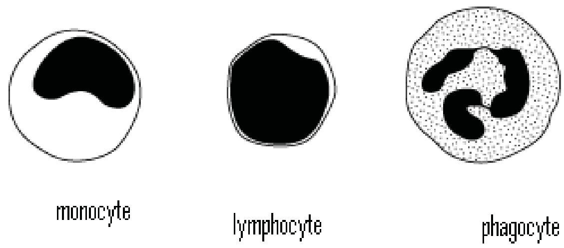

Fig. 2: Types of white blood cells (Cambridge International Examinations Science Diagrams for Examiners)

At this stage, we are only going to learn about phagocytes and lymphocytes as these are the only cells covered in the HSB syllabus at this level.

i) **Phagocytes**
These cells defend the body from pathogens by engulfing them. They are able to do this because they can change shape to surround the pathogen. Once surrounded, the pathogen is killed and digested. The process of engulfing and destroying bacteria is known as phagocytosis.

Phagocytes have a multi-lobbed nucleus as shown on Fig. 2.

ii) **Lymphocytes**
Lymphocytes defend the body by producing chemicals called antibodies. Antibodies are released during infection and they kill pathogens. Pathogens have substances called antigens. These are the substances sensed by the lymphocytes and trigger them to release antibodies.

Lymphocytes have a large nucleus that almost fills the entire cell as shown on Fig. 2.

Before we discuss the last two components of blood, complete activity 2 which will help you differentiate between red and white blood cells' structure and functions.

Give two structural differences and one functional difference between red blood cells and white blood cells.

Activity 2

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Feed back:

You will be very correct if you wrote that:

White blood cells have a nucleus while red blood cells don't. Red blood cells have a disc, biconcave shape while white blood cells have different shapes. Red blood cells transport oxygen around the body while white blood cells defend the body against infection.

Platelets

Platelets are not cells, but are fragments (small pieces) of cells. They are produced in the bone marrow. The main function of platelets is initiating the process of blood clotting.

If you have a cut on your skin, you start bleeding. After some time the bleeding stops and the blood solidifies around the cut. If it wasn't for the platelets, this would not happen.

How does clotting occur?

When one has a cut, platelets cluster around the cut. They then release enzymes that convert the soluble plasma protein fibrinogen into fibrin which is insoluble. Fibrin then forms a network of fibers around the cut. Blood cells and more platelets will be trapped in this network until they seal the cut.

Think about why clotting is important, and then write your answer down on the space below.

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You have got it right if you wrote: *to prevent excessive loss of blood and to prevent entry of pathogens*.

If it wasn't because of clotting, we would lose a lot of blood and die from that. As blood dries over the wound, it forms a barrier which prevents entry of pathogens.

Plasma

This is the liquid component of blood in which all the three above mentioned components float. Plasma is a solution of many substances (plasma proteins, mineral ions, products of digestion, waste materials, vitamins and hormones) in water. Plasma is responsible for the transportation of these to where they are required in the body. It is also responsible for the distribution of heat throughout the body.

That was the last component of blood. Now complete activity 2 which will help you recall the food substances and waste materials transported in plasma.

Activity 3

From Unit 3, The Digestive System, you may recall the end products of digestion that have to be transported in blood. List them below. Also give waste materials transported in blood.

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Feedback:

I hope you were able to recall that the end products of digestion are glucose, amino acids, fatty acids and glycerol. The waste materials include urea, nitrogenous waste and carbon dioxide. If you did not remember these products and waste materials, you should revise the relevant topic in Unit 3.

Summary

In this topic we have learned that blood is a reddish liquid that flows in our blood vessels. It is composed of a liquid component called plasma, and blood cells. The cells are the red blood cells, white blood cells and platelets (cell fragments).

The main functions of blood are to transport materials around the body, to distribute heat through the body and to protect the body against infection. The red blood cells transport oxygen, blood plasma distribute heat and transport food materials, wastes, mineral ions vitamins and hormones. The white blood cells, on the other hand, are responsible for protecting the body against infection.

We have come to the end of the first topic. In topic 2, we will discuss the structure and function of the heart. There is, however, one last activity that you have to do before moving on to topic 2. As mentioned earlier, there is assignment 1 which is meant to assist you recall what you learnt in the topic. Do this assignment now. You can thereafter check your answers against the model answer provided at the end of the unit. If you are studying with friends at home or at a learning centre, do the assignment alone first and then discuss your answers with your friends, as I had suggested in the teaching and learning approach section at the beginning of this unit. During your discussion you can compare your answers with the answers provided at the end of the unit. If you got all your answers correct, you can then proceed to unit 2. If some of the answers are incorrect, revise the relevant sections before proceeding.

Topic 2: The Structure and Function of the Heart

In the last topic, you learned about the composition and the functions of blood. In this topic, you will learn about how this blood is made to circulate around the body.

For blood to circulate around the body, it has to be pumped. This is done by an organ known as the heart. We are going to learn about the structure of the heart, its function and how it is able to perform its function.

Have you ever wondered how your heart is able to pump blood every minute, hour and day? It uses the energy you learned about in unit 3. We will also learn about heart related diseases. Let us together discuss this magnificent structure in our bodies called the heart.

Learning Objectives

At the end of this topic, you should be able to:

- Identify and label parts of the heart.
- Describe the pumping action of the heart.
- Explain how direction of blood flow is controlled.
- List the likely causes of coronary heart disease.

The Heart

I believe that all of us have seen an animal heart, and some may have even eaten it. So those who have eaten it may already be thinking “meat” and salivating, mmmm!

The question is have you scrutinized the heart to see how it looks like? If not, make sure you do so the next time you get a chance. Let’s look at the diagram below and see if it looks familiar.

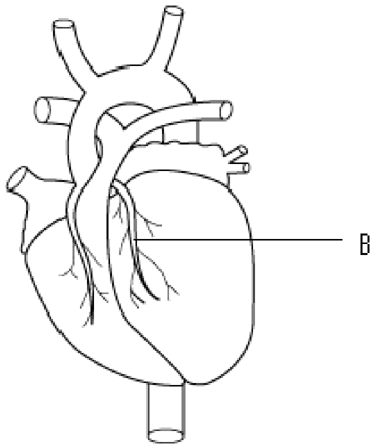

Fig. 1: External view of the mammalian heart (Cambridge International Examinations Science Diagrams for Examiners)

Does it look familiar? I guess so, except maybe for the top part which may not always be that outstanding in a real heart. Those are the blood vessels that bring blood into and out of the heart. From those blood vessels branch others which are labeled **B** in Figure 1. These blood vessels supply the muscles of the heart with blood. They are known as coronary blood vessels.

Having seen the external parts of the heart, let me now take you through the internal structure of the heart, which I believe not most of you have scrutinized.

Section Through the Heart

Internally, the heart has four compartments or chambers. There are two chambers at the top and two at the bottom. The top chambers are known as the **atria** (singular = atrium) while the bottom ones are known as **ventricles**. The heart can also be divided into the left hand side and the right hand side, which are divided by a thick chunk of muscle.

right atrium	left atrium
right ventricle	left ventricle

Fig 2: Simplified Model of the Heart

Thinking of it, we can simplify it and say the heart looks like a box divided into four parts as the Fig. 2 above. The four components have been labeled as the chambers of the heart. Look for the chambers labeled here in figure 3 below.

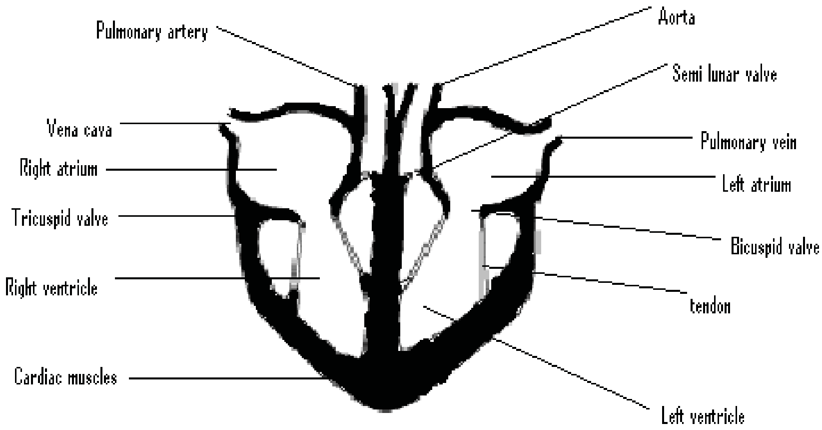

Fig. 3: Section through a Heart (Cambridge International Examinations Science Diagrams for Examiners)

From the diagram, Figure 3, we can see that in addition to the four chambers, there are four outlets. These are the blood vessels that either bring blood into or out of the heart. The blood vessels are the **vena cava** and the **pulmonary vein**, which bring blood into the heart and the **aorta** and the **pulmonary artery** which transport blood out of the heart. Review Figure 3 and identify these four blood vessels. In the next section we will discuss how blood flows in and out of the heart.

Flow of Blood into and out of the Heart

The heart as already stated has four chambers which play a very important role in the circulation of blood. The roles of these chambers are:

i. **Right atrium:** This chamber receives blood rich in carbon dioxide from the different parts of the body. The blood flows to the right atrium in the vena cava. The right atrium then pumps the blood down to the right ventricle.

ii. **Right ventricle:** It receives blood rich in carbon dioxide from the right atrium and pumps it out to the lungs for oxygenation. The blood flows from the right ventricle to lungs in the pulmonary artery.

iii. **Left atrium:** The chamber receives blood rich in oxygen from the lungs, and then pumps the blood into the left ventricle. Blood flows from the lungs to the left ventricle in the pulmonary vein.

iv. **Left ventricle:** This chamber receives blood rich in oxygen from the left atrium and pumps it out to the different parts of the body. Blood flows from the left ventricle in an artery known as the aorta.

Let me again take you back to unit 4. Remember that you learnt that oxygen is taken from the lungs and taken to different body tissues by blood! Now remember that this blood has to be pumped by the heart.

Figure 3 below shows the link between the heart, the lungs and the rest of the body (tissues). Read on to get how blood flows between the regions.

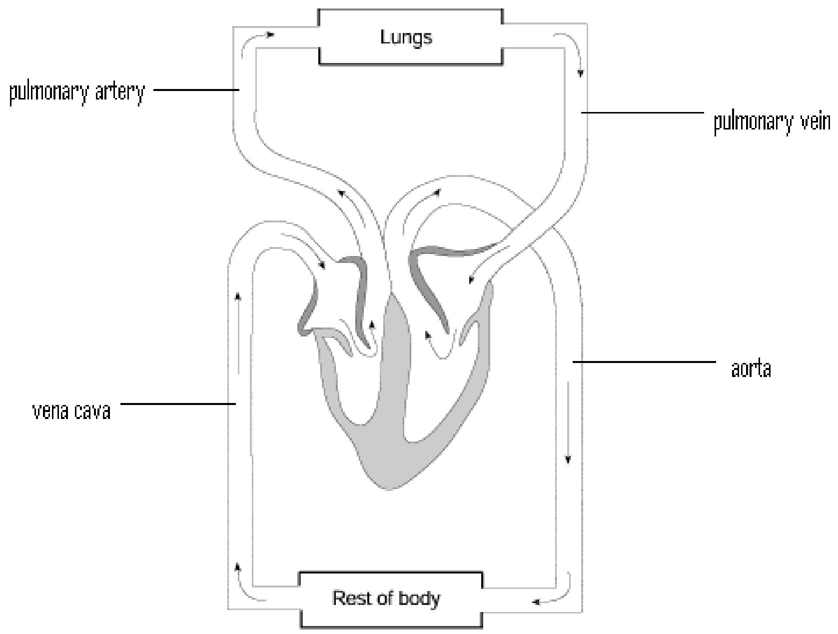

Fig. 4: Flow of blood into and out of the heart (Cambridge International Examinations Science Diagrams for Examiners)

In summary, blood flows towards the heart in the vena cava. It enters the heart on the right hand side, into the right atrium. Identify the right atrium of the heart in figure 4 using figure 3 above. From the right atrium it's pumped into the right ventricle. The right ventricle then pumps the blood out of the heart for the first time to the lungs where it will be oxygenated.

NB: follow the arrows in figure 4 as you read, they show the direction of blood flow.

The blood flows to the lungs in the pulmonary artery. From the lungs the blood flows back to the heart in the pulmonary vein and enter the heart for the second time, this time on the left hand side. It enters the left atrium which will then pump the blood into the left ventricle. The left ventricle now pumps the blood out of the heart. It leaves the heart for the second time, this time going to the different parts of the body.

Therefore for blood to make a complete revolution around the body, it has to pass through the heart twice. In the first path it goes to the lungs and back, while in the second one it goes to the different parts of the body and back. The route between the heart and lungs is known as the **pulmonary circuit** while the route between the heart and the rest of the body is known as the **systemic circulation**.

Now complete activity 1 below. The activity will help you recall the route followed by blood in and out of the heart as we discussed it above.

Activity 1

In the space below, write in the correct order the route followed by blood from the vena cava to the aorta. Include in your list all the four chambers, the four blood vessels attached to the heart and the lungs.

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……………………………………………………………………………

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Feed back:

I am sure you were able to get the correct order of the route followed by blood. To get the correct order, you should start at the vena cava in figure 4 above. Follow the arrows until you arrive at the aorta. The correct sequence is as follows:

Vena cava, right atrium, right ventricle, pulmonary artery, lungs, pulmonary vein, left atrium, left ventricle, aorta.

We have been discussing that it is the heart that pumps blood. For it to pump it needs muscles to produce movement. You will learn in detail in unit 6 how muscles produces movement, but for now in section 1.3 below, we will just discuss the different sizes of heart muscles and the reasons behind that.

Muscles of the Heart

As I mentioned in the topic introduction, the heart is responsible for pumping blood around the body. On average, the human heart beats about 72 times in a minute throughout one's life.

I think most of you are already imagining how old their grandparents are! Yes their hearts have been beating ever since you can imagine. **It's quite a busy organ, isn't it?**

Since it's so busy, the heart is relatively very muscular, so that it can tirelessly pump blood around our bodies throughout our lives.

Before we discuss the different sizes of the heart muscles, do the activity below to help you see for yourself this difference.

Activity 2

Now look at **fig. 3** and write in the space below the difference you see in the thickness of the walls of the ventricles and those of the atria.

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……………………………………………………………………………

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Feed back:

You got it right if you wrote that the walls of ventricles are thicker than those of the atria.

Although the whole heart is a muscular organ, the bottom chambers which are the ventricles are more muscular than the atria at the top.

The reason for this is because the atria only pump blood within the heart into the ventricles, while the ventricles have to pump blood out of the heart. They therefore need more muscles so as to exert more pressure and pump blood out of the heart.

Now look at **Fig. 3** again very closely. This time compare the thickness of the wall of the left ventricle with that of the right ventricle. You will notice that the wall of the left ventricle is thicker than that of the right one. The reason for this is the right ventricle has to pump blood to lungs, which are not very far from the heart. The left ventricle on the other hand has to pump blood to the different parts of the body, some of which are very far from the heart, eg the toes. The left ventricle therefore needs more muscles so as to exert more pressure and make blood reach those distant body parts.

We have discussed most of the features of the heart shown in Figure 3 like the blood vessels that bring and take blood away, the muscles and the chambers of the heart. If you look closely, there are valves labeled on the diagram. These we have not discussed and they are what we will discuss in the next section.

Valves of the Heart

The flow of blood into and out of the heart described in 1.2 above is a one way flow. Therefore within the heart there are valves that ensure one-way flow of blood. We can also say these valves prevent backflow of blood.

Have you ever wondered why air is pumped into a tyre/tube but does not come out after the pump is removed?

This is because the tire has a valve that only allows air in, but prevents it from escaping out. The valves of the heart work in the same way, allowing blood in but stopping it from escaping. E.g. allowing blood to flow from the right atrium into the right ventricle and not back. Below we discuss the different valves of the heart and their roles in controlling blood flow. As you read about these valves, review Fig 3 to see the location of each of the valves.

i. **Tricuspid Valve:** This valve is located between the right atrium and the right ventricle. Its function is to prevent blood from flowing back into the right atrium as it relaxes to receive blood from the vena cava, and the right ventricle contracts to pump blood out of the heart to the lungs.
ii. **Bicuspid Valve:** It is located between the left atrium and the left ventricle. Its function is to prevent blood from flowing back into the left atrium as it relaxes to receive blood from the pulmonary vein, and the left ventricle contracts to pump blood out of the heart to the rest of the body.
iii. **Semi lunar Valves:** There are two of these in the heart. One is located at the base of the aorta, and the other at the base of the pulmonary artery. These valves prevent blood from flowing back into the ventricles as they relax to receive blood from the atria.

We have discussed the different parts of the heart ant how they function to ensure blood flow around the body. Now, you need to be aware that despite it being such an active organ, the heart sometimes has some problems. I believe you have heard of someone dying of a heart attack haven't you?

In the next section we discuss how a heart attack comes about and the possible causes of heart attack.

Coronary Heart Attack

I guess you have heard on a number of occasions it being said that someone has died from a heart attack. Well, there are different ways in which a heart attack may occur and there are different causes.

A coronary heart attack may result from the blockage of one of the coronary blood arteries. Blockage in most cases results from deposits of insoluble fatty substance known as **cholesterol**. These deposits are known as **atheroma**. If this happens, the part of the heart supplied with blood by that particular artery will not receive glucose and oxygen, resulting in weak muscular contraction. This may result in heart failure. The blockage may sometimes result from a blood clot in one of the coronary arteries, resulting in heart failure. The different possible causes of coronary heart attack are the subject of the next section.

Possible Causes of Coronary heart attack

There are different possible causes of coronary heart attack.

a) Diet: Eating certain food substances may increase chances of one having a heart attack. Eating a lot of food rich in animal fat increase the person's blood cholesterol level. The cholesterol will be deposited in the arteries, blocking them and causing heart attack.

b) Smoking: Some chemicals in cigarette smoke corrode the inner smooth lining of arteries. This makes them more permeable, allowing the liquid component to leak out and leave the insoluble cholesterol to be deposited. The corroded lining also becomes rough and easily traps the insoluble cholesterol leading to the formation of an atheroma.

c) High blood pressure: When someone suffers from high blood pressure or hypertension, a lot of fluid is lost from blood to the cells. This leaves behind the insoluble cholesterol which will be deposited in the arteries forming an atheroma.

d) Stress: Emotional or psychological stress lead to hypertension and this result in loss of fluids as explained in (c) above.

Summary

I hope you enjoyed learning about this organ which is always throbbing in our chests. Let us recap on what we have learned.

In this topic we learned that the heart is a muscular organ divided into four chambers, the atria at the top and ventricles at the bottom. These chambers play an important role in the human dual circulation system. The two circuits of the system are the pulmonary and the systemic circuit. Since it is very busy, contracting on average 72 times every minute, the heart is very muscular. The ventricles are however more muscular than the atria because they pump blood out of the heart while the atria pump blood within the heart. The left ventricle is more muscular than the right one because it pumps blood to distant parts of the body while the right ventricle pumps blood to the lungs not very far from the heart.

Coronary heart attack results from the blockage of a coronary artery. Possible causes of coronary heart attack include smoking, stress, diet and high blood pressure.

We have come to the end of topic 2 of this unit. In the next topic, we discuss the different types of blood vessels which are the ones responsible for carrying the blood we discussed in topic 1 around the body. Before you move on to topic 3, complete assignment 2 at the end of the unit to check how much you have been able to grasp in this topic. You should follow the same steps suggested at the end of topic 1 to verify and rectify your answers.

Topic 3: Blood Vessels and Circulation

In topic 2 we learned about the heart and how it pumps blood. We also learned about the composition of this blood pumped by the heart in topic 1.

In this last topic of the unit, we are going to learn about the blood vessels into which this blood is pumped, and what also transports the blood around the body. We are going to learn about their different types, their functions and their structure.

Stretch your arm and look at the inside part of the arm. Are you able to see a network of blue lines, or bulging tube-like structures through your skin in your arm? These are some of your blood vessels.

Blood vessels form a continuous network around the body, taking blood to every living part of the body. The vessels vary in size, ranging from about 0.001mm to 1cm in diameter.

Learning Objectives

At the end of this topic, you should be able to:

- Identify the three types of blood vessels from diagrams.
- State the functions of the blood vessels and how their structure is related to function.
- Name the blood vessels to and from the heart, lungs, head, liver and kidneys.
- State origin and function of tissue fluid.
- State the origin and function of lymph.

Structure and Function of Different Blood Vessels

There are different blood vessels in the body. Do you still remember the labels on figure 3 and 4 in topic 2? These figures have blood vessels labeled veins and arteries, e.g. pulmonary artery and pulmonary vein. These are examples of the different blood vessels that we are going to discuss. The different vessels have different functions. Their structures make it possible for them to perform these different functions. Arteries and veins have an almost similar structure of an outer fibrous coat, a middle layer of muscle and elastic tissue and a smooth inner layer commonly known as **endothelium.**

We will look at the different types of blood vessels, their functions and structure, and how the structure help the vessels perform their functions. We start with arteries.

Arteries

Function:

- Their function is to carry blood away from the heart. Because they carry blood away from the heart, this blood is of high pressure due to ventricular contraction. That is, the pressure is exerted by the ventricles as they contract. Blood in arteries flows in pulses. This happens every time the ventricle contracts and relaxes.

Structure:

- They have a relatively narrow lumen. Remember we said a lumen is the opening at the center of a blood vessel. The narrow lumen helps to maintain the high pressure of blood flowing in the arteries.
- They have relatively thick walls with lots of muscles and elastic tissue. The thick walls help them to withstand the pressure of blood flowing in them, preventing them from rupturing. The elastic tissue stretches as the ventricles pump blood into the arteries, helping them to absorb the pressure.

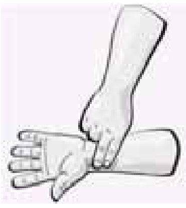
Arteries divide into smaller ones known as **arterioles.** The arterioles further divide to form capillaries.

NOTE: The stretching of arteries as the ventricle pump blood into them can be felt at certain points in the body. These are felt as slight throbs on the finger tip touching that point. These points are known as **pulse points**.

Before we move on, please do this activity. It will make you feel the throbs that we talked about above. You can do the experiment with a friend to feel their pulses, and even count their pulse rates.

Activity 1

1. Place your index finger and pointing finger of one hand on the wrist of the other hand as shown below. You should feel a slight throb on your finger tips.



2. Now if you have a stop watch or watch, count the number of throbs in one minute. That is your **pulse rate**.
3. Now ask a few friends to also read their pulse rates, and then record them in the table below for comparison.

Name	Pulse rate

.

Feedback: *you should feel some throb at your finger tips and would have noted your rate and compared it with your friends. Did you see any* *difference in your pulse rates? There is bound to be some slight differences.*

Other pulse points are at the side of the neck and on the temples.

Remember we said as they move further away from the heart, arteries divide into arterioles which go on to divide into capillaries. Therefore, next we discuss the functions and structure of capillaries.

Capillaries

These are the tiniest blood vessels in the body.

Function:

- Responsible for exchange of materials between blood and cells.

Structure:

- Their walls are so thin that they are only one cell thick.
  The thin walls allow substances to easily pass through them either into the blood or out of the blood. Capillaries form a dense network such that they pass next to each and every living cell. Their lumen is so narrow that only one red blood cell can pass through at a time. The thin wall and the narrow lumen is shown in fig 5, note the wall made of a single layer of cells, and the red blood cells passing through one at a time.

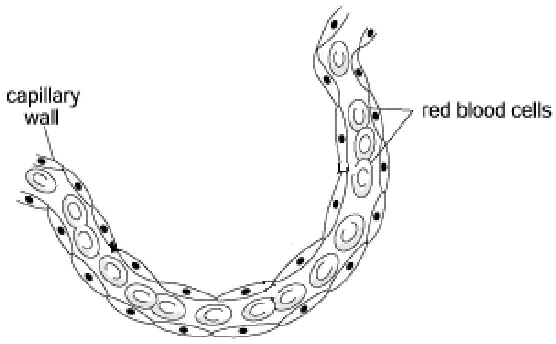


Fig. 5: section of a coiled capillary (Cambridge International Examinations Science Diagrams for Examiners)

The tiny capillaries ultimately join up to form bigger vessels known as venules. The venules join up to form veins, which are the next type of blood vessels we discuss.

Veins

Function:

- All veins transport blood towards the heart.
  The pressure of blood flowing in veins is lower than in arteries, and the blood flows smoothly and steadily.

Structure:

- They have a relatively wider lumen through which blood flows smoothly.
- Their walls are relatively thin with little muscle and elastic tissue. These thin walls of veins can easily be squeezed by the contracting limp muscles to push blood back towards the heart.
- Veins have valves throughout their entire length. These valves are there to ensure one-way flow of blood or prevent backflow as pressure is low.

We have discussed functions of veins and their structure. Do activity 2 below so that it helps you understand the importance of the structure in blood movement.

Activity 2

Have you ever thought why most people experience swollen ankles if they stand for a long time without moving? You may have also experienced it. Write down the reason below.

……………………………………………………………………………
……………………………………………………………………………

……………………………………………………………………………
……………………………………………………………………………

……………………………………………………………………………
……………………………………………………………………………

Feedback:

There is slow flow of blood up the body because of no/less muscle contraction. This causes the ankles to swell as fluid accumulates.

Having discussed the structure of veins and arteries, let's compare their structure to see how the structure of the two types of blood vessels differ

A Comparison of Arteries and Veins

Do activity 3 below. This activity is all you need to get the differences. Note that you can get the differences by reading through sections 1.2 and 1.3 above.

Activity 3

The table below shows differences in structure and function between arteries and veins. Write down the other differences, the first one has been done for you.

	Arteries	Veins
I	Carry blood away from the heart	Carry blood towards the heart
Ii	Walls are thick muscular and have lots of elastic tissue	
Iii	Valves are absent except at the base of the aorta and pulmonary artery	
Iv		Blood flows slowly under low pressure
V		Wide lumen
Vi	Blood flows in pulses	

Feedback: *Note that the differences must be directly opposite, that is, don't just list them. The contrast will be clearer when you put them opposite.*

	Arteries	Veins
I	*Carry blood away from the heart*	*Carry blood towards the heart*
Ii	*Walls are thick muscular and elastic*	*Walls are thin with little muscle and elastic tissue*
Iii	*Valves are absent except at the base of the aorta and pulmonary artery*	*Valves are present throughout their entire length*
Iv	*Blood flows rapidly under high pressure*	*Blood flows slowly under low pressure*
V	*Narrow lumen*	*Wide lumen*
Vi	*Blood flows in pulses*	*Blood flows smoothly*

Now that we have discussed the different types of blood vessels, we have to be aware that it is these blood vessels that make up the circulatory system. In the next section, we look at some of the main blood vessels of the circulatory system.

Main Blood Vessels of the Body

In addition to the four blood vessels that bring blood into and out of the heart mentioned in topic 2, there are other blood vessels responsible for distributing blood to and bringing it back from all the organs of the body. These blood vessels make up the circulatory system, and you need to be able to label them and the organs they supply with blood. Study figure 6 below and make sure you are able to label the different blood vessels.

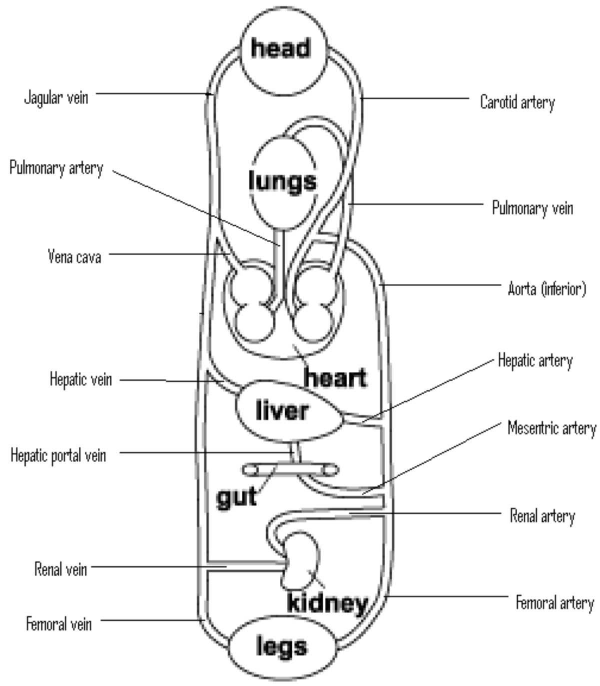


Fig. 6: The circulatory system (Cambridge International Examinations Science Diagrams for Examiners)

Blood always flows in blood vessels, and nowhere else. It however needs to distribute materials to cells as well as transport wastes from cells. Because of this, blood is linked to two other important body fluids, lymph and tissue fluid. Due to this close association, we have to discuss these two fluids in the section below.

Tissue Fluid and Lymph

These are two fluids that play an important role in the transfer of materials between blood and cells and the carrying of wastes from cells to blood.

Tissue Fluid

When blood reaches the capillaries, materials dissolved in plasma leak out of the permeable capillary walls. Once outside the capillaries the fluid bathes/surround the cells. This fluid is now known as **tissue fluid**.

Tissue fluid therefore originates in blood and it is plasma without cells and plasma proteins, and is outside blood vessels. The cells are too big, and the proteins have molecules too big to pass through the permeable capillary walls.

The Lymph

In the vessels of the system known as lymphatic vessels/lymph vessels flows a fluid know as **lymph**.

Earlier in the above subtopic, it was explained that tissue fluid moves back into the capillaries after cells have absorbed food from it. However, excess tissue fluid moves into the lymph vessels and will now be known as lymph.

The lymphatic system empty its contents back into the blood circulatory system at certain points, thus returning fluid back into the blood.

Figure 7 below shows some lymph vessels and ducts distributed through the human body. The lymph vessels labeled in the diagram are the tubes through which lymph flows. In the lymph nodes there is a concentration of white blood cells, and they play an important role in the body's defense.

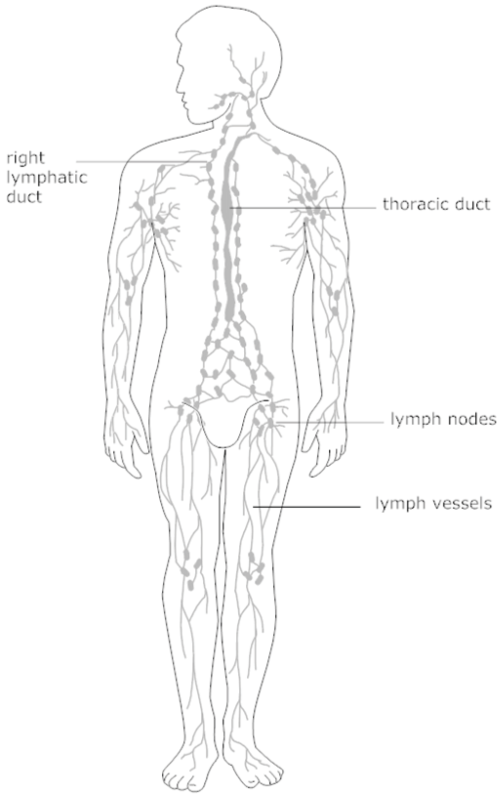


Fig. 7: The lymphatic system (FCTVE workbook)

<u>Fuctions of the Lymphatic System</u>

- Returns fluid to the blood.
- Carry end products of fat digestion away from the ileum (remember you discussed this in unit 3).
- Help in prevention of diseases. The lymphatic system has some bean shaped swellings along its vessels known as lymph nodes. These nodes filter and remove bacteria and other foreign bodies from the lymph before it's emptied into the blood. The bacteria are then destroyed by lymphocytes contained in the lymph nodes. Lymph nodes are found in the neck, armpit, groin and small intestines.

You may have felt your lymph nodes at one point in time.

Do activity 3 anyway, it will help you feel your lymph nodes.

Activity 3

Put your thumb and index finger on either side of your throat as if you are chocking yourself. Roll them a bit until you feel some small lumps on either side of the throat.

Feedback: These are the lymph nodes.

You may also have at one time developed a wound say on one of your fingers. This may have caused some painful swelling in your armpit. Those would be swollen lymph nodes.

As already mentioned, the fluids discussed above help distribute what is transported by blood to different cells. Below we discuss how material leaks out of blood and wastes enter the blood.

Transfer of Materials Between Tissue Fluid and Cells

Each organ of the body is supplied with blood by a network of capillaries called a **capillary bed**. Actually there are many of these in an organ. Figure 8 shows this network and the connection between arteries, veins and capillaries.

High pressure of blood at the arterial end of the capillary bed forces blood plasma to leak out of the permeable capillary walls. The plasma carries with it all the soluble substances (glucose, amino acids, vitamins, hormones etc). Once outside the capillaries, the fluid is now known as tissue fluid. This fluid surrounds and bathes the cells so that they can absorb all the substances they need. At the same time, the cells release carbon dioxide, urea and other wastes into the fluid.

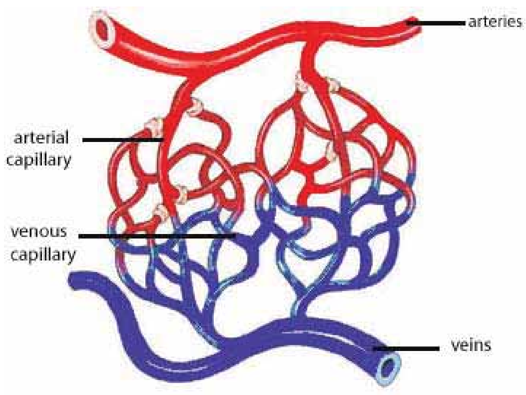


Fig. 8: Connection between arteries, veins and capillaries (FCTVE workbook)

As the blood moves towards the venous end of the capillary bed, it's now thick and concentrated. This is because it has lost a lot of fluid. On the other hand, the blood is dilute because most of the substances have been absorbed by the cells around it, leaving behind mainly water. Water will move back into the capillaries by osmosis because there will be more water in the tissue fluid. Wastes will also move from the tissue fluid into the blood by diffusion since they are more concentrated there. If they are less concentrated in blood, they will move in by active transport.

Summary

In this topic we learned that there are three main types of blood vessels; arteries, capillaries, and veins. Arteries carry blood away from the heart; veins carry blood towards the heart while capillaries distribute substances to the tissue cells. Blood in arteries flows in pulses while that in veins flows smoothly.

During exchange of materials between blood and cells, plasma leaks out of permeable capillary walls to bathe the cells. Once outside blood vessels it is now known as tissue fluid. The tissue fluid returns back into the blood carrying wastes like urea and carbon dioxide. Some of the fluid seeps into another system known as the lymphatic system. Once in the system, the fluid is now known as lymph.

We have now come to the end of topic 3. Please do assignment 3 below. It is meant to help you recall and demonstrate your understanding of what we have been discussing in the topic.

At the end is an assessment exercise for the entire unit. Do that as well and submit or mail it to your local college of distance learning.

This is the end of unit 5 and I hope you enjoyed it. Prepare yourself to move into the next unit.

Wishing you the best of luck, and brace yourself for the next unit which discusses the skeletal system and movement.

Unit Summary

Summary

In the first topic we have learned that blood is a reddish liquid that flows in our blood vessels. It is composed of a liquid component called plasma, and blood cells. The cells are the red blood cells, white blood cells and platelets (cell fragments).

We learned that the main functions of blood are to transport materials around the body, to distribute heat through the body and to protect the body against infection. The red blood cells transport oxygen, blood plasma distribute heat and transport food materials, wastes, mineral ions vitamins and hormones. The white blood cells, on the other hand, are responsible for protecting the body against infection.

In the second topic we learned that the heart is a muscular organ divided into four chambers, the atria at the top and ventricle at the bottom. These chambers play an important role in the human dual circulation system. The two circuits of the system are the pulmonary and the systemic circuit. We also learned that the heart is a very muscular organ. The ventricles are however more muscular than the atria because they pump blood out of the heart while the atria pump blood within the heart. The left ventricle is more muscular than the right one because it pumps blood to distant parts of the body while the right ventricle pumps blood to the lungs not very far from the heart.

In topic 3 we learned that there are three main types of blood vessels; arteries, capillaries and veins. Arteries carry blood away from the heart; veins carry blood towards the heart while capillaries distribute substances to the tissue cells. Blood in arteries flows in pulses while that in veins flows smoothly.

As already mentioned, at the end of the topic assignments is an assessment exercise for the entire unit. Do that as well and submit or mail it to your local college of distance learning.

This is the end of unit 5, hope you enjoyed it. Prepare yourself to move into the next Unit which deals with the skeleton and movement.

Wishing you the best of luck, and brace yourself for the next unit.

Assignment

Assignment

Assignment 1

1. Give three general functions of blood.

   ……………………………………………………………………
   ……………………………………………………………………

   ……………………………………………………………………
   …………………………………………………………….... (3)

2. Name the three types of white blood cells.

   ……………………………………………………………………
   ……………………………………………………………………

   ……………………………………………………………………
   ……………………………………………………………… (3)

3. Which cell from the ones you mentioned above engulf bacteria to destroy it?

   ……………………………………………………………………
   ……………………………………………………………… (1)

4. State a feature of these cells which enables them to engulf and destroy bacteria.

   ……………………………………………………………………
   ……………………………………………………………… (1)

5. Name four substances carried by blood plasma.

   ……………………………………………………………………
   ……………………………………………………………………

   ……………………………………………………………………
   ……………………………………………………………… (4)

6. In which blood cells is haemoglobin found?

   ……………………………………………………………………(1)

7. Give two reasons why blood clotting is important.

   ……………………………………………………………………

……………………………………………………………………

……………………………………………………………………
……………………………………………………………….. (2)

Total = [15 marks]

Assignment 2

1. Name the blood vessel which supplies the muscles of the heart with blood?

   ……………………………………………………………………
   ……………………………………………………… (1)

2. How many chambers does the heart have?

   ……………………………………………………………………
   ………………………………………………………… (2)

3. What is the other name for the heart muscle?

   ……………………………………………………………………
   ………………………………………………………… (1)

4. Where is the tricuspid valve located?

   ……………………………………………………………………
   ………………………………………………………… (1)

5. Which blood vessel carries blood to the right atrium of the heart?

   ……………………………………………………………………
   ………………………………………………………… (1)

6. Which blood vessel carries blood from the lungs to the heart?

   ……………………………………………………………………
   ………………………………………………………… (1)

7. Why are the walls of the left ventricle thicker than those of the right ventricle?

   ……………………………………………………………………
   ……………………………………………………………

   ………………..……………………………………………………
   …………………………………………………………… (2)

8. What is the function of the bicuspid valve?

………………………………………………………………………
…………………………………………………………..

………………………………………………………………………
…………………………………………………………… (2)

9. Give two possible causes of coronary heart attack.

………………………………………………………………………
…………………………………………………………… (2)

10. Where are the two semi lunar valves located?

………………………………………………………………………
…………………………………………………………….

………………………………………………………………………
…………………………………………………………… (2)

Total = [15 marks]

Assignment 3

1. Place a cross (×) in the box of a blood vessel that matches the characteristic.
The first one has been done for you.

Characteristic	**Arter y**	**Vein**
Carries blood to the heart		×
Blood flows in pulses		
Valves present through entire length		
Has a narrow lumen		
Blood flows under low pressure		

(4)

2. List three points on the body where pulse can be felt.

………………………………………………………………………
…………………………………………………………………….

………………………………………………………………………
…………………………………………………………………… (3)

3. List three functions of the lymph.

………………………………………………………………………
……………………………………………………………………

………………………………………………………………………
…………………………………………………………… (3)

4. Below is a list of blood vessels. Write each against its correct function in the table below.
Renal vein, hepatic portal vein, jugular vein, aorta, hepatic artery.

	FUNCTION	BLOOD VESSEL
1	Transport blood from the head	
2	Transport blood from gut to liver	
3	Transport blood from heart to body	
4	Transport blood to liver	
5	Transport blood from kidney	

(5)

Total = [15 marks]

Answers to assignments

Assignment 1

1. a) transportation of materials
   b) heat distribution
   c) protect body against infection
2. Phagocyte, lymphocyte, monocytes
3. Phagocyte
4. They are able to change their shape
5. Proteins, mineral ions, end products of digestion, waste materials, vitamins, hormones. (any 5)
6. Red blood cells
7. a) prevent loss of a lot of blood
   b) prevent entry of pathogens

Assignment 2

1. Coronary artery
2. Four
3. Cardiac muscle
4. Between right atrium and right ventricle
5. Vena cava
6. Pulmonary vein
7. Right ventricle pumps blood to the lungs which are not very far from the heart while the left ventricle pumps blood to the different parts of the body, some of which are very far from the heart, e.g. toes. It therefore needs more muscles to exert more pressure.
8. To prevent blood from flowing back into the left atrium as it relaxes to receive blood from the pulmonary vein, and the left ventricle contracts to pump blood out of the heart.

Assignment 3

1.

Characteristic	**Arter y**	**Vein**
Carries blood to the heart		×
Blood flows in pulses	×	
Valves present through entire length		×
Has a narrow lumen	×	
Blood flows under low pressure		×

2. Temples, wrist, side of neck
3. a) returns body fluid to blood
   b) carry some end products of digestion to ileum
   c) helps in prevention of diseases
4. 1. Jugular vein, 2. Hepatic portal vein, 3. Aorta, 4. Hepatic artery, 5. Renal vein.

Assessment

Assessment

Section A carries 5 marks.

1. *Which person is **least** likely to suffer from heart disease?*

person	*Exercises regularly*	*Smokes regularly*
A	*No*	*No*
B	*No*	*Yes*
C	*Yes*	*No*
D	*Yes*	*Yes*

2. *Which statement describes blood in the pulmonary artery?*
   - *A. It is poor in oxygen and under high pressure*
   - *B. It is poor in oxygen and under low pressure*
   - *C. It is rich in oxygen and under high pressure*
   - *D. It is rich in oxygen and under low pressure*

3. *Which blood vessel supplies the heart muscles with oxygen?*
   - *A. Aorta*
   - *B. Coronary artery*
   - *C. Pulmonary artery*
   - *D. Pulmonary vein*

4. *The main functions of the heart chambers are labeled T, U, V and W.*

   T – receives blood from the pulmonary vein
   U – receives blood from the vena cava
   V – pumps blood into the aorta
   W – pumps blood into the pulmonary artery

   Which statements describe the functions of the right ventricle and the left atrium?

	Right ventricle	*Left atrium*
A	*T*	*U*
B	*T*	*W*

C	*V*	*W*
D	*W*	*T*

5. *Which is the shortest route that can be taken by blood travelling from a leg to an arm in the human body?*
   - *A. Leg → heart → lungs → heart → arm*
   - *B. Leg → heart → lungs → liver → arm*
   - *C. Leg → liver → heart →lungs → arm*
   - *D. Leg → lungs → heart → lungs → arm*

Section B carries 25 Marks

1. *a) Describe how oxygen is transported in blood.*

   ……

   …… *[2]*

   b) Blood capillaries are narrower than veins and capillaries. Explain how this feature enables them to carry out their functions.

   ……

   ……

   ……… *[3]*

   c) Distinguish between blood plasma and tissue fluid.

   ……

   ……… *[2]*

2. *State the main function of each of the following components of blood.*

   Red blood cells:
   ……………………………………………………………………………………………………….

White blood cells:
……………………………………………………………………………
…………………………………

Platelets:
……………………………………………………………………………
………………………………………………

Plasma:
……………………………………………………………………………
………………………………………….. *[4]*

3. *"Mammals have a double circulation" What does this statement mean?*

……………………………………………………………………………
………………………………………………………………

……………………………………………………………………………
…………………………………………………………… *[2]*

4. *Give two possible likely causes of coronary heart attack.*

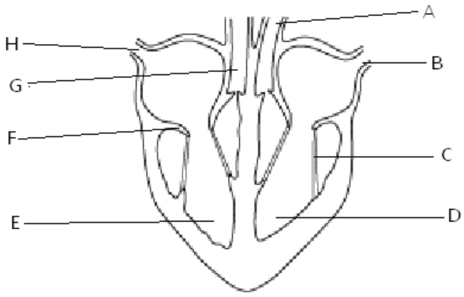
……………………………………………………………………………
………………………………………………………………

……………………………………………………………………………
………………………………………………………….. *[2]*

5. *Where in the body are red blood cells produced?*

……………………………………………………………………………
…………………………………………………………… *[1]*

6. *The diagram below shows a mammalian heart with some of its blood vessels.*
   a) *Give the names of the parts labeled A to H.*



A: …………………………………………………………………… B: ……………………………………………………………..

C: …………………………………………………………………… D: ……………………………………………………………..

E: …………………………………………………………………… F: ………………………………………………………………

G: ………………………………………………………………….. H: ……………………………………………………………..

[8]

b) *State the function of F.*

……………………………………………………………………………… ………………………………………………………………

……………………………………………………………………………… ………………………………………………………….. *[1]*

Contents

HSB Unit 6

Skeleton, Muscles and Movement

Introduction

Welcome to **unit 6,** which deals with the skeleton, muscles and movement. We are going to discuss the skeletal system and the functions of the skeleton. We shall also discuss how muscles are attached to the bones, and how movement is effected. Movement is effected by the contraction of muscles as they pull the bones. The bones are also joined at some points where they bend during movement. We will, therefore, also discuss the different types of joints, the directions in which they allow movement, and the extent of the movement in terms of the angle a given movement covers.

This unit is composed of two topics, namely:

Topic 1: The Functions of the Skeleton
Topic 2: Muscles and Movements

These are based on the Human and Social Biology Syllabus for the Botswana General Certificate of Secondary Education. The specific objectives are covered within the teaching of these topics.

Teaching Approach

The approach used in this unit is that the teaching has been made interactive with learning. There are activities and their feedback is distributed in the study material. Doing activities instead of just reading only is meant to engage you into active learning.

Conversation is evident in the unit to create dialogue between you and I, inviting you to think about some issues or to check and verify what I have presented. Conversation is also used when giving you activities and feedback. Activities are meant to make you an active learner by engaging you in thinking and recalling what you learned previously. Feedback is to alert you on the issues you should consider when answering a question or give you a hint to stimulate your thought towards a correct answer. You are welcome to disagree with me, especially where other learners and your tutor agree with you. That means before you reject what or how I have presented, you need to consult other learners and your tutor at the

Study Centre or at the next tutorial session, so that you are on the side of the majority.

In preparing this material I assumed you have achieved some level of earlier learning in the biology of the human body. I am certain that Junior Certificate and even Primary School Syllabuses have topics on the skeleton and muscles and how the two work together to bring about the movement of the whole or part of the body. So, my assumption is not far-fetched. The assumption is meant to encourage you to draw knowledge from the store of your earlier learning instead of boring you by repeating what you already know. It is also to remove from you the idea that this unit is something completely new, and therefore difficult; this is not right, because you are familiar with running, dancing, playing soccer, and other exercises that involve movement.

What might be new to you is well explained and linked to your past learning and personal experience on the bones, muscles and movement. The most interesting thing about the Human and Social Biology course is that you are learning about yourself as a human, what takes place inside your own body, and within the society you live in. Unit 6 is addressing things you experience every second of your life. Do you ever stop breathing? No! Even when you are asleep your ribs and muscles surrounding them are moving when you breathe in and out. So, you surely have a lot of personal knowledge and experiences you bring to this course and in particular to Unit 6!

I have also used a ‘test yourself approach’ in which there is a self-assessment exercise at the end of each topic with its corresponding feedback at the end of the unit. As a self-disciplined learner, I suggest this: study the topic, revise it and after that, attempt the exercise. Compare your answers with mine at the end of the unit. Resist the temptation to look for answers in the text as you answer the questions! Finally, check in the text to verify the answers you are in doubt of. Apart from training in self-discipline, this approach allows you to constantly evaluate yourself in preparation for the Tutor Marked Assignment, which you write at the end of the Unit. Also, this will help you prepare for any final examination you might sit, for certification purpose at the end of the HSB course.

Time Frame

It is estimated that to complete studying this unit you will need between 15 to 20 hours. Do not worry if you take longer in finishing this unit. Remember that we all have different abilities and hence we study at different paces.

You are encouraged to spend about 2 hours to answer the assignment in this unit. You will also need approximately 3 hours on the assessment at the end of the unit.

The total hours for completing the unit will thus be between 20 and 25 hours.

Learning Resources

Unit 6 needs no special resources to achieve its outcomes at the level and the ODL context I am teaching. Common home materials, appliances, and equipment like doors, hinges, yourself, and moving parts of your body are stated in the topic under which, it is suggested that you use them. These resources are mentioned because they can enrich your understanding, but to avoid disadvantaging learners in contexts that may not afford them, the teaching is such that they are not a mandatory precondition to learning. So, try to get these resources and use them if you can, but if you can't get them, don't worry because you can learn from the examples and illustrations given.

Outcomes

Upon completion of this unit you will be able to:

- Describe the various functions of the skeleton.
- Explain the various types of joints and the movement they effect.
- Explain how the actions of muscles with or without bones bring about movements.

Terminology

Accommodation: Ability of the eye to see distant and near objects.

Antagonistic muscles A pair or group of muscles that oppose each other's action.

Involuntary muscles: Muscles that work without conscious control.

Iris reflex: How the iris responds to light of different brightness.

Ligament: Tough, yellowish, elastic fibres, which join bones to other bones.

Sutures: Lines along which bones of the skull and pelvis girdle appear fused.

Tendon: Tough, white, non-elastic fibres that join muscles to bones.

Voluntary muscles: Muscles that work under the conscious control of the organism.

Online Resource

If you can get on the internet please utilize the resources at www.hippocampus.org. It is an excellent source of information for biology and the topics discussed in this unit. Here you will find:

- Presentations
- Simulations
- Videos
- Online Study Groups
- Links to Even More Information
- Textbook Correlations
- Online Courses

Topic 1: The Functions of the Skeleton

Introduction

As already stated, this is the first topic of Unit 6. We are going to discuss the functions of the skeleton and the types of bones that make up the skeleton. You are likely to have met all these ideas in your earlier studies, so start to remember them in preparation for the sections where they are taught.

In this topic, we shall also name the types of joints that are found on the skeleton and the extent and direction they bring about movements. The structures (tendons and ligaments) that attach bones to muscles and bones to bones are also mentioned, although they are discussed in detail in Topic 2, under muscles, where they appear to fit better.

Learning Objectives

At the end of the topic you should be able to:

- List and describe the functions of the skeleton.
- Name the materials that make up the skeleton.
- Identify from a diagram, a hinge joint and a ball and socket join.

Describe movements permitted at a hinge joint and ball and socket joint.

The Human Skeleton

Introduction

You must have studied the skeleton in your earlier studies, especially at the Junior Certificate level. Even in Primary Education, children are introduced to the basic ideas about a human skeleton. This topic is therefore not new to you. What is a skeleton then, and what is its function? Write your answers in your notebook before you read on to learn about these questions.

(a) The Skeleton

You might have remembered and included in your notes that a skeleton is a framework of bones that supports other parts of the body and is able to transport them around. You must have seen a bicycle. A bicycle is a familiar object with a framework of metal parts. On this frame is attached other things like wheels, handle bars, a seat, a night lamp and so on. In this way the bicycle is able to carry people around, riding on it.

Similarly, the different bones in our bodies are joined together to form our skeletal system (Figure 1). The skeleton consists of two parts; the **axial skeleton,** which consists of the vertebral column, ribcage and skull, and **appendicular skeleton**, consisting of the limbs and girdles (pelvis and scapula). On this frame is attached other organs both outside and inside the skeleton. With health and a source of energy, a person is able to move around as a whole independent organism.

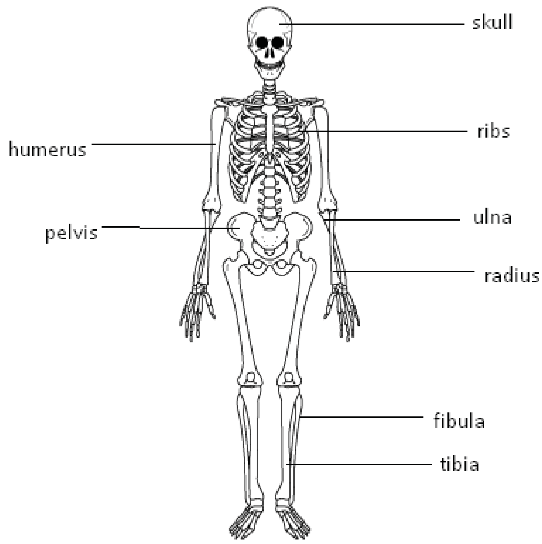


Figure 1: The Human Skeleton

There are two types of skeletons, the **endoskeleton** and the **exoskeleton**. The prefix **'endo'** means inside, while **'exo'** means external or outside. An endoskeleton is found inside the animal's body. The human skeleton is an example of an endoskeleton. Write down other animals you think have an endoskeleton. An endoskeleton is important for big animals like mammals because they are able to grow without shedding off their old skeletons like it happens in insects.

An exoskeleton, on the other hand, is found outside the animal's body, e.g. in insects like the cow dung beetle, and some sea creatures, like crabs. For these organisms to grow, they have to shed (moult) their exoskeleton several times before they reach maturity.

The endoskeleton of humans is made of two tissues - the **bone** and the **cartilage** tissues. The bone tissue is harder than cartilage tissues because of calcium minerals that are present in bones.

Cartilage

Cartilage tissue is flexible and one can easily chew it. You must have eaten a chicken breast. At the end of the breast bone, also known as the keel, there is a soft part of the bone; this is cartilage. Next time you eat chicken breast look out for it. There are three kinds of cartilage each with specific physical properties. **Hyaline**

cartilage looks like glass and it covers the ends of long bones. The cartilage in outer ear (ear *pinnae*) is **elastic cartilage**. The cartilage that forms the discs between vertebrae is **fibrous cartilage**. Each of these kinds of cartilage serves a specific function in the body.

Bone

You could have during your daily meals tried to chew a bone. How hard is the bone tissue? Except, perhaps, chicken bone, other bones are hard. The bone structure is portrayed in Figure 2.

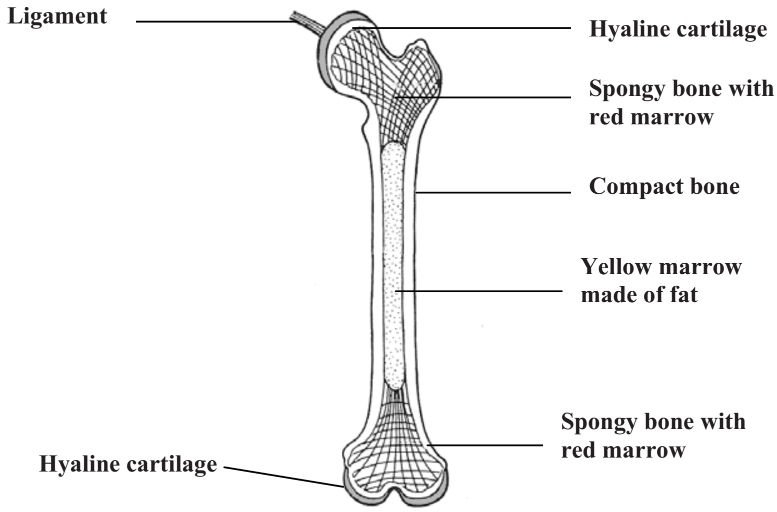


Figure 2: Vertical section through the long bone of a mammal

[BOCODOL graphic]

You may have seen a long bone or may have eaten some meat on long bones. When a bone is cut across you will see some soft materials inside. That material is called bone **marrow**. The next time you eat meat on long bones observe that there are two kinds of **marrow** in the bone. **Yellow marrow** is found in the centre of the long bone; that marrow is composed of fats. **Red marrow** is found in the spongy bones of ribs, sternum and many other bones. Red marrow makes blood cells.

The structure and nature of bones and cartilage give the skeleton the ability to do its functions in life. Let us learn about more of these functions.

(b) Functions of the Skeleton

We have already mentioned some functions in the introduction. Since you are likely to have met this topic in your earlier studies, I would like you to jog your brain in the activity below, and remember some of the functions.

Activity 1: Remembering the functions of the skeleton

Use your memory or the notes you might have taken before and find out the functions of the skeleton. You can also use textbooks of human biology and read under the skeletal system. This topic is always present in textbooks of biology. You can also use the internet, just write ‘functions of the human skeleton’ into the Google search, and a long list of publications will emerge. Read the most relevant ones, and in your notebook, explain at least 4 functions of the human skeleton from your reading.

Feedback

It is difficult to provide a feedback to different people who have different backgrounds and have read different books. The only thing I can do is to have a general presentation of the various functions of the skeleton as I have done below, and leave you to compare the information with that from your reading experience.

(a) **Support**

I am sure you know what the word ‘support’ means. Think about its meaning in the context of the skeleton. A support is something that other things hold on to, and thus prevent them from falling apart. The skeleton provides such support and raises the body from the ground. Being firm and solid, the skeleton supports the less firm organs of the body, giving it a definite shape. Imagine how we would look like if we didn’t have a skeleton! I guess we would just be a shapeless pile of flesh! We would be like such organisms like amoeba. Do you remember amoeba from your earlier studies of biology? Such organisms do not have a skeleton. They are shapeless mass of cytoplasm, which flows inside a cell membrane that encloses it.

These terms should not be strange to you since you learnt them under animal and plant cells. Like the firm cell wall of a plant cell gives a shape to the cell, so does the skeleton give a permanent shape to a human body. That is why a human body shape is unique to an individual; even identical twins have some differences. That is why, though with difficulty, you can identify them.

(b) **Protection**

Similarly, you understand the word 'protection' in relation to the skeleton. Write what protection means in your notebook. To protect is to guard against loss, damage or injury or theft. A skeleton can be viewed as casing of bones that protects very delicate but important organs of the body. Most body cavities (buccal cavity, thoracic cavity, abdominal cavity) containing vital organs are enclosed in cages of bones. You are familiar with the brain; it is enclosed in a very hard casing of bones called the skull. The skull also protects the delicate sense organs like the eyes, nasal cavity, inner and middle ear parts as well as the tongue which is protected by the jawbones. The spinal cord is enclosed in a chain of bones forming the vertebral column. The heart and the lungs lie in the thoracic cavity and are enclosed inside a ribcage. The hip girdle and upper leg bones protect the reproductive organs, while the hanging ribs of the ribcage protect the kidneys. Do you now see how protective the skeleton is?

(c) **Movement**

You are definitely aware that movement is one of the major characteristics of living things. However, the next time you watch athletes and gymnastics in action, you will appreciate how humans have taken movement to another level. For humans, it is not a matter of throwing limbs left and right, but they have perfected very difficult maneuvers with their entire bodies.

This is mainly because many bones of the skeleton act as levers. They produce movements when pulled by muscles, and they are articulated together in such a way that they are able to multiply a small effort into a large force. You might have watched boxers. The muscles of the chest and shoulder work together with those of the upper and lower arm to deliver a heavier blow than it would be if the arm muscles were to act alone. You could also have observed sprinters; those people who run 100 or 200 metres. Virtually all muscles are involved; like those which operate the bones of the back, hips, thighs and lower legs to multiply the sprinting speed. The muscles of the arm also operate the shoulder, upper arms and lower arms to increase speed and balance at high speed. Name other movements in the human body that you can think of? Write some of them in your notebook. Such notes will enrich your learning of the different points discussed in this unit. They could also form part of your discussion with other learners at your study centre.

(d) **Attachment for Muscles**

We have mentioned how the bones and muscles bring about movement. To be able to do so, the way muscles are attached influences movement. The skeleton provides a suitable surface for the attachment of muscles. Generally, muscles are elongated elastic tissues with one end of the muscle attached to the movable part of the skeleton, while the other part is attached to a fixed part.

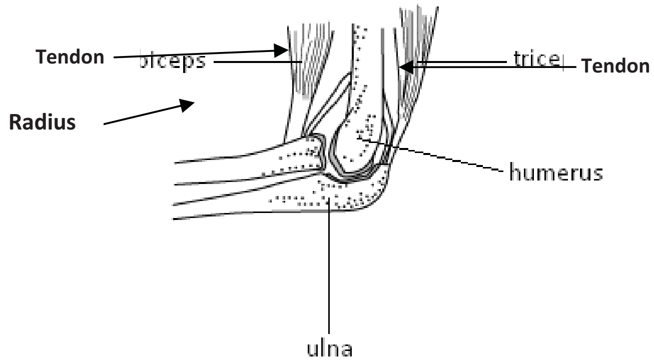
(e) **Formation of blood cells**

From your experience and your study of Unit 5, you are aware that blood appears red because it contains red blood cells. Most of the red blood cells are made in the bone marrow of long bones, like the bones of the legs and arms. You might have seen people who like to crush bones to get and eat the materials in the centre of long bones, or even like chewing on chicken bones. That brown material they are eating is bone marrow. Inside that marrow, red blood cells and other cells like white blood cells, lymphocytes and platelets are made. This marrow looks brown when cooked, but when not cooked it is red in colour.

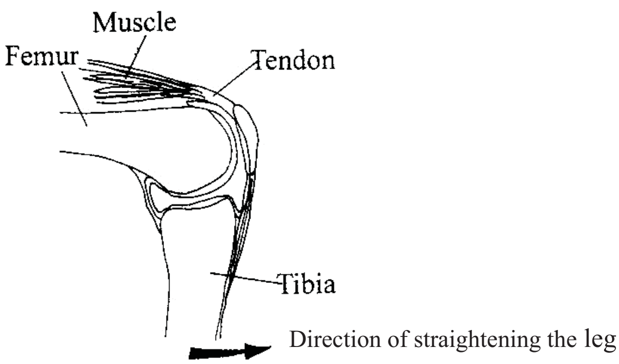
(f) Other functions of the skeleton include the role of the **ribcage** during breathing. The ribcage, together with the diaphragm, help in acting like bellows to breathe air in and out of the lungs. The transmission of sound impulses by the **middle ear bones** helps humans to hear sound.

Tendons and Ligaments

As mentioned earlier, muscles are attached to suitable surfaces of the bones so that they are able to effect movements. Figure 3 below, shows bones of the elbow joint. These bones produce movement when we flex or extend our arms. If you can recall what was stated earlier, one end of the muscle is attached to the movable part of the skeleton while the other end is attached to the fixed part. The long biceps and triceps muscles are fixed to bones by tough, white, elastic tissue called **tendons**, which get fixed to the lower arm bones and the knee cap (Figure 3 (a) and (b)) below.



(a) Elbow joint



(b) Knee joint

Figure 3: Tendons at (a) the elbow joint (b) knee joint
[BOCODOL graphics]

The tissues that bind bones to each other are called **ligaments** (see Terminologies). These tissues have no relationship with muscles. They are tough but slightly elastic which allows the joint to bend and straighten to some extent. Most vital joints, like those connecting the foot bones to the tibia, the hip bones to the femur, and the shoulder bones to the humerus, and the tibia and the femur at the knee joint, are secured by ligaments (Figure 4).

Too big and sudden of a force on the ligament can tear it. This happens commonly among football players and sprinters (short distance runners) when the ligament receives a stronger twist or impact than it can bear. If you are a soccer fan, you have at one time heard that a player like Samuel Etoo, has had a torn knee ligament, or that Rhonaldinho has a torn ankle ligament, and so on. These injuries arise from a strong and sudden twist of the joint which shears the ligament into two pieces. Fortunately, there are medical experts who can reunite the pieces and heal the wound caused. The healing process may usually take three to five months.

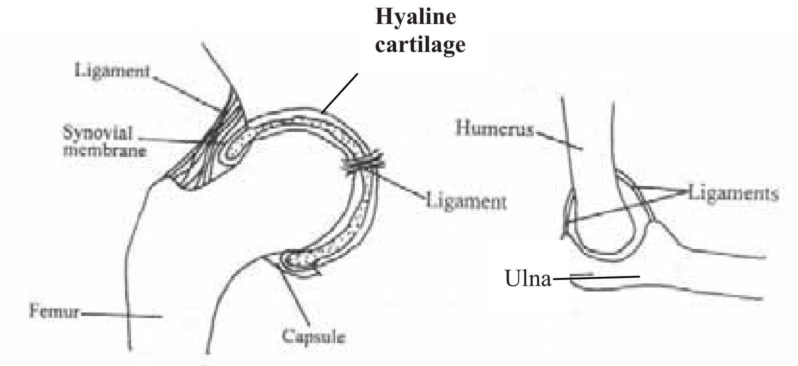


Figure 4: Ligaments attaching bones to bones at elbow and hip joints

[BOCODOL graphics]

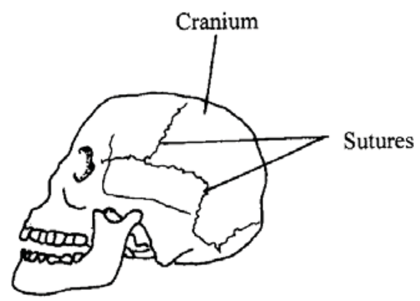
Types of Bone Joints

What is a joint? I am sure you are familiar with things at home that have joints. Can you name some? I will give you an example of a door. It is joined to the wall of a house in such a way that it opens, commonly, in one direction. A joint is a place where two things are joined together. In this topic, the two things are bones. In this case, a joint is the point of contact between two or more bones.

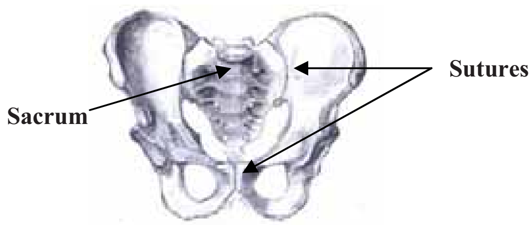
In the example of a door, I mentioned that it opens in one direction. Similarly, bones of the skeleton are joined together in such a way that they allow movement in some direction and at a certain angle. The direction and angle of movement depend on what the organ is specialised to do. A limb, like a leg, which has to stretch wider in many directions, can move in several directions at wider angles compared to the restricted movements of the forearm, for example. There are two types of bone joints, namely **immovable joints** and **movable joints.** In the next sections you will learn what these joints are and their functions.

(a) Immovable Joints

This term should be self-explanatory to you. Try to explain what this type of joints is in your notebook. These are joints, which do not allow movement at all. They are called **immovable joints** because they cannot be moved. Immovable joints are sometimes also called **fused** or **fixed** joints. Examples of such joints are the sutures of the **cranium** of the skull and the joint between the **sacrum** and **pelvic girdle** (Figure 5 (a) and (b)).



(a) Human skull



(b) Human hip girdle

Figure 5: Immovable joints (a) the skull *[BOCODOL graphic]* **(b) the hip girdle** *[Adapted: Wikipedia, free encyclopaedia]*

(b) Movable Joints

You definitely know what the meaning of the term ‘movable’ is. These are joints whereby the joined bones can move freely to some extent. They are also known as **synovial joints.** In these joints, ligaments hold the two bones together**.** We learned what ligaments are in Section 2.0 above. As mentioned earlier, ligaments are strong and tough, but can stretch a little to allow the bones to move.

To prevent wearing of the bones during movement as the two bones rub against each other, the ends of the bones are covered with a layer of **hyaline cartilage**. Since cartilage is not as hard as the bone, it acts as a cushion between the two bones. There is also a small amount of fluid between the bones known as **synovial fluid**. The fluid acts as a lubricant in the joint so that there is smooth movement. The fluid is produced and kept in place by the **synovial membrane**. The cartilage and the synovial fluid also act as shock absorbers when there is a heavy impact on the joint, like when running or landing from a high jump. You should study Figure 6 to see the location of the hyaline cartilage, synovial fluid, and synovial membrane on the knee.

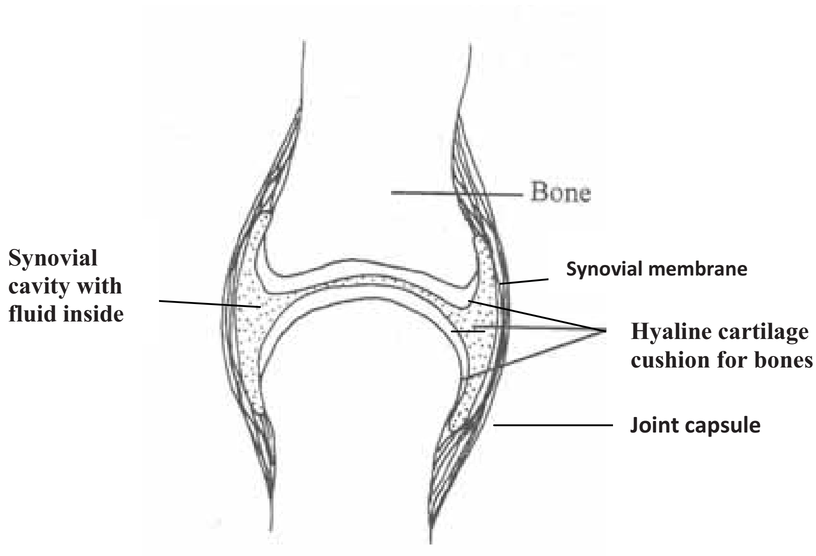


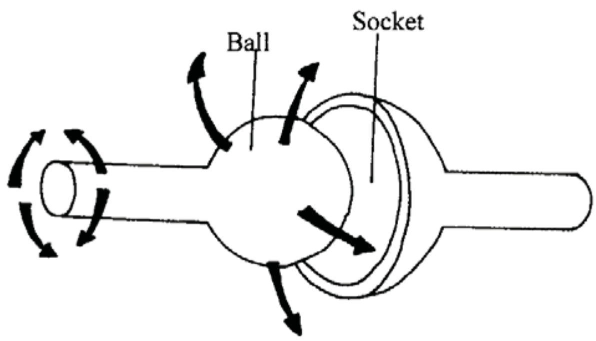
Figure 6: The Synovial joint at the knee *[BOCODOL graphic]*

There are several types of movable joints in our body. We will, however, only discuss two.

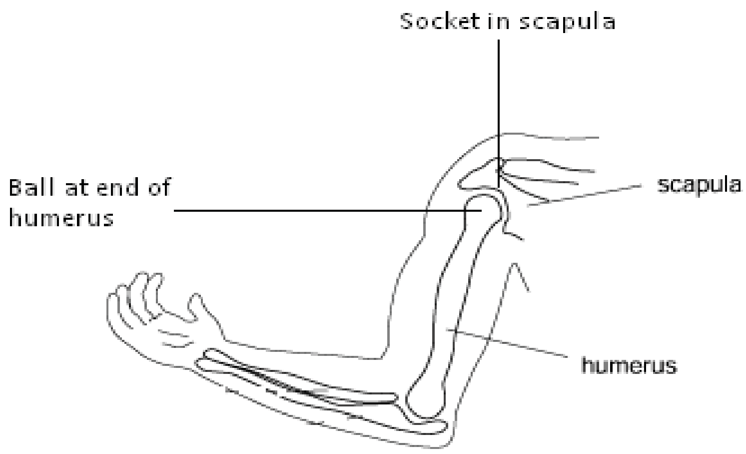
(i) Ball and socket joint

In this joint, a "ball" at the end of one bone fits into a "socket" at the end of another bone. For example, a ball at the upper end of the humerus fits into a socket in the shoulder blade (**scapula**) (Figure 7 (b)).

