DEPARTMENT OF EDUCATION

GRADE 10

SCIENCE

UNIT 2

MICROBIOLOGY

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GRADE 10

SCIENCE

UNIT 2

MICROBIOLOGY

IN THIS UNIT YOU WILL LEARN ABOUT:

TOPIC 1: INTRODUCTION TO MICROBIOLOGY
TOPIC 2: USEFUL MICROBES
TOPIC 3: HARMFUL MICROBES
TOPIC 4: PREVENTION OF DISEASES

Acknowledgement

We acknowledge the contributions of all Secondary Teachers who in one way or another have helped to develop this Course.

Our profound gratitude goes to the former Principal of FODE, Mr. Demas Tongogo for leading FODE team towards this great achievement.

Special thanks to the Staff of the Science Department of FODE who played active roles in coordinating writing workshops, outsourcing lesson writing and editing processes, involving selected teachers of Central Province and NCD.

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PRINCIPAL

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TABLE OF CONTENTS

SECRETARY'S MESSAGE

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

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

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

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

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

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

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

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

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

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

UKE KOMBRA, PhD
Secretary for Education

UNIT INTRODUCTION

Dear Student,

Welcome to Unit 2 of your Grade 10 Science Course! I hope that you enjoyed studying the earlier Units. I also hope that this Unit, on Microbiology, will be an interesting and enjoyable subject to study too.

In this Unit, there are 19 Lessons on four Topics. The four topics are:

- **Introduction to Microbiology**
- **Useful Microbes**
- **Harmful Microbes**
- **Prevention of Diseases**

There are seven (7) Lessons in the first Topic. The lessons will discuss about the microbes and different groups of microbes. You will also learn from this Topic about the use of microscope and different types of microscopes.

The second Topic is composed of four (4) Lessons and will discuss about the useful microbes and their importance in food and chemical industry.

In the third Topic, there are again four (4) Lessons that will discuss the harmful microbes that cause vector, airborne, food and water diseases.

The last Topic also has four (4) Lessons. It will talk about prevention of diseases especially the control and elimination of malaria. You will also learn from this Topic about blood, immunity and vaccination.

Remember, you have to do all the activities and carry out the Practice Exercises after each lesson. Answers to Practice Exercises are at the end of each Topic.

If you have any problems in understanding any of the lessons in this Unit, please do not hesitate to inform the Science Department at FODE Headquarters. This will help the teacher to revise the lessons for the next edition.

You may study this Unit now following the Study Guide on the next page.

All the Best!

STUDY GUIDE

Follow the steps given below and work through the lessons.

Step 1 Start with Topic 1 and work through it in order. You may come across new terms in your lessons which are written in bold with an asterisk (*) For example in Lesson 1, you will come across **animalcules*.** Words like this will require you to look up their meaning in the glossary section at the end of this book.

Step 2 When you study Lesson 1, do the Activities. When you complete the Activities, check your work. The answers are given at the end of each Lesson. (Note: Short lessons may not have an activity.)

Step 3 After you have completed the Practice Exercise, correct your work. The answers are given at the end of each Topic.

Step 4 Then, revise and correct any mistake.

Step 5 When you have completed all of these steps, tick the check box for Lesson 1, on the Contents page, like this:

 Lesson 1: Microbiology and Microbes

Then, go on to the next Lesson. Repeat this process until you complete all the Lessons on a Topic. When you have done this, revise using the Review Section.

Remember, as you complete each lesson, tick the box for that lesson on the Contents page. This will help you check your progress.

Assignment: Topic Tests and Unit Test

When you have completed all the lessons in a Topic, do the Topic Test for that Topic, in your Assignment Book. The Unit Book tells you when to do this. When you have completed all the Topic Tests for the Unit, revise well and do the Unit Test. The Assignment Book tells you when to do the Unit test.

When you have completed the entire Assignment Book, check and revise again before sending it to the Provincial Centre. If you have any questions, write them on the Student's page. Your teacher will advise you when he/she returns your marked Assignment.

The Topic Tests and the Unit Test in each Assignment will be marked by your Distance Teacher. The marks you score in each Assignment will count towards the final result. If you score less than 50%, you will repeat that Assignment.

Remember, if you score less than 50% in three consecutive Assignments, your enrolment will be cancelled. So, work carefully and ensure that you pass all Assignments.

TOPIC 1

INTRODUCTION TO MICROBIOLOGY

In this topic you will learn about:

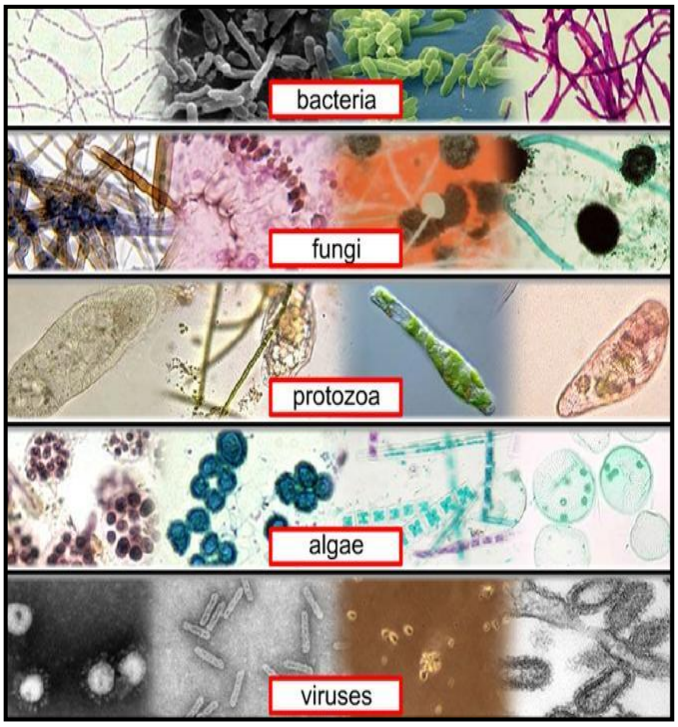
- **microbiology and microbes**
- **the microscope**
- **fungi**
- **algae**
- **protozoa**
- **bacteria**
- **viruses**

INTRODUCTION TO TOPIC 1: INTRODUCTION TO MICROBIOLOGY

Microbiology is defined as the study of living things too small to be clearly seen by the unaided eye which include: bacteria, viruses, yeast, moulds, protozoans, algae, fungi. In this topic you are introduced to the wonderful world of micro-organisms.

The aim of this topic is to enable you to understand, and study the concepts underlying the living world of microbes. We will achieve this aim by examining aspects of their structures that differentiate microbes from larger organisms.

First you are to explore the different types and shapes of microbes and later closely examine useful and harmful microbes.



Micro-organisms

Microbiology is important because it helps us to understand and treat diseases. It also is economically important because it impacts the environment, research fields and biotechnology.

Micro-organisms are everywhere, including the air, on and inside our body. They are important to life on Earth, acting as decomposers in various ecosystems and playing a vital role in the nitrogen cycle. Microorganisms make their home on food, plants, humans and lots of other living things. Look hard and spot places where you think they might be at work. Learn about bacteria that live in decaying leaves, diseases, moldy fruit, yeast in breads, bacteria in yoghurt, salmonella in uncooked food and more.

By the end of the topic you will be expected to apply concepts to any practical situation and develop a response to a problem or issue that involves microbes.

This Topic 1 will include lessons on the study of the microscope and the following groups of microorganisms: the fungi, algae, protozoa, bacteria and viruses and you should be able to answer the following questions?

- What is a micro-organism?
- What are different groups of micro-organism and their importance?
- How do microbes reproduce?
- What is a microscope and its functions to the study of microbiology?

In this Topic, you will find the answers to these questions and all other questions relating to the introduction of microbiology

Lesson 1: Microbiology and Microbes

Welcome to Lesson 1. Large numbers of different kinds of living things live in almost every possible place in land, in the atmosphere, in the seas, rivers and lakes. Some live at the top of the tallest mountains and at the bottom of the deepest oceans. In this lesson you will learn that not all organisms that live on Earth can be seen by your naked eyes. We will discuss the simplest living things that can be found everywhere called Microbes.

Your Aims:

- define microbiology and microbes
- describe the different types of microbes
- explain how microbes reproduce

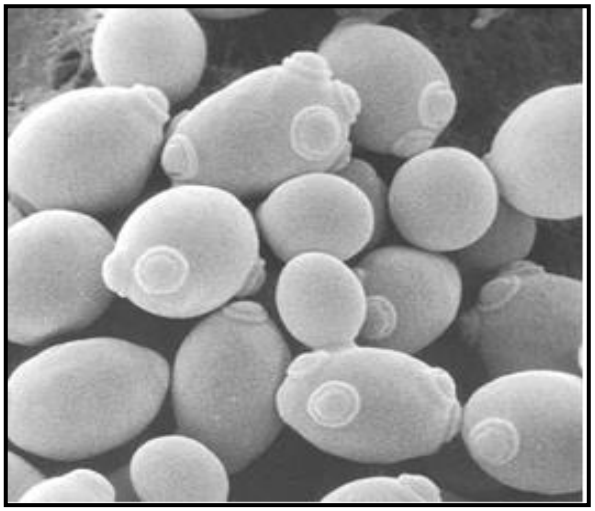
What is a Micro- Organism?

Micro-organisms or microbes (*my-crobes)* for short is a term for tiny creatures that individually are too small to be seen with the unaided eye. Microbes include bacteria (*back-tear-ee-uh*), archaea *(are-key-uh)*, fungi *(fun-jeye)* and protists *(pro-tists).* You have probably heard of bacteria and fungi before. Archaea are bacteria-like creatures that have some traits not found in any true bacteria. Protists include primitive algae (al-gee), amoebas (ah-me-buhs), slime molds and protozoa (pro-toe-zoh-uh). We can also include viruses (vye-rus-is) as a major type of microbe. The study of all these tiny organisms is known as **microbiology**.

What makes a microbe?

Microbes are just too tiny that millions can fit into the eye of a needle. They are so small that they can only be seen through a microscope an apparatus that we are going to learn more on our next lesson. Understanding microbes is vital to understanding the past and the future of ourselves. Without us, they had probably be just fine. Microbes are everywhere. There are more of them on a person's hand than there are people on the entire planet! Microbes are in the air we breathe, the ground we walk on, the food we eat—they are even inside us!

There are large numbers of microbes in and on our bodies, in the food we eat, in the air we breathe, in the water we drink and in the soil beneath our feet. They can live and grow in hot springs and in very frozen sea ice such as the Arctic.



Microbes

So, most microbes are harmless to humans, you swallow millions of microbes every day with no ill effects. In fact, we are dependent on microbes to help us digest our food. We could not digest food without them animals could not, either. Without microbes, plants could not grow, garbage would not decay. In fact, without these invisible companions, our planet would not survive as we know it! and there would be a lot less oxygen to breathe.

But they sometimes cause diseases in man, animals and plants. They are also involved in food spoilage too.

Activity 1: **Now you can test yourself by doing this activity.**

A. Answer the following questions.

1. What is Microbiology? _____

2. List at least four (4) different places in which microbes have been found.
   i) _____
   ii) _____
   iii) _____
   iv) _____

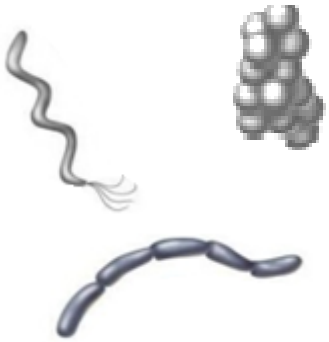
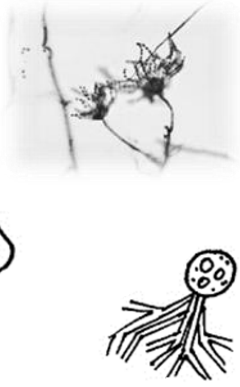
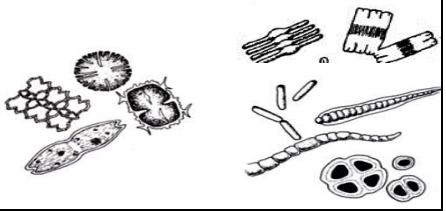
3. What is a microbe? _____

4. Are all microbes harmful? Yes or No? Explain why.
   _____
   _____
   _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 1.

Groups of Microbes

There are five groups of microbes. The table below can be used to classify the microbes.

TYPE OF MICROBE	CHARACTERISTICS	SAMPLE IMAGES
1. Viruses	They are the smallest microbes. Some of these cause common diseases such as colds, flu, HIV and Aids. Viruses must enter living cells before they become active and reproduce to make more viruses.	
2. Bacteria	They are very small and usually consist of only one cell. Many types of bacteria help to produce soil. They also cause diseases such as cholera and typhoid. Bacteria can be simply divided into three groups by their shapes – cocci (balls), bacilli (rods) and spirals. • They are so small that 1000s of bacteria could fit on the full stop at the end of this sentence. Some bacteria are helpful in cooking, for example, making yogurt and cheese.	
3. Fungi	Fungi are the largest of all microbes. Fungi can be found in the air, on plants and in water. They do not contain chlorophyll and cannot make their own food. Fungi usually get their food from rotting material. Some fungi may be seen without a microscope when they form large groups of several cells. A mould is a fungus which can be seen in this way Yeast, which is used in making bread, is a fungus. Mould, which grows on bread, is a type of fungus Some antibiotics are made by fungi. Mushrooms are also large fungi.	
4. Algae	They are simple green plants that live in water and have no stems, roots or leaves. The green slime in stagnant water is an example of algae. Seaweeds are also algae**.**	
5. Protozoa	They are single-celled animals. They live in water or damp places. The disease malaria is caused by a protozoan which is injected into the human body by a mosquito.	

Some microbes such as algae can be classified as plants. Other microbes, such as protozoan can be classified as animals. Both of these groups can be classified as microbes because of their structure and the way they live.

Bacteria, fungi and viruses cannot easily be classified as either plants or animals and for this reason scientists often classify microbes as a distinct group of organisms, separate from plants and animals.

Activity 2: **Now you can test yourself by doing this activity.**

Microbe Mania

There are 3 different types of microbes – bacteria, viruses and fungi. From the pictures and descriptions, can you work out which microbe is which?

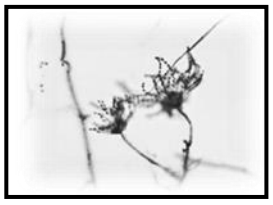
1. My name is Staphylococcus. I am round in shape and I like to live in your nose or armpit! If I live in your skin I can give you spots. If I get into your bloodstream I can make you ill! What type am I?
   Staphylococcus is _____.

2. My name is Lactobacillus. People call me 'friendly' because I change milk into yogurt! When you eat me in yogurt I live in your guts and help you digest other food. What type am I?
   Lactobacillus is a: _____.

3. I am called a Dermatophyte and I like to live on your skin. I especially like living in damp places like between the toes on sweaty feet! When I live there I give people athlete's foot! What type am I?
   Dermatophytes are: _____.

4. My name is Influenza but my friends call me the 'flu'. I am very generous; I like to give people headaches and fever. I easily spread from person to person through coughing and sneezing. What type am I?
   Influenza is a: _____.

5. My name is Penicillium and you will find me growing on old oranges or stale bread making them look mouldy. Humans use me to make an antibiotic known as Penicillin which can make them better, but only from bacterial infections! What type am I?
   Penicillium is a: _____.

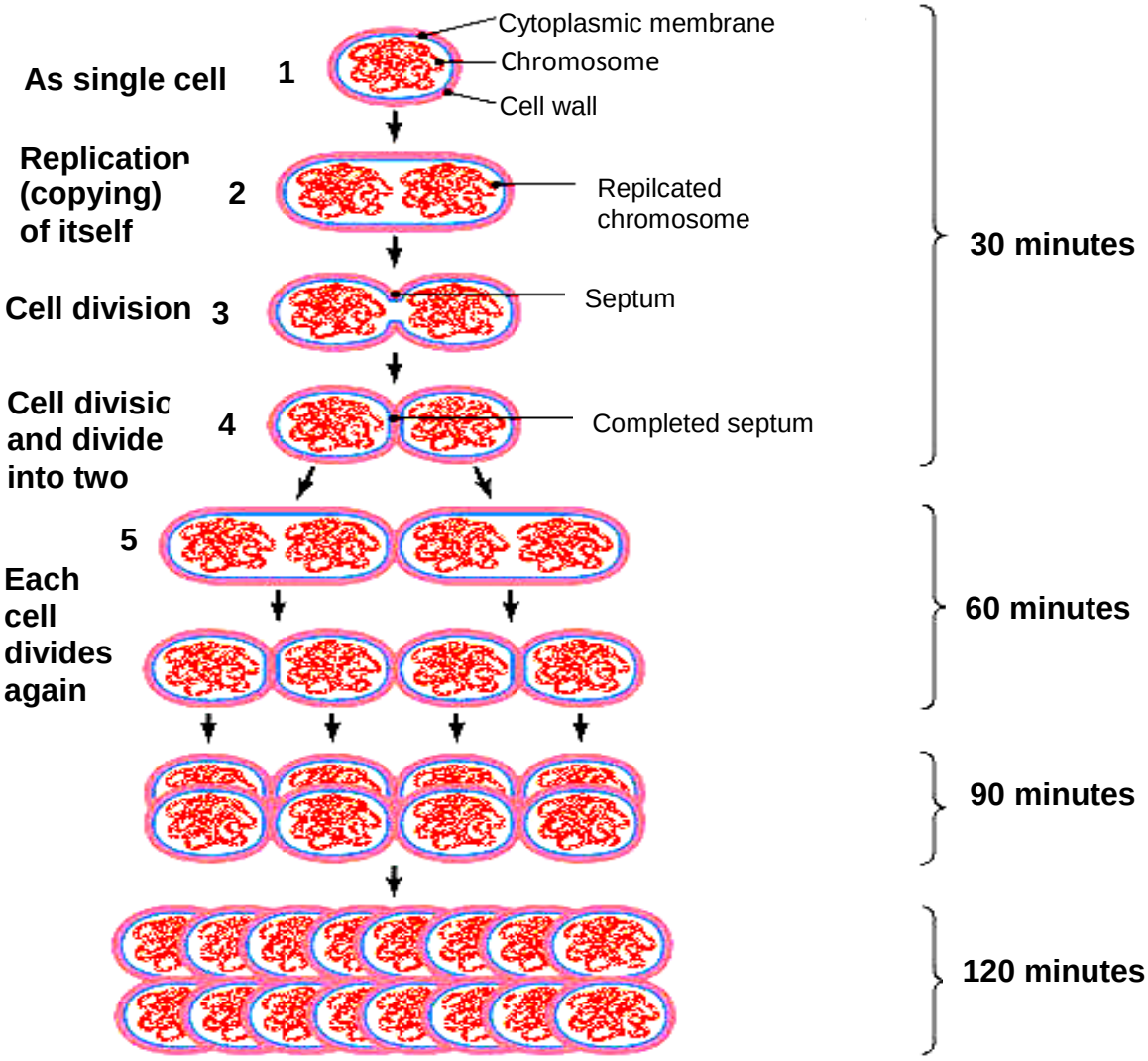


Reproduction of Microbes

All microbes reproduce mostly through asexual reproduction. Asexual reproduction is without the formation of **gametes*** or sperm and egg cells

The diagram below shows generally how microbes reproduce. Cell division takes place every thirty minutes and imagines, in a very short time, millions of microbes have been produced. In thirty minutes there would be two, sixty minutes, four. In one and half hour, there would be eight, then sixteen, thirty-two, sixty four in four hours. At the end of twenty-four hours there would be millions of microbes.

Reproduction of Microbe Population



Activity 3: **Now you can test yourself by doing this activity.**

Write True if the statement is true and False if the statement is false on the space provided.

1. _____ HIV-AIDS Virus become active and reproduce once inside a living cell.
2. _____ Cholera is spread through contaminated water and food. It is caused by bacteria.
3. _____ The disease malaria is caused by fungi.
4. _____ Yeast, which is used in making bread is a protozoa.
5. _____ All microbes reproduce from a single cell.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 1.

Summary

You have come to the end of lesson 1. In this lesson you have learnt that:

- microbiology is the study of micro-organisms.
- microbes are very small organisms that can only be seen through a microscope.
- microbes are the simplest living things and can be found everywhere.
- the five main groups of microbes are viruses, bacteria, algae, fungi and protozoan.
- microbes can be classified as a distinct group of organisms, separate from plants and animals.

NOW DO PRACTICE EXERCISE 1 ON THE NEXT PAGE.

Practice Exercise 1

Briefly answer the following questions.

1. Briefly, describe with examples, the five main groups of micro-organisms.
   (i) _____
   _____
   (ii) _____
   _____
   (iii) _____
   (iv) _____
   (v) _____
   _____

2. Explain why microbes can be classified as a distinct group of organisms, separate from plants and animals.
   _____
   _____

3. Explain how microbes reproduce.
   _____
   _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 1.

Answers to Activities

Activity 1

1. Microbiology is the study of micro-organisms or microbes.

2. Microbes have been found in the:
   (i) food we eat
   (ii) air we breathe
   (iii) water we drink
   (iv) soil beneath our feet

3. Microbes are very small organisms that can usually only be seen through a microscope. They are also called micro-organisms.

4. No, although there are microbes which can be harmful to us there are also a lot of microbes that are very useful to us that we use every day, for example, Saccharomyces (fungi) is used to help bread rise, Lactobacillus (bacteria) help make yogurt and cheese.

Activity 2

1. bacteria
2. bacteria
3. fungi
4 virus
5. fungi

Activity 3

1. True
2. True
3. False
4. False
5. True

Lesson 2: The Microscope

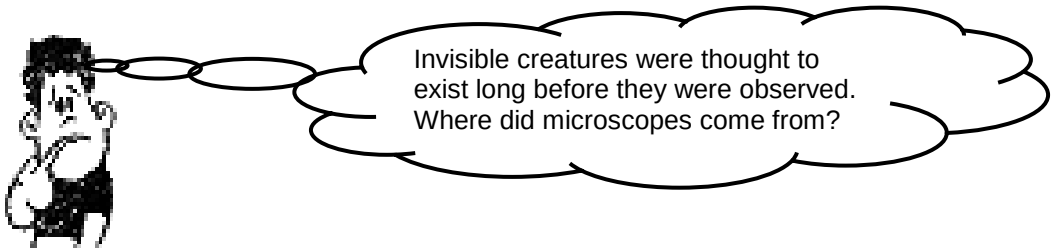
Welcome to Lesson 2. In our previous lesson, we learned that microbes are living things. They too need food. They also grow, reproduce, respire and excrete just like the plants and animals we see in the world around us. They too have an important role to play in maintaining the natural balance within the living world. Their only difference from other living things is their size and that they are extremely tiny organisms that can only be seen through a microscope. So in this lesson, we will discuss an instrument called microscope which is essential for studying microbiology.

Your Aims:

- state the importance of a microscope
- identify the types of microscopes
- describe the different parts and functions of the light microscope
- differentiate between turret scope and zoom scope

Importance of a Microscope

Many things around us are so tiny that we cannot see them with our eyes. An instrument that we can use to make things appear larger is called a **microscope**. It contains a series of magnifying glasses or convex lenses to make things appear larger.



Anthony van Leeuwenhoek *[ley-vuh n-hoo k; Dutch ley-y-wuh n-hook]* (1632-1723) who invented the first microscope lived in Holland about three hundred years ago. The microscope he made could magnify up to 300 times. He was able to grind his own lenses, and use them to make very small things look bigger. He could see in water tiny creatures never seen before. He was the first person to accurately observe and describe micro-organisms.

Anthony van Leeuwenhoek

He assembled nearly 250 microscopes, some of which magnified objects 270 times. As he looked at things with his microscopes, he discovered the presence of **micro-organisms**, organisms so tiny that that they were invisible to the naked eye. He called these tiny living organisms **animalcules***. He first described bacteria and the protozoans. Leeuwenhoek opened a world that eventually led to the control of many diseases. Recently, scientists have developed the electron microscope which can magnify things over 70,000 times. It is of great importance in the field of medicine.

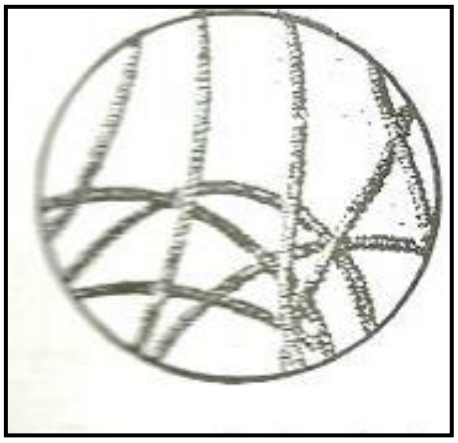
Types of Microscopes

There are many types of modern microscopes. We will discuss only the common ones.

1. **Light Microscope**

This microscope uses a beam of light to help magnify objects. Ordinary school microscope can magnify up to approximately 400 times.

The picture below shows a human hair seen under a light microscope shown on the right.



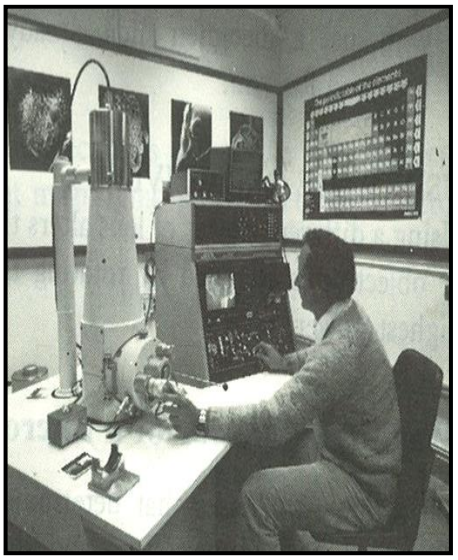
Human hair as seen under light microscope (400x magnifications)

Light Microscope

2. **Electron Microscope**

There are even more powerful microscopes, which are called **electron microscopes**. They use a beam of electrons, rather than a light to help magnify very tiny objects many thousands of times.

Electron Microscopes are much larger than light microscopes. A light microscope is around forty centimeters high, whereas an electron microscope can be more than two metres high.

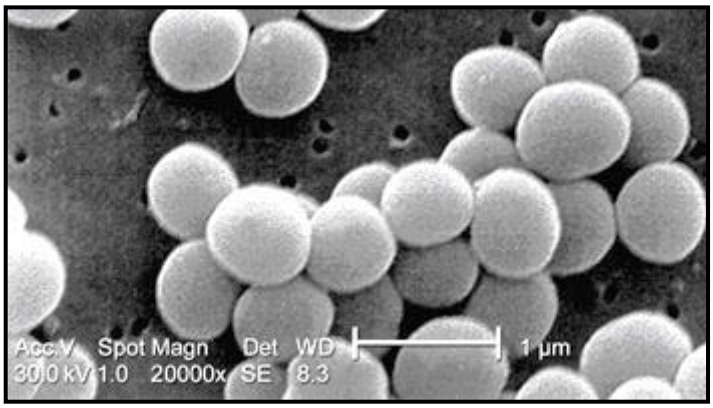


An electron microscope used in very high power

- **Light microscope uses a beam of light to help magnify objects.**
- **Electron microscope uses a beam of electrons rather than light to help magnify very tiny objects many thousand times.**

An electron microscope can magnify thousands times. As they are very expensive, they would normally be found in universities and other research institutions. They could not be found in ordinary schools.

The picture below shows bacteria cells magnified 2,000 times. An electron microscope is used to achieve such tremendous magnification



Bacteria sample magnified 2000 times

Light microscope can be carried from place to place around a laboratory. But because electron microscopes are so heavy, they are fixed permanently to the floor of a laboratory.

- **Lenses of light microscope are made from glass.**
- **Lenses of electron microscope is made from tubes with coils of wire wrapped around them through which electrons travel and are bent in a magnetic field similar to the way that light is bent when passing through a glass lens.**

Activity 1: Now test yourself by doing this activity.

Briefly answer the following questions.

1. What are the two types of microscopes?
   (a)_____ (b) _____

2. In which branch of Science is microscope an essential tool?
   _____

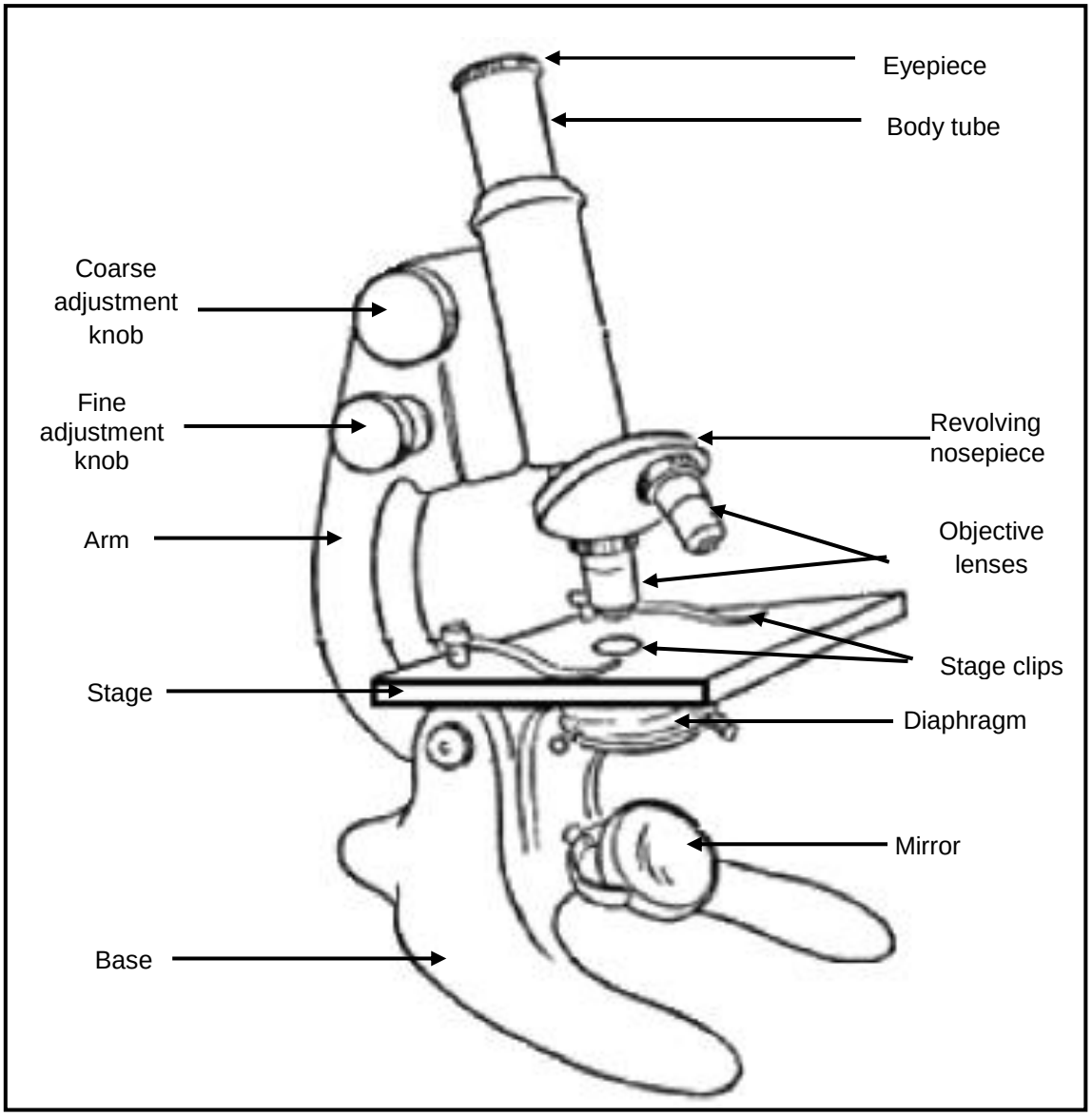
3. Who invented the first microscope and also the first to observe and describe micro-organisms? _____

4. Fill in the blank spaces.
   Ordinary school microscopes can magnify up to approximately four_____times. An electron microscope can magnify objects many _____of times.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 1.