The ball and socket joint allow movement in three planes. The illustration below shows some of these planes (Figure 7 (a)).



(a) Planes of rotation allowed by a ball and socket joint *[BOCODOL graphic]*



(b) The ball and socket joint at the shoulder

Figure 7: Ball and socket (a) possible planes of movement (b) joint at the shoulder. *[BOCODOL graphic]*

It is easy for you to demonstrate the planes and angles a ball and socket joint can move. You could have observed this in primary school during physical education class. Refresh your memory by doing the following activity.

Activity 2: Movements of arm's ball and socket joint

In this activity you should preferably stand upright and try to do the following movements of your whole arm. Rotate it clockwise, then anticlockwise. Swing it backwards and forward**.** You can also swing it in the reverse direction, that is, backwards like one swimming a back stroke. Swing it away from the body such that it makes a right angle with your body. Are all these movements possible?

List all the directions and angles the arm can move at the shoulder joint.

Feedback

Like I mentioned, the ball and socked joints can execute movements in *several planes at wide angles. For example, the arm can rotate horizontally at 360^o. You can also raise the arm parallel to you head and down through 180^o. Some people can swing their arms in vertical plane parallel to the trunk at 360^o.*

Let's see another important joint of the body.

(ii) Hinge joint

This is a joint that allows movement in one direction (or one plane). Can you check one of the doors of the building you are in? How is the door fixed to the wall? If you look carefully or you already know that there is a metallic structure that is welded on the metal frame. This structure is called the door hinge and is fixed on to the wooden door with screws. In that way the door is made to open in the required direction, usually towards the inside or outside. A door fixed on the wall of a doorway is an example of a hinge joint. This is because a door joint allows the door to open only in one direction. In our bodies the joint is found at the knee and at the elbow.

Let's do an activity to demonstrate how a hinge joint facilitates movements.

Activity: Movements at a hinge joint

You can do this activity alone using your arms. Try not to make the shoulder and wrist joints move.

1. Straighten your arm in front of you and then bend it upwards at the elbow.
2. Try to bend the arm sideways at the elbow.
3. Try to twist the elbow joint without involving the shoulder joint.

Which ones of these movements are possible comfortably?

Feedback

It must have been clear to you that the hinge joint can move in one plane at 180^o. There is only a slight twist of the forearm bones at the elbow, and only to a limited extent. Other movements are forced and uncomfortable.

Now that we have come to the end of Topic 1, let us summarise what we have learned in it.

Summary

The skeleton is a framework of bones and cartilage. It supports the human body and protects vital organs. The skeleton makes it possible to move providing attachment for internal and external organs and muscles that bring about movements. Other functions include formation of blood cells, the role of the ribcage in breathing, and transmission of sound impulses by the small middle ear bones.

The skeleton is a hard structure made of bones joined together to form a system of levers that make humans execute intricate and powerful intentional movements.

The major joints of the body are ball and socket joints which execute wide angle movements in several planes. The hinge joint executes one plane movement at 180^o, and movable cartilaginous joints of the spinal column which allow some flexibility in the column.

This is the end of Topic 1; try an exercise to check your understanding thus far. This self-assessment exercise is at the end of Unit Summary. Do it and after that compare your answers with those provided at the end of the unit. If some of your answers are incorrect, revise the relevant sections of the unit before proceeding to the next topic. If all your answers are correct, congratulations! You are ready to start Topic 2.

Topic 2: Muscles and Movements

Introduction

You have learned about the characteristics of living things. Do you remember them? At least you remember that movement is one of those characteristics. In Topic 1 of this unit you also learnt that one of the functions of the skeleton is movement. Do you think the bones can move by themselves? Certainly it is not possible. Although some types of muscles can move without being attached to bones, bones cannot move unless muscles are attached to them. From your earlier studies in Human Biology, do you agree with these statements? Verify your opinion regarding my statements with your tutor and other learners.

In this topic you will learn that any movement of the body, or parts of it, is due to the contraction and relaxation of the muscles. The movement may either be **voluntary** or **involuntary**. For voluntary movements the muscle must be attached to the bones for the movement to occur. This topic is designed to teach you the various types of muscles and how, together with or without attachment to bones, they bring about movement of the whole body or parts of it.

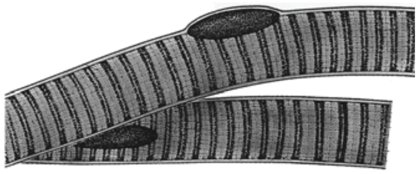
Learning Objectives

By the end of the topic you should be able to:

- Describe muscle as a tissue, which effects movement in the body.
- Identify the bones of the arm and shoulder, and show the origins and insertions of the biceps and triceps muscles.
- Define antagonistic muscle action.
- Describe the role of the circular muscles in peristalsis, and the movements in the iris and ciliary body of the eye.

Types of Muscles

All muscles in the body are composed of very many muscle cells arranged lengthwise into muscle fibres. Many muscle fibres are in turn bound together by muscle sheath to form muscles that are able to perform a function. Muscle cells are specialised to perform under certain conditions. This gives rise to three kinds of muscle cells (Figure 8). These cells, once bound together by muscle sheaths, form three types of muscles. It is important to note that muscle bundles act because of energy produced in each cell.



(a) striated muscle cells

(b) smooth muscle cells

(c) Cardiac muscle cells

Figure 8: The three types of muscle cells *[BOCODOL graphics]*

The striated muscle cells (Figure 8 (a): these types of cells make up the skeletal muscles. The skeletal muscles are those muscles that are attached to bones and are also known as **voluntary muscles**. The muscles of the legs, arms and abdomen are some of the body belonging to this type.

The cells of this type of muscles are well supplied with energy and are under constant control by the brain. These types of muscles can do a large amount of work, but get tired quickly when cells cannot supply sufficient energy to keep working. This experience, commonly known as **fatigue,** is discussed under voluntary movements below.

The smooth muscle cells (Figure 8 (b): these make up the muscles found in the walls of the alimentary canal and bladder. Smooth muscles are also known as **involuntary muscles**. Do you ever realize that your stomach is working on the food your have just eaten? Unless you are starting to feel hungry, or you have a stomach upset, you will not notice that something is happening. Stomach muscles will keep working between meals without your will to encourage them or stop them. Stomach muscles are an example of involuntary or smooth muscles. They are able to work slowly for life without stopping to have a rest.

Cardiac muscle cells (Figure 8 (c): these are found only in the heart. Have you ever seen or eaten heart meat? It is softer and tastes differently from the bone meat (skeletal muscle). The walls of the heart are made of specialised cardiac muscles that are able to work non-stop for years. The cells are well supplied with energy for constant **involuntary action**. Can you stop or speed up the action of the heart? It is impossible, unless you intend to commit suicide! That is what is meant by involuntary action. You cannot consciously allow or deny the heartbeat to occur.

As mentioned earlier, the different muscles bring about different types of movements in some parts of the body, and that is what we are about to learn in the following paragraphs.

Involuntary movements occur when **involuntary muscles** do actions that we don't have control over. You remember that involuntary muscles are also called **smooth muscles**. Name some of your body actions that you cannot stop for a long time. Examples of involuntary action are: contraction and relaxation of the circular muscles of the gut during peristalsis. I guess you still remember peristalsis from your **Unit 3** [the involuntary contraction of the gut wall muscles to push food along]. Another example that you will learn later in this topic is the contraction and relaxation of the circular muscles of the iris and ciliary muscles of the eye. Of course others you could have named are breathing and urinating. Can you stop these actions for more than half an hour? Try! The main characteristics that enable these movements to occur is that involuntary or smooth muscles contract and relax slowly and do not get tired quickly.

Voluntary movements occur when **voluntary muscles** do actions that we have control over, or actions that we think about. You are certainly aware that voluntary muscles are also called **skeletal muscles.** As you learned in Topic 1, these muscles are always attached to bones to form what is known as the **musculoskeletal** system.

Can you imagine movements that happen because you think about them or do them intentionally? Think about them before you read on. An example is when you decide to raise your hand in class to answer a question. The muscle of your arm will contract to raise the arm; the other muscle will relax to put the arm down. Of course most of our actions involving moving our whole body or parts of it are voluntary; like walking, running, nodding our head, and so on.

The major characteristics of the voluntary muscles that enable them to perform their functions are that they are supplied with a lot of energy and contract and relax under the control of the brain. Their contraction is rapid and powerful; they can do a lot of work within a short time, but get tired quickly.

Whether they are cardiac, voluntary or involuntary, muscles can only do work (produce movement) when they are supplied with energy. The amount of energy demanded will depend on the amount and speed at which muscles do work. That is why skeletal muscles require the most energy when there is heavy physical exertion like during sprinting, boxing, soccer playing, and so on. Energy demand by other muscles also will depend on the state of the body. For example, the cardiac muscles will require less energy when the individual is healthy and at rest, but more energy when the individual is suffering from certain diseases and during heavy exercises when the cardiac muscles have to pump blood all over the body.

I am sure you want to ask, where does that energy come from? The answer is simple; the energy comes from the food we eat. Revise Topic 4 of Unit 3 on Absorption and Assimilation of Food. You can also refer to Unit 4 on the Respiratory System. In those parts of the course you will remember that all energy for the body processes comes from respiration when the food we eat gets burnt inside cells. Therefore respiration will take place inside the muscle cells where the blood from the heart will supply glucose and oxygen. These two will react in the presence of enzymes to release energy, carbon dioxide, and water. The energy will be used to cause contraction and relaxation of muscles, while water will pass out as urine or sweat, and carbon dioxide and some water vapour will be breathed out.

Have you ever done strenuous exercise like running very fast or doing press ups quickly? What happened to your body? You probably felt so tired that you could not go on any more. You could have sweated profusely and panted (breathing heavily and fast). What is the name of the condition of the body in that state of panting and sweating?

What happened to your body is called **fatigue** or tiredness. Your muscles got fatigued (tired). Fatigue occurs when the muscle cells are burning glucose at a faster rate than the amount of oxygen supplied to working muscles. In this situation, glucose is not burnt to energy, carbon dioxide and water, but to a small amount of energy and another substance called **lactic acid.** It is this lactic acid that accumulates in the muscles and causes fatigue. The heavy panting is due to **oxygen debt** created by incomplete burning of glucose. You have to keep on panting (breathing heavily) so as to take in sufficient oxygen to burn the lactic acid to carbon dioxide and water. In this way the oxygen debt has been paid and the load of lactic acid has been eliminated. Only then does the fatigue go away and you can start the exercise again or whatever work that brought about the fatigue.

Let me suggest that you do the following activity to find out whether what is written above is true.

Activity 1: Muscular activity depends on energy supply

Choose one physical activity that is suitable to your body condition. It may be running, brisk walking, sit ups, press ups, or if you have the opportunity a machine called a **treadmill,** or even cultivating your backyard garden. Whatever the exercise you choose, you should do it non-stop until you can't go on anymore. You have to make sure that the muscular action is faster and continuous to get the results. Immediately you should stop, and use a watch or clock to determine how long it takes you to get rid of fatigue (tiredness).

(a) How is your rate of breathing and rate of heartbeat (pulse rate) immediately after the exercise?

(b) How do you feel in the muscles that did the heaviest work?

(c) Did you breathe heavily and sweat?

(d) How long did it take you to stop breathing heavily and sweating?

Feedback

I don't know what exercise you chose. Bu,t if you followed the instructions and performed the activity fast and non-stop until you could not go on, you should have observed these suggested responses to questions (a) to (d).

(a) Your rate of breathing should be fast and the heartbeat is many heartbeats per minute; over 80 beats per minute. A normal adult person at rest has a pulse rate of 72 beats per minute.

(b) The muscles feel heavy and at times one can get cramps. You may even feel pain that may last a few days, especially if it is an exercise after a long time of an idle life style. If

you did press ups, most muscles are involved; like the muscles of the arms, legs, abdomen and back; sit ups the muscles of the abdomen, legs and lower back are involve;, running and walking, of course, involves muscles of the legs, arms and upper body and so on. Monitor how all muscles feel.

(c) *Breathing should be deep and fast involving both the ribcage and abdominal muscles. The breath is hot and contains a lot of water vapour. If you breathe against a windowpane, mist will cover a large area and may drip as water. Sweat should be profuse (sweat coming from almost all parts of the body) and if you are putting on a vest, it is soaked with sweat.*

(d) *This varies from individual to individual, but may take 20-30 minutes. However, individuals who regularly exercise their muscles to execute fast and powerful movements, like boxers, recover from fatigue very fast.*

In the following section we are going to learn about the muscle and bone system of the arm. As you know, the arms are always doing something in our daily lives, therefore involved in all sorts of movements. Arms are critical organs of the human body.

Musculoskeletal System of the Arm and Shoulder

As you now know, the skeletal muscles are made of elongated tiny muscle fibrils. These are arranged lengthwise into muscle fibres. Many muscle fibres that are enclosed into a muscle sheath make up whole muscles, like those you see bulging when body builders flex their legs or arms and chests.

Observe Figure 9 below. It represents a human arm with the skin removed. It shows the bones of the arm, which you also learned about in Topic 1. Check the names of the bones of the arm in Figure 9. It also shows the two thick muscles that operate the arm. The diagram shows a pair of muscles, one muscle at the front of the arm and the other at the back of the arm. You should have met this diagram in your earlier learning, so this should be a revision. What is the name of the muscle at the front and the muscle at the back? What are the names of the bones of the whole arm? Write each name in your notebook before you read on.

As mentioned earlier, muscles are attached to suitable surfaces of the bones so that they are able to effect movements. Figure 8 shows bones of the forelimb (arm). These bones produce movement when we flex or extend our arms. If you can recall what was stated earlier, one end of the muscle is attached to the movable part of the skeleton while the other end is attached to the fixed part. Muscles are attached to the bones by **tendons**. The long muscle starts tapering towards its ends changing from muscle tissue to a tough, white, non-elastic tissue called a tendon, which gets fixed to the bone (Figure 9).

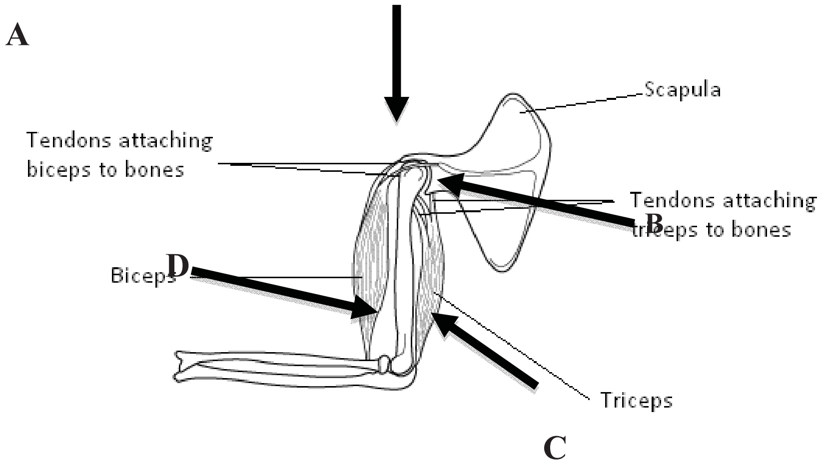


Figure 8: The bones and muscles of the arm *[BOCODOL graphic]*

Study the diagram again and you will see that each muscle starts as **branching tendons** at the shoulder blade and then thickens into one big muscle down the upper arm towards the forearm. This point, where the muscle is attached to the **immovable bone** of the arm at **A,** is called **origin**. The front muscle, called the **biceps,** has its origin at the tip of the shoulder blade and **collarbone** (also known as **clavicle**) at **A**. The muscle at the back, called the **triceps,** has its origin at the head of the **humerus** and the collarbone at points **B** where the branching tendons are coming from.

Look at the diagram again and you will see that the thick muscle becomes thinner and thinner until it becomes a tendon just before it gets attached to the lower arm bones. This point of attachment to the **movable bones** of the lower arm is called **insertion**. You will observe that the biceps has its insertion at the beginning of the **radius** at **D** while the triceps has its insertion at the beginning of the **ulna** in the elbow joint at **C**.

However, bones are attached to each other by slightly elastic tissue called **ligament.** This tissue makes the joint strong and yet flexible to do some movements**.** Ligaments are of two kinds, the **elastic ligament** found in some parts like the vocal cords, and the **fibrous ligament**, which connects bones across most joints.

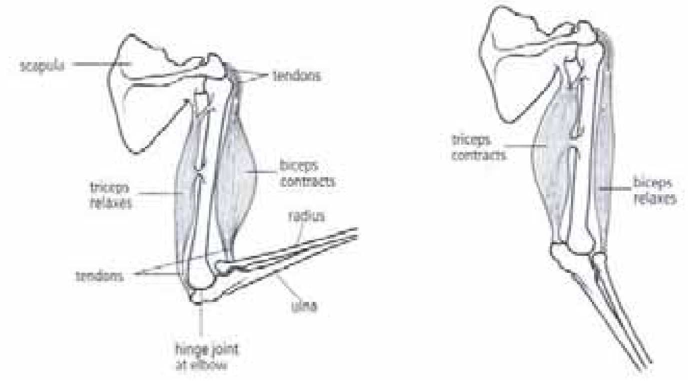
In summary, a pair of muscles, the biceps and triceps muscles, work together with the bones, humerus of the upper arm, and radius and ulna of the lower arm. The muscles have origins as tendons fixed on the shoulder blade and clavicle, and have insertions on the radius and ulna at the hinge joint of the elbow. Ligaments strengthen joints by linking bones to bones and they are slightly elastic to facilitate flexibility at joints. These articulations facilitate leverage linked to other parts of the body that enable arms to execute movements when manipulating tools and to lift very heavy loads.

Let us now learn how the two muscles, the joint and the bones of the arm, bring about the movement of the arm.

3.0 Antagonistic action of the arm muscles

Do you know the meaning of the word '**antagonist'**? If you don't know it, check in the dictionary. Muscles of the body work in pairs. These pairs are antagonists; they oppose or hate each other's action and work differently to it. An antagonist is actually an enemy or an opposer, if you haven't checked in the dictionary. The pair of the arm muscles is voluntary muscles which effect a movement by working in opposing fashion. When one of the muscles pulls, the other pushes. Both voluntary and involuntary body muscles work antagonistically. In this section we will deal with voluntary muscles.

As we have just learned in Section 2.0, one end of a muscle is attached to a fixed part of the skeleton while the other end is attached to a movable part of the skeleton. When the muscle contracts, the movable part of the skeleton is pulled and it moves. In case of movement of the lower arm, the biceps, that is attached to the immovable scapula at the top, **contracts** and pulls the bones of the lower arm (radius and ulna) upwards. The lower arm will then be bent upwards as shown in Figure 10 below.



Arm is bent **Arm is straight**

Figure 10: Antagonistic action of biceps and triceps muscles
[BOCODOL graphic]

The muscles of the arm demonstrate antagonistic action. In the movement of the lower arm, the biceps acts antagonistically to the triceps. When the biceps **contracts** to **flex** the arm, the triceps relaxes, and when the triceps contracts to **extend** the arm, the biceps **relaxes**.

This movement happens in any of the movable joints we learned about in Topic 1, like raising the leg forward or flexing it backward at the knee joint. The skeletal muscles are named according to the action they effect at the joint of bones. We have **flexors**; these muscles cause the limb to **bend** (e.g. the biceps); **extensors** cause the limb to **straighten** (e.g. the triceps); **abductors** move the limb **away** from the body (e.g. muscles of the shoulder); **adductors** move the limb **closer** to the body (antagonists of abductor muscles).

In summary, these are the skeletal muscle types whose roles in the body can be divided into two. The **locomotor muscles**, this is the type that is involved in the locomotion or mobility of the whole body. They work together, antagonistically of course, to move the whole body from place to place. Another broad functional group is the **postural muscles**. As the name suggests, these are involved in maintaining the body posture. The natural human body has an upright posture with the head maintained in upright position on the trunk. The muscles that keep the body that way are called postural muscles.

Let us now learn about the antagonistic action among involuntary muscles. Do you remember the other name for this type of muscle? If you don't remember the name, you can check in Section 1.0 above.

Antagonistic action of involuntary muscles

We learned about involuntary muscles in Section 1.0 of this topic. Mainly these are smooth muscles that bring about slow involuntary movements in our body. They are found in organs and systems where humans don't have to consciously allow such movements to happen. For example, breathing, digestion, urinary and nervous systems have some involuntary movements in them. In this section however, we shall only talk about two common life examples of this type of movement and the muscles that bring it about. The two examples are: peristalsis in the digestive system, and the widening and narrowing of the opening into the eye as a result of changes in brightness of light. We shall also learn how the muscles of the eye control the way we are able to see objects that are far and those that are close to us. Let us begin with peristalsis.

Peristalsis

Do you still remember peristalsis? You met this term in Unit 3. If you forgot about it, check what it means in Topic 3 of Unit 3. I want you to imagine and answer these questions. When you swallow food, can you change your mind and stop it half way down the gullet? Can you consciously speed up or slow down the process of digestion? These two questions address the actions of the smooth muscles of the gullet and the whole of the digestive system.

In Unit 3 we learned that the walls of most parts of the digestive system are made of two types of muscles. Write down the names of the muscles that make up the wall of the stomach. The **circular muscles** run around the alimentary canal, while the **longitudinal muscles** run lengthwise along the alimentary canal. These two muscles are antagonistic. That means when one contracts, the other opposes and relaxes. These opposing actions bring about peristalsis. You must have remembered by now that peristalsis is the contraction and relaxation of the muscles of the alimentary canal resulting in the forward movement of food (Figure 11).

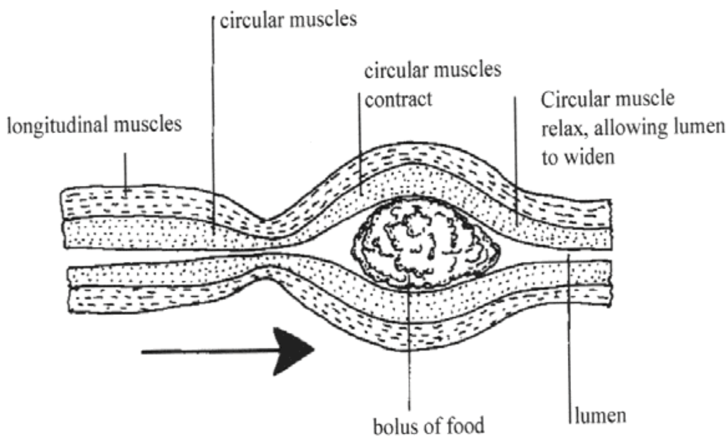


Figure 11: Peristalsis in the alimentary canal *[BOCODOL graphic, Workbook 3 2001]*

What happens is that as the food enters the gullet, the longitudinal muscles contract while the circular muscles relax. The opening becomes wider and the bolus of food enters the gullet. The swallowing action makes the circular muscles to contract and the longitudinal muscles to relax squeezing the food forward. Thus, each time the **circular muscles contract,** the food passage (lumen) becomes **narrower**; and when the **longitudinal muscles relax,** the food passage (lumen) becomes **wider**. A squeezing and widening action creates a wave of movement of the food bolus along the food passage (Figure 11).

Stand in front of a mirror and swallow something while looking at your front neck region. You will notice an up and down movement in this region - you are watching peristalsis in action!

Next, let us learn what happens in the eye when there are changes in the brightness of the light entering it.

The Iris and Pupil of the Eye

You must have learned about the structure of the eye in your Junior Certificate. You can even now stand in front of a mirror and look at your eye. You can see the part of the eyeball which is white in colour - the **eyeball (R) in Figure 12;** a round black or brown part, the **iris** (**P**) that gives the eye the identity colour that is written in your passport, when you decide to have one; and a small hole, the **pupil** (**Q**), in the centre of the black/brown part. There are hairy parts around the eye as well. In Figure 12, label the parts you can see in and around your eye as I have described them above.

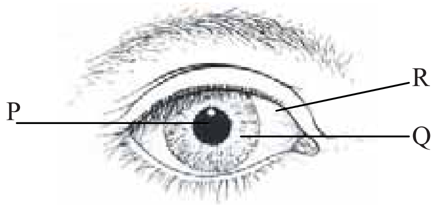


Figure 12: External parts of the eye *[BOCODOL graphic]*

Our concern is the black or brown part, the **iris,** and the little hole in its centre, the **pupil**. What is called the **pupil reflex** is the pupil's response to the amount of light entering the eye. The pupil must allow in the amount of light that is not harmful to the function of the **retina**. As you might recall, the retina is the part at the back of the eyeball that forms images of objects and enables a person to see.

For the pupil to be able to respond to light depends on the antagonistic muscles in the iris. The iris has a set of **circular**

muscles that run around the pupil. It also has **radial muscles** that radiate from around the edge of the pupil like the spikes of a bicycle. These muscles act antagonistically to narrow or widen the pupil at different brightness of light. The following is the process.

When a person enters a **dimly lit** room (a room with a weak light), the **circular muscles relax** while the **radial muscles contract** and the **iris becomes smaller**. This action makes the **pupil open wider** so that as much light as is needed to see can reach the retina.

When the person leaves the dimly lit room into **bright light** (a place with a strong light), the **radial muscles relax** while the **circular muscles contract**. This action makes the **iris larger** and the **pupil narrower** and reduces the amount of light reaching the retina (Figure 13).

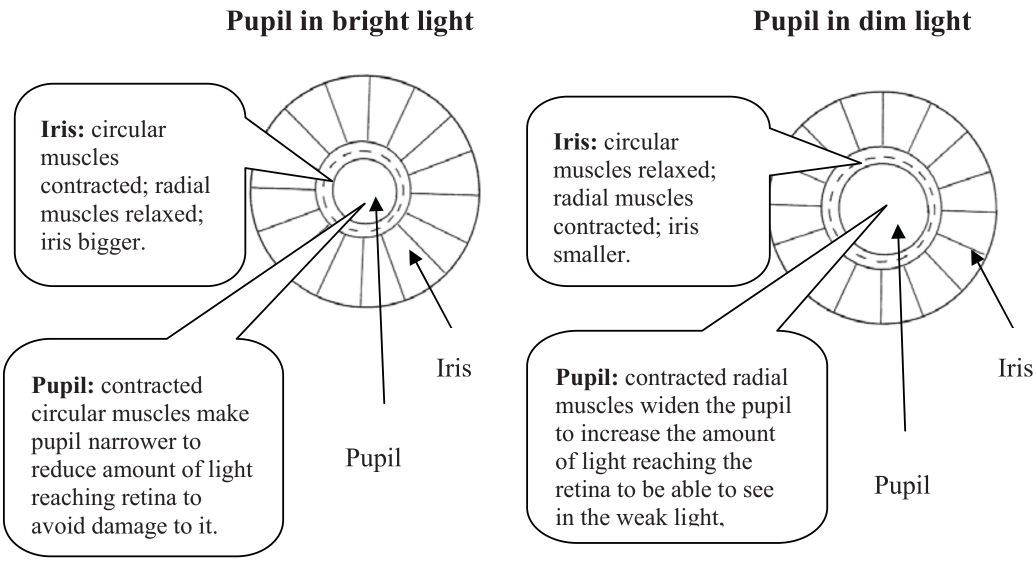


Figure 13: The pupil reflex *[BOCODOL graphic]*

You can prove that pupil reflex indeed does occur by itself. Find time and do the following activity. You may need the help of a friend, since it might be difficult for you to carry out an action and observe yourself at the same time.

Activity 3: Observing pupil reflex

Find a room at home, or anywhere possible. The room should allow the creation of dim and bright light conditions. Follow these steps:

1. Observe the sizes of the pupil and the iris when your friend is in a dim light, like when the room curtains are drawn and the light bulb is switched off. There must be enough light for you to see what is happening.

2. Suddenly switch on the light bulb and observe how the iris and pupil in the eye of your friend behave. The light should be bright. A 100 watts bulb is enough to produce bright light.

3. Write notes on your observation of the changes in the size of the iris and the pupil.

4. You can repeat the activity with lights of different brightness until you see the changes happening.

Feedback

As explained earlier, in dim light the iris is thin because the radial muscles have contracted and the circular muscles have relaxed. The pupil has widened in order to gather as much light as possible and be able to see in the semi-darkness of the room.

When the bright light goes on, the iris muscles quickly adjust; the circular muscles contract while the radial muscles relax. This combined action makes the iris thicker and the pupil narrower. The resultant effect is that the pupil, now a small opening, allows in the amount of light that is not harmful to the retina.

Let's learn about another involuntary action in the eye.

The Ciliary Muscles and Suspensory Ligament

These two structures also work antagonistically. Like in the case of the iris and pupil, the same antagonistic action takes place when the eye lens adjusts its thickness in order to focus images on the retina. Adjustment of the thickness of the lens, in order to focus images from objects that are at different distances, is called **accommodation.** How the eye focuses is another science in human biology that you might have studied in your earlier course of study. A ring of ligament called **suspensory ligament (A**), as seen in Figure 14, surrounds and suspends the eye lens. The lens is responsible for focusing images on the retina. The ligament is in turn linked to a ring of muscles called **ciliary muscles (B)** (Figure 14). Although the lens is crystalline like glass, it is flexible and can respond to stretching and squeezing.

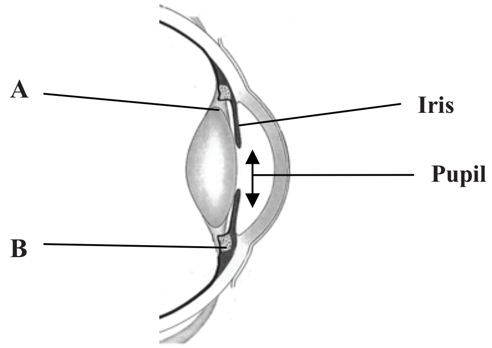
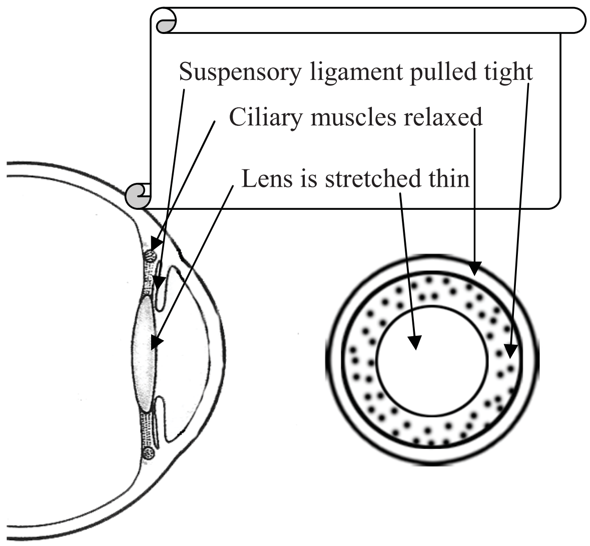


Figure 14: Parts of the eye involved in accommodation
[BOCODOL graphic]

How does the focusing take place? When looking at a distant object, the **ciliary muscles relax** making the **suspensory ligaments pull tight,** or become tense. Since the suspensory ligaments are pulled tight, they in turn **pull on the lens and make it thin**. The thin lens is then able to **focus light rays from the distant object** on to the retina. Conversely, when a person is looking at a **nearby object**, the **ciliary muscles will contract,** making the **suspensory ligaments loose,** or less tight around the lens. Since there is no pull on the **lens, it bulges out and becomes thick**. The **thick lens** is then able to **focus the light rays from the nearby object** on to the retina (Figure 15).

(a) Focusing on a distant object



(b) Focusing on nearby object

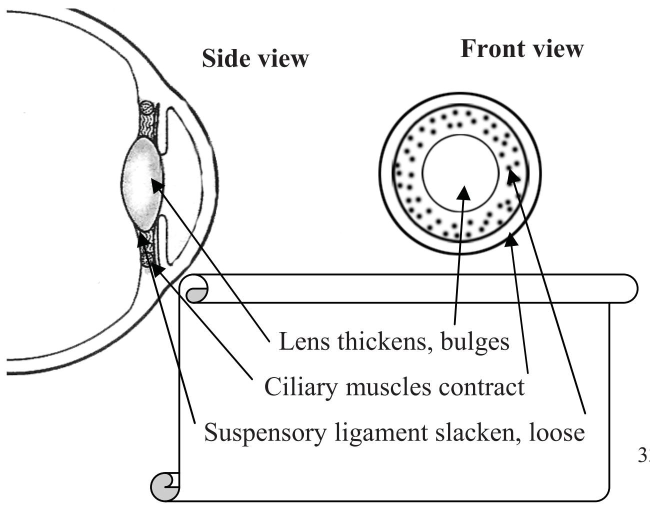


Figure 15: Action of the lens ligament and ciliary muscles
[BOCODOL graphic]

This antagonistic action of the two eye structures enables a person to vary the focus even within a short time, and adjust the lens to focus on objects that are far and then those that are close.

You have come to the end of Topic 2; it is time to summarise what we have learnt in it. Before you read my summary below, jog your memory and understanding by trying to make your own summary first. Then compare mine below with yours.

Summary

Muscles are important tissues in the human body. They bring about movement of the whole body, and together with the skeleton, they maintain the upright posture that is unique to *homosapiens* (humans).

Voluntary muscles are also known as skeletal muscles because they work together with bones to produce movements. The muscles are under constant control of the brain; hence the movements they effect are intentional. They contract and relax using energy from burning glucose within muscle cells in the presence of oxygen. Both glucose and oxygen are pumped into muscle cells with blood from the heart. Using this energy, the muscles are able to produce much work in a short time, but get tired quickly.

Cardiac muscles are special muscles found only in the walls of the heart. They contract and relax at various speeds depending on the condition of the body. They are also involuntary and work non-stop for life.

Involuntary muscles have a very important role to play in the well being of humans. They are also known as smooth muscles. Although humans have no control on their actions, they make certain body processes, like those we have just learned about possible. The muscles contract and relax slowly and take a long time to get tired.

You have come to the end of Topic 2; it is time to do Self-assessment Exercise 2 which is towards the end of this unit. After doing it, compare your answers with those provided, also at the end of the unit.

When you have completed the Self-assessment Exercise 2, read the Unit Summary below and then do the Tutor Marked Assignment. You may need to go over the whole unit before you attempt the Tutor Marked Assignment.

Unit Summary

Summary

In this unit we learned that the supporting system of the human body is made up of the skeleton and the muscles.

In **Topic 1** we said that basically the skeleton is a general term for bones that are put together to produce a shape of a human being. In addition to that, the skeleton helps in body movements, it helps in the formation of blood cells in the bone marrow, it stores calcium, and it protects the inner delicate parts of the body.

Joints are all places where bones meet. The main types of joints are movable joints and immovable joints. Types of movable joints are hinge joints and ball and socket joints. Two examples of a hinge joint are the knee joint and the elbow joint. Examples of ball and socket joints are joints formed where the humerus meets the shoulder blade (scapula), and where the femur or thigh bone meets the hip bone or pelvis.

In **Topic 2** we learned that muscles are the fleshy parts of the body. The two main types of muscular actions are the involuntary action and voluntary action. Involuntary action is the type of muscular action that we don't have control over and we don't think about doing. Voluntary action is the type of action we think of and decide to carry out.

Antagonistic muscles are muscles that work by opposing each other's action, they usually work in sets or pairs, and one of the pairs is located at the opposite side. Examples of antagonistic muscles are the circular and longitudinal muscles of the gut, the circular and radial muscles of the iris, the biceps and the triceps etc. Muscle movements are a result of contractions and relaxations done by muscles using the energy they produce by respiration.

Assignment

Assignment

Self-assessment Exercise 1

Answer the following questions in your notebook, and then compare your answers with those provided at the end of the unit.

1. What is a skeleton? [1 mark]
2. Differentiate a bone from a cartilage. [3 marks]
3. Why is it possible for the human limbs (legs and arms) to do a heavy job in a short time? [4 marks]
4. Explain which type of the body joints a soccer player will use most and why, during a game of soccer. [6 marks]
5. In which part of the body will you find: [4 marks]
   (a) Elastic ligament?
   (b) Hyaline cartilage?
   (c) Fibrous ligament?
   (d) Immovable cartilaginous joint?
6. Explain the functions of the human skeleton. [10 marks]
7. Write short notes on the types of joints on the skeleton. [7 marks]

Total = [35 Marks]

Self-assessment Exercise 2

Answer the following questions in your notebook. Then compare your answers with those provided at the end of the unit.

1. List **three** types of muscle cells. [3 marks]
2. Explain how skeletal muscles produce movements. [5 marks]
3. Describe how the smooth muscles of the esophagus propel food to the stomach. [5 marks]
4. Name the structures of the eye that allow a person to see near and far objects. [2 marks]
5. Give the meanings of the terms: [10 marks]
   (a) Extensor

(b) Flexor
(c) Adductor
(d) Abductor
(e) Locomotor

6. Explain how iris reflex occurs (use of diagrams earns more marks). [5 marks]

Total = [30 Marks]

Assessment

Assessment

Tutor Marked Assignment

1. List **five** functions of the human endoskeleton. [5 marks]
2. The table below shows some parts of the skeletal system and the organs of the body they protect. Draw lines to match the part of the skeletal system with the correct part of the body it protects. [4 marks]

Part of skeleton	**Organ of the body**
Skull	Lungs
Pelvic girdle	Brain
Ribcage	Spinal cord
Vertebral column	Uterus & bladder

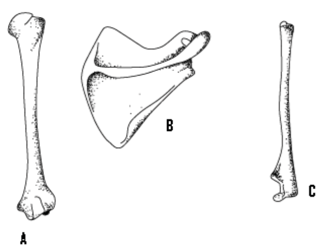
3. (a) Give **one** structural difference between tendons and ligaments. [1 mark]

   (b) Explain how tendons and ligaments are attached to bones and how the attachment influences movement at the joint. [5 marks]

4. (a) State any pair of antagonistic muscles in human body. [2 marks]
   (b) Describe how antagonistic muscles of the gullet propel food into the stomach. [5 marks]

5. (a) The diagram below shows some bones of the forelimb.

   Name bones A, B and C



A: ....

B: ....

C: .... [3 marks]

(b) Describe how the muscles and bones of the arm bring about the lifting of objects from the ground. [5 marks]

3. It is midday on a sunny day and a girl comes from the outside and enters her dimly lit room. After 2 minutes her sister hiding in a wardrobe suddenly flashes a torch light in her face; explain the changes that take place in the girl's eyes under the three situations. [5 marks]

Total = [35 Marks]

Answers to Self-assessment Exercises

Exercise1

After you have done the self-assessment exercise, compare your answers with mine below. Finally, use the information in the text to verify the information you are in doubt of.

1. A skeleton is a framework of bones, which when muscles are attached to it, gives support, body shape and movement.

2. A bone is made of a protein called collagen and calcium and other mineral salts and, as such, it is harder than cartilage. Cartilage, on the other hand, is made of collagen, and is pliable, i.e. flexible and can resume its shape after pressure is applied to it.

3. Human limbs (legs and arms) are operated by well articulated bones, **which act as levers** to **multiply a small effort into a big force**. The bone joints are operated by **powerful muscles** that are well supplied with **glucose and oxygen** to **produce energy** by respiration in muscle cells. The muscles are under the **control of the brain;** hence the force does not only come from the articulation of bones and muscles, but also from stamina and **psychologically**

induced endurance. That explains why marathoners can run up to 40 miles in less than 25 minutes, and weight lifters can lift loads several times their own weight.

[Well-articulated answer with any four points, 4 marks]

4. The player will use almost all the joints of the body, but since the major action will be running and kicking, he/she will mostly use the **joints of the arm and legs**. Arms are important for **speed** and **balance** whilst in full flight. Arms are also important in **absorbing the shock** of falling or **hassling** with opponents. There will be a lot of flexing and extending of the arm muscles and joints.

   The leg joints at the **knee** and **hip** will be fully occupied by **running**, **dribbling, shielding** and **kicking** the ball and executing **sliding tackles**.

[Any 6 points of a well-articulated answer]

5.

Structure	***Where used/found***
(a) Elastic ligaments	Vocal cords
(b) Hyaline cartilage	Ends of long bones
(c) Fibrous ligament	Between bones of most joints
(d) Immovable cartilaginous joint	Between discs of spinal column

6. The human skeleton has many functions, which include:
   (a) Protection
   (b) Movement
   (c) Body shape
   (d) Production of blood cells
   (e) Attachment of muscles
   (f) Support
   (g) Transmission of sound impulses by the middle year bones
   (h) Breathing mechanisms by the ribcage

*Any **five** points 1 mark each and 1 mark each explanation; 10 marks]*

7. Notes on the types of joints:

Immovable joints
Movable (a) ball and socket joints; (b) hinge joints

[Each explained (3 x 2 marks) + 1 mark for examples]

Exercise 2

1. Three types of muscle cells are the striated muscle cell, smooth muscle cell and cardiac muscle cell. *[3 marks]*

2. Skeletal muscles produce movement by antagonistic contraction and relaxation. They do so through direct control of the brain and supply of energy from burning glucose inside muscle cells. *[5 marks]*

3. When a bolus of food is swallowed, **it stimulates the circular muscles of the gullet to relax** while the **longitudinal muscles contract** and the food passage to **become wider**. Then the **bolus enters the now wider gullet**. In the next phase the **circular muscles contract narrowing** the food passage at the **upper end of the bolus** while the **relaxation of the longitudinal muscles** at the lower end of the bolus widens the food passage. As a result, the food is pushed forward. *[5 marks]*

4. The structures are ciliary muscles and suspensory ligament. *[2 marks]*

5. Meanings of terms:

   (a) **Extensor:** a muscle that straightens a limb, e.g. triceps.
   (b) **Flexor:** a muscle that bends a limb, e.g. biceps.
   (c) **Adductor:** a muscle which moves a limb closer to the body.
   (d) **Abductor:** a muscle which moves a limb away from the body.
   (e) **Locomotor:** a muscle that moves the whole body from one place to another. *[10 marks]*

6. The antagonistic muscles of the iris are used to control the amount of light reaching the retina in order to protect it from damage by intense light. In a dim condition, the circular muscles will relax while the radial muscles will

contract. This action will make the iris thinner while the pupil will be wider to admit in as much light as possible. In bright light the radial muscles will relax while the circular muscle will contract. This action has the effect of making the iris thicker and the pupil narrower to reduce the amount of light reaching the retina. *[5 marks]*

Answers to Tutor Marked Assignment

1. The **five** functions of the skeleton are:
   (a) Support
   (b) Protection
   (c) Movement
   (d) Muscle attachment
   (e) Formation of blood cells.

[Any 5 correct, each 1mark, 5 marks]

2.

Part of skeleton		**Organ of the body**
Skull		Lungs
Pelvic girdle		Brain
Ribcage		Spinal cord
Vertebral column		Uterus & bladder

[Each 1 mark, 4 marks]

3. (a) Ligament is elastic while tendon is inelastic.

   (b) Tendons and ligaments are attached to bones **differently.** The tendons that link a muscle to an immovable part of the skeleton are called **origins,** and the tendon at the muscle end linking the muscle to a movable bone is called **insertion**. The fibrous ligament links a movable bone to an immovable one **across the synovial cavity,** or the ligament may be **present within the joint capsule**.

   Being **slightly elastic, the ligament** allows **freedom of joint movement**. Tendons, on the other hand, being **non-elastic** they hold the **muscle firmly to the bone**, allowing the elasticity of the muscle to bring about movement. *[Any 5 points each 1 mark]*

4. (a) Any two of voluntary or involuntary muscles e.g. biceps and triceps. *[2 marks]*

   (b) When a bolus of food is swallowed, **it stimulates the circular muscles of the gullet to relax** while the **longitudinal muscles contract** and the food passage to **become wider**. Then the **bolus enters the now wider gullet**. In the next phase the **circular muscles contract narrowing** the food passage at the **upper end of the bolus** while the **relaxation of the longitudinal muscles** at the lower end of the bolus widens the food passage. As a result, the food is pushed forward. This **wave of contraction and relaxation** of the muscles **pushes the food up to the stomach**. It is the same muscular action that pushes the food along the entire length of the gut.
   [Any 5 points each 1 mark]

5. (a) A: Humerus
   B: Scapula
   C: Radius

   (b) The muscles of the arm, the triceps and biceps, are **voluntary muscles**. If something is to be lifted from the ground, the **brain is involved,** since it is a voluntary action. It is the forearms that grip the load to be lifted. To begin with, the arms will be in extended form, where the **biceps is relaxed** and the **triceps** at the back of the arm **are contracted**. The hands will grip the object and the arms will be flexed to lift the object. To flex the arms in a lifting position, the **biceps will contract** while the **triceps will relax** causing **radius and ulna to bend upwards lifting the load** now gripped by hands. The effort put in by the muscles will depend on how heavy the load is and how fast it is to be lifted.
   [Any 5 points each 1 mark]

6. There are three situations to which the girl's eyes are exposed.

   (a) **Midday sun outside:** Here the girl's pupils are small to allow in less harmful sunlight that could harm the retina. In this state the circular muscles of the iris are contracted and the radial muscles relaxed and pupil is as small as it can be.

(b) **In her dimly lit room:** The pupils will quickly adjust to the semi-darkness of her room. The circular muscles will relax while the radial muscles will contract pulling the iris to be thin and the pupil to widen up to gather as much light as the room can provide. If you were to look at her pupil it would be wide open.

(c) **Sudden torch light**: The naughty sister must have caused sudden adjustment by the iris to prevent that torch light from damaging the girl's retina. The now wide pupil had to be made smaller quickly enough by the circular muscles contracting and the radial muscles relaxing, so that the pupil becomes even narrower than when the girl came from the midday sun.

[Any 5 correct points each 1 mark]

References

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Contents

HSB Unit 7

Sense Organs and the Nervous System

Introduction

Welcome to unit 7 of the Human and Social Biology course on sense organs and the nervous system. Remember that in unit 1, we learnt that living things have the ability to detect changes around them, and respond to those changes. We also learnt that a group of tissues performing the same functions can form a functional unit called an organ. Amongst these organs formed there are some sensory organs which are responsible to detect changes surrounding living things. In this unit, topic 1, we are going to deal with sensory organs –receptor cells and their stimuli and you will learn about **one** particular sense organ in great detail - the **eye.**

In the second topic of this unit, you will be learning about the nervous system, specifically about how it helps our bodies to detect and respond to changes in the environment. Sensory receptors are able to detect changes in the environment. These receptors then pass the information to a coordinating centre called the **central nervous system.** Upon receiving the information from the sensory receptors, the nervous system will come out with an appropriate response which is then sent to the organs responsible for coming up with the action to counteract the change. The organs responsible for responding to the changes in the environment are referred to as **effectors.**

The central nervous system is made up of the brain and the spinal cord. In this topic you are going to learn about how this system copes or rather deals with the information from the sensory receptors.

Time Frame

It is estimated that to complete studying this unit you will need between 15 to 20 hours. Do not worry if you take longer in finishing this unit. Remember that we all have different abilities and hence we study at different paces.

You are encouraged to spend about 2 hours to answer the assignment in this unit. You will also need approximately 3 hours on the assessment at the end of the unit.

The total hours for completing the unit will thus be between 20 and 25 hours.

Teaching Approach:

The teaching and learning approach for this topic, as in other units of this course, is learner centred and based on your previous knowledge and experience. This is meant to motivate you to explore information on your own or as a group at home and even in your study centre. You are encouraged to form study groups with other learners in your area to discuss the subject matter and assist each other in your studies. This will help you do research and develop an interest and initiative to study. A number of activities have been included in the unit to help you interact with learning material and you are encouraged to do all the activities in the unit. There are also some practical activities designed to have a greater emphasis on the understanding and application of scientific concepts and principles discussed in the unit to everyday life situations.

The unit itself is a challenge to us in the sense that it helps us to understand ourselves. We shall focus mainly on the sense organs and the central nervous system. We have in-text questions and activities with feedback to assist you as you work through the unit. The activities will facilitate your understanding of concepts of life as well as help you build skills, knowledge, and practical applications. At the end of the unit there are assignment and assessment activities with feedback provided to help check your understanding of the unit content.

Outcomes

Upon completion of this unit you will be able to:

- *Discuss* the different sense organs and how they are affected by the environmental stimuli.
- *Describe* the structure of the eye and its parts and their functions.
- *Explain* how the nervous system works.

Terminology

Accommodation: is the ability of the eye lens to change its shape so that the eye can focused on distant or near objects.

Dendrite: is a short, much-branched process, which receives impulses from other neurons and conducts them towards the cell body.

Effector: is a specialized animal tissue or organ that performs a response to stimulus from the environment.

Motor Neurones: carry nerve impulses from the CNS to a muscle or gland (called an effector).

Reaction time: is time taken between reception of stimulus and response.

Reflex action: is an immediate response or reaction of the body to a stimulus.

Reflex arc: is a pathway for a reflex action which links receptors and effectors.

Relay Neurones: connect sensory and motor neurons within the CNS. They are also known as intermediate neurons, connector neurons and associate neurons.

Sensory neurones: carry impulses from receptor (in a sense organ) to the central nervous system(CNS).

Synapse: Is a small gap along the length of a neuron.

Online Resource

If you can get on the internet please utilize the resources at www.hippocampus.org. It is an excellent source of information for biology and the topics discussed in this unit. Here you will find:

- Presentations
- Simulations
- Videos
- Online Study Groups
- Links to Even More Information
- Textbook Correlations
- Online Courses

Topic 1: Sense Organs

Sense organs are normally referred to as receptors. Receptors are cells that detect stimuli and they help the organism to respond to stimuli. What is a stimulus? A stimulus, as already mentioned in unit 1, is a change in an organism's internal or external environment, such as a change in the light intensity or even a sudden loud noise. There are many stimuli and they even include sudden temperature drops or increases.

Most of the receptors respond to one type of stimuli. The table below shows the stimulus, the receptor and the type of sense that it detects.

Stimulus	**Receptor**	**Type of sense**
Light	The eye	Sight
Sound	The ear	Hearing
Pressure and temperature	Touch and temperature receptors in skin	Touch
Chemicals in air	Nose	Smelling
Chemicals in food	Taste buds in the tongue	Tasting

From the table we can see that the light is detected by the eye and the type of sense is sight. We can also see that sound is detected by the ear and so on.

We are constantly subjected to all sorts of stimuli. It is important that we are able to detect these stimuli and respond to them in the right way. Sometimes our receptors are not very good at telling us the stimuli correctly. Let's do the activity below to see how parts of the body can respond to stimuli.

Activity 1

Obtain three bowls; the first should contain ice cold water, the second hot water and the third, water at room temperature.

Place your left hand in the cold water and the right hand in hot water for a minute.

When one minute is over, place both hands in the room temperature water.

What does each hand feel like?

What does this investigation tell you about the sense concerned with temperature?

Feedback

The hand placed in cold water will feel cold and the hand placed in hot will feel the heat. When you place both hands in water at room temperature you will feel either the heat or cold leaving your hands.

From the above activity we can tell that some parts of our skin are more sensitive than others. For example the outer part of a hand is more sensitive to touch and pain than the inner part. The change in temperature will therefore be felt by the outer part of the hand more than the inner one.

All the sensory organs of the body are very important but for this course we shall look at the eye in more detail.

The Eye

Most people depend more on their eyesight than on any other sense because it tells us so much about the world around us. The eye, one of our most precious sense organs, is for sight. Our eyes lie in two bony sockets in front of the skull. These sockets protect the eye.

In unit 6, topic 2 we discussed the external part of the eye particularly the iris and the pupil. The iris (i.e. the black/brown part of the eye), as we have already seen in unit 6 controls the light levels inside the eye. At the centre of the iris there is an opening called the pupil. This controls the amount of light entering the eye. You may have to refer to figure 12 unit 6 and look at the external part of the eye.

In this section we shall look at other parts of the external structure of the eye namely; the sclera, cornea and conjunctiva.

The eyeball is surrounded by a thick coat. This is transparent at the front and opaque at the sides and back. An opaque substance is the one which does not allow light to pass through whilst a transparent one allows light to pass through. Can you think of any opaque substance and also a transparent one?

Ans: ____

____

You should have thought of a brick wall as an opaque substance and ordinary glass as a transparent substance. There are many examples of these types of substances.

We mentioned earlier on that the eye is surrounded by a thick coat. This coat is called the 'white' of the eye, or **sclera** and it keeps the eyes in shape and protects its delicate internal parts. The transparent front part is called the **cornea**. The cornea does not contain any blood vessels and it gets all nourishment from the fluid found inside the eye ball. It is covered by a very thin membrane called **conjunctiva**, and this is the eyes first layer of protection against infection. Sometimes this part gets infected and inflamed by bacteria resulting in a disease called pink eye or **conjunctivitis**.

Let us now look at the internal structure or parts of the eye.

Internal Structure of the Eye

In this section we will identify each part and then state the functions of the parts. The parts to discuss are shown in the diagram, keep checking their positions when studying the table that comes below the diagram.

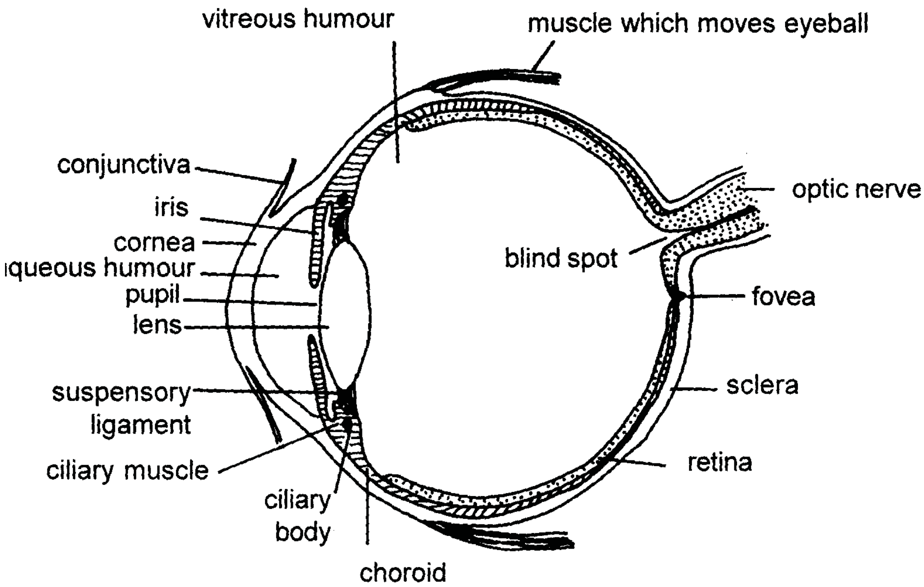


Figure 2: Vertical section of the eye

The table below gives the functions of the parts labelled in the diagram above.

STRUCTURE	**NOTES AND FUNCTIONS**
1. Conjunctiva	It admits light and is a protective covering against germs entering the eye.
2. Cornea	Bends or reflects light rays as they pass through it.
3. Sclera	Thick wall of eyeball gives shape and protects the delicate inner parts of the eye.
4. Choroid	Layer of pigmented cells and blood vessels behind retina which absorbs light and prevents internal reflection. It also nourishes the eye.
5. Retina	This is where an image of what one is looking at is formed. It contains cells that are sensitive to light.

6. Iris	Controls the amount of light into the retina by changing the size of the pupil.
7. Pupil	Aperture (hole) through which light rays pass into the eye.
8. Lens	Transparent part which refracts or bends light rays and makes them focus on the retina.
9. Ciliary muscles	Contract and relax to change the shape of the lens.
10. Suspensory ligaments	They hold the lens in place.
11. Aqeous humour	Runny fluid nourishes the cornea and maintains correct pressure in front of the eye.
12. Vitreous humour	Jelly like fluid which maintains the spherical shape of the eyeball. It also refracts light.
13. Yellow Spot(Fovea)	Most central part of retina responsible for precise vision.
14. Blind spot	Part of retina where no light sensitive cells are present. This is the point where the optic nerve emerges from the eyeball.
15. Optic nerve	Carries visual impulses from the retina to the brain. When we look at something, messages are sent through this nerve from the front part of the eye to the brain.

We have been looking at parts of the eye and their functions. All these parts contribute in the formation of a clear image of what we are looking at. In the next part of the lesson we will look at how the eye forms an image.

Formation of the image on the eye

In unit 6, topic 2 we learnt that the image is formed on the retina and it enables the person to see. What happens here is that the light rays from the object are bent (refracted) inwards, by the cornea and the eye lens, and meet on the retina. The light stimulates the light sensitive cells in the retina and nerve impulses pass along the optic nerve to the brain, producing an image of the object.

When looking at an object, light rays from that object enter the eye, and for an image to be in focus, the light rays must meet on the retina.

Seeing things through two eyes is called binocular vision. Seeing things in depth depends on using both eyes. Each eye sees a slightly different aspect of the same object. The two messages are combined by the brain and it gives us a three dimensional view of the object. It also helps us to judge distances.

(a) How is the amount of light entering the eye controlled?

In the previous unit we learnt that the amount of light entering the eye is controlled by the iris. Circular and radial muscle fibres in the iris change the size of the pupil automatically according to the amount of light available.

Do you still remember the activity that we did where we were observing pupil reflex?

If you don't please go back to unit 6, topic 2, activity 3 and do it again.

When there is less light or low light intensity, the circular muscles relax whilst the radial muscles contract, pull the circular muscles outwards and thus the pupil size increases. When there is too much light, the radial muscles relax whilst the circular muscles contract and thus decreasing the size of the pupil. These are reflex actions which control the amount of light entering the eye. The diagrams that follow show how the eye looks like when the light is and dim how it looks when the light is bright.

Eye in dim light

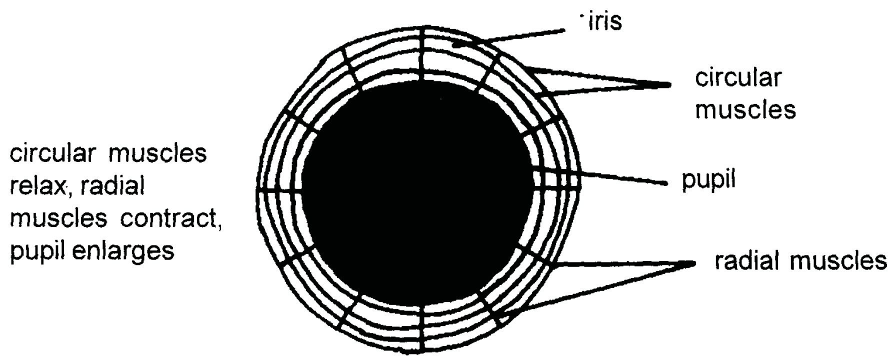


Figure 3: Response of the Eye to Dim Light or Low Light Intensity

As you can see in the diagram above, the black part represents the pupil. Under dim it becomes bigger to allow more light into the eye so that we can see, but when there is too much light the pupil gets smaller, as shown below, to allow enough light into the eye so that we can see.

Eye in bright light

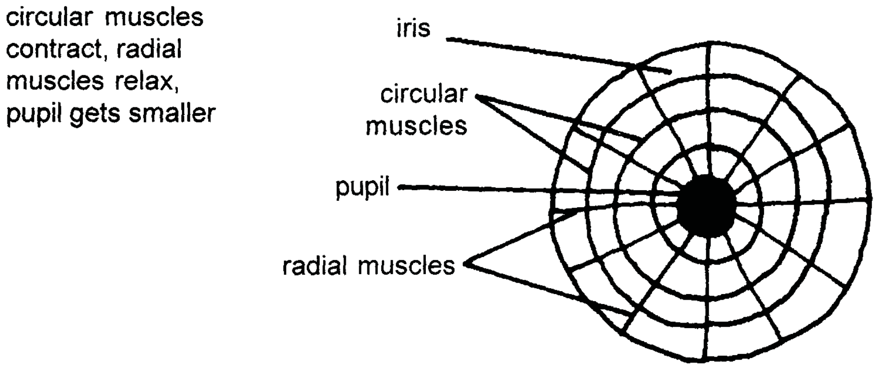


Figure 4: Response of the pupil to a high light intensity or bright light

Below is a summary of what happens when the eye is exposed to a bright light or a dim light.

Dim light	**Bright light**
Circular muscles relax	Circular muscles contract
Radial muscles contract	Radial muscles relax
Pupil dilates	Pupil contracts
More light enters the eye	Less light enters the eye

(b) Accommodation

In unit 6, we learnt that the eye's lens can change its thickness in order to focus images from objects that are at different distances and this called accommodation. The eye lens changes its shape to ensure that light rays meet on the retina. If light rays fall in front of the retina or behind the retina, the image will not be visible and it is said to be out of focus. The diagrams below show how the eye lens adjusts in order to view distant and near objects respectively.

(i) For distant objects

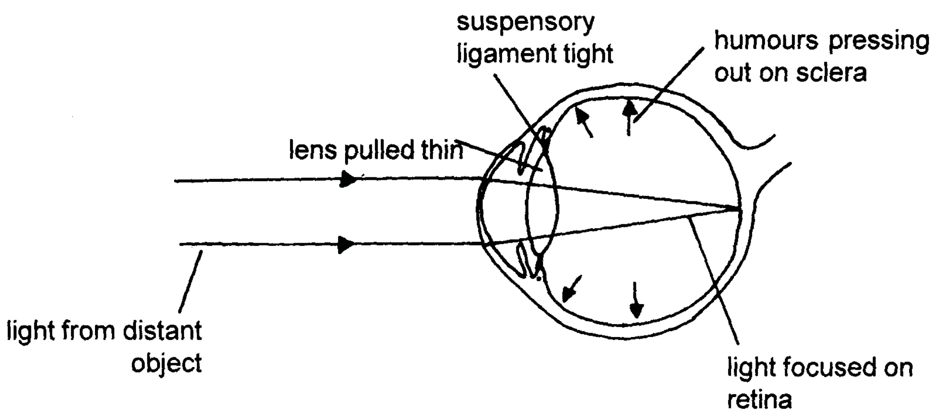


Figure 5: Shows Accommodation for Distant Objects

When viewing distant objects, you normally open your eyes wider and by so doing the lens of the eye is pulled thin as shown in the diagram above. This will then bend the light rays from a distant object and allow the image to fall onto the retina.

(ii) For near objects

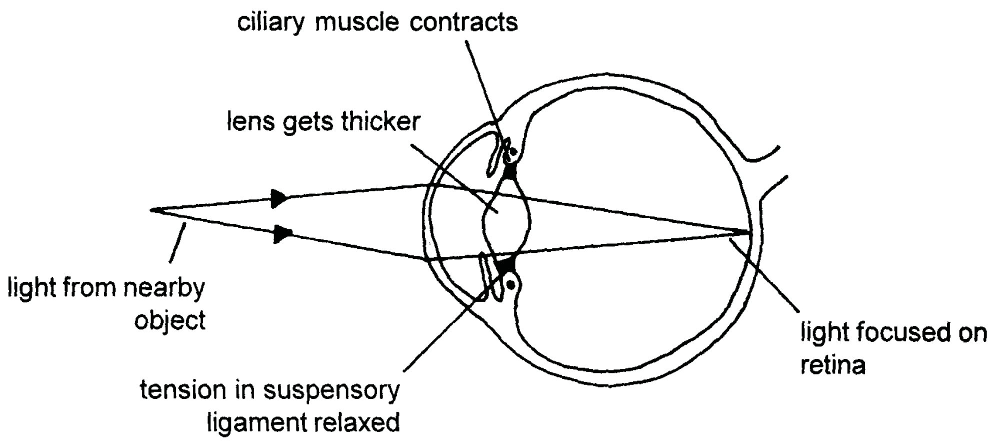


Figure 6: Shows accommodation for near objects

Again when viewing nearby objects you close your eyes a bit and the lens of the eye gets thicker as shown in the diagram above. The light rays will bend as shown in the diagram to allow the image to be formed in the retina.

What sorts of cells are found in the retina?

The retina consists of two types of light sensitive cells called **cones** and **rods.** They differ in structure and function.

Cones are broad in structure and found in the centre of the retina, particularly the fovea. Their function is to give precise vision in colour. Images formed by cones are usually very detailed.

Rods on the other hand are narrow in structure and are found in more peripheral parts of the retina. They produce less defined images in black and white. They respond to light of low intensity.

Cones and rods contain pigments. When light strikes the cell, the pigment is broken down. This causes the cell to send an impulse into the optic nerve. Meanwhile the pigment is re-made and can be used again. Rods can function in poor light because their pigment is broken down by only very small amounts of light. Cones see things clearly because they are very close together and each one has its own nerve fibre to the brain.

We have now come to the end of the section on accommodation, now let us continue and look at defects of the eye.

Defects of the Eye

There are many abnormalities that can occur to the eye in humans. They include short sightedness, far sightedness, and astigmatism. Let's look at each one of them in detail.

We will start with short-sightedness

Short Sightedness

The other name for this defect is **myopia**. The person can focus near objects but not far objects. This is caused by long eyeballs or a strong eye lens.

The image from a distant object falls in front of the retina, as shown in the diagram and therefore is not seen. The image can be seen only when it falls in the retina.

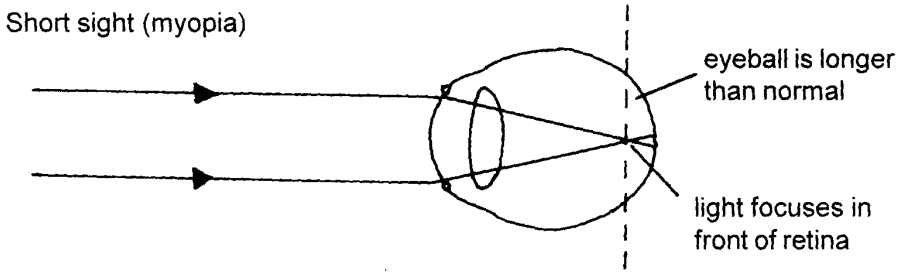


Figure 7: Short sightedness

This can be corrected by wearing glasses with a diverging or concave lens and the figure below shows how this can be corrected. The rays from the diverging lens are spread out a bit and then the lens of the eye will bend them so that they fall on to the retina.

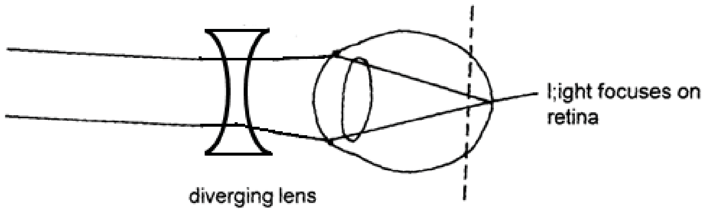


Figure 8: Correcting short-sightedness

Before moving on to next section can you try and think about what happens in long sightedness.

Far Sightedness

Far sightedness is sometimes referred to as **hypermetropia**. The person with such a defect can see far objects but not near objects. This is due to the eyeball being too short or the lens being too weak. The image from a near object falls behind the retina as shown in the diagram below.

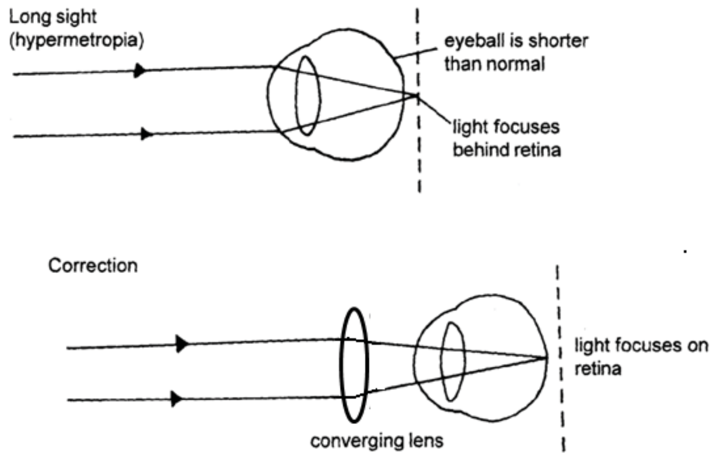


Figure 9: Long sight

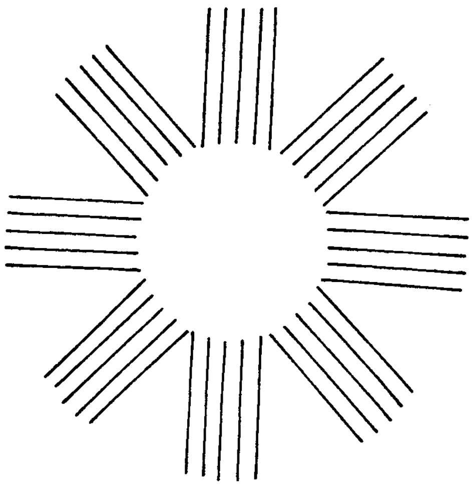
This can be corrected by wearing glasses with a converging or convex lens and this is illustrated in the second diagram above. The converging lens will bend the light rays, which will then be bent further by the eye lens so that the image falls on to the retina.

Astigmatism

Some people suffer from this defect. This is caused by the cornea and/or lens from being unevenly curved. The light rays meet on the retina in one plane but not in another. This can be corrected by wearing cylindrical lenses. Now try the activity below to check if you have astigmatism.

Activity 2

Shut one eye and look at the figure below. If all the lines appear equally dark, you do not suffer from astigmatism. If some lines appear dark and those at 90° to them appear light, then you have astigmatism.



If you think you have astigmatism please visit your eye clinic.

Blind spot

The point where the optic nerve leaves the eye is called the blind spot. It is the only point at the back of the eye without sensory cells and so it is incapable of forming any image.

The next activity will help you to find the blind spot in your eye.

Activity 3

Take a careful look at the next two spots that is the circle and the cross.

1. Hold the page in front of you about 50 cm from your eyes.
2. Close your left eye and concentrate on the circle with your right eye.
3. Slowly bring the page towards your eyes. Even though you are looking at the circle you will still be able to see the cross out of the corner of your eye. But at a certain point, the cross will disappear from view. This occurs when it is focussed on the blind spot.
4. Now continue to move the page towards your eyes, and you will see the cross re-appear.

Feedback

I hope you were able to see what the activity was meant to show.

Let us now move on to how the eye protects itself.

Protection of the Eye

At the outer edge of each eye is a **lachrymal or tear gland** which secretes a watery solution which is distributed over the surface of the eyeball by the eyelids when we blink. The fluid keeps the surface of the eye moist and clean. It contains a substance called **lysozyme** which kills germs and so it acts as a mild disinfectant. Surplus fluid drains into the duct in the corner of the eye and runs down to the nasal cavity.

This brings us to the end of the topic and I hope you have learned a lot from it.

Summary

In the previous topic, you have learned about sense organs and the fact that they respond to stimuli. Stimuli are any change in an environment which the organism is likely to respond to. Light, sound, touch and temperature are examples of stimuli. These stimuli are detected by receptor cells which make up receptor organs or sense organs. The eye is an example of such an organ. It is responsible for sight. The eye is able to focus on far and near objects by changing the shape of the lens. This is called accommodation. When looking at near objects, the lens becomes more convex or bulges in the middle. For distant objects, the lens becomes less convex or thinner in the middle. There are people who have defects in their eyes and as a result cannot accurately focus on certain objects. As an example, some people are short sighted. This means they cannot see distant objects, but can only focus on near objects. The other type is long sightedness. This is the opposite of short sightedness.