Parts of the microscope and their functions

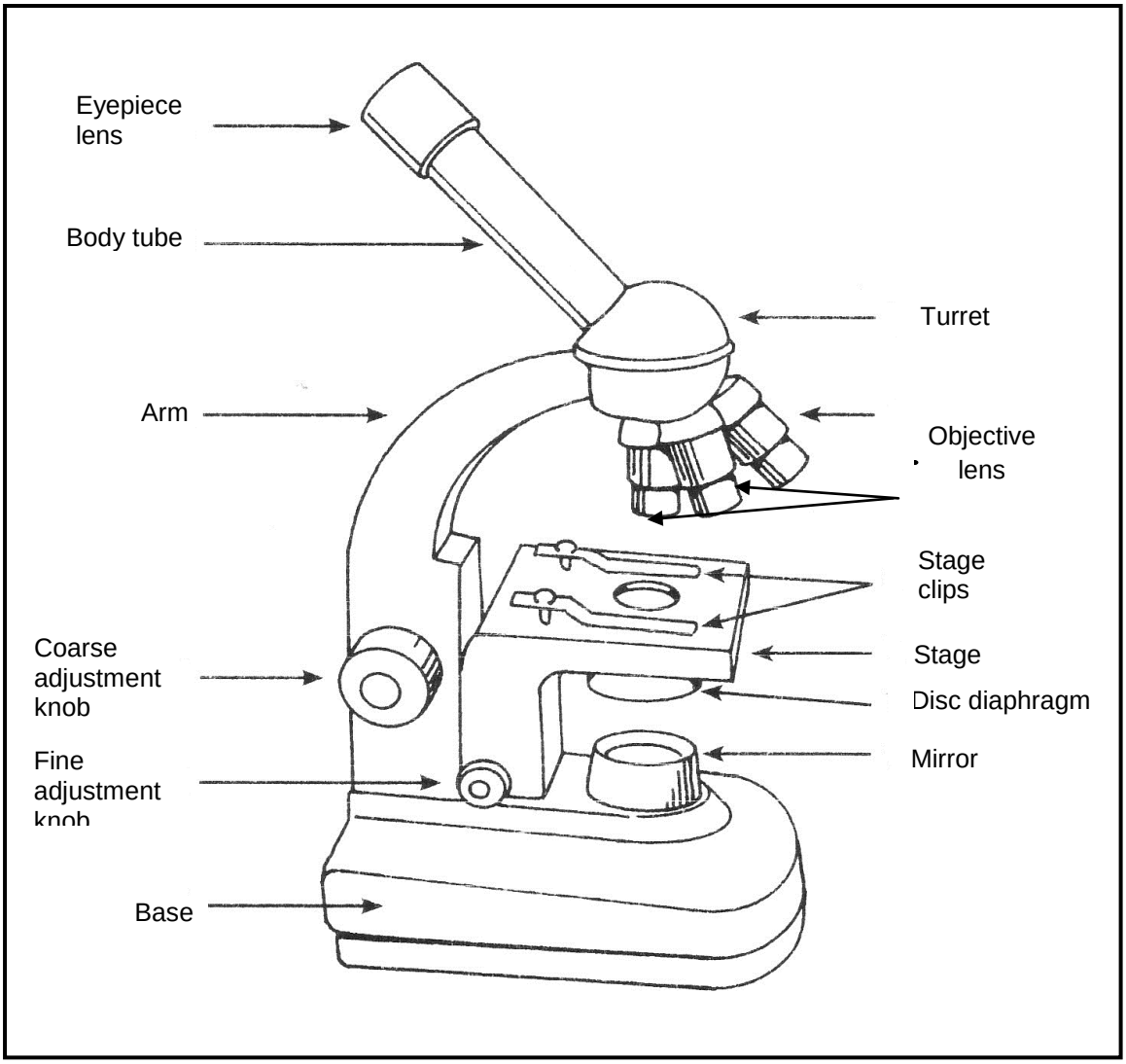
1. **Arm -** supports the body tube
2. **Eyepiece** - contains the magnifying lens you look through.
3. **Body tube** - maintains the proper distance between the eyepiece and objective lenses.
4. **Revolving nosepiece** - holds high and low-power objective lenses and can be rotated to change magnification.
5. **Objective lenses** - a low-power lens which usually provide 10X magnification, and a high- power lens which usually provides 40X magnification.
6. **Stage clips** - hold the slide in place.
7. **Stage** - supports the slide being viewed.
8. **Diaphragm** - regulates the amount of light let into the body tube.
9. **Mirror** - reflects the light upward through the diaphragm, the specimen, and the lenses.
10. **Base** - supports the microscope.
11. **Coarse adjustment knob** - moves the body tube up and down for focusing.
12. **Fine adjustment knob** - moves the body tube slightly to sharpen the image.



The microscope

Light Microscope: The turretscope

Many students in school laboratories use such a type of microscope known as a **turretscope**. To help you identify the parts that make up the turretscope, refer to the labeled diagram shown below.



The turretscope

Basically, the **turretscope** consists of a glass lens called the **objective lens** and another lens called the **eyepiece** through which the object or specimen is observed. The objective lens and the eyepiece lens (which is a combination of two lenses) form the opposite end of a cynical or a cynical tube which is about 15 centimetres long, with a diameter of about 3 centimetres.

The objective lens forms a magnified image of the object being studied. This image is further magnified by the eyepiece lens. The height of the objective lens above the object can be varied by rotating a focusing knob. When in focus, the magnified image of the object is sharp and clear as possible. The object is placed on the stage or platform where it is clipped between two pieces of flat glass. Below the stage is a circular mirror. Light, either from a lamp or daylight is reflected from the mirror through the stage onto the object, causing it to be illuminated.

The microscope normally has three different objective lenses attached to a rotating disc called a turret. Only one objective lens can be rotated into a position at a time.

With this arrangement, a person who uses a microscope can turn the turret to the light location to use the objective lens.

You may wonder why the microscope has three objective lenses when only one can be used at a time. Well, each lens has a different magnifying power. On each of the three small tubes holding the objective lenses, there is a **times** sign followed by a number (normally written smaller than the 'times' sign), in on the first X4, on the second X10 and on the third X40. The 'times' sign usually X5, or X10 means that the lens magnifies 4 times or 10 times the natural size of the object being observed.

To find the total magnifying power of a microscope, we multiply the magnifying power of the objective lens by the magnifying power of the eyepiece lens.

Here is an example of how to work the magnifying power of a turretscope

- **Magnifying power of the objective lens = X4**
- **Magnifying power of the eyepiece lens = X5**
- **Since 4X5 =20, then the magnifying power of the turretscope =X20**

Activity 2: Now test yourself by doing this activity.

Fill in the blanks to complete the following sentences.

1. The most powerful type of microscope is a _____ microscope.
2. The purpose of the mirror on a microscope is to reflect the _____. so that it passes through the _____ onto the object.
3. Two lenses that determine the magnification are the _____. lens and _____ lens.
4. If the power of the eyepiece is X20 and the objective X10, then the magnification is _____.
5. Increasing the magnification makes the specimen being looked at appear _____.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 2.

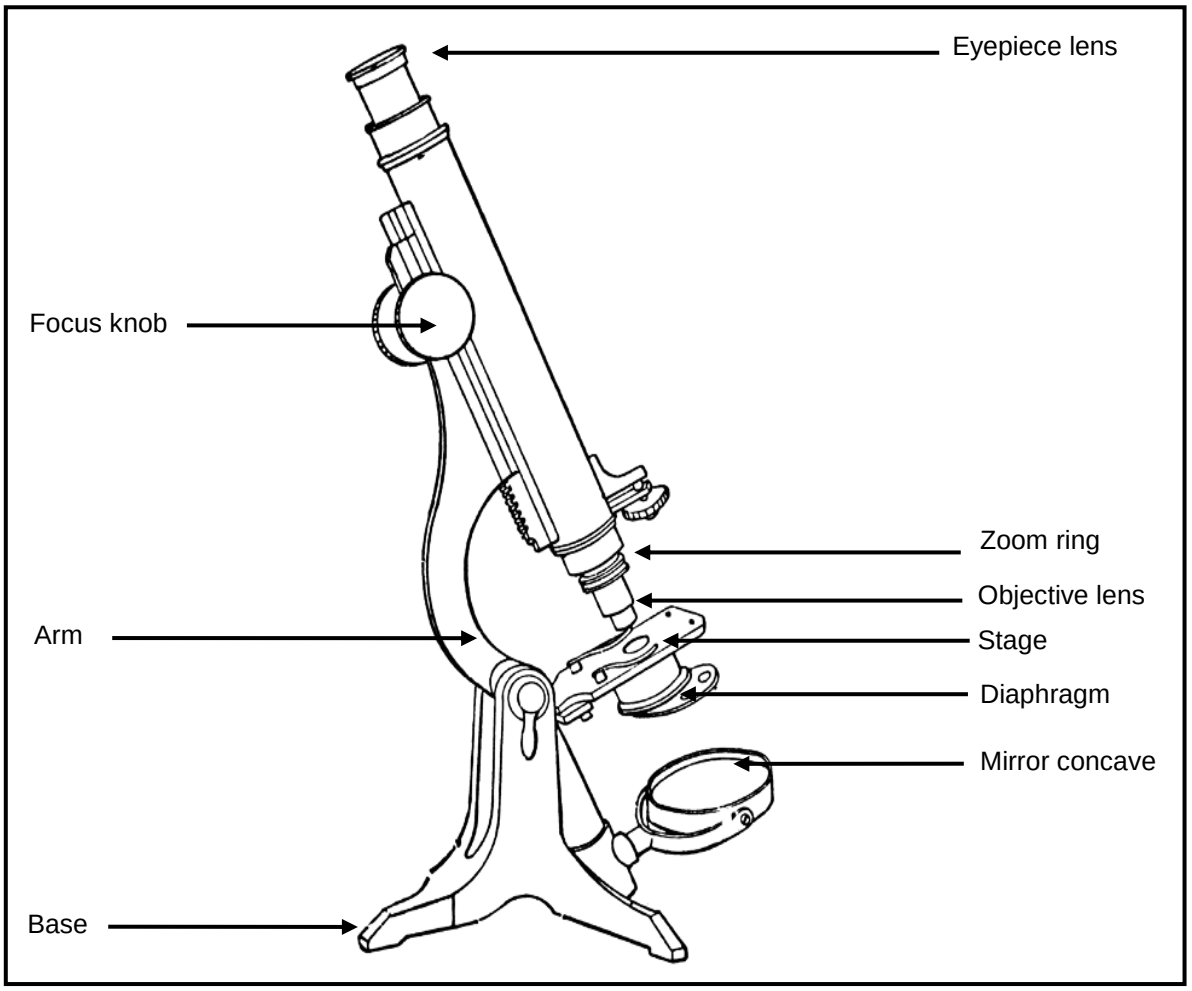
The Zoomscope

Another type of light microscope is the zoom scope. It shares many common features with the turretscope. Like the turretscope, is often used in a school laboratory.

The main difference between a turretscope and a zoomscope is that:

- **A turretscope has three objective lenses.**
- **A zoomscope has a single lens called a zoom lens.**

The magnifying power of the zoom lens can be increased or decreased by rotating by hand, the housing of the zoom lens. The different magnifying powers can be read off from a circular, numbered scale on the zoom lens housing. A labeled diagram of a zoomscope showing the parts that make up the zoomscope is given below.



The zoomscope

Summary

You have come to the end of lesson 2. In this lesson you have learnt that:

- microscopes are instrument which magnify or make things appear bigger than they really are.
- light microscope uses a beam of light to help magnify objects.
- electron microscope uses a beam of electrons rather than light to help magnify objects.
- a turretscope has three objective lenses.
- zoomscope has a single lens called a zoom lens.

NOW DO PRACTICE EXERCISE 2 ON THE NEXT PAGE

Practice Exercise 2

Briefly answer the following questions.

1. What is a Microscope?

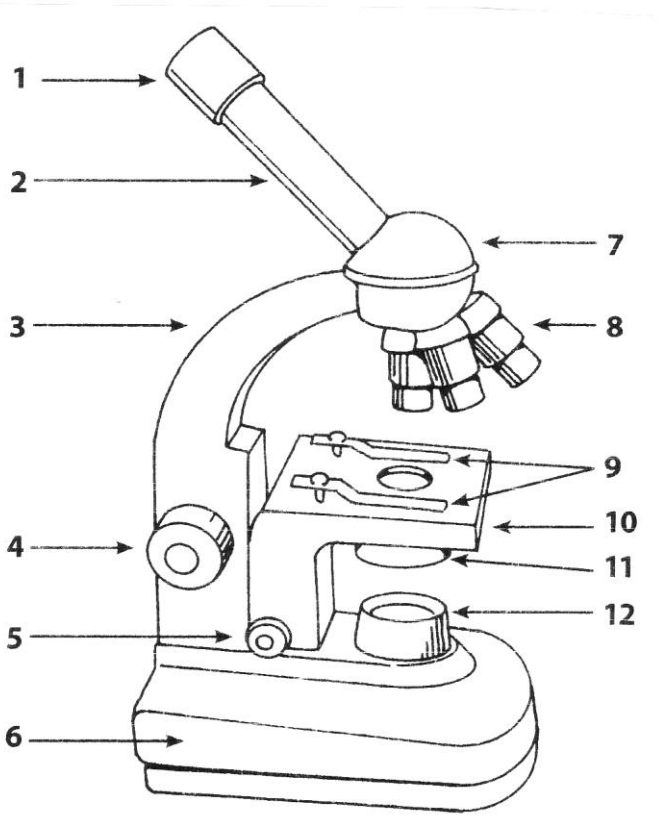
   _____

2. Calculate the total magnifying power of the following microscopes.

   (i) Magnifying power of objective lens = X20
   Magnifying power of eyepiece lens = X5

   (ii) Magnifying power of objective lens = X40
   Magnifying power of eyepiece lens = X10

3. From the diagram below, label the given parts of a microscope.



1.	_____	5	_____	9.	_____
2.	_____	6.	_____	10.	_____
3.	_____	7.	_____	11.	_____
4.	_____	8.	_____	12.	_____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 1.

Answers to Activities

Activity 1

1. (a) Light microscope
   (b) Electron microscope
2. Microbiology
3. Anthony van Leeuwenhoek
4. Hundred, thousands

Activity 2

1. Electron
2. Light, stage
3. Eyepiece and Objective
4. X200
5. Larger

Lesson 3: Fungi

Welcome to lesson 3. In our previous lesson, we learnt that microscope is an instrument which magnifies or makes things appear bigger than they really are. It contains a series of magnifying glasses or lenses to make things appear larger. So microscope is used to see extremely tiny organisms that we cannot see with our naked eyes known as micro-organisms. And in lesson 1, we mentioned that there are five groups of microorganisms. One of these groups is the group of Fungi which we are going to study in this lesson.

Your Aims:

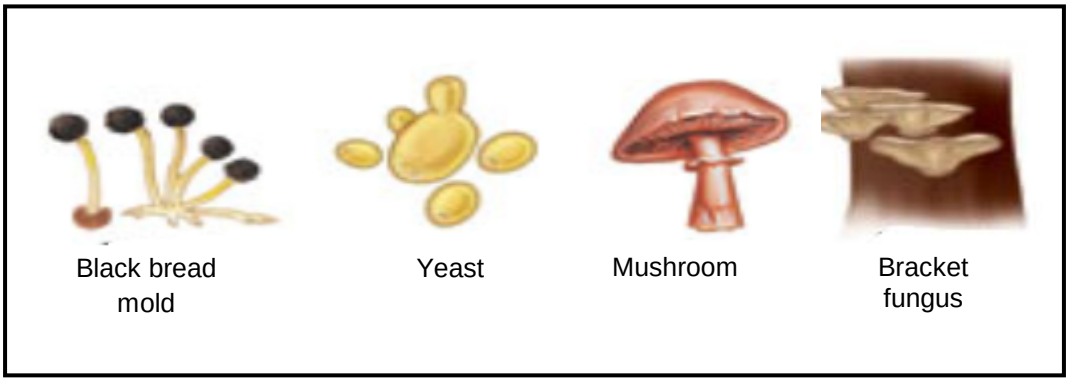
- define fungi, parasite, saprophytes, hypha, spores, sporangia, fermentation and decomposers
- state the characteristics of fungi
- state the reproduction and feeding processes of fungi.
- identify disease causing fungi
- state the characteristics of fungi
- identify disease causing fungi

Characteristics of Fungi

Fungi (singular: fungus) are **heterotrophic*** organisms. The word ‘fungi’ is Latin for mushrooms. Fungi vary widely in size and shape from unicellular microscopic organisms. Some fungi, like mushrooms and toadstools are quite large but others such as moulds, rusts, yeasts and mildews are very small and can only be seen through a microscope.

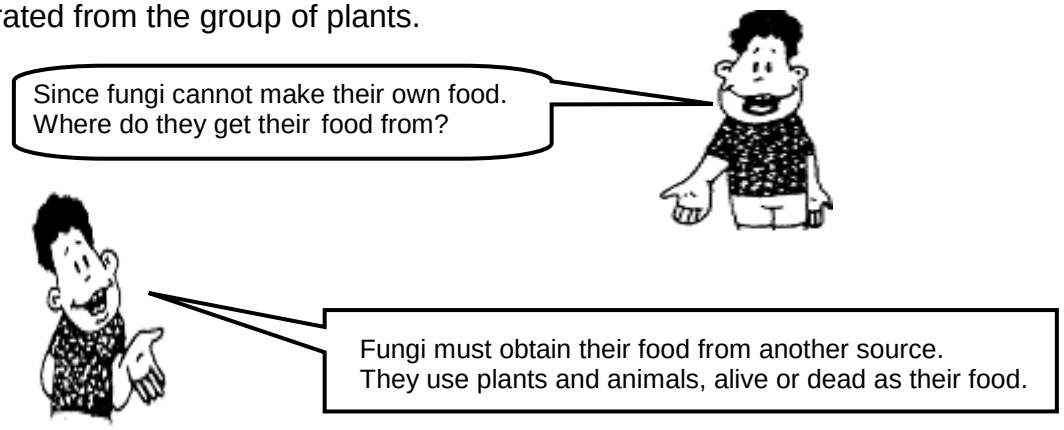
Some rot fruit and some grow on bread. Others cause plant diseases like taro blight and coffee rust. However,xnot all fungi are bad. Some like penicillium fungus are important in curing diseases.

The pictures below show some different types of fungus.



For many decades, fungi were classified as plants, but laboratory studies revealed properties that distinguish fungi from plants.

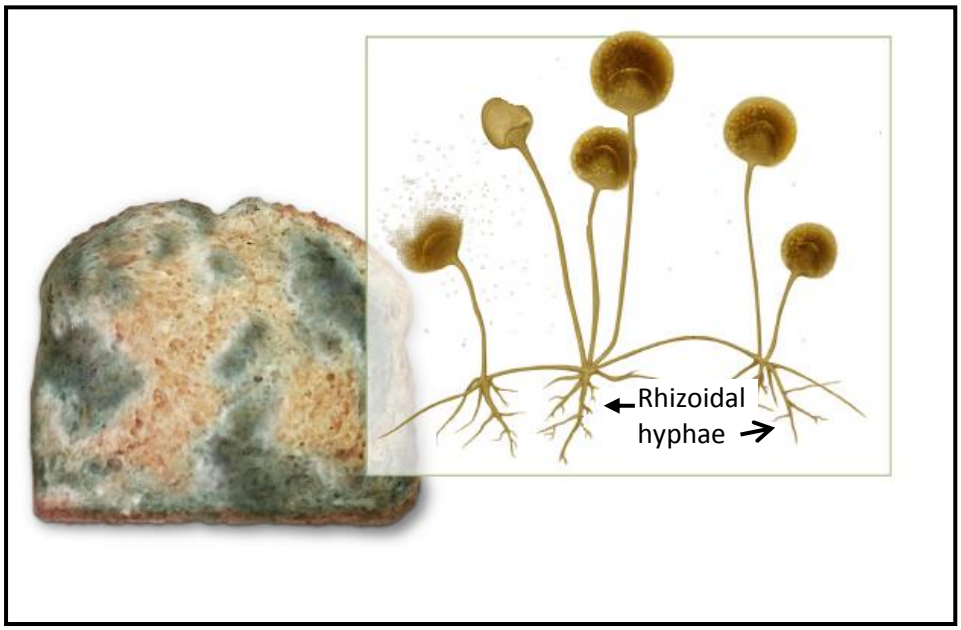
Fungi lack **chlorophyll*** therefore cannot produce their own food through **photosynthesis,** and fungal cell walls contain a carbohydrate called **chitin*,** while plant cell walls have **cellulose*.** Some fungi are single-celled like yeasts but most form complex multicellular bodies, in most cases they form above ground structures commonly known as mushrooms and are **heterotrophic*** while plants are **autotrophic*.** For these reasons they are placed in their own **Kingdom* Fungi** separated from the group of plants.



Fungi are not able to manufacture their own food the way plants do and are not able to ingest their food like animals do instead fungi feed by **absorption*** of nutrients from the environment around them. They accomplish this by growing through and within the **substrate*** on which they are feeding.

Most fungi are **saprophytes,** feeding on dead or decaying material. Many of the saprophytic fungi cause food to spoil and bodies of dead organisms to rot and decay. These decomposers play an important role in the recycling of nutrients in nature. This helps to remove leaf litter and other debris that would otherwise accumulate on the ground. Nutrients absorbed by the fungus then become available for other organisms which may eat fungi. Fungi feed by using special root-like feeding threads of filaments called **hyphae*** (singular: hypha).

The picture below shows the black mold on bread. The hyphae penetrate and digest the substance that is being used as food. Digestion takes place outside the fungus, as digestive chemicals flow out from the hyphae onto the food. The chemicals break down the food and also release energy which is absorbed by the fungus.



Black bread mold (Rhizopus stolonifer) on bread

Many fungi are **parasitic**, feeding on living organisms without killing them. Ergot, corn smut, Dutch Elm disease, and ringworm are all diseases caused by parasitic fungi.

- **Fungi that feed on dead or organic materials are called saprophytes.**
- **Fungi that feed on living organisms are called parasites.**
- **Parasitism is a relationship between two different organisms which one organism (parasite) benefits and the other (host) is harmed.**

Activity 1: Now test yourself by doing this activity.

Answer the following questions.

1**.** Do fungi contain chlorophyll? _____

2. Is mushroom part of the fungi? _____

3**.** Name a drug, mentioned in this lesson, which is made from a fungus and is used in curing diseases? _____

4. What is the purpose of hyphae? _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 2.

Fungi Reproduction

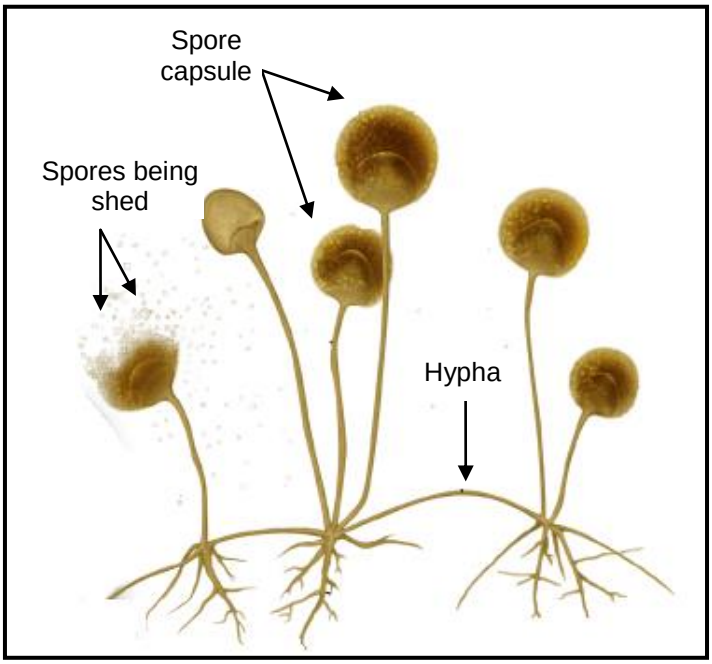
Fungi reproduce sexually or asexually, or both depending upon the species and environmental conditions. As the name implies, sexual reproduction is the result of the union of two spores.

Fungi reproduce by the production of **spores**. The spores are produced from special parts known as **sporangia***.

Spores are produced asexually. In many ways they are very similar to very tiny seeds.

They are so small that they are easily carried from place to place by gentle air currents. They can be found in almost every environment and are often extremely hard to destroy. Many of them can be boiled for an hour and still remain alive.

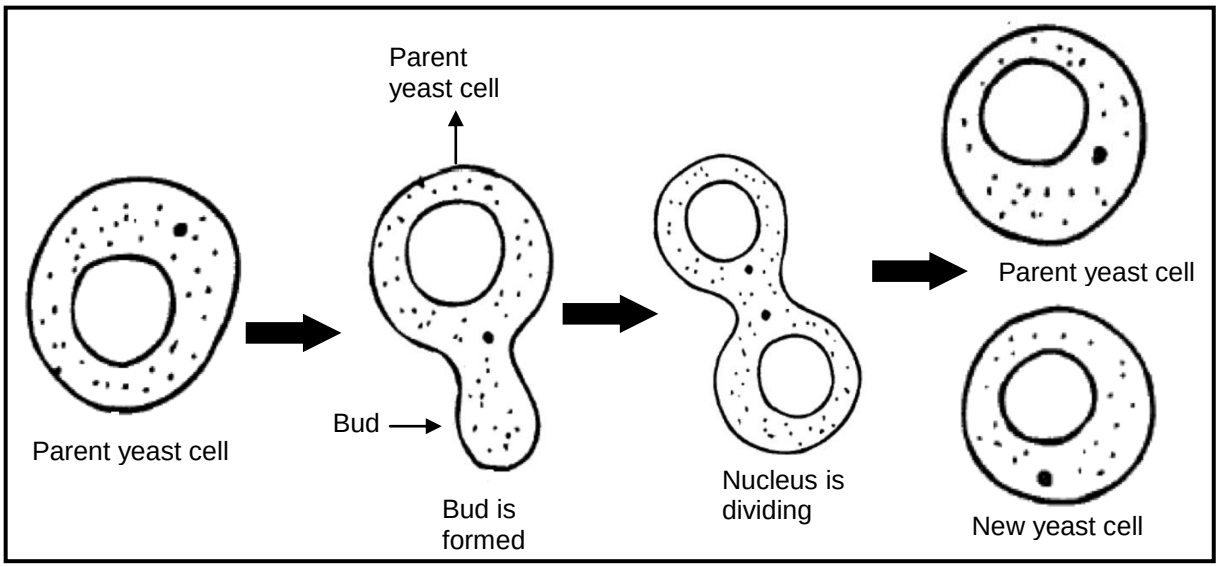
The picture on the right shows the reproduction of fungi through the production of spores.



Fungal spores

Some fungi reproduce asexually by **budding** which is a form of asexual reproduction in living organisms in which new individuals form from outgrowths (buds) on the bodies of mature organisms. These outgrowths grow by means of **mitotic cell division***. Many simple **multicellular*** animals such as hydras and **unicellular*** organisms such as yeasts reproduce by budding.

The diagram below shows the process of budding in yeast.

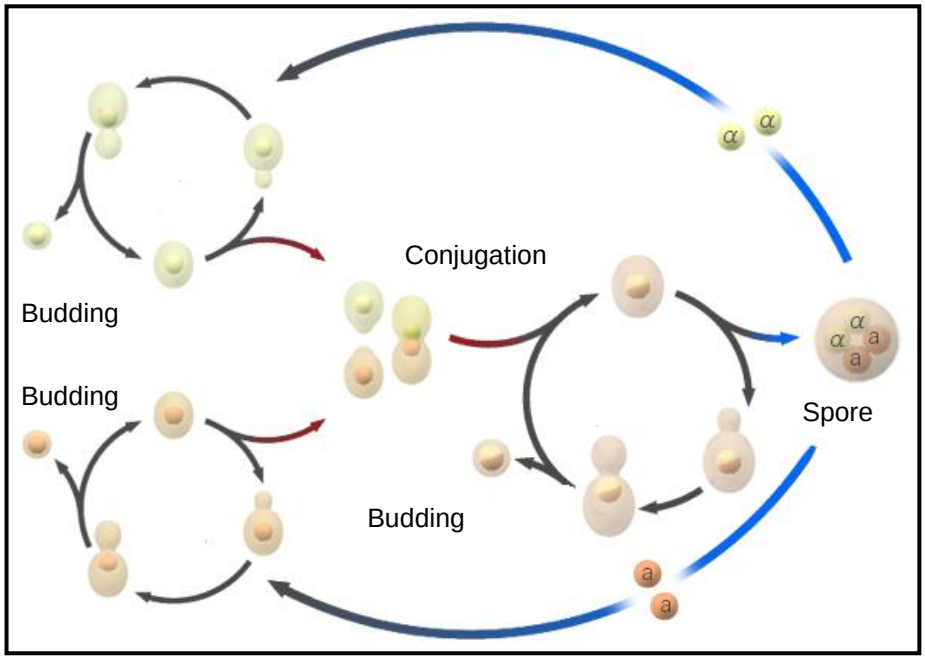


Budding in yeast

Sexual reproduction*may also occur in some fungi by **conjugation.**

Conjugation is a type of sexual reproduction in single-celled organisms, such as bacteria and some algae and fungi, in which two organisms or cells from the same species join together to exchange genetic material before undergoing cell division.

Conjugation between two yeast cells occurs when the fused contents divide twice to produce four individuals with a thick wall around each. These are the spores. The spores may be carried by wind and germinate under suitable conditions to produce new yeast cell.



Asexual and sexual reproduction in yeast

Four main kinds of Fungi

1. **Yeasts**

Yeast which is one of the simplest of fungi is an example of single-celled fungi. Yeast are normally saprophytes, though some species of yeast are parasites of plants and animals.

Examples:

- Saccharomyces cerevisiae – baker's or brewer's yeast
- Saccharomyces boulardii is a part of normal intestinal flora; available in pharmacies as probiotic, which can prevent antibiotic associated diarrhea.
- Pityrosporum ovale, a part of normal skin flora can be converted to a pathogenic form Malassezia furfur that cause tinea versicolor or ringworm infection of the skin.
- Candida albicans is normally present in the mouth, esophagus, bowel and vagina; if it overgrows, it may cause oral thrush, esophageal, bowel or vaginal yeast infection; usually only in persons with lowered immune system. If candida invades the blood, it may cause life threatening systemic candidiasis.
- Cryptococcus neoformans can cause cryptococcosis or cryptococcal meningitis (an infection of the brain membrane)

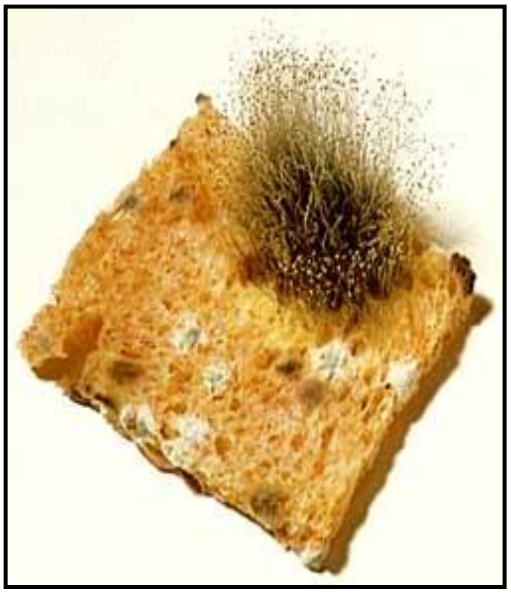
2. **Moulds** are multi-cellular fungi, which have irregular shape.

Common examples are:

- Penicillium which was originally used to produce antibiotic penicillin; also used in production of cheese
- Aspergillus commonly contaminates starchy foods, corn (maize) and peanuts; certain species of Aspergillus secrete mycotoxins that can cause miscarriages, inborn defects, liver cancer. Aspergillus may also cause aspergilloma (fungus ball) in lungs or paranasal sinuses.
- Mucor causes mucormycosis. which is a serious but rare fungal infection

- Rhizopus molds appear on old bread, decaying fruit and vegetables, and feces.

Bread mould fungus is found on the surface of most soils and since it is a decomposer, it produces fertile soils. But bread mould is a nuisance when it makes bread go moldy. Several species of mould will begin to grow on the bread; normally they would be blue-green in colour.



Rhizopus molds on bread

However, the common black bread mould will take over from these other moulds. The black mould quickly sprouts hyphae which grow into white fluffy clusters of filaments. These filaments in turn produce thousands of black spores, eventually causing the surface of the bread to turn black.

A term **mildew** refers either to certain kinds of mold or to mold growth on plants, walls, leather, paper, and clothes.

Mildew (mold growth) on the ceiling and walls

3. **Mushroom i**s a type of fungus, is usually shaped like an umbrella, many of which are edible

4**.** **Toadstool** is any of several mushroom-like fungus,some of which are poisonous.

Mushrooms and toadstools are large enough to be seen by naked eyes.

.

Small toadstool mushrooms

Fungi mushroom (Psilocybe zapotecorum)

.

Activity 2: Now test yourself by doing this activity.

Write True if the statement is true and False if the statement is false on the space provided.

1. _____ Yeast cell is a very important microbe in alcohol production and baking industries.
2. _____ Fungi reproduce by the production of spores.
3. _____ The spores are produced from special parts known as hypha
4. _____ Black mould on bread is caused by bacteria
5. _____ Spores are produced asexually

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 3.

Importance of fungi

As you learnt earlier in this lesson, some fungi such as the penicillium fungus are used as medicines for curing many diseases. Also Cortisone is a drug which is made with the help of the mould called rhizopus. **Cortisone** is used in the treatment of rheumatism and other diseases.

Fungi as food

Yeast cells that rely on sugar as an outside food source, break down the sugar in the process called **fermentation**, producing alcohol, carbon dioxide and energy. These products make the yeast cell a very important microbe in alcohol production and baking industries. The carbon dioxide causes the dough to rise and produces little air holes that make the bread light and fluffy. One species of fungi is also used in cheese making. Some mushrooms are edible, but others are poisonous. Yeast are often used in dried form as food, example vegemite, and marmite.

Fungi as decomposers

Fungi decompose dead plant and animal matter. The decomposed materials provide important nutrients for the soil.

Fungi as parasites

Fungal parasite on plants can cause serious effects, indirectly to humans. We have already mentioned taro blight, coffee rust and also black pod disease on cocoa pods caused by a fungus.

Coffee rust on coffee and black pod disease on cocoa has been a serious fungal problem in these two cash crops in the eighties and nineties. Fortunately, with latest research taking place, these cash crops can now be protected by spraying them with fungicides which are chemicals that kills fungi.

The most common fungal parasite which attacks people is ‘athlete’s foot’. This causes damp, peeling skin between the toes. Another common parasite is the ringworm fungus, which also affects the skin, causing it to itch and go scaly. These infections can now be easily treated with fungicidal powders.

Activity 3: Now test yourself by doing this activity.

Observing Bread Mould

What you need: a slice of bread, a dish

Do this:
Place a slice of bread in a dish. Place the dish on a shelf in a dark, warm damp place (example, under the kitchen sink). Then each day afterwards note the colour of moulds that develop on the bread. Do this for about a week.

Record your observations on the change of colour of the fungi. You should be able to observe three types of colour changes.

_____
_____
_____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 3.

Summary

You have come to the end of Lesson 3.In this lesson you have learnt that:

- fungi are important in the process of decay because they recycle nutrients in nature.
- yeast is important in the process of fermentation and is used to make bread, beer and wine.
- the antibiotic penicillin is made from the fungus penicillium.
- the products of fermentation process are alcohol, carbon dioxide and energy.
- fungi are useful in areas like food, drinks, medicine, and recycle of nutrients.
- fungi are also harmful like causing sickness to humans, plants and animals and they are also parasites to other plants and animals.

NOW DO PRACTICE EXERCISE 3 ON THE NEXT PAGE.

Practice Exercise 3

Briefly answer the following questions.

1. What is parasitism?

   _____
   _____

2. What are saprophytes?

   _____
   _____

3. Fungi reproduce by the production of _____

4. What are the three (3) products of fermentation?
   (i) _____
   (ii) _____
   (iii) _____

5. Name three (3) fungal parasites of plants.
   (i) _____
   (ii) _____
   (iii) _____

6. Name two (2) common fungal parasites, both affecting the skin.
   (i) _____
   (ii) _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 1.

Answers to Activities

Activity 1

1. No
2. Yes
3. Penicillin
4. For feeding

Activity 2

1. True
2. True
3. False
4. False
5. True

Activity 3

(i) blue-green colour
(ii) light brown to grayish colour
(iii) black colour and sprouts hyphae which grow into white fluffy clusters of filament

Lesson 4: Algae

Welcome to Lesson 4. As we said in the previous lesson fungi is one group of microbes which are mostly plants. Some fungi are quite large like mushrooms while others are very small like moulds and yeasts which can only be seen through a microscope. Some fungi are useful and used as food and medicine while others cause diseases to plants, animals and human beings. So in this lesson, we will also discuss another group of microbes called Algae.

Your Aims:

- define algae as a phytoplankton, motile, hyphae and diatoms
- identify the types of algae and their characteristics
- classify groups of algae
- state the reproduction of algae
- state the importance of algae in the food chain

Algae

Algae (singular: alga) are simple plants, without roots, stems or leaves. The word algae comes from the Latin word ‘alga’, some types of algae are seaweeds. Unlike fungi, they contain chlorophyll and so can carry out photosynthesis. They live everywhere that water is found, such as ponds, puddles, rivers, lakes, seas and wet soils. Some even grow in hot springs at temperature as high as 90ºC.

Algae play very important roles in many food webs since many algae are very rich in proteins and other nutrients, all of which are needed by animals to survive. Some forms of marine algae make up a large part of the free floating microscopic life in water called **phytoplankton**, which is the main food for a lot of marine life, including some whales. Some algae are very large like the seaweeds, but many are microscopic and are therefore classified as microbes. Some of these microscopic algae are single celled and others are many celled.

Sometimes, algae occur in such great abundance that the landscape becomes coloured by the pigments in their cells. Often masses of algae float close to the surface of the water where there is sunlight available for photosynthesis, causing the surface of the water to become coloured, usually green.

Algae are the most important photosynthesizing organisms on Earth. They capture more of the sun’s energy and produce more oxygen than all plants combined.

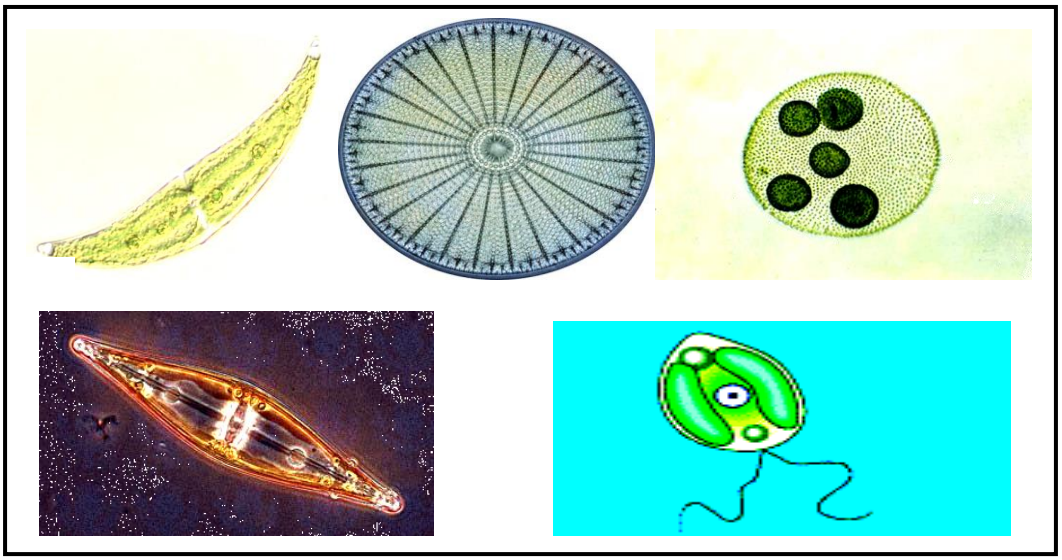
- **Algae vary greatly in size and grow in many diverse habitats. Microscopic algae, called phytoplankton, float or swim in lakes and oceans.**
- **Phytoplankton is so small that 1000 individuals could fit on the head of a pin.**

Algae characteristics

Many algae consist of only one or single cell. They may be spherical, rod-shaped or variations of these designs.

Other species of algae form **colonies*** up of which are made ball of cells and others of cell making up strands. Some colonies are groups of singles identical cells cling together.

Some species of algae are composed of different kinds of cells whose different kinds of activities are good for the whole colony.



Single-celled algae and algae colonies

Motility

Many algae are **motile**, which means that they are capable of instinctive or automatic movement. They have thread or hair-like structures called **flagellae*** (singular: flagellum) which they use to whip their way through the water. Algae with flagellae belong to a group called **dinoflagellates***.

Below are some examples of dinoflagellates. Note the very fine thread-like flagellum on each of the algae.

Dinoflagellates

Activity 1: **Now test yourself by doing this activity.**

Answer the following questions.

1. What is a phytoplankton?

   _____

2. What causes the surface of the water to become coloured, usually green?

   _____

3. Many algae are motile, what does this mean?

   _____

4. What are colonies?

   _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 4.

Algae classification

Some of the main algal classifications are by colour.

Green algae are name for their green chloroplasts, which are similar in composition to the chloroplasts found in land plants. They are very often seen on the surface of the ponds and moving water.

Green Algae

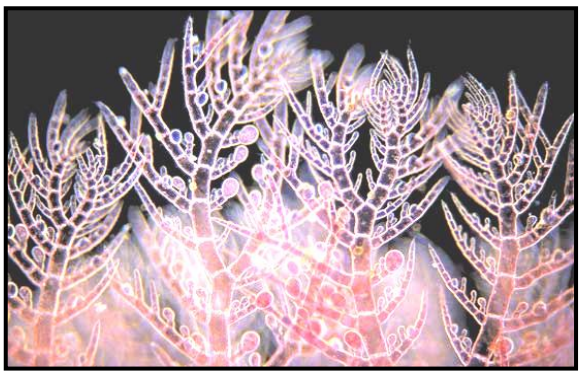
Green algae range in shape from plankton that grows in lakes and oceans to colonial filaments to leaf like seaweeds that grow along rocky and intertidal areas.

Some green algae also live on tree trunks and soil. Green algae may also be found inside fresh water sponges, giving the sponges a bright green colour

Red algae are usually found living in total submerged, not even exposed to air at low tides.

Almost all red algae live in marine habitats, although some species are found in fresh water or damp soil.

Many types of seaweed are red algae, typically found growing along the coast and attaching firmly to the sea floor using a root like hold fast.



Red Algae

Some red algae absorb lime from sea water into their tissues. This results in deposition of lime in ocean and plays a part in the formation of coral reefs.

Blue-green algae

Blue-green algae are the simplest and probably the oldest group of plants. They occur mainly in fresh water and on moist land. Many of these plants are found in phytoplankton.

Brown algae are marine living plants; many are hundreds of metres long. Many of this group, such as kelps (also known as brown seaweeds) is used as food by man and other animals.

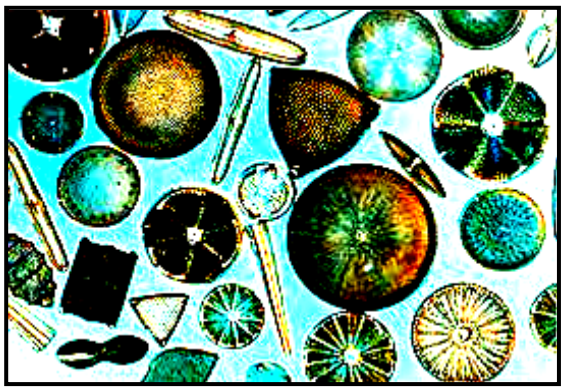
Brown algae

Giant Kelp
The largest of all marine plants, the giant kelp grows to a length of over 60 metres.

Commonly called sea weed, the giant kelp and other kelp species differ from the advanced plants in lacking true leaves, stems, roots and a vascular system for transporting water and nutrients.

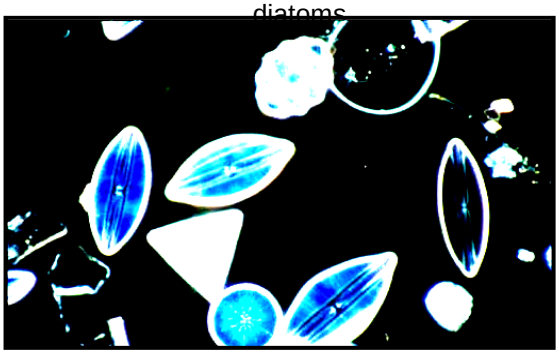
The giant kelp and other kelp species are a staple food in Japan and other areas. Substances extracted from kelp are used in the manufacture of ice cream, cosmetics and other materials.

Yellow-green algae include the single-celled algae group known as **diatoms**, which are found in fresh, and seawater and moist soil. Diatoms are an abundant food source for marine life. The picture on the right shows samples of different diatoms of different shapes.



Different types of diatoms

Diatoms are a type of micro-organism. They are single-celled and have a cell wall made of silica, which is essentially glass. Diatoms make up a large proportion of planktons, which float near the surface of the sea. They are sources of food for much sea life.

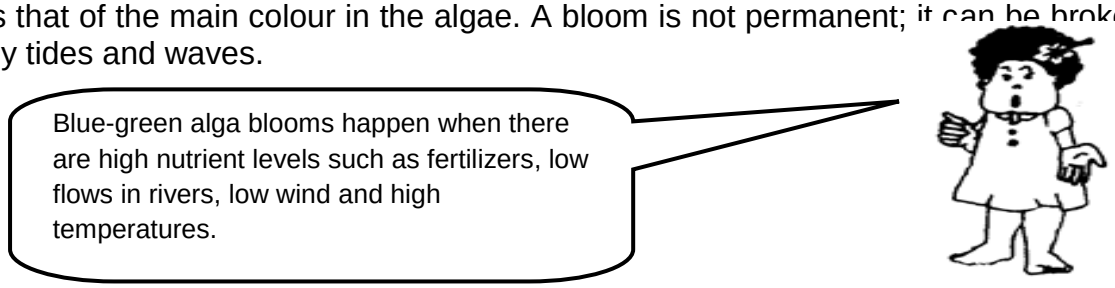


Diatoms

Discoloured water
One of the most interesting effects of algae is the discolouration of water.

For centuries, sailors have been puzzled by the appearance of patches of red, brown, yellow and other colours in the sea. We know that this discolouration is due to the activities of algae.

A **bloom** is the appearance of highly coloured phytoplankton. The colour of the water is that of the main colour in the algae. A bloom is not permanent; it can be broken up by tides and waves.



The picture on the right is an example of a blue-green algal bloom at Darling River System in Queensland between October – November, 1991.This bloom impacted greatly on water supplies, agriculture, fish and aquatic animals, tourism and recreation.

Reproduction

Some algae reproduce sexually and others asexually. Most asexual reproduction involves the production of single-celled spores, many of which have flagella and can move themselves. In sexual reproduction, in the more evolved species, the sex cells become characteristically male and female. The female egg is large and non-motile, whereas the male sperm cells are actively motile.

Blue-green algal bloom

Activity 2: **Now test yourself by doing this activity.**

Briefly answer the following questions.

1. What is an algae bloom?
   _____

2. Name three (3) causes of algae blooms.
   (i) _____
   (ii) _____
   (iii) _____

3. Algae is classified in groups based on its _____.

4. Diatoms are part of which algae group? _____.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 4

Importance of Algae
Some green algae which have high protein content are cultivated and used as food source and brown algae – kelps are used as food by people and other animals. Furthermore, some algae are rich in iodine, a chemical element, which is a nutrient for many living things.

Three further examples of the important uses of algae are listed below.

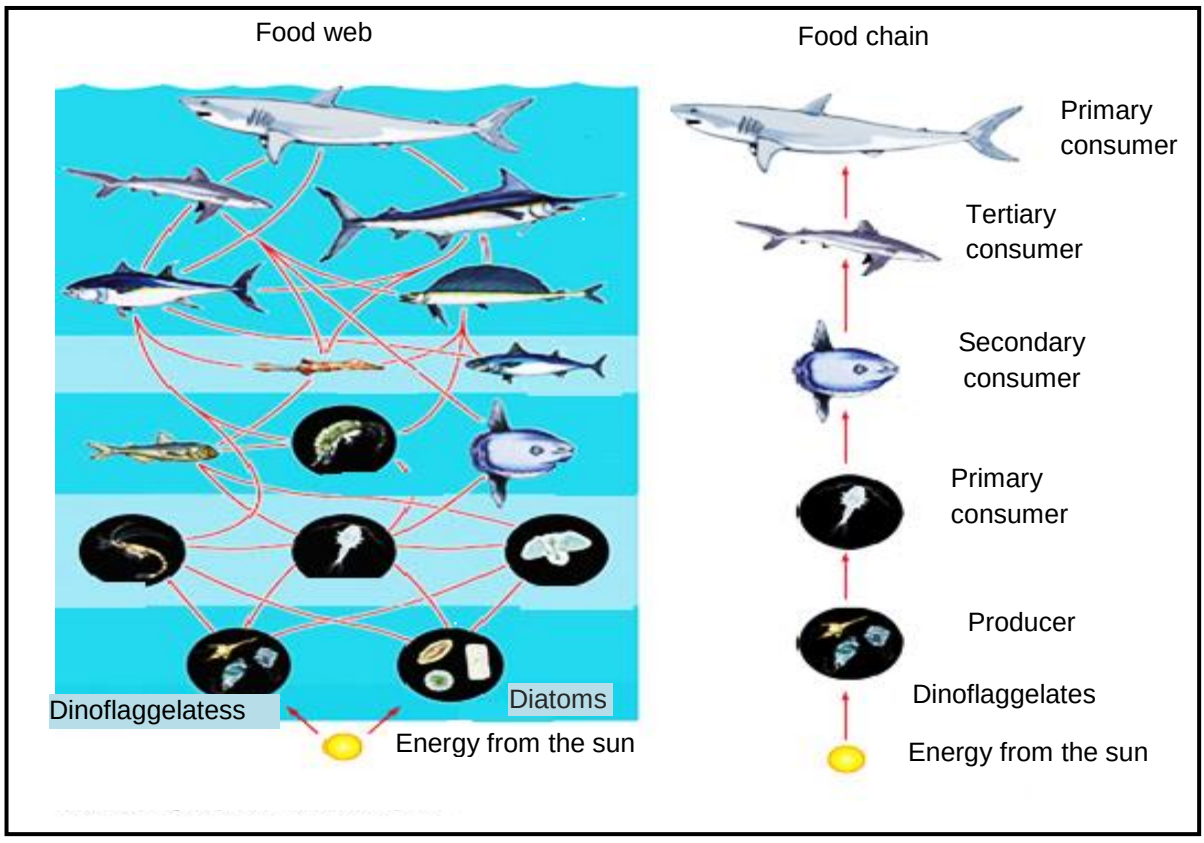
Soil fertility
Some blue-green algae which live in soil are able to extract nitrogen from the atmosphere, thus making the soil more fertile.

Chemical extraction
As a source of chemicals some algae are rich in bromine, potassium and iodine which was mentioned earlier,. These and other chemicals are obtained from marine algae.

Fertilizer source
In many countries where the large red and brown algae are plentiful, they are used as fertilizers. For example, France uses 3 million tonnes of these algae per year for this purpose.

Importance of algae in the food chain
Algae form organic food molecules from carbon dioxide and water through the process of photosynthesis, in which they capture energy from sunlight. Similar to land plants, algae are at the base of the food chain, and the existence of non - photosynthetic organisms is dependent upon the presence of photosynthetic organisms.

The diagram below represents a marine food chain and food web.



Nearly seventy five percent (75%) of Earth is covered by water, and since the so-called higher plants are virtually absent from the major water sources (example, the oceans), the existence of nearly all marine life including whales, seals, fishes, turtles, shrimps, lobsters, clams, octopuses, starfish, and worms—ultimately depends upon algae.

In addition to making organic molecules, algae produce oxygen as a by-product of photosynthesis. Algae produce an estimated 30 to 50 percent of the net global oxygen available to humans and other terrestrial animals for respiration.

Algae, primarily diatoms, dinoflagellates, and coccolithophorids, which are often collectively called phytoplankton, are the base of the food chain for all marine organisms.

Summary

You have come to the end of lesson 4. In this lesson you have learnt that:

- algae are simple plants without roots, stems or leaves.
- phytoplankton is some form of marine algae that make up a large part of the free floating microscopic life in water.
- many algae consist of only one cell and may be spherical, rod-shaped or variations of designs.
- the main algal classifications are by its colour.
- algae reproduce by both sexually and asexually.
- phytoplankton is the base of the food chain for all marine organisms.
- the important uses of algae are for food, soil fertility, chemical extraction and fertilizer source.

NOW DO PRACTICE EXERCISE 4 ON THE NEXT PAGE.

Practice Exercise 4

A. Write True if the statement is true and False if the statement is false on the space provided.

1. _____ Algae are plants with roots, stems and leaves.

2. _____ Green algae are named for their green chloroplasts.

3 _____ Algae are the base of the food chain for all marine organisms.

4. _____ Algae reproduce asexually only.

B. Answer briefly the following questions.

1. What are the three (3) important uses of algae?

(i) _____
(ii) _____
(iii) _____

2. Sea weed is used as food by man and other animals. Which algal group does it belong to? _____

3. What are flagella? _____

4. Algae with flagella belong to a group called _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 1.

Answers to Activities

Activity 1

1. Phytoplankton is microscopic algae that freely float on water
2. When masses of algae float close to the surface of the water where there is sunlight available for photosynthesis
3. This means that some algae are capable of instinctive or automatic movement
4. Colonies are made up of ball of cells or groups of single identical cells cling together

Activity 2

1. Is the appearance of highly coloured phytoplankton
2. (i) high nutrient levels
   (ii) low flow in rivers
   (iii) low wind and high temperature
3. Colour
4. Yellow-green algae

Lesson 5: Protozoa

Welcome to Lesson 5. In the last lesson you learnt about a group of microbes called Algae. These microbes are simple plants without roots, stem or leaves. In this lesson you will learn about another group of microbes, the Protozoa.

Your Aims:

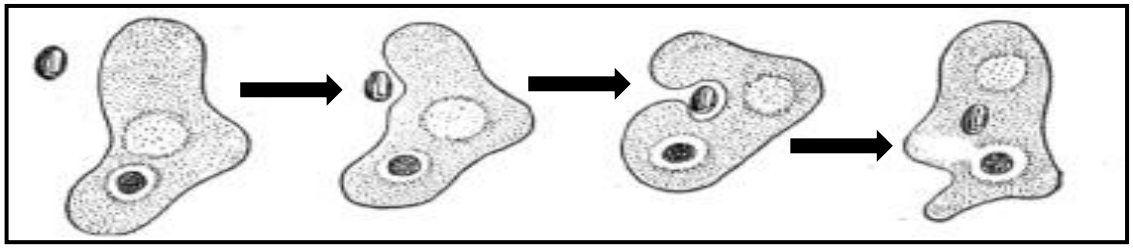
- define protozoa, cilia and flagella
- state the types of protozoa
- state the functions and movement of protozoa
- explain reproduction of protozoa
- identify disease-causing protozoa

Protozoa

Protozoa (say ‘pro-toe-zoe-a’, singular: protozoan) unlike fungi and algae, are tiny animals. Their name derived from the Greek words ‘protos’ and ‘zoan’ which means ‘first’ and ‘animal’. They are the most simplest of all animals and consists of only one cell. Some are harmless, some useful, while others cause diseases.

There are about 30 000 kinds of protozoa, varying in shape and structure. A few protozoa can reach a length of 0.25mm, and can be just seen with the naked eye. Others can only be seen with a microscope.

Most protozoa live in water, in the sea, in streams, in the fresh water of ponds and in moist soil. Some are parasites and live in bodies of other animals. These parasites surround some of the animal’s cells and absorb them to obtain their food. This process is shown diagrammatically below.



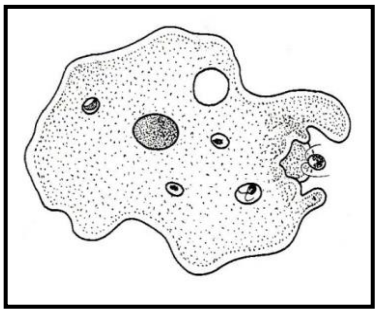
A protozoa surrounding and then absorbing a cell

Protozoa classification

Most Protozoa are able to move by themselves and are divided into four classes according to the way they move.

1. Movement by changing body shapes
   The simplest are the **amoeba**, which achieve movement by changing their shape by sending out bits of their bodies in one direction after which the whole cell follows. Amoeba get their name from the Greek word ‘amoibe’ which means ‘change’, they are continually changing the shape of their bodies.

Here is how an amoeba, a type of micro-organism, is enclosing a smaller microorganism and feeds on it. Once it has enclosed it, the amoeba will then use its enzymes to break down, or digest, the smaller organism so that it can absorb what is left. This is how amoebas feed. The picture on the left shows an amoeba feeding.

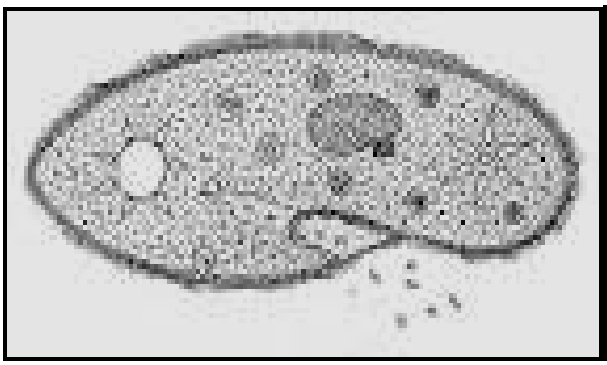


Amoeba feeding

2. Movement by using cilia

A more complex group of protozoa has rows of many small hair-like structures called **cilia** on their surface. The cilia can beat rhythmically in both forward and backwards directions propelling them through fluids.

These protozoa are called **ciliated protozoa**. The protozoa known as the paramecium shown below, moves in this way.



A paramecium

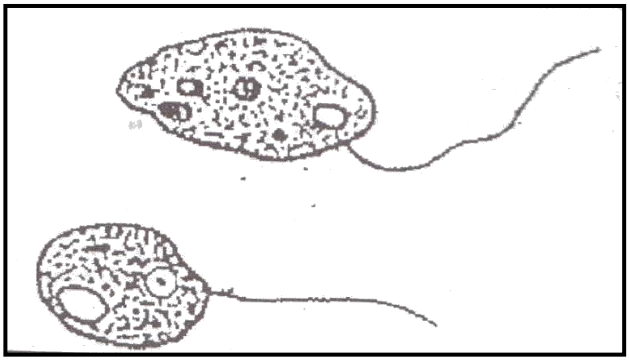
A ciliated protozoa

Ciliated protozoans are single-celled organisms that are propelled by minute or tiny hairlike projections called **cilia**. In addition to locomotion, cilia also create currents that help sweep food particles into a small depression in the body surface through which food is ingested. Ciliated protozoans can be found in water or soil and in parasitic or symbiotic relationships with other organisms. In soils, ciliated protozoans function as decomposing organisms, breaking down organic matter into substances that can be used by other organisms.

3. Movement by flagella. **Flagellated protozoa** move by using their flagella. They use these hair-like structures for propulsion (movement).**Monads** have a single flagellum, as do some other types of protozoa, but others have many flagellae.

4. Non-motile protozoa

The fourth class of protozoa usually has no means of movement in the adult stage and is all parasites. One example of this class of protozoa is the disease causing plasmodium in human bodies and also transmitted by mosquitoes causing malaria.



Monads move by using a single flagellum

Activity 1: Now test yourself by doing this activity.

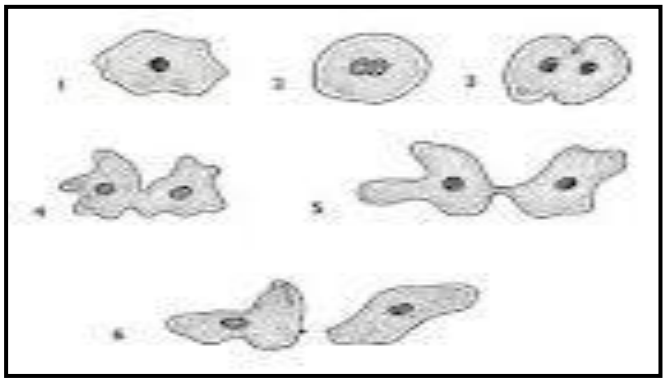
Write True if the statement is true and False if the statement is false on the space provided.

1. _____ Most protozoa live in the bodies of human beings and animals.
2. _____ Protozoa move by changing body shapes
3. _____ Some protozoa are plants and can make their own food
4. _____ Protozoa are animals.
5. _____ Protozoa is consist of only one cell.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 5.

Reproduction

Some protozoa, for example amoeba, reproduce asexually when they get too large to function normally. The cell splits into two halves.



Amoebic reproduction

Some protozoa reproduce sexually. Paramecia (the singular to paramecium) reproduce sexually when two individual organisms fuse (join together), interchange material and then separate.

The process is known as **conjugation**.

Further division of these two organisms then takes place, each producing four new organisms.

Conjugating paramecium as seen under the microscope(x100)

The ability to undergo sexual reproduction is confine to ciliates.
Example: paramecium
Sexual reproduction among the ciliated protozoans takes the form of conjugation.

Asexual reproduction is the most common means of replication by protozoans

Cysts

Many protozoa can survive when water dries up by forming protective **cysts** bag-like structures around themselves. Inside the cysts the protozoan reproduces by dividing into two. When conditions improve, the cysts break open and many new protozoa are released.

Disease causing protozoa

Several species of protozoa are responsible for causing diseases such as diarrhea, dysentery and 'sleeping sickness' which is found in Africa and is transmitted by the bite of the tse-tse fly.

Malaria, which is transmitted by the female anopheles mosquito, is caused by protozoa known as **plasmodium**. When biting a person, the mosquito injects the plasmodium. These reproduce and destroy a person's red blood cells, resulting in chills and fever and often death. You will learn more about malaria in Topic 4 of this unit.

Anopheles mosquito biting through the skin of a person

Activity 2: Now test yourself by doing this activity.

Answer the following questions.

1. What is the name of the simplest type of protozoa?

   _____

2. How does Amoeba reproduce?

   _____

3. Where do most protozoa live?

   _____

4. What type of protozoa transmits sleeping sickness found in Africa.

   _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 5.

Importance of protozoa

One interesting species of flagellated protozoa is able to digest wood cellulose. These tiny creatures live in the intestines of termites. The termites, by themselves, are unable to digest wood cellulose. These protozoa digest the cellulose and convert it into carbohydrates which are easily digested by termites. Another species of flagellated protozoa is, indirectly, an important food source for people. Initially, these protozoa are eaten by mollusks, such as clams and mussels, which in turn are eaten by people.