I do hope you have enjoyed this topic. Please attempt to answer the questions in assignment 1 which can be found at the end of the unit. Thereafter check the answers at the back before proceeding to the next topic. You may revise some of the sections that you found difficult in this assignment.

Topic 2: The Nervous System

In the previous lesson, you have learned about the sensory receptors. One of the things you have learned about them was that they are able to detect changes in the environment. These receptors then pass the information about any changes to a coordinating centre called the **central nervous system**. Upon receiving the information from the sensory receptors, the nervous system will come out with an appropriate response which is then sent to the organs responsible for coming up with the action to counteract the change. The organ responsible for responding to the change in the environment is referred to as an **effector**.

The central nervous system is made up of the brain and the spinal cord. In this topic, we are going to learn about how the nervous system deals with the information from the sensory receptors.

Learning Objectives

At the end of the topic, you should be able to;

- State the main divisions of the nervous system
- Distinguish between a neurone and a nerve
- Define reflex arc
- State the role of the sensory, motor, intermediate neurons and spinal synapses
- Relate the control of the movement of the elbow in withdrawing a hand from a stimulus to a reflex action
- Carry out simple experiments to demonstrate a reflex action and measure reaction time

The Nervous System

The nervous system consists of two parts; the **CENTRAL NERVOUS SYSTEM (CNS)** and the **PERIPHERAL NERVOUS SYSTEM (PNS).** The central nervous system is made up of the brain and the spinal cord. It is connected to all parts of the body by many long, thin nerves which make up the peripheral system.

In the diagram below you will notice that the brain is enclosed within the cranium, which is the bony part of the skull. The spinal cord runs down the centre of the backbone. The whole of the **CNS** is surrounded and protected by the skeleton.

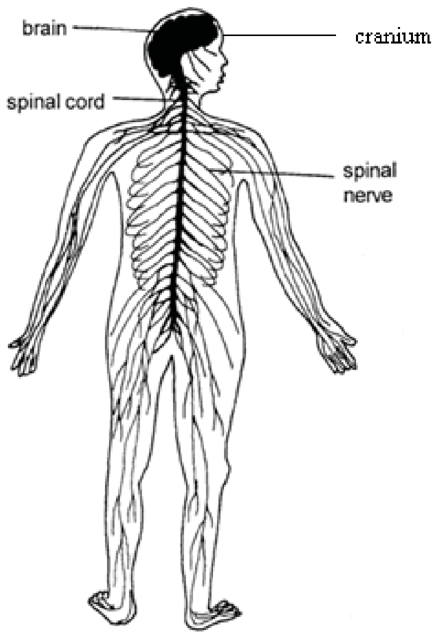


Figure 1: The Nervous System

The peripheral nervous system is made up of two kinds of nerves. Some of the nerves come from the brain and go to structures in the head such as the eyes, nose, and jaws etc. These are called **cranial nerves**. Others come out of the spinal cord and go to the legs, arms and various other structures in the trunk of the body. These are called **spinal nerves.**

The diagram in **Fig.2** below illustrates that the nervous system can be divided into the **central nervous systems** (CNS), and the **peripheral nervous system**, consisting of cranial nerves and spinal nerves.

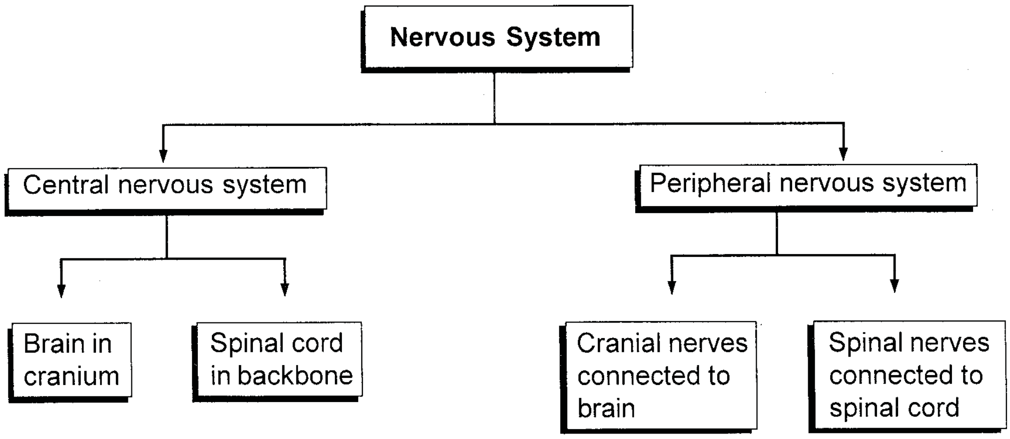


Figure 2: Parts of the nervous system

The function of the nervous system is to transmit messages rapidly from one part of the body to another and to coordinate the organism's actions. A nerve message is a tiny pulse of electricity. It is called a **nerve impulse.** It travels along the nerve fibres within the nervous system. Nerve fibres are tiny extensions of nerve cells (neurons).

Neurons

A neuron is a specialized cell which conducts impulses from one part of the body to another. The diagrams in **Fig.3** illustrate to you three different types of neurons.

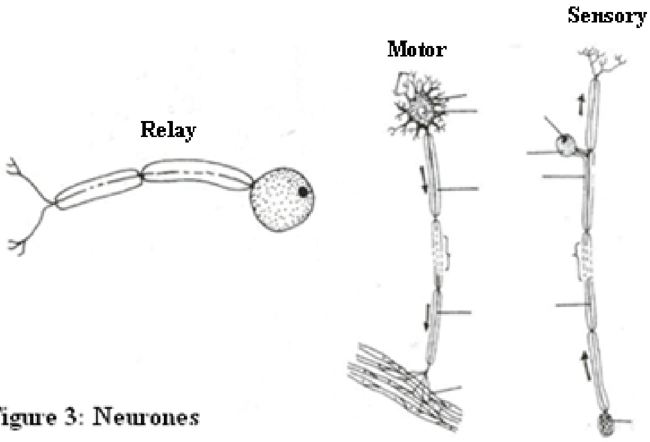


Figure 3: Neurones

A neuron is made up of a cell body, axon and a dendron. A cell body contains a nucleus and many energy providing mitochondria and protein making ribosomes. I hope you remember mitochondria and ribosomes from unit 1, if you don't review unit 1, topic 4. An axon is a long threadlike part of the neuron that conducts impulses away from the cell body while a dendron on the other hand conducts impulses towards the cell body.

These parts can be seen labeled later when you learn about the structures of the motor neuron and the sensory neuron.

At the end of the axon, a neuron may connect with another neuron by means of a synapse or it may connect with an effector such as a muscle or a gland. The nerve impulses travel along these nerve fibres, or rather neurons, in only one direction

There are three types of neurons. They are sensory neurons, motor neurons and relay neurons. These neurons are capable of transmitting nerve impulses over long distances. Let us look at these one by one.

Sensory Nerve Cells or Sensory Neurons

These carry impulses from sense organs to the central nervous system. A sensory neuron has a similar structure to the motor neuron, but the cell body is located on a side branch of the fibre, just outside the CNS. The diagram below shows the structure of a sensory neuron.

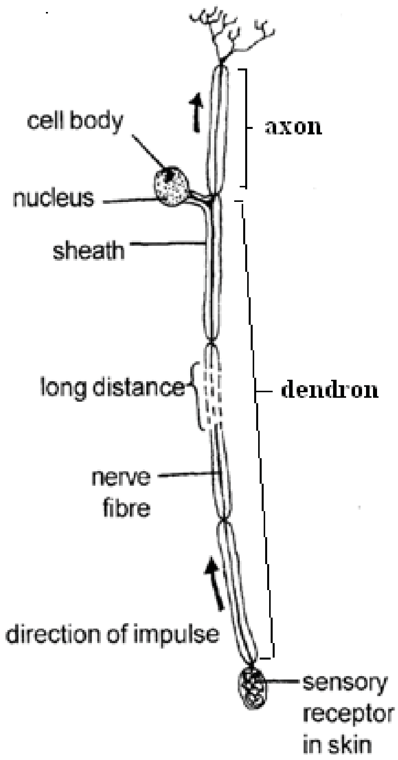


Figure 4: Sensory neurone

From the diagram we can see that an axon and a dendron are similar, they are both a nerve fibre covered with a sheath. They are like electrical cables with a wire inside a plastic insulator. The only difference is that an axon carries impulses away from the cell body and the other towards the cell body as the arrows in the diagram indicate.

Motor Nerve Cell or Motor Neurons

These nerve cells carry impulses from the central nervous system to the effectors. By effectors, we are referring to muscles and glands which carry out necessary actions to counteract the stimuli in question. As you can see in the diagram below, impulses are taken away from the body to the motor nerve muscle for the necessary action to be taken.

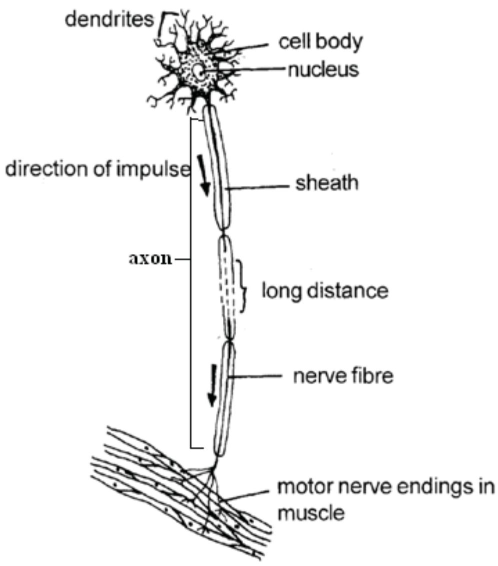


Figure 5: Motor neurone

Relay Neuron Or Associate Nerve Cell

Relay neurons carry impulses from sensory to motor neurons and to neurons which enter and leave the brain. They act like a bridge in between the sensory neurons and the motor neurons

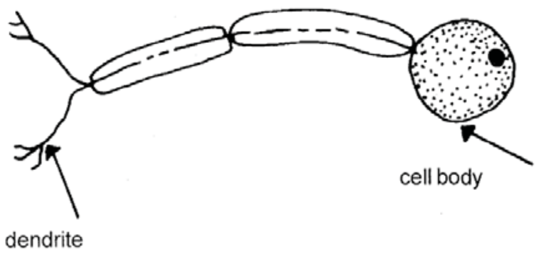


Figure 6: Relay nerve cell

Characteristic Features of Nerve Cells

If you carefully observe figures 4, 5, and 6 you should be in a position to come up with the physical characteristics of nerve cells. What are they? Can you list them on the space below?

You should have come up with the following characteristics;

*a) They have delicate outgrowth called **dendrites** which are in close contact with other nerves*

*b) A nucleus surrounded by cytoplasm. This part is called the **cell body***

*c) They have one or more extremely long extensions running from the cell body. These are called **axons.***

d) Each axon ends in a number of twigs-like branches called dendrites

*e) The axons are covered by a fatty material called a **myelin sheath***

***PLEASE REMEMBER*;**

THERE ARE THREE TYPES OF NEURONS;

- **Sensory neurons**
- **Motor neurons**
- **Relay neurons**

Sensory neurons relay impulses from the sensory organs or receptors to the central nervous system whilst motor neurons transmit the impulse to the effector organs where a response takes place. In between the sensory neuron and the motor neuron there is a neurone which links the two and it is called the relay neuron.

Nerves

A **nerve** consists of nerve cells. It is a specialized tissue consisting of a bundle of long fibres, as shown in the diagram below, through which impulses pass to and from the central nervous system. A nerve is surrounded by a protective sheath of connective tissue.

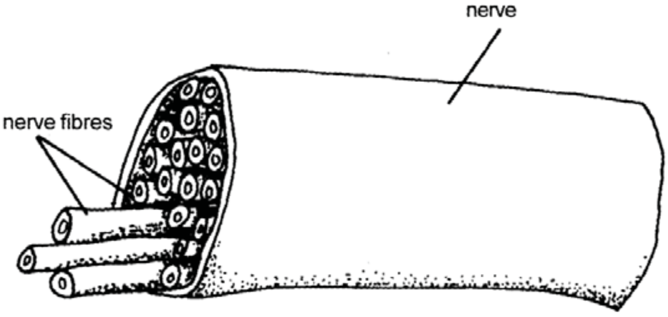


Figure 7: A nerve

The Spinal Cord

This is a cord running from the brain through the backbone or rather vertebral column. It is covered by a membrane called the meningitis which acts as a cushion to protect the delicate nerve tissues against damage from banging inside of the vertebrae. The diagram below shows a section through the spinal cord.

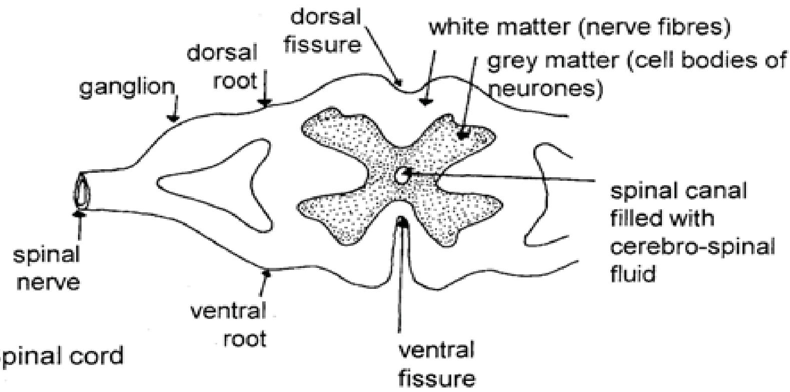


Figure 11: Spinal cord

The three nerve cells, discussed earlier on this topic, are connected to each other by junction inside the spinal cord. These junctions are called synapses. When an impulse travels through the reflex arc, it has to cross these synapses. When a nerve impulse arrives, the end of the cell produces a chemical called **acetylcholine** which diffuses across the space. Pain killers and drugs can interfere with the effect of this chemical. The diagram below shows the structure of the synapse.

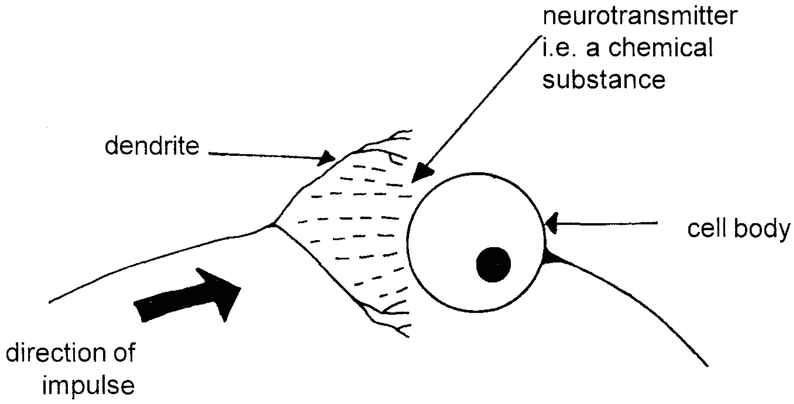


Figure 12: Synapse

Synapses are affected by alcohol and drugs. Some drugs prevent synapses from transmitting; others make them transmit more easily

How the Nervous System Works

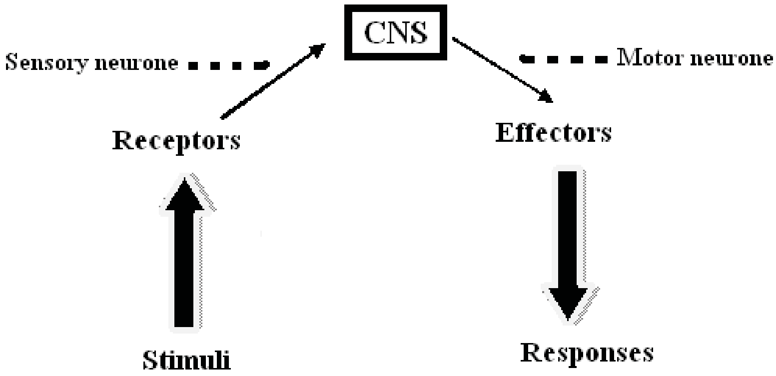
The main components which help to respond to stimuli are;

a) Cells or **organs** which can detect stimuli. These are called stimulus receptors as mentioned in the previous unit. They must be able to produce an impulse in response to a stimulus

b) **Nerve** cells which are the means of conveying impulses from one part of the body to another

c) Cells or tissues called effectors which do a particular action in response to a stimulus e.g. gland, muscle etc

The nervous system brings about coordination between the body receptors and effectors as shown in the diagram below. This ensures that all the body's organs and systems work together as an integrated whole.



The nervous system brings about two types of responses to stimuli. One response is automatic, that is you do not have to think about it when performing such an action. It just happens automatically. An example of such a response will be pulling away your hand from a very hot object. You do not have to think about it. The pulling away of that hand just happens instantly. This type of action is called **reflex action.** In a reflex action, the responses takes place before the person is conscious of what is happening. If you touch a hot object, you move your hand away quickly. In this case the pain is the stimulus while the response is the moving away of the hand.

The other type of response is called a voluntary response or rather a **voluntary action.** This type of response is voluntary, that is, you think about it before actually doing it. An example can be when somebody touches your hand. If you want to pull your hand away, you can actually do that and if you do not want to do that, you can let then to continue touching you.

Reflex Action

A **reflex action** is an immediate response or reaction of the body to a stimulus. Examples of such responses include;

- Knee jerk
- Withdrawing a hand from a hot object
- Closing of pupil in response to bright light

Have you ever wondered what happens when you withdraw you hand from a hot object? Well, the next diagram will explain what happens;

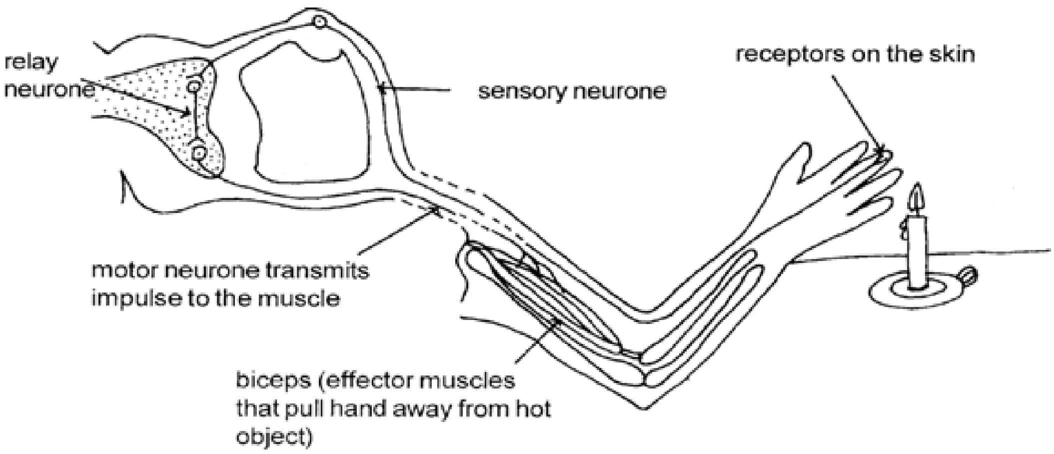


Figure 9: Reflex action

What happens in the above diagram is that the receptors (on the skin of the hand) detect the stimulus (fire from the candle). The sensory neuron then sends the signal to the relay neuron. The relay neuron then sends the signal to the motor neuron which then sends the signal to the effector. The effector then produces a response i.e. the hand is then pulled away quickly.

Reflex Arc

A reflex arc is the route (path) along which nerve impulses travel in bringing about a reflex action. Most of the things that we do in our day to day living calls for immediate action. If you touch a hot object with your hand, your system won't have time to send the sensory information to your brain. You will just move your hand away. This is because the reflex arc provides a means for immediate withdrawal from dangerous stimuli. While all the sensory information does eventually get to the brain, the advantage of reflex arc is that it can process the rapid and protective response directly in the spinal cord, as shown in the diagram below, without the need to wait for the response from the brain. The response is made even before the pain is perceived at a conscious level. The diagram below illustrates this.

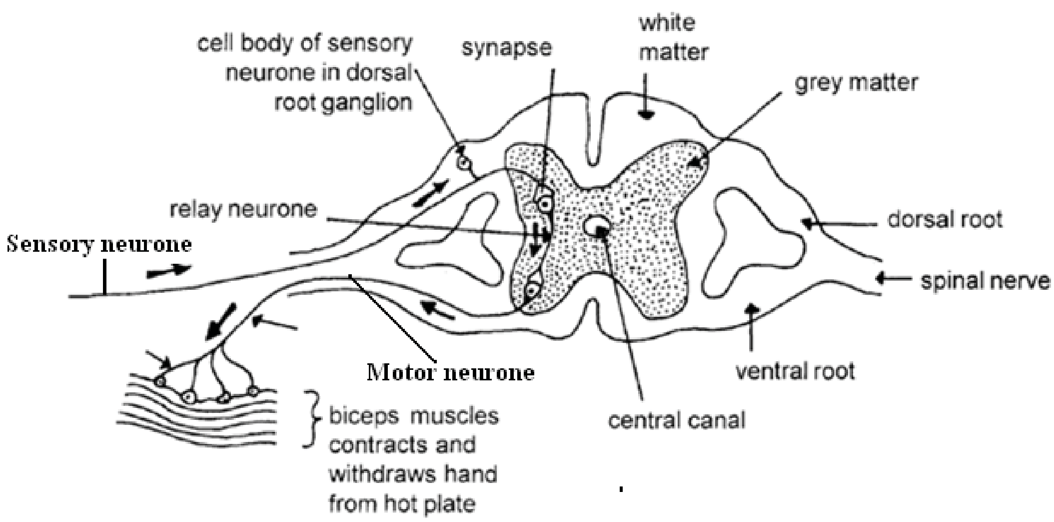


Figure 10: Reflex arc

When you touch a hot plate, the receptor cells in the sense organ (skin) will detect the stimulus. Then an impulse is conveyed along the sensory neuron to the spinal cord. The direction followed is shown by thick arrows coming from the left in the diagram above. In the spinal cord the impulse is passed on the relay neuron and then onto the motor neuron. The motor neuron then conveys the impulse from the spinal cord to the effector organ (biceps muscles) which contracts and withdraws hand from the hot plate.

Examples of Reflex Actions

Reflex	Stimulus	Response
Sneezing	Irritation of mucus membrane	Contraction of abdominal muscles
Contraction of circular iris muscles	High light intensity	Decreased pupil
Coughing	Irritation of wind pipe	Closure if glottis
Knee jerk	Tap on tendon which causes muscles to stretch	Lower leg is raised

Salivation	Smell of food	Salivary flow

Voluntary Action

These are actions which need voluntary thought. It is up to an individual to decide whether to do that particular thing or not. Examples include tickling a friend; walking etc. Many of these actions are controlled by the nervous system.

.Summary

Receptors pass stimuli to the nervous system. The nervous system consists of the brain and spinal cord. The peripheral system consists of nerve fibres. Nerves belong to two groups. There are cranial nerves and spinal nerves. Nerve impulses or electrical messages travel along nerve fibres within the nervous system.

Nerve fibres are made up of nerve cells or neurons. There are three types of neurons; motor neurons, sensory neurons and relay neurons

The nervous system obtains information in forms of impulses. This information is transmitted in the form of impulses to the central nervous system. The central nervous system will come up with necessary responses that counteract the stimuli. The body can come up with two types of responses which are voluntary and involuntary responses.

We can control voluntary responses but not involuntary ones. The latter just happens automatically.

I do hope you have enjoyed this topic. Please attempt to answer the questions in Assignment 2 which can be found after the unit summary and. Check the answers at the end of the assignment and if necessary revise the sections that you may have had difficulties. Once you have done this read the unit summary to as a revision for the whole unit.

Unit Summary

Summary

In this unit you have learnt that there are different sense organs that the human body has and that they do help the body to detect changes in the environment so that the body can make an appropriate response. Examples of such organs are: the ear, the skin, the nose, the eye and the tongue. Each and every sense organ has a specific stimulus that it detects. One particular sense organ that we have looked at in great detail is the eye. You have learnt about how the eye enables you to see the world around you and is regarded as a precious sense organ.

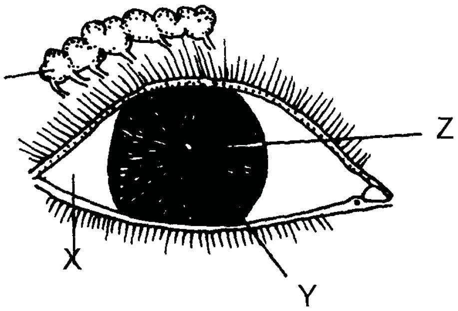
Also you have learnt that the nervous system is the main communication system of the body. It receives and interprets information from both inside and outside the body. Your nervous system coordinates muscles so that you can do things which need thought, like cycling, dancing, or reading. It also coordinates things that you don't need to think about, like your heartbeat and breathing. The nervous system consists of the brain, spinal cord, nerves, and sense organs. The brain and the spinal cord constitute what is called the central nervous system (CNS). Its main job is to get information from the body and send out instructions so that an appropriate response is made.

Assignment

Assignment

Topic 1 Assignment

1. Label the points X, Y and Z in the diagram below.[3 marks]



(a) Which parts of the eye bends light? [2 marks]

____

____

(b) What shape are your eye lenses when you look at your finger nails? What shape are they when you look at a building which is at a distance? [2 marks]

____

____

2. (a) Where in the retina are rods and cones found? [1 mark]

____

____

(b) Which ones detect colour, and which ones work in dim light? [2 marks]

____

____

3. (a) Kabo is short-sighted. He visited an optician who recommended a certain brand of glasses for him. Which type of lens did those glasses have? [1 mark]

____

(b) Sadi on the other hand had problems with seeing near objects. If you were an optician which type of glasses will you recommend for her? [1 mark]

____

(c) How would these glasses help? You should use diagrams and the space below to clarify your answer. [4 marks]

____
____
____
____
____
____

Topic 2 Assignment

1. Name the parts of the nervous system (3 marks)

____
____
____
____
____
____

2. What is a nerve impulse? (2 marks)

____
____
____

3. What is a reflex action? (1 mark)

____
____
____

4. Sort these into reflex and voluntary actions (10 marks)

Sneezing, reading, sweating, writing, blinking, laughing, contraction of eye pupil, flushing of skin, swallowing, eating.

5. What is meant by the term synapse? (1 mark)

6. Explain in your own words, what happens when you put your hand on a hot cooking pot. Why does this happen? (3 marks)

Answers to Assignments

Topic 1 Answers

1. X = Sclera
   Y = Iris
   Z = Pupil

2. (a) Cornea and Lens
   (b) Thin and long when looking at fingernails and fat as well as bulged when looking at a building.
   (c) Rods in the centre of sclera cones at the peripheral points
   Rods for black and white, cones for colour vision

3 (a) Diverging or concave lens
  (b) Converging or convex lens
They would focus the image onto the retina which could otherwise have been focused behind it. The image would that of an object which is nearer or not far from the eye.

Topic 2 Answers

1. Central nervous system and peripheral nervous system

2. It is a tiny pulse of electricity

3. It is an immediate response or reaction of the body to a stimulus

Reflex action **Voluntary action**

Sneezing
Reading
Sweating
Writing
Blinking
Laughing
Contraction of eye pupil

Flushing of skin

4. It is a small gap along the length of a neurone.

5. I withdraw the fingertip or hand from the hot object by reflex action. This is done by the sensory nerve cells which give the message to the spinal cord and from there, the impulses are carried by the motor nerve cell to the muscle in the hand.

Assessment

Assessment

Instructions to Learners

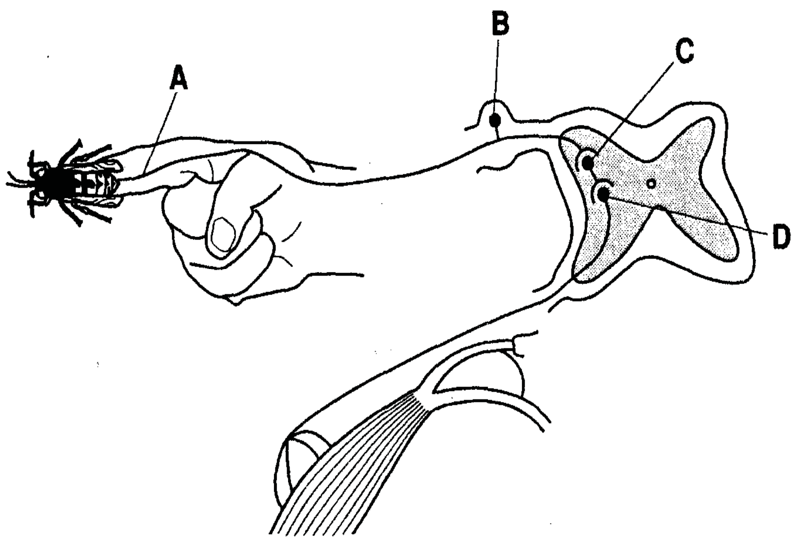
1. Answer all questions in Section A and B.
2. Each question in Section A carries one mark.
3. Answer Section B in the space provided against each question.
4. You may take two hours to do this assignment.

Section A [20 Marks]

Write the correct letter in the box.

1. The diagram shows a simplified example of a reflex arc.

Which part is the relay neuron?



2. The list contains some parts of the human eye.

T: aqueous humour
U: cornea
V: lens
W: vitreous humour

What is the order through which light passes before it reaches the retina?

A	U	T	V	W
B	T	U	W	V
C	V	W	U	T
D	W	V	T	U

3. Which diagram correctly shows the direction of nerve impulses in the two types of nerve cell?

A W and X
B W and Z
C X and Y
D Y and Z

4. Which part in humans detects changes in the environment?

A effectors
B synapse
C receptors
D spine

5. Which part regulates the amount of light entering the eye?
A cornea
B iris
C lens
D sclera

6. What changes take place in the iris of the when a person moves quickly from darkness into bright light?

Circular muscles of the iris	Radial muscles	Diameter of pupil
A contract	relax	increases
B contract	relax	decreases
C relax	contract	decreases
D relax	contract	increases

7. Which part of the eye contains cells which are sensitive to light?

A iris
B lens
C pupil
D retina

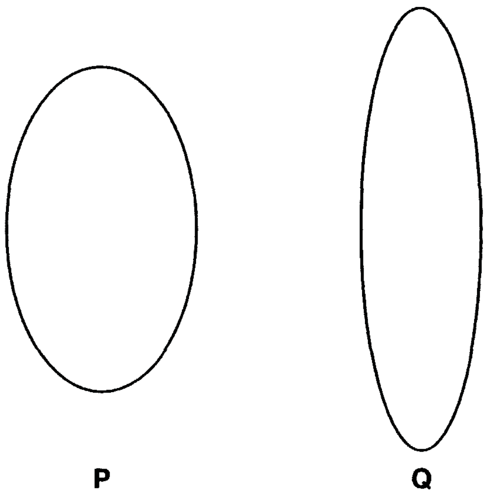
8. Student draws a dot and a cross as shown below.

With his right eye closed, the student looks hard at the cross with his left eye. He brings the drawing towards his eye until the dot disappears.

On which point inside the eye does the image of the dot fall, when it appears?

A Retina
B Fovea
C Optical
D Blind spot

9. The diagram shows eye lenses taken from two individuals.



Which lens was obtained from an individual observing a close object, and what is the process called?

	Lens	Process

A	P	accommodation
B	Q	assimilation
C	P	assimilation
D	Q	accommodation

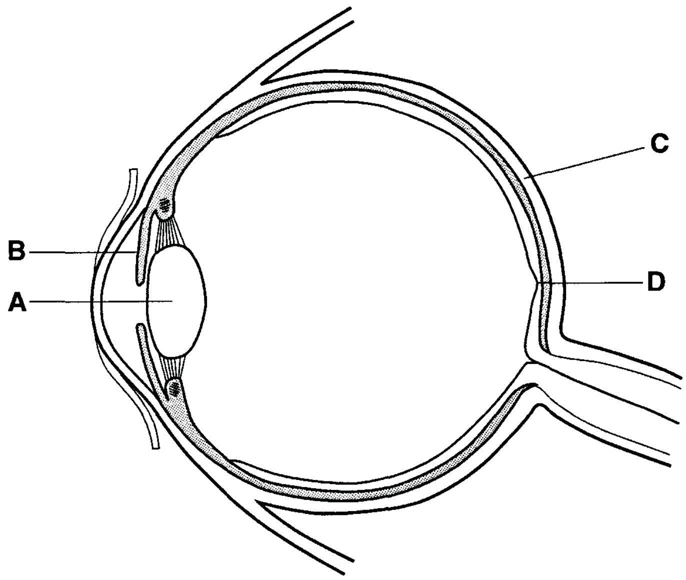
10. Which of the following are specialized cells in sense organs?

A effectors
B nerves
C glands
D receptors

11. Which of the following is reflex action?

A. A child waves to her father who is leaving for work.
B. A cat jumps over a fence when chased by a dog.
C. A boy runs for cover when a gun is fired.
D. A gardener sneezes when cutting a grass.

12. The diagram shows a cross-section through the human eye.
Which part is the fovea?



Section B

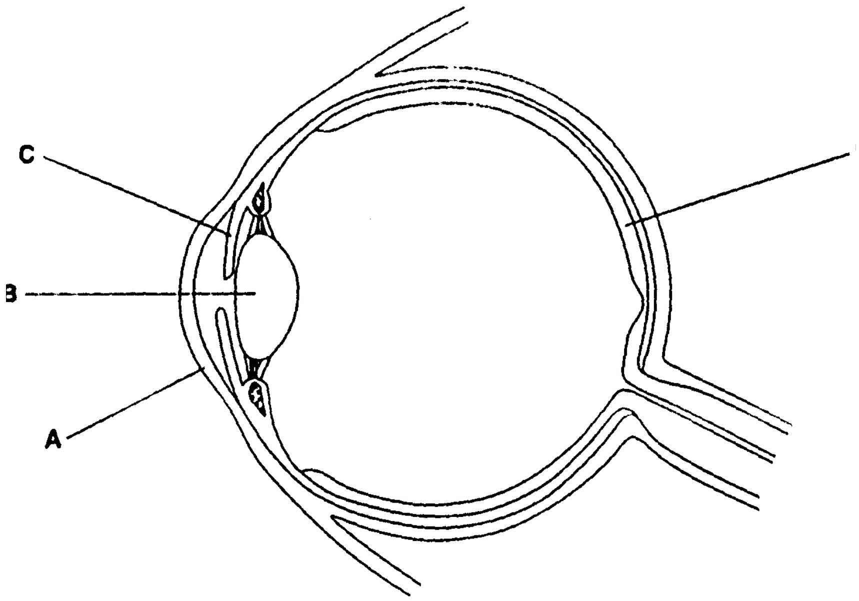
1. Compare table 1 to show the different stimuli and associated sensory organs.

Table 1

Stimulus	Sensory organ
--------------------	Eye
Sound	-----------------------
-------------------	Skin
Taste	----------------------

[4 marks]

2. Fig. 2 .1 shows the eye in section.



(a) State the function of each of the labeled part of the eye.

A---

B---

C---

D---

[4 marks]

(b) Fig 2.2 shows two external views of the eye.

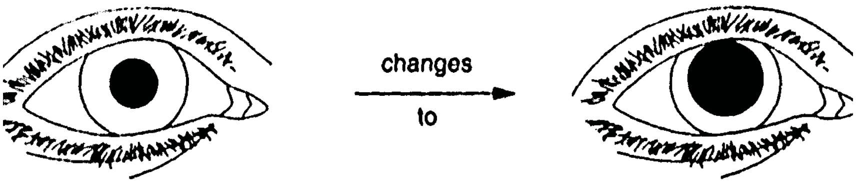


Fig 2.2

The change shown in fig. 2.2 happens when a certain drugs are present in the blood.
Suggest how this could affect a person's vision.

[2 marks]

3. Fig. 3 shows the pathway taken by an impulse in a reflex action.

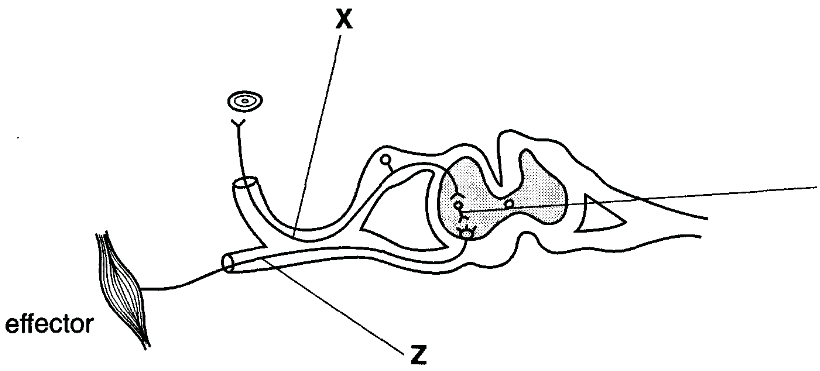


Fig 3

(a) Identify structure Y

-- [1mark]

(b) On the diagram draw arrows to show the direction in which impulses travel at X and Z [1mark]

(c) What is the role of the effector?

---[1mark]

Contents

HSB Unit 8

The Endocrine System

Introduction

Welcome to unit 8 of Human and Social Biology. In this unit you will learn about another body system that can send messages from receptors to effectors. It is slower than the nervous system we learnt about in the previous unit and it sends messages through chemicals and not through electrical impulses like in the nervous system. In this unit we will explain how messages in the endocrine system are carried through chemical substances called hormones. The hormones are produced in special organs called endocrine glands. They are released directly into the blood and not through a tube or duct.

Unlike the other body systems you have studied that are formed by physically linked organs, the endocrine system is made up of glands that are separated from each other. Each gland has a very specific task. Some of the endocrine glands have non-endocrine parts that have a function other than hormone secretion. For example, the pancreas has a major part that produces enzymes as part of the digestive system as well as producing insulin in the endocrine system. The ovaries release eggs in the reproductive system and hormones in the endocrine system. In this unit we will also discuss functions of some of these glands and then compare the endocrine system with the nervous system since both systems deal with the exchange of messages in the body.

Resources:

You will need to refer to diagrams on the reproductive system and hormonal systems you learnt about at Junior Secondary.

Time Frame

It is estimated that to complete studying this unit you will need between 5 to 10 hours. Do not worry if you take longer in finishing this unit. Remember that we all have different abilities and hence we study at different paces.

You are encouraged to spend about 1 hours to answer the assignment in this unit. You will also need approximately 2 hours on the assessment at the end of the unit.

The total hours for completing the unit will thus be between 8 and 13 hours.

Upon completion of this unit you will be able to:

Outcomes

- Describe hormones.
- Identify endocrine glands and the hormones they release.
- Describe functions of adrenaline, testosterone, oestrogen and progesterone.
- Differentiate between the nervous and hormonal control systems.

Terminology

Endrocrine glands	Ductless glands that release hormones directly into the bloodstream.
Hormones work.	Chemical messengers that are produced in small quantities by endocrine glands in one part of the body and transported by the blood to other parts of the body.
Homeostasis	The maintenance of a stable internal environment in the

	body.
Adrenaline	The maintenance of a stable internal environment in the body.
Testosterone	A hormone produced by the testis that causes the development and maintenance of male secondary sexual characteristics.
Oestrogen	A hormone produced by the ovaries that promotes the development of reproductive organs and secondary sexual characteristics in females. It also repairs the uterine wall after menstruation.
Progesterone	A hormone produced by the ovaries that is responsible for stimulating the growth of the lining of the uterus for implantation of embryo. It helps to maintain pregnancy.

Online Resource

If you can get on the internet please utilize the resources at www.hippocampus.org. It is an excellent source of information for biology and the topics discussed in this unit. Here you will find:

- Presentations
- Simulations
- Videos
- Online Study Groups
- Links to Even More Information
- Textbook Correlations
- Online Courses

Topic 1: Hormones and their Functions

Hormones are chemicals needed by the body for various body functions. These chemicals form part of the endocrine system which functions in regulating and maintaining various body functions. You must be able to recall the information you learnt about hormones from your topic on puberty at the junior secondary level. Remember that hormones are released directly into the bloodstream so that they may be carried to other cells and organs where they are needed. Hormones are, therefore, very important because most body functions would not take place without them. Do you recall how it was said that hormones affect the reproductive systems and their functioning? In this lesson we will discuss what hormones are and identify some endocrine glands and the hormones they release. Some of the hormones we will be discussing are the same ones you covered at in junior secondary level.

Learning Objectives:

At the end of the topic you should be able to:

- Describe hormones.
- Identify some endocrine glands and list hormones released by these glands.
- Describe functions of adrenaline, testosterone, oestrogen and progesterone.

Hormones

Hormones are chemical messengers. They are produced in small quantities by endocrine glands in one part of the body and transported by the blood to other parts of the body where they produce an effect. The part where the hormone is transported to produce an effect is called the *target organ*. This is because they are produced specifically to work on that particular organ. Endocrine glands have a rich blood supply through which hormones travel to reach their target organs.

Hormones alter the metabolism of target organs by increasing or decreasing their activity. These changes in activity are strictly balanced to maintain homeostasis (a stable internal environment). To explain how this happens, we will discuss the hormone *insulin*.

We dealt with insulin in unit 3 when we discussed the digestion and assimilation of food. Your also learnt how the hormone is necessary for controlling sugar levels in the body. You will be expected to apply that information here.

Activity 8.1

Do you remember where insulin is produced and what its target organ is?

If so, please write what you remember on the space below.

____

____

What is the function of insulin in the body?

____

____

What disease is caused by lack of insulin in the body?

____

____

Feedback

You should have remembered insulin as a hormone that is produced by the pancreas which acts in the liver.

Insulin travels in the bloodstream to reach its target organ.

It initiates the conversion, by the liver, of excess glucose into glycogen.

Absence of insulin leads to a disease known as diabetes which may lead to death, if untreated.

The importance of hormones in the body is evident from the activity you have just done. Note that in the end we said that absence of the hormone insulin leads to diabetes - a disease that may result in death. This is the case with most hormones - they are there to regulate body functions such as metabolism and growth, thus preventing diseases. We will now look at other hormones which are produced all over the body.

There are many organs which secrete hormones and they include the thyroid glands, adrenal glands, ovaries, testes and pituitary gland. The next diagram highlights some of the main endocrine glands in humans.

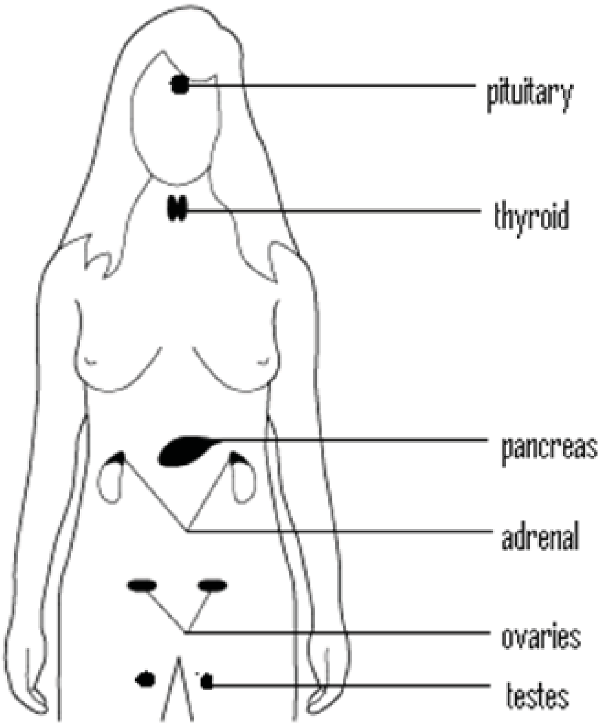


Figure 8.1 Positions of some human endocrine organs

Do you notice how endocrine glands are distributed throughout the body? Do you realize how they are available in almost all regions of the body to cover the organs situated around the body? This is because endocrine glands work on specific organs - endocrine glands are situated near organs on which they work. Remember that there are no ducts to carry the hormones; therefore they travel in the bloodstream. It therefore helps if the place of secretion or production is not far from the place of action.

The table below shows the effects of hormones produced by the endocrine glands pictured above.

Gland	Hormone and influence
Pituitary	Controls other glands. It releases eight different hormones – the main one is endorphin, which helps the body to cope with pain.
Thyroid	Thyroxin is released, which controls body growth and metabolism.
Pancreas	Insulin is released, which controls blood glucose levels by converting excess to glycogen.

Adrenal	Adrenaline is released, which helps the body deal with stressful situations.
Ovaries	Progesterone and oestrogen are released, which control the female reproductive system, secondary sexual characteristics and the menstrual cycle.
Testes	Testosterone is released, which controls male secondary sexual characteristics.

Table 8.1 Table on functions of certain hormones

Do you realize that the glands are not at the target organs but in different places? Remember that earlier we said that hormones travel around the body in the bloodstream to reach target organs and that once they get there they result in several activities that enable the body to function better**.**

The endocrine glands you will learn about in detail are those produced by the adrenal glands, testes and the ovaries. These glands produce the following hormones respectively: adrenaline, testosterone, oestrogen and progesterone. We will discuss them in the next lesson.

Functions of the Hormones Adrenaline, Oestrogen, Progesterone and Testosterone

We said earlier that the body needs hormones to function well and that they perform many various things. In this lesson we will discuss the functions of some hormones in detail so that we may appreciate the role of hormones. Some of the hormones we will learn about in this lesson are those that we can all relate well to because we learnt about them at Junior Secondary Level. We are talking especially about the “sex hormones” or hormones responsible for secondary sexual characteristics, also known as the onset of puberty.

Do you remember what was said about puberty at Junior Secondary Level?

You may remember that it is a stage during which the body develops secondary sexual characteristics. Take a moment to recall some of the changes that happen in both boys and girls at that stage.

Yes, males develop deep voices, beards and muscles. Similarly, females develop breasts and their hips get wider. Both males and females also start getting pubic hairs and they develop a liking for one another.

Also, it was said that these changes are a result of hormones and that they would not occur if it were not for those hormones. What are the names of those hormones?

Don’t worry if you can’t remember them because we are now going to discuss them in detail. We will also discuss a hormone that helps us to deal with stressful situations.

Adrenaline

This hormone is produced by the adrenal glands. The adrenal glands are on top of each kidney. Each gland has a cortex (outer region) and a medulla (inner region). The diagram below shows the position of the adrenal glands on the kidneys.

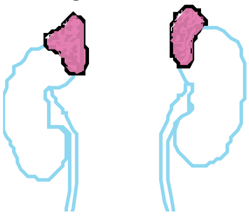


Figure 8.2 Kidneys showing position of adrenal glands

Have you ever heard someone saying to another person, "You have too much adrenaline in your blood?" If you have, what do you think the person would be implying?

What the person is saying that (s) he feels that the other person is too excited or aggressive. You should know from your study of the previous unit, on the nervous system, that adrenaline is sometimes called "the fight or flight hormone". Why do you think it is called that?

It is called that because it is produced when you are angry or frightened. It therefore prepares you for action – to fight or to run away (flee).

An increased level of adrenaline causes the following in your body:

- An increased metabolic rate.
- The heart beats faster and blood pressure increases so blood flows faster around the body carrying more oxygen and glucose to the muscle cells.
- Faster and deeper breathing to take up more oxygen and to release carbon dioxide faster.
- Constriction of the arterioles in the skin to divert more blood to muscles.
- Increased rate of conversion of glycogen to glucose to make food available for the release of energy.
- Pupils dilate to allow more light into the eyes.
- Hair muscles contract producing goose bumps/pimples.

Some people say that they sometimes experience these two when they are nervous or frightened:

- Becoming pale in the face.
- Getting funny feelings in the stomach.

Why you think this happens?

If you said that people become pale and feel funny in the stomach due to less blood flowing to the skin and the stomach so that more is taken to the muscles for action, then you are right. Their heart beat goes up and they breathe faster so more blood and oxygen goes to their muscles to give them more energy.

At the same time less blood is sent to the skin and stomach so that all the energy can be focused on the threatening situation.

These effects prepare the body for the "Fight or Flight" response (instant physical activity), enabling the individual to think quicker, fight harder, and run faster. These hormones also constrict the blood vessels supplying the skin, kidneys, gastrointestinal tract, and other areas of the body not needed for the response.

In stressful situations, nerve impulses are sent from the brain to the adrenal glands to release adrenaline into the blood. Examples of such situations can be running away from danger, fighting etc. As adrenaline circulates around the body it affects many organs. This hormone is therefore sometimes referred to as the action hormone; this is because it prepares the body to react to an emergency.

By now you should be able to describe the hormone adrenaline and its functions. We are now ready to discuss the next hormone, testosterone.

Testosterone

Testosterone is a hormone produced by the testis. Since it is produced in the reproductive system, it can also be referred to as a sex hormone. Testosterone triggers the onset of puberty in males.

I am sure you can come up with a definition of puberty. What is it?

You should have remembered it as the stage when reproductive organs start to function or a stage where secondary sexual characteristics develop.

The testes shown in the diagram below produce the hormone testosterone. Testosterone is required for sperm formation and for the development of secondary sexual characteristics, or traits such as beard growth, chest hair, and elongated vocal cords.

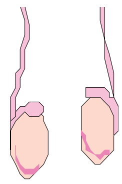


Figure 8.3 Testes

For puberty to take place in males, the testes have to start producing the hormone testosterone. This hormone controls the development of male sex organs and secondary sexual characteristics.

But what do we mean by secondary sexual characteristics?

These are changes that occur when one reaches puberty and some of those in males are:

- Deepening of the voice.
- Appearance of facial and pubic hairs. Pubic hairs are hairs in the arm pits and around sexual organs, that is, around the penis.
- Muscular development, that is, boys become more muscular or rather their muscles become more pronounced.

Can you think of other changes that occur in males when they reach puberty?

____

____

Testosterone also stimulates the testes to produce sperm.

Can you imagine what will happen when someone does not produce this hormone?

Failure to produce this hormone can result in someone not developing adult male characteristics. In some cases they do develop but they are not well defined.

We will now deal with another sex hormone. However, this one is found in females.

Oestrogen

The ovary is the site of oestrogen and progesterone synthesis. Oestrogen is a female sex hormone required to form the ovum (egg) and for preparing the uterus for implanting a fertilized egg. The ovaries are the endocrine glands responsible for producing oestrogen. This hormone is the female version of testosterone. The reason why it is referred to as the female version of testosterone is because just like testosterone, it is responsible for the development of reproductive organs and secondary sexual characteristics which result in puberty.

Write the changes that occur in females as a result of reaching puberty.

____

____

You will get the feedback to your response in the next paragraph.

The ovaries are joined to the uterus or womb as part of the reproductive system. The diagram below shows the position of the ovaries in relation to the uterus and oviducts, which are all part of the female reproductive system.

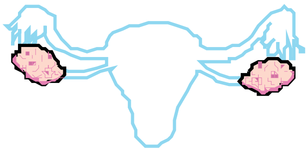


Figure 8.1 Ovaries

Below is what happens in females as a result of oestrogen secretion. All these are the changes that occur in females as a result of reaching puberty.

- Reproductive organs begin to develop. Examples of development can be the thickening of the vaginal walls. Another one is the increase in the size of the clitoris and the vulva, and the development of breasts.
- Repair and growth of the uterine wall.
- More fat is deposited on the hips, thighs, buttocks and breasts.
- The pelvis widens.
- Ovaries start releasing ova, this is known as ovulation.
- Menstruation starts, this is the periodic flow of blood coming from the uterine wall breakdown.
- Overall body growth, though it is not as pronounced as in males.

The activity below provides information on the menstrual cycle and ovulation and requires you to compare the two.

Activity 2:

Compare the processes ovulation and menstruation from the notes below.

The Menstrual Cycle

The menstrual cycle is normally a 28- day cycle. Changes in the levels of oestrogen and progesterone in the blood control the menstrual cycle. The menstrual cycle starts with menstruation, the flow of blood caused when the lining of the uterus breaks down and passes out of the body. Usually around day 14 of the cycle, ovulation occurs and the ovum is released from the ovary. The ovum travels along the oviduct to the uterus. If sperm are present in the oviduct as a result of intercourse, then the ovum becomes fertilized. An unfertilized ovum is passed out of the body. If the ovum is not fertilized the uterus lining disintegrates and menstruation begins again.

Feedback:

Menstruation:

- This is the start of the menstrual cycle which is normally a 28-day long cycle.
- It is the flow of blood caused when the lining of the uterus breaks down and passes out of the body.

Ovulation:

- This is the midpoint of the menstrual cycle in that it usually around day 14 of the cycle.
- It is the release of the ovum from the ovary.

We will now discuss the other hormone produced in the ovaries.

Progesterone

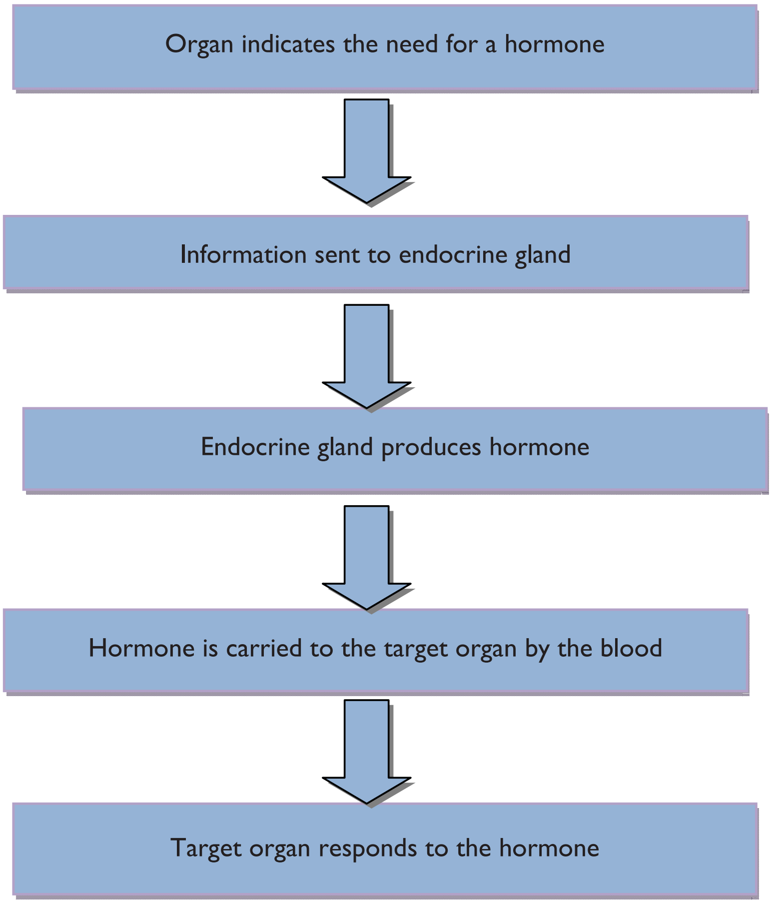
This is another female sex hormone. The ovaries also produce it. Progesterone prepares the breasts for lactation during pregnancy and works with estrogen to regulate the menstrual cycle.

Progesterone stimulates the growth of the lining of the uterine for implantation of the embryo. It also inhibits ovulation and maintains pregnancy.

When the body does not produce enough of this hormone, it can lead to a miscarriage.

Summary:

The flow chart below is a summary of how the endocrine system works:



The diagram also simplifies the production of hormones.

In this topic we also learnt about the roles of some hormones in coordination. Key points to remember are that different hormones have different functions and that they are all vital for the body to function well.

Please remember to attempt the assignment provided at the end of the unit. Please attempt the end of topic assignment before reviewing the answers provided at the end. If any of your answers are incorrect, please revise the relevant section before moving on to the next topic.

In the previous unit we learned about the nervous system and its role in coordination. Now in the next topic we will compare these two types of system, the nervous and the hormonal or endocrine systems.

Topic 2: Comparison of Hormonal and Nervous Control Systems

We have learnt that human beings respond to stimuli in many ways and that their ability to respond appropriately to stimuli depends on both the nervous and the hormonal systems. This is because both the hormonal and nervous systems deal with the control of body functions so that it may function well. In this topic we are going to compare these two systems so that we may understand how they function. You are going to have to remember what you learnt in unit 6 about the nervous system.

Learning Objectives:

At the end of the topic you should be able to:

- Describe the structural differences between the endocrine and the nervous systems.
- Differentiate between functions of the endocrine and nervous systems.

Difference Between Nervous and Hormonal Systems

To start this topic I would like you to think of the following terms - nerves and hormones. What comes to mind when you think of these terms?

You should have said that nerves are specialized cells or neurons that help in transmitting electrical impulses or messages around all parts of the body. Hormones, on the other hand, are chemical messages that are transported between their place of production and the place where they act. We will now look more into the two so as to compare them.

Because the topic focuses on differentiating between the nervous and hormonal system to see how they respond to messages, you are expected to recall a lot of previous content that you studied in this course - especially from Unit 6.

The endocrine system and the nervous system are so closely associated that they are collectively called the neuro-endocrine system. Neural control centers in the brain control endocrine glands. The main neural control center is the hypothalamus, also known as the "master switchboard." Suspended from the hypothalamus by a thin stalk is the pituitary gland. The hypothalamus sends messages to the pituitary gland; the pituitary gland, in turn, releases hormones that regulate body functions.

The next table highlights the differences between these two types of systems.

Comparison of nervous control and hormonal control

Nervous System	Hormone system
Message is a nerve impulse (Electrical)	Message is a hormone (Chemical)
Message travels along nerves	Message travels in the blood
Responses are localized i.e. may be restricted to one target organ.	Responses are wide spread
Responses are short lived	Responses are long lasting

Messages are carried all over the body	Messages are carried to specific effectors
Responses are rapid, e.g. withdrawing arm from a hot object	Responses are often slow, e.g. growth
Maybe voluntary or involuntary	Always involuntary

Table 2: Comparison of Nervous and Hormonal Systems

Let us now briefly elaborate on some of the above mentioned points in detail. One particular difference that we should start with is the fact that nervous responses are localised. By localised, we mean that they affect only a particular part within the body. An example can be the knee jerk reflex. This affects the knee only.

This is unlike in hormonal control where the hormones are released into the blood stream. They are then transported throughout the body and as a result may come into contact with several organs. This is shown by the effect of the adrenaline on the heart, arteries, eyes and the metabolic rate.

Another difference is the fact that the secretion of hormones is an involuntary process. We will use the secretion of one of the sex hormones as an example. One does not have to think about whether they should start producing testosterone in order to develop adult male characteristics or oestrogen so as to develop adult female characteristics. The production and secretion of these hormones just happens without any conscience decision from us.

Even when you are frightened, the glands just secrete adrenaline without you having to think about it. It just happens automatically.

There is an endocrine gland that is important in discussing the difference between these two systems and it is the hypothalamus.

The main function of the hypothalamus is to link the nervous system and the endocrine systems. It constantly checks that the body systems function well and the body has a stable internal environment (homeostasis). The outcome of this checking is communicated (mainly) to the pituitary gland. This gland will produce/release the hormones (the chemical messengers) to carry information to target organs and tissues. The target organs/tissues will respond to the input information (the message from the hormones).

Summary:

Although we rarely think about the endocrine system, it influences almost every cell, organ, and function of our bodies. The endocrine system is instrumental in regulating mood, growth and development, tissue function, metabolism, and sexual function and reproductive processes.

In general, the endocrine system is in charge of body processes that happen slowly, such as cell growth. Faster processes like breathing and body movement are controlled by the nervous system. But even though the nervous system and endocrine system are separate systems, they often work together to help the body function properly.

Please remember to attempt the assignment provided at the end of the unit. Please attempt the assignment before reviewing the answers provided at the end.

Unit Summary

Summary

In this unit you learned that:

- The endocrine system is a group of hormone producing glands known as endocrine glands.
- The endocrine glands release the hormones produced directly into the blood stream – no ducts or tubes are involved. These glands are therefore called ductless glands.
- The endocrine system's main function is to regulate many aspects of metabolism, growth, fluid balance and reproduction.
- Hormones are chemical message carriers that tell target organs what to do in order to maintain a balanced stable situation in the body (homeostasis).
- Testes are male glands which produce the hormone testosterone whilst ovaries are female glands which produce oestrogen and progesterone.
- These hormones are responsible for the development of secondary sexual characteristics. As a result of this, they are sometimes called sex hormones.
- Adrenal glands produce the hormone adrenaline. This hormone prepares the body for action in an emergency situation.
- Most hormones produce their effects slowly. They bring about long term changes in the body such as growth, sexual development and so on.
- Some hormones are quick acting, e.g. insulin and adrenaline.
- Most hormones do not last for very long in the blood stream. Enzymes break them down and the kidneys excrete the products of this breakdown.

Please remember to attempt the assessment at the end of the unit. Please attempt the assessment before reviewing the feedback given.

Assignment

Assignment

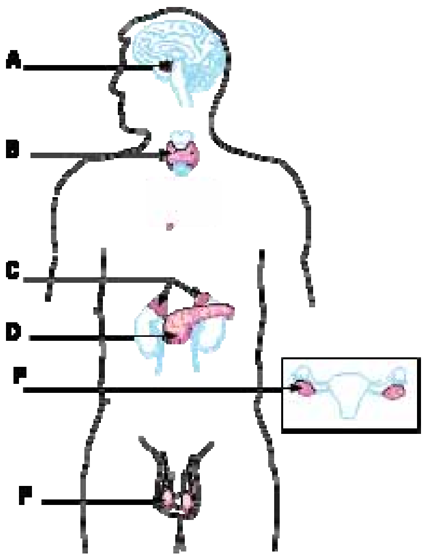
Topic 1 Exercise

1. The table below shows some hormones and their actions, complete it by filling out the missing areas.

Endocrine gland (hormone)	**Target organs**	**Action**
Adrenal gland (adrenaline)	Vital organs – eg. liver and heart	
Pancreas (insulin / glucagon)	Liver and muscles	
Ovaries (oestrogen)		Controls development of sex organs and secondary sexual characteristics during puberty. Controls the menstrual cycle.
	Male reproductive organs	Controls development of sex organs and secondary sexual characteristics during puberty.

(4 Marks)

2. Name the endocrine glands labeled A to F. (6 Marks)



3. Why are endocrine glands called ductless glands? (2 Marks)

Topic 2 Exercise:

1. Why is the endocrine gland called “ductless’?

2. Write two similarities between the endocrine and the nervous systems.

3. Complete the table below.

	BOYS	GIRLS
List four changes that occur at puberty.		
Name the hormones that bring about these changes.		
Name where the hormones are produced		

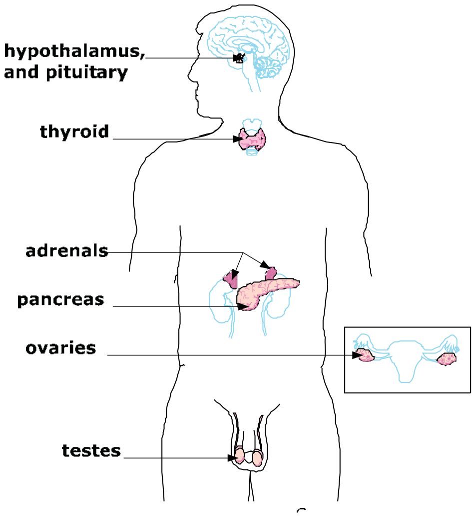
Responses to Assignments:

Topic 1 Exercise

1.

Endocrine gland (hormone)	**Target organs**	**Action**
Adrenal gland (andrenaline)	Vital organs – eg. liver and heart	Prepares body for action ('fight or flight')
Pancreas (insulin / glucagon)	Liver and muscles	Controls blood sugar levels by increasing / decreasing uptake of glucose
Ovaries (oestrogen)	Ovaries, uterus	Controls development of sex organs and secondary sexual characteristics during puberty. Controls the menstrual cycle Maintains womb-lining
Testes (testosterone)	Male reproductive organs	Controls development of sex organs and secondary sexual characteristics during puberty.

1.



2. These glands are called ductless glands because they do not have any ducts or tubes by which they can take hormones directly to target organs. They just release the hormones into the bloodstream for them to travel to the target organs.

Topic 2 Exercise:

1. Endocrine glands are called ductless because they do not have ducts or tubes that carry or conduct the hormones, they just pour them into the blood system.

2. Both endocrine and nervous systems respond to stimuli, both control specific functions of the body.

3.

	BOYS	GIRLS
List four changes that occur at puberty.	Any four of the following: Development of muscles Chest and shoulders become broader Deeping of the voice Growth of pubic hair Enlargement and development of sexual organs	Any four of the following: Body becomes more rounded Breasts develop and enlarge Growth of pubic hair Enlargement of pelvic area resulting in wider hips Ovulation, followed by menstruation begin

	Sperm production	
Name the hormones that bring about these changes.	Testosterone	Oestrogen
Name where the hormones are produced	Testes	Ovaries

Assessment

Assessment

1. Name a hormone directly responsible for each of the following? [4 marks]

   (a) Causing breast to develop in females

   ____

   (b) Increasing metabolic rate

   ____

   (c) Lowering the concentration of blood glucose level

   ____

   (d) Causing hair to grow in the chest of males

   ____

2. What in the hormonal system is equivalent to each of the following in the nervous system? [2 marks]

   (a) Nerve impulse ________________

   (b) Nerve fibre ________________

3. Nerves and ductless glands both provide a way of sending message from one part of the body to another. Write down four differences between the two systems.

   ______________________________________ [4 marks]

   ____

   ____

   ____

4. While walking to school, Kago encountered a very large hyena which had strayed from the game reserve.

   (a) What would happen to the level of adrenaline in his blood? [1 mark]

   ____

   (b) Why? [2 marks]

   ____

   ____

   ____

   ____

   (c) What would happen to the blood flow to the muscles and the skin? [2 marks]

____

____

Total = [15 Marks]

Answers to TMAss

1. a) oestrogen

b) thyroxin

c) insulin

d) testesterone

2. a) hormone

b) blood stream

3.

Nerves	**Ductless glands**
Message is a nerve impulse (Electrical)	Message is a hormone (Chemical)
Message travels along nerves	Message travels in the blood
Responses are localised i.e. may be restricted to one target organ	Responses are wide spread
Responses are short lived	Responses are long lasting
Messages are carried to specific effectors	Messages are carried all over the body
Responses are rapid Maybe voluntary or involuntary	Responses are often slow Always involuntary

4. a) The level of adrenalin would go up.

b) This would be a reaction of the body so that it is prepared to deal with the situation.

c) Blood flow to the muscles would increase so that the muscles get more oxygen and glucose to either run or fight back.

Blood flow to the skin is reduced so that more blood is carried to the muscles.

Contents

HSB Unit 9

Homeostasis

Introduction

You are now only five units away from completing your Human and Social Biology course. In the first three units you studied the characteristics of living things, nutrition and diet, and digestion and absorption of food. In the next units, you will learn about the different systems of the body; namely the respiratory, circulatory, skeletal, nervous, and endocrine systems. In this unit you will study homeostasis.

Homeostasis is defined as the maintenance of a constant internal body environment. This is the statement you will come across many times in this unit. The unit is divided into two topics. The first topic describes homeostasis in the body and how it is regulated by different organs. This includes what you learned in units 3 and 8 about how the hormones insulin and glucagon regulate blood glucose level. The second topic focuses on the skin and how it keeps body temperature constant.

Teaching Approach

Like in most of the units that you have already studied in this course, the teaching approach used in this unit is learner centered. It is meant to encourage you to find information on your own as well as develop your own ways of studying. This will motivate you to carry on with your studies and to apply the skills acquired to your everyday life. Most of the units are related so there will be references to previous units. Also note that what you learned at lower levels (e.g. Junior Certificate) and what you experience on a daily basis will form a foundation to the teaching and learning approach.

This unit contains six activities and in text questions that will help you recall and apply what you are learning as you progress through the unit. The activities may be in the form of small experiments that relate your daily life experiences to the course content. Remember that this unit is not a standalone from the other units of this course. An understanding of previous topics will help you have a continuous learning experience.

At the end of each topic in this unit, there is an assignment that will further test your understanding of the topic content. You can complete the assignment and discuss the answers (which are provided at the end of the unit) with your peers. This can be done at the learning centers if you are not very far from them. At the end of the unit, complete the assessment test and mail it to your local college of distance learning for marking.

Time Frame

It is estimated that to complete studying this unit you will need between 5 to 10 hours. Do not worry if you take longer in finishing this unit. Remember that we all have different abilities and hence we study at different paces.

You are encouraged to spend about 2 hours to answer the assignment in this unit. You will also need approximately 3 hours on the assessment at the end of the unit.

The total hours for completing the unit will thus be between 10 and 55 hours.

Upon completion of this unit you will be able to:

Outcomes

- *Name* the different organs responsible for keeping internal body conditions constant.
- *Describe and explain* how the body regulates its temperature.

Terminology

Hypothalamus: Is a part of the cerebrum in the brain which controls involuntary action and links the nervous and endocrine systems. It also detects changes in the internal environment.

Hormone: A chemical released often into the blood by endocrine glands to affect the activities of one or more target organs.

Endocrine gland: A ductless gland in the body that secretes hormones.

Anti-diuretic hormone (ADH): A hormone produced by the pituitary gland to regulate water re-absorption in the kidneys.

Pituitary Gland: An endocrine gland located in the mid brain.

Online Resource

If you can get on the internet please utilize the resources at www.hippocampus.org. It is an excellent source of information for biology and the topics discussed in this unit. Here you will find:

- Presentations
- Simulations
- Videos
- Online Study Groups
- Links to Even More Information
- Textbook Correlations
- Online Courses

Topic 1: Homeostasis

As we have already stated in the introduction, homeostasis is the maintenance of a constant internal body environment. For body cells to function properly, certain conditions in the body have to be kept within a specific range. Recall regulation of blood glucose level from unit 3 (Digestion and Absorption of Food). You learned that the liver lowers blood glucose level if it is too high, and increases it when it is too low. It is not only glucose that needs to be kept constant. The amount of water and temperature in the body also has to be monitored.

In this topic we are going to learn about the different organs responsible for keeping the above mentioned conditions within acceptable range.

Learning Objectives

At the end of the topic you will be able to:

- Define homeostasis.
- Locate and label organs involved in homeostasis in diagrams.
- List the roles of the different organs involved in homeostasis.

Homeostasis

To help you get started with this section, first do the following activity to help you recall what was discussed in the unit and topic introductions.

Activity 1

We have already defined the term homeostasis. Refresh your memory by writing down the definition in the space below.

………………………………………………………………………

………………………………………………………………………

……………………………………………………………………....

………………………………………………………………………

………………………………………………………………………

Feedback: You got it right if you wrote "the maintenance of a constant internal body environment". The question probably going through your mind is what the internal environment is or what constitutes the internal environment.

To try and answer the first part, we can say that our body's internal environment is the conditions in which our body cells operate. For the second part, it is factors such as body temperature, blood glucose concentration, pH, oxygen levels, and concentration of wastes such as carbon dioxide and urea that make up our body's internal environment.

Homeostasis is the body's ability to keep these factors within a range suitable for the proper functioning of the body cells. For this to be possible, the body needs to be able to detect any extreme changes in the internal environment so as to bring it back to the required range.