Summary

You have come to the end of lesson 5. In this lesson you have learnt that:

- protozoa are the simplest of all animals and consist of only one cell.
- most protozoa live in water, in the sea, in streams, in the fresh water ponds and in moist soil.
- protozoa are classified into four classes according to the way they move.
- protozoa reproduce by both sexually and asexually.
- malaria which is transmitted by the female anopheles mosquito, caused by protozoa known as plasmodium.

NOW DO PRACTICE EXERCISE 5 ON THE NEXT PAGE.

Practice Exercise 5

Answer the following questions.

1. What characteristic divides protozoa into four different classes?
   _____

2. (a) What are cilia? _____

   (b) What are cilia used for?
   _____

3. Which one of the following belongs to the class of flagellated protozoa?
   Monads Paramecium Plasmodium Amoeba

4. One class of protozoa usually which are all parasites has no means of movement in the adult stage.

   (a) Name one type of these protozoa. _____

   (b) What disease is transmitted by the female anopheles mosquito?
   _____

5. Some protozoa reproduce sexually when two individual organisms join together, interchange material and then separate. This process is known as _____.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 1.

Answers to activities

Activity 1

True or False Questions

1. False 2. True 3. False
4. True 5. True

Activity 2

1. Amoeba
2. By asexually
3. They live in water, in the sea, in streams, in fresh water ponds and in moist soils
4. By the bite of the tse-tse fly

Lesson 6: Bacteria

Welcome to Lesson 6. In the previous lesson you learnt about Protozoa. Protozoa is one group of microbes which are the most simplest of all animals and consists of only one cell. In this lesson you will also learn about another group of microbes, the bacteria.

Your Aims:

- define bacteria, dipplo, strepto and staphylo
- identify the types of bacteria
- describe the cell arrangement of bacteria
- explain how bacteria reproduce
- identify food source and growth of bacteria
- identify disease-causing bacteria
- state the importance of bacteria in life

Bacteria

Bacteria (singular: bacterium) are very important micro-organisms. The word bacterium comes from the Greek word ‘bakterion’ which means a little rod or stick.

Bacteria seem to be among the first organisms to evolve on planet earth after life originated around 3.5 billion years ago and were the only organisms on earth for almost the next two billion years.

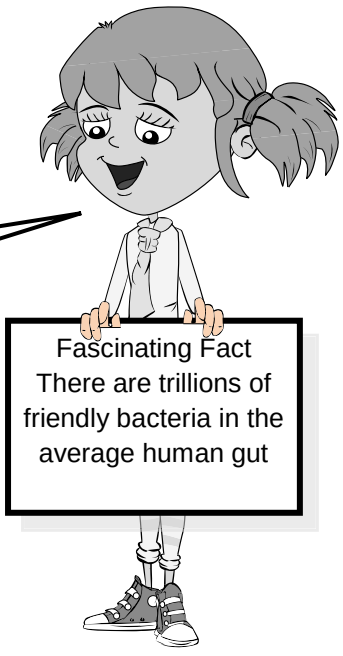
Bacteria are very small single-celled organisms. They are extremely small and are among the smallest living cells. They range in size from about 0.0001mm to about 0.0005 mm. To see a single bacterium, a microscope with a magnifying power of at least 600x is required.

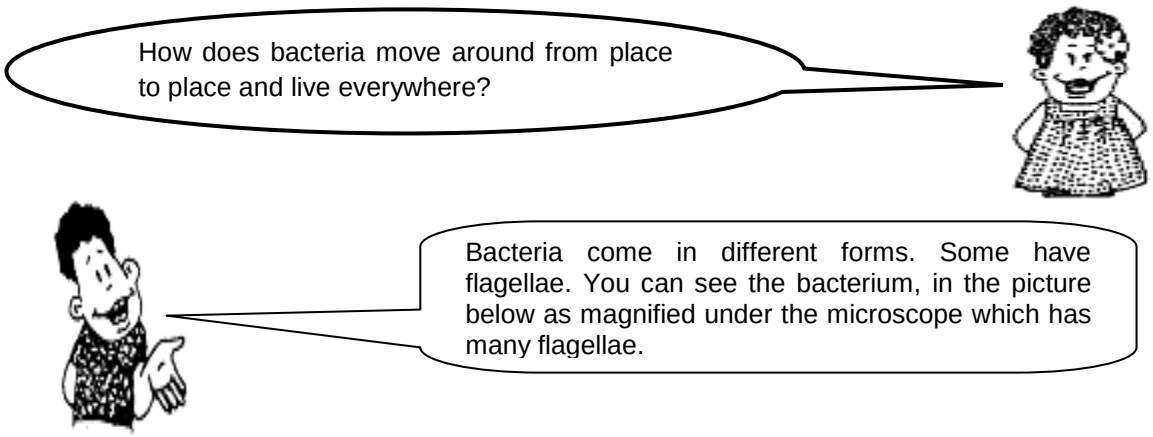
They have been found everywhere, in the depths of the ocean, in the upper layers of the atmosphere and in the ice sheets at the Poles. Bacteria exist in huge numbers

A normal person’s skin may have more bacteria on its surface than there are on human beings living on Earth.

A single grain of soil may contain 2,000,000 to 100 million bacteria, depending on the type of soil. The air in a town may have about 40 000 bacteria per cubic metre, mostly do dust particles.

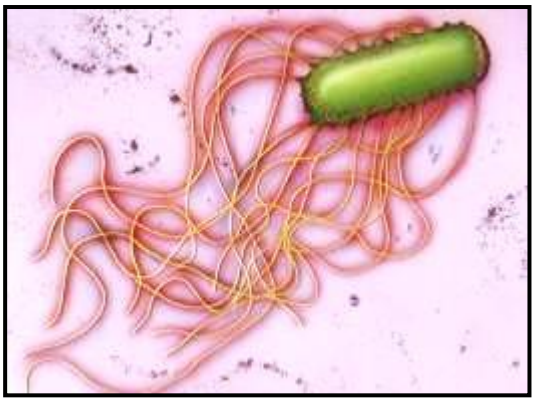
Did you know?
The average adult carries approximately 2kg of good microbes in their guts – the same weight as 2 bags of sugar!





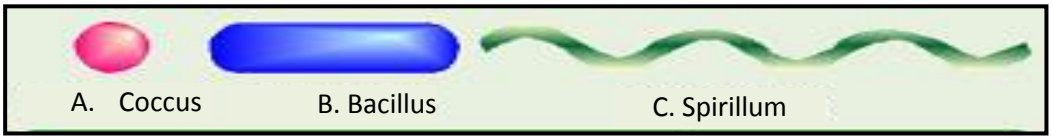
Many types of bacteria are not able to move on their own. Some, like Salmonella, are able to move. Thanks to the hair-like flagella on the outside of the bacteria cells. Different types of bacteria have different patterns of flagella.

They can be just at one or both ends, or all over the cell's surface. By rotating the flagella, the bacteria can move forwards, or tumble without moving forwards



A bacterium with many flagellae

Bacteria are classified according to the three basic shapes. They are rod-shaped, sphere-shaped and spiral-shaped (corkscrew shape). In the illustration below you can see examples of these three basic shapes of bacteria.



Different shapes of bacteria

The scientific name for the sphere-shaped bacteria, like the ones shown in A above is **cocci** (singular: coccus)

The name given to the rod-shaped bacteria is **bacilli** (singular: bacillus). Some of these rod-shaped bacteria are shown in B in the illustration.

The spiral-shape bacteria, shown at C of the illustration are called **spirilla** (singular: spirilium).

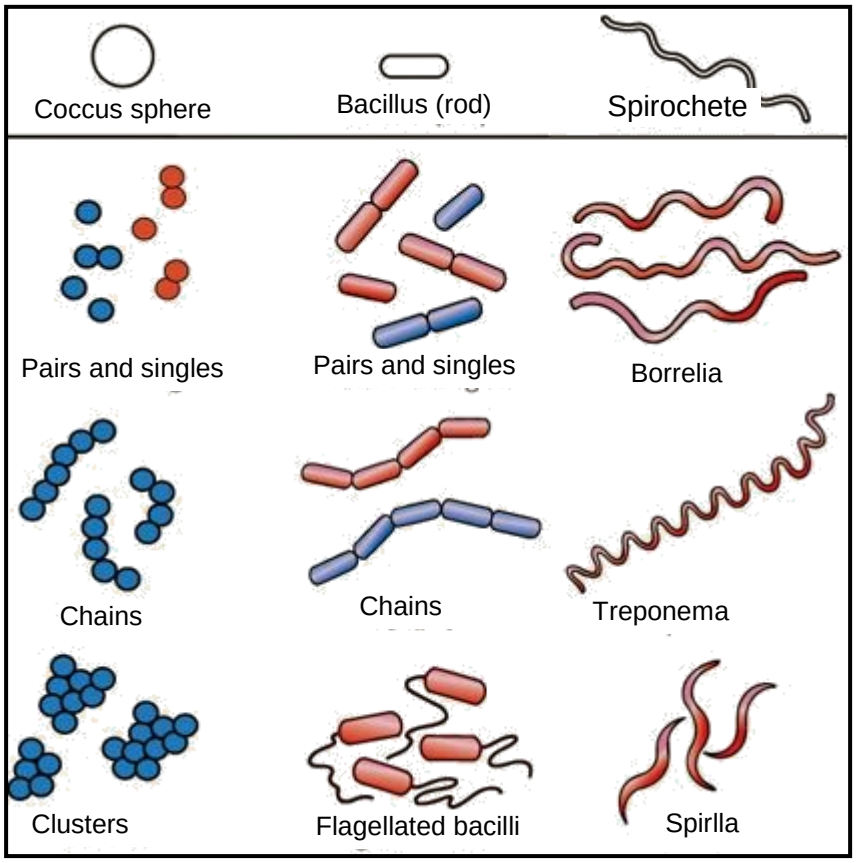
Cell arrangement

Bacteria can exist as single cells, in pairs, in chains and in clusters. These arrangements are named by the following **prefixes**, a prefix is a word put in front of another word to change its meaning.

(i) **Dipplo** means double. It is used to describe a pair of cells attached to each other, so dipplococci refers to a pair of sphere-shaped cells.

(ii) **Strepto** means a chain. It describes cells linked together in a chain-like formation, forming long strands, like a string of beads. Streptococci, which cause sore throats, therefore are chains of sphere-like cells.

(iii) **Staphylo** means a cluster. It refers to cells attached to each other in a cluster of bunch, so staphylococci, which cause boil, is a cluster or clump of sphere-shaped cells.



Bacterial cell arrangement

Activity 1: **Now test yourself by doing this activity.**

Answer the following questions.

1. Bacteria are classified according to three basic shapes. What are these three basic shapes?

   a) _____
   b) _____
   c) _____

2. Bacteria can exist as single cells, in pairs and in two other arrangements. What are these other two arrangements?

   a) _____

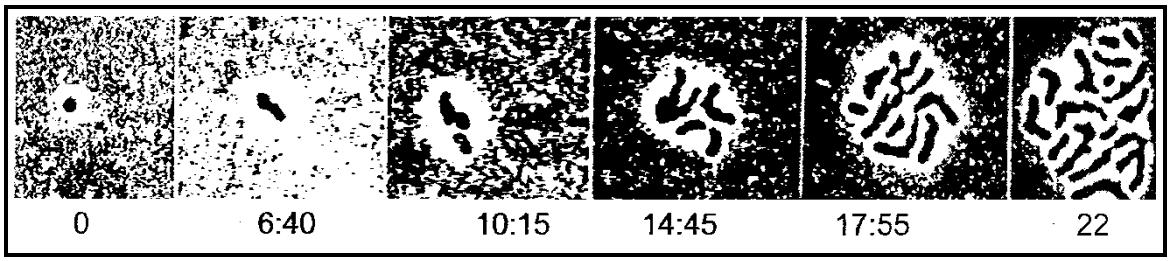
   b) _____

3. Some bacteria have hair-like substance called _____ which allow them to move around.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 6.

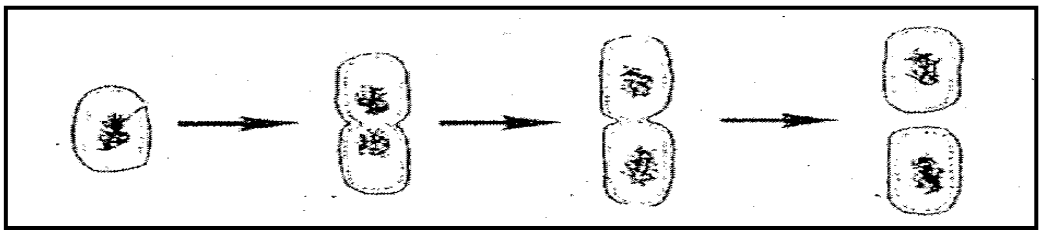
Reproduction

Bacteria usually reproduce asexually, by dividing in two by **binary fission**. This process can occur very rapidly.

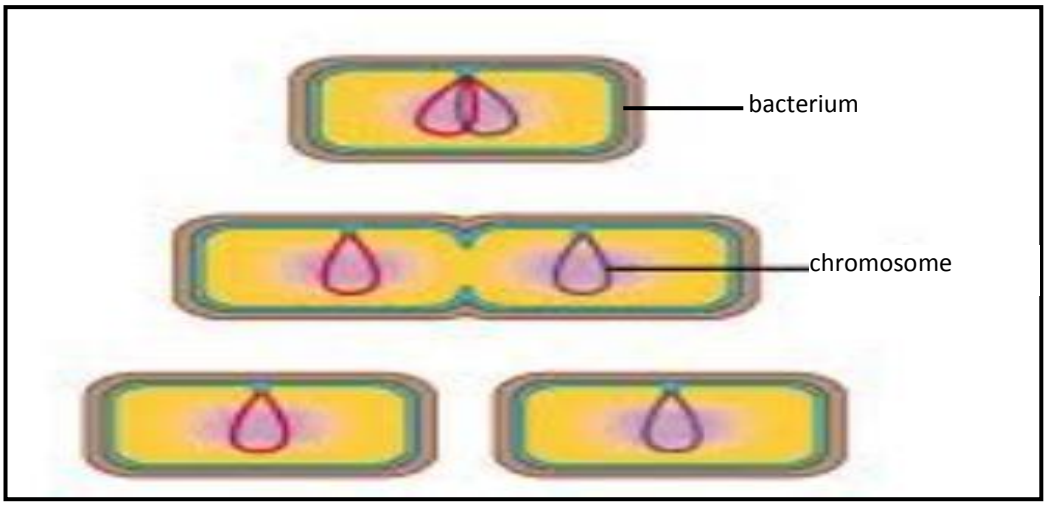


The growth of bacteria during 22 hours. The numbers below the pictures refer to the number of hours and minutes from the start of growth.

Many bacteria can reproduce every 20 minutes. They have the potential to produce huge populations in a very short time when the conditions for the growth are very good, such as warm, moist conditions and an adequate food supply.



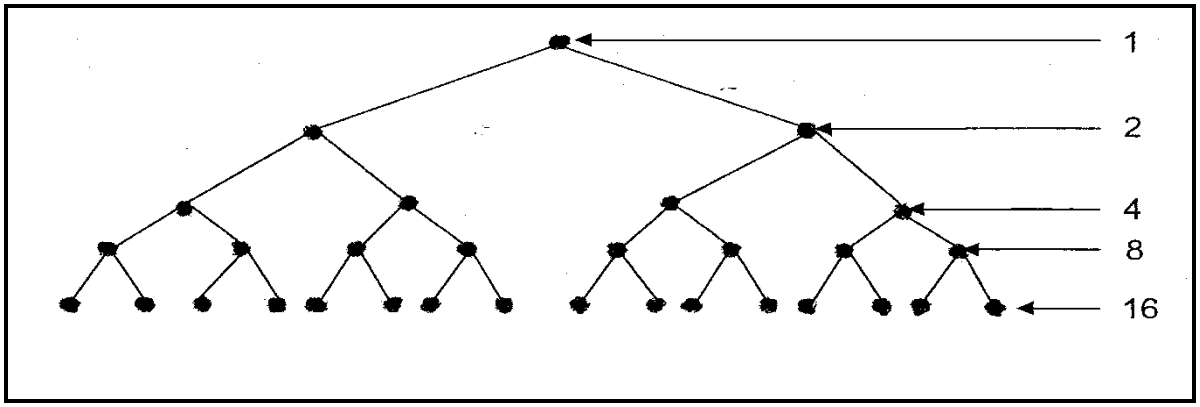
Cell division in bacteria



Binary fission

Each bacterium divides into two so that the bacterial population doubles with each generation. A bacterium on reproduction becomes two cells. These two bacteria on reproduction become four.

These four double to eight, the eight doubles of sixteen and so on. This is shown in the diagram below.



Bacterial reproduction

Thus the number of bacteria in each generation is given by the sequence:
1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048 and so on.

Conditions for bacterial growth
We stated previously that bacteria grow in warm conditions. You might wonder how bacterial growth occurs over a range of temperatures. Below is a table that describes what happens to the bacterial growth on food at different temperatures.

To give you some idea of how to compare these temperatures, some of the things that you are familiar with in everyday life are included at the table with the temperature range.

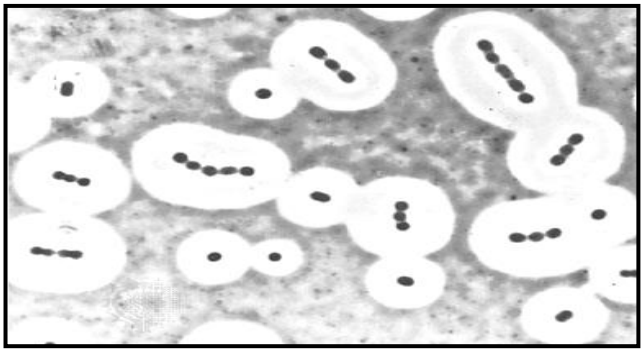
Temperature	**Bacterial growth**	**Comparative temperatures**
-30ºC to under -10ºC	Alive but not growing	Fridge ice box (-15ºC)
-10ºC to under -20ºC	Growing slowly	Main part of the fridge (-5ºC)
20ºC to under 40ºC	Growing and multiplying rapidly	Your body temperature
40ºC to under 70ºC	Some killed but a few survive	Very hot day (40ºC)
70ºC to under 110ºC	Almost killed	Boiling water (100ºC)
Over 110ºC	All killed	Long life milk is heated for 2 second prior to packaging (135ºC)

You can see from the above table that the bacteria grow best in food, in the temperature range, 20ºC to 40ºC. Over 110ºC all bacteria are killed.

Bacterial spores
When conditions are bad, example, no food, no water, too hot, bacteria form spores with a protective protein coating called **capsule**. These bacteria are described as **capsulated** bacteria.

The capsules are highly resistant to mechanical and chemical attack. Inside the capsule, bacteria may remain alive for many years until favourable conditions return, and then they immediately start reproducing and growing. For this reason, many bacteria are very difficult to kill.

On the right is a photograph of slime forming bacteria, greatly magnified. Note the large capsules (white areas) around each cell



Bacteria inside capsules

Food sources of bacteria
Most bacteria obtain food by breaking down organic material in much the same way as fungi do.

The bacteria's digestive chemicals break down the food and also release energy. The bacteria absorb this liberated energy directly or soluble products of digestion for further break down inside bacteria itself. Like fungi, many bacteria, especially those found in the soil are saprophytes. They feed on dead organisms causing decay. These decomposers are extremely important as the products of decay are then made available for other living things.

Activity 2: Now test yourself by doing this activity.

Answer briefly the following questions

1. How do bacteria usually reproduce?
   _____

2 Give three conditions that cause bacteria to reproduce very rapidly
   (a) _____
   (b) _____
   (c) _____

3. Many bacteria are called _____ since they feed on dead organisms, causing them to decay.

4. Bacteria grow best on food, in the temperature range from _____ to _____.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 6.

Disease causing bacteria

Many bacteria are parasites living on or within the bodies of other organisms. Many of them are **pathogens**. This means that they cause diseases in their host organisms.

Many serious diseases in humans are caused by bacteria. The classification table below shows some of the different types of bacteria and the disease they cause.

TYPE	APPEARANCE	EXAMPLES
Cocci (spheres)	Single cocci Diplococci Streptococci (chains) Staphylococci (clumps)	Bacterial pneumonia Scarlet fever Tonsilitis Gonorrhoea Boils
Bacilli (rods)	Single bacilli Diplobacilli Chains or bacilli Bacilli with flagella	Anthrax Bubonic plaque Diptheria Salmonella Tetanus Typhoid Tuberculosis (TB) Leprosy
Spirilla (spirals)	Simple spirilla Spirilla wth flagella Corkscrew type of flagella (spirochaetes)	Cholera Meningitis Jaundice Syphilis

Bacteria also cause diseases in other animals and in plants. You will read more about harmful bacteria in Topic 3 of this Unit. Although some bacteria are obviously harmful, it is important to realize that they form a very small part of the total bacterial population.

Importance of bacteria

Bacteria living in the soil, water, faeces, in sewerage systems and rubbish dumps all use wastes or dead organisms for their food and assist in the decaying process. They are also useful in many other ways.

Bacteria that live in the soil and also in special lumps or nodules on the roots of legume plants such as beans take in nitrogen from the air and provide the plant with nitrate that increase the fertility of the soil.

Bacteria are also used to manufacture products such as vinegar, dairy products like cheese, textiles and in the fermentation process like making wine, beer, bread etc. Bacteria are also use in the digestion of cellulose in the digestive system of animals.

You will learn more about useful bacteria in Topic 2 of this unit.

Remember, most bacteria are harmless. In fact, many of the bacteria provide great benefits to humans, other animals and plants.

Summary

You have come to the end of lesson 6. In this lesson you have learnt that:

- bacteria are very small single-celled organisms
- some bacteria are harmful, but most bacteria are useful
- bacteria can make plants and animals sick but they can also help to recycle nutrients and to improve soil fertility.
- bacteria are used to make bread, cheese, wine and beer, and to treat sewage
- bacteria are classified according to the three basic shapes.
- bacteria can exist as single cells, in pairs, in chains and in clusters.
- bacteria usually reproduce asexually, by dividing in two by binary fission.

NOW DO PRACTICE EXERCISE 6 ON THE NEXT PAGE.

Practice Exercise 6

A. **Write TRUE if the statement is true and FALSE if the statement is false.**

_____ (i) Bacteria have been found living everywhere, where life exists.
_____ (ii) Bacteria have single cell.
_____ (iii) Bacteria growth on food occurs very rapidly in temperatures over 100ºC
_____ (iv) Harmful bacteria form a large part of the bacterial total population.

B. **Answer the following questions.**

1. Bacteria may form spores protective protein coating called _____ when conditions are bad.

2. Many bacteria are pathogens. What does pathogen mean?
_____

3. (i) Bacteria in many plants take in nitrogen from the air. What substance does it provide to the plant?
_____

(ii) Why are these substances important?
_____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 1.

Answers to Activities

Activity 1
1. (a) rod-shaped bacteria (b) sphere-shaped bacteria
(c) spiral-shape bacteria
2. (a) in chains (b) in clusters
3. Flagella

Activity 2
1. Bacteria usually reproduce asexually, by dividing in two by binary fission.
2. (a) warm conditions (b) moist conditions (c) adequate food supply
3. Saprophytes
4. 20ºC to 40ºC

Lesson 7: Viruses

Welcome to Lesson 7. In the previous lesson you learnt about Bacteria, another group of microbes. Bacteria are known to be important small single-celled organisms. Most bacteria are harmless, and they provide great benefits to humans and other plants and animals. In this lesson, you will learn about Virus which is another group of microbes.

Your Aims:

- define virus
- state the characteristics of virus
- explain the reproduction of virus
- identify diseases causing virus
- identify how virus is transmitted

Viruses

Viruses (singular: virus) are the smallest of all microbes. Most viruses are much smaller than bacteria and can be seen only with the electron microscope. Virus means “slimy liquid or poison” in Latin. Viruses cause diseases in many cases.

The largest virus is smaller than the smallest bacterium. They can pass through filters that catch bacteria. After many studies, scientists have concluded that microbes or micro-organisms smaller than bacteria, which we now call virus, cause disease.

Virus can also attack plants and animals. For example, virus can attach tobacco plants, causing their leaves to become mottled or blotched, calling it the “tobacco mosaic virus”. A photograph of these viruses is seen through an electron microscope as shown on the right.

Tobacco mosaic virus envelope high-resolution electron microscopy of helical specimens

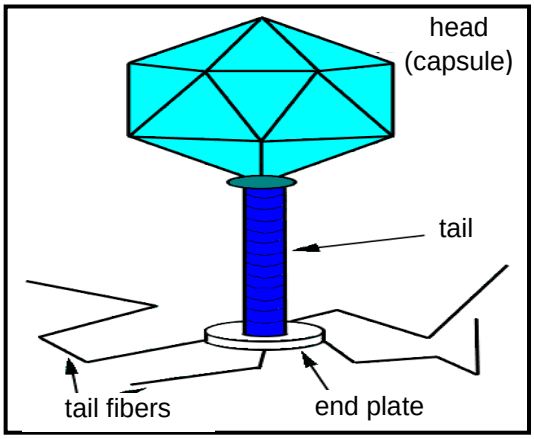
Characteristic of viruses

Viruses are thought to be the starting point for creation. They have characteristics of non-living things as well as living things. Therefore viruses connect the non-living things and the living world. Like the tobacco mosaic virus, all viruses are so small that they can only be seen under an electron microscope.

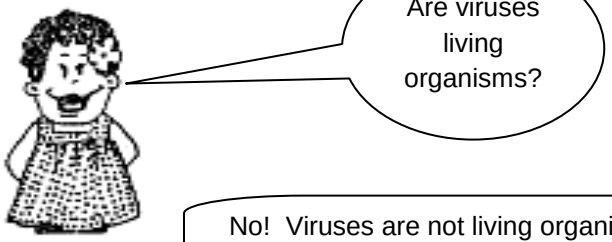
Their average length is about 0.00003mm.It is not known whether they are true living things or just complicated chemicals. They are not cells. Their structure is very different from other microbes. Viruses do not live freely.

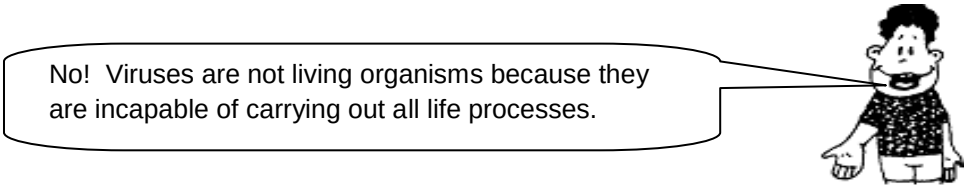
They live on or in another organism, so they are complete parasites. They can only grow and reproduce inside other living cells. Outside of a living cell, a virus shows no signs of life as it does not grow, feed, reproduce, respire or excrete.

Like other microbes, viruses have different shapes and sizes. You will have notice that the tobacco mosaic virus shown above has a rod-like shape. Others are much more complicated in shape. For example, the bacteriophage virus, shown in the picture opposite, which infects bacteria, has a 'head', a 'body' and a 'tail'.



Bacteriphage virus





Activity 1: **Now test yourself by doing this activity**

A. **Write True if the statement is true and False if the statement is false on the space provided.**

1. _____ It is not known whether viruses are true living things or just complicated chemicals
2. _____ Viruses are made up of cells.
3. _____ All viruses must live on other organisms.
4. _____ A virus shows no normal signs of life, outside of a living cell.

B. Name the type of microscope used to see viruses.

_____

Reproduction

Viruses can survive outside the host cell, but in order to reproduce they must penetrate into a living cell. They only become active after invading a cell. They then take control of the cell's activities. Viruses do reproduce, but only inside the cells of living organisms, using materials provided by the host cell.

The host cells, instead of making their own chemicals and proteins, begin to make chemicals which are beneficial only to virus.

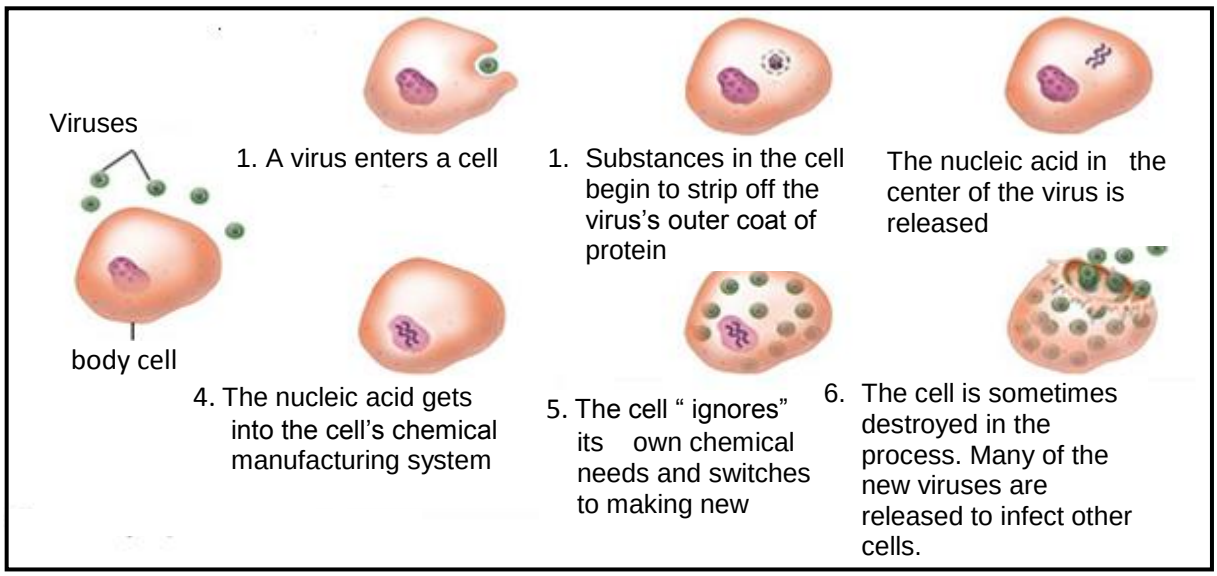
Viruses (black dots) invading a cell (X25)

The virus then starts to reproduce hundreds of new viruses, exactly like the original virus that infected the cell. Poliomyelitis and influenza viruses attack the human cells in this way.

Other viruses reproduce in a similar manner, but instead of the whole virus invading the cell, only material produced by the virus is injected into the cell. An example of the process is the action of the bacteriophage virus, which attacks bacteria. The virus attaches itself and then injects material into the bacterium. This forces the bacterium to burst, thus killing it and releasing new bacteriophage viruses. Each one now attacks a new bacterium. The diagram below shows this process.

The first illustration shows the virus entering the bacterium, the final illustration shows the bacterium bursting and new bacteriophage viruses being release.

How a virus invades a cell?



Viral diseases

All viruses are pathogenic, which means it causes disease in the host organism. They are pathogenic because of the way they reproduce.

As you know, viruses attack cells then multiply within these cells and destroy their structure. Viruses can reproduce only inside other cells, and so all viruses are parasitic.

In humans, they cause diseases such as common colds, influenza, poliomyelitis, herpes, mumps, measles, chicken-pox, hepatitis and Aids. Some viruses can remain dormant (inactive) in certain body cells without immediately producing symptoms of disease.

Human viral diseases

The common cold is caused by droplets in the air containing viruses. These viruses are produced by sneezing, coughing or talking.

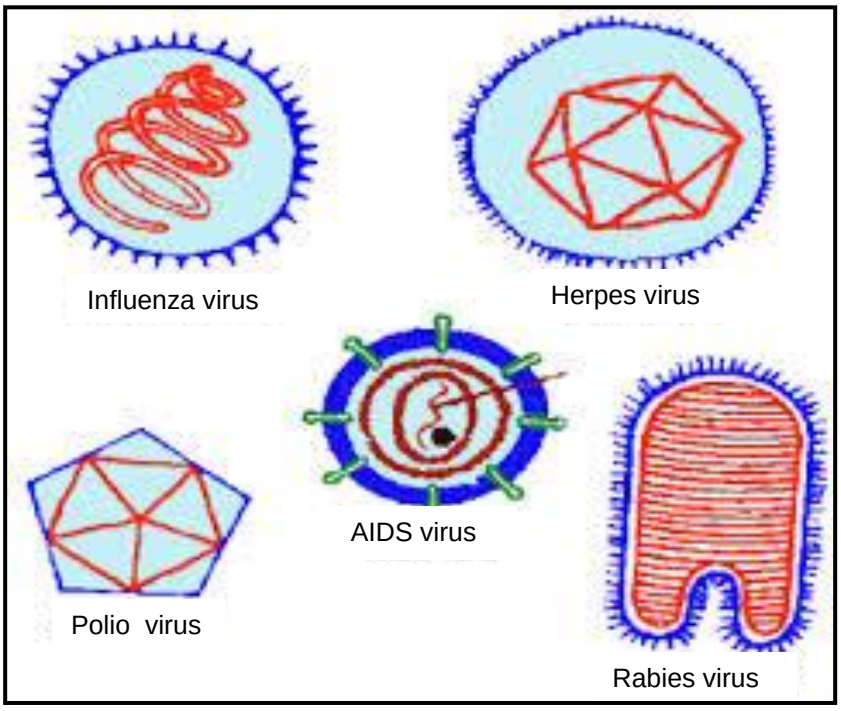
Points to remember about viruses:

- **are not made of cells**
- **cannot reproduce on their own**
- **cannot grow or undergo division**
- **do not transform energy**
- **lack machinery for protein synthesis**

The AIDS virus, transmitted by one person to another by body fluids, causes an infected person's immune system to be destroyed. Yellow fever, transmitted by the bite of an infected culex mosquito, is caused by the Yellow Fever virus which enters the cells of the liver.

Viruses do not produce toxins. The harm they cause is probably the result of the destruction of the cells they invade. When they destroy cells, for example, the lining of the wind pipe and bronchi, bacteria can invade the damaged tissues. After entering the body and reproducing in a small group of cells, the viruses may be carried to other organs in the circulation.

Illustrations of some diseases causing viruses are shown below. The illustrations are greatly magnified. The almost sphere-shaped poliomyelitis virus attacks nerve cells, frequently resulting in paralysis. The influenza virus causes fever and breathing problems. The herpes virus causes inflammation of the skin often in the form of blisters.



Activity 2: **Now test yourself by doing this activity.**

Write True if the statement is true and False if the statement is false.

1. _____ Viruses only grow and reproduce inside other living things
2. _____ Viruses are largest of all microbes.
3. _____ All viruses are pathogenic .
4. _____ Influenza virus causes fever and breathing problems.
5. _____ One of the viral diseases is Tuberculosis.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 7.

Viral diseases in animals and plants

In animals, viruses causes diseases such as foot and mouth diseases in cattle, myxomatosis in rabbits and rabies in dogs. **Myxomatosis** is caused by the myxoma virus, a poxvirus spread between rabbits by close contact and biting insects such as fleas and mosquitoes. The virus causes swelling and discharge from the eyes, nose and anogenital region of infected rabbits. Most rabbits die within 10-14 days of infection however highly virulent strains of the myxoma virus may cause death before the usual signs of infection have appeared. **Rabies** is a deadly virus that attacks the nervous system and can cause brain inflammation. Although survival is possible, the virus almost always kills its host. The virus grows in the muscle tissue before moving into the spinal cord and brain.

Plant viruses are transmitted in a number of ways. The most important of which is through insect bites, by aphids and plant hoppers. Examples of viruses that attack plants are the tobacco mosaic virus. Tobacco mosaic virus affects tomato plants as well as tobacco. The other one is the white leaf virus which causes discolorations of leaves and flowers. The photograph below shows a diseased tobacco and tomato plants affected by the mosaic virus.

A diseased tobacco plant affected by the mosaic virus

A diseased tomato plant affected by the mosaic virus

Summary

You have come to the end of lesson 7. In this lesson you have learnt that:

- viruses are the smallest of all the microbes
- viruses can only be seen with an electron microscope
- viruses must live in other organisms so they are complete parasites.
- viruses are all pathogenic microbes
- a virus is not like any other microbe, it is not known whether they are true living things or just complicated chemicals.
- viruses are not cells
- viruses affect people and cause diseases such as colds, aids and others
- viruses also affect other animals and plants.
- viruses connect the non-living and the living world.

NOW DO PRACTICE EXERCISE 7 ON THE NEXT PAGE.

Practice Exercise 7

Answer the following questions.

1. Name the common human disease caused by the droplets in the air containing virus. _____

2. What type of virus infects and destroys a person's immune system?
_____

3. Name a virus that frequently results in paralysis of an infected person.
_____

4. Name the type of insect that transmits the Yellow fever virus _____

5. Which animals are affected by the following diseases?
   (i) Foot and mouth _____
   (ii) Myxomatosis _____

6. Give one example of a virus that attacks plants _____

7. What type of virus attacks bacteria? _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 1.

Answers to Activities

Activity 1

A. 1. True 2. False 3. False 4. True

B. Electron microscope

Activity 2

1. True
2. False
3. True
4. True
5. False

Answers to Practice Exercises 1 - 7

Practice Exercise 1

1. (i) Viruses are the smallest microbes; they cause diseases such as colds, flu, HIV and AIDS.
   (ii) Bacteria are extremely small, single-celled organism. They cause diseases such as cholera and typhoid.
   (iii) Algae are simple green plants that live in water with no stems, roots or leaves. Examples are sea weeds.
   (iv) Fungi do not contain chlorophyll and cannot make their own food. Examples are mould on bread, yeast for making bread and mushrooms.
   (v) Protozoa is a single-celled organism. They live in water or damp places. The disease malaria is caused by a protozoan.

2. Because of their structure and the way they live.

3. Microbes reproduce by cell division every twenty to thirty minutes.

Practice Exercise 2

1. Microscopes are instruments which magnify or make things appear bigger than they really are.

2. (i) Magnifying power of objective lens = X20
   Magnifying power of eyepiece lens = X5
   =X100

   (ii) Magnifying power of objective lens = X40
   Magnifying power of eyepiece lens = X10
   =X400

3. 1. Eyepiece lens
   2. Body tube
   3. Arm
   4. Coarse adjustment knob
   5. Fine adjustment knob
   6. Base
   7. Turret
   8. Objective lens
   9. Stage clip
   10. Stage
   11. Diaphragm
   12. Mirror

Practice Exercise 3

1. Parasitism is the relationship between two different organisms which one organism (parasite) benefits and the other (host) is harmed.

2. Fungi that feed on dead organisms.

3. Fungi reproduce by the production of spores.

4. (i) Alcohol (ii) carbon dioxide (iii) energy

5. (i) taro blight (ii) coffee rust (iii) cocoa black pod

6. (i) athletes foot (ii) ring worm

Practice Exercise 4

A. 1. FALSE
2. TRUE
3. TRUE
4. FALSE

B. 1. (i) soil fertility
(ii) chemical extraction
(iii) fertilizer

2. brown algae

3. Flagella are algae that have thread or hair-like structure

4. Dinoflagellates

Practice Exercise 5

1. Based on their movement

2. (a) Cilia are rows of many small hair-like structures
(b) For movement in both forward and backwards directions propelling them through fluids.

3 Monads

4. (a) Plasmodium
(b) Malaria

5. Conjugation

Practice Exercise 6

A. (i) True
(ii) True
(iii) False
(iv) False

B. 1. Bacteria may form spores protective protein coating called CAPSULE when conditions are bad.

2. Bacteria that cause diseases in their host organisms

3. (i) Nitrates
(ii) They give nutrients/fertilizers to the soi.l

Practice Exercise 7

1. Common cold

2. Aids virus

3. Poliomyelitis virus

4. Infected culex mosquito

5. (i) foot and mouth Cattle
(ii) myxomatosis Rabbits

6. Tobacco mosaic virus

7. Bacteriophage virus

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

REVIEW OF TOPIC 1: INTRODUCTION TO MICROBIOLOGY

Now, revise all lessons in this Topic and then do **ASSIGNMENT 1.** Here are the main points to help you revise.

Lesson 1: Microbes and Microbiology

- Microbiology is the study of micro-organisms.
- Microbes are very small organisms that can usually only be seen through a microscope.
- Microbes are the simplest living things and can be found everywhere.
- The five main groups of microbes are viruses, bacteria, algae, fungi and protozoan.
- Microbes can be classified as a distinct group of organisms, separate from plants and animals.

Lesson 2: The Microscope

- Microscopes are instrument which magnify or make things appear bigger than they really are.
- Light microscope uses a beam of light to help magnify objects.
- Electron microscope uses a beam of electrons rather than light to help magnify objects.
- A turretscope has three objective lenses.
- Zoomscope has a single lens called a zoom lens.

Lesson 3: Fungi

- Fungi are important in the process of decay because they recycle nutrients in nature.
- Yeast is important in the process of fermentation and is used to make bread, beer and wine.
- The antibiotic penicillin is made from the fungus penicillium.
- The products of fermentation process are alcohol, carbon dioxide and energy.
- Fungi are useful in areas like food, drinks, medicine, and recycle of nutrients.
- Fungi are also harmful like causing sickness to humans, plants and animals and they are also parasites to other plants and animals.

Lesson 4: Types of Volcanoes

- Algae are simple plants without roots, stems or leaves.
- Phytoplankton is some form of marine algae that make up a large part of the free floating microscopic life in water.
- Many algae consist of only one cell and may be spherical, rod-shaped or variations of designs.
- The main algal classifications are by its colour.
- Algae reproduce by both sexually and asexually.
- Phytoplankton is the base of the food chain for all marine organisms.
- The important uses of algae are for food, soil fertility, chemical extraction and fertilizer source.

Lesson 5: Protozoa

- Protozoa are simplest of all animals and consist of only one cell.
- Most protozoa live in water, in the sea, in streams, in the fresh water ponds and in moist soil.
- Protozoa are classified into four classes according to the way they move.
- Protozoa reproduce by both sexually and asexually.
- Malaria which is transmitted by the female anopheles mosquito, caused by protozoa known as plasmodium.

Lesson 6: Bacteria

- Bacteria are very small single-celled organisms
- Some bacteria are harmful, but most bacteria are useful
- Bacteria can make plants and animals sick but they can also help to recycle nutrients and to improve soil fertility.
- Bacteria are used to make bread, cheese, wine and beer, and to treat sewage
- Bacteria are classified according to the three basic shapes.
- Bacteria can exist as single cells, in pairs, in chains and in clusters.
- Bacteria usually reproduce asexually, by dividing in two by binary fission.

Lesson 7: Viruses

- Viruses are the smallest of all the microbes
- Viruses can only be seen with an electron microscope
- Viruses must live in other organisms so they are complete parasites.
- Viruses are all pathogenic microbes
- A virus is not like any other microbe, it is not known whether they are true living things or just complicated chemicals.
- Viruses are not cells
- Viruses affect people and cause diseases such as colds, AIDS, etc.
- Viruses also affect other animals and plants.

NOW DO TOPIC TEST 1 IN YOUR ASSIGNMENT 2.

TOPIC 2

USEFUL MICROBES

In this topic you will learn about:

- **useful microbes**
- **fungal uses**
- **bacteria in food industry**
- **bacteria in chemical industry**

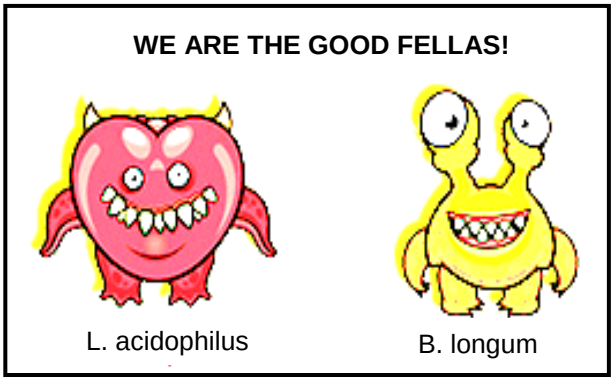
INTRODUCTION TO TOPIC 2: USEFUL MICROBES

In our previous topics, we have described different types of microbe. We have learned that some microbes are free living organisms and others are parasites. The words “microbe” and bacteria are associated with disease for most people, but not all bacteria and microbes are “bad guys’. Microorganisms can be harmless, beneficial or **pathogenic***, which means harmful. This chapter looks at the beneficial types of micro-organisms.

What are beneficial micro-organisms?

Micro-organisms are able to produce enzymes necessary for building up and breaking down of organic compounds.

Bacteria are widely 'employed' by humans. Microbes are involved in the “cleaning” of the earth of remnants of dead organisms.

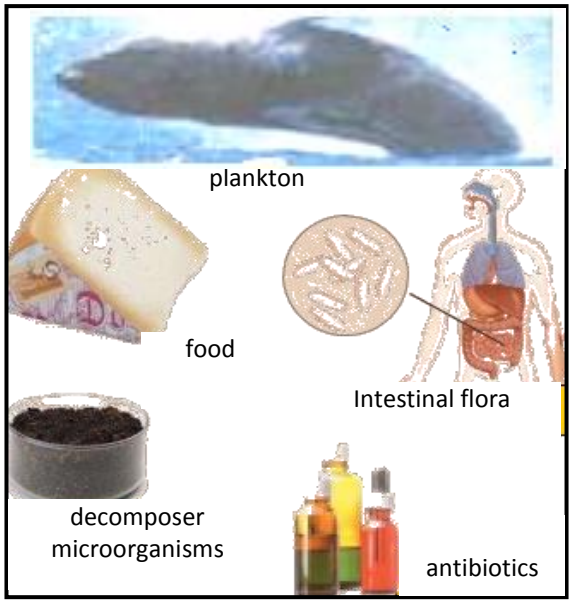


They participate in the earth’s cycles including carbon and nitrogen cycles. Micro-organisms are involved in the production of oxygen, biomass control, food, medicines, and metal refining called bacterial leach.

Some microbes also lead a symbiotic type of lifestyle in most multicellular organisms. The community of beneficial microorganisms living in human intestines is called intestinal flora.

Topic 2 will include lessons on the uses of fungi and bacteria in both food and chemical industries and you should be able to ask yourself the following questions as you study this topic.

- What are beneficial bacteria?
- What is the role of fungi and bacteria in decay
- What are important uses of fungi
- What are important roles of bacteria in food and chemical industries?



Importance of microbes

In this Topic, you will find the answers to these questions and all other questions relating to useful microbes.

Lesson 8: Useful Microbes

Welcome to Lesson 8. In the last lesson you learnt about the group of virus which is the only group of microbes which are not beneficial in anyway. All viruses are harmful. However, you will recall that many of the other four different types of microbes, algae, protozoa, fungi and bacteria are mainly harmless and are very beneficial to us and other organisms. In this lesson, you will learn about some of these benefits.

Your Aims:

- identify the useful microbes in daily life
- explain the roles of useful microbes

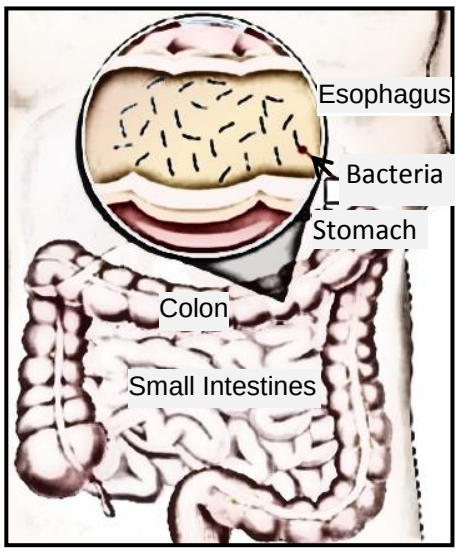
Benefits of Microbes

Beneficial and harmless bacteria are far more numerous than harmful microbes. There is constant interaction between microbes, because of their presence in all walks of human life. The great mass of bacteria in the body is harmless by the protective effects of the immune system, and a few are beneficial. In fact, the relationship between microbes and humans is delicate and complex.

Microbes are useful for us in many ways.

Food Digestion

There are many microorganisms living in the large intestines of human beings such as bacteria. The bacteria secrete **enzymes*** in the large intestines. The enzyme breaks down undigested food and produces Vitamin K that plays a key role in helping the blood clot, preventing excessive bleeding.



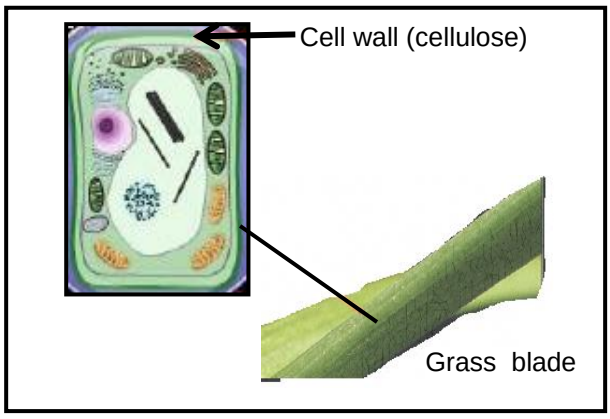
Useful bacteria in food digestion

Digestion of cellulose

As you know, both animals and plants must obtain energy from food. Animals get it from the food they eat, such as fats and carbohydrates.
Green plants obtain their food in a different way.

The carbon dioxide produced when animals respire is released into the air. This carbon dioxide is used by green plants in a process called photosynthesis to produce sugar, starch and **cellulose***.

The cell walls of a plant are made of cellulose and so are tough fibers and strings which strengthen their leaves and stems.

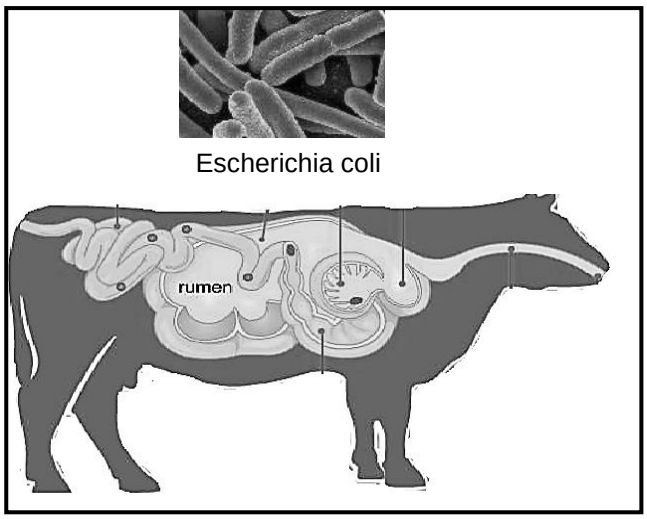


Cellulose in grass blade

Most animals, including humans, are not able to digest cellulose and so are not able to use directly the energy it contains. However, some bacteria can digest it.

The cellulose digesting bacteria live in the stomach of grass eating animals like cattle and sheep and wood eating insects, like white ants and some termites.

They digest cellulose that their hosts eat and so provide energy for both themselves and their hosts. The hosts, such as cattle, respire releasing carbon dioxide into the air**.**



Escherichia coli

Bacteria in the rumen of cattle, a compartment in the stomach that helps digest grass

Medical, pharmaceutical applications
Certain microbes can help us in the fight against other microbes. In human and veterinary medicines that are used to treat and prevent infectious diseases, microbes are a source of antibiotics and vaccines.

Antibiotics are substances produced by microorganisms that kill or inhibit other microbes. They are used in the treatment of infectious diseases. Antibiotics are produced in nature by moulds such as Penicillium and bacteria such as Streptomyces and Bacillus.

Vaccines are substances derived from microorganisms and are used to immunize against disease. The microbes that are the cause of infectious disease are usually the ultimate source of vaccines.

Production of foods
Lactic acid bacteria are used to make yoghurt, cheese, sour cream, buttermilk and other fermented milk products.

Vinegars are produced from bacteria's secretion acetic acid to carry out the fermentation process.

Yeast is used in the manufacture of beer and wine and for the leavening of breads. It is also involved in fermentations to convert corn and other vegetable carbohydrates into ethanol to make beer, wine, or **gasohol*** but bacteria are the agents of most other food fermentations.

Other fermented foods include soy sauce, sauerkraut, dill pickles, olives, salami, cocoa and black teas.

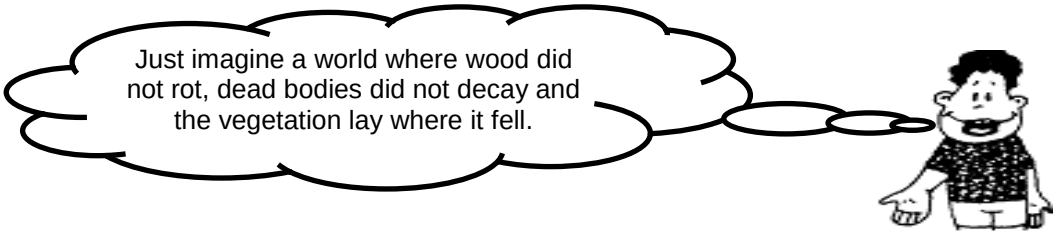
Other benefits of microbes
The microbes that normally live in association with humans on the various surfaces of the body (called the normal flora), such as Lactobacillus and Bifidobacterium, are known to protect their hosts from infections and otherwise promote nutrition and health. They help purify waste water in waste water treatment facilities. They help reduce atmospheric nitrogen and transform it to ammonia which is important for agriculture.

Microbes are vital to the environment because they participate in the Earth's element cycles like the carbon and nitrogen cycles. Microorganisms are involved in the production of oxygen, biomass control and 'cleaning' the Earth of remnants of dead organisms.

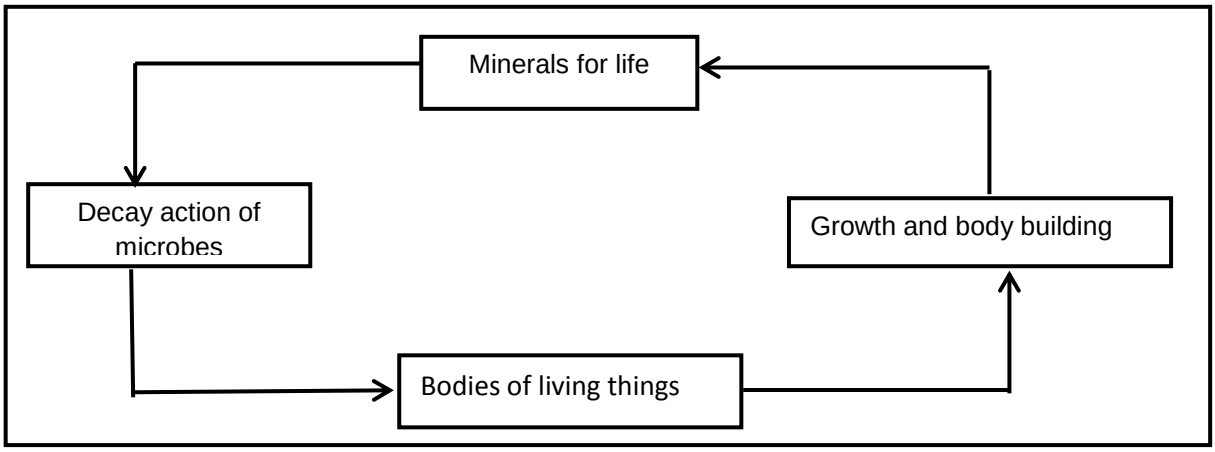
The role of fungi and bacteria in decay
Nature has its own recyclers which are the micro-organisms. As you know, microbes live everywhere, microbes living in the soil, water, faeces, in sewerage systems and rubbish dumps and they all use wastes or dead organisms for their food.

When something dies, micro-organisms use the dead matter as food so they can grow. This process is called **decay** or **decomposition***. Leaves that fall to the ground begin to decay because of the actions of microorganisms in the soil.

They return to the soil many essential substances which can then be used again for further plant and animal growth. Without the action of these decay causing microbes, the supply of these essential nutrients would eventually be exhausted, causing all life to come to an end. Rain provides the water that is needed to complete the chemical reactions. Fallen leaves turn dark and crumble because microorganisms are breaking down the larger chemicals in the leaves into simple materials that are released into the air and soil and can be used by other organisms.



Fungi organisms and bacteria play a vital part in the natural cycle of birth, death, decay and rebirth by using dead organic matter for food. This cycle is shown below.



The cycle of birth, decay and rebirth

The leaves of plants are slowly decayed by fungi and bacteria, first into a brown leaf mould, then into smaller particles of soil called **humus**. The humus decays into nitrogen compounds (example, nitrates).

Plants then make proteins which are needed by all living things, by using carbon dioxide in the air, water and the nitrogen compounds. When these plants die and eventually decay, they provide more food. Animals, which get their protein from plants or other animals, also add nitrogen compounds to the soil when bacteria and fungi cause their dead bodies to decay.

Activity 1: **Now test yourself by doing this activity.**

Briefly answer the following questions.

1. Name the three main types of microbes which are beneficial to mankind.

   i. _____ ii. _____ iii. _____

2. What compound is formed from humus decays that plant take in as their food?
_____

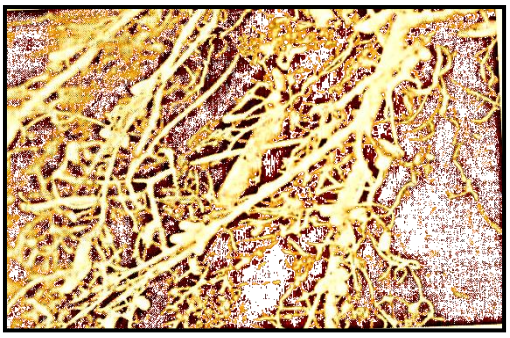
3. Explain the role of microbes in the process of decay.
_____
_____

4. Which group of microbes is not beneficial to man?
_____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 8.

Nitrogen fixation

We mentioned on the previous page that nitrogen compounds, like nitrogen enter the soil when plants and animals decay. Also, from the decay of plants and animals, nitrogen gas is produced. This nitrogen gas goes into the air. Although nitrogen makes up about 79% of all gases in the air, most living things cannot use it directly.



Nodules on legumes

But there are certain bacteria which are able to extract nitrogen from the air and convert it directly into nitrogen compounds by a process called **nitrogen fixing.** These bacteria are found in the soil and also in special lumps or nodules on the root of plants called **legumes,** examples beans, peas, peanuts. These bacteria increase soil fertility.

As well as the special bacteria we have just mentioned, you read in Topic 1 that there is another types of microbe that is also able to fix nitrogen from the air. These microbes are some of the **blue-green algae**, which live in soil. Thus, like some bacteria, some algae help to make the soil more fertile.

Other uses of Algae

Apart from their role in nitrogen fixing, we mentioned in Topic 1 other ways in which algae are beneficial. To remind you these benefits are listed below.

1. **Food source**
   Some green algae are cultivated and used as a source of high protein. Kelps (brown weeds), are used as food by man and other animals. Some algae are rich in iodine, a chemical element which is a nutrient for many living things.
2. **Soil fertility**
   Some blue-green algae which live in soil are able to extract nitrogen from the atmosphere, thus making the soil more fertile.
3. **Chemical extraction**
   As a source of chemicals some algae are rich in bromine, potassium and iodine. These and other chemicals are obtained from marine algae.
4. **Fertilizer source**
   Where large red and brown algae are plentiful, they are used as fertilizers.

As mentioned in Topic 1, one species of protozoa is able to digest wood cellulose. They are in the intestines of some termites. The termites cannot digest wood cellulose but these protozoa are able to digest the cellulose and then convert it into substances easily digested by termites.

Termite mound an astonishing feat of architecture

Other uses of protozoa

You also discovered in Topic 1 that some protozoa are useful not just in the digestion of wood cellulose but they are also used as a source of food. They are eaten by mollusks examples, clams and mussels which in turn are eaten by man.

Activity 2: Now test yourself by doing this activity.

Briefly answer the following questions.

1. What types of microbes are eaten by mollusks?
   _____

2. Name the two types of microbes which are able to fix nitrogen from the air.
   i. _____
   ii. _____

3. Name the type of microbe which is a source of iodine and potassium.
   _____

4. What do you think is the most important way in which microbes help mankind?
   _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 8.

Summary

You have come to the end of lesson 8. In this lesson you have learnt that:

- microbes are able to use feaces and dead organisms for food.
- microbes are important in the process of decay because they recycle nutrients.
- some microbes are able to digest the cellulose found in green leaves.
- these microbes are found in the stomach of cattle and sheep.
- nitrogen-fixing bacteria are able to improve the fertility of the soil by changing nitrogen and oxygen into nitrates.
- without the action of decay causing microbes, the essential nutrients would be locked within the bodies of dead plants and animals and the supply of these materials would have been exhausted.

NOW DO PRACTICE EXERCISE 8 ON THE NEXT PAGE

Practice Exercise 8

Answer the following questions.

1. Why are microbes so important to animals that eat grass?

   _____
   _____

2. How are kelps (brown seaweeds), a type of algae are beneficial to us?

   _____

3. What gas, resulting from decay of both animals and plant life by fungi and bacteria goes into the air?

   _____

4. What substance make up the walls of plants and tough fibers, which strengthened the leaves and stem?

   _____

5. Most animals, including humans, are not able to digest the substance referred to in question 4. Name two types of:

   (a) microbes that play an important part in the digestion of substance

   i. _____ ii. _____

   (b) animals mentioned in this lesson that can digest the substance.

   i. _____ ii. _____

. (c) insects that can digest the substance

   _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 2.

Answers to Activities

Activity 1

1. i. bacteria
   ii. fungi
   iii. algae
2. Nitrogen compound or nitrates
3. In the process of decay, they return to the soil many essential nutrients which can then be used again for further plant and animal growth.
4. Viruses

Activity 2

1. Protozoa
2. i. Bacteria
   ii. Algae
3. Algae
4. Microbes return to the soil many essential nutrients which are used again for plant and animal growth, and humans eat these same plants and animals for their food.

Lesson 9: Fungal Uses

Welcome to Lesson 9. In the previous lesson you learnt about useful microbes. Four of the different microbes are useful except for virus, which is a harmful. In this lesson, you will learn about fungi which is one of the useful microbes.

Your Aims:

- define aerobic, anaerobic and fermentation
- state the importance of fungi in yeast production
- identify the use of yeast in wine and alcohol making
- identify the uses of alcohol for beer, wine and fuel

Importance of Fungi

We often think that fungi as organisms that cause disease and rot food, but fungi are important to human populations on many levels and one of the most important groups of organisms on the planet. This is easy to overlook, given their largely hidden, unseen actions and growth. They are important in an enormous variety of ways.

1. **Food**

Fungi are used as food for humans and while this is very small proportion of the actual food that we eat, fungi are also widely used in the production of food and drinks.

Morel mushroom is an ascomycete appreciated for its delicate taste.

Many mushrooms are edible and different species are cultivated for sale worldwide. Morels, shitake mushrooms, chanterelles, and truffles are considered delicacies. The meadow mushroom, *Agaricus campestris*, appears in many dishes. Foods like cheeses, bread, some cakes, soya beans and drinks like beer and wine are produced with the use of fungi. The brewer's yeast is not only important for the production of delicious consumables but is nutritious being especially rich in vitamin B12.

Some moulds are important in the maturation of cheeses like blue cheeses (the colour comes from mould spores) and for providing a meat- like flavor in the production of many rice, wheat, and soybean products (for example tempeh, miso, soy sauce) used extensively in Asian cuisine.

The horse mushroom (*Agaricus arvensis*) is a good, sought-after edible fungus, related to the common cultivated mushroom (A. bisporus).

Edible mushrooms are also common 'vegetables' that provide an important source of dietary fiber and complete protein. Fungal proteins provide all of the essential amino acids, a consequence of their close relation to animals.