In unit 7 you learned that your body detects and adjusts to changes in the **external** environment; for example, feeling cold and putting on a jacket. In unit 3 you learned that when blood glucose levels exceed the normal level for good health, which is 85 mg of glucose per 100 ml of blood, it will be detected by the brain which instructs the cells within the pancreas to start secreting a hormone called insulin. The insulin circulates in the blood to the liver, where it stimulates the liver cells to extract excess glucose from the blood and convert it to glycogen for storage. In both these instances, changes to the body's environment have been regulated: in the first instance the wearing of a jacket returns the temperature to normal, while in the second, the liver with the help of insulin returns the glucose level to normal.

During homeostasis, the hypothalamus in the brain detects any changes in the internal environment and sends messages to the responsible organs to counteract the change. This process of detecting change and normalizing the conditions is known as **negative feedback** and we discuss how it occurs in the next section.

Negative Feedback

The corrective action by the body to detect change and normalize the internal environment is known as **negative feedback**. The feedback system has sensors or a regulatory centre that detects any changes in the internal environment. It then sends messages (in the form of hormones or electric impulses) to the effectors which will normalize the situation. The feedback is called negative feedback because when the effectors normalize the situation, the effect is the negative (or opposite) of what was happening. The hypothalamus is usually the sensor that detects changes in body temperature, blood water concentration, etc. The different homeostatic organs which normalize the situation are the effectors. These will be highlighted in the next section.

EXAMPLE OF NEGATIVE FEEDBACK IN THE KIDNEYS

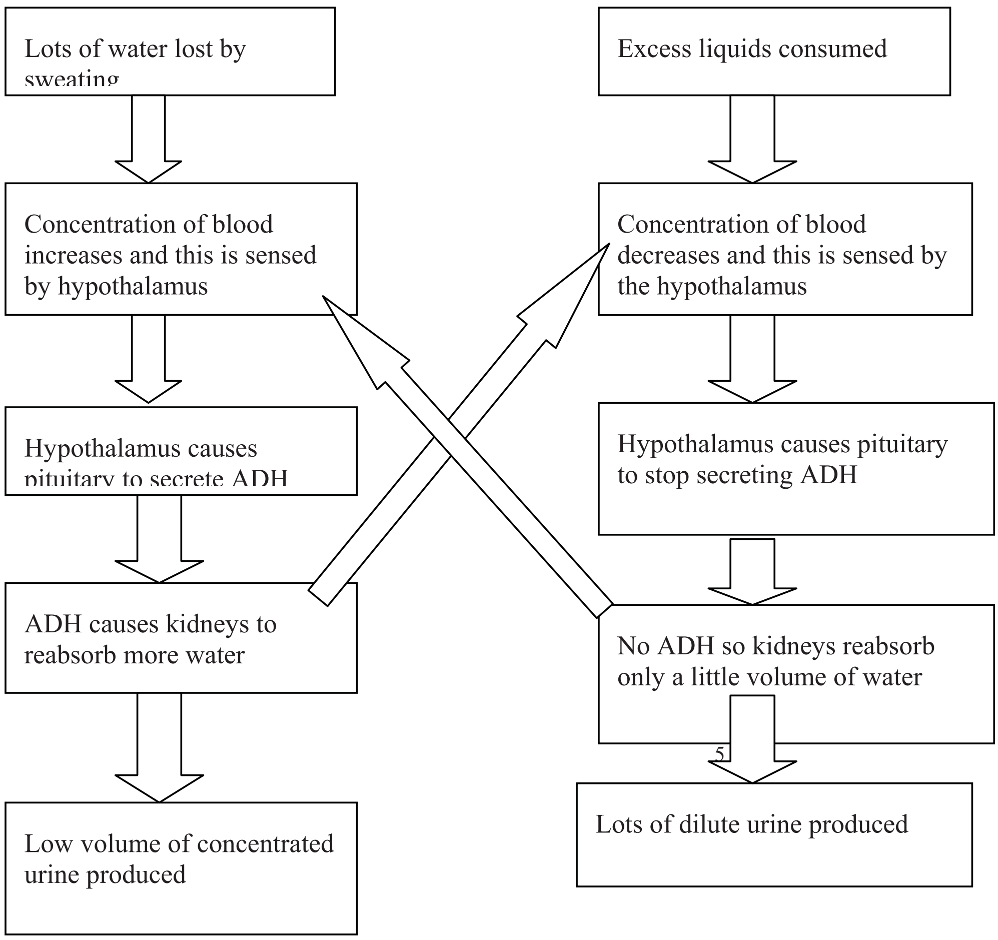


Fig. 1: Negative Feedback in Kidneys

Although you will learn the details of how the kidneys regulate blood water concentration in the next section, the above diagram summarizes how this happens. The boxes on the left show what happens when there is less water in the blood (blood is concentrated), while the ones on the right show step by step what happens when there is too much water in the blood. The two crossing arrows at the center show the effect that ADH can have on blood concentration. It can change the condition from positive to negative.

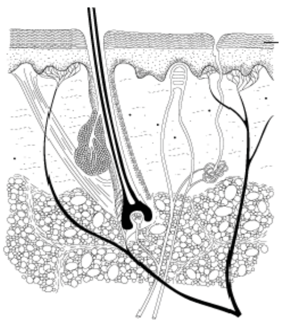
In the next section, we will briefly look at the various organs that play a role in the process of homeostasis.

Organs Responsible for Homeostasis

There are several organs involved in the maintenance of a constant internal environment. As stated in section 1.1 above, these are coordinated by the brain and they act as effectors of the messages from the hypothalamus to normalize the situation.

The Skin

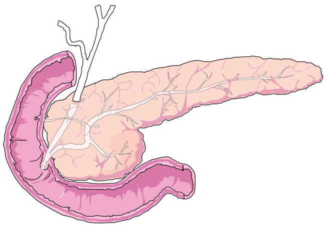
The skin (shown in the diagram on the left) is responsible for the maintenance of a constant body temperature. There are various processes that occur in the skin that ensure the body temperature is increased if it is too low or decreased if it is higher than normal. We are going to discuss these processes in detail in the next topic.



2.2 The Kidneys

The kidneys (see diagram below) and the urinary system are responsible for the regulation of the blood water concentration and the concentration of urea in the blood. If there is too much water in the blood it will get filtered out and excreted as urine. Alternatively, if the blood is too concentrated water will be reabsorbed back into the blood. The kidneys also excrete urea and maintain blood pH (a metabolic waste product), thereby keeping its concentration in blood at acceptable levels.

2.3 The Pancreas



You have learnt in units 3 and 8 that the pancreas (which is depicted below), together with the liver, regulates blood glucose concentration. You should, therefore, find it easy to complete Activity 2.

Activity 2

Name the hormone released by the pancreas (i) when the blood glucose level is high, and (ii) when the blood glucose level is low.

(i)……………………………………….
(ii)……………………………………..

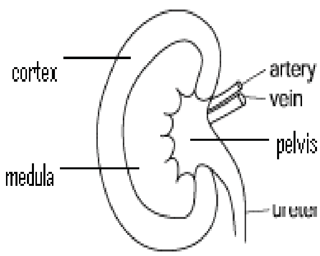
Feedback:

I am sure that from what you learned in Units 3 and 8 you were able to provide the correct answers to these questions. These are:

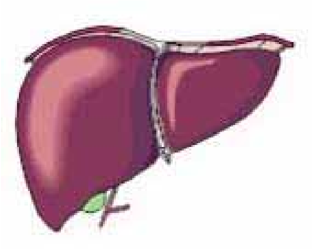
(i) Insulin (ii) glucagon

The Liver

Just to refresh your mind, when the blood glucose level is high, the pancreas releases the hormone **insulin**, which makes the liver convert excess glucose to glycogen, thus lowering the blood glucose level. When the blood glucose level is low, the pancreas releases the hormone **glucagon** which makes the liver (see diagram below) convert stored glycogen to glucose, thus increasing the blood glucose level. This ensures that the glucose level in the body is neither too

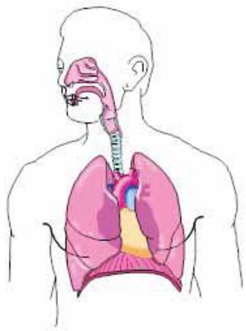


low nor too high.



The Lungs

The lungs are responsible for the removal of carbon dioxide from the blood, thereby minimizing its concentration in the body. The lungs also allow diffusion of oxygen into the blood, ensuring it is maintained at a reasonable concentration.



Acknowledgement: All the in- text diagrams above come from the Cambridge International Examinations Science Diagrams for Examiners and FCTVE workbooks.

Summary

In this topic, we learned that **homeostasis** is the maintenance of a constant internal environment. This includes keeping factors like temperature, blood water concentration and blood glucose concentration constant. The hypothalamus in the brain is responsible for detecting these changes (acts as the sensor) and sending messages to the homeostatic organs (effectors) to normalize the situation. These organs include the skin, the kidneys, the pancreas, the liver, and the lungs.

We have now come to the end of the first topic. Please do assignment 1 which you will find at the end of the unit to remind yourself of what you have learned so far. You may do this with your colleagues taking the same course if they are in your area. Once you have completed the assignment, check your answers against those provided. You can also discuss these answers with your colleagues. Make revisions to any incorrect answers before moving on to topic 2.

Topic 2: Regulation of Body Temperature

In this topic we are going to learn about temperature regulation in human beings. Human beings maintain their internal temperature at about 37°C. This temperature must be kept constant, despite fluctuations in the environmental conditions, because processes and reactions in body cells can only take place within a narrow temperature range. Various body organs play an important role in maintaining a constant body temperature, and the skin is one of them. These organs were introduced in topic 1. Our main focus in this topic will be the skin and how it regulates our internal body temperature. Recall from the first topic that the skin brings the temperature down when it is high, and helps raise it when it is low.

Learning Objectives

At the end of this topic you should be able to:

- Define regulation of body temperature as maintaining a steady internal body temperature by balancing heat generation and heat loss.
- Describe the maintenance of a constant body temperature in human beings.
- Discuss the coordinating role of the brain in maintenance of a constant body temperature.
- Identify and label on a diagram of the skin: hairs, sweat glands, receptors and blood vessels.
- Describe the effects of vasoconstriction and vasodilation of blood vessels in the skin.
- Relate the evaporation of sweat to the concept of heat loss.
- Describe the loss of heat through the lungs during breathing.

Maintenance of a Constant Body Temperature

As already stated, it is important for body temperature to be kept constant for the proper functioning of body cells. The body is able to maintain body temperature constant by balancing heat generation and heat loss. This is achieved through:

a) Generating more heat through increased metabolism (e.g. respiration) and muscular contractions (e.g. shivering).
b) Regulating the amount of heat lost to the environment.

Once these are balanced, the body temperature is maintained at around 37°C. All these processes are coordinated and controlled by the brain. The hypothalamus senses any changes in blood temperature and will trigger the corrective responses.

The next subtopic will discuss the skin and its processes in maintaining body temperature in more detail.

The Skin

The skin is the largest organ in the body. Although very thin in appearance, the skin is made of several layers. In Figure 1 below, you will see that the outermost layer is the **epidermis.** This layer is subsequently divided into three sub layers, the cornified layer, granular layer and the germinative (malpighian) layer.

Under the epidermis is the **dermis**. These two main layers, the epidermis and dermis, make up the skin. Beneath the skin is a tissue of fat cells known as the adipose tissue/layer. This is also shown in **Fig. 1** below.

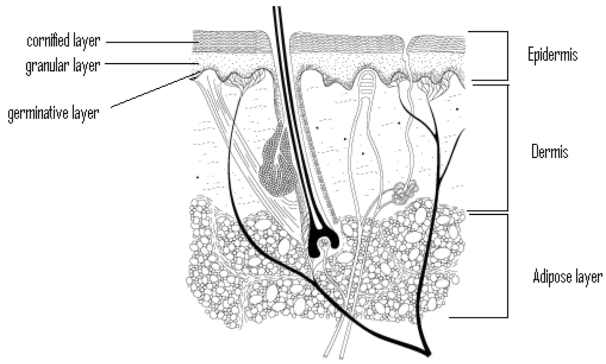


Fig. 1: Layers of the Skin (Cambridge International Examinations Science Diagrams for Examiners)

As you are now familiar with the skin, do the following activity to remind yourself of the functions.

Activity 1

List the general functions of the skin.

…………………………………………………………………

…………………………………………………………………

…………………………………………………………………....

…………………………………………………………………

……………………………………………………………………

Feedback: *We are sure you were able to answer this question from your previous and general knowledge. We hope you were able to list most of the functions. If you had forgotten some of the functions, check our list below and amend your list accordingly. If you have all of them on your list, that is good!*

The general functions of the skin are:

- *Protection against infection*
- *Sensing external stimuli*
- *Temperature regulation*
- *Maintaining a water proof barrier*
- *Protection against ultra-violet rays*

The diagram below (Fig. 2) shows the detailed parts of the skin. The image is the same as the one in Figure 1, however the parts of the dermis are labeled in detail instead. Study Figure 2 and note the parts of dermis. You will later discover how most of these are involved in temperature regulation.

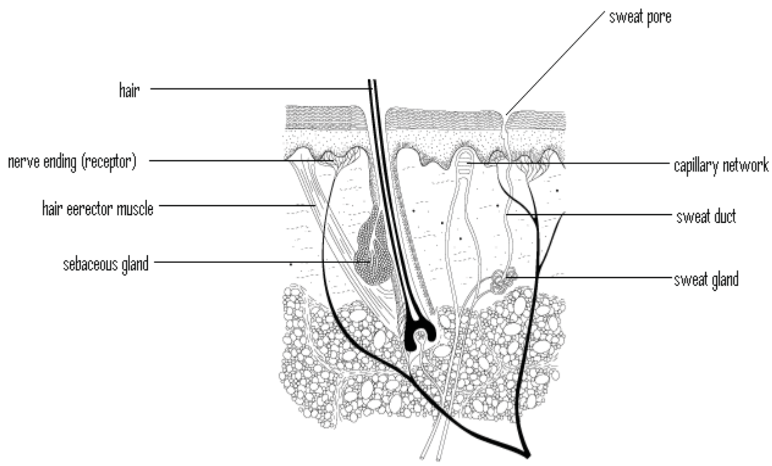


Fig. 2: Parts of the Skin (Cambridge International Examinations Science Diagrams for Examiners)

In the next section, we will discuss how the skin responds to an increase in temperature.

Reaction to Increase in Body Temperature

If the body temperature increases beyond 37°C, the body will respond by lowering it. Do you still remember what we call this kind of adjustment? Yes, we said it is homeostasis. In this section we will look at some of the processes that take place in the body to bring down internal temperature. Increases in temperature are sensed by the hypothalamus, which will trigger the processes discussed next: vasodilation and sweating.

Vasodilation

This is the widening of arterioles that bring blood to the skin. The arterioles are the blood vessels that bring blood to the capillary network shown in Figure 2 above. As they widen, blood flow to the skin is increased, and therefore more heat is brought to the skin. The heat will then be lost from the skin surface by radiation, thus reducing internal body temperature.

Increased sweating

Complete the activity below as it will help you relate your daily life experiences with what we discuss in this section.

Activity 2

What usually happens when you are feeling very hot? This can be due to walking in the heat, running, or when it is just a hot day. Write down what happens below.

……………………………………………………………………

……………………………………………………………………

Feedback: You got it right if you said you sweat a lot when you feel hot.

When it is very hot, the sweat glands absorb more fluid from the capillaries that surround them. More sweat is then produced and conducted up the sweat duct to the skin surface. As the sweat evaporates from the skin surface, the body is cooled. Fig. 3 below shows a dilated blood vessel of the skin (as explained in 3.1 Vasodilation) and some sweat produced. This is the sweat that, upon evaporation, cools the body.

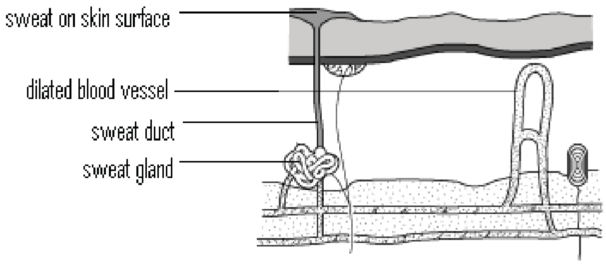


Fig. 3: Vasodilation and sweating (Cambridge International Examinations Science Diagrams for Examiners)

You have learned that vasodilation and increased sweating are the two processes that take place in the body to bring down body temperature. In the next section, we will discuss how the skin responds to a decrease in temperature.

Reaction to Decrease in Body Temperature

If human internal body temperature falls below 37 °C, this is again sensed by the hypothalamus, which will trigger the following processes to return the temperature to normal. Vasoconstriction and reduced sweating are the opposite processes of what occurs in response to increased body temperature (which we have just discussed above).

Vasoconstriction

This is when arterioles that supply the skin with blood become narrow. This reduces the amount of heat brought by blood to the skin. This will in turn reduce the amount of heat lost from the skin surface by radiation.

Reduced Sweating

As less blood will be flowing towards the skin surface due to vasoconstriction, the sweat glands absorb less fluid from the capillaries that surround them. Less sweat will be produced, and therefore very little will be excreted to the skin surface. The body will therefore not be cooled by evaporation of sweat, thus conserving heat.

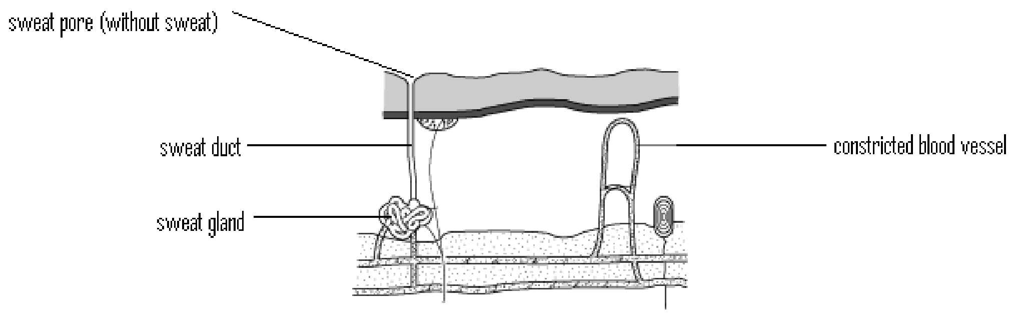


Fig. 4: Vasoconstriction (Cambridge International Examinations Science Diagrams for Examiners)

Do activity 3 below. This is meant to help you appreciate the diagrammatic representations of vasoconstriction and vasodilation.

Activity 3

Compare the size of the blood vessel shown in **Fig. 3** with that of the one shown in **Fig. 4** above. Write the difference in the space below.

…………………………………………………………………

…………………………………………………………………

………………………………………………………………....

…………………………………………………………………

*Feedback: You should have written that the blood vessel in **fig. 3** is wider (exhibits vasoconstriction) than the one in **fig. 4** (exhibits vasodilation).*

Shivering

You may remember how you used to tremble in your cold primary classroom during the winter. Your whole body would be shaking, and some of your classmates would even be crying. That trembling is called shivering. Shivering is the spasmodic contraction of body muscles, which happens when one is very cold. As the muscles contract, they generate heat which warms the body and helps to return body temperature to normal.

Note,that shivering does not necessarily occur in the skin, but in all body muscles. Nonetheless, it plays an important role in generating heat and increasing body temperature.

Hairs in Regulation of Heat Loss

In hairy/furry mammals, the hairs on the skin also play an important role in regulating body temperature.

- When it is cold, the hair erector muscles contract and pull the hairs upright. This forms a canopy above the skin surface and traps warm air. As air is a poor conductor of heat, this warm air forms an insulator that reduces heat loss from the skin.

  NB In human beings, goose pimples appear when the hair erector muscles contract because of the small amount of hair present on the skin.

- When it is hot, the hair erector muscles relax and the hairs lie flat on the skin surface. This allows the wind to carry warm air away from the skin surface. This allows the skin to cool and return body temperature back to normal.

The activity in the next section is a very easy demonstration of how breathing contributes to heat loss. We trust that you will find it useful in clarifying the explanation that follows.

Breathing and Heat Loss

Breathing out (exhaling) contributes to heat loss. Perform the following activity to test this.

Activity 4

Take a deep breath.

Now cover your mouth with the back of your hand.

Breath out (exhale) onto the back of your hand.

What do you feel?

Write your answer on the space below.

…………………………………………………………………

…………………………………………………………………

……………………………………………………………….…

Feedback

You should have written that you felt warm air on the back of your hand.

You may be asking yourself why the air is warm. The exhaled air comes from the lungs, which received its components from the blood. Recall that one function of blood is to distribute heat around the body, so gas diffusing into the lungs is warmed from the blood. This means that the body loses some heat through breathing.

Summary

In this topic we learned about parts and layers of the skin and how it regulates body temperature. When it is cold, the following processes are triggered:

- Vasoconstriction
- Decreased sweat production
- Skin hairs becoming upright
- Shivering

When one is feeling hot, the following processes are triggered:

- Vasodilation
- Increased sweat production
- Skin hairs lying flat

We also learned that the hypothalamus in the brain senses the changes in body temperature and will trigger the above mentioned processes to normalize the situation.

We have now come to the end of topic 2. Please do assignment 2 below to help you revisit what we have discussed in this topic. Follow the same procedure that we recommended in topic 1 to check and correct your answers.

Unit Summary

Summary

In the first topic, we learned that **homeostasis** is the maintenance of a constant internal environment. This includes keeping factors like temperature, blood water concentration, and blood glucose concentration constant.

We also learned that the hypothalamus in the brain (sensor) is responsible for detecting these changes and sending messages to the homeostatic organs (effectors) for regulation. These organs include the skin, the kidneys, the pancreas, the liver, and the lungs.

In the second topic we learned about parts and regions/layers of the skin. We also learned of the roles played by the skin in temperature regulation.

When it is cold, the following processes are triggered: vasoconstriction, decreased sweating, shivering and erection of skin hairs.

When one is feeling hot, the following processes are triggered: vasodilation, increased sweat production and skin hairs lying flat.

At the end of this unit is an assessment exercise for the entire unit. Complete and submit it directly or by mail to your local college of distance learning.

We wish you the best of luck, and prepare yourself for the next unit which discusses the excretory system.

Assignment

Assignment

Assignment 1

1. Define the term homeostasis.

   ……………………………………………………………
   …………………………………………………………(2)

2. Which organ is responsible for:
   a) Maintaining constant body temperature?

      ……………………………………………………………
      ……………………………………………………… (1)

   b) Maintaining constant blood water concentration?

      ……………………………………………………………
      ……………………………………………………… (1)

3. Name two hormones released by the pancreas to normalize blood glucose level.

   ……………………………………………………………
   ……………………………………………………………(2)

4. Which organ do the hormones from your answer to #3 affect?

   ……………………………………………………………
   …………………………………………………………… (1)

5. Name the part of the brain responsible for detecting most of the changes in the internal body environment.

   ……………………………………………………………
   …………………………………………………………… (1)

6. Apart from regulating blood water concentration, what else do the kidneys do?

   ……………………………………………………………

…………………………………………………………(1)

7. Name the waste removed by the lungs to keep its concentration in the body constant.

……………………………………………………………
…………………………………………………………(1)

Total [10 marks]

Assignment 2

1. Define the following terms:
   a) Vasoconstriction

   …………………………………………………………
   …………………………………………………………
   ……………………………………………………..(2)

   b) Vasodilation

   …………………………………………………………
   …………………………………………………………
   …………………………………………………… (2)

2. Give two processes, other than vasodilation, that occur in the skin to return body temperature to normal when it is hot.

   ……………………………………………………………
   ……………………………………………………………
   ……………………………………………………….. (2)

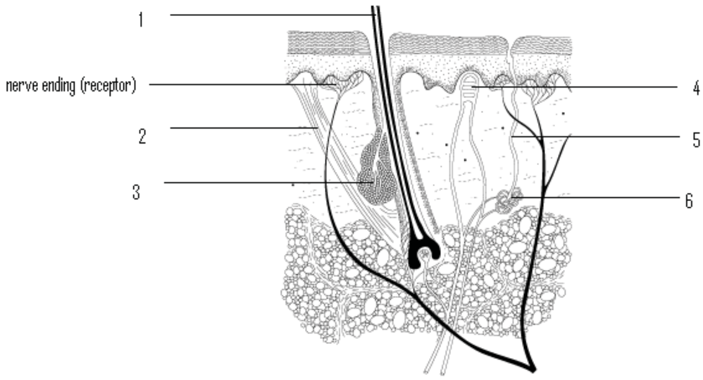
3. Name the part of the brain which detects changes in body temperature.

   ……………………………………………………………
   ……………………………………………………………
   ………………………………………………………... (1)

4. Give any two general functions of the skin apart from temperature regulation.

   …………………………………………………………
   …………………………………………………………
   ……………………………………………………… (2)

5. Label the parts number 1 to 6 on the diagram below.



(6)

Total [15 marks]

<u>Answers to Assignments</u>

Assignment 1

1. Maintenance of a constant internal body environment.
2. a) skin b) kidneys
3. insulin and glucagon
4. liver
5. hypothalamus
6. excrete urea
7. carbon dioxide

Assignment 2

1. a) Narrowing of blood vessels that supply the skin with blood.

   b) Widening of blood vessels that supply the skin with blood.
2. increased sweating and skin hairs lie flat
3. hypothalamus
4. sense organ, protection against infection, waterproof, protection against ultra violet rays (any two)
5. 1. hair, 2. hair erector muscle, 3. sebaceous gland, 4. capillary (network), 5. sweat duct, 6. sweat gland

Assessment

Assessment

Human and Social Biology

Assessment for Unit 9

Section A **[10 marks]**

1. What role does shivering play in temperature control?

   A. Decreases rate of heat conduction
   B. Increases rate of heat conduction
   C. Generates heat by muscle contractions
   D. Uses energy for muscle contraction

2. Which of the following organs are associated with the control of glucose level in the blood?

   A. Skin, liver, pancreas
   B. Liver, pancreas, kidney
   C. Skin, kidney
   D. Liver, pancreas

3. In what form is excess glucose stored in the liver?

   A. Amino acids
   B. Urea
   C. Glycogen
   D. Glucagon

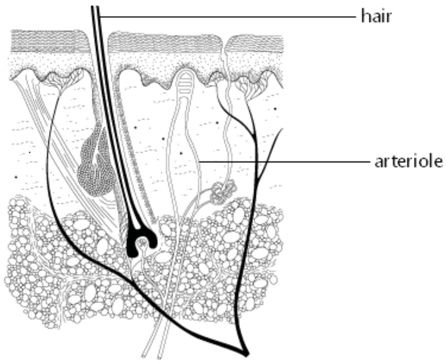
4. Why does the body become cooler after sweating?

   A. Evaporation of sweat removes heat
   B. Sweat removes heat from the body by conduction
   C. Sweat is absorbed by clothing and so removes heat
   D. The rate of sweating is greater than the rate of evaporation

5. Excess glucose is absorbed from the blood by organ **P** after stimulation by insulin secreted from organ **Q**. Which organs are **P** and **Q**?

	Organ **P**	Organ **Q**
A	Kidney	Pituitary gland
B	Liver	Pancreas
C	Pancreas	Liver
D	Pituitary gland	Kidney

6. The diagram below shows the structure of the skin.



What would happen to the hair and arteriole on a cold day?

	Hair	**Arteriole**
A	Become erect	Constrict
B	Become erect	Dilate
C	Lie flat	Constrict
D	Lie flat	Dilate

7. Homeostasis is defined as the maintenance of a constant

A. blood pressure
B. external environment
C. internal environment

D. water content

8. What happens to the sweat glands and the arterioles of the skin when body temperature rises above 37^{o}C?

	Sweat glands	Skin arterioles
A	Secrete less	Become narrower
B	Secrete less	Become wider
C	Secrete more	Become narrower
D	Secrete more	Become wider

9. In which of the following situations does the secretion of insulin increase?

   A. After eating a lot of food rich in carbohydrates
   B. At the beginning of puberty
   C. After a long vigorous physical activity
   D. While sleeping

10. Vasodilation, sweating, and expiration are all processes through which the body loses…

   A. Heat and water
   B. Salts and water
   C. Urea and water
   D. Urea and salts

Section B **[20 marks]**

1. During physical activity, the body temperature increases.
   a) Describe how the increase is brought about.

      …………………………………………………………
      …………………………………………………………
      …………………………………………………………

……………………………………………………... [3]

b) Explain how arterioles of the skin help to lower the body temperature back to normal.

………………………………………………………
………………………………………………………
………………………………………………………
………………………………………………………
…………………………………………………….. [3]

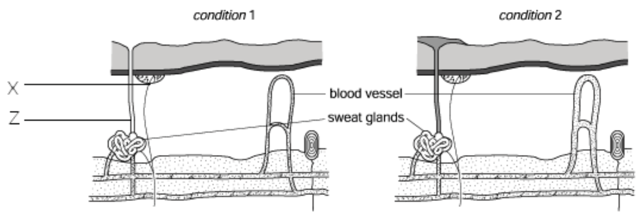
c) During illness, the body temperature can rise to about 42°C. The homeostatic mechanisms cannot always bring the body temperature down to normal. Explain the effect high temperature could have on metabolism.

………………………………………………………
………………………………………………………
………………………………………………………
………………………………………………………
………………………………………………………
………………………………………………………
……………………………………………………... [3]

d) Name the part of the brain involved in regulating body temperature.

………………………………………………………
………………………………………………………
……………………………………………………... [1]

2. The diagram below shows blood supply to the skin with sweat glands.



a) Identify the structures **X** and **Z**

X:
…………………………………………………………
…………………………………………………………

Z:
…………………………………………………………
…………………………………………………… [2]

b) State two visible differences between the diagram of condition 1 and that of condition 2.

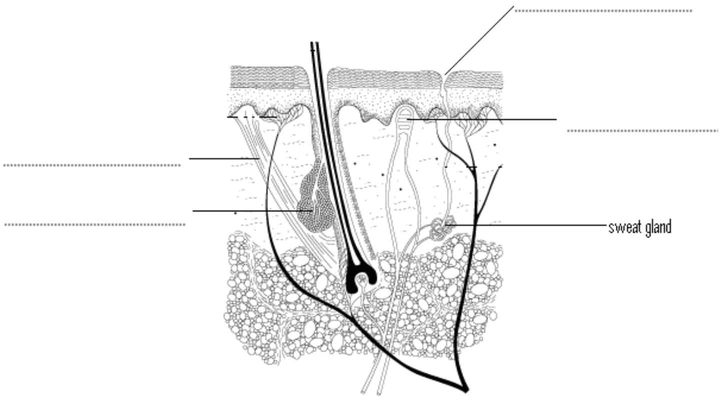
…………………………………………………………
…………………………………………………………
…………………………………………………………
…………………………………………………………
…………………………………………………………
…………………………………………………………
………. ……………………………………………..[2]

c) What are conditions 1 and 2?

Condition 1:
…………………………………………………………
…………………………………………………………

Condition 2:
…………………………………………………………
…………………………………………………… [2]

3. Label the diagram of the skin below.



[4]

Contents

HSB Unit 10

Excretory System

Introduction

In unit 1, you learned that one of the features of living things is that they remove waste materials from their bodies and that is called excretion. In this unit you will learn more about excretion and the excretory system. Excretion is the removal of waste products from your body such as carbon dioxide, water and salts, and used hormones, in order to keep the body balanced and healthy.

In unit 9 you also learned about homeostasis, which is the maintenance of a constant internal body environment. Now in this unit, we are going to learn about excretion, which is the removal of metabolic waste products from the body in order to keep the amount and composition of body fluids constant (homeostasis).

The first topic of the unit will look at the organs of the excretory system, followed by the urinary system and lastly we will look at how waste products are removed from the body.

Time Frame

It is estimated that to complete studying this unit you will need between 5 to 10 hours. Do not worry if you take longer in finishing this unit. Remember that we all have different abilities and hence we study at different paces.

You are encouraged to spend about 2 hours to answer the assignment in this unit. You will also need approximately 3 hours on the assessment at the end of the unit.

The total hours for completing the unit will thus be between 10 and 15 hours.

Upon completion of this unit you will be able to:

Outcome
s

- Define *excretion.*
- Identify *organs of the excretory system.*
- Explain *functions of each of the excretory organs.*
- Identify *parts of the urinary system.*
- State *the functions of the parts of the urinary system.*
- Describe *the function of the kidney.*
- Explain *how the kidneys remove waste products from the blood.*
- Outline *the process of filtration to blood pressure.*

Terminology

Excretion:	The process of removing metabolic waste from the cells of the body.
Metabolism:	Chemical process by which cells are supplied with energy.
Homeostatsis:	A process by which the body maintains a constant internal environment.
Metabolic waste:	Waste produced from the chemical reactions taking place inside body cells during breakdown of food.
Urea:	Waste product of protein breakdown formed in the liver during digestion.
Urine:	Fluid formed in the kidneys from extraction of urea to be transported out of the body.
Nephron:	The part of the kidney which filters and purifies the blood.
Glomerulus:	A knot of capillaries found inside the nephron. Filters blood to form urine.
Ureter:	Thin tubes that carry urine from the kidneys to the bladder.
Urethra:	A tube that carries urine from bladder to the outside of the body.

Bile: Substance produced in the liver to break down fats ready to be acted on by digestive enzymes.

Bile Pigments: Waste product produced in the liver when it breaks down old red blood cells.

Sweat: Liquid made up of water, salts and urea, which is excreted by the sweat gland through pores in the skin; helps with regulation of body temperature.

Renal artery: The main blood vessel that supplies blood to the kidney.

Tubule: The last part of a long twisting tube that collects urine from the nephrons.

Online Resource

If you can get on the internet please utilize the resources at www.hippocampus.org. It is an excellent source of information for biology and the topics discussed in this unit. Here you will find:

- Presentations
- Simulations
- Videos
- Online Study Groups
- Links to Even More Information
- Textbook Correlations
- Online Courses

Topic 1: The organs of the Excretory System

Excretion is the name given to the process of removing metabolic waste made in the cells of the body. By removing waste products the excretory system regulates the amount and the make-up of the body fluids and chemical products of metabolism in order to keep a constant internal environment in your body.

Lesson Objectives

At the end of the lesson, you should be able to:

- Define excretion.
- Explain the process of excretion.
- Identify organs of the excretory system.

- Explain why we need an excretory system.

Excretion

For the body to function properly it must have the correct amounts of various chemical components such as water, salts, and nutrients. If there is too much or too little of any of these, the body will not function and it could even suffer from poisoning. Your excretory system ensures that your body has the right amount of water, salts and nutrients and is not poisoned by waste products such as, urea and other acidic products of food breakdown. Let us look at why the excretion system is necessary for our body in some detail.

Why we need an excretory system?

Your body absorbs useful nutrients from digested food and uses them to maintain all bodily functions, such as providing energy to do work, and using nutrients for growth and keeping you healthy. After your body has taken what it needs from the food, waste products are left behind in the blood and in the colon.

The urinary system works with the lungs, skin, and intestines to keep the chemicals and water in your body balanced. Excretion is important to your body's health because waste products are poisonous and if they are not removed from the body, they can cause serious health problems.

You know that carbon dioxide and water vapour are removed by the lungs. Other waste products, namely urea, uric acid, various salts, and nitrogenous wastes are removed by the kidneys and sweat glands.

A discussion of all the organs involved in the excretory system is our focus in the next sub-section. You have learned about some of these organs in previous unit. Some parts of what we will discuss next will be more of a revision exercise for you.

The Excretory Organs

Remember that in Unit 1 we learned that similar tissues may be grouped together to form a functional unit called an organ. There are four organs involved in the excretory system.

Activity 1

Do you know any of the organs which are involved in the excretory system?

Feedback

During excretion, different organs in the body are responsible for the removal of different substances. We have learned in Unit 4 (Respiration) that lungs remove carbon dioxide and water vapour. The kidneys remove excess water, urea and other salts. The liver (and large intestines) excrete chemical waste in the form of bile. The skin removes urea, salts, excess water (as sweat). Do not worry if you don't understand some of these terms, we will explain them later.

The main organs involved in excretion are:

- the lungs
- kidneys
- the liver
- the skin

Let us now look at the organs of the excretory system in more detail and see how they work together.

The Lungs

The lungs are the major organs in the respiratory system, but they are also part of the excretory system. The lungs are the excretory organ that removes carbon dioxide and water vapour from your body. See Figure 1 to remind yourself of the shape and position of the lungs.

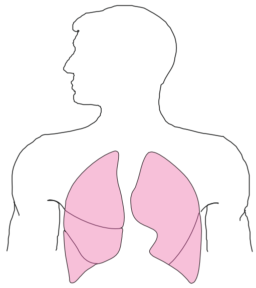
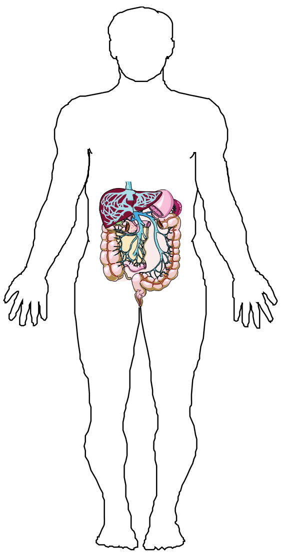


Figure 1: The lungs

In the cellular respiration process, energy is produced along with the waste products, carbon dioxide and water.

Kidneys

The kidneys, together with the ureters, the urinary bladder and the urethra, play an important role in excretion. They form the urinary system, which will be discussed in more detail in the next topic, so kidneys will be discussed in more detail in that section.



The Liver

The liver, see figure 2 on the right, is the largest internal organ in your body. It has several functions and is part of 3 different body systems - the circulatory, digestive, and excretory systems. Remember that in Unit 3 (Digestion and Absorption) and Unit 9 (Homeostasis) we learned that the liver lowers the glucose level in the blood when it is high and increases it when it is low.

The liver is also part of the **circulatory** system because it 'purifies' the blood. It is part of the **digestive** system and nitrogenous compounds are broken down in the liver. It is also part of the **excretory** system because the waste products formed by the breakdown of the red blood cells, and other chemicals removed from the blood, are excreted in the bile. This is why the liver is part of the excretory system. These waste products leave the body with the feces formed in the rectum. Please note that excretion does not include the removal of waste material from the digestive track through the anus. This is called egestion.

Figure 2: The Liver

The Skin

The skin was discussed in more detail in topic 2 of the previous unit - that is Unit 9. In this section we are just going to mention that the skin is part of the excretory system because, if you are very hot, sweat or perspiration comes out of the pores in your skin. Sweat is a mixture of water, salts and urea.

If you sweat, two things happen:

- your body cools down;
- metabolic waste products are excreted.

It is because the skin excretes metabolic waste products that it is an organ of the excretory system.

We have now come to the end of the first topic and once you have read the topic summary, please do assignment 1 which is at the end of the unit. Once you have completed the assignment check your answers against those provided. Revise any sections that you may have found difficult before moving to the next topic.

Summary

In this topic you learned that excretion is the removal of metabolic waste products from the body in order to keep the amount and composition of the body fluids constant (homeostasis). Excretion does not include the removal of waste material from the digestive track through the anus.

The metabolic waste products are:

1. Water
2. Carbon dioxide
3. Salt
4. Urea (formed when protein is broken down)

The four main human excretory organs are:

1. The lungs.
2. The liver / large intestines (colon).
3. The skin.
4. The kidneys (the urinary system).

The table lists the excretory organs, the waste excreted by them, and where the waste was produced.

Excretory Organ	**What Waste is Excreted**	**Where Waste is Made**
Lungs	Carbon dioxide and water vapour	All cells
Kidneys	Urea and nitrogen compounds	Liver cells
Skin	Excess water; small amounts of salts and urea (as sweat)	Liver and body cells
Liver	Urea waste product of nitrogenous products in the liver; Bile pigments resulting from red blood cells	Liver cells

That brings us to the end of topic 1. We will now continue and look at topic 2 after you have completed and corrected the Topic Assignment as recommended above. topic 2 deals with the urinary system.

Topic 2: The Urinary System

In Topic 1 we were looking at organs of the excretory system, now in this topic we shall focus on the urinary system. The **urinary system** is responsible for removing **urea** from your blood. Urea is produced in the liver when protein foods, such as meat, chicken, beans, are broken down. Urea produced during the metabolism process is carried in the bloodstream to the kidneys where it is extracted for excretion in the urine.

The main organs of the urinary system responsible for producing **urine** are the kidneys. The other parts of the urinary system are the **ureters**, the **urinary bladder** and the **urethra,** which are illustrated in Figure 3. These parts do not produce urine but just transport it from the kidneys to the outside of the body.

The main function of the urinary system is to control the amount of body fluids and what is contained in the body fluids. The urinary system gets rid of waste products that are formed as a result of cellular metabolism. The urinary system helps your body to maintain a constant internal environment (homeostasis).

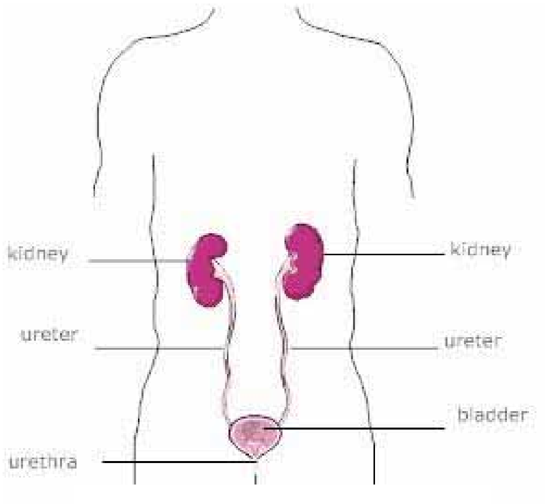


Figure 3: The urinary system

Lesson Objectives

At the end of the lesson, you should be able to:

- Describe the urinary system.
- Identify organs of the urinary system.
- Explain why we need an urinary system.

The Kidneys

The kidneys, as mentioned in Unit 9, are responsible for the regulation of the blood water concentration and the concentration of urea in the blood. They are bean-shaped organs about the size of your fists. They are near the middle of your back, just below the rib cage, one on each side of the back bone. The kidneys remove urea, which has been produced in the liver, from your blood through tiny filtering units called nephrons. Figure 4 shows a cross section of the kidney and a magnified nephron.

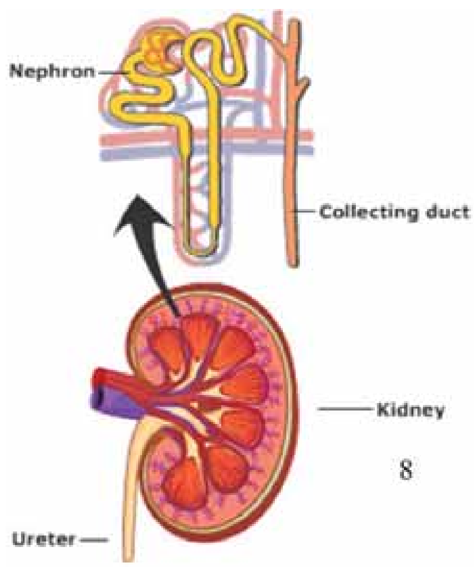


Figure 4: Cross-section of a kidney showing the detail of one nephron (magnified – made much bigger).

In Figure 4, the nephron has been made much bigger so that you can see what it looks like. In reality, the nephron is very small. You have about 1.25 million nephrons in each kidney!

Each nephron is made of a ball formed of small blood capillaries, called a **glomerulus**, and a small tube called a renal tubule. Urea, together with water and other waste substances, forms the urine as it passes through the nephrons and down the renal tubules of the kidney. The functions of the kidneys are to:

- Remove liquid waste from the blood in the form of urine.
- Keep a stable balance of salts and other substances in the blood.

You will learn how the kidneys work later in Topic 3 of this unit.

After our discussion of the first organ of the urinary system, we are left with three organs still to discuss. We will discuss these remaining organs in the following order: ureters, urinary bladder, and urethra.

The Ureters

The ureters are thin tubes that carry urine from each kidney to the urinary bladder. Urine drains through the ureters to the urinary bladder by gravity, but the smooth muscular walls of the ureters also help move urine along. They compress in a series of wavelike contractions (an action known as peristalsis) that move the urine through the ureters in only one direction. Do you remember that you learned about peristalsis in the digestive system, in Unit 3? It is the same muscular movement which helps to move things through the body. When urine has entered the urinary bladder, it is prevented from flowing back into the ureters by small, valve like folds of membrane that flap over the ureter openings.

The Urinary Bladder

The urinary bladder is a hollow, collapsible, muscular sac that stores urine temporarily. See Figure 19. It is found in the pelvis behind the pelvic bones, and is held in place by ligaments. In women, the bladder is behind the uterus; in men, it is above the prostate gland.

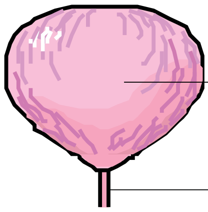


Figure 5: The urinary bladder

The size of the urinary bladder varies depending on the amount of urine it contains. When it is empty, it is about 5-7 centimetres long and the walls are thick and heavily folded. As it begins collecting urine, the muscular walls of the urinary bladder stretch and expand, and it moves higher in the abdominal cavity. When moderately full, the bladder measures about 13 centimetres in length and holds just over half a litre of urine. When completely full, it can contain more than 1 litre of urine. Normally, at this point, you will start feeling some pressure pain and great discomfort. At times it actually becomes very difficult to hold the urine in the bladder to an extent that it might just come out.

To relieve yourself, the muscular walls of the urinary bladder contract to expel urine out of the bladder into the urethra. A ring of muscle surrounding the opening to the urethra controls the flow of urine. This is an involuntary muscle, meaning you cannot consciously control its workings.

The Urethra

The urethra is a thin-walled tube that carries urine from the urinary bladder to the outside of the body. The length and function are different for females and males.

In females, the urethra measures about 3-4 centimetres in length. Its external opening lies in front of the vaginal opening. The only purpose of the urethra in females is to carry urine outside of the body.

In males, the urethra serves a dual purpose. It transports semen and urine to the body exterior, but never at the same time. Thus, it serves both the reproductive and urinary systems. In men, the urethra extends from the urinary bladder through the prostate gland to the tip of the penis, a distance of 15 to 20 centimetres.

In both sexes, the urethra contains a ring of skeletal muscle that forms the external urethral sphincter as the urethra passes through the floor of the pelvis. A person is normally able to control the opening and closing of this sphincter. When the sphincter is voluntarily relaxed, urine flows into the urethra, emptying the urinary bladder. However, when the bladder fills with urine and becomes stretched beyond normal, it is no longer possible to control the sphincter voluntarily.

Summary

You have learned that the urinary system removes metabolic waste products and also regulates the amount of water in the blood. The main organs of the urinary system are the kidneys and the other parts are the ureters, urinary bladder, and urethra. Their functions are as follows:

Kidney: Responsible for the regulation of the blood water concentration and the concentration of urea in the blood.

Ureter: Thin tubes that carry urine from each kidney to the urinary bladder.

Urinary bladder: A hollow, collapsible, muscular sac that stores urine temporarily.

Urethra: A thin-walled tube that carries urine from the urinary bladder to the outside of the body.

We have now come to the end of the second topic, please do assignment 2, which is at the end of the unit. Once you have completed the assignment check your answers against those provided.

Topic 3: Removing Waste Products from the Body

Now that you know what the excretory system does and the structure of the major organs, we are going to look at how waste products are removed. You already know about some of the waste products as you learned about them in Topic 4 (Respiratory System) and in Topic 3 (Digestive System) and we have mentioned them earlier in this topic.

Now we will look at the way these different waste products are excreted via the organs of the excretory system.

Lesson Objectives

At the end of the lesson, you should be able to:

- Identify metabolic waste products.
- Explain how different excretory organs extract waste products from the body.

Metabolic Waste Products

Let us start with a short activity on what you already know about waste products.

Activity 2

Can you name the waste products that are excreted from the body?

Feedback

You probably mentioned sweat and urine. In fact, there are 4 metabolic waste products:

1. *Carbon dioxide (formed in cells when food molecules are broken down to release energy).*
2. *Urea and bile pigments.*
3. *Heat.*
4. *Water and salts.*

We will now discuss these one by one.

Carbon Dioxide

The lungs remove carbon dioxide from the blood. Carbon dioxide is formed by the metabolic processes which take place in the cells of the body. You remember from your study of the respiratory system in Unit 4, that you learned that the body needs oxygen in every cell. The oxygen is taken into the body through the lungs and it is in the alveoli of the lungs that the oxygen is exchanged for carbon dioxide and then exhaled from the body.

Urea & Bile Pigments

You learned in Topic 1 that the liver forms part of the digestive system and the circulatory system, but also plays a part in the excretory system. Urea is formed in the liver during the breakdown of protein. The urea is taken by the blood to the kidneys.

From your study of the digestive system, can you remember the name of the substance produced in the liver to help with the breakdown of fats?

Did you remember that this substance is called bile? Bile is produced in the liver and stored in the gall bladder. From the gall bladder it is released into the small intestines to break down fats. Bile also contains pigments that are waste products of the red blood cells which have been broken down in the liver. The bile pigments are removed from the body with feces (undigested food).

That is why we also include the large intestines as part of the excretory system, as it removes the waste products of the red blood cells.

Heat

Heat is a waste product that is removed from the body by the process of sweating as we have mentioned in Unit 9, Topic 3. Figure 20 shows a diagram of the skin with the sweat gland lying below the surface of the skin and the sweat being able to leave the body via the pore.

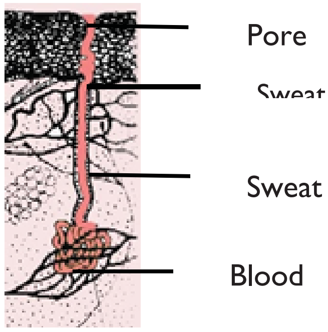


Figure 6: A sweat gland in the skin

The sweat gland is a tubular structure with small blood vessels (capillaries) all around it. Waste products in the blood (salts, urea) or excess water can easily move from the blood into the sweat gland. If the body temperature goes up the fluid (sweat) is released from the gland and moves through the tube (duct) to reach the skin surface through small openings on the skin (pores).

Water and Salt

The kidneys are the main excretory organ. They function to balance the levels of water and salt in the body. You need to understand the detail of how they work and the next section discusses this and the processes involved.

How the Kidneys Work

As blood circulates around the body, it enters each kidney through the **renal artery**. This is the blood carrying waste products. The artery branches into capillaries that surround the **nephrons**. The nephron, as you already know from Topic 1, is the functional part of the kidney that purifies and filters the blood.

Filtration in the Glomerulus

Look at Figure 7. As the blood goes into anephron, in the glomerulus part of the nephron, it is at high pressure. This pressure causes everything that is dissolved in the blood (waste products, food) to be pushed out of the blood into the kidney. This process removes both waste products and essential nutrients from the blood, including:

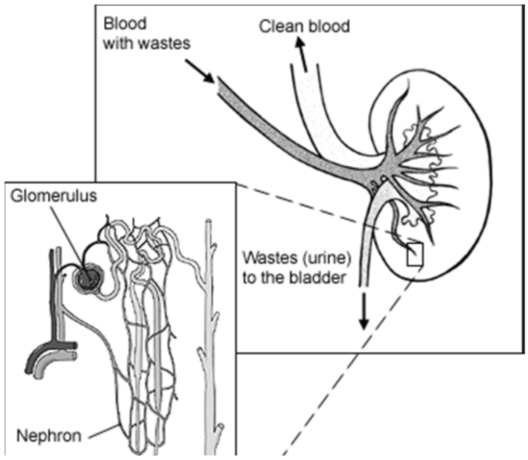


Figure 7: How blood is filtered in the kidney

- water
- urea
- salts
- glucose
- amino acids, the building blocks of proteins
- yellow bile compounds from the liver
- other trace substances from the blood.

Re-Absorption

The fluid filtered from the blood by the glomerulus then travels down a tiny tube-like structure called a **tubule**. As this fluid moves through the long, looped tubule, the water and anything else the body needs, goes back into the blood. It is *reabsorbed* into the blood to be reused by the body to maintain normal body functions.

Removal of Excess Products and Waste Products

The rest of the dissolved waste products (urine) keep moving through the tubule into the ureters, the tubes that carry urine to the bladder. The bladder then collects the urine. When the bladder is emptied, the urine passes out of the body through the urethra.

The filtered blood (which now has all the waste products removed) leaves the kidney through the **renal vein** and flows back to the heart.

In summary – this is how the urinary system works:

- If there is too much water in the blood, then it is removed in the kidneys and is excreted as urine.
- If there is not enough water in the blood, the kidneys will not remove it.

- If there is too much urea or other substances in the blood, the kidneys will remove these.
- By regulating the amount of substances and water in the blood, the kidneys maintain homeostasis in the body.

Summary

In this topic you have learnt the functional units of the kidney, where blood is 'filtered' to produce urine, are the nephrons. The kidneys carry out a process of filtering all substances in the blood (except the red blood cells and blood plasma) and then reabsorbing only the essential nutrients back into the blood. The waste products in the urine are then transported via the ureters from the kidney to the urinary bladder for storage and final removal.

The urinary bladder is a temporary storage vessel for urine. The urethra is the final passageway for the flow of urine. Its function is controlled by an involuntary internal urethral sphincter and voluntary external urethral sphincter.

We have now come to the end of the third and last topic of the unit and please remember to do Assignment 3, which is at the end of the unit. Once you have completed the assignment check your answers against those provided.

Unit Summary

Summary

In this unit you learned that excretion is the removal of metabolic waste products from the body in order to keep the amount and composition of the body fluids constant (homeostasis).

The metabolic waste products are: water, carbon dioxide, salt, and urea. The four main human excretory organs are: the lungs, liver, skin, and kidneys.

You have learned that the urinary system removes metabolic waste products and also regulates the amount of water in the blood. The main organs of the urinary system are the kidneys and the other parts are the ureters, urinary bladder, and urethra.

The functional units of the kidney, where blood is 'filtered' to produce urine, are the nephrons. The kidneys carry out a process of filtering all substances in the blood and then reabsorbing only the essential nutrients back into the blood. The waste products in the urine are then transported via the ureters from the kidney to the urinary bladder for storage and finale removal.

This completes your work on the excretory system in Unit 10. It is a good idea to check the learning objectives again and make sure you have covered them all. Once you are happy you have mastered this unit, do the assessment that follows, submit it for marking by your tutor and then move on to the next unit.

Assignment

Assignment

Topic 1 Assignment

1. Explain what is meant by excretion.

2. What is the main function of the excretory system?

3. Name the four main organs of the excretory system.

   a.
   b.
   c.
   d.

3. Describe the difference between feces and excretory products.

4. Which of the following is NOT a correct description of excretion?

   A. removal of metabolic waste

   B. removal of undigested food

   C. removal of heat through sweating

   D. removal of carbon dioxide when breathing out

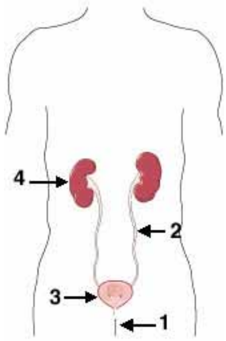
5. Explain why the liver is part of three different body systems.

6. Explain why the large intestines (colon), is part of the excretory system.

7. Explain why the skin is an excretory organ.

Topic 2 Assignment

1. Name the 4 parts of the urinary system that are numbered 1 to 4 in the diagram.



   1.
   2.
   3.
   4.

2 What is the ureter?

   A. The thin tube that connects the bladder to the outside of the body.

   B. The tube that leads from each of the kidneys to the bladder.

   C. The inner lining of the bladder.

3. What is the urethra?
   A. The thin tube that connects the bladder to the outside of the body.
   B. The collective name for the thousands of nephrons contained in each kidney.
   C. The main vein that transports clean blood from the kidney back to the heart.

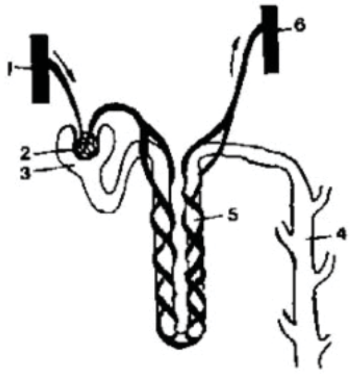
4 Which is the correct pathway for the removal of urine?
   A. kidney, ureter, bladder, urethra
   B. kidney, urethra, bladder, ureter
   C. kidney, bladder, ureter, urethra

5. What are the functions of the urethra in a man?

6. Describe the main features of the kidney as an excretory organ.

Topic 3 Assignment

1. List three excretory organs that remove excess water from your body.
2. Why is the liver an excretory organ?
3. Describe how the skin acts as an excretory organ.
4. Use the diagram to describe how the kidneys work to 'clean' the blood.



Answers to Assignments

Topic 1 Answers

1 The main function of the excretory system is to remove metabolic waste products in order to keep a constant internal environment in the body – to maintain homeostasis.

2 The four main organs of the excretory system are.

- lungs
- liver / large intestines (colon)
- skin
- kidneys (urinary system)

3 The difference between feces and excretory products is that excretory products are waste formed during metabolism in the cells of the body.

Feces are undigested food – a product of digestion. Excretory products such as urea, salt and water are a result of cell metabolism.

4. **B. removal of undigested food** is NOT a form of excretion.

5. The liver is part of three different body systems because:

- In the circulatory system – it 'cleans' the blood.
- Digestive system – produces bile for digestion of fats.
- Excretory system

- produces bile pigments (waste of breakdown of red blood cells)
- produces urea (waste product of breakdown of nitrogenous molecules)

6. The large intestines (colon) is part of the excretory system because it excretes bile pigments, the waste product of the breakdown of red blood cells.

7. The skin is an excretory organ because it excretes sweat (perspiration) containing water, salts and urea which are the waste products of metabolism in the cells.

Topic 2 Answers

1. The 4 parts of the urinary system are:

   1. Urethra
   2. Ureter
   3. Urinary bladder
   4. Kidneys

2. What is the ureter?

   A. The slender tube that connects the bladder to the outside of the body.

   B. The tube that leads from each of the kidneys to the bladder.

   C. The inner lining of the bladder.

3. What is the urethra?
   A. The slender tube that connects the bladder to the outside of the body.
   B. The collective name for the thousands of nephrons contained in each kidney.
   C. The main vein that transports clean blood from the kidney back to the heart

4. Which is the correct pathway for the removal of urine?
   A. kidney, ureter, bladder, urethra
   B. kidney, urethra, bladder, ureter
   C. kidney, bladder, ureter, urethra

5. What is the function of the urethra in a man?

   Transport of semen and urine.

6. Describe the main features of the kidney as an excretory organ.

   The kidneys are bean-shaped organs about the size of your fists. The main features of the kidneys are the tiny filtering units called nephrons. Each nephron consists of a ball formed of small blood capillaries, called a glomerulus, and a small tube called a renal tubule.

Topic 3 Answers

1. Three excretory organs that remove excess water from your body:

   - kidneys
   - skin
   - lungs

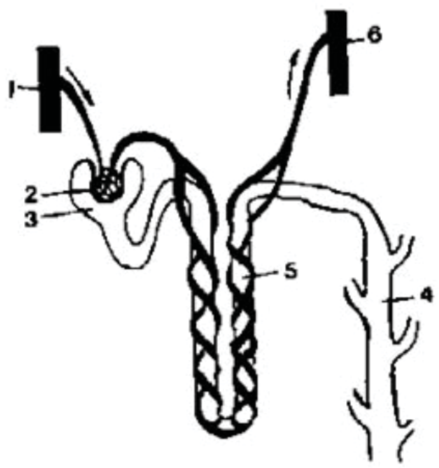
2. The liver is an excretory organ because it excretes

   - bile pigments
   - urea

3. Describe how the skin acts as an excretory organ.

   Waste products in the blood (salts, urea) or excess water, move from the blood into the sweat gland. If the body temperature goes up the sweat gland fluid (sweat) moves through the tube (duct) to reach the skin surface through the small openings (pores).

4. Use the numbers in the diagram to describe how the kidneys work to ‘clean’ the blood.



- (1) Blood containing metabolic waste products enters each kidney through the **renal artery.**

- The artery branches into capillaries (2) that surround the **nephrons (3)**.
- In the glomerulus part of the nephron (3), metabolic waste products from the blood are removed.
- The fluid filtered from the blood by the glomerulus then travels down a tiny tube-like structure called a **tubule (5).** As this material moves through a long, looped tubule, the water and anything else the body needs goes back into the blood (is re-absorbed).
- The rest of the dissolved waste products (urine) keep moving through the tubule into the ureters (4), the tubes that carry urine to the bladder.
- Filtered blood leaves the kidney through the **renal vein** (6) and flows back to the heart.

Assessment

Assessment

1. Draw and label the diagram of the human excretory system.

    a. Give the function of each part named above.
    b. Describe the purpose of the excretory system.
    c. Name the waste products eliminated by the human excretory system.

2. Describe the main features of the kidney as an excretory organ.
3. Draw and label the diagram of the nephron.

    a. Give the function of each part named above.
    b. Describe the processes by which the nephron makes urine.

4. Describe the source(s) of ammonia and where it is converted into urea.
5. What is the main function of the excretory system?
6. Describe the difference between feces and excretory products.
7. Which of the following is NOT a correct description of excretion?

    a. removal of metabolic waste
    b. removal of undigested food
    c. removal of heat through sweating
    d. removal of carbon dioxide when breathing out

8. Explain why the liver is part of three different body systems.
9. Explain why the large intestines (colon) is part of the excretory system.
10. Explain why the skin is an excretory organ.
11. Which is the correct pathway for the removal of urine?

    a. kidney, ureter, bladder, urethra
    b. kidney, urethra, bladder, ureter
    c. kidney, bladder, ureter, urethra

Contents

HSB Unit 11

Reproduction and Continuity of Life

Introduction

Welcome to unit 11 of the Human and Social Biology course, this unit is about reproduction and continuity of life. We are going to learn about the different types of reproduction and why reproduction is important for continuity of life. It is important to understand that it is essential for all living things to reproduce and produce young ones, because if they didn't then life will cease to exist and animals and plants would become extinct. So. we can therefore define reproduction as ***the ability of living things to produce young ones.***

There are two types of reproduction: Sexual Reproduction and Asexual Reproduction. In sexual reproduction there is sexual intercourse between two organisms of opposite sex. Since we are dealing with human beings, then sexual reproduction will be a result of sexual intercourse between a man and a woman. It involves the fusing together of a male gamete (sperm) with a female gamete (ovum) to create an offspring (child). In asexual reproduction, on the other hand, there is no sexual intercourse and only one parent is involved. This normally happens with plants.

In this unit we will only look at human reproduction and learn how females produce eggs, males produce sperm, and how reproduction takes place. However, we have to be aware that it does not necessarily mean that every intercourse will result in production of an offspring. There are many reasons that may prevent reproduction to take place, some being deliberate such as the use of contraceptives, while some are due to health problems such as sexually transmitted diseases resulting in infertility or just natural infertility courses.

We will also be looking at the transfer of characteristics from parents to offspring. This process is called heredity**.**

Time Frame

It is estimated that to complete studying this unit you will need between 15 to 20 hours. Do not worry if you take longer in finishing this unit. Remember that we all have different abilities and hence we study at different paces.

You are encouraged to spend about 2 hours to answer the assignment in this unit. You will also need approximately 3 hours on the assessment at the end of the unit.

The total hours for completing the unit will thus be between 20 and 25 hours.

Outcomes

Upon completion of this unit you will be able to:

- *Demonstrate* knowledge of the human reproductive system.
- *Identify* different parts of the human reproductive system.
- *State* the functions of the different parts of the human reproductive system.
- *Explain* the menstrual cycle and fertilisation.
- *Differentiate* between the various types of family planning methods.
- *Acquire* knowledge and understanding of gametes.
- *Explain* genes, chromosomes and mutation.
- *Discuss* and appreciate variation in living things.
- *Explain* inheritance.

Terminology

Gametes:	Male and female sex cells.
Copulation:	The act in which the male reproductive organ enters the female reproductive tract during sexual intercourse.
Puberty:	Period of sexual transformation from childhood to adulthood.
Spermatogenesis:	Formation of sperm in the testes.
Menstruation:	A woman's monthly bleeding when the body sheds the lining of the uterus.
Oogenesis:	Formation of ova in the ovary.
Fertilisation:	The fusion of gametes to produce a new organism.
Ovulation:	The process in a female's menstrual cycle by which a mature ovarian follicle ruptures and discharges an ovum.

Online Resource

If you can get on the internet please utilize the resources at www.hippocampus.org. It is an excellent source of information for biology and the topics discussed in this unit. Here you will find:

- Presentations
- Simulations
- Videos
- Online Study Groups
- Links to Even More Information
- Textbook Correlations
- Online Courses

Topic 1: Reproductive Systems

In this topic we will discuss the process by which human beings reproduce. Recall that in unit 1 we learnt how bacteria reproduce. Do you still remember how they reproduce? Obviously you remembered reproduction in bacteria as simple cell division. In this case, the bacteria just divides into two cells. Well, human beings are different, as they do not just undergo cell division. However, this does not mean that they do not reproduce. If it were so, we would not have multiplied in numbers. You know that human beings do have children but they do not simply divide into parts in order to achieve this.

Unlike bacteria and other unicellular organisms, human beings have separate reproductive systems. They have organs, which are responsible for producing young ones. These organs are grouped into male and female reproductive systems. The male reproductive system is different and separate from the female reproductive system, each residing in a separate person, a man and a woman respectively. In this lesson we will be looking at these two systems in detail.

Learning Objectives

At the end of the lesson, you should be able to:

- Describe sexual reproduction.
- Define a gamete.
- Describe the structure and functions of both the male and female reproductive systems.
- Define puberty.
- Explain puberty in males and females.

Sexual Reproduction: Gametes

We will first start by looking at the basic cells that are responsible for reproduction to take place in mammals. These are called Gametes. Gametes are also called **sex cells.** Sex cells are cells that are involved in the production of young ones. We have male sex cells and female sex cells. Female gametes are called **ova,** whilst male gametes are called **sperms**. Sex cells form through a process called **gametogenesis**. The word gametogenesis is derived from two words:

- **Gametes** - meaning reproductive cells.
- **Genesis** - meaning origin or creation or formation.

Now use the information above to define the term gametogenesis.

What is gametogenesis?

Well, this is a process involving the formation of sex cells or gametes. Since there are two types of gametes, it means there are also two types of gametogenesis. There is **spermatogenesis** and **oogenesis**. I suppose just like gametogenesis, these two words are self-explanatory.

Activity 1

You already know the meaning of ***genesis***, so I would like you to come up with the definition of **spermatogenesis** and **oogenesis** and say where they occur.

____

____

____

____

Feedback

***Spermatogenesis** is the formation of sperms. This occurs in the two testes. During spermatogenesis millions of sperms are manufactured daily. On the other hand, **Oogenesis** is the formation of ova, which takes place in the ovaries.*

Let us move on to discuss the structures of the sperm cells and ovum.

(a) The Structure of a Sperm Cell

You might have noticed that the sperm has features which are common to other animal cells such as a nucleus, a cell membrane and a cytoplasm, as shown in Fig 1 below. However, it also has a distinct feature, a tail. Unlike other cells, the sperm can move and it uses this tail for movement. It also contains some energy producing organelles called mitochondria located in the middle piece, which provide the sperm with the energy needed to swim, see Figure 1 below.

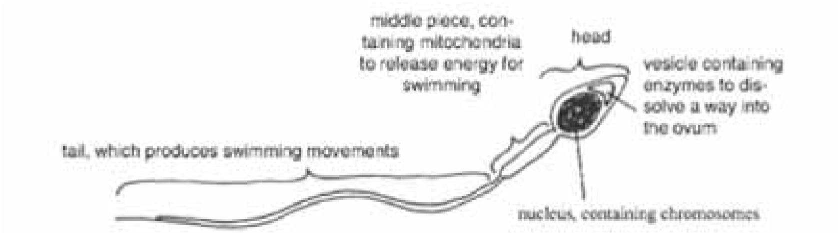


Figure 1: Sperm cell

(b) The Structure of an Ovum

Most of the features of the ovum are also present in the sperm. Using the diagram of the ovum shown in Fig 2 below, list those features which are common to the two sex cells.

____

____

You definitely should have mentioned the fact that it has a nucleus, a cell membrane and a cytoplasm.

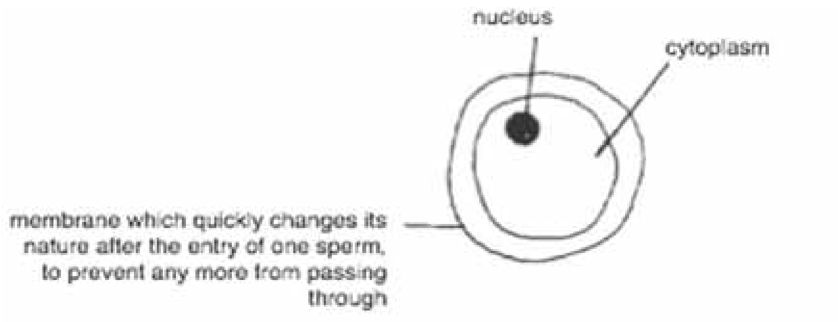


Figure 2: Ovum

The two gametes fuse during fertilisation to produce a fertilised egg called a **zygote**. This ultimately develops into a baby in human beings.

You know the basic cells that are responsible for reproduction to take place in mammals, the formation of sex cells or gametes and the structures of these cells. We will now progress to discuss the reproductive systems.

Reproductive Systems

Now we are going to learn about the parts of the female and male reproductive systems.

Female Reproductive System

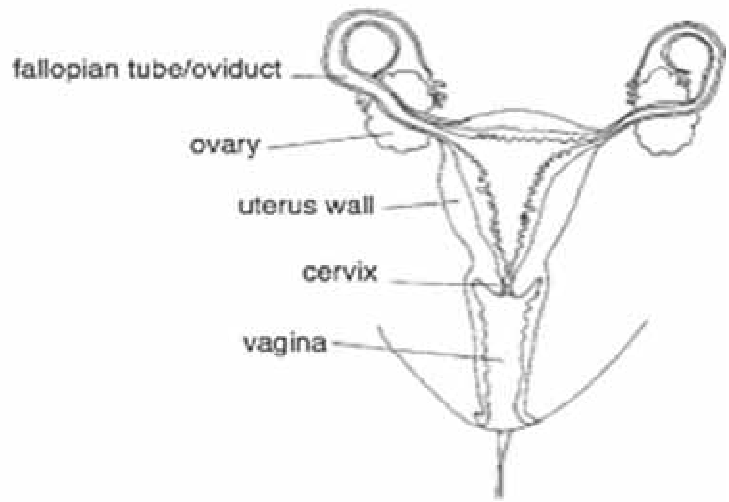


Figure 3: Human female reproductive system

The above figure is a diagram of the human female reproductive system. Study the diagram carefully. You should note the shapes of the following parts: ovary, fallopian tube, uterus, cervix, and vagina. We will now describe these parts in terms of structure and function. As you read the descriptions, refer to Figure 3 to get a clear picture of where each part is located on the reproductive system and the features that are described.

(a) Ovary

These are two oval-shaped organs, which lie at the back of the lower abdominal cavity as indicated in Figure 3 above. Their function is to produce female gametes, or to be more specific ova.

Some people sometimes tend to refer to ova as eggs. Under normal circumstances one ovum is produced every month.

The other function of the ovary is to produce two hormones called oestrogen and progesterone.

Do you remember what hormones are? Well, remember that when we discussed this in Unit 8, we said that 'Hormones are chemical substances produced by glands in the body and they regulates the functioning or growth of a specific tissue or organ.' These hormones are very important in reproduction. This is because they:

- bring about the development of secondary characteristics,
- cause the thickening of the lining of uterus which occurs each month.

Do you have an idea of what secondary sexual characteristics are? If you don't, do not worry as we will deal with them in later parts of the lesson.

(b) Fallopian tube

The fallopian tube is also known as ***oviduct***. At the end (near the ovary), the oviduct widens to form the ***fallopian funnel.*** The funnel has ***finger-like structures,*** which help to pick the egg and direct it into the (fallopian tube) oviduct. The fallopian tube (oviduct) becomes narrower and narrower but widens up near the uterus. The fallopian tube receives the ovum. It is also the place where fertilization takes place. It has hair-like structures called ***cilia***, which directs the fertilized ovum (zygote) to the uterus.

(c) Uterus

The uterus is also called ***womb.*** It is a pear-shaped organ with a muscular wall. The lower entrance to the uterus is called the ***cervix***. This entrance is always closed except at the time of the ***menstrual period*** and at birth. This is because at the menstrual period the menstrual discharge, or mense, has to come out and at birth the baby has to come out. One of the functions of the uterus is to provide a suitable environment for the nourishment and growth of the foetus until birth. The contraction of its thick muscles also helps to push out the baby during birth.

(d) Cervix

As mentioned above, it is a narrow canal opening into the uterus on one end and the vagina on the other. It is controlled by a ***ring of elastic muscles,*** which make it widen during birth. The cervix serves as a passage for sperm cells, menstrual discharge, and the baby during birth.

(e) Vagina

It is a muscular canal which opens to the outside through flap-like structures called **vulva**. The walls of the vagina have glands which provide lubricating fluids during intercourse and birth, and also which reduces friction. The vagina serves as a passage through which sperms pass to the uterus and the baby passes to the outside.

(f) Clitoris

This is the most sensitive part of the female reproductive system. It is an organ for stimulation. The clitoris is analogous to the penis in a man, that is, "a woman's penis". It is found as a protrusion outside the vagina.

This completes our discussion of the female reproductive system. Our next focus is on the male reproductive system. Compare and contrast the two systems as you read. This will help you to understand the differences and appreciate the systems of the opposite sex.

The Male Reproductive System

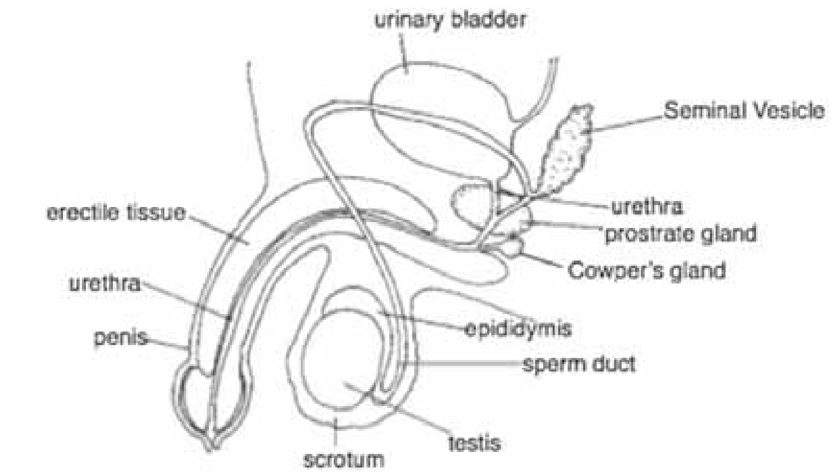


Figure 4: Human male reproductive system

I would like you to study the above diagram carefully. You should only move onto the next part of the lesson after doing that.

Let us now discus the parts of the male reproductive system in detail. As you study each part, refer to Figure 4 to see what it looks like.

(a) Scrotum

This is a skin that completely covers the testes and their contents. The two testes are suspended in the scrotum outside the abdominal cavity between the legs. This is not only the case in human beings but also in other mammals such as dogs, cats and even monkeys. The scrotum also protects the testes from mechanical injury and attack by micro-organisms.

(b) Testis

This is an oval shaped organ. In fact, there are two of such structures and they are suspended in between the legs, or rather where the two legs meet. As noted in Figure 4 above, the testes are enclosed in a sac or bag like structure called a **scrotum.** Inside each testis are a mass of tiny tubes in which sperms are produced. These tiny tubes form ducts which join to form another structure called **epididymis**.

Can you think of any reason why the testes are hanging outside the body?

If you can, then please note that down, if you cannot then you should not worry, continue with the lesson as this will be mentioned later.

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This provides a suitable place for the testis because sperm cells are produced and survive best at a temperature below the body temperature. That is why on a cold day, the scrotum shrinks to prevent heat loss and when the temperature is high, they relax to expose a bigger area for losing excess heat.

(c) Epididymis

This is a long coiled tube lying on the side of the testis. It serves to store sperms. The sperm cells are also nourished to maturity inside the epididymis and are ready to be discharged. At one of its ends, the epididymis joins a muscular and a bit bigger tube called the **sperm duct.**

We will now move on to the next part, which is the sperm duct.

(d) Sperm Duct
This is a tube leading from the epididymis in to the urethra. The duct contains smooth muscles. Sperms are pushed into the sperm duct by the forceful contraction of the muscles of the epididymis. The function of the sperm duct, therefore, is to provide a passage for movement of sperms to the urethra when a person is ejaculating.

(e) Accessory Glands
This is a collective term given to the three glands within the male reproductive system. These glands are the **prostate gland**, **Cowper's gland,** and **seminal vesicle.** As you saw (Figure 4), the glands are located at the junction of the urethra and sperm duct, i.e. at the base of the **urinary bladder.** The function of these glands is to produce seminal fluids in which the sperms swim. Apart from making the sperms mobile, the fluids also provide them with nourishment.

(f) Urethra
This is a tube, which opens to the outside. It is an extension of the sperm duct. Much of the length of the urethra is surrounded by **muscular tissue.** The urethra has two functions. These are:

- to expel urine to the outside from the urinary bladder, and
- to provide a passage for sperms from the testis to the outside of the body.

This happens when a male **ejaculates**. But what exactly do we mean when we say somebody ejaculates?

Well, ejaculation is the expulsion of semen out of an erect penis due to contractions of the epididymis.

(g) Urinary Bladder
The urinary bladder is not an organ of reproduction. It is an organ of excretion. Remember, that we studied the excretory system in Unit 10. I hope you still remember the function of the bladder, if not please review Unit 10 again. In this Unit we mention the urinary bladder because the urethra serves two functions as mentioned above. The bladder is a membrane-like sac opening into the urethra. Its function is to store urine which it releases through the urethra to the outside.

(h) Penis
This is an organ that is able to be erect (stand). This behaviour is caused by the erectile tissues that make up the penis. These

tissues are like a sponge and are able to accumulate blood in the same way as a sponge accumulates water. Under sexual excitement, the tissues of the penis accumulate a lot of blood and make it stand erect. It is in this state that it is able to penetrate through the vagina and discharge the semen with a pumping action. The functions of the penis therefore, are to:

- discharge sperms, and
- pass out urine through the urethra.

In this part of the topic, you have learned about both the female and male reproductive systems. If you heeded my suggestions on noting the similarities between the two while reading, this is an opportune time to note these down and keep your notes for use later when you revise the unit. Once you have done this, you can move to the next section of the topic which is about puberty and adolescence.

Puberty or Adolescence

This is a period in which an individual is sexually transformed from childhood to adulthood. There are quite a number of changes that occur during puberty in both girls and boys. In girls puberty lasts from 12 to 14 years, while in boys this lasts from 14 to 16 years. The changes that develop are called **secondary sexual characteristics**. These sexual characteristics develop as a result of the production of sex hormones by both male and female adolescents.

Audio

These secondary sexual characteristics are discussed in detail in the audio cassette. So can you please listen to the cassette accompanying the unit.

Activity 2

List the characteristics of puberty in males and females.

Feedback

The secondary sexual characteristics are listed below.

Puberty in Males

Characteristics of puberty in males include:

- Enlargement of the prostate gland, the testes and the scrotum.
- Pectoral girdle (shoulder width) widens and the pelvic girdle narrows.
- Growth of hair on some parts of the face, armpits and pubic regions.
- Deepening of the voice.
- Slightly higher metabolic rate. The increased metabolic rate is because of the fact that boys are undergoing a period of rapid growth, which increases energy demands. This greatly enhances their appetite.

Puberty in Females

These are some of the characteristics that arise as a result of puberty in females.

- Ovulation begins around the ages of 12 to 14 years.
- Breasts enlarge prior to puberty.
- Increase in size of uterus.
- Increase in size of vulva/vagina.
- Hair begins growing around pubic areas.
- Pelvic girdle widens.
- Slightly lower metabolic rate.
- Slightly lower appetite.

Summary

Human beings have separate reproductive systems for males and females respectively. The female reproductive system consists of the ovaries, oviduct, uterus (or womb), cervix, vagina, and the clitoris. The male reproductive system consists of the testes (enclosed in the scrotum), scrotum, epididymis, sperm duct, cowpers gland, seminal vesicle, urethra, and penis. These systems produce sex cells which are responsible for reproduction.

These organs undergo maturity through a process called puberty. Puberty is when the individual is sexually transformed into an adult through changes in the physical appearance due to hormonal changes in the body. In males this change is mainly characterised by enlargement of the penis and production of semen, whilst in females it is mainly characterised by production of ova and menstruation. Other changes include deepening of voice and growth of beard for males, whilst female breasts grow larger and hips enlarge. These characteristics arising from puberty are called secondary sexual characteristics.

When somebody has reached the stage of puberty, they are sexually mature and can produce young ones.

We have come to the end of the first topic. As in previous units, there is an end of topic exercise in the Assignment section of this unit. Complete the assignment and thereafter check your answers against those provided. Continue to the next topic only after you are satisfied that you understand all aspects of this topic. If necessary please revise the sections you are uncertain about before moving on to the next topic.

Topic 2: Fertilisation

Introduction

In Lesson 1, you learnt about parts of both the male and female reproductive systems and their functions. Can you remember all of them?

If you cannot then briefly look at these functions, especially those of the ovary, oviduct and the womb. In this lesson, we will be looking at fertilisation and one particular secondary characteristic that develops in females as a result of puberty, and that is menstruation.

Learning Objectives

At the end of the lesson, you should be able to:

- describe the production of ova
- describe the menstrual cycle
- describe the roles of oestrogen and progesterone in the menstrual cycle and in pregnancy
- define copulation
- describe fertilisation and early development of the zygote
- describe implantation.

Formation of Ova (Oogenesis)

Oogenesis is the production of ova. This process occurs in both ovaries. At puberty the pituitary gland releases a hormone called ***follicular stimulating hormone***. This hormone stimulates the ovary to release a hormone called oestrogen. Recall the topic of hormones that we discussed in Unit 8. Oestrogen stimulates cells in the ovary to grow into ova. These cells are at different stages of development. About 70,000 eggs are present in the ovaries in the female at birth. Of these, only about 500 eggs will mature. From these 500 that mature, very few are fertilised. If 10 eggs are fertilised, then the woman will give birth to 10 children. Usually, only one egg is released every month and if sexual intercourse takes place at the same time, it is that egg which is fertilised.

Oestrogen also has other roles to play in human sexual development. From what you learned in Lesson 1, you should be in a position to say what these roles are. What are they?

Please note that down on the space below.

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Feedback

It promotes the development of secondary sexual characteristics in the females. These include pubic hair growth, hip enlargement, menstruation, etc.

As we mentioned in the introduction, our focus in this topic is on fertilisation and menstruation, which is one secondary characteristic that develops in females as a result of puberty. Let us see how menstruation takes place and its importance in fertilisation.

Menstruation

Menstruation is the break down of the inner wall of the uterus. It is followed by the loss of "dead" tissues, blood, and the unfertilized egg through the vagina. Every month, a woman's body prepares for pregnancy. If no pregnancy occurs, the uterus sheds its lining. The menstrual blood is partly blood and partly tissue from inside the uterus, or womb. It passes out of the body through the vagina in the form of a bloody discharge.
Once a girl starts to menstruate, the process continues throughout her reproductive life unless she is pregnant. In most women, the period of bleeding (menstruation) commences every 27 to 30 days and lasts for 3 to 5 days. Have you ever wondered about the stages leading to the release of the bloody discharge from the vagina?

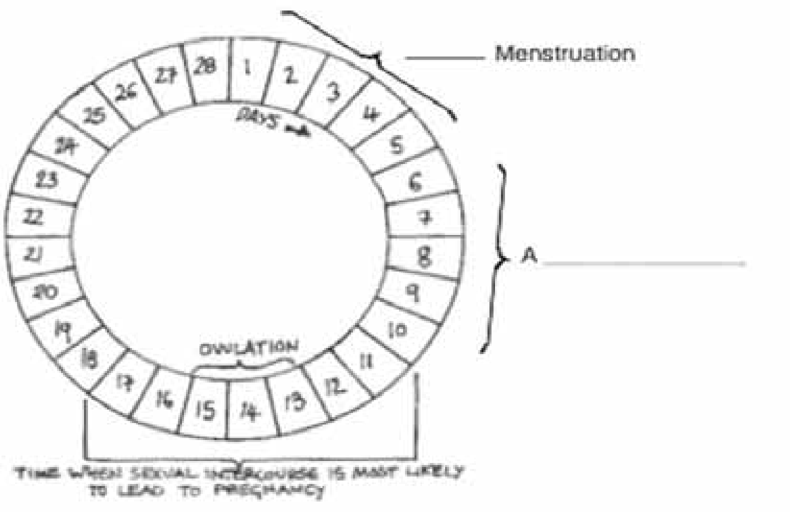
Well, the entire cycle starts with the production of ova and ends with the production of yet another ovum after the previous one has been discharged as a bloody liquid. This is called the **menstrual cycle**.

The Menstrual Cycle

This is a 28 day cycle. During the menstrual cycle, the walls of the uterus go through four phases, under the influence of the hormones oestrogen and progesterone. During the first phase, which lasts about five days, the lining of the uterus is shed, accompanied by a loss of blood. This phase is termed a woman's period, or more correctly the ***menstrual phase*.**

The other phases of the cycle prepare the uterus to receive and protect the fertilised egg which will later develop into an embryo.

Let us now look at the menstrual cycle in detail



C________________

Figure 5: The menstrual cycle

As mentioned earlier on, this can be divided into four stages. We will take the stage starting from day one to day five as the first stage. I would like you to fill in the spaces, marked with alphabets, on Figure 5 with words from the text. Therefore, as you read through, refer to the figure and label it.

Stages of the Menstrual Cycle

Stage 1: Menstruation

Menstruation days are not necessarily fixed; some people can have the first phase lasting up to 6 or even 7 days. The five days is just an average. What happens in these first five or so days is that there is discharge of a bloody liquid from the vagina. This, as mentioned earlier, is called **menstruation**. The discharge coming from the vagina has been described as a bloody discharge. From this description, the impression one will have is that it consists of blood only, but the discharge definitely does not consist of blood only.

What else does the discharge contain other than blood?

The discharge also contains ***dead cells*** *and* ***unfertilised ovum****.*

Stage 2: Preparation of the uterus

From day 6 to day 12, the walls of the uterus are repaired. This is because they have been shed during menstruation. The walls are now being replaced. Uterine wall growth is accompanied by growth of blood vessels of the uterus. As a result of this repair, the uterine wall becomes very thick.

Do you have any idea why the uterine walls have to be repaired?

Well, it is because it has to prepare itself for the developing baby, in case fertilisation takes place. The repair of the uterine wall is stimulated by the presence of the hormone oestrogen.

Apart from the above mentioned function, what else does oestrogen do in females?

Feedback

Hormones bring about the development of secondary characteristics.

Stage 3: Ovulation

Ovulation occurs when an ovum is released from the ovary into the oviduct as shown in Figure 6. This lasts from day 13 to roughly day 15 of the menstrual cycle. When ovulation occurs the follicle (ovum cover) is left behind to form the **corpus luteum.**

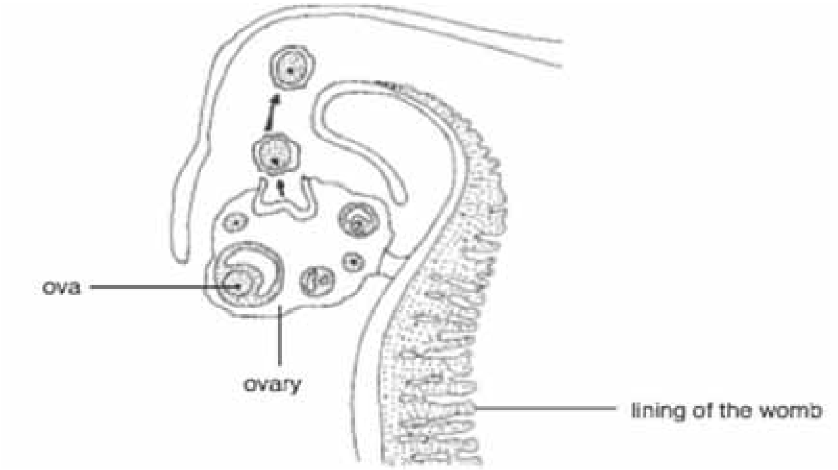


Figure 6: **Ovulation**

Can you think of any reason why ovulation has to take place?

Well, it is because fertilization can only take place in the oviduct. So for the ovum to stand a chance of being fertilised, it has to be moved to the oviduct.

In human beings and other animals, only one ovum is released at a time. In some mammals, many ova are released from the ovaries in one menstrual cycle. This is referred to as **super ovulation**. Super ovulation mostly occurs in mammals such as dogs, cats and pigs.

Animals that super ovulate give birth to many offspring at a time. We all have seen dogs with many puppies. In fact, dogs can have as many as ten puppies. This does not mean that they cannot have one puppy though. They sometimes do.

Stage 4: Fertilization

At this stage, the uterine lining is now well developed. If fertilization occurs, the embryo will be implanted in the uterine walls. This condition lasts for 6 to 7 days after ovulation, i.e. from day 16 to day 21. If the ovum is not fertilised, it dies and eventually comes out during menstruation.

Stage 5: Menstruation

If fertilisation has not occurred, the uterus lining starts to break apart (shed off). This is because the progesterone levels starts to fall off. It happens from day 21 to day 28. This is followed by the loss of the ovum and the uterine walls as menstruation through the vagina.

By now you should have completed filling in the spaces **A, B** and **C** in the diagram in Figure 5 above with the correct words. If you have not yet done so, please do so now before you continue to the next section on fertilization.

Events Leading to Fertilization

Copulation and Movement of Sperm

During copulation an erect penis is placed into the vagina with up and down movements to cause sexual excitation in both the man and woman. Mucus produced from vaginal walls, cervix and Batholin's glands on the vulva lubricates the vaginal canal to reduce friction during sexual intercourse. As sexual intercourse goes on, a maximum sexual interest called **orgasm** is reached. At this time, ejaculation occurs and a large quantity of semen is deposited into the upper vagina. The semen has many sperm. These sperm move through the female reproductive system to the oviduct where fertilisation is to take place.

Do you still remember how sperm moves around in the female reproductive system? Remember we mentioned this earlier when dealing with the structure of a sperm.

The factors that promote sperm movement in the female's reproductive system are:

- The lashing side of sperms' tails. Sperms can actually swim using their long tails.
- The force created by ejaculation.
- Contraction of walls of the vagina, uterus, and oviduct, which sucks the sperms upwards.
- A chemical in semen stimulates vaginal and uterine walls, to contract greatly.
- Fluids from seminal vesicles, prostate and cowper's glands dilute the sperms and increase their mobility.

The movement of sperm in the vagina and through the cervix can be likened to the movement of tadpoles in water.

Do you know what a tadpole is?

A tadpole is a young frog. There are many Setswana names for the tadpole, depending on which part of the country you come from. Some of these include: koloti, kwididi and koduntwane.

You may have seen a tadpole swimming in stagnant water. How does it do that? You can easily find out by doing the next activity. This is just an extra exercise. If you cannot get your hands on a tadpole do not worry.

Activity 3

Try and obtain a tadpole. You might find it in stagnant water, in a pond, or a lake. Put it in a clean bowl of water and observe its movements. If the water in the pond is clear it might not be necessary to place it in a container. You could just observe it in the pond.

How does it move?

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Feedback

It uses its tail to swim. The tadpole swings its tail in different directions and this propels it to move in different directions.

Just like tadpoles, sperms use their tails to swim through the cervix towards the ova. The liquid medium through which they swim is provided by the semen.

But what about ova, how do they move from the ovary to the oviduct? We will discuss these questions in the following sub topic.

Movement of the Ovum

Remember that we said ova are produced in the ovary and end up in the oviduct as shown in Figure 6 above. They are able to move because the muscles of the ovary have the ability to contract and relax and as they contract, the ovum is pushed into the oviduct. The oviduct muscles also contract which pushes the ova in the direction of the uterus. It is not only the muscular contractions of the two organs that push the ova towards the uterus, but also hair-like structures called cilia, which lines the walls of oviduct. These hair-like projections also continuously flick forward and backward, thereby pushing the ova towards the uterus.

We have discussed ovulation, menstruation, and the events leading up to fertilisation. Ensure that you understand these aspects of the topic before moving to the next section which is on embryo formation which includes fertilisation and implantation.

Embryo Formation

Fertilisation

To produce a baby, male and female sex cells must join together. This process of joining together is called **fertilisation.** Fertilisation means the union (fusion) of a sperm cell and an ovum cell to form a single cell called zygote as shown in Figure 7 below.

One Sperm + One Ovum = One Zygote

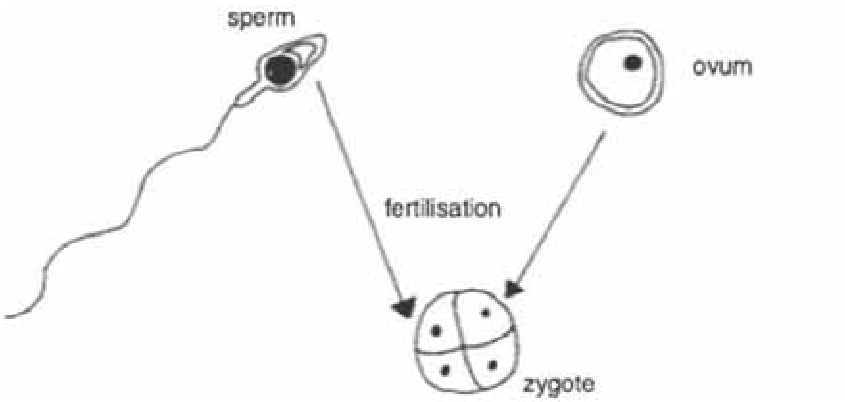

Figure 7: Fertilisation

The zygote formed begins to divide immediately by cell division called **mitosis**. The zygote is moved by cilia towards the uterus as it divides rapidly into an embryo.

For fertilization to take place the penis has to be inserted into the vagina and sperms are ejaculated into the female reproductive tract. This act is called **sexual intercourse**. It is also known as copulation or coitus.

Sexual intercourse may result in fertilisation. After ejaculation the sperm cells swim through the cervix past the uterus and push into the oviduct. If an ovum is present in the oviduct, one sperm cell will penetrate it. The nucleus of the ovum will then fuse with the nucleus of the sperm. At this stage we are now in a position to say that fertilisation has taken place.

You should bear in mind that during fertilization only one sperm is able to penetrate the egg and fertilise it.

The following diagrams illustrate how fertilization takes place.

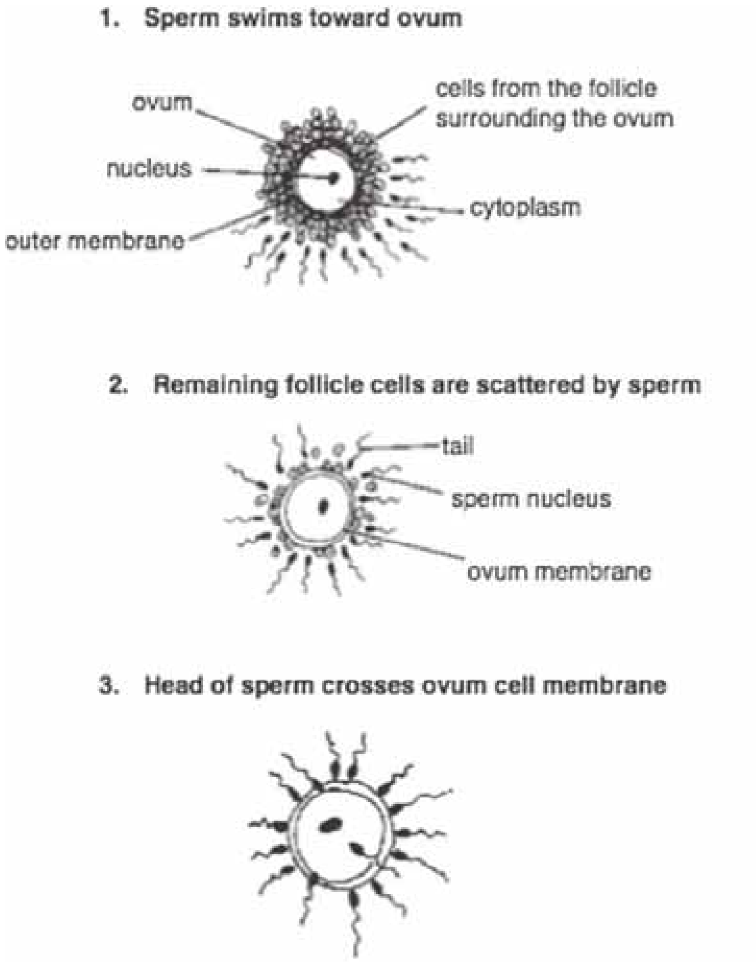

Figure 8: How fertilisation takes place

Now let us describe what happens at each stage.

Stage 1: The sperms swim towards an ovum (egg).

Stage 2: By the action of sperms the follicle cells surrounding the egg disperse, exposing the ovum/egg to the sperms.

Stage 3: One sperm penetrates the egg membrane and enters the cytoplasm. The membrane changes its form immediately so that no other sperm is able to enter.

Stage 4: The sperm nucleus and egg nucleus fuse to form a zygote. Only after fusion of the nuclei, has ***fertilisation*** taken place.

What happens after fertilisation?

As a result of fertilisation a zygote is formed. Once the ovum is fertilised menstruation stops until after the baby is born. After that, the zygote undergoes rapid cell division - that is it divides into two cells, then four cells, eight-cells, sixteen cells, thirty two cells and so on.

However, the zygote does not remain in the oviduct. As it divides, it moves into the uterus where it will undergo its final transition into a baby.

In the uterus, it sticks onto the walls of the uterine walls and proceeds with its final development. This is called ***implantation***.

Implantation

The attachment of the zygote onto the walls of uterus is called implantation**.**

This mass of cells thickens to form a hollow ball. At this stage, the zygote is now changing into another stage of growth, and therefore it is called the ***embryo***. The uterus has a thick spongy lining and the embryo sinks into it. The uterine lining provides the embryo with nutrients.

Once the egg cell is fertilized and implantation has taken place we are in a position to say that the woman is pregnant.

But do human beings reproduce throughout their life? Definitely not! There comes a time when people, especially females, cannot reproduce. This is called **menopause**.

Menopause

Between the ages of forty-two and fifty-two a woman loses her ability to reproduce. At this stage, ovulation ceases hence menstruation stops. We say that the woman has reached **menopause.** The woman can never be pregnant once she has reached menopause. Men do not undergo menopause and can, therefore, produce sperms up to the age of 100 years and even beyond.

Summary

We have now come to the end of our topic. However there are certain key processes that we discussed and these are production of ova, menstruation, copulation and fertilisation. You should by now be able to define and describe these processes giving examples where necessary.

The production of ova by females is termed *ogenesis*. This happens in ovaries. The ovum is then transferred to the oviduct and this is termed *ovulation*. It is only when ovulation has taken place that there is probability of the ovum being fertilised by a sperm. If it is not fertilised, the ovum will be lost, together with pieces from the walls of the uterus, through menstruation. This happens every 28 days. The whole sequence of events starting with menstruation and including uterine wall growth and ovulation is termed the *menstrual cycle*.

It is again time for you to complete the end of topic assignment and to follow the processes described in the first topic to correct your answers and decide whether to move on to the next topic. Topic 3 is about pregnancy and includes labour and birth.

Topic 3: Pregnancy

Introduction

In Lesson 2 you learnt about sexual intercourse and fertilisation. Sexual intercourse does not always lead to fertilization but if it does an embryo arises. The embryo will then be implanted on the walls of the uterus. The uterus is where the embryo will complete its final development into a baby. In this lesson, we will study how this embryo develops into a baby. This starts the moment after implantation until birth.

Learning Objectives

At the end of the lesson you should be able to:

- Describe the development of the foetus in terms of dependence on the placenta.
- Describe the placenta as a barrier, separating maternal and foetal red blood cells.
- Distinguish between the different types of pregnancy.
- Distinguish between identical and fraternal twins.
- Describe the passage of nicotine, alcohol and some viruses from the mother to the foetus.
- State the protective function of the amniotic fluid.
- Describe the three stages of birth.

Types of Pregnancy

Pregnancy can be of different forms depending on several factors. Below is a discussion on the different types of pregnancy.

Failed Pregnancy

In this situation the fertilised egg dies and is lost out with the menses (menstrual blood) during menstruation. The amount of blood lost in this case is quite a lot and is therefore referred to as a heavy period.

A heavy period is menstruation in which a woman loses (bleeds) out too much blood exceeding 80ml.

Ectopic Pregnancy

This type of pregnancy may also be described as lost pregnancy or tube pregnancy.

Ectopic pregnancy is an abnormality in which the fertilised egg (embryo) fails to implant itself in the uterus. The fertilised egg may begin to develop in any of the following places:

- Oviduct
- Ovary
- Near the cervix
- Abdominal cavity

Successful Pregnancy

The corpus luteum left in the ovary secretes a hormone called progesterone that prepares the uterus for pregnancy. You should remember this term from our discussion of ovulation. If you do not, go back to that section in Topic 2 and refresh your memory. By the time the fertilised egg reaches the uterus, the uterus is heavily vascularised (supplied with blood). When the embryo reaches the uterus, it sticks (or becomes implanted) onto the inner wall of the uterus. Once the embryo sticks onto the wall of the uterus we say pregnancy has occurred and the development of the embryo can begin.

The Development of the Embryo

As already mentioned earlier on, after fertilization the zygote moves down the oviduct and sinks into the wall of the uterus. It continues dividing to form a mass of cells.

The mass of cells formed by cell division eventually change into four parts.

- **The embryo** - grows into a baby.
- **Part of the placenta** - attaches the embryo to the uterus wall.
- **The amnion**- a membrane which surrounds and protects the embryo.
- **The umbilical cord** - feeds the embryo.

We will deal with the functions of the above mentioned embryonic parts in detail later on in the lesson.

The embryo then continues to grow by cell division until it changes to a **fetus.** The fetus is a stage when the mass of cells start to change into visible parts of a human being, like eyes, head, ears and others. **Embryo** is the term used to describe the unborn baby during the first two months of pregnancy and the term **fetus** is used during the last seven months.

The flow diagram below gives a summary of the stages in the development of the zygote into a baby.

Zygote ____________Embryo ___________Foetus

The fetus has some of the main features of adult life, but it is still enclosed inside the mother. How then does it survive?

Well, cellular differentiation results in the formation of the embryonic membranes we mentioned earlier on. The next diagram shows the relationship between the embryo and those membranes.

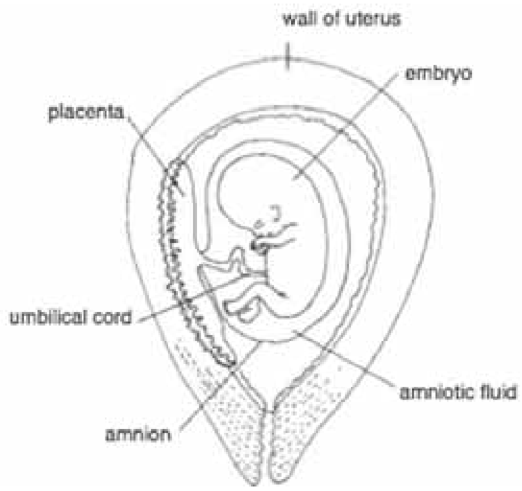

Figure 1: Human embryo

Study the above diagram carefully. We will now discuss each one of the parts in detail.

The Amnion

The embryo is enclosed in a sac called amnion. This sac is filled with a fluid called *amniotic fluid*, which protects the embryo from mechanical damage. The fluid acts as a cushion that protects the embryo from shaking when the mother moves.

So, the amniotic fluid protects the foetus if the mother has a knock on the lower abdomen. This liquid also supports the embryo and protects it from physical damage. The embryo actually floats in this fluid so it provides some kind of cushion, which can absorb any kind of shock and protect the child from external harm.

Placenta

This is a structure that supplies food and oxygen to the developing embryo. It has a tube like extension leading into the embryo. This tube is called the umbilical cord. Nutrients pass through this tube from the mother to the embryo.

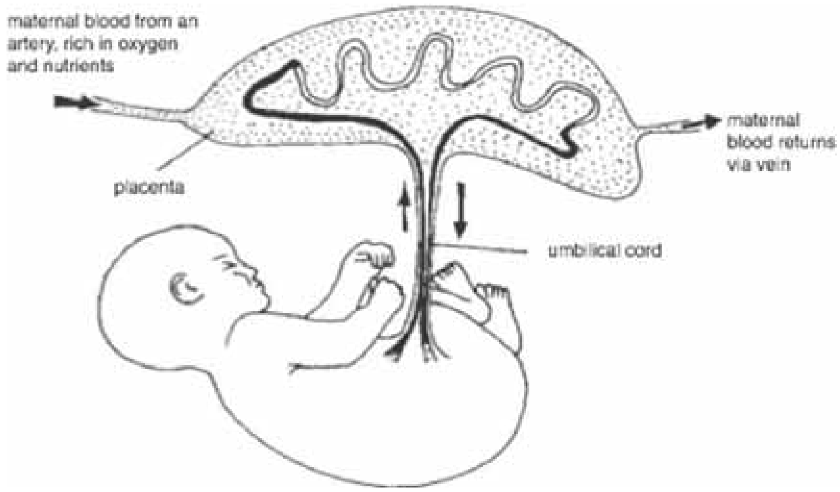

Figure 2: Human embryo showing the umbilical cord in detail

The umbilical cord connects the foetus to the placenta. It has blood vessels, which transport food and oxygen to the embryo and waste materials such as carbon dioxide from the foetus. So, functions of the placenta can be summarised as follows:

- Passage of useful substances (food and oxygen) from mother to foetus.
- Passage of excretory products (e.g. carbon dioxide and urea.) from foetus to mother.
- Produces hormones (oestrogen and progesterone) that stop any other ovulation and normal pregnancy continues.

There are other substances, apart from nutrients and excretory products, which have the ability to pass through the placenta. Some of these can affect the developing embryo and are discussed below.

(a) Viruses

Examples of these include HIV and the rubella virus. When an HIV positive person falls pregnant there is the possibility of them passing the virus to the foetus. The end result will of course be that the child will be born HIV positive.

I would like you to do the next activity. You might find it helpful to consult any family welfare educator in your area.

Activity 4

In Botswana, pregnant women are advised to go for an HIV test. In fact, you must have seen placards on taxis and very big bulletin boards around the country with the message:

"Be a responsible parent, go for an AIDS test"

Can you think of any reason why pregnant women should do an HIV test? Please note that down on the space below.

____

____

____

Suppose Kesego is pregnant. She goes for an HIV test at Tebelopele Voluntary Testing Center and finds out that she is HIV positive. What provisions has the government put in place to help her and her unborn child?

____

____

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Feedback

We are not going to provide you with feedback on this activity. You can do that yourself by visiting the local clinic or any Redcross Center and talk to them about this issue. This will enable you to interact with people who have first-hand knowledge of the issues involved and provisions made for HIV by government and others.

(b) Alcohol

Alcohol crosses the placenta very easily. Excessive drinking can affect the foetus in the following ways.

- The child can be born with special needs.
- It can also affect the development of the head and the brain. In fact, it can be such that the child has a small head. The head will be smaller than the expected average size of a human being.
- The face will be flat with a long and thin upper lip and the nose will be short and very small.
- The child will be very small. In fact, delayed growth continues even after birth. You may have seen such children. They are usually so small and skinny that you can be right if you were to liken them with malnourished

children.

Actually reduced growth is the most common problem for children born from a parent who drinks heavily.

- They have problems with concentrating. This is probably the reason why such children don't perform well at school.

You have just learned about the consequences of drinking during pregnancy. Now think about those poor children who were born with such problems just because of the irresponsibility of their parents. Do you think it is fair?

Definitely not! They were born disadvantaged by something they were never a part of to start with. We could help to solve this problem as responsible members of the community. Try to pass on this message to expectant mothers. It is not the government's sole responsibility to do this, we should all help as citizen of this country to help prevent some of these problems that arise either from ignorance or just carelessness.

(c) Nicotine

If you were to walk around your home, you will most likely not finish your walk without seeing somebody smoking. Despite the fact that smoking is a health hazard, a lot of people smoke. Some do not actively indulge in this unhealthy habit, but they still do so indirectly.

Strange statement isn't it? How do they do that? Well, those are the people who are constantly in contact with cigarette smoke from hanging around smokers. Such type of exposure to cigarette smoke is called passive smoking.

Cigarette smoke contains nicotine and carbon monoxide. These two compounds have the ability to cross the placenta into the baby's circulation. A child expected by a mother who smokes can experience any of the following problems:

- They are usually born underweight.
- They can be born premature.
- There can be late miscarriages.

It is therefore very crucial for an expectant mother to avoid smoking.

(d) Drugs

The embryo is most sensitive to drugs during the stage when it is developing organs. This is during the third week of pregnancy. Examples of such drugs include cocaine and heroin.

If a woman is addicted to one of these drugs, her baby is likely to become addicted and will usually undergo withdrawal symptoms after birth. Permanent damage to the brain resulting in mental retardation may also occur.

The table below shows some of the substances that can pass between the mother and the foetus.

Table 1: Substances capable of passing from the mother to the embryo.

Substances That Pass From Maternal To Foetal Circulation	**Substances That Pass From Foetal To Maternal Circulation**
1. Glucose or fructose	1. Carbon dioxide
2. Amino acids	2. Urea
3. Water	3. Uric acid
4. Lipids	4. Water
5. Vitamins	
6. Mineral salts e.g. Fe, Ca, P	
7. Hormones	
8. Oxygen	
9. Antibodies	
Others	
• Drugs, Nicotine and CO in cigarette smoke	
• Viruses e.g. Rubella, HIV	
• Bacteria	
• Alcohol if taken by the mother	

Foetus take much calcium (Ca) and phosphate (P) from maternal circulation. If the mother does not eat a diet rich in Ca and P, the minerals are taken from her bones and passed through the placenta to the foetus. These are for foetal bone growth. This is why the bones of a malnourished pregnant woman are very weak.

Our discussion has taken you through the development of the embryo as it grows into a baby and some of the substances that can affect the developing embryo like viruses, drugs, nicotine etc. Let us now look at the stages of development of the foetus during the gestation period.

Foetal Developments in the Uterus

Study the table below and the diagrams that follow. They all show stages of foetal development in the uterus which we have already discussed.

Table 2: A summary of the stages of foetal development in the uterus.

Time after Fertilisation	**Stage of development**
1 – 10 days	Hollow ball of cell, thick on one end Implantation (pregnancy) occurs
3 weeks	Head region is obvious Spinal cord and heart start development
6 weeks	Brain growing rapidly Eyes and ears are developing Arm and leg buds forming
12 weeks	The embryo becomes a foetus Has external appearance just like a human baby
9 months	Birth or parturition occurs

The next flow diagram shows stages of growth and development of the foetus in the uterus.

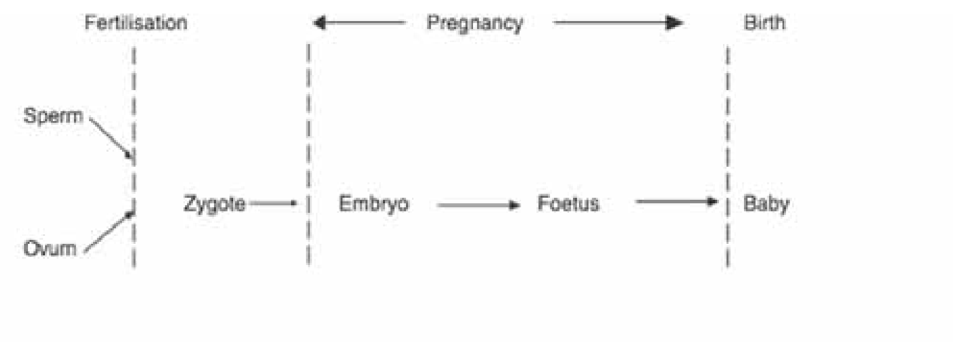


Figure 3: Stages of growth and development of the foetus

At one stage of development (after 12 weeks of pregnancy) the embryo begins to resemble a human, hence it is called foetus. How then is a baby born? Read the next section for an answer to this question.

Labour and Birth

In the previous section you learnt about the stages of growth and development of the foetus in the womb. In the next part of the lesson you will be dealing with three things and these are:

- How to calculate the date of birth
- Labour
- Birth

How to Calculate Date of Birth

In order to calculate the date of birth, the following steps can be followed:

Step		**Example**
1.	Write down the first date of menstruation	= 1st March 1998
2.	Add 14 days	= 15th March 1998
3.	Add 9 months	= 15th Dec. 1998
	Date of birth	**= 15th Dec. 1998**

Explanation

We add 14 days because from the first day of menstruation, ovulation and fertilisation occurs around the 14th day of the menstrual cycle. The 9 months we add are the gestation period of a human being.

Note

Birth normally occurs between 280 ± 7 days (273 to 287 days) after fertilisation.

Labour

This is a period of pain before the actual birth process starts. Labour period involves the cut down of the following substances to the foetus by the mother:

(i) Hormones – progesterone level falls down but oestrogen level remains high.

(ii) Foods.

(iii) Other substances useful to the foetus.

What causes the pain felt by the mother during labour?

During labour time the uterine wall begins to contract. The contraction is stimulated by the high level of the hormone oestrogen. Oestrogen promotes uterine contraction but progesterone inhibits it.

The uterine contraction continues with an increase in the frequency and magnitude as the birth process nears.

Birth or Parturition

Birth or parturition is the expulsion of the foetus/child out of the reproductive system at the end of pregnancy, see Figures 4 and 5. Here the uterine wall contracts vigorously. This is caused by the secretion of the hormone ***oxytocin***, from the pituitary gland.

Birth involves three stages: opening or dilation, delivery, and afterbirth.

(a) Opening or Dilation

In this stage the cervix and birth canal dilate (widen or open) to enable the passage of the foetus. The amnion breaks and the amniotic fluid flows out.

(b) Delivery

In this stage the foetus passes through the cervix and birth canal and out of the mother's reproductive system. The umbilical cord is tied twice and cut in the middle near the child. The baby breathes in or inhales air for the first time and normally cries as a response to cold air reaching the lungs. The normal birth weight of a baby is about 3kg.

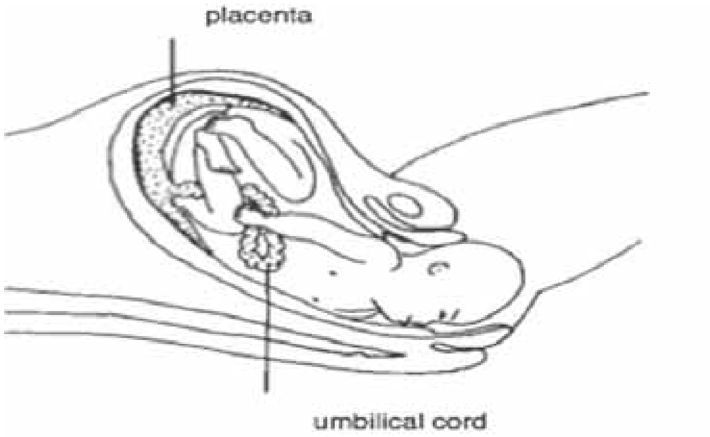


Figure 4: Birth

(c) Afterbirth

The placenta comes out between 10 to 20 minutes after delivery. If the placenta fails to come out, it will begin to rot in the womb. This can kill the mother if not removed fast.

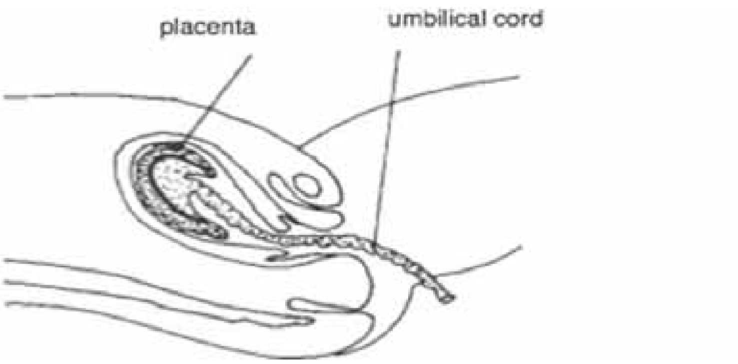


Figure 5: Removal of placenta from the uterus

After birth, a hormone called ***prolactin*** is released from the pituitary gland. When it reaches the breast, it stimulates the mammary glands to produce milk. The process of production of breast milk to feed the baby after birth is called ***lactation.***

The mother provides the child with the following things at the early stages of growth and development during the post-natal life.

1. Food
2. Security
3. Shelter
4. Education
5. Clothes
6. Medical care

Summary

You have learned that in the uterus, the embryo completes its stages of development into a baby. The embryo cells divide rapidly to produce many cells. These cells are then differentiated according to the role they are going to play in this final development. The tissues that arise as a result of this cellular differentiation include: placenta, umbilical cord, and amnion.

The placenta provides a stable environment for the embryo to develop. The fetus is attached to the placenta by the umbilical cord. It is surrounded by the amnion. The amnion is a very strong membrane, which protects the embryo. It has the amniotic fluid, which acts as cushion and thus protects the embryo from mechanical shock.

The embryo then develops inside these structures for nine months and then birth takes place.

I am sure that you remember that at this stage it is time to do the end of topic exercise. Before moving on to the next topic, you should follow the steps explained in earlier topics to correct your work. The next topic is about family planning.

Topic 4: Family Planning

Introduction

In the previous lessons, you learnt about pregnancy and foetal development. Remember that we said pregnancy comes about as a result of sexual intercourse, which leads to fertilisation. In this lesson you are going to learn how we can prevent pregnancy. This is the practice whereby couples choose, or rather, decide on the number of children they want to have and when they want to have them. Many people decide to have fewer children or to space out pregnancies with a few years between children. Prevention of pregnancy is called

contraception. People occasionally do have sex just for pleasure. This does not mean that when they do that, their intention is to have babies. The spacing apart of pregnancies may be achieved through the use of contraceptives. Contraceptives prevent pregnancy. Using contraception allows couples to choose when they want to have babies, the number of children they want, and lastly the age differences between their children. It is very important for people to plan on the type and size of families they want to have. This is called **family planning.** Contraception is an essential part of family planning. There are many methods of contraception. However, they can be grouped into two categories. Theses are: natural methods, and artificial methods.

Learning Objectives

At the end of the lesson, you should be able to:

- Describe family planning.
- Discuss the dangers of teenage pregnancy.
- List and describe the various birth control measures.

Natural Methods

These are family planning practices which do not involve the use of artificial devices. They are based on knowledge of a person's reproductive cycle and sexual behaviour and are discussed below.

Calendar or Rhythm or Safe Period

In this case the woman makes a chart for her menstrual cycle. The menstrual cycle has three main parts:

(i) Menstruation period.

(ii) Unsafe period or period of ovulation (fertilization occurs if mating takes place).

(iii) Safe period (no fertilization even if mating occurs in this period).

This method has a failure rate of 24%.

Below is an illustration of the calendar method of birth control and indicates the three parts of the menstrual cycle listed above.

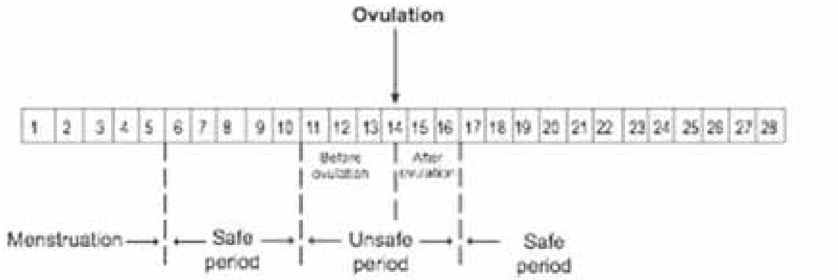


Figure 1: Menstrual grid showing safe period during the cycle

Body Temperature Method

Body temperature of a human rises by about 0.5 degrees celsius at ovulation time.

In this method, the woman should measure her body temperature frequently towards ovulation time. She stops sexual intercourse if her body temperature rises because ovulation has occurred. The disadvantage is that thermometers are rare and some people do not know how to read thermometers.

Withdrawal Method

In this method, mating occurs normally but a few seconds to the man's orgasm (ejaculation) he withdraws his penis from the vagina. This method has a high failure rate. In fact, it is probably the most ineffective method of birth control.

Disadvantages

(i) Fluid coming out of the penis before ejaculation has numerous sperm which make fertilization possible.

(ii) STDs can be transmitted.

Breast feeding method

Some women do not have sex during their period of breast feeding the child. They take longer to breast feed their children in order to space the children.

Disadvantage
Long breast feeding overburdens the woman and she may have to take time off work, if she is employed to go home and breast feed.

Post coital Douching

This involves cleaning the vagina with a device that runs a stream of water. To douche means to wash with a stream of water. Douching is done immediately after sexual intercourse.

Disadvantage
This method has a very high failure rate and it does not stop the spread of STDs.

As we mentioned earlier natural methods are one of the two family planning methods we discuss in this topic. The second methods are artificial ones and this is what we will be discussing next.

Artificial Family Planning Methods

These methods use man-made products or synthetic products. Examples include the diaphragm, condom, and all the others discussed below. They are usually dispensed in clinics and hospitals. They provide a high degree of efficiency and safety as compared to natural methods.

Condoms

This is a thin rubber tube, which is inserted on to an erect penis. During sexual intercourse it prevents sperms from entering the vagina. It is easily available and can also help prevent sexually transmitted diseases.

Figure 2: **Condom**

The Pill

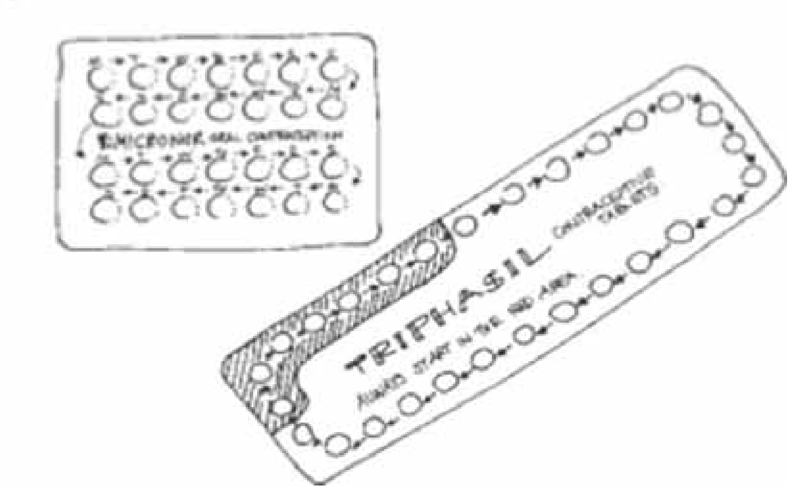


Figure 3: The pill

These contain the female hormones mentioned in our previous lessons. They prevent pregnancy in three ways:

(i) They produce a sticky substance which fill the opening into the womb preventing the sperm from swimming through.

(ii) They prevent ovulation.

(iii) They stop the ovum from moving along the oviduct.

The pill must be prescribed by a doctor. This is because of the possible side effects that can come about as a result of usage.

Diaphragm

This is a rubber tube that is inserted into the vagina and closes the cervix. It is only fitted during sexual intercourse. It fits inside the vagina and closes the uterus. It is initially fitted by a doctor or nurse and it is very effective if used with spermicides.

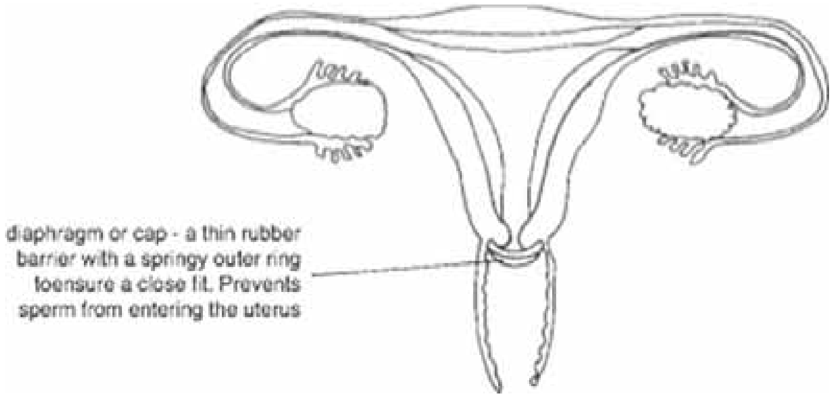


Figure 4: Diaphragm

Spermicides

Spremicides are chemicals that kill sperms. They will be effective only if used with diaphragm or condom, ie they have to be smeared onto either the diaphragm or the condom.

The IUD (intra-uterine device /loop)

An IUD must be inserted by a doctor or nurse. It can remain in the womb for 2 -3 years.

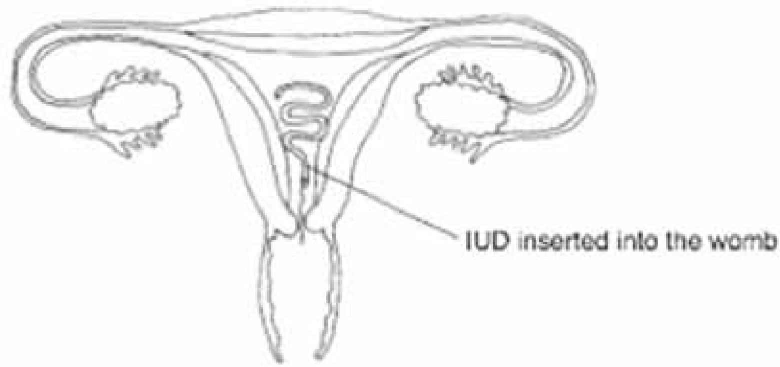


Figure 5: IUD inserted into the female reproductive system

Sterilization

This is a simple operation or cut on the reproductive parts. In males, the sperm duct is cut to prevent sperms from being released into the vagina during sexual intercourse. It does not prevent the testis from producing sperms nor does it affect sexual activity. Male sterilization is also called **vasectomy.**

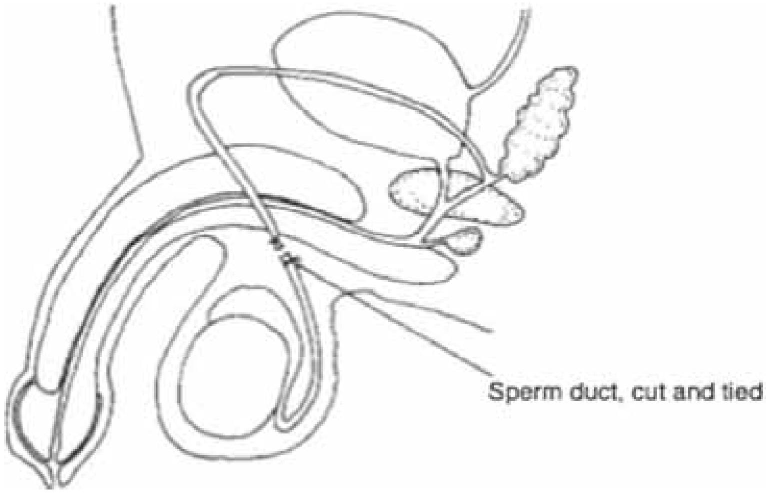


Figure 5: Vasectomy

In females, the oviducts are cut and tied (see the diagram below). This prevents the ova from being released into the oviduct and thus they can never have any contact with the sperm. Female sterilization is also called **laparatomy.**

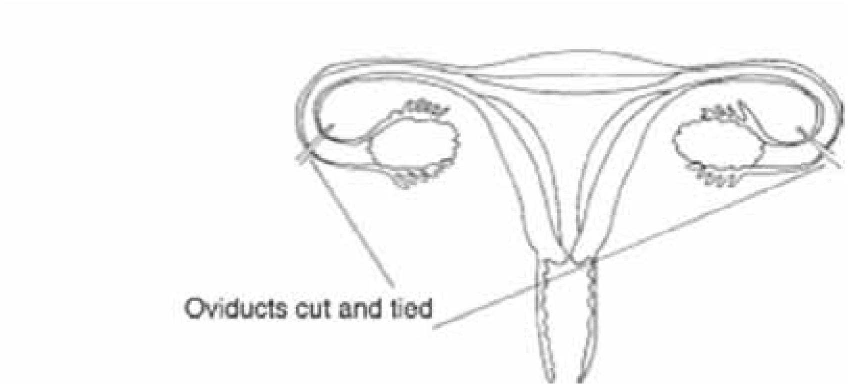


Figure 6: Laparatomy

Let us now compare the various birth control measures by looking at their advantages and disadvantages.

Comparison of the Various Birth Control Methods

We have learnt about the different methods of birth control. These birth control methods have their advantages and disadvantages and these are summarised in Table 1 below.

Table 1: Comparison of birth control methods

Method	Advantages	Disadvantages
Condoms	Easily available Helps prevent STDs	Risk of being defective which may lead to accidental pregnancy
Diaphragm	Effective if used with a spermicide	Foreign object within the body has a risk factor of being infected Needs medical assistance for insertion
Pills	Easy to use regularly Dependable if correctly used	Must be prescribed by doctor Possible side effects in physical conditions and menstrual cycle
Spermicides	Effective if used with condom or diaphragm	Unreliable if used alone
I.U.D	Very reliable	Must be inserted by doctor Long periods of insertion might lead to infection Sometimes causes cramps, pains and even bleeding
Periodic Abstinence	No contraceptives used hence no religious taboos attached	Unreliable because menstrual cycle can change
Sterilization	Very reliable	No chance of getting pregnant even if desired Almost always irreversible Not suitable for young couples

Family Planning Advice and Service

There are many outlets that provide family planning advice and services. The methods adopted may differ from one country to the other. The Botswana government's main concern is that the national resources of food and space will not be able to meet demand if populations continue to increase.

Hence certain countries, such as India and Singapore have well organised publicity campaigns directed at limiting family size. Some offer inducements ranging from transistors, radios, special medical, and educational facilities. Every country has family planning clinics and centres even in the rural areas, which provide information to common people in the form of pamphlets, booklets, articles, slides, and pictures. They also provide counselling advice and slogans, which are spread throughout the country.

Summary

We have now come to the end of our topic and please remember that the methods of birth control we just learned about can be grouped into two categories as follows:

Natural methods		**Artificial methods**	
1.	Calendar	1.	Condom
2.	Abstinence	2.	Diaphragm
3.	Body temperature	3.	Contraceptive pills
4.	Withdrawal	4.	Sterilisation
5.	Mucus	5.	Intrauterine Device
6.	Long breastfeeding	6.	Injection
7.	Post coital douching	7.	Norplant
		8.	Spermicide

It is important to remember that all natural methods of family planning, except abstinence, can not prevent the spread of sexually transmitted diseases.

Remember to again complete the topic assignment. At this stage that is after having completed the previous three topic assignments of this unit, you know exactly what to do.

The last topic of the unit, Topic 5 on heredity, is next.

Topic 5: Heredity

Introduction

In Unit 1 we learnt about chromosomes. Do you still remember what they are? Well if you don't, please revise Unit 1 again before continuing with this topic.

As a reminder, we said that chromosomes are units of inheritance. They are found in the nucleus of each and every cell in all living organisms. It does not matter whether the cell is a body cell or a sex cell, they all have chromosomes. Inheritance means the ability of living things to pass genetic information onto their offspring.

In this lesson, we shall study inheritance, the way in which genetic information is passed from generation to generation. This information determines certain characteristics which include height, skin colour, eye colour, physical features etc.

Learning Objectives

At the end of the lesson, you should be able to:

- Define inheritance as the transmission of genetic information from one generation to the other.
- Define a gene as length of DNA coding for a particular characteristic.
- State how genes are passed on from generation to generation.
- Define mitosis and meiosis.
- State the difference between mitosis and meiosis.
- Define the terms dominant, recessive, genotype, phenotype, heterozygous and homozygous.
- Using symbols, draw and interpret diagrams to show the inheritance of sex.

Inheritance

This refers to the handing down of characters or traits of parents to their offspring. The word that is commonly used for offspring is **progeny** so we might as well stick to the term throughout this lesson. These characters are passed on to the progeny during reproduction. For example, whatever characteristics that we have obtained from our parents took place during fertilisation. The characters that we inherited from our mothers came with the ovum during fusion with the sperm. The sperm in turn also brought with it those traits that we inherited from our fathers. The characteristics are passed on in units that are called genes.

Genes

Genes are found inside chromosomes. A gene is a part of a chromosome that determines a particular characteristic of an individual. Genes control many characteristics.

Examples of such characteristics are many and they include, hair colour, skin colour, eye colour, blood types, gender, shape of the face, etc. One gene controls the development of a particular characteristic, that is, the gene responsible for eye colour only controls that particular character. It will not control the development of skin colour. Skin colour therefore has its own gene.

Each of your cells contains a pair of each kind of gene. The pair of genes or rather the combination of genes, which code for a particular characteristic, is called the **genotype**. The characteristic is called the **phenotype**. Phenotype is the outward appearance or the physical appearance of an organism. It can therefore be seen.

Let's use the inheritance of eye colour as an example.

Human beings have two types of eyes. They can either be brown or blue. The phenotype of a person who has brown eyes is brown eyes, whilst the phenotype of a person who has blue eyes is blue eyes. You should bear in mind that these phenotypes are only with respect to eye colour. We will now do some examples to clarify this point.

1. Kago has brown eyes whilst Mpho has blue eyes. What are their phenotypes with respect to eye colour?

____

2. Skin colour is an example of an inherited characteristic. Tiro has brown skin whilst Dineo is albino. What are their phenotypes?

____

____

Kago's phenotype is brown eyes whilst Mpho 's phenotype is *blue eyes.*

Dineo's phenotype is albino whilst Tiro's phenotype is brown skin.

All of the cells of an organism have the same pair of genes. One gene of each pair comes from the mother and the other one comes from the father. The pairs of genes are in the same place on the chromosomes. For genes to fully express themselves well, they have to be paired. One gene might be stronger than the other one and as a result will express itself fully if paired with the weaker gene.

The stronger gene can be said to be dominant over the weaker one, so it is always referred to as the **dominant gene**. The weaker one is called **recessive gene**.

The weaker gene can only express itself if paired with its kind, that is another weaker gene. In genetics, letters are sometimes used to represent genes.

Let us do an example to illustrate this point. We will use the inheritance of eye colour in human beings. Brown eye colour is dominant to blue colour in human beings. We will take B to represent the gene for brown eyes and b for the gene for blue eyes.

Example:
The combination of genes for brown eyes can either be BB or Bb. We are using two letters because as we said earlier, genes exist in pairs. These letters represent the genotype of the individual. A person with B and b has brown eyes too.

If Tiro has brown eyes, what are his possible genotypes?

____

Tshepho has blue eyes. what is his possible genotype?

____

Tshepho has the genotype bb, Tiro has either the genotype BB or Bb. This is because B is dominant over b so when they are paired, the dominant gene expresses itself in the phenotype.

There is a pair of genes that play an important role in determining the sex of an individual. These genes are found in chromosomes that are called the X and the Y chromosomes.

Inheritance of Sex

The sex of a child is determined by the combination of two sex cells or gametes. But then what is a gamete? Remember, that we talked about gametes in Topic 1 of this unit. Well, a gamete is a reproductive cell containing half the number of chromosomes as compared to the number of chromosomes contained in each body cell. We learned about chromosomes in Unit 1. So definitely you must remember what a chromosome is. If you don't please revise this topic again and write down what a chromosome is in the spaces below.

____

____

Feedback

Well, you probably remembered it as an organelle that is found in the nucleus of cells.

But then what is their role? Are they just ornaments that are found in cells? Definitely not! They contain information that is passed from generation to generation. This information is also sometimes referred to as hereditary information. This information is stored in particles called genes.

Human cells have many thousands of genes which code for many different characteristics. For example, you have a gene which codes for the colour of your eyes, another one is for skin colour, a gene for blood group type, another for ear shape, type of chin and so on.

All those characteristics that you inherit from your parents are through genes.

You must have seen people who resemble their parents in someway. For example, say they have the same type of nose or ears as one of their parents. Well we can say they have inherited the nose or ear type from the parent. This characteristic was passed onto them from the parents during fertilization, inside chromosomes, which are found in the sex cells or gametes.

Activity 5

I would like you to observe your parents and list all those characteristics that you think you might have inherited from your parents. It may also be any of your close elderly relative.

Consulting your tutor might help if you have any problems with this activity.

____

____

____

What about the ability to speak a particular language? I am a Motswana by nationality and I speak this language extremely well. Did I inherit this fluency from my parents? You should justify your answer

____

____

____

Feedback

Discuss your answers with your tutor as there is no definite answer for this activity. This activity will generate a lot of discussion between you and your tutor and even other learners at your study centre. You may also discuss this with your family members.

Sex Chromosomes

A normal body cell contains 46 chromosomes inside the nucleus whilst a gamete contains 23, which is half the normal number. So when two gametes fuse during fertilisation, they each bring 23 chromosomes, which adds up to 46, hence there are 46 chromosomes in a body cell, as Figure 1 below demonstrates.

Gamete	**Body cell**
Number of chromosomes 23	Number of chromosomes 46

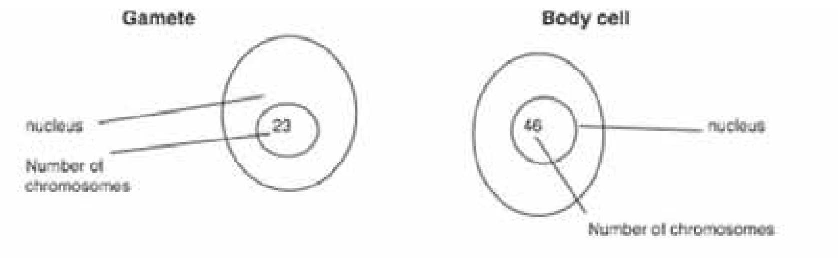


Figure 1: An illustration showing number of chromosomes in gamete and body cell.

During fertilisation, a sperm (with 23 chromosomes) combines with an ovum (also with 23 chromosomes) to form a cell with 46 chromosomes in it. That is the 23 chromosomes from the sperm combine with the 23 chromosomes from the ovum to make 46 chromosomes.

Chromosomes exist in pairs inside the nucleus so a human cell has 23 pairs of chromosomes.

Please note: A pair is two chromosomes. So 23 pairs make 46 chromosomes.

Out of the 23 pairs of chromosomes in human cells, only one pair is responsible for determining whether a zygote develops into a male or female.

Since the pair is responsible for determining whether the child will be male or female it is therefore called **a pair of sex chromosomes.**

One member of this pair comes with the sperm from the father and the other member comes with the ovum from the mother.

There are two types of sex chromosomes. There is an X-sex chromosome and Y-sex chromosome.

What is a sex chromosome?

____

How many pairs of chromosomes does a human being have?

____

If you cannot answer the questions above, go back and read the section again.

We will now look at how these chromosomes determine the sex of an individual.

As we mentioned earlier on, a sex chromosome can either be X or Y. Now, a male has an X sex chromosome and Y sex chromosome to make the sex pair. Remember chromosomes exist in pairs. This now implies that the sex pair in males will be a combination of an X and Y chromosome. Males are therefore always XY. When a male produces sperms, these two chromosomes separate to produce two different types of sperms. One sperm will be an X sperm whilst the other will be Y sperm.

The X-sperm contains the X sex chromosome in its nucleus whilst the Y- sperm contains the Y sex chromosome in its nucleus, see Figure 2.

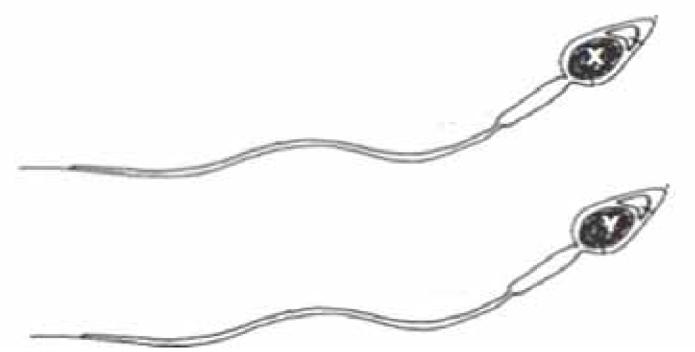


Figure 2: Types of sperm

Females contain the X chromosome only, that is the sex chromosome pair is always two X chromosomes, XX.

Now think about this a moment, how many types of ova do you think a female can produce during gamete production?

If you thought females can produce only one type of ova, you were definitely right.

There is only one type of ovum being X. It has the X sex chromosome as illustrated in Figure 3.

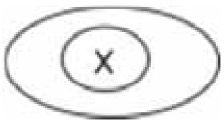


Figure 3: Ovum

So females only have two X chromosomes (XX), whereas males have both an X chromosome and Y chromosome (XY).

Let us now look at how a baby boy and a baby girl are formed during fertilization.

(a) How a Baby Boy is Formed

If during sexual intercourse, a Y- sperm unites with the ovum during fertilization, a baby boy will be born as illustrated in Figure 4.

Male gamete + Female gamete = Fertilization

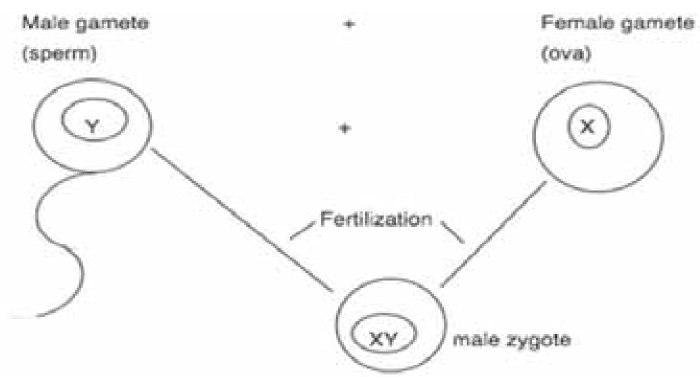


Figure 4: Formation of a male zygote.