Studies have shown that the protein content of the edible penny bun mushroom (Boletus edulis, also known as porcino, cep, king bolete) rivals and even exceeds some meat.

This fact is especially important for people who subsist on wild-collected foods and have limited access to other sources of protein. Moreover, some mushrooms used as food may have medicinal properties, providing a smattering of health benefits.

Boletus edulis, known as the Cep, Porcino or Penny-bun Bolete, is a most sought-after edible bolete. It is frequently found at the edges of clearings in broad-leaved and coniferous forests.

While a great many wild fungi are edible, some mushrooms are deadly if they are eaten. It can be difficult to correctly identify them. In some countries, collecting wild mushrooms to eat is a popular activity. It is always wise to be totally sure that what you have collected is edible and not a poisonous look-a-like. Fungi with names such as 'Destroying Angel' and 'Death Cap' give us some indication that it would not be a terribly good idea to eat them!

2. **Nature's cleaning crew/ recycling**

Fungi together with bacteria are decomposers, so they specialize in digesting things. They are responsible for most of the recycling which returns dead material to the soil in a form in which it can be reused.

Some fungi, such as oyster mushrooms, have shown promise cleaning up sites contaminated by oil, diesel and other petrochemical spills.

Oyster mushrooms

Others are with enzymes that can break down compounds in wood and other contaminants, filter microbes out of water, and concentrate heavy metals. We would effectively be lost under piles many meters thick, of dead plant and animal remains without fungi, these recycling activities would be seriously reduced.

3. **Fungal healers /medicines**

Many fungi produce antibiotic substances, which are now widely used to control diseases in human and animal populations. The discovery of antibiotics revolutionized health care worldwide, examples are antibiotics, immunosuppressants (drugs that suppress or reduce the strength of the body's immune system), cholesterol medicine. The cephalosporins (antibiotics derived from the mould Cephalosporium), cyclosporine (a drug obtained from

a fungus, with immunosuppressive properties used to prevent the rejection of grafts and transplants), and statin drugs are all based on natural chemicals produced by fungi.

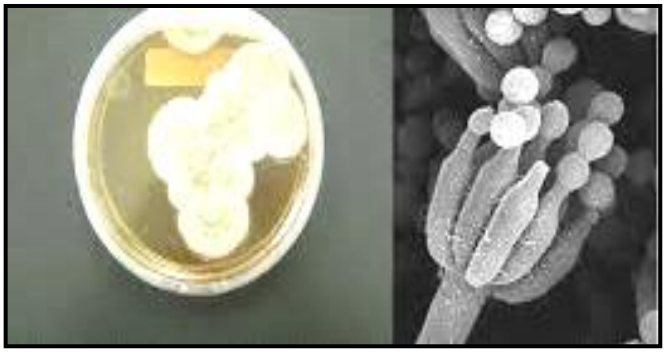
Penicillin, perhaps the most famous of all antibiotic drugs, is derived from a common fungus called **Penicillium.** Some fungi which parasitize caterpillars have also been traditionally used as medicines. The Chinese have used a particular caterpillar fungus as a tonic for hundreds of years. Certain chemical compounds isolated from the fungus may prove to be useful treatments for certain types of cancer.

Mushrooms are also important ingredients in Traditional Chinese Medicine (TCM) and myriad therapeutic activities have been attributed to them, including anti-inflammatory, anti-viral and even anti-tumour effects.

4. **Biological insecticides/ biocontrol**

Fungal parasites may be useful in biocontrol. Fungi help to control the population of damaging pests.

These fungi are very specific to the insects they attack; they do not infect animals or plants.



Some fungi produce antibiotics. *Penicillium notatum* makes **Penicillin** (antibiotic). Grows naturally in some fruits –oranges.

Fungi are currently under investigation as potential microbial insecticides, with several already on the market. For example, the fungus *Beauveria bassiana* is a pesticide being tested as a possible biological control agent for the recent spread of emerald **ash borer***.

Beauveria bassia synnemata from hawkmoth pupa

Fungi such as the Chinese caterpillar fungus, which parasitize insects, can be extremely useful for controlling insect pests of crops. The spores of the fungi are sprayed on the crop pests.

Spittlebugs, leaf hoppers and citrus rust mites are some of the other insect pests which have been controlled using fungi. This method is generally cheaper and less damaging to the environment than using chemical pesticides. Fungi have been used to control Colorado potato beetles, which can devastate potato crops.

5. **Restore forests**

Forests would not exist without fungi. Mycorrhizal fungi have occurred naturally in the soil for 450 million years. They form a close symbiotic

relationship with plant roots. They are called mycorrhizae (from the Greek "mukés", meaning fungus, and "rhiza," meaning roots).
Many plants, especially trees, have mycorrhizae living in and on their roots. These fungi can help the plant absorb nutrients from the soil. In addition to helping trees grow, fungi can also be employed to restore habitat, as well as reduce forest fires and erosion. Without the fungal partner in root systems, 80–90 percent of trees and grasses would not survive

6. **Farming**
The mycorrhizal relationship between fungi and plant roots is essential for the productivity of farm land.

When mycorrhizal fungi colonize the plant's root system, they create a network that increases the plant's capacity to absorb more water and nutrients such as phosphorus, copper and zinc. This process in turn enhances growth and favors rapid development of roots and plants.

However, in most soils that have been disturbed by residential construction, or intensive cropping practices with applications of fertilizers containing pesticides and other chemical products, the mycorrhizae content has considerably diminished, and has become insufficient to significantly enhance plant growth.

Mycorrhizal fungal inoculants are available as soil additives from gardening supply stores and are promoted by supporters of organic agriculture.

Fungi are vitally important for the good growth of most plants, including crops, through the development of mycorrhizal associations. As plants are at the base of most food chains, if their growth was limited, all animal life, including human, would be seriously reduced through starvation.

Looking at the above list, it is clear that fungi play a role in just about every part of our daily lives!

Importance of Fungi in Yeast Production
If you are to ask someone what is the role of fungi in industry, most likely the answer that you will get is the use of yeasts in bread making, brewing and wine making.
Brewing and baking rely upon simple principle of fermentation.

Fermentation commonly results in the release of **alcohol***, but l**actate***, **glycerol*** and other organic molecules can also be released. It is a form of anaerobic respiration in which sugar is broken down to produce carbon dioxide and alcohol

What is an anaerobic respiration? And what is respiration?
When food is turned into energy and other chemicals in a cell this is process called **respiration.**

There are two (2) types of respiration
Aerobic respiration involves the use of oxygen in the breakdown of food material.

In the presence of oxygen, sugar in the food material is broken down completely to water and carbon dioxide and energy is released during the process. The process goes slowly, controlled by many different enzymes in the cells of living organisms.

Below is the equation representing the aerobic respiration

Sugar + oxygen = water + carbon dioxide + energy

Anaerobic respiration is the release of energy from food material like sugar.

Here the process of chemical breakdown does not require oxygen. Many fungi, including some yeast and many other bacteria derive all or most of their energy from anaerobic respiration.

The end products of the process of anaerobic respiration are alcohol, carbon dioxide and energy. The process is called **fermentation**.

The equation representing fermentation of sugars is shown below.

Sugar = alcohol + carbon dioxide + energy

Fermentation is a process that converts sugars to acids, gases, and/or alcohol. The alcohol part is where we often see fermentation in a commercial use.

For instance, to make wine and beer, it requires the process of fermentation. For wine, grapes are often fermented in order to produce high quality wine. Occasionally, such with apple wine, there may be different fruits involved in the fermentation process. To make beer, it is usually wheat or barley that is fermented. Thus, every time you drink a beer there has been a process of fermentation associated with it before it's produced and lands in the hands of consumers.

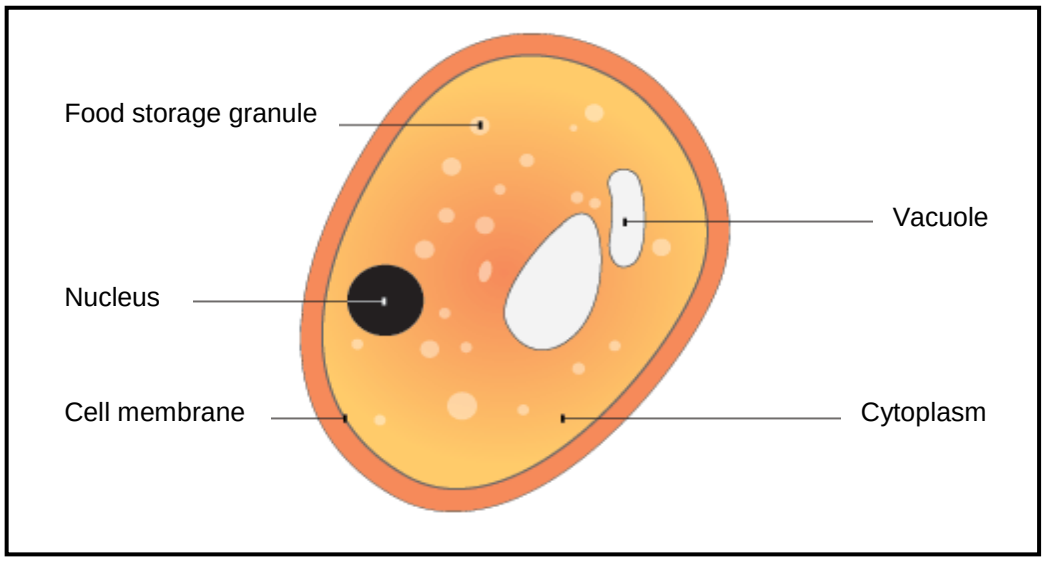
Yeast

Yeast is a microscopic, one-celled organism belonging to the group of organisms called fungi. It belong to the family of fungi. The yeast cell is oval or round and has a thin membrane. The majority of yeasts consist of separate spherical or ball-like shells, which only can be seen under a microscope.

Yeasts live in conditions where sugar is likely to be available in the nectar of flowers and on surfaces of fruits. Yeast cells contain **enzymes**. Enzymes are substances which cause chemicals changes in other substances without themselves being changed. They increase the rate of most chemical changes. Without enzymes, chemical reactions would be too slow.

Yeasts are found in the soil, in water, on the surface of plants, and on the skin of humans and other animals. Like other fungi, yeasts obtain food from the organic matter around them; they secrete enzymes that break down the organic matter into nutrients they can absorb.

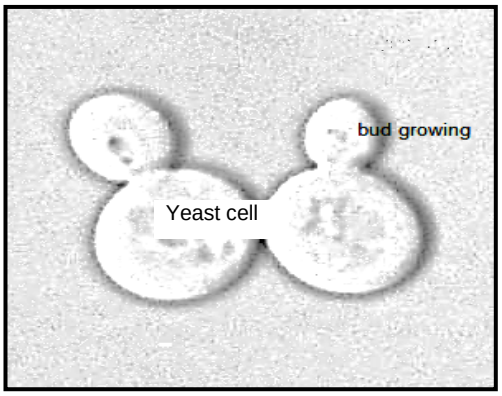
Below is a diagram of the structure of a yeast cell.



Yeast cell

Yeast production

Yeast cells reproduce by budding. A photograph of budding yeast is shown opposite. Under ideal conditions of moisture, temperature, and food supply, it reproduces asexually, by budding. When a yeast cell reaches full growth, a budlike swelling forms on its surface.



Budding in yeast

In the process of budding, another bud is produced and separates from the parent, becoming an independent cell

Part of the parent cell's nucleus goes into this bud, and a wall is formed between the parent cell and the bud, which then becomes a separate cell.This new cell may break off when it is full grown. It may, however, remain attached as it produces another bud. In this way, chains or clusters of cells are formed. Budding is a rapid process, requiring about 20 minutes to produce a new organism.

When conditions are adverse, a yeast cell typically reproduces sexually, by fusing with another yeast cell. The combined cell develops into an ascus, a thick-walled, protective structure containing one to eight spores. When favorable conditions return, the spores are released and each develops into a new yeast cell.

Yeast and fermentation yeasts obtain food from fructose, glucose, and other monosaccharides (simple sugars), which are found in most fruits. Yeast enzymes chemically break down the sugars into products that the cell can use. Other yeast enzymes can make simple sugars out of disaccharides (double sugars), which are found in certain organisms.

Importance of Yeast

There are many kinds of yeasts, some of them of great importance to humans. Yeast is necessary to make leavened bread, beer, cheese, wine, and whiskey. It is rich in B

vitamins; a form of yeast called brewer's yeast is used as a diet supplement. Yeast is also used in genetic engineering to produce large quantities of certain hormones and enzymes, which are used for medical purposes such as healing wounds and reducing inflammation. Some types of yeast, cause disease, for example candidiasis, a skin disease.

The breaking down of sugars, or fermentation, produces alcohol and carbon dioxide as by-products. Fermentation turns fruit juices into wine and helps turn wort (diluted grain mash) into beer or whiskey. The carbon dioxide produced by fermentation makes the bubbles in beer and some kinds of wine, and causes bread to rise. As bread bakes, the alcohol produced by fermentation evaporates.

Yeast enzymes do not act upon starches. However, enzymes found in malt (germinating barley) can change starches into sugar. For this reason, malt as well as yeast is added when it is necessary to bring about the fermentation of substances containing starch

Commercial Yeasts Fruits and grains carry "wild" yeasts that have settled on them. However, wine-makers, brewers, and bakers do not rely on these yeasts because they may produce undesirable qualities in the finished products. Instead, the wild yeasts are washed off or killed by high temperatures, and pure strains of cultivated yeasts are added.

Yeasts that produce desirable qualities in beverages or bread are isolated and cultivated in a fluid (usually a solution of sugar and mineral salts). As masses of yeast form, they are skimmed off for further processing. Compressed yeast consists of a mass of yeast that has been washed and mixed with starch. The mass is then pressed to remove about 30 per cent of the moisture, cut into cakes, and packaged.

Due to its moisture content, compressed yeast must be refrigerated. It remains fresh for up to five weeks. Dry yeast is made by removing over 90 per cent of the moisture from the yeast mass at a low temperature. It does not need to be refrigerated, and has a shelf life of six months. Both compressed and dry yeast are classed as active yeast because they are made up of living yeast. The yeast is in a dormant state when packaged but becomes active when combined with hot water or milk.

Activity 1: Now test yourself by doing this activity.

A. Write TRUE or FALSE for the following statements concerning yeast cells.

(a) _____ They are bacteria.

(b) _____ Their shapes are mainly rod-like.

(c) _____ They live in conditions where sugar is likely to be available.

B. Answer the following questions.

1. Respiration that does **not** require oxygen is called _____.

2. How do yeast cells reproduce?
_____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 9.

Other uses of yeast fermentation
The alcohol produced during fermentation is used to make drinks such as wine, beer, rum and whiskey. In the next section, we will look at how beer and wine are manufactured.


Barley

Making Beer
Beer can be made by fermentation grain in water. Beer is made from four basic ingredients. Barley,water, hops and yeast. The basic idea is to extract the sugars from grains (usually barley) so that the yeast can turn it into alcohol and CO2, creating beer.

Barley is a commonly used grain. When yeast is added to barley in water, no fermentation would occur since the yeast cannot convert the starch and proteins in the barley to sugar.

The enzymes manufactured in the barley, after it has been soaked in water converts the starch and the proteins in the barley into sugars.

After the sugar are produced, yeast is added, which then acts on these sugar causing fermentation to take place. This results in the production of alcohol and carbon dioxide.


Hops

Wine manufacture
Just as beer is made from fermenting barley, wine is the fermented juice of fruits. The fruits mostly used are grapes, which have yeast on their skins. Grapes are grown in temperate countries which include most parts of Europe and Australia. Grapes differ in colour, size, texture (firm or soft), sugar content and the amount of acid they contain. These different varieties form different flavoured and coloured wines, red or white wine.

There are five basic components of wine making process. Wine makers typically follow these five steps but add variations and deviations along the way to make their wine unique.

1. **Harvesting**
Harvesting can be done by hand or mechanically. Many wine makers prefer to harvest by hand because mechanical harvesting can be tough on the grapes and the vineyard. Once the grapes are taken to the winery, they are sorted into bunches, and rotten or under ripe grapes are removed.

.2. **Crushing and pressing**

Grapes are ready to be de-stemmed and crushed after they are sorted. For many years, men and women did this manually by stomping the grapes with their feet. Nowadays, most wine makers perform this mechanically. Mechanical presses stomp or trod the grapes into what is called must.

3. **Fermentation**

Must (or juice) begins fermenting naturally within 6-12 hours when aided with wild yeasts in the air. However, many wine makers intervene and add commercial cultured yeast to ensure consistency and predict the end result.

4. **Clarification**

It is the process in which solids such as dead yeast cells, tannins, and proteins are removed. Wine is transferred or “racked” into a different vessel such as an oak barrel or a stainless steel tank. Wine can then be clarified through fining or filtration. Fining occurs when substances are added to the wine to clarify it.

5. **Aging and Bottling**

Aging and bottling is the final stage of the wine making process. A wine maker has two options: stainless steel tanks, or oak barrels. Aging the wine in oak barrels will produce a smoother, rounder, and more vanilla bottle the wine right away or give the wine additional aging.

After aging, wines are bottled with either a cork or a screw cap, depending on the wine maker’s preference.

Yeast's crucial roles in bread baking

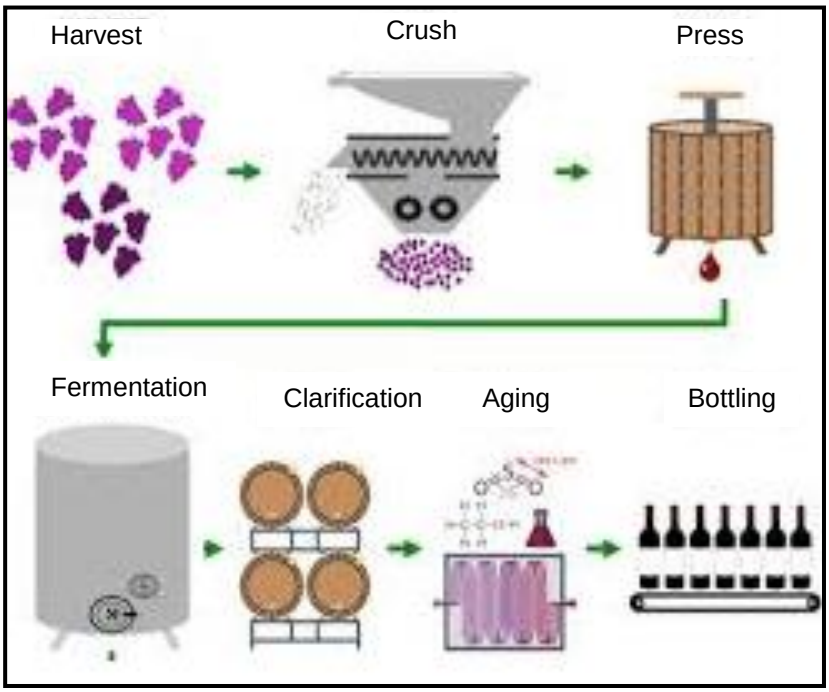
Yeast is the driving force behind fermentation, the magical process that allows a dense mass of dough to become a well-risen loaf of bread.

And yet yeast is nothing more than a single-celled fungus.

How does it do it?

Yeast works by consuming sugar and excreting carbon dioxide and alcohol as byproducts.

In bread making, yeast has three major roles. Most of us are familiar with yeast's **leavening ability**. But you may not be aware that fermentation helps to strengthen and **develop gluten** in dough and also contributes to incredible **flavors in bread**.



Wine making

Fermentation generates flavor in bread

"Why does bread dough smell like beer?"

Fermentation occurs when yeast and bacteria inside the dough convert carbohydrates to carbon dioxide causing gas bubbles to form, which has a leavening effect on dough. This process is very similar to wine, beer and sour kraut and causes a strong aromatic sensation that is usually pleasing.

At the beginning of fermentation, enzymes in the yeast start breaking down starch into more flavorful sugars. The yeast uses these sugars, as well as sugars already present in the dough, and produces not only carbon dioxide and alcohol but also a host of flavorful by products such as organic acids and amino acids.

Activity 2: Now test yourself by doing this activity.

Answer the following questions:

1. Beer making relies on sugar fermentation. What are the three products of fermentation?

   (i) _____ (ii) _____ (iii) _____

2. Name the fruit that is mostly used in making beer?

   _____

3. Name the fruit that is mostly used in wine making?

   _____

4. Name the two types of wine produced in the wine making process.

   (i) _____ (ii) _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 9.

Yeast fermentation on cocoa, coffee, fuel and medicine

Cocoa processing involves fermentation of cocoa beans. During fermentation, the beans become warm due to the action of yeasts feeding on the sugary pulp surrounding the beans. The sugary pulp is also broken down by bacterial action which also takes place if oxygen is present.

The processing of coffee also involves fermentation. After the pulp has been removed by a pulping machine or by hand, the coffee beans are soaked in boxes filled with water. This is called fermenting stage and usually takes about three days. Fermentation causes the sticky coating around the beans to soften.

This enables the farmers, after this process has finished washing the beans to remove the sticky coating. When all the coating is removed, the beans are put out in the sun to dry.

Alcohol, which is produced by fermentation, is used for drinks like beer and wine. It can also be used as fuel as substitute for oil products such as petrol.

In Brazil, which is a tropical country in South America has little fuel oil but many large plantations of sugar cane are produce. Alcohol is produced from fermented sugar cane. The Brazilian, by combining the alcohol with petrol made a fuel called **gasohol*** Nowadays, many cars in Brazil use gasohol rather than petrol.

The fungus called **penicillium** is a green mould that could be used to fight diseases.

The term antibiotic is used to classify penicillin and an increasing number of substances, usually fungal mould, which destroy or prevent disease causing microbes, especially bacteria from forming.

Activity 3: Now test yourself by doing this activity.

Answer the following questions.

1. In cocoa processing, how can you tell that fermentation is going on?

   _____

2. In coffee processing, what happens to the coffee beans during the fermentation stage?

   _____

   _____

3. What is the name of the fuel used in Brazil made from alcohol called?

   _____

4. What is a penicillium?

   _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 9.

Summary

You have come to the end of lesson 9. In this lesson you have learnt that:

- aerobic respiration involves the use of oxygen in the breakdown of food material
- anaerobic respiration is the release of energy from food material like sugars by a process of chemical break down that does not require oxygen.
- fermentation is a form of anaerobic respiration in which sugar is broken down to produce carbon dioxide and alcohol.
- yeast cells reproduce by budding.
- the alcohol produced during fermentation is used to make drinks such as wine, beer, rum and whiskey.
- the fungus called penicillium is a green mould that can be used to fight diseases.

NOW DO PRACTICE EXERCISE 9 ON THE NEXT PAGE

Practice Exercise 9

Answer the following questions.

1. Define Aerobic respiration.
   _____

2. Define fermentation .
   _____

3. Name the flowers which are added in the beer-making process to give beer its bitter taste._____

4. What is the general name given to drugs, mainly produced by fungi which kill or prevent the growth of disease-causing microbes?
   _____

5. Explain what is malt wort.
   _____
   _____

6. Explain how yeast cells reproduce.
   _____
   _____

7. Explain what is meant by anaerobic respiration.
   _____
   _____

CHECK YOU WORK. ANSWERS ARE AT THE END OF TOPIC 9.

Answers to Activities

Activity 1

1. (a) False
   (b) False.
   (c) True
2. Anaerobic
3. By budding

Activity .2

1. (i) Malt wort
   (ii) Alcohol
   (iii) Carbon dioxide
2. Barley
3. Grapes
4. (i) White wine
   (ii) Red wine

Activity 3

1. The beans become warm due to action of yeasts feeding on the sugary pulp surrounding the beans.
2. It causes the sticky coating around the beans to soften.
3. Gasohol
4. Is a green mould fungus that could be used to fight diseases.

Lesson 10: Bacteria in Food Industry

Welcome to lesson 10. In the previous lesson you learnt about the uses of fungi. Fungi are important in the yeast production and the use of yeast in making alcohol. In this lesson, you will learn about bacteria and its importance in the food industry.

Your Aims:

- define bacterial leaching
- state uses of bacteria in dairy products
- describe the process of cheese production using bacteria

What is the Economic Importance of Bacteria?

Bacteria play very important role in the continuous sustenance of life. They are man's best friends as well as enemy, thus we identify them to be either beneficial or harmful bacteria.

Bacteria are useful and beneficial in the following areas and activities:

A. Soil fertility in agriculture

Soil bacteria plays important role for the soil fertility. When soil will be fertile, automatically agricultural production will be increased. Some bacteria increase soil fertility. Examples - Fusarium and other soil bacteria.

Nitrogen is essential for all plants. Nitrogen occupies 78% of the atmosphere. The plants take nitrogen in the form of nitrates. In soil nitrates are formed by three processes:

1. **Nitrogen fixation**
   Atmospheric nitrogen cannot be utilized by plants directly, so nitrogen fixing bacteria converts this atmospheric free nitrogen into molecular nitrogen or nitrogenous compounds through the process known as nitrogen fixation.

   Examples are Rhizobium, Azobacter, Clostridium is called Nitrogen fixation

2. **Nitrification**
   It is a process of conversion of organic substance into nitrate form which are utilized by green plants easily.
   Nitrifying bacteria(nitrosomes and nitrococcus) convert nitrogen of ammonia into nitrite (NO_2) like ammonia salts to nitrites (nitrobacter) – Nitrates

3. **Decay of dead plants and animals**
   Some bacteria attack dead bodies of plants and animals and convert their complex compounds into simpler substances.

   Manure
   Saprophytic bacteria acts on animal dung, farm refuse and organic waste of industrial house resulting manure which is the best for agricultural production.

B. In dairy

All dairy products (cheese, butter, yoghurt) are made with different types of strains of lactobacillus bacteria. The prefix 'lacto' is the Latin word for milk, while bacillus', as you know, tells us that these bacteria are rod-shaped.

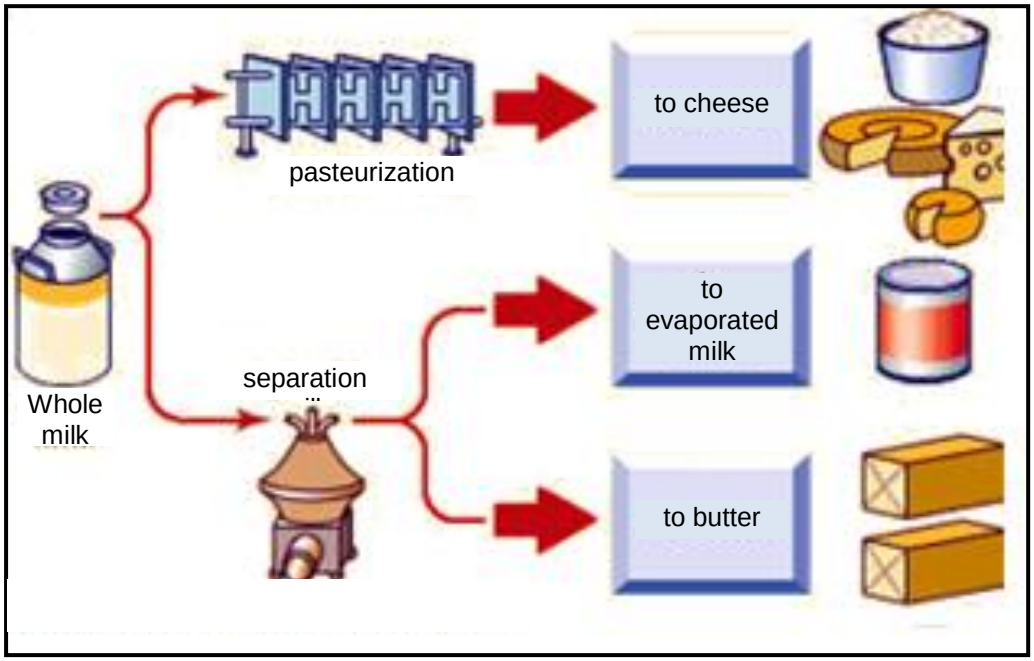
Dairy products are generally defined as food produced from the milk of mammals. They are usually high energy-yielding food products. A production plant for the processing of milk is called a dairy or a dairy factory. Apart from breast fed infants, the human consumption of dairy products is sourced primarily from the milk of cow.

Dairy products

Bacterium **lactici acidi and B. acidi lactici** are found in milk. These bacteria ferment lactose sugar found in milk to form lactic acid by which milk becomes sour.

Processing of milk products

If the milk is heated at 62.8°C for 30 minutes and is simultaneously cooled, the number of lactic acid bacteria is reduced but all spores and cells of these bacteria are not destroyed and pathogenic spores are destroyed. In this way milk becomes sour but it takes longer time to become sour than ordinary milk. This process is known as **pasteurization**.



Essential steps in the processing of whole fresh milk into butter, evaporated milk and cheese.

Lactic acid bacteria bring together droplets of **casein***, a protein found in milk and help in the formation of curd. On churning of curd, butter is derived in the form of fat's rounded droplets. The butter on heating is converted into "ghee".

On freezing of case in of milk protein it is fermented by bacteria which results to foamy and soft substance, with different in taste.

Cheese

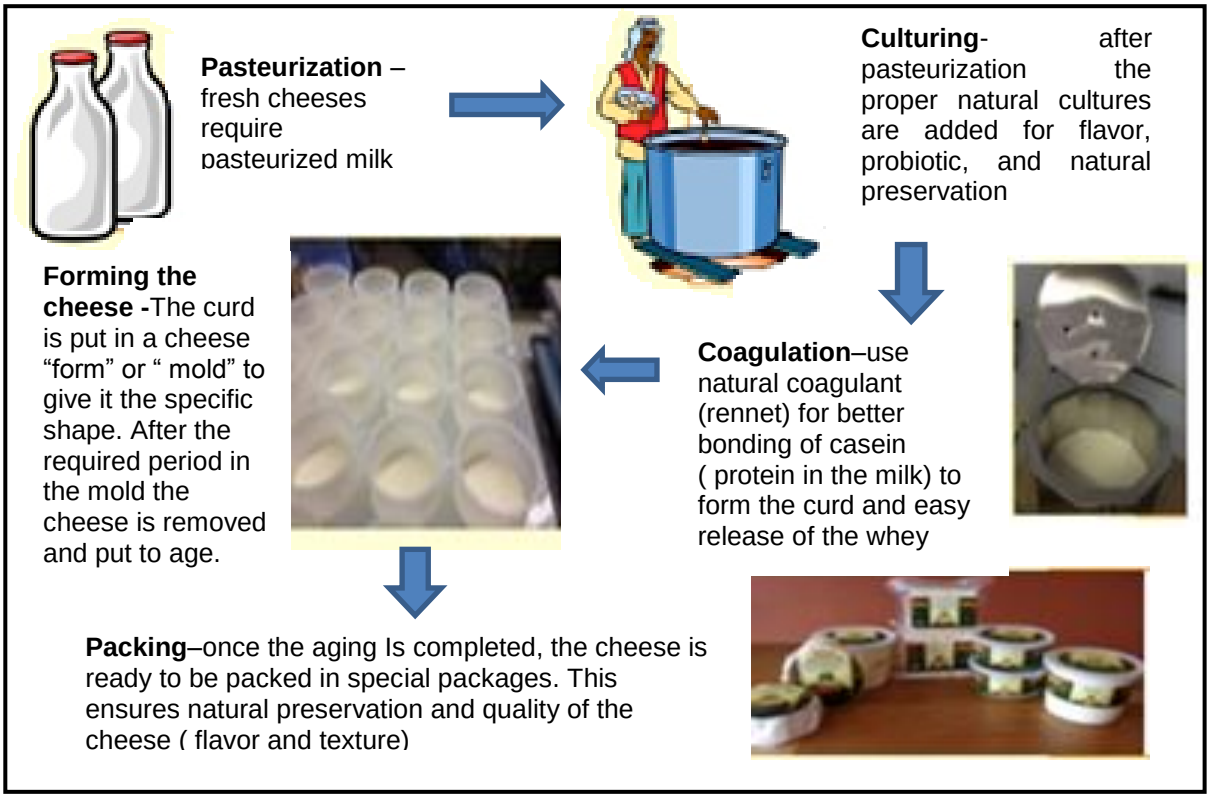
Cheese may be made from raw milk of any kind. In the United States, however, the milk that is used to make cheese is usually cow's milk that has been pasteurized, or treated with heat to kill harmful bacteria.