Why is this so? Remember we said males are always XY. This combination can only happen if a Y sperm has been involved in fertilization.

The population of the X and Y sperms are the same, that is, equal numbers of X and Y– sperms are made in the testes. Hence the X and Y sperms have equal chances of fertilizing the X ovum released by the female. This therefore means that there is an equal chance of a male or female offspring being born out of any fertilisation. You may be asking yourself how then is a baby girl formed? Read the next section to get the answer.

(b) How a Baby Girl is Formed

This time, during fertilization, the X sperm is the one which is involved. It unites with the ovum which of course is always an X. See the illustration below, Figure 5 and compare it with Figure 4 above to consolidate your understanding of how boys and girls are formed.

Male gamete + Female gamete = Fertilization

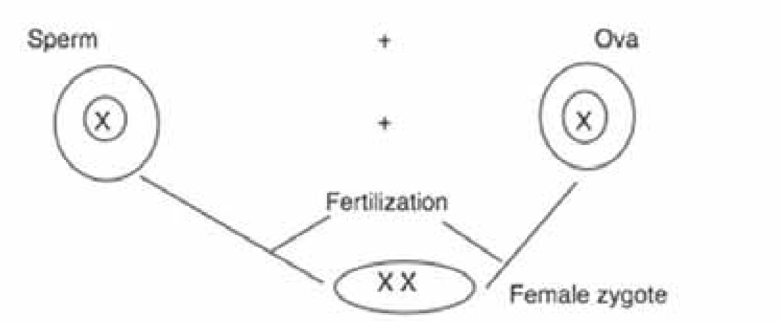


Figure 5: Formation of a female zygote

Bear in mind that females do not have a Y sex chromosome, this is only found in males. Gamete formation is our next discussion item in this topic on inheritance.

Gamete Formation

Gametes just like any other cells are formed through cell division. But the type of cell division is different from the normal cell division that takes place in most body cells. It is called **meiosis**. This is opposed to mitosis in body cells.

In order to understand how these types of cell division differ, lets go back to the arrangement of chromosomes in cells. Body cells have 23 pairs of chromosome (46 chromosomes) in their nucleus. This is opposed to the 23 single chromosomes in sex cells. The number of chromosomes in the sex cells is always half the number found in normal body cells. However, the sex cells are formed from body cells. But then, how do we end up with 23 chromosomes instead of 46?

Well this comes about as a result of a cell division called meiosis. The next diagram explains how meiosis takes place. Ensure that you study the diagram and the information summarised in the five stages to fully understand meiosis.

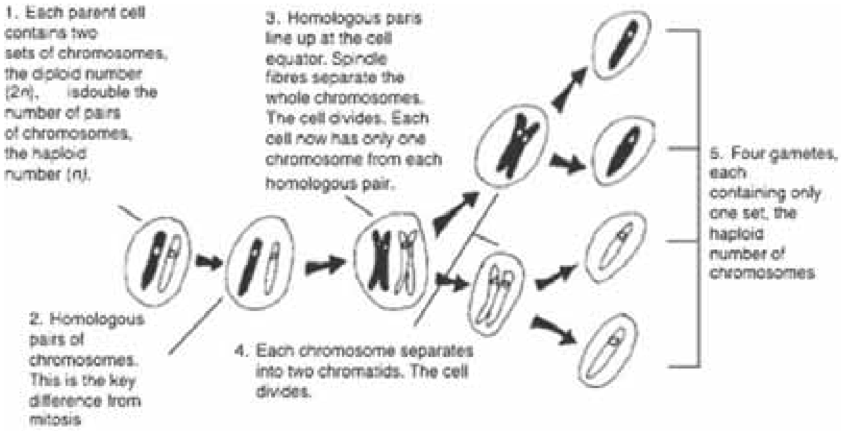


Figure 6: Meiosis

Meiosis results in the formation of sex cells. It takes place in the ovaries for females and the testis in males.

Summary

We have now come to the end of our lesson and please remember that cells have chromosomes in their nucleus. As human beings we have 23 pairs of chromosomes. Out of this 23 pairs only one pair is responsible for determining the sex of an embryo. This pair is called the sex chromosome pair. Sex chromosomes are of two types and these are the X chromosome and the Y chromosome. The sex chromosome pair in females is two X chromosomes therefore females are referred to as XX. The males on the other hand have both an X sex chromosome and Y sex chromosome therefore they are referred to as XY.

Chromosomes contain genes. Genes are particles of inheritance, that is, they pass on hereditary information from one generation to another generation. Genes are of two types. The physical characteristics that arise from genes are called phenotypes, whilst the combination of genes that make a particular phenotype is called a genotype.

What is the next task that you have to do? Remember to complete the topic assignment. You also know exactly how to correct your answers. But because this is the last topic of the unit remember to read the unit summary as well.

Unit Summary

Summary

In this unit you learned human beings have different reproductive systems, i.e. the male and the female reproductive systems. These systems produce sex cells. The female reproductive system consists of the ovary, oviduct, uterus, cervix, vagina, and the clitoris. The male parts are the testis (which are enclosed in the scrotum), epididymis, sperm duct, accessory glands, urethra, and the penis.

These organs undergo maturity through a process called puberty. Puberty is when the individual is sexually transformed into an adult. It is characterised in males amongst others by enlargement of the penis and production of sperms, whilst in females the characteristics include production of ova and menstruation. The characteristics that arise from puberty are termed secondary sexual characteristics. When somebody has reached puberty, they are now in a position to produce young ones. There are certain key processes that we discussed and these are production of ova, menstruation, copulation, and fertilisation .You should by now be able to define and describe these processes giving examples where necessary.

The production of ova by females is termed *oogenesis*. This happens in the ovaries. The ovum is then transferred to the oviduct and this is termed *ovulation*. It is only when ovulation has taken place, that there is a probability of the ovum being fertilised by a sperm. If it is not fertilised, the ovum will be lost, together with pieces from the walls of the uterus, through menstruation. This happens every 28 days. The whole sequence of events starting with menstruation and including uterine wall growth and ovulation is termed the menstrual cycle.

In the uterus, the embryo completes its stages of development into a baby. The embryo cells divide rapidly to produce many cells. These cells are then differentiated according to the role they are going to play in this final development. The tissues that arise as a result of this cellular differentiation include: placenta, umbilical cord, and amnion.

The placenta provides a stable environment for the embryo to develop. The foetus is attached to the placenta by the umbilical cord. It is surrounded by the amnion. The amnion is a very strong membrane which protects the embryo. It has the amniotic fluid which acts as cushion and thus protects the embryo from mechanical shock.

The embryo then develops inside these structures for nine months and then birth takes place.

The methods of birth control we just learned about can be grouped into two categories.

Natural methods	Artificial methods
1. Calendar	1. Condom
2. Abstinence	2. Diaphragm
3. Body temperature	3. Contraceptive pills
4. Withdrawal	4. Sterilisation
5. Mucus	5. Intrauterine Device
6. Long breastfeeding	6. Injection
7. Post coital douching	7. Norplant
	8. Spermicide

All the natural methods, except abstinence cannot prevent the spread of sexually transmitted diseases.

You would also remember that we learned that cells have chromosomes in their nucleus. As human beings we have 23 pairs of chromosomes. Out of this 23 pairs only one pair is responsible for determining the sex of an embryo. This pair is called the sex chromosome pair. Sex chromosomes are of two types and these are the X chromosome and the Y chromosome. The sex chromosome pair in females is two X chromosomes therefore females are referred to as XX. The males on the other hand have both an X sex chromosome and Y sex chromosome therefore they are referred to as XY.

Chromosomes contain genes. Genes are units of heredity that, they pass on genetic information of different characteristics from one generation to another generation. Genes are of two types. The physical characteristics that arise from genes are called phenotypes whilst the combination of genes that make a particular phenotype is called a genotype.

We have come to the end of Unit 11. If you have not yet completed Topic 5's assignment, do so now. Thereafter revise the whole unit if necessary before completing the Unit Assessment which can be found at the end of the Assignments. This Assessment should be sent to your tutor for marking. Good luck with this task. The next

Unit is on health and disease.

Assignment

Assignment

Self-assessment Exercise 1

1. What do you call the release of sperm when a boy dreams at night? [1 mark]

____

2. Name the **three** accessory glands. [3 marks]

____

____

3. The skin sack holding the testis is called: [1 mark]

____

4. (a) Name **four** female reproductive organs of a human being. [4 marks]

____

(b) Which cells are produced in the female reproductive system? [1 mark]

____

5. What is the function of the penis during sexual intercourse? [2 marks]

____

6. (a) What is the function of semen? [2 marks]

____

(b) Where is it produced? [1 mark]

____

Total = [15 Marks]

Self-assessment Exercise 2

1. Define gametogenesis. [2 marks]

____

____

2. (a) How many types of gametogenesis are there?[1 mark]

____

(b) Name them. [2 marks]

____

____

3. Where does gametogenesis take place [2 marks]

(a) in males_______________________________________

(b) in females_____________________________________

4. (a) Define ovulation. [2marks]

____

____

(b) When does it take place? [1 mark]

____

5. What makes it possible for dogs, cats and pigs to have many offspring? [2 marks]

____

6. Define the following words [3 marks]

(a) menopause:

____

(b) copulation:

____

(c) menstruation:

____

Total = [15 Marks]

Self-assessment Exercise 3

1. Explain why a pregnant woman frequently urinates.
[2 marks]

____

____

2. Comment on both metabolic rate and the appetite of a pregnant mother. [2 marks]

(a) Metabolic rate

____

____

(b) Appetite

____

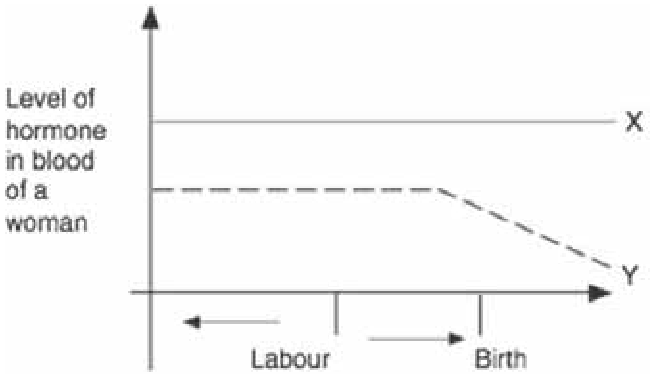
____

3. Define ectopic pregnancy. [2 marks]

____

____

4. The graph below shows fluctuation of two sex-hormones, oestrogen and progesterone during labour and birth time in a pregnant woman.



(a) Which curve (X or Y) shows level of oestrogen?[1 mark]

____

(b) Which curve, (x or y) shows the level of progesterone?[1 mark]

5. Describe briefly the following terms.

(a) Labour [2 marks]

(b) Parturition [2 marks]

(c) Abortion [2 marks]

(d) Still-birth [2 marks]

(e) Miscarriage [2 marks]

Total = [20 Marks]

Assessment

Assessment

1. A man feels pain when urinating and he has sores on his penis. This could be caused by having unprotected sexual intercourse with a woman:

   A. With a sexually transmitted disease

   B. Who is using the pill

   C. Who has bilharzia

   D. Who is menstruating

2. Which one of the following is a method of birth control?

   A. Sterilization

   B. Fertilization

   C. Menstruation

   D. Ejaculation

3. Which method of birth control minimises the spread of STD?

   A. The pill

   B. The loop

   C. The condom

   D. The diaphragm

4. Which one of the following is the most effective way of avoiding pregnancy and AIDS?

   A. The contraceptive pill

   B. The diaphragm with spermicides

   C. The condom with spermicides

   D. Total abstinence from sex

5. Having a small family is more advisable because

   A. Parents are able to give adequate financial support to children

B. The government will give money to raise your children

C. If they are many they will fight among themselves

D. When few, children have to look after their parents

6. How does a diaphragm prevent pregnancy?

A. It kills the sperm

B. It prevents sperms from passing to the oviduct

C. It prevents ovulation

D. It initiates menstruation

7. When a man is sterilized

A. He is unable to have an erection

B. He is less interested in sex

C. His sex life may be improved

D. He will ejaculate a fluid with no sperms

8. Which of the following statement is TRUE about sterilisation. (A method of birth control)

A. It is good for older couples who are sure they do not want children any more

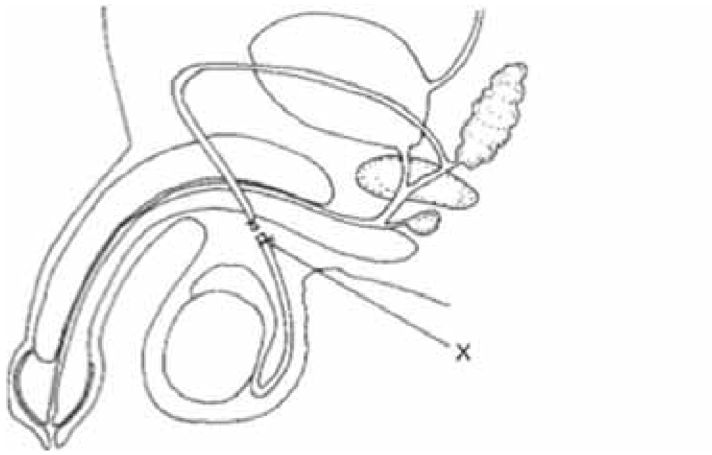
B. It is good for Learners because it is very cheap

C. The method can easily be reversed

D. It is only used by couples who want only one child

B. Short Answer Questions

1. Study the diagram below and use it to answer the following questions



(a) Which method of birth control has been used in the diagram? [1 mark]

____

(b) The part labelled X is the _______________[1 mark]

2. Write down the advantages of a small family. [5 marks]

____

____

3. Define the following words [6 marks]

(a) Chromosomes

____

(b) Sex chromosomes

____

(c) Genes

____

4. How many types of sex chromosomes does the following have? [3 marks]

(a) human being

____

(b) a female person

____

(c) a male person

____

5. What is the gender of an individual who has the following combination of sex chromosomes? [2 marks]

XX : ______________________________________

XY : ______________________________________

6. Define the following words [4 marks]

(a) genotype

____

____

(b) phenotype

____

____

Total = [40 Marks]

Assignment Answers

Self-Assessment Exercise 1

1. Wet dreams

2. Cowper's glands
   prostrate glands
   seminal vesicle

3. scrotum

4. (a) womb
   ovary
   oviduct
   vagina ,etc
   (b) ovum

5. It is to discharge sperms into the female reproductive system

6. (a) provides nourishment to the sperms
   provides a swimming media for the sperms.
   (b) in accessory glands

Self-Assessment Exercise 2

1. Formation of sex cells.

2. (a) Two
   (b) spermatogenesis and oogenesis

3. (a) testis
   (b) ovary

4. (a) release of ovary from ovary to the oviduct

(b) 14th day of the menstrual cycle

5. They super ovulate. That is, they release many ova into the oviduct at a time during ovulation and these can all be fertilized.

6. (a) menopause is the period in females when menstruation stops

(b) copulation is mating

(c) menstruation is the release of the unfertilized egg together with some blood after 28 days

Self-Assessment Exercise 3

1. - Because she is getting rid of both her excretory products and the developing embryo's products.

- High hormone levels results in the need for a way to get rid of them since the liver its own cannot cope on its own.

2. (a) Increases in order to make provisions for the child. Excretory products have to be eliminated faster by increasing metabolic rate.

(b) Increases to meet the high demands for food placed on the mother by the embryo.

3. This is a pregnancy in which the fertilized egg fails to implant itself in the uterus.

4. (a) X

(b) Y

5. (a) A period of pain before birth starts.

(b) Expulsion of foetus out of the reproductive system at the end of pregnancy.

(c) Is the termination of pregnancy.

(d) Birth in which a baby is born dead.

(e) Premature birth in which the baby does not survive.

ASSESSMENT ANSWERS

A. Multiple Choice

1. A
2. A
3. C
4. D
5. A
6. B
7. D
8. A

B. Short Answer Questions

1. (a) Sterilization - Simple operations done to cut the sperm ducts. That is the method of birth control used in the diagram.

(b) The part labelled X is the sperm duct.

2. Advantages of a small family

(a) If it is a small family better parental care can be provided

(b) There will be economic stability in the family

(c) Better health condition for mother

(d) Proper education facilities can be provided

(e) Prevents risks of passing on serious genetic defects

(f) It prevents population explosion, which helps the government to meet the demands of the people

(g) If it is a small family parents are able to feed cloth and look after their children properly.

(Any **five** points will do)

3. (a) Rod like particles found in the nucleus and containing hereditary information.

(b) Chromosomes that determine the sex of an offspring.

(c) Particles of inheritance that are found in chromosomes.

4. (a) Two

(b) One

(c) Two

5. XX female
   XY male

6. (a) Genotype is the genetic makeup of an organism or rather the gene combination of an individual.

(b) Phenotype is the physical characteristic that comes about as a result of a combination of genes.

Contents

HSB Unit 12

Health and Diseases

Introduction

Welcome to Unit 12 of Human and Social Biology. This is a unit that will teach us about health and diseases. We will discuss what health is and how it is maintained. We will also discuss some diseases, their causes and how to prevent them, as well as some things that can place our health at risk. The importance of learning this is to make us more health conscious. Learning in this unit will require you to recall content from a number of units learnt earlier. These are the units on Nutrition and Diet (Unit 2), Circulatory System (Unit 6), Homeostasis (Unit 9) and Reproduction and Continuity of Life (Unit 11).

A healthy organism is one in which all the physical and chemical processes of life are working in harmony. One of the chief causes of diseases in humans is the presence of another organism inside the body, which lives as a parasite. You should be familiar with some organisms, which live as parasites on people. In Unit 1: Living things, you were introduced to some of these organisms. An example is a fungus which causes ringworms. These parasites are mostly microorganisms. This group of organisms includes bacteria, fungi and viruses which are the main parasitic microorganisms that cause diseases. These may also be referred to as pathogens.

As said above, this unit will also discuss how some diseases are spread and how we can control them. We should, however, bear in mind the fact that contact with pathogens does not always lead to infection. This is because our body does have resistance to such organisms. Resistance to disease causing organisms is called immunity. Immunity can either be natural or induced. We will learn about immunity in later parts of the unit. We will also learn about other ways of avoiding diseases such as practicing proper hygiene and taking medications such as antibiotics. We will also discuss how alcohol and drug abuse may result in ill health. Hopefully, we will all become more health conscious by the time we have gone through all the lessons of this unit.

Time Frame

It is estimated that to complete studying this unit you will need between 15 to 20 hours. Do not worry if you take longer in finishing this unit. Remember that we all have different abilities and hence we study at different paces.

You are encouraged to spend about 2 hours to answer the assignment in this unit. You will also need approximately 3 hours on the assessment at the end of the unit.

The total hours for completing the unit will thus be between 20 and 25 hours.

Outcomes

Upon completion of this unit you will be able to:

- *Describe* good health and how it is maintained.
- *Describe* disease causing organisms and control of some diseases.
- *Describe* non-transmissible diseases and disorders.
- *Explain* what transmissible diseases are with a particular emphasis on influenza, cholera, typhoid, TB, Sexually transmitted infections and HIV and AIDS.
- *Explain* how alcohol and drug abuse result in ill health.
- *Practise* good personal hygiene.
- *Describe* the concept of control of diseases by immunity, use of antibiotics and other practices.

Resources:

You will need the following resources to conduct some of the activities:

Colourful pens, markers, mannila paper, children's preschool or health card and funds to be able to visit health centers in your area.

Terminology

Health:	A state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.
Disinfectants:	Chemicals that are used for cleaning and they can kill germs that might cause diseases.

Disease:	An illness that affects the body (a single area or the whole system) and/or mind within a single organism and when a person is in a diseased state, they are no longer classified by modern and traditional medical diagnosis as "healthy".
Hygiene:	Practice of keeping oneself and their surroundings clean so as to prevent illnesses.
Antibiotics:	Medical drugs used to kill bacteria and fungi; they are also used to treat infections.
Degenerative Diseases:	Diseases that arise due to the wear and tear of the body; these are also conditions that get worse as time progresses.
Cancer:	A disease in which cells in a person's body increase rapidly in an uncontrolled way producing abnormal growths.
Drug:	Any substance that alters the physiological state of an organism.

Topics

There are six topics in this unit.

The topics have been arranged in this way so that you first appreciate the importance of good health before understanding about diseases, the control of diseases, including hygiene, and about immunity and immunization. You will also learn about alcohol, tobacco and other drugs, so as to show you their effects on health. All these topics call on you to reassess your environment and how people live to ensure that you develop some element of health consciousness.

Online Resource

If you can get on the internet please utilize the resources at www.hippocampus.org. It is an excellent source of information for biology and the topics discussed in this unit. Here you will find:

- Presentations
- Simulations
- Videos
- Online Study Groups
- Links to Even More Information
- Textbook Correlations
- Online Courses

Topic 1: Health and Diseases

When you hear someone say "I think there is something wrong with the food here that is why I am not feeling well", what do you think s/he is talking about?

It means that the persons' health has been affected. It also means that the person suspects the food as the root cause of their ill health. Now what do you understand the word "health" to mean?

You have learnt in the past Units that the human body is an integrated and closely knit set of organ systems that function together for its well-being. When you are in good health, the different body systems not only function well, doing their normal duties, but your body as a whole is able to adjust itself to the changes taking place within its environment. Remember Unit 9 on homeostasis, and how the circulatory system functions in the body's immunity (Unit 5)? You will need to recall the contents of those units in order to grasp easily what health is all about.

In this Topic we are going to discuss health and diseases. We will address how health is affected by various things one of them being diseases. Now, what do we mean by disease?

This is a condition in which your body is not functioning properly. It can be due to an infection by disease causing organisms or an abnormality which interferes with the way the body is supposed to do its work.

Learning Objectives

At the end of this Topic you should be able to:

- Define good health.
- Define the term disease.
- Describe examples of diseases and disorders by looking at the following:
  - A nutritional deficiency
  - A degenerative disease
  - A cancer
  - An inherited disorder
- Describe a transmissible disease.
- Distinguish between signs and symptoms of diseases.

The sub-topics have been sequenced as such because one topic's content is necessary for the understanding of the next topic. For example, to fully appreciate why we must take care of our health we must first learn about good health and personal hygiene before we look into diseases and their causes. This helps us to appreciate the importance of keeping healthy as a way of avoiding diseases.

Good Health

Good health is a condition where your body is functioning normally. This is when all body organs are working properly and there is a general feeling of wellness in the body, mind and soul. It is also said to be the state of physical and mental well-being, and is dependent on receiving a balanced diet and an appropriate physical and mental activity.

The World Health Organisation (WHO) defines health as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. This means that being in good health is not just about the body and the mind, but about how we lead our lives and how we interact with the environment and other human beings in it.

Today we find ourselves adopting lifestyles characterized by less physical activity and poor dietary habits.

For example, most of our leisure time is centred on television, riding in motor vehicles and doing less physical energy and worse even, the consumption of junk food. As a result of this, new health problems have been discovered.

How do you think you can maintain good physical and mental well-being?

Below are some ways we should practice to maintain our body in a state of good health, and these are:

- Personal hygiene
- Domestic hygiene
- Diet
- Exercise and relaxation

We will now discuss these, although they will be covered in detail later on in the unit.

Personal Hygiene

Personal hygiene is personal cleanliness. It is a practice aimed at keeping one’s body free from disease causing organisms or germs. But it is not only about the body, but also the environment that we live in. So, personal hygiene has two dimensions, and that is:

- The state of our bodies, and
- the environment we live in or our surroundings.

Poor personal hygiene causes poor health which can sometimes be fatal. It is therefore vital for all to practice good personal hygiene.

Good personal hygiene involves, among other things, the following:

- Cleaning the whole body, focusing on the pubic region, anus, mouth, and hands.

- Washing hands thoroughly before and after eating.
- Washing our hands after visiting toilets or latrines.
- Wearing clean clothes that have been washed and ironed.
- Eating the right type of food in the right amounts.
- Having adequate rest.

Apart from practising personal hygiene, people should also practice domestic hygiene as it also results in reduced chances of the body getting in contact with germs.

Domestic Hygiene

Keeping our houses and yards clean is a must. Cooking pots, plates, cups, all utensils which are used in the house should be washed and kept clean. This reduces the incidence of bacteria and flies in the house. We will learn about the health hazards associated with house flies in the next Topic, so we will leave them for now. Let us now do an activity on how to reduce flies in the homes.

Activity 1

Suppose you had been away from your house for four days. You had left cooked food on top of the stove. After returning you find that there are lots of flies in the house and there is even a strong pungent or bad smell.

What action should you take?

Feedback

You probably will throw the food outside and it has to be in a dustbin, i.e., not anywhere. Secondly, you might spray the house with an insecticide and then open up the windows. Of course the last stage is to clean the plates and the house with a disinfectant so as to get rid of the disease spreading organisms. Do you know what disinfectants are?

Disinfectants are chemicals that are used for cleaning and they can kill germs that might cause diseases.

Diet

The food, which we eat, has to be used in three principal ways, i.e. for energy, growth and replacement, or repair of worn out tissues, recall Unit 2 on Nutrition and Diet. The substances, which meet all these requirements, are chemical materials with food value, namely proteins, fats and carbohydrates. Besides, these the diet must contain vitamins, water, salt and dietary fibre or roughage. Even though the latter do not have energy value they do take part in bodily functions and without them the diet is said to be unbalanced. Unbalanced diets can result in people becoming more susceptible to various kinds of diseases.

Therefore, we should have a balanced diet at least once a day, this is a diet that contains enough carbohydrates, fats, proteins, minerals, vitamins, water and dietary fibre. This diet should meet our energy needs and provide us with essential materials for the repair, maintenance, and growth of tissues.

Sometimes the food is made unsafe for consumption by other means.

An example is when we eat fruits and vegetables without first washing them. I am sure that you have seen people buying fruits from street vendors and just eating them without first washing them. This is wrong because a lot of potential customers touch these fruits and may transfer germs from their hands to these fruits.

Can you think of other examples that may result in the acquisition of germs?

I hope that you said things like eating without washing your hands or placing dirty objects in your mouth. Yes, these are just examples of ways in which germs are picked up. Review the earlier section on Personal Hygiene to get more ways before moving on to read the next section.

Exercise and Relaxation

Have you realised how people who work hard are always in stress? This is because the hard work results in tensions within their bodies. In order to remove the tensions and stress, these people need regular exercise. Regular exercise during work or recreation plays an important role in their health. It helps to maintain the heart and circulatory system in good working order in that it increases the flow of blood through the muscles and help to remove waste products. Exercise also helps to keep your body weight down.

Apart from exercise, enough sleep and rest also help to maintain good health especially mental health. It is recommended that we should get at least eight hours of sleep daily. Regular physical activity performed most days of the week reduces risks of developing lifestyle related illness such as obesity and also improves health in the following ways:

- Reduces the risk of heart disease
- Reduces feelings of depressions and anxiety
- Reduces the risk of developing high blood pressure.

As you move around your neighbourhood, you might have seen somebody jogging along the road. Have you ever thought why they are doing that?

They are probably doing this exercise to reduce their body weight, that is true, and also to relieve stress.

Most importantly, exercising and getting enough rest or relaxation helps in people appreciating their bodies and themselves more, this is also important to our overall well-being.

So far we have been dealing with health and have said that it is, among other things, the absence of diseases. Now what do we mean by the word disease?

Diseases

Disease is not easy to define but we shall try.

When you see a person suffering from tuberculosis you can say he is a diseased person. What about a person who has broken his arm? Would you say he is diseased?

Definitely not! He is not suffering from any disease. Although a broken arm makes the body to be in a disordered state, it does not conform to the conventional idea of diseases. A person with a broken arm is therefore just said to be sick as there is a malfunction of the body part.

A person who is suffering from influenza can have his body temperature above 37ºC (37ºC is the normal body temperature). They may have headaches and fevers and aches in their body limbs. But, on the other hand, a person who is suffering from tuberculosis may have a persistent cough and might be weak but still he can do work which doesn't need any physical effort. Both influenza and tuberculosis are diseases in which parts of the body do not function normally or efficiently. Both these diseases are due to the invasion of microorganisms. As for the broken arm, the body also does not function well, but since it is not caused by a disease causing organism, it is not usually referred to as a disease. Please note this difference between a sick and a diseased person.

How can you define a disease?

The World Health Organization defines a disease as an illness that affects the body (a single area or the whole system) and/or mind within a single organism. Basically, when a person is in a diseased state, they are no longer classified by modern and traditional medical diagnosis as "healthy".

Diseases can, thus, be defined as the loss of health resulting from a disturbance of the normal processes of the body, or due to various causes such as malnutrition, infectious organisms, and degeneration of tissues or organs, or even due to environmental pollution. Therefore, for one to avoid contacting any disease, they should ensure they do what is mentioned above, under good health. For example, to avoid malnutrition, one should ensure they consume a balanced diet. To avoid infectious organisms, one should practice both personal and domestic hygiene.

Diseases occur in all living things, and normally affect the functioning of cells, tissues, organs, or systems. They are usually characterized by specific symptoms and signs, which can be mild and short-lasting (such as the common cold) or severe enough to decimate a whole species such as HIV and AIDS. We will learn about the difference between signs and symptoms later on the unit.

Can you give examples of diseases?

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Some examples of common diseases worldwide are: Influenza, Asthma, Syphillis and other STDs, HIV/AIDS, Malaria, and Tuberculosis.

In addition, diseases are generally classified into different categories, which include: genetic, infectious, and non-infectious.

Infectious diseases are caused by micro-organisms, such as bacteria and viruses, invading the body; they can be spread across a species, or transmitted between one or more species.

All other diseases can be grouped together as non-infectious diseases. These can have many causes: they may be inherited (congenital diseases); they may be caused by the ingestion or absorption of harmful substances, such as toxins; they can result from poor nutrition or hygiene; or they may arise from injury or ageing. The causes of some diseases are still unknown. Some diseases occur mainly in certain climates or geographical regions of the world. These diseases are said to be endemic in the regions concerned. For example, African sleeping sickness, which is carried by the tsetse fly, is found mainly in the very hot, humid regions of Africa. Similarly, malaria, a disease spread by mosquitoes, is usually found in or near the marsh or stagnant water that provide breeding grounds for the insect. Other diseases may be seasonal – such as influenza, which tends to occur mainly in winter, or intestinal illnesses that result from food contamination in summer.

Some age groups may be more prone to certain diseases, such as measles in children, meningitis in young adults, and coronary heart disease in the elderly. Other diseases may tend to occur only in certain racial types and are usually genetic in origin, such as sickle-cell disease which is found mainly among people of black African descent. Other diseases, such as black lung, or coal-workers' pneumoconiosis, result from occupational hazards. We will discuss a few diseases according to some of the groups mentioned above. For now we will discuss diseases that come about as a result of inheritance, nutritional deficiency, degeneration, and cancer.

Nutritional Deficiency Diseases

The ability to move, grow and reproduce are all characteristics shared by living organisms. For all this to take place the right food, and in the right amounts, have to be made available. I hope you can still remember what we said about diet in Unit 2 and at the beginning of the unit.

We said that a diet should consist of nutrients that are essential for the healthy growth of our bodies. These nutrients are grouped into six main classes. They are: carbohydrates, fats, proteins, minerals, water, and vitamins. Lack of these can lead to nutritional deficiencies. Nutritional deficiency means a shortage of nutrients within the food resulting in body disorder.

Since we have discussed deficiency diseases before - we will now do a short activity that will help refresh our memory on them. This will help us understand the topics that follow better.

Can you now name some deficiency diseases that occur in children?

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They include kwashiorkor, marasmus, and rickets.

We discussed kwashiorkor and marasmus in Unit 2. If you have forgotten what these are, revise Unit 2 before proceeding to the next section. We will now only look at rickets in detail. Let us see how this deficiency disease occurs in children.

Rickets

It is a deficiency disease mainly seen in young children.

You might have seen that small children at home are provided with milk most of the time. It is always said that young children should have enough calcium in their diet. Calcium is good for the development of teeth and bones. When calcium is not deposited properly in the bones, this can cause rickets in young children because the bones remain soft and are deformed by the child's weight.

Take a moment to refer back to the figure showing a child suffering from rickets that is shown when discussing mineral salts under the topic Classification of Nutrients in Unit 2.

You can see that the legs of the child are bent and deformed.

This is due to a deficiency of vitamin D (also known as calciferol) in the diet which has resulted in a disease called rickets. It is common amongst children.

Lack of exposure to ultra violet light, especially in tropical conditions where diets have fewer sources of vitamin D, can also cause rickets.

Vitamin D is essential for the absorption and utilization of calcium and phosphorous in our body. It promotes the formation of normal bones. This is the reason why the above child has such kind of legs – the bones were not properly formed.

Degenerative Diseases

Do you know that there are diseases that arise due to ageing? You might have heard old aged people complaining about pains on their joints and poor eyesight. Have you ever thought why they are complaining?

Well, as people grow old, their tissues lose their efficiency. The syndromes, which arise from this, are called **degenerative diseases**. To degenerate means to lose biological function due to a decrease in cell, tissue, or even organ size. Examples of tissues, which get worn out, include those in the joints, eyes, and even ears. Ageing of the tissues in the joints leads to **arthritis**. Arthritis is a condition in which the joints become inflamed and swollen. Joints may become permanently damaged and as a result pose a lot of difficulty in movement. People with arthritis experience a lot of pain in their limbs. Eye muscles also do degenerate as one gets older. This is accompanied by loss of sight.

There is another type of degeneration known as mental degeneration. Our country is experiencing an increase in this type of degeneration and the major and common cause of it is alcohol and marijuana use. At present, there are a lot of mental cases in our institutions of health, which are caused by excessive intake of marijuana. This is despite the belief that this drug is not harmful to mankind. We will learn about these later in the unit under the topic Alcohol, Tobacco and other Drugs.

We will discuss how degenerative diseases occur and ways of avoiding them. A degenerative disease is a disease that arises from the gradual breakdown of tissues and organs resulting in them becoming less effective. This is more common in adults, particularly the elderly. Common degenerative diseases include cardiovascular diseases, and arthritis. Cardiovascular diseases, which affect the heart and blood vessels, include atherosclerosis, high blood pressure, heart attacks, and strokes. Rheumatoid arthritis, the cause of which is unknown, occurs in people of all ages, although it is most common in middle-aged adults. Its effects are pain and swelling in many joints throughout the body, and it can lead to deformity and crippling. Osteoarthritis results from wear and tear on the joints, especially those of the knees, hips, and fingers. It is mainly a disease of older adults, although it can develop in younger people, particularly professional sportspeople. The disease seldom causes crippling, although the pain may severely restrict the sufferer's activities.

Apart from the degenerative diseases we have addressed, there are also those that are caused by the malfunctioning of certain vital body tissues and organs. In the next section we discuss one that affects the heart.

Coronary Heart Disease

This is one of the most common causes of death in countries with a high standard of living.

You might have seen on television, or read in magazines or papers, that people should be careful about their diet. They should avoid fatty and oily food. They should eat steamed vegetables, low fat food, etc. Why are they being warned about their diet?

This is because lots of fat is harmful. Fats can get deposited in the lining of the heart vessels causing them to block.

Do you remember what the functions of the coronary vessels discussed in

Unit 5 of the circulatory system are?

Yes, they transport substances to and from the cardiac muscles. When there is a deposit of fatty material, say on the coronary arteries, the arterial lining also grows thicker. Ultimately they become blocked.

When a clot is formed inside the blood system, it is trapped by fatty material blocking the artery. Blockage of these vessels means that the heart muscle does not get enough oxygen or glucose. We all know that oxygen and glucose are necessary for respiration to take place and respiration provides energy.

If respiration does not take place, then the heart may stop pumping properly and it may ultimately stop. This is what is always referred to as a heart attack.

Look at the Figure 1 below which shows a section through a healthy artery wall but gets thicker due to the deposit of fatty material.

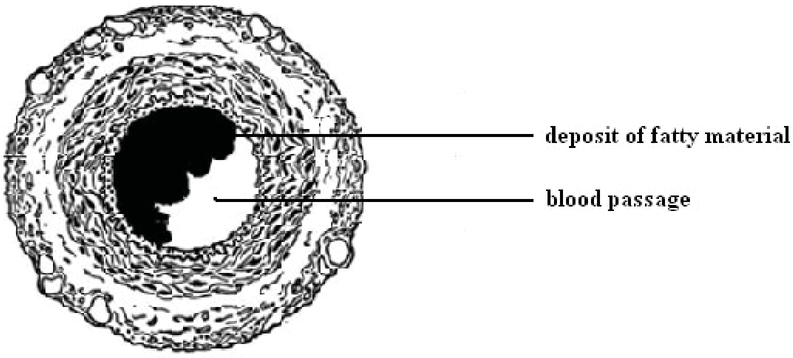

Figure 1: *Artery with a deposit of fats, which reduces the flow of blood.*

Now do the following activity based on Figure 1.

Activity 2

Look thoroughly at the diagram above and say how you think the fat deposit will affect the artery. In your response, recall the functions of the arteries. You will have to go back to Unit 5 of the Circulatory System.

Feedback

You should have noted that the movement of blood through the artery will be greatly disturbed thus resulting in reduced blood reaching the heart. The shortage of blood reaching the heart means that the heart muscles do not get enough oxygen and digested food. This may lead to an ultimately death.

People can greatly reduce their chances of early death from coronary heart disease by taking regular exercise, keeping their body weight at reasonable level, and also not smoking.

Do you remember that we said earlier that when people grow older there is a tendency for the arteries in them to lose their elasticity? How do you think this is related to coronary heart attacks?

If you said that this also increases the risk of people getting a heart attack then you are right. This therefore means that coronary heart diseases may be due to the heart not getting enough oxygen and dissolved foods, as well as the reduced elasticity of the heart muscles. Both these effects result in heart muscles not pumping and the heart stopping. This is how "heart attacks" occur.

We are now going to deal with cancers.

Cancers or Tumours

Since we learnt about cells of living things in Unit 1, you should be in a position to say what a cell is. It is a basic unit of living organisms and there are many different types of them (cells).

In the human body, new cells are continuously being formed through cell division. What is meant by cell division?

Cell division is a process that occurs more or less continuously in most of the body tissues in order to replace cells. It is a process where the existing cells divide into new cells so as to produce more cells or replace worn out ones. When old cells are damaged or worn out, they have to be replaced. The division of the cells depends upon the rate of breakdown of old cells.

There is a process in our body to control the rate of cell division. That phenomenon is known as ***contact inhibition***. It is really a system built into the body to prevent overcrowding of cells in certain places. Cells that are too close to other cells do not divide.

When there is failure in this system, group of cells continues to divide in spite of close contact with surrounding cells. This forms a swelling otherwise known as a ***tumour*** or cancer.

There are many different kinds of tumours, but for our purposes we can divide them into two groups. One is harmless and the other one is harmful.

(a) Harmless tumours

The other name for such a tumour is *benign*. Specialists in hospitals can remove such a tumour surgically. It does not grow again or recur after it has been removed.

(b) Harmful or malignant tumours

These tumours are referred to as *cancerous*. They are capable of invading surrounding tissues and as a result spread throughout the surrounding tissues. Cancer cells may spread by means of blood and the lymphatic system to other parts of the body.

There are two ways in which one can get cancer. It is either through cancer causing agents, which are sometimes referred to as *carcinogens,* or a person can actually inherit such a trait from their parents. To understand this better you have to remember our topic on inheritance in Unit 11. You can revise that topic to refresh your memory.

Carcinogens are substances that cause cancer. Examples of carcinogenic substances include tobacco smoke and X-rays.

Despite the fact that smoking causes lung cancer, lots of people smoke. This is probably the reason why in our discussions we place a lot of emphasis on cancer of the lungs.

So far we have been dealing with diseases that the patient may have control over. We are now going to discuss some diseases that just come about due to inheritance.

2.6 Inherited disorders

We have probably heard that we have inherited some characteristics from our ancestors. What is it that you have been told you inherited from any one of your parents?

Not all traits that are inherited from parents are useful or helpful. Some can be harmful to the child. Examples are inherited disorders which are passed from one generation to the other, despite the fact that they are harmful. In this topic we will discuss Albinism and Down's syndrome as examples of inherited disorders.

(a) Albinism

It is a condition that results from the absence of pigment from the skin, hair, and iris. The person with such a condition has white skin, very blond hair, and pink eyes. Many people tend to associate albinism with bad luck or witchcraft, this is, however, not true. Albinism is a trait that is inherited from parents. If a normal couple had an albino child, it means that both the parents had an albino gene in their genotype. The parents in turn had obtained that particular gene from one of their parents.

(b) Down's Syndrome

Do you remember from your study of Unit 11 how many chromosomes a human cell has?

Well, you probably thought "a normal human body cell has 46 chromosomes". Half of these chromosomes are from the father and the other half are from the mother. These chromosomes were paired during fertilization of an ovum to produce a person. The ovum has to have 23 chromosomes, this also applies to the sperm. Now think about a situation where the ovum that is being fertilized has 24 chromosomes instead of 23. What would happen?

Well, the resultant zygote will end up with 47 chromosomes instead of 46. The end result is the formation of an offspring with 47 chromosomes. The presence of the extra chromosome is known as Down's syndrome. Mental development of people with such a defect is seriously affected.

Apart from the diseases discussed so far, which may not necessarily be transmissible, there are those that are easily passed on or transmitted. We will now learn about those diseases in the next section.

2.7 Transmissible Diseases

We have been dealing with health and diseases without going into detail about different diseases. You know that there are different kinds of diseases. There are some diseases which are transmitted from person to person by contact, by contaminated drinking water or food or by insects. Such diseases are called transmissible diseases. But there are diseases which cannot be spread from person to person. They are called non-transmissible diseases.

The diseases we have learnt about thus far have been non-transmissible diseases and disorders. We will now learn about transmissible ones.

As mentioned earlier on under personal hygiene and the introduction on diseases, there are diseases that can be spread from one person to another. The other name for such diseases is infectious diseases.

From your previous knowledge can you name some organisms that cause such diseases?

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They are viruses, bacteria, round worms, flat worms and fungi.

Most of the diseases are spread by parasites. What is a parasite?

You might have seen some plants growing on another plant or tree. They get the food from the plant or tree they are growing on. In the same way there are also other organisms, which enter the body of another organism and feed on its living tissue. These organisms depend on the host organism for survival without contributing anything to its welfare.

Some common transmissible diseases include influenza, gonorrhoea, syphilis, AIDS, tuberculosis, cholera, and malaria. We will describe each one of them in detail in the next Topic.

How can you define a transmissible disease?

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This is unlike tuberculosis or cholera, or even measles. These diseases are transmissible or contagious. That is, they can be passed from one person to another person.

We have learnt about the many different diseases. For all diseases there are ways we can tell if someone has the disease. These are known as signs and symptoms of diseases. We will now discuss what they are.

Signs and Symptoms of Diseases

Most diseases are accompanied by signs and symptoms, which make a person aware that he is unwell.

Do you know what examples of those are?

They are ways by which the body tells us that “all is not well”. These are things we can feel or others can notice or measure in our bodies that show that we are not well.

A *sign* is defined as a thing indicating quality or state and is also a mark or gesture conveying an order. Signs of diseases are therefore those things that show that a disease exists. Signs of diseases can be seen or measured and they include rash, changes in colour of the eyes, or even urine. They also include things such as high blood pressure, high temperature, or high and low levels of blood cells.

Symptoms of diseases on the other hand are those that can only be described by the patient. They are also signs or indications of a disorder or a disease and are usually a noticeable change in how a person feels or looks. These are pains such as a sore throat, headache or itchiness. Symptoms may also include things like lack of appetite or trouble sleeping. Can you see that these are examples of what the person suffering from the disease feels? Only he or she can feel these things as they cannot be measured. Most symptoms are similar for different illnesses.

Though symptoms are only felt by patients, they are used by health personnel to identify what the illness the patient may be suffering from is. It is important for patients to say the truth so that they may get the right treatment for their illness.

Summary

In this Topic we were dealing with how we can keep our health in physical and mental well being. Good health begins with us and for us to achieve it, we must know how diseases start and spread. We learned about definition of diseases and a brief explanation of diseases. Focus was given to non-transmissible diseases which are diseases that are not transmitted from one person to another. Examples of that we learnt about are those which are caused by malnutrition, degeneration, inheritance, cancers, and tumours.

We also described what transmissible diseases are so that we can differentiate between these and the non- transmissible ones. Finally, we also discussed the difference between signs and symptoms of diseases.

As you proceed with the unit you will learn more about diseases. You will find different types of disease and how they are caused and their causes as well as how they can be prevented.

Please remember to do the exercise for this topic at the end of the unit. After completing the exercise compare your answers with those provided. If you find that some of your answers were incorrect, revise the relevant section of this topic before moving on to Topic 2. You can also discuss your answers and those provided with your colleagues at the study centre or with friends.

Topic 2: Understanding Different Disease

We are still learning about diseases. In our previous Topic we learnt about diseases and health by looking at how diseases come about. The importance of this is so that people may be able to avoid diseases and maintain good health. We also dealt with some non-transmissible diseases.

In this Topic we are going to learn about transmissible diseases, these are diseases that can be passed on to others. Examples we will be discussing are influenza, typhoid, tuberculosis, and cholera as these are common in most countries. You may have heard of or seen many posters and adverts in the papers about these diseases in our community or even on the radio or television. I think you are aware how these diseases are spread. The method of spread is different from the other diseases, which we have learnt about in our previous Topic. Let us, in this topic, see how these diseases are different from the ones we have discussed earlier.

Learning Objectives

At the end of this Topic, you should be able to:

- State the chief signs and symptoms of the following transmissible diseases: influenza, cholera, typhoid, tuberculosis, gonorrhoea, syphilis, and HIV/AIDS.
- State their causative organisms.
- Describe the methods of their spread.
- Describe how to limit/control their spread.

The sub-topics have been arranged in an order that enables you to ease into the content by starting with a common disease that is well known to everybody - influenza or common flu.

Transmissible Diseases

Sometimes the disease causing organisms may be present in our bodies without us falling sick. In other words, when you are not sick it does not mean that you have no pathogens in your body. You may have the germs but they are still in their window or incubation period. You will fall sick only after they have multiplied and developed within your cells. It might also be that the germs are attacking your cells but your body is defending itself well against them. This will help you not fall sick.

Falling sick or getting diseases is possible even if you are practicing proper hygiene. The human body has a natural way of controlling diseases. This is through its immunity system - this was addressed under Unit 5 of the Circulatory System under functions of white blood cells. We are also going to learn about it (immunity) in a later Topic. For now, we will learn about some diseases which are transmissible starting with influenza, and for each disease we shall look at the signs, method of spread, and lastly the control.

Influenza

This is a disease that affects the respiratory system. A virus called the influenza virus causes it. We will now deal with the signs of this disease.

(a) Signs

We can tell that a person has influenza when they show the following signs.

They have a:

- fever
- headache
- sore throat
- pain in the back and limbs.

These signs usually occur within 2 days of infection.

(b) Method of spread

Inhaling water droplets, which contain the virus, spreads it. That is why it is commonly referred to as a droplet infection. An infected person breathed out the droplets containing the virus. This could be when they were sneezing or even coughing. This is because the flu virus is present in the mouth and nasal cavities of the victim.

How can we prevent the spreading of this disease?

(c) Method of control

There is no particular treatment other than rest. This has to be done away from infected people. Antibiotics can also be used to prevent secondary infection.

Nowadays there are vaccines, which give immunity for a short time.

Typhoid

Unlike influenza, typhoid is a water-borne disease. A bacterium causes it. But then, why do we class this disease as water borne disease?

This can easily be inferred from the word itself. It is transmitted mostly by contaminated water. But then, it is not only water which has the capability of spreading such a disease, it can also be transmitted through contaminated food. Typhoid is only referred to as water borne because it is mostly transmitted through contaminated water.

(a) Signs

What signs and symptoms can be seen in a person who is suffering from typhoid? A person suffering from typhoid can have:

- A fever for several weeks.
- Abdominal pains with constipation accompany the fever.
- Ultimately the person has watery diarrhoea and increased pain in the abdomen.
- The bacteria invade small patches of the small intestine and causes

ulceration.

(b) Method of spread

There are people who use river or other areas to draw water. If untreated sewage reaches a river or other source from which people consume water without being chlorinated, then the pathogens are likely to be ingested. Poor disposal of urine and faeces cause contamination of the water supply, which infects healthy individuals.

In the tropical world the main cause of typhoid is drinking contaminated water. Typhoid fever can also be spread by flies. Flies are very mobile and if they get into contact with contaminated faeces, there is the danger of them transmitting the typhoid pathogen to food. This can happen if we leave food uncovered.

It is, therefore, very important that whenever you store food, it has to be covered.

(c) Method of control

How can we prevent and control this disease? This can be done through the following:

- Proper sanitary disposal of the sewage. Flies carry bacteria from faeces and garbage and there is the possibility of them getting access to the food we eat.
- Control of houseflies. We did the control of houseflies in Topic 1, so we are not going to touch on it again.
- Purification of water supplies. This ensures that the water we drink is free from bacteria.
- Typhoid vaccine can be used to prevent infection by the disease.

Various antibiotics can be used and they include ampicillin and chloramphenicol.

Tuberculosis

You must be familiar with this disease because there is a lot of talk about it in our country. Just like influenza, it is a respiratory disease. Let us see what the causative organism of this disease is. The microorganism that causes this disease is a bacterium. Its name is ***mycobacterium tuberculosis.***

These bacteria are very resistant to adverse conditions and can remain alive (in dust) for several months. The bacteria form an infection called ***tubercle*** in the lung tissue.

The tubercle is formed when the host's tissue forms a wall around the bacteria. Inside the tubercle, the bacterium multiplies and forms lesions in the membranes of the lung. These lesions, or clusters of bacteria, liberate them into the lungs and they are coughed out in sputum.

How does someone get tuberculosis?

(a) Signs

A person who is suffering from tuberculosis may show the following signs:

- Continuous coughing and spitting. Due to continuous coughing the blood vessels may burst and sometimes blood is seen in the sputum. Pathogens are blown out of the lung at each cough.
- There will be difficulty in breathing.
- Loss of appetite.
- Mild fever.
- Sweating at night.
- Might have chest pain.

(b) Method of spread

It is spread chiefly by droplet infections. A person can get lung tuberculosis by inhaling the bacterium which an infected person has released into the atmosphere.

You may wonder how this happens!

When a sick person talks, coughs, or sneezes, they release into the air thousands of germs along with air and minute water droplets. Now these airborne droplets which contain the TB pathogen could be inhaled by people around that person. Drinking milk which is contaminated with the bacteria can also result in you getting the disease.

If you do not have strong resistance to these pathogens, you can get the disease. It does extensive damage to the lungs.

(c) Method of control

Tuberculosis is a killer disease, which, if left uncontrolled, can lead to deaths of many people. It is therefore very important for us to be able to control and prevent it. But then how can we do that?

- A good diet with clean well-ventilated living conditions reduces the possibility of infection. A balanced diet strengthens resistance to infection.

What about a clean well ventilated environment? How does it help?

Well ventilated living conditions eliminate contaminated dust and reduce the possibility of droplet infection. We should also try to avoid overcrowded areas. This is because such areas in most cases are humid and thus favour the prevalence of the bacterium.

- Vaccination: This is with a vaccine called BCG. We will learn what BCG stands for but, this is for interest sake, that is, you do not have to memorize the full name.

BCG stands for ***Bacilli Calmette-Guerin***. This is quite a difficult word, isn't it? However, don't worry, as you do not have to memorize it.

When children are born they are given the BCG vaccination. This is just a preventative measure against infection.

- At the early stage antibiotics are effective. But if the disease has been advanced, there is no quick way of cure rather than antibiotics and having proper rest. Some of the antibiotics that are commonly used include streptomycin.
- Infectious patients should be isolated so that they can't spread the disease among their families. This is done in specialized hospitals. Patients are kept in very well ventilated wards, partly to reduce the risk of infecting patients suffering from other complaints.
- Milk should be pasteurized before being consumed. Pasteurization is the boiling of milk to kill microorganisms.

Another example of a transmissible disease is cholera.

Cholera

This disease is mainly found in poor countries with inadequate supply of clean water. It is an acute infection of the intestines. Just like tuberculosis, cholera is a bacterial disease. Its bacterium is called ***vibrio cholerae.***

(a) Signs

What are the signs shown by a cholera patient?

Bacteria release powerful toxin causing inflammation of the gut. By inflammation we mean swelling. This also results in the victim developing a severe form diarrhoea.

Victims also vomit, which leads to dehydration. How does this dehydration exactly happen?

Due to severe diarrhoea and vomiting the patient not only loses the water he drinks but also a considerable volume of digestive juices, which are secreted by different parts of digestive system. Water is withdrawn from the tissues to maintain the secretion of juices. Since there is net loss of water, the patient is subjected to dehydration.

(b) Method of spread

Cholera is a waterborne disease. This means that it is spread through water. People might get this disease if they use contaminated water, either for drinking or even bathing.

In the previous section we dealt with another disease that is spread through water. Which one is that? You probably remembered it as typhoid fever.

The next figure illustrates how cholera is spread.

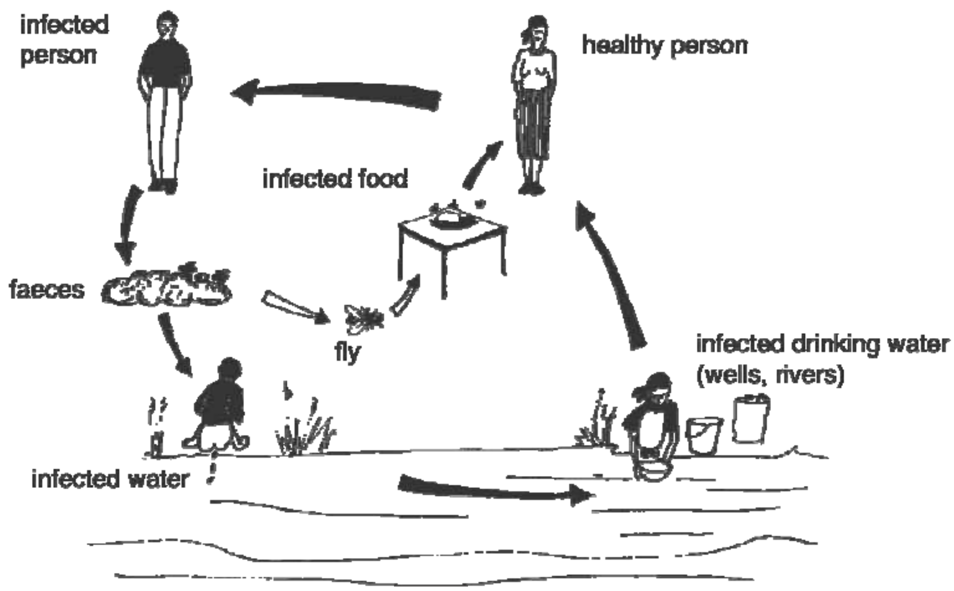

Figure 2: *Disease cycle of cholera.*

(c) Method of control

Cholera can be controlled through the following means:

- Purification of water and treatment of sewage is an important control measure.
- Vaccination also helps control cholera. The vaccine offers a 3 to 12 months protection period.
- Victims of cholera can be treated with an injection of a salt solution to replace the water they lost due to dehydration.
- Drugs such as tetracycline, chloramphnicol, and sulphadiazine can also help.

Summary

In this Topic we learnt about a number of diseases that are transmissible and are common. We discussed their causative agents, transmission modes, and control or prevention strategies. These diseases are highly transmissible, but man can limit their spread by practising the control measures mentioned above. Knowing all this information can and should help us to avoid, prevent and control the diseases.

Please remember to do the Exercise for this topic at the end of the unit. As recommended at the end of Topic 1, compare your answers with those provided only after completing all the questions in the exercise and then revise the sections that you feel you did not understand well.

Topic 3: Sexually Transmitted Infections and HIV and Aids

In this topic we will continue to learn about other transmissible diseases that we did not cover in the previous topic. You must now know that diseases are transmitted in several different ways. The diseases we will learn about now are those that are transmitted mainly through sexual intercourse.

Learning Objectives

At the end of this Topic, you should be able to:

- State the chief signs and symptoms of the following transmissible sexually transmitted infections (STIs): gonorrhoea, syphilis and HIV and AIDS.
- State their causative organisms.
- Describe the methods of their spread.
- Describe how to limit/control their spread.

Topic Content:

Introduction to topic content:

In this topic we will start with common sexually transmitted disease such as gonorrhoea before dealing with the major one - HIV and AIDS ,which is also known as a sexually transmitted disease.

Gonorrhoea

Gonorrhoea is a sexually transmitted disease that is caused by a bacterium. This bacterium is very small and survives only inside the human body. It is easily killed by drying when it is outside.

Signs and symptoms

How does a person infected with this disease look like? Well, any male who is infected with this disease will:

- have white pus like discharge from the penis
- experience a painful sensation when urinating.

If gonorrhoea is not treated, it may lead to sterility.

Females sometimes do not show any symptoms. However, they may feel pain in the lower abdomen. This disease can also cause sterility in females so utmost care should be taken to treat it.

Methods of spread

Gonorrhoea is spread through sexual intercourse from an infected person to an uninfected person.

Methods of control

There are two ways of controlling this disease and these are through prevention or treatment. We shall now look at each of the methods.

(i) Prevention

Firstly, people should abstain from having sex. This is the best and safest method of preventing any sexually transmitted disease.

Secondly, if they do have sex, they should use condoms. People should avoid casual sex by all costs.

(ii) Treatment

Antibiotics should be taken at the early stages of infection. Examples of such antibiotics include penicillin.

We have looked at one sexually transmitted disease and will now move onto another one known as syphilis.

Syphilis

This is another disease that is transmitted through sexual intercourse. Its causative organism is a bacterium called ***treponema pallidium.*** This bacterium can survive only inside human tissue.

Signs and Symptoms

You can tell that somebody has this disease when they:

- have painless sores on penis or vagina- that is followed later by painful rashes and swollen glands
- have swollen joints
- have sore throat and sores in the mouth
- have skin rash and swollen lymph nodes. When this disease is not treated the bacteria invades the body and cause skin rash and swollen lymph nodes, which forms the secondary phase.
- have heart disease, paralysis and can even die if no treatment is done on time.

Methods of Spread

Syphillis is spread through sexual intercourse from an infected person to an uninfected person.

Methods of Control

The methods of control are the same as those for gonorrhoea. The following gives examples of controlling all STIs. Cross check the information at the nearest Local Clinic or Health post.

Control of STIs

The best way to try to control the spread of STIs is through public education. People must be encouraged to:

- Avoid sexual relationships with unknown persons, or with many different people.
- Use condoms.
- Seek treatment whenever they get infected with any other sexually

transmitted disease.

Measures taken in clinics to control the spread of STIs include:

- Tracing and treating contacts of an infected person.
- Checking all pregnant women who attend antenatal clinics.
- Special eye-ointment given to newborn babies.

Antibiotics and the Treatment of Gonorrhoea and Syphillis

Most sexually transmitted diseases can be treated using antibiotics. The main exception is AIDS. This disease unlike other diseases has no treatment at all. In fact the only treatment for AIDS is to avoid infection by the virus that causes it.

Now, as for gonorrhoea, it can be treated with antibiotic called penicillin. This is administered either as a tablet or as injection in clinics. However, despite the fact that gonorrhoea has a treatment, it is always advisable to avoid infection by the disease. This is because sexually transmitted diseases do increase the probability of one getting HIV / AIDS.

Please attempt the following activity which requires you to think more about what we have just discussed.

Activity 3

1. Can you think of the reason why the prevalence of other STIs increases the chance of one getting AIDS? Write that down on the space below.
2. Also, come up with a strategy of educating your family, peers and community about this.

Hint: Having STDs means one has engaged in unprotected sex.

Feedback

1. *The prevalence of STIs increases the chances of cuts on the sexual reproductive organs thus exposing blood vessels. This then increases the chances of HIV passing from an infected person to an uninfected one. We will deal in detail with this disease later.*
2. *Your strategy could entail things such as talk shows or presentations by Health workers during "Kgotla" meetings. You could also get a copy of a chart that shows the various STIs - it could be obtained from any health post or clinic in your area. You could also get books that have pictures on STIs. The chart and some pictures clearly show how the sexual reproductive organs are affected by STIs. The sight is not a pretty one and usually has strong effects on people. You*

could make a small write up based on the pictures and ask questions such as what they see happening? How they think the people with the STIs feel and what the dangers of having the STIs are.

AIDS

You definitely know what this stands for. Please write it down below.

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I will not provide you with the answer to this question. This is because there is no single time when you would not hear people talking about AIDS. It is the latest killer disease to hit this planet. We all know that the Human Immuno-deficiency Virus causes it. But then what does this virus do to the body?

HIV weakens the body's immune system. AIDS is not a particular disease as such. And until the person gets infected with any disease he will appear to be normal and will feel and look healthy. A person has AIDS only when the immune system no longer works efficiently and she/he starts showing symptoms. It will take 2-10 years for an HIV positive person to start showing AIDS symptoms. Hence people may carry the virus but will appear to be normal.

What do you think is the best way to know if one has the virus?

If you said it is by getting tested then you are right. The only way you can tell if anybody has HIV, the virus that causes AIDS, is by getting an HIV and AIDS test. This test is done at voluntary counselling and testing centres, as well as some clinics and all major hospitals in the country.

We will now discuss where one may get tested. Please do this activity because nowadays it is advisable for all to get tested.

Activity 4

Find out where HIV and AIDS tests are done in your area and surrounding areas and prepare a card that has the information as well as other services offered at the testing centre.

Please note: *There is no direct feedback from me on this activity because the information on your card will be specific to your area. What is important is to ensure that this information is correct so that you can use and share it with friends whenever necessary.*

We all know what an immune system is. This is the system, which defends the body from infection by disease causing organisms such as bacteria, fungi and viruses. White blood cells are part of the immune system and play an active role in preventing infection.

The AIDS virus (HIV) attacks the white blood cells and makes them ineffective. It multiplies inside these cells until it is released into the blood stream where it will attack more cells.

Now, think about a situation where all the white blood cells have been attacked and destroyed by the virus. What will happen to the body now that it will not be having any defence against disease causing organisms?

Other diseases, e.g. TB, which the body could cope with under normal circumstances, will get the opportunity to infect the body. This results in the presence of HIV in the body developing into AIDS. The diseases that arise from this situation are called AIDS related diseases, e.g. tuberculosis, pneumonia, etc. What are other AIDS related diseases that you have heard of? Please visit your nearest health center, library or testing centre If you have not heard of any other diseases known as AIDS defining diseases to get more information. You may also talk to people who work in a home-based care volunteers group or any other support group for people living with HIV and AIDS.

Transmission of HIV

An HIV positive patient may feel or look healthy but he/she is capable of passing the virus on to others. HIV does not spread through air, food or water. In fact no one can get HIV by living or being friends with someone who is HIV positive provided proper hygiene is adhered to. This virus cannot live outside the human body.

The methods of transmission of this virus are as follows:

- Sexual intercourse, i.e. having unprotected sex with an infected person.
- Receiving an injection of blood from an infected person. This is mostly through sharing of needles especially amongst drug users. During blood transfusions, if the donated blood was not screened then the blood with the virus might be injected into the body of the patient. This will end up with him/her being HIV positive.
    - ➢ There is the risk of getting HIV during ear piercing, tattooing, and circumcision if these are performed using unclean or unsterilised instruments that have been in contact with infected blood.
    - ➢ In areas where donated blood is not screened, transfusion is also a potential risk for contracting the virus.
- From mother to baby during pregnancy, delivery or breast-feeding. HIV is capable of passing through the placenta and infecting the developing child.
- Infected body fluids such as vaginal discharge, semen, blood.

Conditions of Advanced AIDS

The symptoms of AIDS and the condition of the patient will differ from person to person. The person may show symptoms like:

- skin disorder
- swollen glands in the neck and armpits
- unexplained loss of weight

- extreme tiredness, which does not go away
- night sweats and fever
- prolonged diarrhoea

Prevention of HIV/AIDS Infection

Sufficient precautions should be taken in order to prevent infections. As a matter of fact there is a common slogan which reads like ***"Avoiding AIDS is as easy as ABC."***

We will do a simple activity to refresh ourselves of a well known slogan that is used to educate on HIV and AIDS.

Activity 5

1. We should all know what ABC means. So write that down on the space below.
2. Get both male and female condoms and find out how to use them correctly. Practice their usage on models and prepare to educate and show family, peers or the community how to correctly use them.

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Feedback

1. *You should have written that A stands for Abstinence from sex- that is delaying sex until one is ready.* ***B*** *for Being faithful to ones partner and* ***C*** *is for Condomising, which just means using condoms consistently at all times and using them properly.*
2. *The condoms are available in clinics, most government offices and non-governmental organisations (NGOs). You may ask an HIV and AIDS or wellness peer educator to show you how to use them properly as well as to borrow male and female models.*

AIDS does not have any cure so the best way is to avoid it at all costs. ***Prevention is always better than cure.***

People can protect themselves from AIDS by:

- Staying away from sex, also known as abstinence. Actually this is the best method as there is no chance of infection.
- Staying with one faithful partner also helps, especially if both partners are committed to remaining HIV negative.

What do you think is the reason for people not to be faithful to their partners?

It is said that alcohol consumption is one of the reasons for unfaithful behaviours. The reason for this is obvious. Alcohol stimulates people especially the youth to engage in irresponsible behaviour, which sometimes leads to sex. It is a common belief and it is true for that matter, alcohol, drugs and sex go hand in hand. The youths of this country abuse these three things at an alarming rate. This is probably the reason why they are hardest hit as far as AIDS is concerned.

Sexually transmitted infections can also increase the risk of AIDS. We all have a moral obligation to help prevent the spread of this disease. We should therefore help in whatever way we can. But then you might ask yourself how you can help. Well, firstly you can do that by setting an example. Don't engage in casual sex, if you do have sex, use a condom. The government has made it very easy for people to have access to condoms. So we should use them whenever we engage in sex. They help prevent the exchange of the virus between two people involved in sexual intercourse.

To avoid infections through blood transfusion, blood from donors is tested for the AIDS virus.

Be reminded that **there is no cure for Aids, so the most sensible thing is to avoid getting it.**

Control of HIV

The best way to try to control the spread of HIV is through public education. The education should be aimed at spreading targeted messages that will assist in preventing the transmission of HIV. Messages should help people to:

- abstain from sex
- avoid sexual relationships with unknown persons, or with many different people, they must be faithful to their partners
- use condoms
- not sharing razor blades, injections or any things that cut the skin
- getting tested
- checking all pregnant women who attend antenatal clinics and enrolling those who are infected in the PMTCT programme. You should know what PMTCT stands for as it is often in the media. This is the prevention from mother to child transmission of HIV. Women who test positive are given drugs that prevent the spread of HIV from them to their unborn babies.

Summary

In this Topic we learnt about more diseases that are transmissible and are common. We also discussed their causative agents, transmission modes, and control or prevention strategies so that we may know how to respond to them. Remember that though these diseases are highly transmissible, humans can limit their spread by practising the control measures

mentioned above.

We learnt that having unprotected sex with different partners can lead to STIs. If STIs are treated at an early stage with antibiotics then most of them get cured. But if they are left untreated they have serious consequences one of them being that one may easily get HIV and AIDS. We also learnt of other ways of getting HIV such as by being exposed to blood, semen, and vaginal fluids. Most of these diseases can be controlled by man, we learnt of some of the control or prevention methods. If we practice them we will be able to avoid getting the diseases.

Please remember to do the exercise for the topic at the end of the unit and to follow the method suggested in previous topics on how to correct your answers. Thereafter continue to the next topic, which is on alcohol, tobacco, and other drugs.

Topic 4: Alcohol, Tobacco and other Drugs

We have been learning about health and how its absence results in various kinds of diseases. We have also addressed several kinds of diseases and how they may be controlled or prevented. In this Topic we will look at alcohol, tobacco and other drugs that affect the body negatively. We will also discuss how they affect certain bodily functions. We hope that this will give us knowledge on the consequences of taking such substances so that we may learn why it is important for our health to avoid them. Alcohol, tobacco and drugs, as stated earlier, contribute to risky behaviours that a lot of people especially youth engage in. It is therefore important to learn about all this as it will help us in staying healthy.

Learning Objectives

At the end of this Topic, you should be able to:

- Discuss drug dependence and drug abuse.
- Describe the short term effect of alcohol.
- Describe the short term and long term effect of excessive intake of alcohol on the brain and liver.
- Discuss the physical and social effects of marijuana, glue and other solvents.
- List some of the toxic substances in tobacco smoke.
- State the effects of the components of tobacco.
- Describe the effects of tobacco smoke on the air passages of the lungs.
- Describe the effects of tobacco smoke on the foetus.

Drugs and how they Affect the Body

You may know of someone involved in either drugs or alcohol abuse.

You might understand the social, economic, and personal problems that this causes not only to the people involved but, even to people around them.

In this Topic, we will learn about the most commonly abused substances in most parts of the world, including Botswana. They include alcohol and marijuana. We will also look at the effect of these drugs on the nervous system.

Let us start by looking at what drugs are. Drugs are externally administered substances, which modify or alter chemical reactions in the body. We will concentrate on drugs that affect the brain. They include:

1. **Sedatives:** These drugs slow down the brain and make you feel sleepy, e.g. alcohol.

2. **Stimulants:** These drugs speed up the action of the brain and make you more alert, e.g. cocaine, caffeine, nicotine.

3. **Hallucinogens:** These drugs cause hallucinations. A hallucination is when a person senses something which does not exist. One drug which causes such a condition is marijuana.

3. **Pain killers:** These drugs suppress the part of the brain responsible for the sense of pain and the end result is that you do not feel pain. An example of such drugs is morphine, or heroin.

From the above, we can say that a drug is any substance that alters the physiological state of an organism. Drugs are widely used in medicines for the treatment and prevention of diseases. They include painkillers and antibiotics. Some drugs are just taken for pleasure. These include narcotics such as alcohol and stimulants such as cocaine. Many of these drugs are habit forming and therefore are illegal to use.

Let us look at those drugs which are used for prevention and treatment of diseases. These are called medicinal drugs.

Medicinal Drugs

In Unit 5 we talked about drugs. In an earlier topic we also mentioned how antibiotics are used to treat sexually transmitted infections. Do you remember what a drug is? Write down what it is below.

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You should have thought of a drug as *"any substance which when taken into our bodies will modify the body's chemical reactions to promote good health*".

Let us look at the most widely used medicines or medicinal drugs.

Painkillers

These are used to reduce pain. Examples of locally available painkillers include, aspirins, paracetamol, and brufen.

Antibiotics

These are administered to our bodies to **destroy pathogenic bacteria**. This means that antibiotics are generally meant for the treatment of bacterial related diseases in our bodies. Recall their usage from the previous topic. They are "anti" -"biotic" because they destroy life especially of their intended victims called pathogenic bacteria.

Examples of this group of drugs include amoxycillin and penicillin. Most antibiotics are effective against a variety of bacteria and as a result they are termed **broad spectrum antibiotics**.

Medicinal drugs should not be taken for a long period without consulting a doctor. This is because the body becomes too dependent on the drug which can be harmful, causing side effects. Sometimes people tend to misuse or rather overuse drugs. This is called **drug abuse**.

Drug Abuse

You have probably heard of the term "drug abuse". The term is common nowadays and is talked of in all countries.

But then what exactly do we mean by drug abuse?

This is the overuse of drugs. Drugs are sometimes taken for reasons that they were not intended for. Some of the commonly abused drugs, like cocaine, are obtained from the leaves of the cocoa plant.

Those who abuse the drug sniff it as a powder to induce a short lived "high feeling". Cannabis (also known as marijuana or hashish) is smoked in home-made cigarettes. Morphine and heroin are used as pain killers that can cause a 'high' or happy. This means that one gets into a state of being slightly drunk. Prolonged use of drugs can lead to a person being used to the drug such that they can not do without it. This is called **drug addiction.**

Drug Addiction

This is a condition where somebody is used to taking in drugs such that they can no longer do without them. It starts off with a person taking in the drug for pleasure. Later it becomes a habit and they can't live without it. They are said to be addicted. An addict is a person who entirely depends on a particular substance such that he cannot function normally unless he has obtained his daily dose. For example, cigarette smokers are addicted to nicotine which is a substance found in cigarettes such that some of them cannot think properly or even feel sleepy unless they have smoked.

Some drugs including alcohol affect the working of the brain and alter people's perception of the world.

Why some people get addicted to drugs?

You have probably heard that someone you know is addicted to drugs.

How do you think this happens?

Well, some people start drugs because they want to get relief from their worries. Other people just derive a lot of pleasure from taking these drugs. This is because some drugs produce a sense of well being, or that of feeling good or high. The drugs dull the sense and make a person less aware of the world and unpleasantness of life. There then comes a time when the person needs that feeling to go on and this is how addiction begins.

Addiction also leads to a lot of intake of the drug. Taking too much of a drug can cause an overdose. This causes side effects and damages the body.

We will now look at the problems arising from the misuse of drugs.

Problems associated with the misuse of drugs?

You should be able to say what the problems of taking drugs are from what we have discussed thus far.

In this country, there is minimal use of drugs such as cocaine, heroine, mandrax, and ecstasy. In fact, these drugs are more common in neighbouring countries, such as South Africa.

You may find out more about these drugs from the library.

In Botswana, the main problem is marijuana. We will be looking at problems associated with this drug which is a plant. There are many names that people give to this drug. However, its Setswana name is *Motokwane* or *Matekwane*.

People who smoke marijuana may:

- See and hear things which do not exist. When they do that, they are said to be hallucinating.
- Usually feel relaxed although they may sometimes feel anxious and frightened.
- May have a problem with hearing, seeing, and even their reaction time, which may lead to accidents, if they are driving.
- If pregnant, the unborn child may be damaged.

Some drug addicts sometimes attempt to get off the drugs, this means do to without taking the drugs. Then they experience withdrawal symptoms.

Withdrawal symptoms are unpleasant side effects like vomiting, diarrhoea, shivering, and even loss of consciousness. Withdrawal symptoms can be treated by milder drugs over long periods to help cure addiction.

Activity 6

Can you now think of some of the ways in which the government has tried to control drug misuse and abuse?

Write them on the next space.

Also, write down other things that you think can be done to control drug misuse and abuse.

Feedback:

If you did not know most of the government's efforts, do not worry, as they will be provided for you. The following are some of the ways of preventing drug abuse:

1. Without prescription from doctors, medicines are not available from the chemist. In Botswana it is illegal to sell harmful and dangerous drugs to the public without valid prescription from medical practitioners.

2. The government has implemented strict laws against drug trafficking by imposing severe penalties for people guilty of this crime.

3. The Ministry of Health has taken steps to educate the youth and members of the public against the harmful effects of drug use.

The Government may also make it difficult for people to get drugs into the country. There could also be "stop and search" activities by the Police.

Alcohol

You must have seen young people at the pub, night club or "shebeen". These places provide a meeting place, company, music, relaxation, and alcohol. Boys usually want to impress their girls and show that they are grown up by drinking beer. Eventually they get addicted.

If alcohol has brought much joy to man, it has also brought much suffering especially to the family members of people who drink. A little alcohol now and then may do no harm. Alcohol, whether it is consumed in beer, wine, cider, whisky, spirits, *chibuku* or in any other form is a drug that affects the nervous system. It is easily absorbed into the blood system.

Alcohol is a depressant of the central nervous system. Small amounts of alcohol may give a sense of well being. It also may release one from anxiety. It gives a misleading sense of confidence. Over 500mg of alcohol in $100cm^3$ blood results in unconsciousness. It also stops the breathing centre in the brain, which may lead to death.

Alcohol is not a desirable food source because it does not have enough nutrients and has bad effects on the body. We will now look at some of the effects of alcohol on the body- these can be divided into short and long term effects.

Short Term Effects of Alcohol

•Depression of brain function. This tends to reduce inhibitions and helps to overcome shyness and nervous tension. It leads to slower thinking and less rational behavior. It blurs judgment and increases reaction time.
•It causes vasodilatation. The blood vessels in the skin dilate and allow more blood to flow near the surface of the skin. This makes a person to feel warm but it leads to greater heat loss. This is probably the reason why some people sweat a lot when they have drunk lots of alcohol.
•It sometimes makes a person to show irrational and anti-social behaviour, such as vandalism and aggression.

Heavy or excessive drinking is one of the underlying causes of major health problems.

Long Term Effects of Alcohol

Heavy drinking over a long period can lead to:

- Liver damage. Alcohol permanently damages the liver. This has a very adverse effect on the body because of the many important functions the liver has in the body.
- Irritation of the stomach lining
- Ulcers in stomach
- Weak heart muscles
- Cirrhosis (disease of the liver)
- Impotence
- Alcoholism

We will now look at how alcoholism and cirrhosis affect the body.

Alcoholism

Some people build up tolerance to alcohol which may lead to dependence on alcohol. Alcoholism can take two forms namely tolerance and dependence.

(a) Tolerance
If alcohol is taken over a long period the dosage has to keep increasing in order to have the same effect. Example, people who start drinking alcohol to relieve anxiety need only one litre during the first week. As the days increase, the one litre alcohol intake does not give any effect so that he/she has to increase it to 2 or 3 litres to get the same effect. If the dosage continues to increase, it will become so large that it causes death.

(b) Dependence
This is a condition in which the user cannot live without alcohol. The user may start developing withdrawal symptoms if alcohol is not available. This is called addiction. The withdrawal symptoms of alcohol are: nausea, vomiting, diarrhoea, muscular pain, uncontrollable shaking, etc.

There are many people who can take alcoholic drinks in moderation without becoming dependent on it. Those who become dependent cannot drink in moderation. Their bodies seem to develop a need for permanently high levels of alcohol.

Liver Cirrhosis

When a person drinks heavily, they stand a chance of having a condition called liver cirrhosis. This is a permanent damage to the liver which ultimately leads to death.

The stages of the development of this condition can be summarised as follows:

1. The heavy intake of alcohol kills the liver cells.
2. These cells are then replaced by a fatty tissue.
3. The fatty tissue is later replaced by a fibrous tissue. At this stage we are now in a position to say the person has cirrhosis of the liver.

Alcohol and Pregnancy

Pregnant women who take alcohol may have a greater risk of spontaneous abortion (miscarriage). This occurs usually because the embryo is defective in some way. The embryo dies and is expelled from the uterus.

Women who drink alcohol during pregnancy produce babies of below average birth weight. These babies are more prone to diseases than normal babies. Heavy drinking during pregnancy may damage the brain of the developing foetus.

We will now discuss other drugs that people tend to abuse- these are glue, petrol, and spirits such as benzene.

Glue, Benzene and Petrol

These solvents are also abused by some people. In Botswana this is mostly common amongst street children. They usually sniff these solvents and the end result is that it gives them a feeling of being drunk.

Effects of the Substances on the Body

- Glue can damage the liver, the brain and even the kidneys.
- Just like any other drug, glue sniffing can result in the user being addicted.
- It can also lead to suffocation or heart failure due to sudden shock.

Another substance that is also abused is cigarettes or tobacco. We will now learn about the toxic substances found in them.

Toxic Substances in Cigarettes or Tobacco

Cigarettes are also considered to be drugs because they contain toxic substances. Some of these substances are even addictive. Have you realised how many people smoke tobacco? Yes many people smoke tobacco even though they know that it is unhealthy to do so. Tobacco smoke contains more than 500 different chemicals. Most of the chemicals found in tobacco smoke are poisonous. For instance tobacco smoke contains nicotine, carbon monoxide, and tar.

Nicotine

Nicotine is one of the most poisonous substances known to man. If introduced into the blood, 1 gram of nicotine is enough to kill a healthy man. Nicotine is addictive – that is why it is difficult to stop smoking once a person has started. Nicotine increases the blood pressure by promoting the release of fat into the blood.

Carbon monoxide

Carbon monoxide is a colourless and odourless gas. It is very poisonous. Carbon monoxide competes with oxygen for the red blood cells.

Remember oxygen is transported in the red blood cells. Now, carbon monoxide takes the position that is usually taken by oxygen. So, if one is exposed to carbon monoxide they would carry less oxygen in their red blood cells. When there is less oxygen carried in the red blood cells, then the body cells would receive less oxygen than they need. Breathing in a lot of carbon monoxide can kill a person.

Tar

Tar contains particles which are larger in size compared with nicotine and carbon monoxide. Tar contains substances that cause cancer. Can you imagine a person inhaling something that causes cancer? What do you think could happen to this person?

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Yes, this person could develop cancer of the lungs.

If we could set up the apparatus as shown in the diagram below, then we would notice that tobacco smoke contains tar.

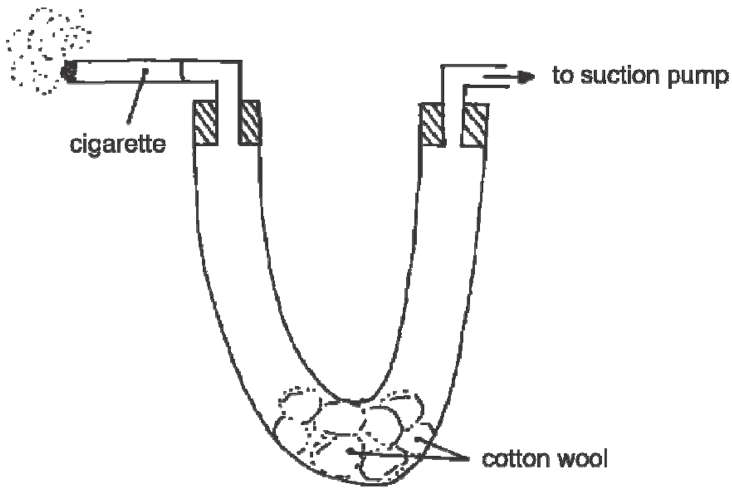

Figure 3: Experimental set up to demonstrate the presence of tar in tobacco smoke.

In the set up above, as the cigarette burns, the cotton wool turns brown. The substance that causes the cotton wool to turn brown is tar. You should now complete the next activity which is based on Figure 3.

Activity 7

1. Which structure in the lungs is represented by the cotton wool?

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2. How does the cigarette smoke affect the cotton wool?

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3. Use ideas from the above experiment to explain how smoking may result in diseases.

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Feedback

1. *The cotton wool represents the alveoli.*
2. *The smoke makes the cotton wool to change from white to black.*
3. *When a person smokes tobacco some substances get trapped in the lungs affecting how they function. This is how diseases occur.*

The above activity shows how the tar in the smoke gets trapped in the lungs during smoking. This may result in other diseases such as lung cancer. Tobacco smoking is associated with a few more illnesses not just lung cancer. Let us look more closely at the diseases that are associated to tobacco smoking.

Diseases Associated with Tobacco Smoking

There are many diseases that one can develop due to smoking tobacco. We are going to discuss only the diseases that affect the respiratory system. These diseases include:

Lung cancer

A person who has lung cancer usually shows these symptoms: coughing bloody sputum, chest pain, running short of breath, losing appetite, and losing weight. Lung cancer can lead to death. Smoking of tobacco is strongly associated with lung cancer. Actually, more than 80% of people with cancer are people who smoke tobacco. People who smoke more cigarettes stand a greater risk of developing lung cancer. Let us use the figure below to show how the number of cigarettes relates to chances of getting lung cancer:

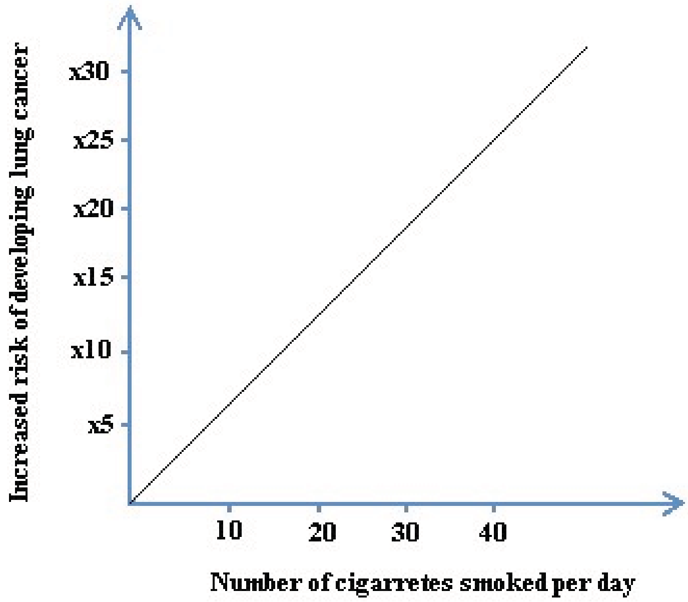

Figure 4: Graph to show association between number of cigarettes smoked a day and risk of dying from lung cancer.

Do you see how the number of cigarettes relates to developing lung cancer? This means that if one starts smoking tobacco while young, the risk of developing lung cancer is increased.

Hopefully this will discourage people from smoking.

Heavy smokers suffer persistent coughs, which damage the lungs. Lung cancer starts in the epithelium of the bronchial tubes. The lining cells divide regularly to replace the worn-out cells. It seems that one of the factors causing these cells to divide more frequently is the cancer inducing chemical found in the tar in cigarette smoke.

When a person who smokes cigarettes inhales the smokes, it means he is breathing the smoke into his or her lungs where the tar settles on the lining of the tube and it can lead to the development of lung cancer. There are short term and long-term effects of smoking.

Short-term effects of smoking cause the bronchioles to constrict and the cilia, which are present on the lining of air passages, stop beating. Due to the smoke the lining produces more mucus.

Long-term effects may take many years to develop but they are severe and often lead to death.

Chronic Bronchitis

Chronic bronchitis is another disease strongly associated with tobacco smoking. A chronic condition is a condition that takes a long time to develop and usually takes a long time to heal or may even never heal. So, chronic bronchitis is a disease that usually takes a long time to develop. When one has bronchitis, their bronchioles become inflamed. This results in the amount of air taken into the lungs being reduced. Apart from the shortage of oxygen, a person suffering from bronchitis also has a painful dry cough.

You probably have come across a person suffering from bronchitis and you might have seen the expression of pain on their face with each cough.

There are many substances that can cause bronchitis, and tobacco smoke is one of them. The more the cigarettes one smokes, the higher the risk of developing bronchitis.

Bronchitis is the inflammation of the walls of the air passages. Chronic bronchitis is a long lasting type of bronchitis, which usually leads to death.

You have already learnt in Unit 4 on the respiratory system that there are hairy structures called cilia that line the air passages. These hairs are continuously flicking to and fro and as a result sweeping any foreign particles out of the air passages. The irritant substance in the smoke causes more mucus to be secreted by the cells lining the respiratory tract. The excess mucus clogs the cilia and as a result they stop moving.

This results in inflammation of the lining of the air passages.

Symptoms of chronic bronchitis include:

- Breathlessness due to reduced gaseous exchange.
- Coughing in which the excess mucus is coughed as a yellow sputum.

Coughing and breathlessness increase as the disease progresses and the respiratory system gets damaged. As the respiratory system gets damaged there is a likelihood of a person getting other infections such as pneumonia.

Emphysema

As learnt in Unit 4, Topic 1 on Breathing and Gaseous Exchange, there are more than 250 million alveoli in the lungs of a human being. Each one of the many alveoli is important for exchange of gases between the blood and the environment. I hope you can remember that we said our lungs have many alveoli because we need lots of oxygen from the environment and also because we take out a lot of carbon dioxide from our bodies.

Smoking tobacco makes the wall of the alveoli to become weak and eventually break. When a person has emphysema, some of his/her alveoli would be broken. When a person suffering from emphysema coughs, some of his/her weak alveoli may break due to the pressure exerted on them.

This occurs due to the breakdown of alveoli. The irritant substances in the tobacco smoke weaken the walls of the alveoli. These irritant substances make the smokers cough and coughing bursts some of the weakened alveoli. The absorbing surface of the lungs also gets reduced. As a result of this, the smoker cannot oxygenate his blood properly and the activities of the heart make him breathless and exhausted.

If you know someone who is a smoker, what would you say to them to stop smoking?

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You could try telling them that smoking leads to poor overall health and a variety of adverse diseases such as lung cancer, bronchitis, emphysema and a lot others that we did not address in this unit. You could also show them books, pamphlets or brochures on the effects of smoking. Visit your nearest health post and library to look for these.

Disturbance of Cilia of the Lungs

The air we breathe in may contain dust particles. What do you think happens to the dust particles that may be in the air that we breathe in?

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Some of the dust particles are trapped by the hair in our nostrils. Most of the small particles of dust may go past our nostrils. The small particles of dust are swept by the small hairs called cilia found along our air passages (e.g. along the trachea). Tobacco smoke stops cilia from sweeping up the dust particles. The smoke also destroys the cilia. So, when a person continues smoking, the cilia would be destroyed. This would allow fine dust particles to go deep into the lung and damage the lungs.

So far we have learnt that tobacco smoke is poisonous to humans. We would like to now consider the effects of smoking when a person is pregnant.

Dangers of Smoking during Pregnancy

As we have discussed earlier, carbon monoxide found in tobacco smoke reduces the amount of oxygen carried by red blood cells. An unborn baby obtains its oxygen from the blood of its mother. So, if there is too little oxygen in the blood of the mother, then the unborn baby would receive too little oxygen.

This can lead to problems associated with tobacco smoking during pregnancy. One of these problems is that the unborn baby cannot develop as quickly as it should such that at birth the baby may be underweight. This means that smoking during pregnancy leads to the birth of underweight babies. Smoking also increases the risk of miscarriage or death of the unborn baby.

Not Smoking

You might have seen some posters, which are written, "*Smoking is injurious to health*". As a matter of fact, it is not only on posters, even cigarette packets have this message printed on them. If you haven't seen that look for a cigarette package and check the message.

In some countries such as our country, smoking is even prohibited in public areas.

We will now engage in an activity that will make us play a role in the fight against cigarette smoke. Please do the activity and share it with as many people as you can to see if it communicates what you wanted to say.

Activity 8

Come up with, that is develop, your poster to discourage people from smoking.

Feedback:

Your poster should be colourful with pictures and having several messages such as smoking discolours the teeth, smoking is prohibited in most public places, smoking is expensive, smoking causes diseases like bronchitis, emphysema, lung cancer etc. Please remember to share your poster with as many people as you can to ensure that it communicates what you wanted to portray as well as the messages you wanted to convey.

It has been clearly established that smoking cigarettes causes bronchitis, emphysema, arteriosclerosis, heart attacks, and lung cancer. It is even said that secondary smoking is also equally dangerous. This is when a non-smoker inhales the smoke exhaled by a smoker. This is why smoking is not allowed in public areas.

Summary

Let us briefly go through what we have covered in this Topic. We learnt about alcohol and drug abuse by looking at how both may result in personal and social problems. Some of the issues we addressed were the following:

- The abuse of alcohol and illegal drugs may result in loss of employment, breakdown of families, and criminal activities.
- Examples of substances that are abused include medicinal and non medicinal substances.
- Medicinal substances include antibiotics, painkillers, etc.
- Non medicinal drugs include glue, benzene, petrol, and caffeine.
- Alcohol, caffeine, and marijuana are the most commonly abused substances in Botswana.
- Caffeine is mostly found in beverages such as coca cola, tea, and coffee. We did not address this in this Unit as we were focusing only on drugs that are not found in food. You are encouraged to read more about this so that you may be informed.
- Marijuana is common amongst youth despite the fact that it is illegal.

We also learnt that tobacco is also a drug because tobacco smoke contains more than 500 different chemicals most of which are poisonous. The chemicals in tobacco smoke include: nicotine, carbon monoxide, and tar. Each one of these substances is poisonous. We also learnt that tobacco smoke causes: lung cancer, chronic bronchitis, and emphysema as well damage to cilia that results in their function of trapping substances like dust particles being affected. Lastly we learnt that smoking during pregnancy can lead to miscarriage or underweight babies at birth. Knowing all this will help us make the right choices so as to stay healthy.

We have come to the end of the topic. Please remember to attempt the topic exercise at the end of the unit, as you have done in earlier units. You are encouraged to attempt the exercise before reviewing the feedback given.

Topic 5: Control of Diseases including Personal Hygiene

So far we have been learning about diseases that exist and ways of controlling them. Most of the diseases we learnt about are caused by pathogens or other things such as drugs. Sometimes the diseases we get are a result of lack of cleanliness or how we look after ourselves and our surroundings. In this Topic we will learn of how we can control diseases by practicing certain levels of hygiene as well by using chemicals and medication.

Learning Objectives

At the end of this Topic, you should be able to:

- Describe the importance of personal hygiene.
- Describe the use of sterilization in the control of diseases.
- Describe sterilisation.
- Distinguish between antiseptics and disinfectants.
- Discuss the action of antibiotics in controlling organisms that cause diseases.
- Describe the control of vectors.
- Explain the need for knowing the life cycle and habits of disease vectors.

As in earlier topics, this topic has been arranged in a manner that enables you to discuss personal hygiene and what it means to you before looking at physical and chemical methods of ensuring hygiene. This will then flow into medicinal drugs such as antibiotics that are also used to maintain hygiene and good health. Lastly, you will learn about vectors and their life cycles so as to get knowledge and skills on how they may be controlled.

Earlier in the unit we discussed the meaning of each of the two terms "health" and "disease". Do you still remember their individual meanings? Can you re-define them? Please don't think that this is repetition treat it as a form of revision.

Activity 9

Compare the terms health and disease?

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Feedback

Hopefully you simply said, "Health is the state of physical and mental being of an organism, dependent on receiving a balanced diet, as well as physical and mental activities". Good health therefore, is the state of good physical and mental condition of the whole being. Bad or poor *health is obviously the opposite. For disease you should have simply recalled that "it is the loss of good health". A person who has lost good health is said to be sick. The opposite of being* ***sick*** *is being* ***healthy****.*

We must have all been sick at one time in our lives. Imagine the odd dose of flu we sometimes experience. It is definitely not a nice feeling. What about the headache, feeling cold, shivering, and even losing the desire to eat? Definitely, every person does not want this to happen to him or her. We all want to remain healthy all the time, so we have to try by all means to avoid being sick or shall we say to avoid contacting any disease.

In this Topic we will study how we can control diseases in order that we enjoy healthful living.

Personal Hygiene

Personal hygiene is personal cleanliness. It is a practice aimed at keeping one's body free from disease causing organisms. But it is not only about the body but also the environment we live in. We dealt with this in detail earlier, so we will not do it in detail again. What we will emphasise is how proper disposal of wastes is vital in reducing harm to the environment and animals. Remember that in Topic 1, under good health, we discussed domestic hygiene and said that it entailed keeping our surroundings clean. This obviously involves the removal of dirt and anything that may attract germs and allow for them to breed. This is done so as to reduce the chances of getting diseases. It is therefore important to know proper ways of removing or disposing of wastes so as to live healthy.

Control of Organisms that Cause Disease

We all would like to lead a clean and healthy life. Life is sweeter and more enjoyable without diseases or sickness than with poor health. However, living things continuously get sick. The life of every organism is always at constant risk of being affected by one disease or another. In fact, nowadays, it is easier to fall sick than to stay healthy throughout your life.

This is because of some of the following reasons:

- Some activities we do have a potential of affecting our health. One such activity is sexual intercourse. When somebody engages in any form of sex there is always a possibility of them contacting some form of disease. From our discussions in earlier topics you already know some of the diseases that can be contracted from sexual intercourse. An example of such a disease can be AIDS. Having unprotected sex can lead to a person contacting HIV, which causes AIDS.

- Some foods we feed on are not good for our healthful living. You might find that they are either deficient in one particular food stuff or they are contaminated with disease causing organisms. As a matter of fact, even ill prepared food can result in somebody being sick.

- Some organisms which live within our environments seek our bodies for nutrients or shelter.

However, the good news is that even despite all these factors affecting our health negatively, something can be done to control the infections by various diseases to minimal levels.

In life, it is mostly those organisms that are better adapted to their environment that will survive and reproduce young ones as they feed better alone than with the weaker ones. The weaker ones usually die out of existence or become extinct. It is therefore very important that organisms live a healthy life and reproduce so as to increase in numbers.

Life is definitely better without diseases because with good health one can:

- have a chance to survive or live longer
- longer life enables you to reach an age when you can pass on your life to your young one by reproduction as a way of continuing our human life, since our individual lives are of limited life spans
- evade the pain inflicted by a disease, including its bitter secondary effects of possible misery, loss of friendships, etc.

From these three reasons you can see why it is important for you to control your chances of being affected by any of these diseases, those discussed so far in your earlier Topics and even those not yet mentioned.

In the Topic sections that follow we will look at the basic methods you can use to control diseases.

Control of Infectious Diseases

The human body has many natural defences against the entry of pathogens. For instance, blood clotting can seal a cut or wound thus preventing the entry of pathogens through the skin. The body also has chemical barriers against infection, such as tears, which not only wash foreign substances from the eyes, but also contain enzymes that destroy many common pathogens. In addition, the mucous membranes release protective chemicals. The body's own senses of smell and taste can often detect the presence of bacteria in food before harmful quantities are ingested. Any bacteria that reach the stomach may be killed off by the hydrochloric acid in the stomach's digestive juices. Pathogens that manage to penetrate the body's defences will be recognized as foreign and come under attack from antibodies produced by the white cells in the blood.

Methods of Disease Control

As stated earlier, it is very important for us to be able to control the diseases that affect mankind. This is because if these diseases are not properly checked, they can completely wipe out the human race from the earth.

We might not be aware of this, but we all practice disease control measures. However, before we discuss this in detail, I would like you to sit down and think about some of the activities you do at home which might prevent the spread of diseases in your household.

Activity 10

List some of the common practices at home, which can prevent the spread or the incidence of diseases in your home and explain in what way each prevents the spread or incidence of diseases.

If you have difficulties in doing this activity, you might find it helpful to consult a friend and even your tutor.

Feedback

You might have answered the question in the above activity differently from the way I will try to address it. Do not worry as we have different ways of approaching some concepts. However, what follows next is some of the responses I expected you to come up with.

Sterilization

This is a method of destroying pathogenic microorganisms that contaminate food, utensils and wounds. Sterilization keeps the utensils or surroundings completely free from microorganisms.

When this has been done the material is then said to be sterile or sterilized. Sterilization completely reduces the prevalence of disease causing organisms. There are many different methods of sterilization and they include the use of heat and chemicals such as chlorine, disinfectants, and antiseptics.

(a) Heat Treatment

This is done at high temperatures to kill pathogens. It is also called heat or thermal sterilization. The use of heat to sterilize utensils is the most common method of sterilization. In heat sterilization, the utensil being cleaned is exposed to high temperatures to kill germs. This is by placing the material or utensil in hot water and boiling it for some time.

Why should the meat be prepared at high temperatures?

Boiling at high a temperature sterilizes the meat and the water.

It is just a precaution to get rid of disease causing organisms.

(b) Chemical Treatment

This involves the use of chemicals as agents of sterilization. This method works by either killing or slowing down the rate of growth of any disease causing organisms present in the substance being sterilized.

Examples of this method include:

- **Disinfectants:** One common disinfectant is Jeyes fluid. Do you know what Jeyes fluid is?

  Well, it is definitely a chemical used in most households to clean toilets and drains. This fluid kills bacteria and germs which otherwise can find their way into food and cause some form of disease. It is poisonous so one has to be very careful when using it.

  It is not only Jeyes, which is a poisonous fluid, but also most disinfectants that can be used for sterilization. So, it is advisable that one does not ingest them. That is, they are not good for human consumption.

  Disinfectants are mostly used for cleaning floors, toilets and sewage systems.

- **Antiseptics:** An antiseptic is a chemical substance that kills or prevents the growth of pathogenic organisms in wounds. Unlike disinfectants they are not toxic or poisonous to body cells. They are mostly used in clinics and hospitals to wash wounds.

  The most common antiseptics include hydrogen peroxide and ethanol or/alcohol.

- **Chlorine:** It is a chemical sterilizing agent, which is used in the large scale treatment of water. When you get water from a pond where there is no purified water from taps, it is advisable to clean it. This can be done by adding chlorine to the water. Chlorine actually kills any germs which might otherwise be harmful to people who use the water. You can actually get a mild form of chlorine from most of these big supermarkets, such as Spar.

  However, water, which circulates in taps in most major villages and towns of Botswana, has been treated before distribution, so you do not have to purify it at all. The people who are responsible for this, i.e. the Water Affairs Department, have already done it using chlorine. Chlorine kills microorganisms, which might be in the water. Unlike disinfectants, it is not harmful so there is no harm in taking small doses of it.

  Most sterilizing agents contain chlorine. An example can be the ones used for cleaning feeding bottles. One common one is called Milton's sterilizing liquid. Lactating mothers who bottle-feed their babies have to take serious precautions with these bottles. First of all before using them, they have to put them in a hot water bath. The next step is then to soak the bottles in clean warm water and then add the sterilizing liquid.

From the above paragraph you should note that a combination of two sterilizing methods could be used to clean utensils or even the environment.

Please do the following activity to get skills on how to minimise getting germs.

Activity 11

Teenager Tuelo was left at home for 2 days with her 8-month-old baby brother. She was asked to feed him using a feeding bottle. She misplaced the bottle and only found it under the couch after a day. What can she do to clean it before preparing the milk solution for the baby?

Feedback

To check your answer, you can go back to the last two paragraphs before the activity as we have just discussed this process.

Antibiotics

You have definitely heard the word antibiotic before. But then, what is an antibiotic?

If you have any idea, you can write that down on the space below, but if you don't, do not worry, as a description will be provided later on in the Topic.

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You might have thought," an antibiotic is a drug they give to sick people". Quite true, but then what kind of sickness are we referring to here? Do we mean headaches or influenza or even cramps? Actually no!

Antibiotics are used to treat bacterial and fungal related diseases. By bacterial related disease we mean all those disease that are caused by bacteria. Examples of such diseases include tuberculosis, gonorrhoea, syphilis, etc.

Can you say what we mean by fungal diseases? Please give examples of these fungal diseases.

You should have said that fungal diseases are diseases caused by microorganisms known as fungi. Some examples of such diseases are thrush, ringworms, and athletes foot.

You should still remember how we said that antibiotics are used to treat sexually transmitted infections. There are several classes of antibiotics. Each class and individual antibiotic acts in a different way and may be effective against either a broad spectrum or a specific type of disease-causing agent. Though antibiotics are used a lot to control diseases, their use has become more selective as they result in side effects such as toxicity, allergy, and resistance. Bacteria have the ability to develop resistance following repeated or insufficient doses, so more advanced antibiotics and synthetic antimicrobials are continually required to overcome them. It is therefore important for people on antibiotic treatment to know how to take them, especially the importance of completing a course.

Control of Vectors

As mentioned earlier on, a vector is an insect that transmits disease-causing microorganisms from one animal to another or one plant to another plant or even from the environment to an organism. In our case we will deal with vectors that affect human beings.

An example can be the female anopheles mosquito. We all have heard of mosquitoes and the disease they are associated with especially in Botswana. This is mostly common especially during the rainy season when there is lots of water.

It used to be a common belief that this disease is mostly common in the Northwest and Chobe regions of Botswana, but this is not the case. During the rainy season in other parts of this country there is a high prevalence of this disease. You must be wondering what this disease is. As mentioned earlier on, the female anopheles mosquito spreads it. What is the disease?

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The disease is Malaria.

One way of controlling diseases that are spread by vectors is by dealing with the vector itself. This is by killing the vector and making sure that it does not breed or get in contact with us. An example can be the control of malaria. The female anopheles mosquito spreads malaria. We can control malaria by destroying its vector, which is the mosquito. This is by spraying areas where the mosquito breeds and even spraying the mosquito itself.

Another vector, which is a health hazard to man, is the housefly. It spreads intestinal diseases. Examples of those diseases include typhoid fever and dysentery.

Houseflies spread microorganisms to human beings, as they move about from refuse and litter dumping grounds into our houses. The housefly is in fact a common insect that likes flying about in your house and everybody's house all over the world. They are mostly found in warm, moist, and dirty places.

Let us now have a look at one of these vector's life cycle and habits, to help us understand how they perform their role as vectors of diseases. Knowledge about the life cycle of a vector is very important for one to be able to control the disease it spreads. From Unit 1, you should be in a position to say what a life cycle is. What is it?

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Well, it is definitely the sequence of events in the development of an organism from fertilization until an adult is formed. As for the housefly it starts with eggs and ends with an adult fly. There are four stages in this development: egg, larva, pupa and adult fly.

We will now look at the life habits of the housefly. Houseflies have roving habits that spread diseases by collecting germs from human excreta, sputum, rotting matter, manure and other dirt, and distributing them all over their paths. The housefly‘s life is characterized by:

- **Curiosity:** This takes them anywhere as well as feed on almost anything.

- **Laying of eggs in moist and rotting matter:** These contain enough warmth and moisture favourable for the development of their larvae.

- **Having a liking for warmth and light, especially from direct sunshine:** This is known as being photophyllic. It makes them mostly active during the day but rest at night or in the dark.

- **Feeding on both flesh and plant foods**: Usually the foods are liquids or solids that can easily be dissolved by the saliva they secrete onto the food. They are not choosy. They can defecate on food while feeding on it. Their saliva, faeces and the hairy body can accommodate or contain germs of up to 18 or more human diseases.

Effective control of houseflies can be achieved by:

- **Preventing them from breeding** (laying eggs or reproducing) at stage one. For houseflies this may involve **burying or burning** garbage and refuse, turning over manure and other rotting matter to remove heat that provides optimum growth temperature for larvae. Turning also removes moisture by drying the rotting matter.

- Using **clean containers as bins**. This provides no attractions to the roving houseflies.

- Providing rubbish pits with **drainage facilities**. This helps to remove moisture from dirt.

- For the adult you can use **insecticides** like Doom and Dyroach.

- Using **fly traps** in form of **nets** and **sticky flypaper**, on windows, doorways or anywhere in the house.

- Keeping utensils such as cooking pots, plates, cups and all others clean. This way the utensils are left with nothing to attract microorganisms and even insects.

- Washing foods with clean water and then keeping them sealed so as to prevent them from being contaminated with microorganisms.

- Keeping our **toilets clean**. Using disinfectants can do this.

- Keeping refuse in covered **garbage bins**. This is so that these places do not become breeding grounds for flies.

In a nutshell to effectively stop houseflies and even other vectors from spreading diseases we should practice **proper sanitation**. This is by having enough toilets, pit latrines, garbage bins and pits, and sewage system.

Please do the following activity that will require you to go out and look for information.

Activity 12

Please go to the nearest grocery shop and list insecticides sold there.

Hint: You will have to look thoroughly at the containers to see how the contents kill or destroy insects.

Feedback:

You should have listed things such as Fast Kill, Baygon, Dyant, Dyroach and Doom.

Avoiding Infected Water

Water in some areas is not good for human consumption. In the tropics, unless you know that a pond, lake or river is free from disease causing organisms and from water snails, which carry schistosomiasis, we should avoid paddling, bathing or washing in such places.

Do you still remember what the role of snails is in the life cycle of the bilharzia fluke?

Well, they are the intermediate hosts of the germs that cause schistosomiasis. From Unit 1, you should be in a position to say what schistosomiasis is. What is it?

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The answer to this question can be found in Unit 1, Topic 3 section 1.2. If you do not know it, revise the relevant section of Unit 1. If you knew it good!

After heavy rains you might notice that water collects in the bucket or tin cans and even in small ditches. This water, if not attended to can be a breeding place for mosquitoes. You should remember that mosquitoes lay their eggs in stagnant water.

Modern medicine has produced many vaccines and antibiotics that can assist the body's own defence mechanisms, or take over when they fail. In addition to alleviating symptoms of disease, some vaccines are used as preventative measures – for instance, the immunization of infants against childhood diseases such as measles and whooping cough, and flu vaccines, which are given to the elderly and vulnerable at the onset of winter. We will in the next topic move onto the last method, which is also used in the control of some diseases.

Summary

We have just learned about disease control and methods that can be used to control diseases. It is very important for us to be able to control the diseases that affect us. This is because among other reasons some diseases are not curable. They include AIDS, which is the latest killer disease to hit the planet. The methods of control include:

- Sterilization: This can be through the use of heat or chemical agents. The most commonly used chemical sterilization agents are disinfectants. They are used to destroy pathogenic microorganisms. Chlorine is another chemical that is widely used in the treatment of water.

- Antiseptics are also widely used in the cleansing of wounds. This is because if wounds are not properly cleaned, there is a danger of them being sceptic and thus failing to heal.

Antiseptics and disinfectants are not fit for human consumption so they should not be ingested.

- Antibiotics on the other hand are drugs. They are used in the treatment of diseases. Unlike disinfectants, antibiotics are consumable.
- Another method, which we learned about, is controlling a disease by controlling the vector that spreads it. This is only possible if one knows the lifecycle and habits of the vector. In this method we control the organisms that spread the disease to stop the diseases.

We have come to the end of the Topic. Please remember to do the exercise at the end of the unit. Please remember to attempt the exercise before reviewing the feedback provided.

Topic 6: Immunity and Immunisation

In this Topic we will learn about immunity, which is all about how the body is able to fight diseases. Under immunity, we will deal with both the naturally acquired one and the artificially acquired one. One commonly practiced way of getting artificial immunity is by immunization. Immunization is an important public health measure. If most of the population has been immunized against a particular disease, it is impossible for an epidemic to take hold. We will learn about this in detail.

Learning Objectives

At the end of the Topic, you should be able to:

- Define immunity to diseases.
- Define active immunity to diseases.
- Define passive immunity to diseases.
- Describe the differences between active, passive, natural and artificial immunity.
- Describe World health organization‘s campaigns to eliminate poor health due to diseases.

Immunity

Would you want to guess what this is? Indeed you can, since you were given a hint in our Topic introduction.

Immunity

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You must have said that immunity is the control of diseases within our bodies. If so, that is certainly true! To be more precise, ***immunity is the ability of an organism to resist diseases.***

But then, how does the body resist the diseases? Well, if you remember, it is through the action of certain types of cells called white blood cells. We dealt with these cells in Unit 1 and also in Unit 5 of the Circulatory System under Composition and Functions of Blood.

I would like you to try and recall the different types of white blood cells and where they are produced in the body. You should note that down on the space below.

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We are not going to provide answers to this for you- please check your answers under Unit 5, Topic 1.

White blood cells protect the body from microorganisms. They do so in a number of ways; these include phagocytosis. Do you still remember what phagocytosis is?

You should write that down on the space below.

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Once again, I am not going to provide answers to this question. For you to check your answers, you should go back to unit 5, Topic 1.

Another way is by producing antibodie***s***. These are chemical substances produced by lymphocytes. Antibodies are proteins and they destroy antigens.

Do you know what antigens are?

Antigens are chemicals produced by pathogens. When a pathogen enters the human body, its antigen causes the body to produce a specific antibody against it. Different pathogens have different antigens. For example the antigen that arises from infection by tuberculosis is different from the antigen that arises from infection by typhoid fever. As a result, the antibodies, which fight them, are also different.

Sometimes, once a person has had a disease, they may develop immunity against getting the disease again. The person develops antibodies against the disease in the body. The antibodies that were released in response to the disease remain in the blood and as a result they can prevent re-infection by the same disease.

This means that each bacterial or viral infection will bring about the manufacture of a specific antibody, which will then fight the disease. Many diseases can only be contracted once because antibodies remain in the blood after the infection has passed, preventing any further invasion.

After this process has taken place the person is said to be immune, usually to a particular disease and pathogen. This means that an individual can never develop the particular disease easily. Many people can gain immunity to diseases such as tuberculosis in this way. This is referred to as natural immunity.

We can also be immunized against some diseases. This is known as artificial immunity. It usually happens in clinics and hospitals. In fact, it is common for newly born babies to be immunized against some disease. This is when the child's resistance to diseases by causing the production of antibodies specific to particular infections is boosted through vaccination. You can easily get information about these diseases from your local clinic or the district health team. Alternatively, you could get this information from the preschool card that is given to babies. It is used to note their development, health problems and even rations if they are given any. The next activity encourages you to get this information before reading our answer.

Activity 13

Try and obtain a preschool card. It is usually orange in colour. On it is a lot of information that includes the names of the diseases and the dates a child was immunized against them. If you cannot get your hands on a card, it is advisable that you ask nurses or family welfare educators at the nearest clinic.

Which diseases are children immunized against?

Feedback

Children are immunized against the following diseases: tuberculosis (TB), hepatitis B, diphtheria (DPT), poliomyelitis (Polio), measles, and even maybe whooping cough.

These diseases are sometimes called the six biggest killers of children aged between 0 to 5 years. This is because they attack the inexperienced bodies so quickly before production of adequate antibodies to fight the antigens. Immunization is mostly done through the injections.

The substances the child is given at "immunization" time are actually called vaccines**.** Vaccines are harmless form of germs, which serve as antigens when introduced into your body. The vaccines are usually either dead pathogens or weakened pathogens**.**

I am sure this statement must puzzle you. It is more like the babies are being intentionally infected by the diseases. Let's examine this concept.

The pathogen is first specially treated. The reasons for this activity is to weaken the pathogen or, should I say, reduce its infectivity. The pathogen's antigen causes the body to produce antibodies, which then protects the body against further infection.

This process of immunization is commonly called vaccination. Let us now define vaccination in detail.

Vaccination is the process of injecting the body with dead or weakened pathogens which cause the body's immune system to produce appropriate antibodies.

The substance that is being injected is called the vaccine. You should bear in mind that most vaccines are administered as injections. However, some are taken by mouth. An example of such a vaccine is the polio vaccine. Drops of the polio vaccine are put in the baby's mouth once each month.

Types of Immunity

There are two types of immunity and that is passive immunity and active immunity. Either one can be acquired artificially or naturally.

Active Immunity

This type of immunity arises when the body produces antibodies in response to invading pathogens. As mentioned earlier on, active immunity can be either natural or artificial.

(a) Natural Active Immunity

This kind of immunity is obtained as a result of an infection. The body produces its antibodies when exposed to an antigen that causes the disease. This type of immunity is the most effective and generally persists for a long period sometimes even for life.

(b) Artificial Active Immunity

This is achieved through vaccination. Do you remember what vaccination is? What is it?

Well, you probably thought of it as "a process of injecting or administering orally, small amounts of antigens into the body of an organism."

Through vaccination people can be immunized against a disease by introducing small quantities of dead or inactive forms of the disease-causing agent (pathogen) into the body. In the vaccine are chemicals which act as antigens. These stimulate the white blood cells to produce antibodies. Antibodies are capable of binding to pathogens, resulting in their destruction. If the body is effectively 'warned' about the antigen by this means, the body is then able to produce enough of the appropriate antibody whenever the real pathogen enters the body. The micro-organism or virus can then be inactivated and removed before it harms the body.

Passive Immunity

In passive immunity, antibodies from one individual are passed into another individual. They give immediate protection, unlike active immunity, which takes a few days or weeks to build. However, it only provides protection against infection for a few weeks.

(a) Natural Passive Immunity

Passive immunity may be gained naturally. For example, antibodies from a mother can cross the placenta and enter the foetus. In this way they provide protection for the baby until its own immune system is fully functional. Passive immunity may also be provided through colostrum. Do you know what colostrum is?

It is a type of milk or shall we say it is the first milky secretion of the mammary glands after giving birth.

(b) Artificial Passive Immunity

In this type of immunity, antibodies, which have been formed in one individual, are extracted and then injected into the blood of another individual that may or may not be of the same species. They may be used for immediate protection. One such instance can be if a person is likely to be exposed to a particular disease. An example of such a case in Botswana can be if you travel to the Ngamiland district. There is a high possibility of you getting infected with malaria. Now, you might be given chloroquine, which is an antibiotic used to prevent the infection by this disease.

Vaccines in Common Use

In the following section we will give examples of some common vaccines in use in Botswana.

Table 1: Common vaccines used in Botswana

Vaccine Method	Type of Vaccine	Vaccination
BCG (Anti-tuberculosis)	Attenuated bacillus	Injection
Anti Tetanus	Toxoid (neutralized toxin of tetanus)	Injection
Anti poliomyelitis (for polio)	Attenuated virus	Oral & Injection
Anti diphtheria	Toxoid	Injection
Anti measles	Attenuated virus	Injection

Anti whooping cough	Killed bacteria	Injection

Note: Attenuated means weakened. Attenuated viruses are therefore weakened forms of the virus that causes a particular disease

Vaccinations are used because they are said to be the best way to deal with virus diseases. This is because antibiotics are not effective against viruses. An example is the MMR vaccine used to protect children against measles, mumps, and rubella. A study of thousands of children in Finland who have had the MMR vaccine has shown that there is only a very low risk of damage being caused to a child as a result of having the vaccine. The risk is much lower than the damage caused by catching one of the diseases. The worries over MMR vaccine have reduced the numbers of children being vaccinated, which increases the risk of measles, mumps, or rubella breaking out in an epidemic.

If vaccination covers a large proportion of the population at risk, a disease can become very rare, or even die out. Smallpox was eliminated in this way. The World Health Organization (WHO) is running global vaccination programmes with the aim of eradicating other infectious diseases as well.

Activity 14

Find out what WHO stands for and what its functions or roles are.

Feedback

The World Health Organization (WHO) was formed specifically to be the custodian of the health of people of the world. It is in fact an organization by world countries and for the world people interested in human welfare. Botswana is a member of this organization.

Roles of WHO

WHO seeks to promote world health standards to higher levels, this is done by:

- Coordinating medical research work and carrying out training **programmes** for local people in *the fight against infectious diseases*, to eliminate such diseases.
- Immunization of both adults and children.
- Being involved in the production and distribution of drugs to help in disease outbreak and pest control and for immunization or vaccination programmes. Examples of such a campaign include the elimination of small pox and tuberculosis.

Summary

Let us now look at what we have learned about in this Topic.

- **Immunity** is the ability of an individual to resist attacks by disease causing organisms. This is by possessing **antibodies**, which actually fight the **antigen** that causes the disease. The antibodies are produced by the white blood cells in response to the antigens. When you cannot develop a particular disease, you are said to be **immune** to the disease.
- Poor immunity can be improved by carrying out **vaccinations or inoculations**. Vaccinations use an inert or inactive form of the virus, which causes a particular disease. These are artificially introduced into the body to cause it to produce antibodies.
- Natural immunization is when your body produces antibodies on its own. This only happens when a person is exposed to pathogens.
- Immunity can either be active or passive. Passive immunity, unlike active immunity is long lasting.
- WHO manages the health promoting activities among the people in the world. It campaigns for the elimination of diseases which if let alone can wipe out all form of life in the world.

We have come to the end of this topic and Unit 12. Please remember to do the exercise at the end of the topic and then review the feedback given. This will help you grasp information better.

Unit Summary

Summary

In this unit you learnt about various health-related issues including diseases so as to increase your skills in maintaining a healthy lifestyle. We focussed on discussing the different common diseases as well as how to control them so that they do not spread easily- some of the ways included keeping our surroundings clean whilst others included understanding the life cycles of disease causative agents as means of reducing diseases.

We also discussed how substances such as tobacco, alcohol and drugs may affect our bodies resulting in ill health. These substances are of major concern these days because more and more people seem to be getting addicted to them resulting in negative consequences. We explained these in detail so that you as a learner may be equipped with the necessary skills to avoid becoming a victim of such consequences.

The unit also addressed issues of how infections may be reduced through the use of antibiotics as well as natural immunity which we are born with. There is also artificial immunity which is what we get immunized against so as to help the body fight off diseases. Application of everything learnt in this unit is meant to help you as a learner to live a healthy life. To check if you have fully grasped all content learnt you are advised to attempt all the assignments as well as the assessment. Good luck!

In the next unit you will learn about community and environmental health, a subject that is related to what you have just studied in this unit.

Assignment

Assignment

Topic 1 Exercise

1. Define good health. [2 marks]

____

2. State **two** health benefits which arise from regular physical activity. [2 marks]

____

____

3. Name a disease that arises from old age. [1 mark]

____

4. (a) What are the **two** types of tumours. [2 marks]

____

____

(b) State the difference between these tumours. [2 marks]

____

____

5. What causes albinism? [1 mark]

____

Total 10 Marks

Topic 2 Exercise

1. What are parasites? Give an example. [2 marks]

____

2. What are different ways in which disease causing organisms are transmitted? [2 marks]

____

3. What causes Influenza and how is it commonly spread?[2 marks]

____

____

4. Give and account of how TB affects the body. [2 marks]

____

____

5. Describe how the disease Cholera affects the body. [2marks]

____

____

Total 10 Marks

Topic 3 Exercise

1. (a) Name an STI learnt about in this Topic. [1 mark]

____

(b) State the name of the causative organism of that disease. [1mark]

____

(c) State two ways of controlling the spread of STIs. [2marks]

____

2. What does AIDS stand for? [2marks]

____

3. Name the body fluids through which HIV can spread.[4 marks]

____

____

Total 10 Marks

Topic 4 Exercise

1. Why is it dangerous to take alcoholic drinks before driving? [2 marks]

____

____

2. It is advisable not to drink alcohol during pregnancy. Why is it so? [2 marks]

____

____

3. Name **two** drugs apart from alcohol that are used to make one high in Botswana. [2 marks]

____

____

4. (a) Name **two** poisonous chemicals found in tobacco smoke. [2 marks]

____

(b) List **one** disease which are caused by cigarette smoking. [1 mark]

____

5. What causes the symptoms of emphysema? [1 mark]

____

Total 10 Marks

Topic 5 Exercise

1. (a) What is personal hygiene? [1 mark]

____

(b) Why is it important to dispose human wastes properly? [1 mark]

____

2. (a) Explain what is meant by sterilization. [1 mark]

____

(b) State the role of each one of the following in sterilization of materials:

(i) Heating [1 mark]

____

(ii) Disinfectants [1 mark]

____

(iii) Antiseptics [1 mark]

____

3. Name **two** regions of your body which may contain a large number of bacteria. [2 marks]

____

4. The housefly is one of our common household creatures.

(a) As a vector of diseases name any **two** diseases that can be transmitted by the housefly. [2 marks]

____

(b) Describe any **two** methods you would use to keep housefly dirt away from food. [2 marks]

____

Total 12 Marks

Topic 6 Exercise

1. (a) Define immunity. [2 marks]

____

____

(b) Name the **two** main types of immunity. [2 marks]

____

2. (a) Explain what vaccination is. [1 mark]

____

(b) Why do we have to be vaccinated at certain times? [1 mark]

____

(c) List **two** examples of diseases that children are inoculated against. [2 marks]

____

____

(d) Define natural immunity. [2 marks]

____

Total 10 Marks

Responses to Assignments

Topic1:

1. A feeling of well being where the body, mind and soul is functioning well and there are no diseases.
2. It keeps body weight down and Maintains circulatory system in good working order.
3. Arthritis
4. (a) Harmful or Malignant Tumours and Harmless Tumours

   (b) Harmful Tumours are cancerous causing harm to the body whilst Harmless Tumours do not harm the body.
5. An inherited gene from parents.

Topic 2:

1. An organism that survives by living off another. A virus or bacterium.

2. Through inhaling droplets of the virus or in water.

3. An influenza virus. It spreads through droplets of water containing the virus.

4. The patient coughs continuously. There are chest pains. Sputum may have blood. There is difficulty in breathing. There is loss of appetite. There is also mild fever accompanied by night sweats.

5. The bacterium results in inflammation of the gut which causes diarrhoea. Vomiting also occurs and the patient loses water as well as digestive juices becoming dehydrated.

Topic 3

1. (a) Syphillis or Gonorrhoea.

   (b) A bacterium.

   (c) By preventing the disease through abstinence or the use of condoms or by treating the disease through the use of antibiotics.

2. 2. Acquired Immune Deficiency Syndrome.

3. Blood, semen, vaginal fluids and mother's milk. **Topic 4:**

1. Alcohol is a depressant of the central nervous system. It depresses brain function leading to slow thinking, blurred judgement and increased reaction time. This may make one to cause accidents.
2. It is not advisable to drink during pregnancy. The foetus may be deformed or killed. Alcohol also causes miscarriages.
3. Glue and benzene.
4. Nicotine and tar.
5. The irritant substance in tobacco smoke makes the walls of the alveoli to become thin so they break easily resulting in emphysema.

Topic 5:

1. a) It is personal cleanliness aimed at keeping one's body free of germs and diseases.

b) This helps to remove things that may attract germs that spread diseases.

2. a) Sterilisation is a method of keeping utensils and surroundings completely free of pathogenic microorganisms.

b) (i) Heating is when pathogens are killed by exposing them to heat or high temperatures.

(ii) Disinfectants are strong toxic chemicals that are used to clean floors, toilets and sewage systems. They kill pathogens such as bacteria.

(iii) Antiseptics are chemicals that kill or stop the growth of pathogens in wounds. They are not as toxic as disinfectants.

3. Pubic region and anus.
4. a) Cholera, diarrhoea, typhoid or dysentery.

b) Washing the dirt off, keeping rubbish bins or pits covered or by using disinfectants to keep flies away.

Topic 6:

1. a) It is the ability of a person's body to resist diseases.

b) Active immunity, artificial active immunity or artificial passive immunity.

2. a) Introduction of specially treated pathogens into the body so as to stimulate the production of antibodies. This helps prevent infection by the disease which is caused by that particular pathogen.

b) To help prevent infection by a particular disease.

c) Measles, Tuberculosis, Tetanus, Polio or Diptheria.

d) Natural immunity is the type of immunity where the body is able to produce antibodies to fight against pathogens either passively or actively.

Assessment

Assessment

Unit Assessment

1. a) Why is it considered unhygienic to clean only the face? [1 mark]

____

b) Apart from proper cleaning, what other three things can be done to achieve good personal hygiene? [3 marks]

____

2. Name **two** types of non-transmissible diseases. Give an example of each type. [4 marks]

____

____

3. Differentiate between signs and symptoms of diseases. [2 marks]

____

____

4. Why are antiseptics preferred over disinfectants in the sterilization of household items? [2 marks]

____

5. (a) Define the term antibiotic. [1 mark]

____

(b) Complete the following sentence: [2 marks]

Penicillin is an ________________________________ that can be used in the treatment of an STD called ________________.

6. a) Differentiate between cholera and typhoid by mentioning how the diseases are spread, and how they can be prevented. [4 marks]

____

____

b) What is the difference between Influenza and TB? [2 marks]

____

____

7. a) During blood transfusion if the blood is not screened there is the risk of getting the disease AIDS, why? [2 marks]

____

b) Briefly discuss how the spread of HIV and AIDS may be controlled. In your discussion include at least three modes of transmission. [6 marks]

____

____

____

____

8. (a) Name an addictive poisonous chemical found in cigarette smoke. [1 mark]

____

(b) List **two** diseases which are caused by cigarette smoking. [2 marks]

____

____

9. a) Write down **two** short term effects and **two** long term effects of alcohol? [4 marks]

____

____

b) Describe three things that are being done in Botswana to discourage alcohol abuse and drug usage. [6 marks]

____

____

____

10. Outline the various sub-divisions of immunity. [3 marks]

(i) ____

(ii) ____

(iii) ____

Contents

HSB Unit 13

Community and Environmental Health

Introduction

Welcome to unit thirteen which deals with community and environmental health. We will be learning about the different types of pollution and deforestation, and the dangers posed by pollution like diseases and environmental degradation. We will also look at how communities can curb pollution to try and reduce the risks that come with it.

This unit is divided into four topics that tackle the different objectives. topic 1 deals with waste disposal, its treatment and the role of microorganisms on sewage treatment. Topic 2 deals with water treatment and how to treat water in both small scale and large scale to make it safe for drinking. In topic 3 you will learn about refuse disposal and the dangers associated with improper refuse disposal. In the last topic, you will learn about air pollution and its negative effects.

You may already be realizing that the topic deals with what happens in our communities on a daily basis. So brace yourself for an interesting unit, good luck!

Teaching Approach

The teaching approach used in this unit is learner centered. It is meant to encourage you to find information on your own as well as come up with your own ways of studying. This will motivate you to carry on with you studies and to apply the skills acquired in your everyday life. Most of the units are related, so you will now and then be referred to a unit you did before. Take note that what you learned at lower levels, e.g. Junior Certificate, and what you experience on a daily basis will also form a base for the teaching and learning approach.

This unit has activities, plus in text questions, which are meant to help you recall what you have learned. The activities and questions also help you relate what you learn to your daily experiences.

At the end of every topic of this unit, there is an assignment that will further test your understanding of the topic content. You should complete this and discuss the answers which are provided at the end of the unit with your friends. You can do this at the learning centers if you are not very far from them. At the end of the unit there is an assessment test which you have to do and mail to your local college of distance learning for marking.

Time Frame

It is estimated that to complete studying this unit you will need between 10 to 15 hours. Do not worry if you take longer in finishing this unit. Remember that we all have different abilities and hence we study at different paces.

You are encouraged to spend about 2 hours to answer the assignment in this unit. You will also need approximately 3 hours on the assessment at the end of the unit.

The total hours for completing the unit will thus be between 15 and 20 hours.

Upon completion of this unit you should have:

Outcomes

- *Acquired* knowledge on sewage disposal.
- *Learned* about water pollution, its sources and effects, and how to keep drinking water safe.
- *Acquired knowledge* about refuse disposal.
- *Acquired* knowledge about air pollution, its causes and effects.
- *Learned* of deforestation and its effects.

Terminology

Septic tank: A big underground hole built of concrete walls, connected to toilet by a pipe, and receives sewage from the toilet.

Sludge: The solid constituents of sewage that are removed during treatment.

Ciliates: Organisms from the kingdom proctista, found in water. They have cilia and feed on other micro-organisms, e.g. *Paramecium.*

Filter: To remove liquid from solid by passing solution through a device that traps solid.

Online Resource

If you can get on the internet please utilize the resources at www.hippocampus.org. It is an excellent source of information for biology and the topics discussed in this unit. Here you will find:

- Presentations
- Simulations
- Videos
- Online Study Groups
- Links to Even More Information
- Textbook Correlations
- Online Courses

Topic 1: Sewage Disposal

Sewage is all the waste that comes from a house (toilets and kitchens), factory or town. I guess you are already imagining what the waste consists of - feces, urine, food remains, etc. If not properly disposed of, the waste can be a breeding place for disease causing micro-organisms, and this can pose a danger to human beings. It is, therefore, important to properly dispose the waste.

In this topic we are going to look at the risks posed by untreated sewage, which is simple sewage disposal by means of a simple pit latrine.

Learning Objectives

At the end of the topic you should be able to:

- Define sewage.
- State the risks posed by untreated sewage.
- Identify and label features of a pit latrine (from sectional drawing).
- Give reasons for proper location of pit latrines.
- State role of micro-organisms in sewage treatment.

Sewage Disposal

Sewage disposal is the process of removing waste material from the surroundings so as to avoid the spread of diseases. There are various diseases associated with sewage, these include: cholera, dysentery, typhoid fever, and bilharzia. Sewage not properly disposed can also cause pollution of air, water and land. But how does sewage cause all this?

- If untreated sewage is left exposed to rain, it will be washed into open water sources like rivers, lakes, shallow wells, and ponds. This will pollute the water such that if people drink it or swim in it, they may contact some water borne diseases. The smell is also unbearable. Imagine the smell in the air if water from a toilet septic tank (drain) spills in front of your house, or if the pit latrine at home was full and over flowing!
- If untreated sewage is left exposed to flies, this encourages the spread of diseases. This is because the flies may get in contact with the sewage. They will carry the sewage on their hairy bodies, and may spread the pathogens in the sewage to food and water, thus spreading diseases.

There are different ways through which sewage can be disposed to prevent pollution and the spread of diseases. The most common way of disposing sewage in our villages and small towns is through the use of toilets. The two commonly used types of toilets are **the pit latrines** and **the water system toilets**.

In large villages and towns, large scale sewage treatment works are used. This is where all the waste from the village/town is treated to make it less harmful.

Pit Latrines

As stated above, this is one of the most common methods of sewage disposal in our villages. It consists of a rectangular pit/hole between 1.7 and 2 meters in depth, with a width of about 1 meter. The pit should not be very deep so as to avoid reaching the water table as this will contaminate underground water.

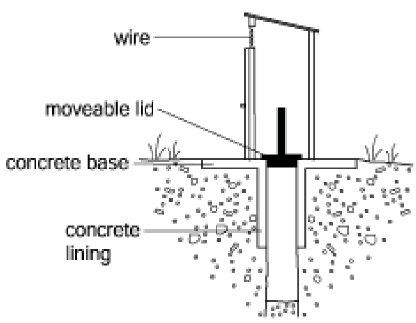


Fig. 1: A Pit Latrine (Cambridge International Examinations Science Diagrams for Examiners)

A good pit latrine, as you can see from fig. 1, must have a concrete base for easy cleaning around it, and to prevent vectors, such as rats, from burrowing into the latrine. It should also have a ventilation pipe to take out the bad smell (not shown in diagram). The pipe should be covered with gauze (wire mesh) at the top to prevent flies from entering the toilet. It should have a roof and door to prevent rainwater from flooding the sewage. The toilet room must also be fully ventilated (e.g. using wire gauze as in diagram).

The hole of the toilet should have a cover to prevent flies and cockroaches from entering the latrine. The handle of the cover should be long to reduce transmission of germs.

The pit latrine contains sewage, which is made of feces, urine and dirty water. In most villages and towns, when the pit is full, local council employees can be called to come and drain away the sewage using sewage trucks. In cases where this is not possible, the wall of the toilet room is brought down over the pit, flattened to bury the sewage underground.

Location Of Pit Latrines

It is very important that pit latrines are properly located, especially in relation to water sources. Before we continue with the sub-topic, do the activity below, to help you appreciate the reasons for the discussion.

Activity 1

Why is it important to position pit latrines away from a water source?

………………………………………………………………………………
…………………………………………………………………………

………………………………………………………………………………
…………………………………………………………………………

Feedback

You should have said this is done so as to prevent contamination of water through underground seepage of liquid sewage.

That is very true. The distance between pit latrines and a water source should actually be 30 meters or more. The pit latrine must also not be positioned uphill to the water source, see fig 2, as this would enhance underground seepage and therefore contamination of water.

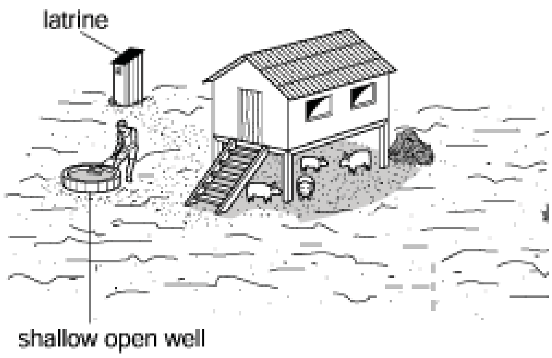


Fig. 2: A Pit Latrine Located Very Close to a Water Source (Cambridge International Examinations Science Diagrams for Examiners)

Water Systems

This type of toilet uses water to flush feces into drains and into septic tanks. A water system toilet may be connected to a network of sewage pipes that lead to a sewage treatment plant, or the waste may just go into a localized septic tank.

Do you know what a septic tank is? Please write that down in the space below:

…………………………………………………………………………
……………………………………………………………………

…………………………………………………………………………
……………………………………………………………………

You should have written that it is a big underground hole (built of concrete walls), connected to a toilet by a pipe and receives sewage from the toilet.

I would like to believe you have seen a water system toilet somewhere, if it is not there at home, e.g. at school, or during your visit to town.

If the toilet uses a septic tank, this has to be drained by council trucks when it is full. If it is connected to the town sewage network system, the sewage flows to the treatment site where it is treated. We will discuss that in the next section.

Sewage Treatment

As already stated, it is important to treat sewage to make it harmless. In this section, we discuss how sewage is treated.

First, as the sewage flows into the treatment system, it passes through metal bars called the **grid**. Large, insoluble objects like card boxes, sanitary pads and pieces of cloth are trapped in this grid.

The sewage then moves into the **grit chamber** where small stones and other small but dense objects settle at the bottom. From the grit chamber, the sewage flows into the **sedimentation tank**, where hard sewage, which at this point looks more like mud, settles at the bottom (i.e. forms a sediment) and the liquid stays on top.

Note: the sediment is removed every three months, dried to kill pathogens, and may be used as fertilizer.

The diagram below shows what happens to the liquid sewage that collects on top of the sediment.

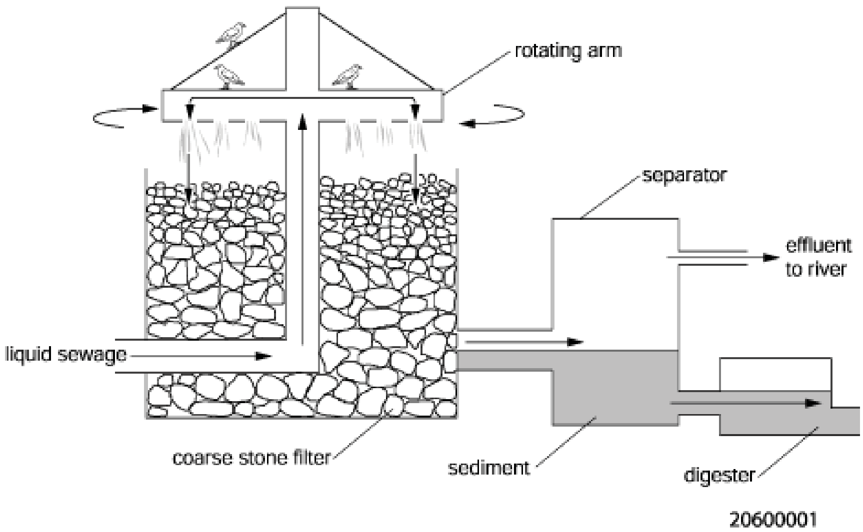


Fig. 3: sewage trickle filter section (Cambridge International Examinations Science Diagrams for Examiners)

The liquid sewage is pumped into a sprinkler which rotates due to the pressure from the pump. The sprinkler showers the sewage onto stones in the filter tank. In between the stones there are some micro-organisms that digest the sewage. These are mainly fungus and aerobic bacteria. As they feed on the sewage, they also feed on pathogens found in the sewage.

NB. Because the population of bacteria and fungus may over multiply due lots of food, it has to be controlled. Therefore, some other microorganisms called ciliates are put in the filter tank to feed on the fungi and aerobic bacteria.

From the filter tank, the sewage goes into the humus separator where the liquid is further separated from any remaining insoluble matter. The water obtained is chlorinated and discharged into rivers as effluent.

Write below what water chlorination is:

…………………………………………………………………………
……………………………………………………………………

…………………………………………………………………………
……………………………………………………………………

Hope you correctly wrote it as the addition of chlorine to water to kill pathogens.

The solid goes into a digester where it is treated to kill any pathogens before it is dried to make organic fertilizers for farms.

The Role of Microorganisms on Sewage

Micro-organisms play a very important role in making sewage harmless. If you recall what we discussed in the previous section, at some stage during treatment, the sewage is sprinkled onto some stones in a filter tank. In between the stones are some micro-organisms (bacteria and fungi) which digest the sewage, breaking down the organic matter in the sewage. They also feed on pathogens in the sewage as it filters through the stones. By doing so, these micro-organisms make the sewage less harmful.

The remaining water can now be chlorinated to kill any remaining pathogens and be discharged into rivers as it will be harmless.

Summary

You have learned in this topic that sewage is waste liquid expelled from a house (toilet and kitchen), factory or town. It is important to get rid of or treat sewage, as untreated sewage that is exposed to rain and flies can pollute the environment and lead to spread of diseases.

Toilets can be used to dispose of domestic sewage. There are two types of commonly used toilets, the pit latrine and the water system toilet. The pit latrine has to be properly built, and must be located away from water sources. The water system toilet empties its sewage in either a septic tank or a sewage network system which flows to a sewage treatment plant. When the pit latrine and the septic tank are full, they are drained by big trucks which carry the sewage to the treatment plant.

Sewage is treated by means of filtration, sedimentation, drying of sludge and the use of micro-organisms to digest pathogens from the sewage. After these methods of treatment, the remaining water (effluent) is chlorinated and discharged into rivers. The dried sludge may be used as organic fertilizers in farms.

It is now time to complete Assignment 1 which you will find at the end of the unit. Thereafter, check your answers with the ones provided as you have done in previous units. If your progress is good, move on to topic 2. If there are questions that you got wrong or did not understand, revise the relevant sections of the topic before moving on to the next topic.

Topic 2: Water

Water is very important in our lives. Can you imagine how life would be like without water? You can't drink, you can't bath, can't cook or do anything you can think of because at the end you will be thirsty and will need water. You cannot even travel in your family car because that engine needs water to cool it. We, therefore, have to treat it as a very precious commodity.

Water can be polluted by various pollutants, and we need to protect it from that as polluted water has some negative effects on the users. Water has to be treated before use as it may be polluted. There are different ways of treating water, depending on the volume to be treated and availability of resources.

In this topic, we will discuss different ways through which water can be polluted, the effects of pollution, and how water can be purified.

Learning Objectives

At the end of the topic you should be able to:

- Discuss the undesirable effects of water pollution.
- Compare the purity of different water sources.
- Discuss the effects of boiling water for drinking.
- Describe large scale treatment of water.

Water Pollution

Water pollution is the contamination of water, making it unsafe to drink or use. Think of things that may pollute water and write them in the space below:

…………………………………………………………………… ………………………………………………………………

…………………………………………………………………… ………………………………………………………………

You should have included in your answer: untreated sewage; chemical waste from industries; surface run-off of chemicals like fertilizers, pesticides and herbicides; as well as solid matter/litter and discharge of oil at sea.

The above mentioned pollutants can affect human beings and other users in different ways as well:

a) Untreated sewage can cause diseases like cholera, typhoid, dysentery and bilharzia.
b) Industrial chemicals are poisonous, and may cause death or cause diseases like cancer.
c) Fertilizers, pesticides and herbicides are also made of from poisonous chemicals that may cause death or be cancerous.
d) Oil and solid litter at sea, kill mostly water animals like birds and fish.