After pasteurization, the milk is inoculated with a 'starter culture' of fermenting micro-organisms.

Milk products Cheese and milk products

Different species of microorganisms result in different kinds of cheese. Rennet is sometimes eaten without further aging in the form of cottage cheese or cream cheese. Cream cheese is made from a mixture of cream and milk and is richer in fat content than cottage made cheese, which is often made from skim milk.

Bleaches or dyes may be added to produce a uniform colour.Salting the curds is an essential part of the process. Salt slows growth of microorganisms and helps to draw the whey out of the curd.



Cheese making process

After these steps, the cheese is pressed into forms or barrels to ripen for a period of weeks or months. Cheese is usually made in the form of large wheels or blocks that are cut apart and sometimes separated into slices before the product is sold to customers.

Butter

All brands of butter like' Anchor' butter, which you have probably seen on sale in trade stores, are made by using a special type of lactobacillus bacteria. The bacteria cause the cream to sour. This causes the particles of cream to come together more easily when the cream is stirred vigorously, producing butter.

Yoghurt

Another dairy product is yoghurt. It is made by the action of another type of lactobacillus bacteria on milk sugars, rather than on milk solids, as is the case with cheese production. These special bacteria help digest the milk sugars, causing the slightly sour taste that gives yoghurt its distinctive taste.

C. Industrial value

From industrial point of view bacteria are most important .Some of the uses of bacteria in industries are as follows:

(i) **Vinegar industry**

Vinegar is manufactured from sugar solution in the presence of Acetobacter aceti. Mycoderm bacteria converts sugar and sugary substance into acetic acid or vinegar.

(ii) **Alcohol and Acetone**

Clostridium acetobutylicum takes part in the manufacture of butyl alcohol and acetone.

(iii) **Fibre ratting**

The intact firbres of jute, hemp, flax, are separated by bacterial action. Fibre plant when immersed in water acted by bacteria dissolves pactic substances of middle la,ella and yiekds fibres, which are used for many commercial use. The process of separation of fibres is known as **ratting**.

This process is carried out by Clostridium butyricum inhabiting the water. In this process the stems are kept under water for some days and when stem begins to decay fibres are separated from the stem on thrashing.

Examples, include making different kinds of ropes bags, shoes and others.

vii) **Leather tanning**-bacteria are used to convert skin of animal (hide) into leather. Recently replaced by chemical for tanning.

D. Medicinal importance

(i) Vitamin B- Riboflavin obtained from clostridium

(ii) Antibiotics-Different antibiotics are obtained from bacteria's like Thyromicin antibiotic by bacillus brevis bacteria. Subtilin antibiotics obtained by bacillus substises.

(iii) Curing and ripening of tea and tobacco leaves- when harvested leaves and hung in shed, they will be acted by bacteria micrococcus resulting flavor and tasty.Bacillus megathenium mycococcus is used for its fermentative capacity for developing flavour and taste in tobacco leaves.

D. Metal extraction

Certain bacteria can live on metal ores. They act on the metal ores and release valuable metals such as copper and gold. This new method of mining can be carried out in areas which cannot be mined by usual methods.

Bacteria can also be used to extract metals from waste ore from a mine. This process is known as **bacterial leaching**. Certain bacteria act on the waste producing metals that can be extracted or washed out.

Microbial leaching of ores depends primarily on bacterial processes which are the essential causes of natural weathering of sulfidic minerals. If sulfidic heavy metal minerals come into contact with air and water they begin to decay with the formation of sulfate or sulfuric acid and water soluble heavy metal cations.

The main bacteria which play the most important role in leaching of sulfidic metal minerals is called <u>Thiobacilli.</u>

Activity: **Now test yourself by doing this activity.**

Answer the following questions.

1. Some bacteria act on the metal ores and release valuable metals. Name two of these valuable metals.

   (i) _____ (ii) _____

2. What type of milk In USA is used to make, cheese? _____

3. Cream cheese is made from _____.

4. Cottage cheese is made from _____.

5. Name the bacterium that is used in making dairy products. _____

6. A production plant for the processing of milk is called _____.

7. Cheese is made from which product? _____
   _____

8. Apart from breastfed infants, human consumption of dairy products is sourced from _____.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 10.

Summary

You have come to the end of lesson 10. In this lesson you have learnt that:

- bacterial leaching is when bacteria live on metal ores and help to extract the metals.
- the main bacteria which play the most important role in leaching of sulfidic metal minerals is thiobacilli.
- dairy products are generally defined as food produced from the milk of mammals.
- all dairy products are made with different types of strains of lactobacillus bacteria.
- cheese is made from raw milk of any kind.

NOW DO PRACTICE EXERCISE 10 ON THE NEXT PAGE

Practice Exercise 10

Answer the following questions.

1. What is the general name of the types of food products which are made with different types or strains of lactobacillus bacteria?

   _____

2. Name three different food products, mentioned in this lesson, that belong to the type of foods referred to in Question 1 above.

   i) _____ ii) _____iii) _____

3. Name the main bacteria which play the important role in leaching of sulfidic metal.

   _____

4. Explain how butter is produced.

   _____
   _____

5. Explain what is bacterial leaching.

   _____
   _____

6. What does the term ‘pasteurized’ mean?

   _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 2.

Answers to Activity

1. i. Copper ii. Gold
2. Cow milk
3. Cream cheese is made from a mixture of cream and milk and richer in fat content.
4. Cottage cheese is made from skim milk
5. Lactobacillus bacteria
6. A dairy or a dairy factory
7. From raw milk of any kind, but in USA is cow’s milk
8. From the milk of cow

Lesson 11: Bacteria in the Chemical Industry

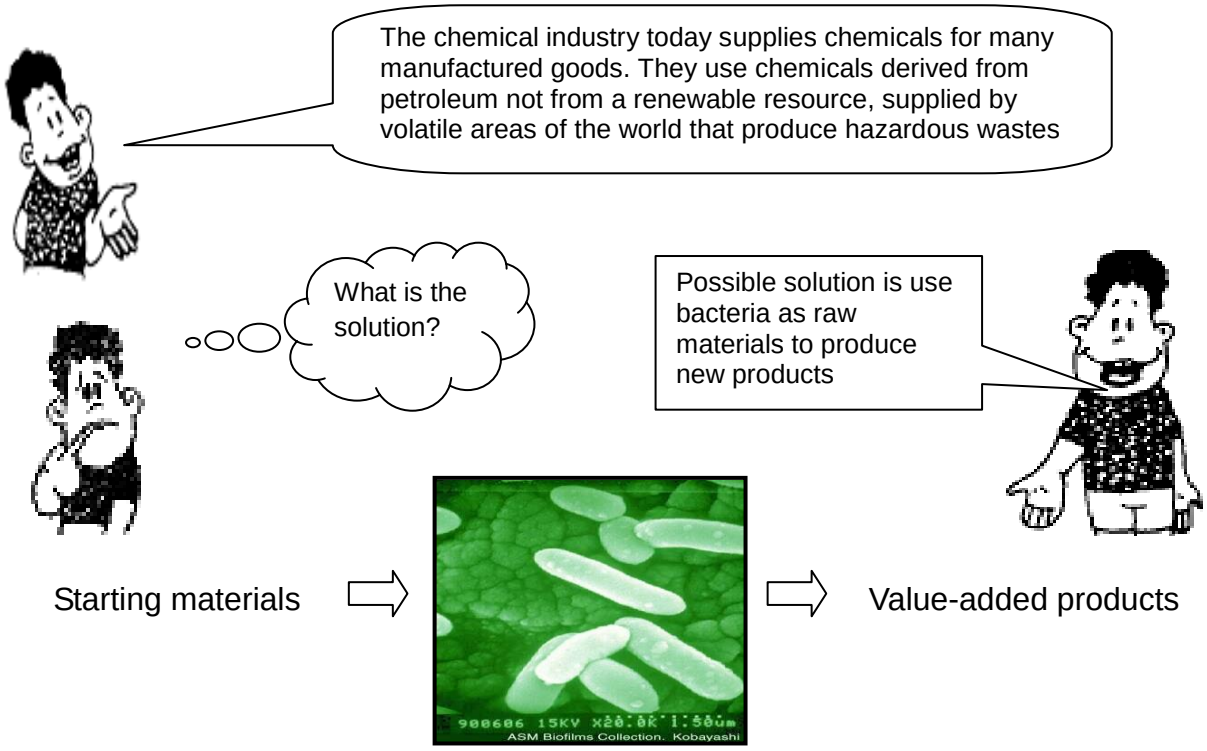
Welcome to Lesson 11.In the previous esson you learnt about bacteria in food Industry. The important use of bacteria in metal extraction and in the dairy products like making of cheese, yoghurt and butter. In this lesson, you will learn about bacteria and its uses in the chemical industry.

Your Aims:

- identify the uses of fuel oil, silage, insecticides and pesticides
- identify fuels used by bacterial action
- explain bacterial action in sewage treatment

Importance of Bacteria in Chemical Industry

Bacteria play an important role in technological fields mainly in mining, medicine, food culture, plastics synthesis and sewage control. One way bacteria are useful to mankind is in the production of complex organic molecules that are of used in small amounts as part of our normal process of living.



Bacteria

By manipulating the **gene*** of the bacteria and ensuring they have ideal living conditions scientists can make the bacteria concentrate almost exclusively on producing just one chemical and made ready for commercial or practical use.

What are the advantages of bacteria versus other cells?

- Relatively small and simple
- Reproduce quickly

- Tremendous metabolic / catalytic diversity
    - thrive in extreme environments
    - use nutrients unavailable to other organisms

Potential products

Natural products (complex synthesis)
- vitamins
- therapeutic agents
- PHAs (biodegradable plastics)
- amino acids
- **viscosifiers***
- pigments
- industrial enzymes

Engineered products
- starting materials for polymers (rubber, plastic, fabrics)
- specialty chemicals (chiral)
- bulk chemicals (C4 acids)

Fuels
- hydrogen gas (H_2)
- methane gas (CH_4)

Alcohol

methanol (CH_3OH)

ethanol (CH_3CH_2OH)

Important fuels

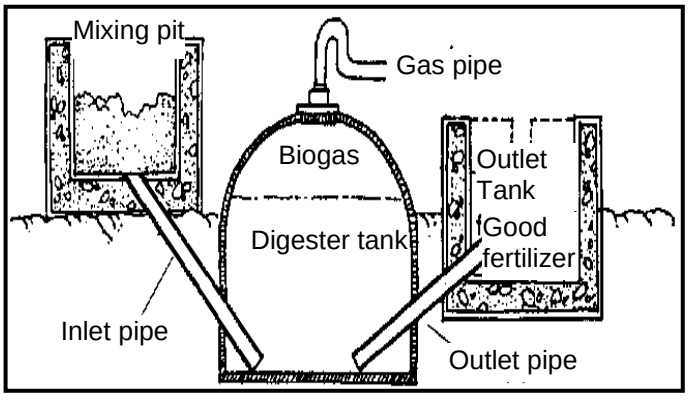
Scientists are now able to produce two important fuels by using bacterial action on different substances. These two fuels are **methane gas** and **fuel oil**.

Methane

You learnt in Lesson 10 that alcohol, made by fungal action (fermentation), is a fuel substitute for some oil products, such as petrol. Similarly, methane gas, made by bacterial action, is an alternative fuel to natural gas. It can be used for heating and cooking purposes. It can even be used as a fuel to run cars.

Some bacteria produce methane gas as a by-product when they feed on wastes such as sewage or manure. The methane gas manufactured in this way is known as biogas. Sewage works use this process to collect methane that bacteria have released.

However, not all biogas is produced in large sewage works. On the right is a picture of a biogas generator. In a biogas generator, bacteria act on animal waste such as cattle manure, to produce methane gas.



A simple type of biogas generator

Fuel oil

In photosynthesis, green plants convert carbon dioxide from the air into organic compounds like sugar. Some bacteria are able to change these organic compounds into oil. Scientists are now trying to make fuel oils commercially using these bacteria.

Vitamins

The vitamin industry is huge and commercially it is worth more than 1 billion USD per year. Most of these vitamins can now be synthesised chemically in **vats***. Some,

however, are too complicated to be produced in this way and are made biochemically. The most important of these is vitamin B12. Vitamin B12 is essential for normal living in all animals and a deficiency of it causes a disease called **pernicious anaemia*.**

Commercially, vitamin B12 is produced by several bacteria, the most important of which is *Pseudomonas denitrificans*. Other important producers are species of the genus *Propionibacterium*. The other important vitamin made commercially by micro-organisms is Riboflavin. Most riboflavin is produced by a fungus called *Ashbya gossifyii* however bacteria are used to produce some as well.

Amino Acids are used in medicine to treat dietary deficiencies and in the food industry as antioxidants, sweeteners and flavor enhancers. Amino acids come in two forms one of which is the 3D mirror image of the other. They are called the D and L isomers of a particular amino acid. Living things use only the L isomer amino acids. Unfortunately, chemical methods of production produce 50% D and 50% L **isomers***, so half of what is produced is of no use to anybody. Bacteria, however being living things, produce only the L form. This is one of the reasons that they are so important in this industry.

Perhaps the best known commercially produced amino acid is glutamic acid which is sold as Monosodium Glutamate, MSG, a flavor enhancer. Two other important amino acid products are aspartic acid and phenylalanine. Mixed together these two become the popular sugar-free sweetener, **Aspartame**.

Lysine, another essential amino acid for humans, is also produced from bacteria, it is used as a food additive to enhance its nutritional value. Lysine is produced by *Brevibacterium flavum* whilst glutamic acid is produced by *Corynebacterium glutamicum.* Over half a million metric tons of amino acids are produced commercially each year, the table below lists a few with their uses.

Bacterially Produced Amino-acids	**Used as Food Additives**
Lysine	Nutritive additive in bread
Glutamate	Flavour enhancer, meat tenderiser
Glycine	Flavour enhancer in sweet foods
Cysteine	Antioxidant in bread and fruit juices
Tryptophan and Histidine	Antioxidant
Methionine	Nutritive additive in soy products
Phenylalanine and Aspartic acid	Sweetener in soft drinks

Plastics

Plastic is everywhere in our modern society. It is ideal for producing a variety of products such as containers for liquids of and all sorts other materials, machinery and plates, tables, cups, etc. However, plastic is a nuisance when it is no longer useful and is left lying around the countryside.

Plastic is still a problem even if it is buried in a landfill. The reason for this is that it is not biodegradable, in other words it cannot be rotted away by bacteria and fungi as is nature's normal method of recycling the materials. Chemically produced plastics are made of multiple units of molecules such as Polypropylene, Polyethylene and Polystyrene, which most bacteria and fungi cannot digest or breakdown. This means

they are non-biodegradable, and so they last for years once abandoned, an ecological waste and often an eyesore.

Plastics do not have to be a problem like this though, science has developed an answer. The chemical giant ICI is manufacturing a plastic in the UK from multiple units of a mixture of two bacterially produced molecules, Poly-B-hydroxybuterate and Poly-B-hydroxyvalerate.

These molecules make a polymer just like ordinary plastic but having the essential difference that once left out in the compost or in a landfill they can be broken down by bacteria and fungi to become part of the cycle of life again. In 1998 only 600 tons of this plastic was produced but in the future, mass production could make it as cheap as ordinary plastics.

Shampoo in a biodegradable plastic

Without further doubt research will reveal more microbial plastics to help save the environment. Why not ask your local politicians what they are doing to encourage the use of biodegradable microbial plastics. The picture (right) is a shampoo bottle sold in Europe, it is made of microbial plastic. The bacterium which does all the work is *Alcaligenes eutrophas.*

Silage

Silage is made from crops such as grass or maize. It is used as an animal feed, especially in winter months, in countries that have very cold winters. To make silage, the green crops are first packed and compressed to remove air. Bacteria cause fermentation of the sugar present in the crops, producing foods.


Without the aid of special bacteria, cattle would not be able to digest grass.

Silage is more nutritional and more easily digested by cattle than other winter foods like hay (dried grass).

Insecticides and pesticides

Crops can be seriously damaged by insects, reducing food production. A number of chemical insecticides have been used. Unfortunately, these insecticides are often poisonous to humans and other animals.


A caterpillar resting on a leaf

It was recently discovered that certain microbes could naturally make insecticides, such as the special bacteria that destroy caterpillars, which cause damage to fruit trees by eating their green leaves. Such insecticides are harmful only to insects.

As well as bacterial pesticides, there is a fungal pesticide that attacks worms which destroy potato crops.

Tanning

In the **tanning** process animal hides (skins) from cattle and other animals such as pigs and crocodiles are treated to make leather. The leather is then used to make such things as shoes and belts. The tanning process is achieved by special bacteria which loosen the hair and make it easier to remove.

Farm machinery spraying pesticides on a crop

Activity 1: Now test yourself by doing this activity.

Answer the following questions.

1. Silage is made from crops such as:

   (i) _____ (ii) _____

2. What type of insecticides is often poisonous to animals and humans?

   _____

3. Name an animal, mentioned in this lesson, which causes damage to the leaves of fruit trees.

   _____

4. In photosynthesis process, what do green plants do?

   _____

   _____

Sewage treatment

In the olden days, sewage would often be thrown into areas where people would walk. In these places, dangerous diseases like typhoid and cholera, which you will learn more about in Topic 3, were common.

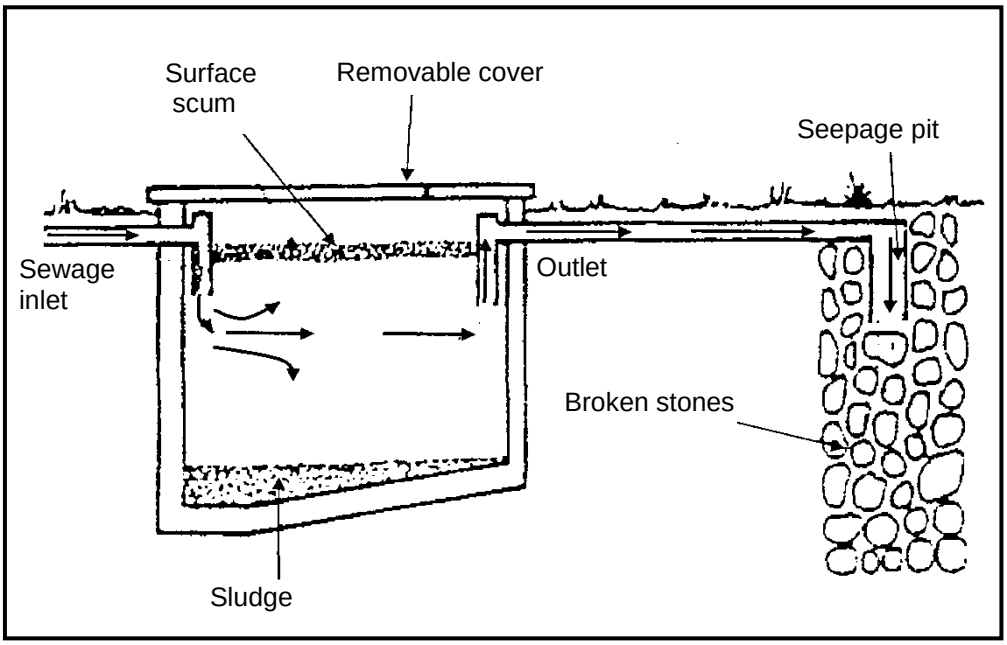
Nowadays, one way to treat sewage produced by a big town is by using special bacteria which digest the sewage. This treatment takes place in large sewage plants.

One method of treating sewage on a large scale is by allowing the sewage to settle in tanks. The liquid in the sewage is then pumped into a digestion tank in which air or oxygen is forced through the liquid. This causes the small solids and the bacteria in the liquid to collect together as **sludge***. The sludge is digested by the bacteria. After further digestion in other digesting tanks, the waste is filtered and liquids pass into rivers or seas, while solids are used as fertilizer.

Another by-product of sewage treatment as mentioned earlier is methane gas, which, as you know, can be used as a fuel.Treatment of sewage on a small scale can be done using septic tanks. In a septic tank the water flows into a concrete or fibreglass

underground tank.Bacteria break the waste down and the safe liquid then flows from the top of the tank into the soil.

The diagram below shows the treatment of a sewage using a septic tank used by many homes in Papua New Guinea



A septic tank

Activity 2: **Now test yourself by doing this activity.**

Answer the following questions.

1. Many bacteria are able to produce fuel as a by-product of their feeding processes when they live on waste such as _____ or manure.

2. The _____ gas manufactured in this way is known as _____.

3. Name two (2) by-products of a sewage treatment plant.

   i) _____ ii) _____

4. One of the by-products from Question 3 can be used as a _____.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 11.

Summary

You have come to the end of lesson 11. In this lesson you have learnt that:

- the methane from manure and other sewage in sewage plants is used as a fuel.
- fuel from methane gas is known as biogas.
- the by-products of the sewage treatment plant are methane gas and fertilizers.
- special bacteria and fungi naturally produce insecticides and pesticides.
- silage, made by bacterial action on green crops is used as a winter animal feed.

NOW DO PRACTICE EXERCISE 11 ON THE NEXT PAGE

Practice Exercise 11

Answer the following questions.

1. In a sewage treatment, the waste is filtered and liquids pass into rivers or seas, while solids are used as _____

2. Scientists are now able to produce two important fuels by using bacterial action on different substances. What are these two fuels?
   i) _____ ii) _____

3. What type of animal feed, made by bacterial action on crops, is used especially in countries which have very cold winters?
   _____

4. Animal hides are bacterially treated to make shoes, belts and other leather articles.
   (a) What is this process called? _____
   (b) What do the bacteria do? _____

5. In earlier times, sewage was often thrown into areas where people walked, causing dangerous diseases. Name one of the diseases caused by this practice. _____

6. Methane gas, apart from being used as fuel for cars, it can also be used for:

   i) _____ ii) _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 2.

Answers to Activities

Activity 1
1. i) grass ii) maize
2. Chemical insecticide
3. Caterpillar.
4. Green plants convert carbon dioxide from air into organic compounds like sugar

Activity 2
1. Sewage
2. i) Methane ii) Biogas
3. i) Fertilizer ii) Methane gas
4. Fuel

Answers to Practice Exercises 8 - 11

Practice Exercise 8

1. The microbes digest cellulose that their hosts eat and so provide energy for both themselves and their hosts.

2. The brown weeds are used as food by man and other animals.

3. The Nitrogen gas

4. Cellulose

5. (a) microbes that play an important part in the digestion of the substance
   i. bacteria ii. protozoa

   (b) animals mentioned in this lesson that can digest the substance.
   i. cattle ii. sheep

. (c) insects that can digest the substance
   i. white ants ii. termites

Practice Exercise 9

1. Respiration is the use of oxygen in the breakdown of food material.

2. Fermentation is a form of anaerobic respiration in which sugar is broken down to carbon dioxide and alcohol.

3. Hops

4. Antibiotics

5. Malt wort is a sugar-rich liquid from the malt enzymes that had digested the starch and protein in the malt.

6. They reproduce by the process of budding in which an outgrowth of bud from a cell enlarges and finally separates from the parent, becoming an independent cell.

7. Anaerobic respiration is the release of energy from food material like sugars, by a process of chemical breakdown that does not require oxygen.

Practice Exercise 10

1. Dairy Products

2. i) Cheese ii) Yoghurt iii) Butter

3. Thiobacilli

4. Special type of lactobacillus bacteria cause cream to sour. This causes the particles of cream to come together more easily when the cream is stirred vigorously.

5. This is when bacteria live on metal ores and help to extract the metals

6. Treated with heat to kill harmful bacteria

Practice Exercise 11

1. Fertilizers

2. i) Methane gas ii) fuel oil

3. Silage

4. (a) Tanning
   (b) They loosen the hair and make it easier to remove .

5. Typhoid or Cholera

6. i) Cooking ii) Heating

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

REVIEW OF TOPIC 2: USEFUL MICROBES

Now, revise all lessons in this Topic and then do **ASSIGNMENT 2.** Here are the main points to help you revise.

Lesson 8: Useful Microbes

- Microbes are able to use faeces and dead organisms for food.
- Microbes are important in the process of decay because they recycle nutrients.
- Some microbes are able to digest the cellulose found in green leaves. These microbes are found in the stomach of cattle and sheep.
- Nitrogen-fixing bacteria are able to improve the fertility of the soil by changing nitrogen and oxygen into nitrates.
- Without the action of decay causing microbes, the essential nutrients would be locked within the bodies of dead plants and animals.
- The supply of these materials would eventually be exhausted, causing all life to come to an end.

Lesson 9: Fungal Uses

- Aerobic respiration involves the use of oxygen in the breakdown of food material.
  Anaerobic respiration is the release of energy from food material like sugars by a process of chemical break down that does not require oxygen.
- Fermentation is a form of anaerobic respiration in which sugar is broken down to carbon dioxide and alcohol.
- Yeast cells reproduce by budding.
- The alcohol produced during fermentation is used to make drinks such as wine, beer, rum and whiskey.
- The fungus called penicillium is a green mould that can be used to fight diseases.

Lesson 10: Bacteria in Food Industry

- Bacterial leaching is when bacteria live on metal ores and help to extract the metals.
- The main bacteria which play the most important role in leaching of sulfidic metal minerals is Thiobacilli.
- Dairy products are generally defined as food produced from the milk of mammals.
- All dairy products are made with different types of strains of lactobacillus bacteria. Cheese is made from raw milk of any kind.

Lesson 11: Bacteria in the Chemical Industry

- The methane from manure and other sewage in sewage plants is used as a fuel. This fuel from methane gas is known as biogas.
- The by-products of the sewage treatment plant are methane gas and fertilizers.
- Special bacteria and fungi naturally produce insecticides and pesticides.
- Silage, made by bacterial action on green crops, is used as a winter animal feed.

NOW DO TOPIC TEST 2 IN YOUR ASSIGNMENT 2.

TOPIC 3

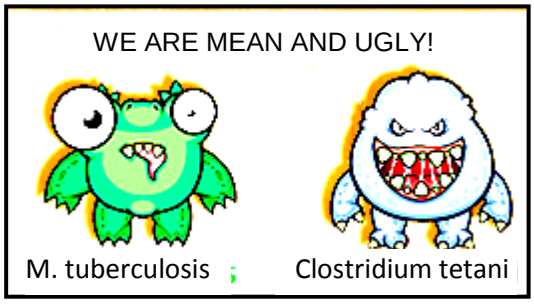
HARMFUL MICROBES

In this topic you will learn about:

- **pathogenic microbes**
- **vector diseases**
- **airborne diseases**
- **food and water diseases**

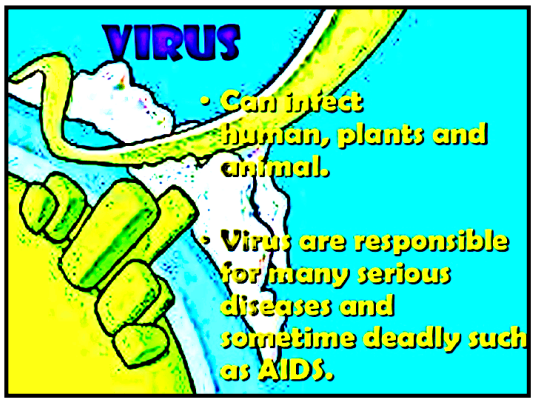
INTRODUCTION TO TOPIC 3: HARMFUL MICROBES

In the previous topic, we have learned about micro-organisms as beneficial, harmless and useful in many ways. But microbes are generally known to be the" bad guys' that cause diseases to most organisms not only humans.

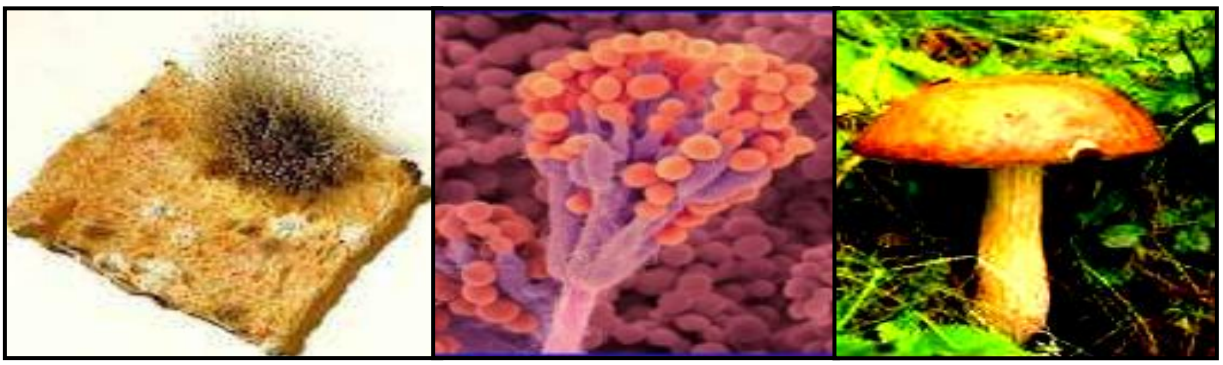


Bacteria and fungi can be parasites of humans, causing anything from food poisoning to athlete's foot to malaria.

All viruses are pathogenic, or disease-causing. Viruses are responsible for deadly diseases such as AIDS and polio, as well as milder forms like the common cold. Some viruses have even been implicated in the development of cancer.



In this topic, we will study lessons on microbes that cause diseases known as pathogens, and basic lessons on different kinds of vector, airborne, food and water borne diseases.



Learning these lessons will help you answer the following questions:

- What are the different pathogenic microbes?
- How do pathogens may enter the body?
- What are the different vector, airborne, food and water diseases?

In this Topic, you will find the answers to these questions and all other questions relating to harmful microbes.

Lesson 12: Pathogenic microbes

Welcome to lesson 12. The earth has many different types of microbes. Some of these microbes are harmless while others are harmful to our bodies because they make us sick. In this lesson we are going to discuss about the different harmful microbes and diseases that cause harm to our bodies.

Your Aims:

- define pathogens
- describe the diseases caused by pathogens and state the ways in which they enter the human body
- describe how the diseases are spread from one person to another.
- describe ways in which the body defends itself from microbes.

.

What is a Pathogen?

Pathogens are parasites which live on or in the body of another organism, known as **host**. The pathogens obtain some life requirements, such as nutrients, from the host and in so doing they damage the host's body.

My father has been suffering from tuberculosis disease lately. That means he is the host while the bacteria which is the pathogen living in his body and causing the sickness is the parasite.

Pathogens can be transferred from one host organism to another by utensils, food, breath droplets, faeces, water supplies, and others.. The disease they cause is said to be **infectious**, that is, one host organism can pass on the disease to another organism.

Therefore, pathogens are organisms that cause disease. All viruses are pathogens. Some bacteria are pathogens and so are a few fungi and protozoa. The pathogens act as *parasites* when they live in or on plants and the host.

How pathogens enter the body?

Through the natural openings in the body

Many microbes can enter the body through its natural openings, the **nose**; **mouth, urinary passages**, **anus** and **vagina** are all possible entrances for pathogens.

Each of these openings leads to a tube lined with a soft, moist mucus membrane. This mucus often contains enough food for microbes to live on. Fortunately if a person is healthy, these membranes are able to resist the penetration of most microbes. But if a person is tired, weak, run-down or not well-fed then his **resistance** will be low.