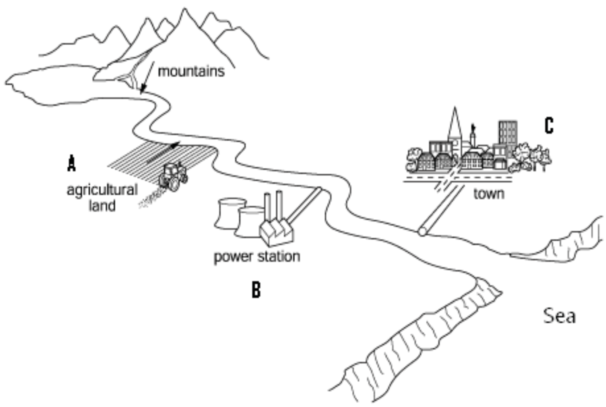
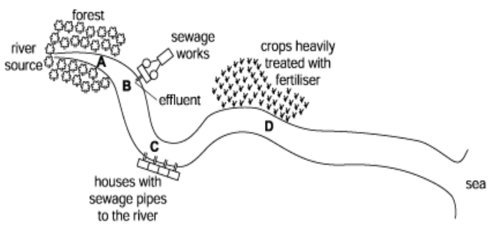


Fig. 1: A river polluted at different points (Cambridge International Examinations Science Diagrams for Examiners)

Fig. 1 shows a river polluted at different points as it flows from the mountains. At **A**, it is polluted by fertilizers, pesticides and herbicides that run-off from the fields. At **B** it polluted by industrial chemicals from the power station, while at **C** it is polluted by sewage from a nearby town.

Do Activity 1 below; it will help you appreciate the different pollutants and the extent to which they pollute water.

Activity 1



Study the diagram above. There will be more pollution at C and D, and less at A and B. Give reasons why.

……………………………………………………………………………… ………………………………………………………………………

……………………………………………………………………………… ………………………………………………………………………

……………………………………………………………………………… ………………………………………………………………………

……………………………………………………………………………… ………………………………………………………………………

Feedback:

*At **A** the water running into the river will be from a natural forest, therefore little pollution. At **B** the effluent from the sewage works would have been treated and chlorinated, so little pollution. At **C** untreated sewage from houses pollute the river water, while at **D** fertilizers running off from the field pollute the water.*

Safe Drinking Water

Safe drinking water is water that does not have any impurities. Impurities are any foreign things that may be found in water that contaminate it.

In this section, we are going to discuss various sources of water and the various ways through which water from these sources become contaminated and unsafe for human consumption. Water that is safe for human consumption should not contain any impurities.

We shall compare the purity of water from rivers, shallow wells, boreholes, and rain water collected from a roof.

Rivers

It is not very common to always have pure water in rivers. This is because river water consists of rain water which has been washed along the land surface. This water contains waste materials, chemicals from crop field and factories, even plant matter from the ground surface. All these are washed by rain water into the river. In addition to that, some people even bath, defecate and urinate in rivers. In some areas, untreated sewage is directly deposited into rivers.

All these result in some pathogens multiplying in rivers, and these will pose danger to humans who consume the water. In some countries, e.g. Botswana, you may find sign posts by some river beds saying “Beware: Bilharzia”. This is because water in that river is contaminated and contains bilharzia causing pathogens.

Refer to **fig. 1** in **Section 1** to see how river water may be polluted.

Shallow Wells

Shallow wells are usually dug in rural areas where there is insufficient/no supply of water. In most cases, there is no consideration for hygiene, except to look at a location where there is plenty of underground water.

Shallow wells can be contaminated by run-off water the same way as it does to rivers. Water can also be contaminated through underground seepage from nearby pit latrines. Uncovered shallow wells water may also be polluted by wind blowing dirt into them, or animals falling in there, dying and rotting there.

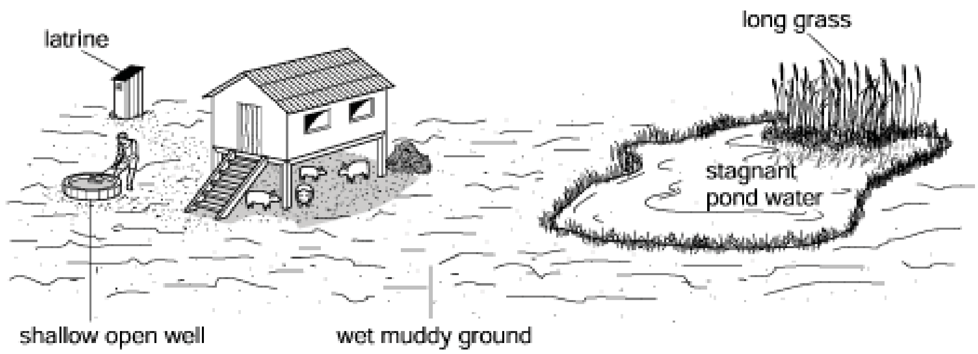


Fig. 2: A Shallow Well Exposed to Various Chances of Pollution
(Cambridge International Examinations Science Diagrams for Examiners)

Fig. 2 above shows a shallow well exposed to various chances of pollution. Firstly, the well is very close to a pit latrine, and therefore there are high chances of pollution through underground seepage. The well is also not covered, thus exposing it to dirt blown by wind. As stated above, animals may also fall into an uncovered well and contaminate the water. There is also mud around which may be contaminated and may contaminate the well water.

Do activity 2 below, to see if you remember other features of wells that may reduce water pollution.

Activity 2

Study fig. 2 above and mention one feature of the well meant to reduce water pollution.

…………………………………………………………………………
…………………………………………………………………

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…………………………………………………………………

Feedback:

There is a small wall around the mouth of the well to prevent run-off water from flowing into the well and contaminating water.

Water from wells is, however, generally cleaner than river water. This is because well water filters through the soil, which cleans most of the impurities, especially the insoluble ones.

A number of things need to be considered when choosing a site for digging a shallow well:

a) The well must be away from pit latrines, and if nearer to any, it should be uphill to minimize underground seepage of sewage.
b) The top part of the well should be lined with a concrete wall to prevent contamination from run-off water. The higher the wall the better.
c) The well must be covered with a lid to prevent dirt and other impurities falling in.

Boreholes

Do you know the difference between a borehole and a well? Write your answer in the space bellow:

…………………………………………………………………………
……………………………………………………………………

…………………………………………………………………………
……………………………………………………………………

You are correct if you wrote that boreholes are very deep while wells are in most cases shallow. Because of their depth, boreholes are usually drilled with machines, while wells can be dug manually by human beings.

Borehole water is generally safer for drinking as compared to river and shallow well water. This is because the water is from deep down the ground, where most micro-organisms cannot survive because of too much heat and because there is little oxygen. The water is, in most cases, also free from insoluble particles since it was filtered as it seeped through the soil to the water table.

Borehole water can however be contaminated by sewage from pit latrines, just like water from shallow wells. This is common when the borehole is on lower ground as compared to the pit latrines. Contamination is also common when the water table is closer to the ground surface.

Rain Water Collected from a Roof

I wish I could say this is the cleanest water as compared to water from the other three sources. A number of factors, however, cause the water not to be so safe. It could be cleanest because it comes straight from the clouds. The water lands on a roof that is constantly exposed to dust which may contain pathogens. The storage tank may also allow contamination of the water by not being regularly cleaned and not being tightly closed to keep out dirt.

From what you have learnt in the above section, you can see that there is always a chance of water being contaminated irrespective of the source. It is therefore advisable to always take precautions, especially if you do not know or are not sure if the water has been purified. How then can water be purified?

Effects of Boiling Water

One of the most simple and cheap ways of making water safe to drink is to boil the water, and this can be done at home. We boil water mainly to kill pathogens, thereby stopping the spread of diseases.

If the water also contains some insoluble particles, it is advisable to filter it through a clean cloth before boiling. This will remove the insoluble particles.

Do you know how to do this? Carry out the following activity.

Activity 3

- Put a white clean cloth tightly over a clean container.
- Pour some water from a river or shallow well through the white cloth into the container.
- How does the cloth look like afterwards?

………………………………………………………………………………
……………………………………………………………………………….

Feedback:

The cloth should look dirty because all the dirt which was in the water was filtered out by it.

Large Scale Treatment of Water

I have already stated that water needs to be purified before being used for human consumption, and that there are different ways of purifying water. The boiling method described in section 3 above is the most simple and is used for small volumes of water. In towns, water is treated in a large plant known as **water works system**. Study fig. 3 below as we discuss how water is cleaned at the water works.

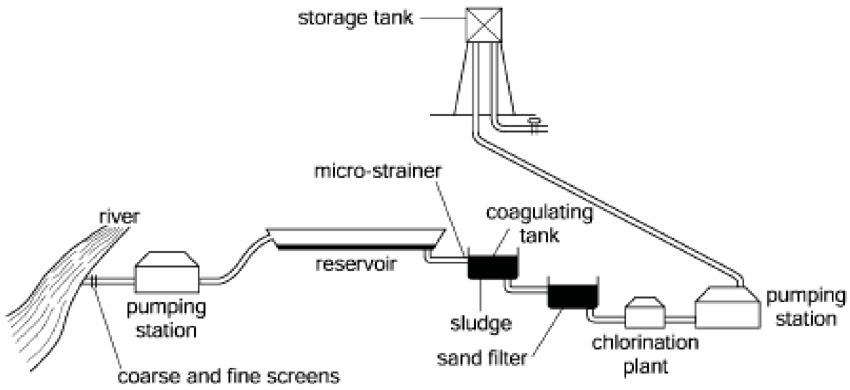

Fig. 3: Water Works System (Cambridge International Examinations Science Diagrams for Examiners)

The water goes through the following steps in the system:

- Water from the river passes through the screens or grid as it enters the system. The grid screens and traps large objects found in the water.
- The water is then pumped into a reservoir, sometimes called a sedimentation tank. In this tank, some small objects that could not be trapped in the screens are allowed to settle at bottom (see the black sediment at the bottom of the reservoir in fig. 3). The water is then drained out of this tank leaving the sediments behind.
- From the reservoir, the water passes through into the coagulating tank. In this tank, some chemicals (e.g. aluminum sulfate, ferric chloride) are added to the water. These make the waste in the water to attach to each other and precipitate.
- The water then passes into the filter tank which contains sand (sand filter in the diagram). The remaining particles in the water will be trapped by the sand while clean water passes through. This is called filtration.
- From there the water flows into the chlorination tank, where chlorine is added to the water to kill pathogens.
- That will be the final section as from there the chlorinated water is pumped into a storage tank from where it will be distributed to houses and other places of use.

Summary

In this topic we learned about water pollution. We learned about different ways through which water can be polluted. We also learned about safe drinking water by comparing the purity of water from different sources.

We learned about purifying water to make it safe for human consumption. There are different ways of purifying water, depending on the volume of water to be purified. We learned that water can be boiled to kill pathogens, thereby reducing the spread of diseases. We also learned how water is cleaned in large scale water works systems in towns. The processes include filtration (in the grid/screens), sedimentation (in the sedimentation tank), and chlorination.

It is again time for you to complete the next assignment, Assignment 2, and to check your answers thereafter. Once you have completed all the steps suggested at the end of topic 1, you can then study the next topic.

Topic 3: Refuse Disposal

Most communicable diseases are a result of a dirty environment. It is therefore very important for us to ensure that our environment is kept clean at all times as this will go a long way in reducing the spread of diseases. Cleaning the environment involves picking refuse/litter and disposing it properly. I am sure there have been litter picking campaigns in your area. Have you been involved? If not, make sure you are next time it is done.

In this topic, we are going to look at the dangers posed by waste, and how it can be disposed properly.

Learning objectives

At the end of this topic, you should be able to:

- State the dangers of accumulation of domestic waste around homes.
- State reasons for, and methods of, controlling the breeding of house flies.
- State the stages of the life cycle of a domestic housefly.
- State the different methods of disposal of domestic waste.

1. Refuse Disposal

Refuse disposal is the process of removing waste material from the surroundings so as to avoid the spread of diseases. There are different ways of disposing of domestic waste. The methods vary according to the amount of litter and availability of resources to dispose of it. Domestic refuse include mostly kitchen leftovers, fruit peelings, etc.

Dangers of Accumulation of Domestic Waste

If domestic waste is left to accumulate around houses, it may be exposed to disease vectors like flies, cockroaches, rats and mice. These vectors are mostly attracted by the bad smell from rotten accumulated refuse. When the vectors come to feed on the refuse, they may carry from them pathogens responsible for decomposing the waste. Upon coming in contact with food, these vectors will transmit diseases.

Do you ever imagine where the houseflies and cockroaches that come into your house come from? They may be coming from refuse that you or your neighbor left at the corner of the fence. Such places are where houseflies and cockroaches enjoy laying their eggs.

Methods of Controlling the Breeding of Houseflies

What is the best way of controlling the breeding of houseflies?

………………………………………………………………………………
………………………………………………………………………

………………………………………………………………………………
………………………………………………………………………

You will be right to say by destroying their breeding places.

As already stated, flies enjoy breeding in wet dirty places like rotten refuse heaps. Therefore to prevent them from breeding, the following should be done:

- Refuse should be kept in covered bins that are emptied regularly.
- If bins are not available, a pit should be dug for throwing all the waste. This pit should be as far from the house as possible. The refuse in the pit must be burned regularly, and when the pit is full, it must be buried and a new one dug. This is because if the bin is not covered, or the refuse pits are close to the house, the flies may easily contaminate food and cause diseases.

The whole idea is to try and interfere with the life cycle of the houseflies, so that they don’t over multiply and pose a lot of danger.

Do the activity below the check if you remember what you learned earlier in the unit and see if you are health conscious.

Activity 1

From what you have learnt, and your common knowledge, list diseases that may be spread by houseflies.

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……………………………………………………………………

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Feedback:

Cholera, dysentery, and food poisoning.

.

You have studied the life cycle of a housefly before in **Unit 1, Topic 3**. Do the following activity before we continue, this will help you recall what you learned before and link it to what we are doing now.

Activity 2

Label the stages of the cycle below before we discuss how the cycle can be stopped at each stage

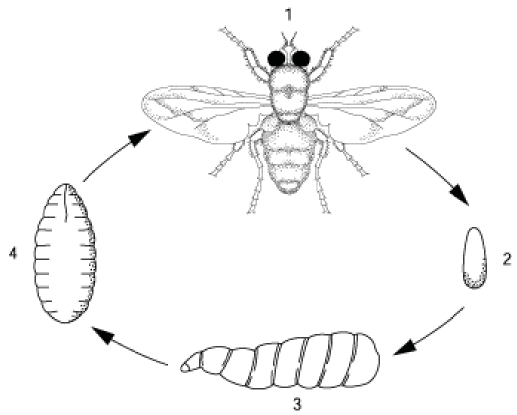

Fig. 1: Life cycle of a Housefly (Cambridge International Examinations Science Diagrams for Examiners)

Stage 1: …………………………………………….

Stage 2: …………………………………………….

Stage 3: ……………………………………………

Stage 4: ……………………………………………

Feedback: Stage 1= adult, Stage 2 = egg, Stage 3 = larva, Stage 4 = pupa.

How then can the cycle be stopped at each stage? The section below addresses this question and includes a description of each stage.

- **Stage 1** is the adult housefly. It is the adult housefly that is responsible for spreading diseases. As the fly feed on refuse or sit on it to lay eggs, dirt sticks to its hairy body. This will be deposited on food when the fly sits on your food that has been left uncovered. That is why bins have to be covered always and emptied regularly, or refuse should be thrown in pits that are far from houses to minimize contact between flies and refuse.
- **Stage 2** is the egg. As stated, these are laid on dirty, dump places. To prevent lying of eggs, bins should be covered and emptied. Refuse in bins should be burned regularly to kill eggs.
- **Stage 3** is the larva, or maggots in the case of houseflies. The eggs hatch into these, and you start seeing the maggots on your food. These can also be killed by burning or even drying of refuse.
- **Stage 4** if the pupa. The larva develops into the pupa which then develops into the adult to complete the cycle. Just like the larva, the pupa can be killed by burning the refuse.

We can therefore conclude that, to control the breeding of house flies, one must destroy its breeding places to prevent it from breeding. This can be achieved by proper refuse disposal.

Methods of Disposing Domestic Waste

Below are some common methods of disposing of domestic waste.

a) **Burying**
This is a process of covering a pit full of refuse with soil. The rubbish in the pit is buried so that it decomposes and becomes part of the organic matter in the soil. This is a good method because as you burry the waste, you also bury the pathogens and the vectors, e.g. then the housefly eggs, larva and pupa will be buried.

b) **Burning and Incineration**
People often prefer to burn litter in the pit because the pit can then be used to throw in more litter. One may decide when to burn the refuse, e.g. once every week or when the pit is full. However, waiting until the pit is full may encourage the multiplication of vectors. If the refuse is still wet, one may use paraffin to burn it.

Incineration is the process of burning waste at very high temperatures. It is usually done in a machine called an **incinerator**. Some incinerators use electricity while others use paraffin. Incinerators are commonly used in hospitals to burn used bandages and plasters, and in boarding schools to burn sanitary pads.

The aim of burning or incineration is to completely destroy pathogens and sometimes vectors at certain stages of their cycle (e.g. larva and pupa), thus stopping the spread of diseases.

c) **Compacting**
In this method of refuse disposal, waste is compressed and compacted tightly together by big machines/tractors. The aim of compacting is to prevent vectors like rats and mice from getting through into the waste. The method is however not very good as rats still manage to get through. The method does not kill pathogens, so diseases can still spread. To compensate for the weaknesses of the method, it is often carried out in large areas called dumping sites far away from where people live.

Is there a fenced dumping site somewhere on the outskirts of your town or village? Find out.

2.0 Summary

In this topic, you learned about the dangers posed by accumulation of domestic waste around houses, like the fact that it provides breeding places for disease vectors like houseflies, cockroaches, rats and mice which may cause diseases. You learned about the life cycle of a housefly and how to interfere with the cycle to reduce the multiplication of houseflies. You also learned about the different methods of disposing of the domestic waste.

Topic 4: Air Pollution and Deforestation

The general definition of pollution is the destruction, damage or contamination of the environment. Air, water, and land form part of the environment that can be polluted. In Topic 2 of the unit, we discussed water pollution, its causes and effects. We are now going to discuss air pollution, its causes and effects.

We will also discuss deforestation, its causes and effects. Trees form part of our environment, and if they are destroyed, this must be a concern to us.

Learning objectives

At the end of this topic you should be able to:

- Define air pollution.
- State the toxic components of motor exhaust fumes and their effects on the body.
- State the causes and effects of global warming.
- Define deforestation.
- State the effects of deforestation.
- State the effects of veldt fires on the environment.

Air Pollution

We all breathe in air, a component of which (oxygen) we use during respiration to release energy. Air pollution is the contamination of this air, making it unhealthy to be breathed in by humans.

There are different air pollutants, and they have different effects on people and the environment.

- Fumes from car exhausts pose a danger to humans and the environment alike, see Figure 1. Exhaust fumes contain carbon monoxide, lead, and nitrogen oxides. Carbon monoxide reduces the body's ability to transport oxygen. The gas readily reacts with hemoglobin faster than oxygen, thus preventing the reaction between oxygen and hemoglobin from taking place.

  Lead causes lead poisoning, which can cause many complications in the body like high blood pressure in adults, anemia, colic, or palsy (wearing of muscles and nervous system). In children it may cause reduced intelligence, delayed motor development, impaired memory, hearing problems and problems with balance.
  Nitrogen oxides may react with water to cause acid rain which damages plants.

  Exhaust gases together with the smoke particles may also combine with atmospheric moisture to form smog. Smog affects visibility in the environment and irritates human skin and eyes.

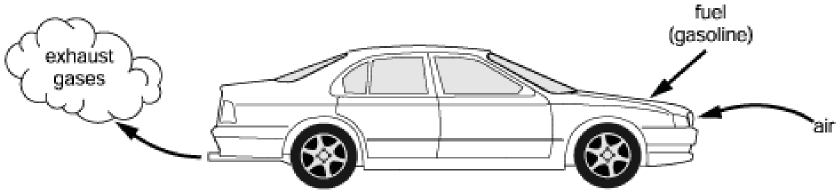

Fig. 1: Exhaust gases produced during fuel combustion (Cambridge International Examinations Science Diagrams for Examiners)

- Fumes from factories, like power stations, also pollute the environmental air. Figure 2 depicts this kind of pollution. These fumes may contain gases like sulphur dioxide which causes acid rain. The acid rain damages plant leaves or roots if they go into the soil. The smoke particles may also cause smog which has effects described above.

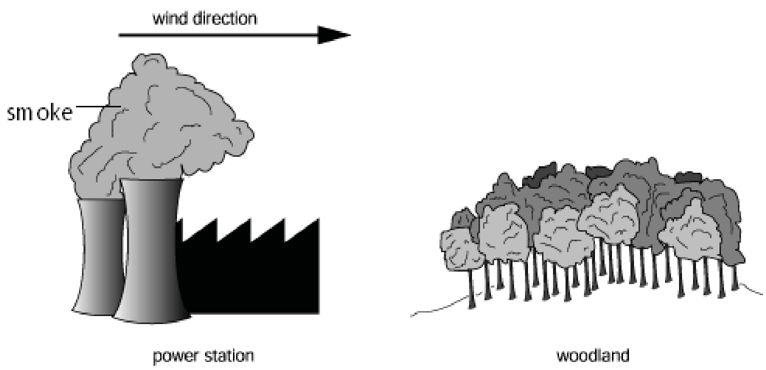

Fig. 2: Wind carrying smoke from a power station over woodland
(Cambridge International Examinations Science Diagrams for Examiners)

- Chlorofluro carbons (CFCs) are chemicals used in refrigerators for cooling. They are also used in perfume sprays. These chemicals are also pollutants, and they remove or deplete the ozone layer when they react with it. This allows more ultraviolet radiation from the sun, which is normally blocked by the ozone layer, to pass to the earth surface. This causes global warming, which is blamed for dissolving of ice at the south and north poles. Ultraviolet rays also cause skin cancer and damages plants.

Activity 1

Do you use perfume spray? If you do, go and look at the tin and read the writings on it. If you don't use one, then look for an empty tin or ask for one from someone and do likewise. Most perfumes are written "CFCs free" and /or "Ozone friendly". Suggest any reasons why.

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……………………………………………………………………

……………………………………………………………………………
……………………………………………………………………

Feedback:

This is to assure the users that the perfume contains no pollutants and is environmental friendly.

NB: there are a lot of campaigns these days against environmental pollution. Governments have even set no smoking areas so as to protect the public from various pollutants.

Deforestation

Deforestation is the process of cutting trees aimlessly without replacing them.

If trees are cut without being replaced, the land is left bare or with no cover. This leads to soil erosion as the trees act as wind breakers. Without trees, wind can easily carry away the top soil (erosion). Rain water can also easily carry away the top soil as trees shield it from rain drops that loosen it while tree roots help to hold the soil particles together.

Deforestation may also cause an imbalance in ecosystems as trees provide shelter for various animal species. When they are cut, these animals will have no shelter, and they will be forced to migrate or may even die, thus disturbing the ecosystem.

Trees help to balance the concentration of certain gases like carbon dioxide and oxygen in the atmosphere. During the process of photosynthesis, they take in carbon dioxide and release oxygen. If excessive deforestation occurs, this balance may be affected.

Apart from cutting by human beings, veldt fires can also cause serious deforestation as they burn down trees. In addition to destroying trees and other plants, which are habitats and food for animals, veldt fires also kill the animals themselves. Veldt fires affect soil fertility negatively as under normal circumstances, the plants die and decompose to improve soil fertility. Veldt fires also seriously pollute the environment through smoke released.

So you can now see how trees are important to us and our environment. Therefore, next time there is a tree planting campaign in your area make sure you are involved to help keep your environment green.

Summary

In this topic you learnt about air pollution, different pollutants, and their effects on the environment and human beings. The pollutants include carbon monoxide, lead, nitrogen and sulphur oxides, and chlorofluro carbons (CFCs).

You also learned about deforestation and its effects. This is the aimless cutting of trees without replacing them. It can lead to soil erosion, destruction of animal habitats and sources of food, as well as an imbalance in atmospheric carbon dioxide and oxygen.

Assignment 3 is at the end of the unit. Follow the same steps as in the other topics to complete the task, check your answers and decide whether to revise some sections of the topic.

Unit Summary

Summary

In the first topic you learned that sewage is waste liquid expelled from a house (toilet and kitchen), factory or town. It is important to get rid of or treat sewage, as untreated sewage that is exposed to rain and flies can pollute the environment and lead to spread of diseases.

We also learned that toilets can be used to dispose of domestic sewage and that there are two types of commonly used toilets, the pit latrine and the water system toilet.

Sewage is treated by means of filtration, sedimentation, drying of sludge, and use of micro-organisms to digest pathogens form the sewage. After these methods of treatment, the remaining water (effluent) is chlorinated and discharged into rivers. The dried sludge may be used as organic fertilizers in farms.

In **topic 2** we learned about water pollution. We learned about different ways through which water can be polluted. We also learned about safe drinking water and we compared the purity of water from different sources.

In this topic we also learned about water purification to make it safe for human consumption and that there are different ways of purifying water, depending on the volume of water to be purified.

In the third topic, you learned about the dangers posed by accumulation of domestic waste around houses, like the fact that it provides breeding places for disease vectors like houseflies, cockroaches, rats and mice, which may cause diseases. You learned about the life cycle of a housefly and how to interfere with the cycle to reduce the multiplication of houseflies. You also learned about the different methods of disposing of domestic waste.

In the last topic you learnt about air pollution, different pollutants and their effects on the environment and human beings. The pollutants include carbon monoxide, lead, nitrogen and sulphur oxides, and chlorofluro carbons (CFCs).

You also learned about deforestation and its effects. This is the aimless cutting of trees without replacing them. It can lead to soil erosion, destruction of animal habitats and sources of food, as well as an imbalance in atmospheric carbon dioxide and oxygen.

At the end of the unit there is an assessment exercise for the entire unit. Do that as well and submit or mail it to your local college of distance learning.

This is the end of unit 13, hope you enjoyed it. Prepare yourself to move into the last unit of your course which is Biotechnology.

Wishing you the best of luck, and brace yourself for the next unit.

Assignment

Assignment

Assignment 1

1. Define sewage.

……………………………………………………………………………

……………………………………………………………………………(1)

2. State the risks of leaving untreated sewage exposed to rain and flies.

……………………………………………………………………………

……………………………………………………………………………

……………………………………………………………………………

……………………………………………………………………………(2)

3. What role is played by micro-organisms in sewage treatment?

……………………………………………………………………………

……………………………………………………………………………

……………………………………………………………………………

……………………………………………………………………………(2)

4. Give two reasons for the need of a concrete slab around a pit latrine.

……………………………………………………………………………

……………………………………………………………………………

……………………………………………………………………………

……………………………………………………………………………(2)

5. Other than the concrete slab, name five other feature of a good pit latrine.

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(5)

6. What is the first part of a sewage treatment plant which traps large insoluble objects like sanitary pads called?

…………………………………………………………………………
…………………………………………………………………………
(1)

7. Name two micro-organisms that digest sewage in the filter tank

…………………………………………………………………………
………………………………………………………………………..
(2)

Total [15 marks]

Assignment 2

1. What is water pollution?

…………………………………………………………………………
…………………………………………………………………………
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…………………………………………………………………………
…………………………………………………………………………
. (2)

2. For each of the following effects, write the correct pollutants.

Effect of pollutant	Pollutant
Causes diseases like cholera and typhoid	
May be poisonous and cancerous	
Kills sea animals like birds and fish	

(3)

3. State the reason for boiling water before drinking.

…………………………………………………………………………
…………………………………………………………………………
(1)

4. Write the water from the following sources in order of purity, starting with the most pure: river, borehole and shallow well.

………………………………….

………………………………….

………………………………….. (3)

5. Give two ways through which rain water collected from a roof becomes contaminated.

…………………………………………………………………… …………………………………………………………………… ……

…………………………………………………………………… …………………………………………………………………... (2)

6. What are the plants in which water in towns is treated called?

…………………………………………………………………… …………………………………………………………………… . (1)

7. Suggest reasons for the following stages of large scale treatment of water:

a) Filtration

…………………………………………………………………… …………………………………………………………………… (1)

b) Sedimentation

…………………………………………………………………… …………………………………………………………………… ….. (1)

c) Chlorination

…………………………………………………………………… …………………………………………………………………… ….. (1)

Total [15 marks]

Assignment 3

1. List the four methods of disposing of domestic waste.

………………………………………………………

………………………………………………………

……………………………………………………..

…………………………………………………….. (4)

2. Name the stages of the life cycle of a housefly in the right order. The first one is given.

Stage 1: Adult

Stage 2: ……………………………………….

Stage 3: ……………………………………….

Stage 4: ……………………………………….. (3)

3. What is the difference between burning and incineration of waste?

………

………
(2)

4. How can breeding of houseflies be discouraged?

………

………

………

……. (2)

5. What are the dangers of accumulation of waste around houses?

………

……

……

………
……

………
(2)

6. Name any two disease vectors that are often found in refuse dumps.

………
……

………
. (2)

Total [15 marks]

Answers to Assignments

Assignment 1

1. Waste liquid expelled from a house, factory or town.
2. (i) Pollute water and cause water borne diseases.
   (ii) Flies get in contact with the sewage and spread diseases.
3. Micro-organisms digest the sewage, breaking down the organic matter in the sewage.
4. For easy cleaning and to prevent vectors such as rats and mice from burrowing into the latrine.
5. (i) long handled cover
   (ii) Door
   (iii) Roof
   (iv) Ventilation
   (v) Gauze to cover ventilation pipe
6. Grid
7. bacteria and fungi

Assignment 2

1. Contamination of water making it unsafe to drink and use.
2.

Effect of pollutant	Pollutant
Causes diseases like cholera and typhoid	sewage
May be poisonous and cancerous	insecticide
Kills sea animals like birds and fish	oil

3. To kill pathogens and stop the spread of diseases
4. Borehole, shallow well, river
5. Dirty roof and dirty storage tank.
6. Water works systems
7. a) remove large objects from water e.g. sanitary pads
   b) smaller objects settle at the bottom, separating them from water.
   c) kills pathogens

Assignment 3

1. i) burying
   ii) burning
   iii) incinerating
   iv) compacting
2. stage 2: egg, stage 3: larva, stage 4: pupa
3. Incineration is burning of refuse at very high temperatures, and is usually done in buildings or machines called incinerators.
4. i) Keep refuse in covered bins that are emptied regularly.
   ii) Throw refuse in pits dug away from houses and burn it regularly.
5. It will be exposed to disease vectors which will spread pathogens.
6. Houseflies/cockroaches/rats and mice

Assessment

Assessment

Assessment

1. Define pollution.

   ……

   ……
   (1)

2. Give any two air pollutants.

   ……

   ……
   (2)

3. List three toxic components of car exhaust fumes.

   ……………………………………………………………………

   ……………………………………………………………………

   …………………………………………………………………… (3)

4. List any three effects of deforestation

   ……

   ……

………………………………………………………………………
………………………………………………………………………
(3)

5. Where are chlorofluro carbons often used?

………………………………………………………………………
………………………………………………………………………
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………………………………………………………………………
………………………………………………………………………
(2)

6. Give two negative effects of veldt fires.

………………………………………………………………………
………………………………………………………………………
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………………………………………………………………………
………………………………………………………………………
(2)

7. Give two parts of plants that may be caused by acid rain.

………………………………………………………………………
………………………………………………………………………
……
………………………………………………………………………
………………………………………………………………………
(2)

Total [15 marks]

Assessment Answers

1. The destruction, damage or contamination of the environment.
2. Fumes from car exhausts/fumes from factories/chlorofluro carbons
3. Carbon monoxide, lead and nitrogen oxides.
4. i) soil erosion
   ii) destruction of animal shelter
   iii) imbalance in atmospheric gases
5. refrigerators and perfume sprays
6. pollute air and negatively affect soil fertility
7. roots and leaves

Contents

HSB Unit 14

Biotechnology

Introduction

Welcome to unit 14 of the Human and Social Biology Course. You must be happy to be nearing the end of this course. This is the final unit of the course. Once you have completed it, you will be ready to begin your review of the whole course in preparation for the final examinations. Congratulations on reaching this milestone.

This unit is about biotechnology. Remember that in units 1 and 12 we discussed micro-organisms and how they affect us, our environment and our health. You will also remember that some micro-organisms can be harmful to our health because they can cause diseases. Yes!, We are saying some because not all of them cause diseases. In unit 1 we looked at organisms affecting human health including microorganisms. In unit 12 we discussed diseases caused by microorganisms and how they are treated. I am sure you still remember that microorganisms are very tiny organisms such as viruses, fungi, and bacteria, and these are found in all parts of the biosphere where there is liquid water. They are found in all living things, plants and animal.

Do you know why micro-organisms are used in biotechnology? Well if you said because some micro-organisms are helpful to humankind you are correct.

In this unit we talk about microorganisms and how we can use them for economic benefit. Some microorganisms are used in service industries such as treatment of sewage. Others are used for production of useful substances such as food (for example, sour milk, bread, cheese), chemicals (like soap, fuels, alcohol), materials (e.g. plastics), and medicines (antibiotics).

There are 3 topics in this unit as follows:

Topic 1: Biotechnology and Food Production - In this topic, we will discuss biotechnology and production of consumable products such as beer, sour milk and bread.

Topic 2: Biotechnology and Chemical Production - In this topic, we will discuss biotechnology in the production of non-consumable but useful chemicals such as fuels and some household chemicals.

Topic 3: Biotechnology and Drug Production - In this topic we will discuss how biotechnology is used to produce medicinal products like vaccines and antibiotics.

Teaching and Learning Approach

The teaching and learning approach for this topic is learner centred and based on your previous knowledge and experience. The content has been organised around two areas broken into three topics covering biotechnology as used to produce edible substances and its use in the production of non-edible chemical substances. It is meant to motivate you to explore information on your own or as a group at home and even in your study centre, (as you may have done in the other units). You are encouraged to form study groups with other learners in your area to discuss the subject matter and assist each other in your studies. This will help you to do research and develop an interest and initiative to study.

A number of activities have been included in the unit to help you interact with the learning material and consolidate your knowledge. You are encouraged to do all the activities in the unit. There are also some practical activities designed to have a greater emphasis on the understanding and application of scientific concepts and principles discussed in the unit for everyday life situations.

As already mentioned above, this unit is divided into 3 topics each short with in-text questions and a total of 3 activities with more than one question. Feedback is provided at the end of in-text questions and activities to assist you as you work through the unit and assess your progress regularly. The activities will facilitate your understanding of concepts as well as help you build skills, knowledge, and practical applications of biotechnology. At the end of the each topic there is an assignment,and at the end of the unit there is an Assessment. Feedback is also provided at the end of the assignments and assessment to help check your understanding of the topics and unit content.

Time Frame

It is estimated that to complete studying this unit you will need between 10 to 15 hours. Do not worry if you take longer in finishing this unit. Remember that we all have different abilities and hence we study at different paces.

You are encouraged to spend about 2 hours to answer the assignment in this unit. You will also need approximately 3 hours on the assessment at the end of the unit.

The total hours for completing the unit will thus be between 15 and 20 hours.

Upon completion of this unit you will be able to:

- *Explain* why micro-organisms are used in food production.
- *Discuss* how biotechnology is used to produce edible substances like

Outcomes

food, alcohol and medicines.

- *Describe* the production of non-edible chemical substances like soap and fuel using biotechnology.

Terminology

Biogas:	A type of gas processed by micro-organism from organic substances like cow dung or sewage. The gas is usually used as fuel for cooking.
Dough:	A mixture of flour and water ready to be baked into bread.
Ethanol:	A type of alcohol.
Fermentation:	The process of changing sugar into alcohol or lactic acid.
Fructose:	A kind of natural sugar found in fruits and in honey.
Lactate fermentation:	A type of anaerobic respiration that produces lactic acid. Usually common in bacteria that work on sour milk and in people when there is a temporary shortage of oxygen.
Alcoholic fermentation:	A type of anaerobic respiration by some type of fungi that uses sugar to produce alcohol, carbon dioxide and energy, e.g. by yeast.
Anaerobic bacteria:	A type of bacteria that does not need oxygen to survive

Online Resource

If you can get on the internet please utilize the resources at www.hippocampus.org. It is an excellent source of information for biology and the topics discussed in this unit. Here you will find:

- Presentations
- Simulations
- Videos
- Online Study Groups
- Links to Even More Information
- Textbook Correlations
- Online Courses

Topic 1: Biotechnology and Food Production

In this topic, we will define biotechnology and explore how biotechnology is used in the production of consumable products such as beer, sour milk and bread. We are also going to learn that microorganisms play a very important role in the production of food through genetic modification. In the United States, more than 70% of foods sold in the supermarket have ingredients derived from genetically engineered plants. These are plants whose original genetic structure has been modified to produce plants that have more desirable traits than the normal original plants. The purpose and intention of these modifications is to try and increase world food production and security.These products have also started to come into our markets as a result of food shortages that we experience in the world today. Consumers often ask, "Are genetically engineered foods safe?" So far there is no evidence that food derived from genetically engineered plants or processes is any less safe than those derived from conventional processes and products. However, the perceptions of the risks and benefits associated with genetically engineered products vary among people involved in the food system. There are those people who find no cause for concern for production of Genetically Modified (GM) food as they see opportunities for potential increase in food production and in many countries this is already happening. Some of these food products like maize and tomatoes have also reached markets like Botswana. On the other hand there are some people who are very much against the use of GM products for fear of possible health risks that might be associated with them.

Learning Objectives

At the end of the lesson, you should be able to:

- explain what biotechnology is
- discuss the use of microorganisms in biotechnology in food production
- explain the use of micro-organisms in biotechnology in alcohol production

What is Biotechnology?

Biotechnology is the application of organisms, biological systems or processes to the manufacturing and service industry. This is the use of living things, i.e., plants, animals and microorganisms like bacteria and fungi, to produce useful substances. These useful substances can be consumables such as alcohol, yogurt and cheese and non-consumables such as plastics and chemicals. Biotechnology is a field in which biological systems and processes are used in manufacturing industries. It is not a new technology as we all apply biotechnology at home and our parents have used it over many years. The only difference is that our parents did not have a term for it, but in most cases they just called it "*go bidisa*" (fermentation) especially when referring to traditional alcohol brewing or any fermented food such as "*ting*" (sour porridge). An example can be in the production of alcohol during traditional ceremonies such as weddings. Though we might not be aware of it, the fermentation of sorghum beer is one very good example. In this process, malt, which is a derivative of plants and bacteria are used. The bacteria feed on the grains and produce alcohol.

Another very simple application of biotechnology is in the treatment of sewage in the biological filter method. Learner, remember that we learnt about sewage treatment in unit 13. Do you still remember the role of bacteria in this process?

Well, you must have remembered that its function is "to feed on the soluble organic matter in the sewage"

We have defined biotechnology and realized that it is something that is not totally unknown to most of us and that it has in fact been used in some of our traditional processes like beer and sour porridge production. We will now discuss how micro-organisms are used as food and in the production of sour milk. As you read the next two sub-sections pay particular attention to the difference between the two. I am sure that you will realise that you have some knowledge of these uses of microorganisms.

Microorganisms as Food

It is not only in production of food that microorganisms are used, in some cases they can actually also be consumed. Algae, bacteria and fungi can also make foods. One common example is marmite, which is made from processed yeast (fungi).Marmite is a very nutritious paste, which is spread on bread. It is just like peanut butter or jam. If you have not seen nor tasted *marmite* please look for it in your nearest supermarket and buy it so that you can have a taste at it. You will find it in bottles similar to the one in Figure 1 below.

Figure 1: Marmite

In this topic we will be discussing micro-organisms found in the production of edible substances such as sour milk, bread, and alcohol. We will begin with sour milk production which is well known in Botswana and requires fewer ingredients than the other foodstuffs we will discuss later.

Production of Sour Milk

I am sure we all know what sour milk is? What is it and what is it called in Setswana?

I am sure you said that it is a type of milk, which has undergone fermentation and that in Setswana, it is called *Madila (sour milk).* A lot of us produce it at the cattle post and sell it at home even in towns. It is also produced commercially and sold in supermarkets. At home it is eaten alone or as relish with *bogobe* (porridge). It is also used for cooking *bogobebamadila or lerotse* at home and even at festive activities such as the celebration of *Letlhafula*. We should all be having an idea of how this is prepared at home. What I would like you to do is to try the next activity. If you find it difficult to attempt, you will find it helpful to consult people around you.

Activity 1

List the ingredients (materials) and describe the steps involved in the production of sour milk (madila).

Feedback
Most of you must have known the ingredients and the steps for producing sour milk or were able to get this information from friends and relatives. You would be correct if you said:

1. *The ingredient for sour milk is just fresh milk. But you will also need a container with a cover and a sac, which is made up of a clean cloth. Learner, you should realise that sour milk (madila) production has only one ingredient, Milk, unlike other food production like alcohol where more ingredients are required.*
2. *The steps to follow are:*

2.1. Pour the milk into a clean container and cover it with a lid to avoid milk contamination by dirt.

2.2 Leave the container in a warm environment for 3 – 5 days. This will provide a conducive temperature for the bacteria to start working.

2.3 After 5 days you will notice that the milk starts to coagulate and thus forms solid pellets.

*2.4 Pour the milk into the sac and leave the sac suspended on a tree branch. You will notice that a white liquid drips through the walls of the sac. The liquid, which had drained through the sac, is called "**whey**".*

*2.5 After some time all the liquid will have drained out leaving behind a white solid substance called "**curd**".*

From the above activity, you have refreshed your knowledge of or if you did not know, you now know how to make sour milk. Let us now analyse what has happened during the sour milk production process.

The resultant solid substance mentioned in the last step 2.5 above is a result of bacteria feeding on the sugar (called lactose) found in milk. The bacteria are called ***lactobacillus***. Lactose is basically a milk sugar and it is converted to ***lactic acid*** by the bacteria. This process is called ***fermentation***. The lactic acid what brings out the sour taste in the sour milk.

Milk contains a soluble protein called ***casein***. Now, the presence of lactic acid in the milk causes this protein to solidify. This solid part of the milk is called ***curd*** and it is what is left in the sac as the filtrate, which in Setswana we call *madila or Sour milk* as it is sometimes called. Nowadays we find *madila* in supermarkets packaged in small 500ml or large 1lt cartoons (e.gIngomazi). Cheese is also produced in the same way as sour milk (Madila) except that it involves several more stages to provide texture and flavour. With cheese the curd is pressed further to remove the remaining water and further action by other types of bacteria and fungi will give the needed flavour to the type of cheese being produced.

Bread making which we will discuss next, is also well known in Botswana but it involves different processes from those we discussed in sour milk production. Note the differences as you go through the next section.

Bread Making

In this part of the lesson, we will learn about the use of microorganisms in the production of bread. Bread making has been a part of all family' activities. We normally eat bread as part of either breakfast or supper, but we also occasionally eat it for lunch too. How many different types of bread do you know and can you name a few? I hope you remembered to mention Magwinya (fat cakes), Mapakiwa (baked bread) Diphaphatha (roasted bread), Madombi (boiled bread). These are some of the ways our parents prepare bread at home. There are also cakes and scones and many more that are normally prepared for special occasions such as birth days and weddings. Well in this lesson we will learn about how bread is prepared. This will help you understand how bread is produced. It is the same way it is produced in bakeries the only difference is that bakeries produce larger quantities because they are commercial.

Activity 2

I am sure you must have prepared or seen somebody preparing bread. Which ingredients do they use? I would like you to list them down on the space below.

Feedback

You probably listed them as bread flour, yeast, sugar, water and salt. Yeast is a microorganism or to be more specific a fungus, which is utilised in the fermentation industry.

But then how do we end up with bread may be your next question?

Let us now list the steps involved in the final preparation of bread.

- The first step is to mix the yeast with warm water in a cup.
- Secondly in a different container, say a bowl, mix the bread flour with the sugar and salt.
- Add the yeast solution onto the flour mixture and stir continuously whilst adding warm water. This should be until a paste is formed. The paste is called bread dough.
- Leave the paste in a warm condition and see what happens.

You might find it helpful to undertake the above, that is, prepare your own bread. You will be expected to do this activity in your own time. This is only if you have not seen it being done before or you have never done it.

Let us now discuss what happens to the dough after being left in a warm environment, for say, 30 – 45 minutes. Normally at home we cover it and put it in the sun to rise. You will notice that after some time the dough starts to rise and increase in volume. What do you think causes this to happen? Well, it is because the yeast cells are using the carbohydrates in the bread flour during respiration. We learned about respiration is Unit 4 and we know that respiration produces at least three products. What are those? They are energy, carbon dioxide and water. When making bread, bubbles of carbon dioxide get trapped in the warm dough making it expand and rise. That is why you find empty space when you slice bread. The dough is now ready for baking. The yeast also produces alcohol during respiration but since alcohol has a very low boiling point it evaporates during cooking/baking. So in essence what we eat, that is, the bread after cooking/baking does not have any alcohol because it has evaporated.

By now you would have noted the differences between sour milk and bread production as suggested at the beginning of this sub-topic. Keep your notes for later.

Remember that when bread fermentation takes place a small amount of alcohol is produced which evaporates during cooking. Well with the right ingredients alcohol can be produced for consumption. In the next lesson we will discuss how alcohol is produced using yeast (fungi). Again note the differences between alcohol production and what you already know about sour milk and bread making.

Alcohol Production

Any form of alcohol production is a result of the activity of microorganisms or to be more specific, yeast. It is produced by the yeast feeding on carbohydrates which ends up producing alcohol and carbon dioxide. When the end products of respiration are frequently alcohol and carbon dioxide, the respiration is called fermentation.
There are many types of alcoholic drinks. They include beer, ciders, wines and even *chibuku*. Do you know *chibuku*? Well I am sure many of us have seen *chibuku* being sold either in our villages or even in your location in town. It is produced from fermented sorghum using yeast and packaged in 1 litre cartons. This is a very common type of beer sold in most homes around the country. Let us look at how yeast produces alcohol. We will use wines and beer as examples.

Wines

Learner how many types of wine do you know? Well I hope that you would have mentioned at least two common types, Red wine and white wine. There are however many other different types, some are called dry wines, and some sweet wines. Have you ever wondered how different types of wines are produced? In this topic we will discuss production of red and white wine only.

Wines are produced from grapes. There are many different types of grapes. There is the red grape variety and white grapes. These produce red and white wine respectively because of the colouring of their skins. They all provide the sugar for fermentation to take place. First of all, the grapes are crushed to form a paste. Yeast is then added to the paste and the mixture left for a few days. Addition of yeast onto the paste is called ***inoculation***. The yeast cells will feed on the wine sugar and convert it to malic acid and alcohol. At this stage the solution is very acidic due to the malic acid produced. Lactic acid bacteria are then added to the solution. It converts the malic acid to lactic acid and carbon dioxide. This reduces the acidity of the wine. The article below will give you more information on wine making. Read it and then complete the Activity

Winemaking (Adapted from wikipedia)

After the harvest, the grapes are taken into a winery and prepared for primary ferment, at this stage red wine making diverges from white wine making. Red wine is made from the must (pulp) of red or black grapes that undergo fermentation together with the grape skins. White wine made by fermenting juice which is made by pressing crushed grapes to extract a juice; the skins are removed and play no further role. Occasionally white wine is made from red grapes, this is done by extracting their juice with minimal contact with the grapes' skins.
To start primary fermentation yeast is added to the must for red wine or juice for white wine. During this fermentation, which often takes between one and two weeks, the yeast converts most of the sugar in the grape juice into ethanol (alcohol) and carbon dioxide. The carbon dioxide is lost to the atmosphere. After the primary fermentation of red grapes the free run wine is pumped off into tanks and the skins are pressed to extract the remaining juice and wine,the press wine blended with the free run wine at the wine makers discretion. The wine is kept warm and the remaining sugars are converted into alcohol and carbon dioxide. The next process in the making of red wine is secondary fermentation. This is a bacterial fermentation which converts malic acid to lactic acid. This process decreases the acid in the wine and softens the taste of the wine. Red wine is sometimes transferred to oak barrels to mature for a period of weeks or months, this practice imparts oakaromsto the wine. The wine must be settled or clarified and adjustments made prior to filtration and bottling.
The time from harvest to drinking can vary from a few months for Beaujolais nouveau wines to over twenty years for top wines. However, only about 10% of all red and 5% of white wine will taste better after five years than it will after just one year.
Depending on the quality of grape and the target wine style, some of these steps may be combined or omitted to achieve the particular goals of the winemaker. Many wines of comparable quality are produced using similar but distinctly different approaches to their production; quality is dictated by the attributes of the starting material and not necessarily the steps taken during vinification.
Variations on the above procedure exist. With sparkling wines such as Champagne, an additional fermentation takes place inside the bottle, trapping carbon dioxide and creating the characteristic bubbles. Sweet wines are made by ensuring that some

residual sugar remains after fermentation is completed. This can be done by harvesting late, freezing the grapes to concentrate the sugar (ice wine), or adding a substance to kill the remaining yeast before fermentation is completed. In other cases the winemaker may choose to hold back some of the sweet grape juice and add it to the wine after the fermentation is done, a technique known as süssreserve.

Source: http://en.wikipedia.org/wiki/Winemaking

Remember that when wine is produced grapes are crushed and mixed with yeast. Notice that the ingredients in this process are few, just grapes and yeast. In the next topic we will discuss how beer is produced and you should notice the difference on the number of ingredients required. Again note the differences between beer production and what you already know about wine making.

Beer

We all know what beer is and also the type of beer that one can find in most of the bars in our communities. I would like you to list some of the brands that are common in your areas.

I am sure you mentioned quite a lot and the list included St. Louis, Castle Lager, Hansa, Lion and Black Label to name a few.

Have you ever wondered how beer is produced?

I will take you through the steps involved in this process. First of all, let us list the substances that are required in this process, these are:

- Barley grain
- Water
- Hops
- Brewer's yeast

The first step is the production of ***malt*** by allowing the barley grains to germinate. When these seeds germinate, they convert the starch stored in their endosperm to a type of sugar called ***maltose***. The whole process is called ***malting***. To speed up this process, enzymes, such as amylase, are sometimes added to the barley.

This also results in alcohol being produced by bacteria and the sugar that is found in the malt.

The next stage is to roast the malt at high temperatures. The purpose of this stage is to stop any further enzymatic action and to kill the grains so as to prevent them from germinating. This is because if grain germination is not stopped, the sugar made will be used in respiration to provide energy for growth. The grains are then crushed and added to hot water so as to extract the sugars. The liquid obtained from this step is called ***wort***. It is then cooled and added to a fermentor.

In the fermentor, the wort is mixed with brewer's yeast. During this process, sugar is converted to alcohol and carbon dioxide. This normally takes 3 – 6 days. After fermentation, the alcohol, or should we say beer is harvested filtered out of the fermentor.

During the course of your reading of Microorgarnisms as Food sub-topics, you were asked to note the differences between sour milk, bread and alcohol production. What were your findings? I am sure that you noted the differences in types of ingredients, steps followed, processes and products of the foods that we discussed. Your notes would of course include details of each of these, for example under ingredients you would have noted that sour milk has only one ingredient while bread and alcohol have more. These notes will be your summary of this sub-topic and they will be more detailed than the topic summary below.

Topic Summary

Despite the fact that microorganisms can be harmful to human beings, they are sometimes used in the production of substances, which can be consumed by mankind. The substances include sour milk, cheese and alcohol. The microorganisms which are widely used in these processes are bacteria and fungi. The process involved is called fermentation. During fermentation, alcohol and carbon dioxide are produced. In fact, it is the carbon dioxide which results in the bread dough rising. The heat evaporates the alcohol produced by the yeast during cooking. During the alcohol production in contrast to bread making, it is the carbon-dioxide that is allowed to escape during fermentation leaving behind the alcohol. You should also remember that some microorganisms like fungi are a source of food, an example of which is marmite, which is used as a bread paste.

In contrast to what we have studied in this topic, we will in the next topic discuss the production of non consumable products.

Please work on assignment questions below and compare your answers with those provided on the feedback. If some of your answers are incorrect, go through the topic again and do the assignment again. If all your answers were correct, congratulations! You are ready to move on to Topic 2.

Assignment 1

Answer the following questions.

1. Define the following words: [10 marks]

(a) Biotechnology

___

___

(b) Fermentation

(c) Anaerobic respiration

(d) Whey

(e) Wort

2. (a) Explain how sour milk is produced. [3 marks]

   (b) Which organism is responsible for its fermentation? [1 mark]

3. List the steps involved in the production of beer. [4 marks]

4. State the similarities in the production of beer and chibuku. [4 marks]

Feedback

1. (a) The use of biological organisms and systems in manufacturing and service industry.

   (b) A form of anaerobic respiration, occurring in micro-organisms, which produces alcohol.

   (c) A type of respiration which does not involve the use of oxygen.

   (d) Filtrate obtained from formation of milk

   (e) A liquid raw material of brewing obtained after mixing water with malt.

2. (a) - Pour fresh milk into a clean container.
   - Leave for a few days in warm environment for the milk to coagulate.
   - Filter the milk by transferring it to a sac.
   - Suspend the sac on a branch.

   (b)- Bacteria feeding on the lactose sugar in the milk produces lactic acid which causes the casein protein in milk to solidify to produce curd.

3. - Production of malt.
   - Roasting of malt to kill the grains
   - Crushing of grains
   - Addition of hot water to form wort.
   - Fermentation with Brewer 's yeast

4. Malting, crushing of grains and roasting.

Topic 2: Biotechnology and Chemical Production

In Topic 1, we dealt with biotechnology, its definition and its role in the production of products, which are edible. They included sour milk, cheese, bread and alcohol. In this topic, we will learn about the role of biotechnology in the production of non-consumable but useful chemicals such as fuels and some household chemicals like soap. The fuels we will deal with are biogas and alcohol. I am sure you must be wondering about the reason why we include alcohol in the same group as we have already discussed it in topic 1 dealing with edible products. It is because there are many types of alcohol. Some can be ingested and others are not edible. The type of alcohol commonly used as a fuel is called ethanol. Alcohol is very flammable and we all know that burning provides energy. The energy that is produced can be harnessed and used in driving equipment and machines such as cars.

Learning Objectives

At the end of the lesson, you should be able to:

- explain the role of micro-organisms in production of fuels
- explain the role of micro-organisms in production of chemicals

Resources

In some of the activities you will need some of the following materials.

- Wood ash or bicarbonate of soda
- Salt
- Animal fat
- Water
- Pot
- Clean bowl

Fuels

The most commonly used form of fuel derived from biomass includes fossil fuels such as coal, gas, oil, and other petroleum products. Other forms of fuels include traditional fuels such as wood and cow dung. In fact most households in Botswana still use wood as fuel. However, it is becoming very difficult to have dry wood due to the fact that trees are getting scarce in some areas.

Traditionally one of the main forms for fuel is cow dung. In fact in some areas where there is a scarcity of wood people still use cow dung as fuel. In what form is the cow dung used as a fuel? You obviously thought it has to be dry. If that is the case then you were definitely right. Wet or fresh animal droppings cannot burn, so they have to be dried first.

Most of the conventional forms of fuels are becoming scarce to obtain. There is therefore a need for alternative sources of fuels. Many new methods are being explored for using living organisms, their products, and biological processes as sources of fuel. These mostly use waste materials such as animal manure, sewage, domestic wastes, and plant products.

The two recent innovations, which are being widely used, are the production of biological gas, also known as biogas, by bacteria and production of ethanol by yeast. Both processes involve anaerobic respiration. We will start with the production of biogas.

Biogas

This is a type of gas, which is obtained from biomass. Biogas consists of around 55 to 70 % methane. The rest is carbon dioxide with traces of nitrogen, hydrogen, and other gases. Groups of bacteria called ***methanogens*** are used. This group of bacteria has the ability to produce methane gas from carbon dioxide and hydrogen. As mentioned earlier on, a wide range of waste materials or plant materials can be used as a substrate in the fermentation process. In Britain, for example domestic waste or rubbish is used. The process is ideal for domestic fuel use that is in households for cooking and even in refrigerators.

In Botswana, the Rural Industries Innovation Centre in Kanye makes machines that produce this gas. It is produced from cow dung. Let us see how this is done.

You should bear in mind that the key process underlying production of biogas is fermentation. Therefore an ideal environment for this process to take place has to be made available. Since fermentation is a form of anaerobic respiration, all effort should be made to prevent the bacteria, which feeds on the cow dung to get oxygen. This is achieved by putting the cow dung in a large pot called a ***digestion chamber.*** (See figure 2 below).

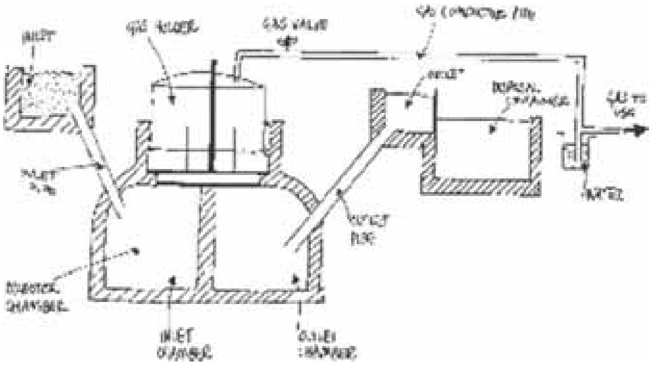

Figure 2: Equipment for the production of biogas

The digestion chamber is colored black on the outside. The purpose of this is to prevent sunlight from passing through the walls of the chamber on to the cow dung.

The temperature in the digestion chamber can be controlled. In fact, there is a direct relationship between temperature and the rate at which the fermentation process takes place. The higher the temperature, the higher the rate of biogas released. When the temperature is low, low amounts of biogas are produced. Fermentation is an enzyme-controlled reaction.

Remember that we had a discussion on enzymes in **unit 4** of this course. Can you now state why an increase in temperature results in an increase in biogas production?

Feedback

You must have remembered that an increase in temperature results in an increase in the rate at which an enzyme controlled reaction proceeds. This continues until the highest possible temperature at which an enzyme can function is reached.

According to a research conducted by the Rural Industrial Innovation Centre, daily temperature averages of around 23 degrees Celsius does produce more biogas as compared to lower winter temperatures.
The bacteria also do quite well under neutral conditions with pH of around 7.2

to 7.4.

Like biogas, alcohol can be a fuel and this is what we will discuss next.

Alcohol

In this section we will look at alcohol as a fuel and not as food. As mentioned earlier, there are many types of alcohol, however, the one that is commonly used, as fuel is ethanol. It is produced from fermentation of glucose. The end result is the production of ethanol and carbon dioxide. This process can be summarised as,

$$\text{Glucose} \xrightarrow{\text{Yeast}} \text{Alcohol and carbon dioxide}$$

The scientific name for the yeast is "*Saccharomycescerevisae.*" You do not have to memorize this scientific name.

Alcohol as a fuel has been used from as way back as the 1970s. In Brazil it was produced from sugar cane juice with some molasses. It was then mixed with a little petrol so as to prevent people from drinking it. The alcohol was used in cars and generators. As a matter of fact there are some cars in that country, which have been designed to run on alcohol. That is they do not use the normal petrol that we use in Botswana. This had an effect of reducing the country's dependence on petroleum products.

We mentioned in this topic's introduction that chemicals were the other non-consumable but useful products of biotechnology. This is what we will be discussing in the next sub-topic.

Chemicals

Microorganisms can also be used in the production of both household and non-household chemicals. An example of a household chemical produced is washing soap.

Making Soap

We all use soap each and every single day. However, there are two main types of soaps. We have washing powder and bathing soaps. All of them have the ability to remove stains, which arose from using any biological product and of course any other stain arising from inorganic matter. Examples of biological products include fats and oils.

Soaps have this ability because they have enzymes. Examples of such enzymes include proteases. Once again I would like you to recall what we did in the previous units. What are proteases?

Feedback

You probably remembered them as enzymes, which digest proteins. That is definitely true.

Now the source of the enzymes, which are used in washing soaps, is microorganism. They are grown in nutrient solutions.

All the dry soap powders we know of are known as washing soda. Best examples of washing soda are examples of domestic soap e.g. Surf, OMO, Punch and Bingo. These types of soap have got microorganisms like bacteria, which are provided with favourable conditions. These bacteria produce enzymes, which digest dirt when washing soda is being used to wash dirty clothes. As washing soda is being used, insoluble things e.g. dirt are made into soluble things e.g. scum or complicated things are changed into simpler substances so that water can remove them easily.

Let us look at how we can prepare our own soap at home.

Making Traditional Washing Soap

In some parts of Botswana, in households, people have the knowledge of making soap. Let us discuss how this soap is made. But first of all we should list the ingredients or substances one would need to do this exercise. These are:

Wood ash or bicarbonate of soda

Animal fat

Salt

Water

Now let's discuss how we go about producing soap at home.

The first step is to prepare an alkaline solution. The solution is necessary for the formation of soap. This is prepared by mixing bicarbonate of soda with water. You might be familiar with bicarbonate of soda. It is a powder sold in shops in small paper packets similar to that of baking powder. You might even get it in big tins. If one does not afford to buy soda, they can use wood ash. But with wood ash you, will have to follow the steps below and which are also indicated in the diagram in Figure 3 to prepare a solution for soap production:

A. mix the wood ash with water,

B. boil it for say one hour and then

C. remove the solid particles through filtration with a piece of cloth.

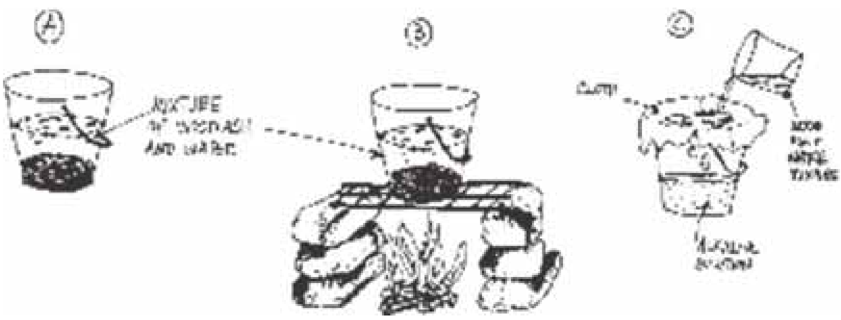

Figure 3: Preparation of wood ash for soap production.

This replaces the soda solution if you did not have any soda. It is an alkaline solution. That is its pH is well above 7.

In a separate container, preferably a pot, add animal fat. The fat can be from a goat, pig or even a cow. It is common practice to use pig fat because it is more concentrated and also we know that pigs have lots of fat. Heat the fat until it melts. You should make it a point not to burn it***. Do not fry the fat, just melt it.***

Add the alkaline solution to the molten fat and then stir. You should continue to heat the solution of alkali and fat whilst continuously stirring. However, you must be careful with the fat since it might burn your hands if some droplets were to fall on you. As the soap forms, the mixture becomes very thick and sticky. You should bear in mind that the soap has already formed, however we have to remove it from the mixture.

This can be done through precipitation. This process results in solid fat forming at the bottom of the pot and water together with some impurities appearing on top. To achieve this, salt is added to the mixture. Just ordinary table salt would do. The solution is then stirred continuously whilst at the same time heating it for an hour or two. Pour the mixture into a bowl and allow it to cool. This should take a day. The soap will solidify at the bottom of the bowl. Pour out the water solution so as to remain with the solid soap. The soap can now be cleaned and used. You can cut it into any shape you like.

Activity 3

You might find it interesting to prepare your own soap. You will be expected to do this activity in your own time. This should be simple if you follow the steps correctly. Remember that you should:

1. Add bicarbonate of soda or wood ash to water. If you use wood ash filter the solution before proceeding to the next step.
2. Melt any type of animal fat.
3. Mix the alkaline solution with the fat.
4. Stir continuously whilst heating.
5. Add salt to the mixture
6. Heat for some time.
7. Allow the mixture to cool
8. Remove the water. That is it. You now have soap.

I suggest that you discuss this activity with members of your study group and/or your tutor. Share with them the highlights of soap making processes and also any challenges that you may have encountered.

Topic Summary

Microorganisms are used in the production of not only food products, but also non-nutritious products which are useful to man. Examples of such products include fuel alcohol, biogas, washing powder, antibiotics and vaccines which we will discuss in the next topic. One such product which is now being used in Botswana is biogas. It is produced from the fermentation of cow dung by bacteria inside a biogas digester. The equipment for such an activity is produced by the Rural Industry Innovation Centre in Kanye. Another type of fuel, which is produced by microorganisms, is a type of alcohol called ethanol. It is produced from glucose by yeast cells also through the process of fermentation.

Please work on assignment questions below and compare your answers with those provided on the feedback. If some of your answers are incorrect, go through the topic again and do the assignment again before moving on to the next topic.

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Topic 3: Biotechnology and Drug Production

In this last topic of unit 14 we will discuss how biotechnology is used to produce medicinal products like vaccines and antibiotics. Remember that in the introduction we mentioned that not all microorganisms are harmful to us. Well despite the fact that some microorganisms cause diseases as discussed in unit 12, some are used in the production of medicinal drugs. They are either used in the production of antibiotics or vaccines for treatment of certain diseases. In this topic we will discuss their role in the production of medicine.

Learning Objectives

At the end of the topic, you should be able to:

- explain the role of micro-organisms in production of antibiotics
- explain the role of micro-organisms in production of vaccines

Antibiotics

Remember that we learned about antibiotics in unit 12 when we were discussing health and diseases. Well can you explain what antibiotics are?

Feedback

Well learner I think you must have remembered that they are definitely substances that kill or at least slow down the growth of micro-organisms such as bacteria and fungi. Examples of antibiotics include penicillin and streptomycin.

Do you still remember which disease can be treated with penicillin?

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Feedback

*I am sure you must have thought of sexually transmitted diseases such as **syphilis** and **gonorrhoea**. We learnt about these in unit 11 when we were discussing Reproduction and the Continuity of Life.*

But then where do we get the antibiotics?

Well, antibiotics are produced by microorganisms. The antibiotics are then extracted from the microorganisms and then processed for human use. An example can be ***penicillin***. It is extracted from fungi. The type of fungi, which is used, belongs to a family of mould fungi called ***penicillium sp*** hence the name penicillin.

Another example is ***streptomycin***. This antibiotic is produced from a bacterium called ***Streptomyces***. It is useful in the treatment of ***tuberculosis***. In fact the family of bacteria called streptomyces has many members. Amongst them, they can produce up to 500 different types of antibiotics. Another common antibiotic produced by this family is ***tetracycline***. It is used to treat ***cholera*** and ***dysentery***.

Vaccines

Once again I would like you to recall what you learned in unit 12. What is a vaccine?
Write your answer on the space below.

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____

Feedback

A vaccine is a medium of specially treated disease causing-organism or its products which, once introduced in the body, stimulates the response (immunity) to the disease caused by that organism.

Vaccines are prepared from specially treated microorganisms. These microorganisms could have either been killed or just attenuated. As explained in unit 12, attenuation is a process of reducing the infectivity of a microbe through some laboratory process. An example of such a procedure can be allowing it to grow in a high temperature environment. When you are vaccinated against a particular disease, your lymphocytes make antibodies just as if real pathogens have entered your body. In that case when that disease infects you, your body already has the right antibodies, which can fight the disease.

Examples of commonly used vaccines include: BCG vaccine, polio, typhoid fever, etc.

Do you still remember which disease is prevented by vaccination with BCG?

Feedback

If you said tuberculosis you are correct.

In the BCG vaccine, attenuated bacteria are used. So when you are being vaccinated for TB you are actually being injected with the bacteria that cause it. However, its infectivity has been reduced.

With respect to typhoid fever, the vaccine is prepared from the typhoid bacteria. Its name is ***Salmonella typhi***. This sounds scary. However, there is no reason to panic as the bacteria are dead. Unlike in the TB vaccine, the bacteria were killed.

Topic Summary

Microorganisms are very useful in medicine either as vaccines or antibiotics. Examples of antibiotics include penicillin, which is produced from fungi, and streptomycin, which is produced from bacteria called streptomyces. Remember that vaccines and antibiotics are medical drugs used for treatment of diseases. Medicines are produced from both fungi and bacteria.

Please work on the assignment questions below and compare your answers with those provided on the feedback. If some of your answers are incorrect, go through the topic again and do the assignment again.

Unit Summary

Summary

In this unit you learned that microorganisms can be harmful to humans but at the same time they are used in the production of substances which can be consumed by mankind. These substances include sour milk, cheese and alcohol. The microorganisms used in the production of these are mainly bacteria and fungi through the process of fermentation. Microorganisms are not only used in the production of food products but also in non nutritious products which are very useful to man. Examples of these include fuel alcohol, biogas, washing powder, antibiotics, and vaccines.

Please work on assessment questions below and compare your answers with those provided on the feedback. If some of your answers are incorrect, go through the unit again and do the assessment again.

You have completed the whole HSB course, you should now be ready to begin your revision of the whole course in preparation for the final examinations. Congratulations once again on reaching this milestone.

Assignment

Assignment

Assignment

Write the answers in the space provided.

1. Define the following words: [6 marks]

   (a) Vaccines

   ____

   ____

   (b) Antibiotic

   ____

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   (c) Attenuation

   ____

   ____

2. List different types of vaccines and diseases they treat
[2 marks]

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3. State how Antibiotics and Vaccines are produce [2 marks]

Feedback

1. (a) A liquid preparation of specially treated pathogens which are used to stimulate and immune response.

(b) Substances obtained from micro-organisms that destroy or inhibit the growth of pathogens.

(c) A process of reducing the infectivity of micro-organisms by chemical treatment or by growing under adverse conditions.

2. BCG treats TB; Polio Vaccine treats Polio

3. **Antibiotics** – these are extracted from micro-organisms and processed for human use.

Vaccines – these are prepared from specially treated micro-organisms which have either been killed or attenuated.

Assessment

1. Define the following words [2marks]

   (a) Biotechnology

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   (b) Fermentation

   ___

2. Write down the word equation for the production of alcohol. [2 marks]

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3.(a) How can Biogas fuel be produced in households [2 marks]

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(b) Which factors affect the rate at which this fuel is produced? [2 marks]

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4. Explain how wine is produced. [2 marks]

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5. List the ingredients used in the domestic production of soap.[4 marks]

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6. How are Vaccines Produced [1 mark]

Feedback

Assessment Answers

1. a) Biotechnology is the use of biological organisms and systems in manufacturing and service industry.

   b)Fermentation is a form of anaerobic respiration, occurring in micro-organisms, which produces alcohol and carbon-dioxide

2.

$$\text{Glucose} \xrightarrow{\text{Yeast}} \text{Alcohol + Carbon dioxide}$$

3. a) Biogas is produced using a wide range of waste materials or plant materials as a substrate in the fermentation process. Normally cow dung is the most commonly used material, but even household waste material such as food left over's can also be used.

   b) Temperature and PH

4. To produce wine, grapes are crushed to form a paste and then yeast is added to the paste and the mixture left for a few days to ferment.

5. Ingredients for soap production are

   Wood ash or bicarbonate of soda

   Animal fat

   Salt

   Water

6. Vaccines are prepared from specially treated micro-organisms which have either been killed or attenuated

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