Common pathogens can enter through any of the body's natural openings and the body has ways to reduce this:

1. **The nose** is the entrance through which airborne pathogens enter the body. When we breathe, tiny droplets of water or dust containing pathogens are taken onto our respiratory system (lungs and bronchial tubes). In this way the pathogens causing respiratory diseases such as pneumonia, influenza, tuberculosis and the common cold enter the body.

2. **The mouth** provides entrance for microbes present in drinking water and food, and also for microbes transferred to the lips by contaminated fingers or cups and spoons and forks. Pathogens causing gastro-intestinal diseases, examples cholera, typhoid, dysentery, food poisoning enter in this way.

3. **The sexual organs**. The bacteria causing the venereal diseases, syphilis and gonorrhoea and the viruses that cause HIV, enter the body through the penis or vagina during sexual intercourse. Other infections not associated with sexual activity can also enter through these openings.

4. **Through the skin**
   - Unbroken skin forms a natural barrier to most microbes. Fortunately very few can penetrate the skin directly. The bacteria that cause boils and pimples invade hair follicles and cause infections there. Spores of the fungi causing grille and athlete's foot (tinea) and the bacteria causing leprosy can pass directly through the skin.

   - Broken skin provides entrance for many pathogens. Skin can be broken in several ways:
     - cuts and wounds allow bacteria such as those causing blood poisoning and tetanus to enter the body.
     - bites, mostly by insects, inject the pathogens causing diseases such as malaria and dengue by mosquitoes and rabies by dog.

How do infectious diseases spread?

1. **Direct contact**

   The easiest way to catch most infectious diseases is by coming in contact with someone who has one. This "someone" can be a person, an animal or, for an unborn baby, its mother. Three different ways infectious disease can be spread through direct contact are:

Person to person. The most common way for infectious disease to spread is through the direct transfer of bacteria, viruses or other germs from one person to another. This can occur when an individual with the bacterium or virus touches, coughs on or kisses someone who isn't infected. These germs can also spread through the exchange of body fluids from sexual contact or a blood transfusion.

Animal to person. Your household pet might seem harmless, but pets can carry many germs. Being bitten or scratched by an infected animal can make you sick and, in extreme circumstances, could even cause death. Handling animal waste can be hazardous, too. You can become infected by scooping your cat's litter box or by cleaning bat or mouse droppings in your house or garage.

Mother to unborn child. A pregnant woman may pass germs that cause infectious diseases on to her unborn pass through the placenta, as is the case of the **AIDS*** virus and the **toxoplasmosis parasite***. Or you could pass along germs during labor and delivery, as is the case for a mother infected with group B streptococcus.

2. **Indirect contact**

Disease-causing organisms can also be passed along by indirect contact. Many germs can linger on an inanimate object, such as a tabletop, doorknob or faucet handle. When you touch the same doorknob grasped by someone ill with the flu or a cold, for example, you can pick up the germs he or she left behind. If you then touch your eyes, mouth or nose before washing your hands, you may become infected.

Infectious diseases spread through the air

Droplet transmission. When you cough or sneeze, you expel droplets into the air around you. When you are sick with a cold or the flu or any number of other illnesses. These droplets contain the germ that caused your illness. Spread of infectious disease in this manner is called droplet spread or droplet transmission.

Droplet transmission

Droplets travel only about three feet because they're usually too large to stay suspended in the air for a long time. However, if a droplet from an infected person comes in contact with your eyes, nose or mouth, you may soon experience symptoms of the illness. Crowded, indoor environments may promote the chances of droplet transmission — which may explain the increase in respiratory infections in the winter months.

Particle transmission. Some disease-causing germs travel through the air in particles considerably smaller than droplets. These tiny particles remain suspended in the air for extended periods of time and can travel in air currents. If you breathe in an airborne virus, bacterium or other germ, you may become infected and show signs and symptoms of the disease. Tuberculosis and SARS (Severe Acute Respiratory Syndrome) are two infectious diseases usually spread through the air, in both particle and droplet forms.

Infectious diseases spread through vectors and vehicles

Bites and stings Some germs rely on insects, such as mosquitoes, fleas, lice or ticks to move from host to host. These carriers are known as **vectors**.

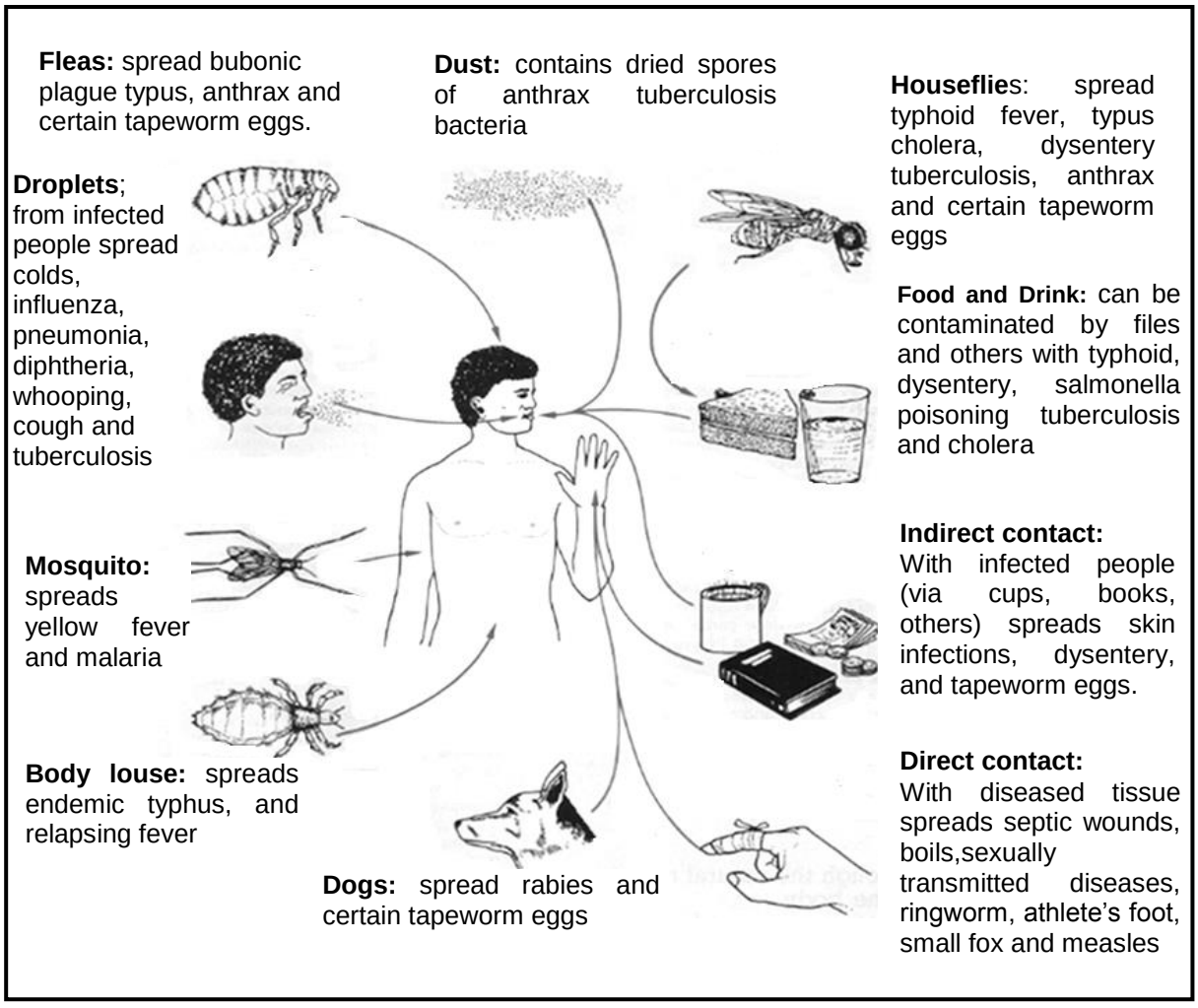
Mosquitoes can carry the malaria parasite or West germ on its body or in its intestinal tract lands on you or bites you. Nile virus, and deer ticks may carry the bacterium that causes Lyme disease.

The vector-borne spread of germs happens when an insect that carries the germs travel into your body and can make you sick. Sometimes the germs that cause infectious disease need the insect for specific biological reasons. They use the insect's body to multiply, which is necessary before the germs can infect a new host.

3. **Food contamination**
   Another way disease-causing germs can infect you is through food and water. Common-vehicle transmission allows the germs to be spread to many people through a single source.

   Food is the vehicle that spreads the germs and causes the illness. For instance, contamination with *Escherichia coli* (E. coli) is common. E. coli is a bacterium present in certain foods, such as undercooked hamburger or unwashed fruits or vegetables. When you eat foods contaminated with E. coli, chances are you will experience an illness, also commonly referred to as food poisoning.

Study the diagram below showing the summary on how microbes may enter the body and how diseases are spread.



How microbes may enter the body

Diseases caused by pathogens.

Study the table below. It shows the four main types of pathogenic microbes and the diseases they cause to the human body.

Microbe	Disease caused
Viruses	Influenza (flu), common cold, small fox, poliomyelitis, dengue, hepatitis, AIDS
Bacteria	Tuberculosis (T.B), pneumonia, tetanus, leprosy, gonorrhoea, syphilis, cholera, typhoid
Protozoa	Malaria, amoebic dysentery
Fungi	Grille, athlete's foot (tinea),

An unhealthy person is said to have a low resistance to diseases because parts of his body is weak and unable to defend itself from the entry of pathogens through the natural openings to his body and make him sick.

Activity 1: Now test yourself by doing this activity.

Answer the following questions.

1. Name the various diseases that can be spread by the methods listed in the table.

Method by which they spread	Names of diseases
A. Dog	
B. Mosquitoes	
C. Body louse	
D. Food and drink	
E. House flies	

2. Why are pathogens called parasites?

_____

3. What are the hosts of the pathogens?

_____

4. Why are diseases said to be infectious?

_____

3. What kind of person is said to have a body that has low resistance to diseases?

_____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 12.

Defending the body against pathogens

Your body is exposed to microbes all the time. This is why when an animal dies it soon decays and decomposes. A living body is able to resist this action, and microbes are normally found only on the skin and in the alimentary canal and not in other parts of the body. When pathogens are able to get inside your body you get sick.

The human body has several methods of defense to prevent infection. These are either external defenses or internal defenses. External defenses make it difficult for microbes to enter the body while internal defenses destroy or make harmless those microbes that do enter the body.

You may now study the table drawn below. They outline the external defenses the body has to pathogens and how this defenses function.

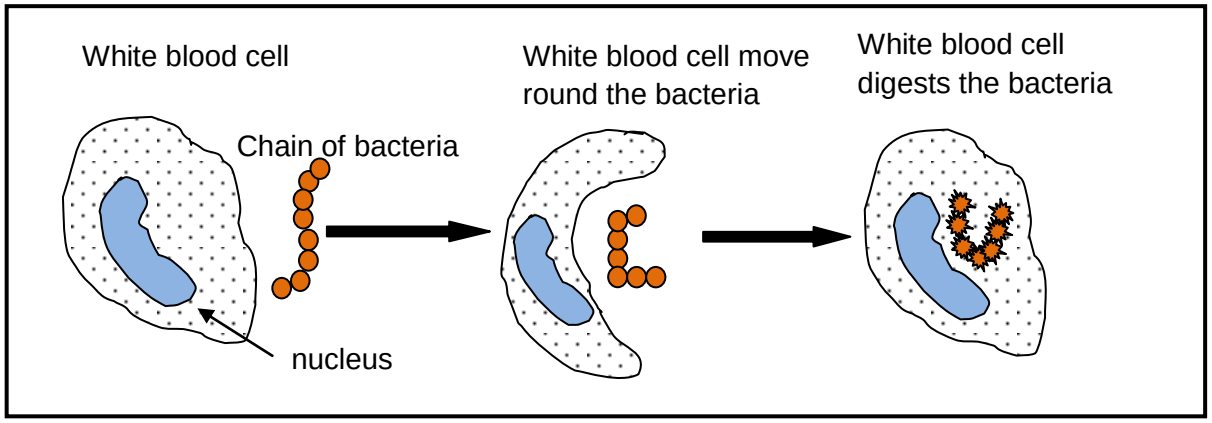
Protectors	Methods of protection
Unbroken skin	The thickness of the surface layer of cells prevents the entrance of bacteria and most other pathogens.
Mucous membranes lining	Mucus is a slimy secretion containing enzymes which destroy some bacteria. Mucus also acts as a barrier and because it is always flowing it prevents bacteria from stopping in one place and doing much damage.
Eyelids, eyelashes	Prevent the entrance of bacteria.
Hairs in the nose	These hairs point outwards and filter dust particles and bacteria from the air a person breathes.
Cilia in the bronchial tubes	These small hairs are constantly moving and force substances such as bacteria towards the mouth so that they can be removed.
Various reflex actions such as sneezing and coughing	These reflexes remove irritating substances from mouth or throat.
Secretions of the digestive system	Saliva in the mouth, gastric juice in the stomach and bile from the liver all destroy some bacteria.
Secretions of the sexual organs	Secretions of the vagina and the penis kill most bacteria, except those causing sexually transmitted diseases.
Formation of clots	Contact with air causes blood to clot and seals off the wound so that more microbes cannot enter.

Internal Defenses

Microbes that are not stopped by the external defenses may be destroyed by one of the following internal defense systems:

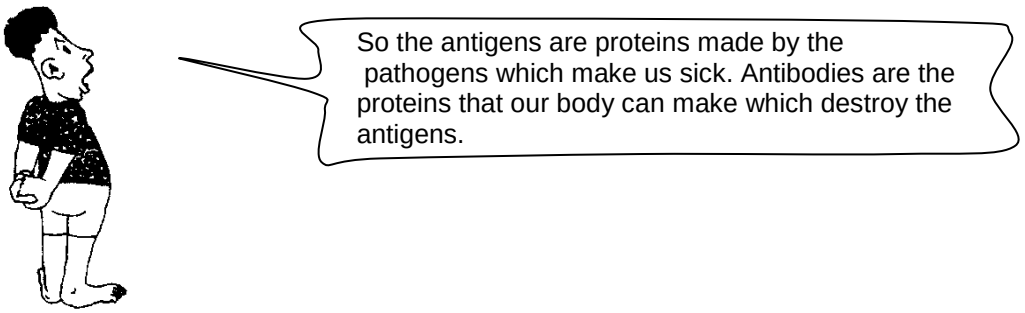
Phagocytes are white blood cells and are either **granulocytes*** or **monocytes***. These cells are able to move independently and are found in the blood and the surrounding tissues. They destroy microbes by ‘eating’ them. They surround and swallow up the microbes, absorb it and then digest it.

If a microbe enters the body through a wound or a cut, phagocytes from all over the body move to the damaged area to fight the infection.



A white blood cell, called a phagocyte, 'eating' bacteria.

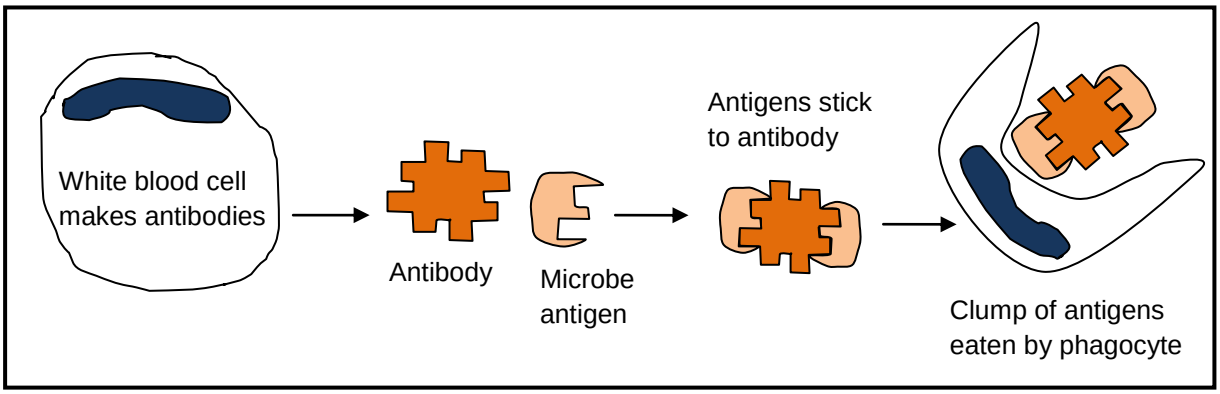
The surfaces of the microscopic pathogens such as the bacteria and viruses contain proteins called **antigens**. When antigens enter the body, **antibodies** are produced. Antibodies are special proteins which are made by white blood cells called **lymphocytes**. These antibodies combine with antigens. This either destroys the antigen, make it harmless or make it more easily caught and eaten by the phagocytes.



Our body produces two types of white blood cells, the phagocytes and the lymphocytes. They both function in different ways to prevent entry of pathogens into our body. The phagocytes surround and 'eat' the antigens while the lymphocytes produce antibodies which attack the antigens.

White blood cells are made in the bone marrow, the spleen and the lymph nodes and are stored in special parts of the liver.

Each antibody is very specific and carries out its own function. This means that an antibody which attacks typhoid bacteria will have no effect against pneumonia bacteria.



How antibodies work

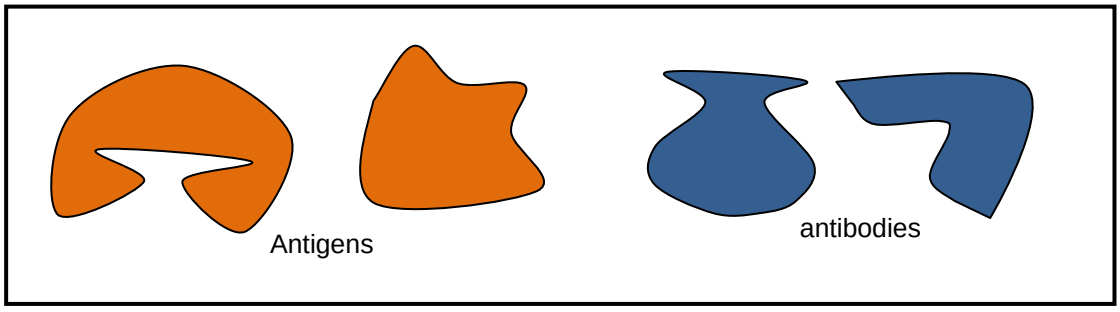
When a person is exposed to a particular disease and makes antibodies against it, these antibodies can remain in the blood for some time. This means that a person will not get the disease because the antibodies will attack the bacteria or viruses as soon as they get into the body. Such a person is said to be **immune** to that disease.

Activity 2: **Now test yourself by doing this activity.**

A. Match parts of the body from column A to the column B by writing the correct letter of your answer.

	A	B	
1	Eyes	A. Secretion of digestive juices	
2	Stomach	B. Secretions of the sexual organs	
3	Skin	C. Hair points out and filter dust particles.	
4	Vagina and penis	D. Thickness of the cells prevents entry of bacteria.	
5	Nose	E. Secretion of tears, eyelids and eyelashes.	

B. The drawings below show two pairs of antigen and antibodies. Match the pairs and draw each pair together as each antigen attacks its opponent antibody.



CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 12.

Summary

You have come to the end of lesson 12. In this lesson you have learnt that:

- organisms that cause disease are called pathogens.
- all viruses, some bacteria and a few fungi and protozoa are pathogens.
- pathogens can enter the body through the natural openings such as the nose, mouth and sex organs.
- unbroken skin forms a natural barrier to most microbes. Cuts, wounds and bites allow pathogens to enter the body.
- the body has external defenses which make it difficult for microbes to enter the body.
- the body has internal defenses which destroy microbes inside the body or make them harmless. These defenses make use of white blood cells (phagocytes) and antibodies.

NOW DO PRACTICE EXERCISE 12 ON THE NEXT PAGE.

Practice Exercise 12

Answer the following questions.

1. What is a pathogen?

   _____

2. List the ways in which pathogens can be spread from one host organism to another.

   _____

3. Name the microbes that cause the following diseases:

   a. Tuberculosis : _____
   b. Malaria: _____
   c. Small fox _____

4. List down 4 openings through which pathogens can enter the body.

   a) _____ c) _____
   b) _____ d) _____

5. What are the two types of phagocytes?

   _____

6. Explain the role of the following in controlling pathogens inside our bodies:

   a. Phagocytes

      _____

   b. Antibodies

      _____

7. Describe the function of lymphocytes?

   _____

8. What are antigens? And what are antibodies?

   _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 3.

Answers to Activities

Activity 1

1. A. Rabies, certain tape worm eggs
   B. yellow fever, malaria
   C. Endemic typhus, relapsing fever
   D. Typhoid, dysentery, salmonella poisoning, cholera, tuberculosis.
   E. Typhoid fever, typhus, dysentery, cholera, tuberculosis, anthrax, tapeworm eggs.

2. Because they live in or on the body of some organisms and obtain some life requirements from them.

3. Plants and animals which the parasites live in

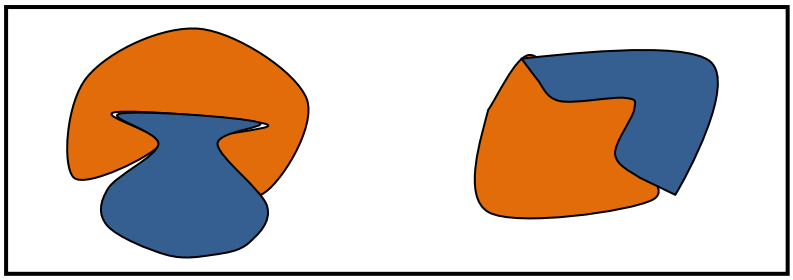
4. When the disease can be passed on from one host organism to another.

5. An unhealthy body that is weak and cannot defend itself from entry of microbes.

Activity 2

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

B.



Lesson 13: Vector Diseases

Welcome to Lesson 13. In the previous lesson we learned about the different types of pathogens and various kinds of diseases that bring sickness to the human body. When a pathogen enters a human body the person becomes sick. These pathogens then spread sickness from one person to another. In this lesson, we will learn about the ways in which pathogens are spread by animals. These animals which spread the pathogens are called vectors.

Your Aims:

- define vector diseases
- describe spread of diseases by insects and arachnids

Vector diseases

Vectors are animals that transmit or spread disease from one organism to another. The most commonly known biological vectors are arthropods but many domestic animals too are important vectors or carriers of parasites and pathogens that attack humans or other animals.

The vectors carry the pathogens with them from one place to another and spread the disease. Some animals also bite on the human skin and inject the pathogens directly into their bodies. Others spread them on the food which people eat or use the utensils. When people eat the food, the pathogens enter their bodies and make them sick.

The diseases that are spread by vectors are called the **vector diseases**.

Insects and arachnids form the largest group of disease vectors which transmit a huge number of diseases. Many such vectors feed on blood at some or all stages of their lives.

In this lesson we will only look at the vectors and the diseases which are very common to us.

Examples of common vectors and the diseases they transmit

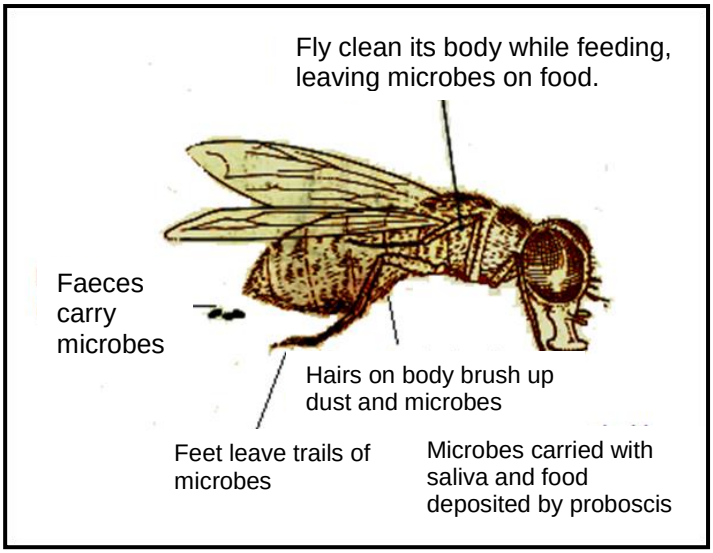
1. **Flies**

Flies however, transmit disease organisms on their bodies from faeces or other contaminated material without being affected by the pathogens. Houseflies are harmful vector to many diseases of the digestive system. The bacteria causing these diseases are carried in two main ways:

(i) Bacteria can be carried on the hairy bodies, feet and in the faeces of flies. Adult insects are attracted by the smell of food or anything that is decaying. When flies land on something that is decaying, bacteria are picked up on their feet and bodies. When flies land on the food or on utensils the bacteria can be transmitted. When a person then eats the food or uses the utensils then the bacteria will be transmitted to the person.

(ii) When houseflies feed they place a tube on its mouth called a proboscis on the food. Saliva is pumped out of the proboscis which dissolves the food so that it can be sucked up.

The proboscis is covered with microbes, and if these include pathogens such as the bacteria of cholera or dysentery then it is likely that the person who eats the food will become infected.



Houseflies: spread typhoid fever, typus cholera, dysentery tuberculosis, anthrax and certain tapeworm eggs.

2. **Cockroaches**

Cockroaches are the vectors of many diseases. Cockroaches hide under floors, in cracks, in walls, and generally in dark and dirty places where there are likely to be pathogens. They like to feed on human food as well as on decaying matter. When they move around to feed themselves they leave microbes wherever they have been. In this ways it is easy for pathogens to be transmitted to people.

Cockroaches feed on human food and deposit disease causing bacteria.

Cockroaches can pick up disease-causing bacteria, such as *Salmonella*, on their legs and later deposit them on foods and cause food infections or poisoning.

They also spread other diseases of the digestive systems, and they can also carry the virus which causes poliomyelitis (polio).When people breathe in house dust containing cockroach faeces and body parts, it can cause allergic reactions which may develop respiratory diseases and asthma in certain individuals.

3. Mosquitoes

Malaria is one of the killer diseases in Papua New Guinea. It is caused by the pathogenic microbe called *Plasmodium*. The transmission of the Plasmodium to humans is done by the female Anopheles mosquito.

The Anopheles mosquito is also a host to the pathogen, which means, it carries the pathogen in its salivary gland. When they bite on a human skin the pathogen is introduced into the person's bloodstream.

Mosquito sucking human blood

In this way the anopheles mosquitoes transmit plasmodium which causes malaria. The anopheles mosquitoes also transmit a microbe called *filariasis* which causes *elephantiasis* disease. This disease causes parts of a person's body such as the fingers, legs, scrotum etc. to grow extra-large in size. Once a person develops the

growth on its body, there is no cure to reverse or stop the growth. The person will have to live with it forever. Mosquito also transmits a virus which causes a disease called dengue fever.

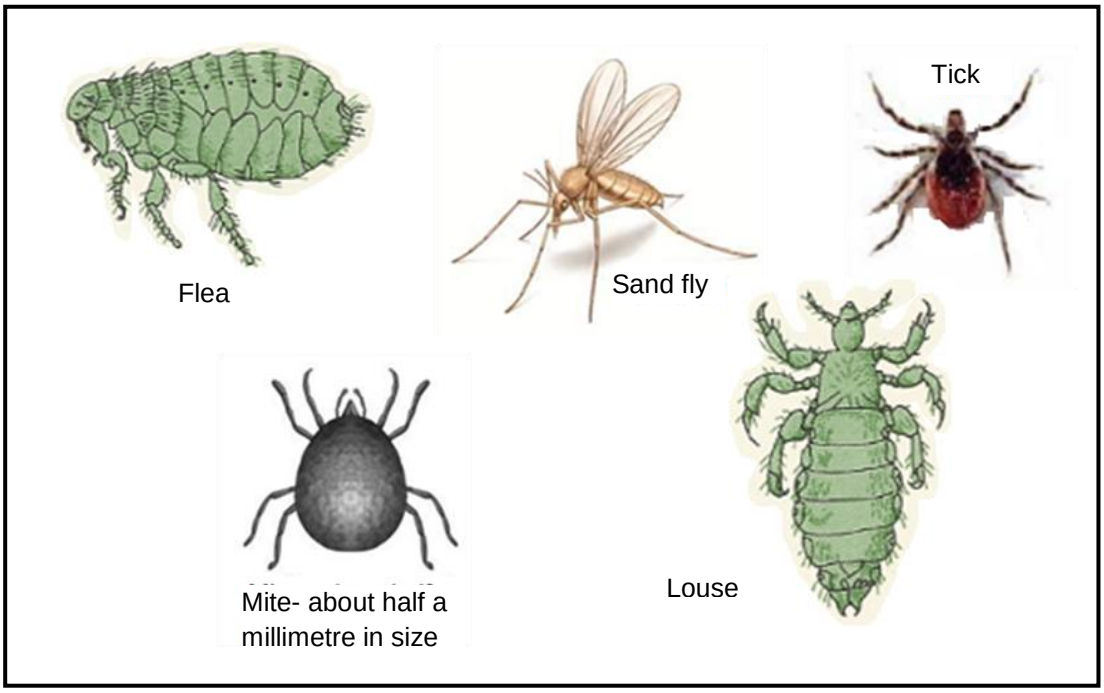
The mosquitoes themselves are not affected by these parasites but they carry the disease from one person to another.

Elephantiasis causes parts of a person's body to grow extra-large. It is a disease spread by mosquitoes.

Mosquitoes inject the pathogens directly into the human blood stream while pool feeders such as sand flies and black flies chew a well on the host's skin. This forms a pool of blood from which they feed and transmit the parasite.

Other arthropod vectors

1. **Blood-sucking mites** carry the virus of typhus. However, the itch-mites, which are responsible for scabies, do not carry disease-causing micro-organisms. The mites themselves do the damage to the skin in which they burrow and reproduce, causing bad itching. The mites are spread from one host to another by direct contact.
2. **Tsetse flies** spread the protozoa causing sleeping sickness.
3. **Fleas, lice and ticks** transmit the bacteria of bubonic plaque and of typhus. Human fleas transmit bubonic plaque and tape worms.



Lice, fleas, ticks, mites and sand flies are all vectors of many diseases.

Other animal vectors

Rats and mice are vectors of many pathogens. They like to live in places where food is stored and they often contaminate the food with pathogens. Salmonella, which causes food poisoning, is also carried in the urine and faeces of rats. Rats also carry other pathogens, including the bacteria that cause bubonic plaque.

Rats and mice are vectors

Dogs can also carry pathogens. The bite of a dog infected with rabies usually results in the wound becoming infected with the rabies virus from saliva on the dog's teeth.

Activity 1: Now test yourself by doing this activity.

A. Answer the following questions.

1. What type of mosquito carry malaria parasite?
   _____

2. Name the mouth part of a fly which transmits pathogens.
   _____

3. Apart from the mouth part, name three other parts of a fly's body that carry pathogens
   (a) _____ (b) _____ c) _____

4. Which part of a house do cockroaches live? _____.

5. Name the pathogen which dogs transmit. _____.

B. Write TRUE if the statement is true and FALSE if the statement is false on the space provided.

_____ 1. Sand flies insect pathogens into the blood stream of other animals.
_____ 2. Fleas, lice, ticks and mites are arachnids, therefore they are not arthropods.
_____ 3. Elephantiasis is caused by malaria
_____ 4. Rats carry pathogens in their urine and faeces.
_____ 5. Sand flies are not blood sucking animals.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 13.

Summary

You have come to the end of lesson 13. In this lesson you have learnt that:

- animals that carry pathogens and spread them from one organism to another are known as vectors.
- most vectors are insects and arachnids, and they belong to a group of animals called arthropods.
- vectors which suck on human flesh such as the mosquitoes, and ticks transmit pathogens directly into the bloodstream.
- some vectors such as the houseflies and rats carry pathogens on their body parts and in their urine and faeces. These pathogens are responsible for intestinal diseases and food poisoning. the microbes are spread on food as they move around from place to place.
- pathogens for malaria and the elephantiasis diseases are carried by the anopheles mosquito that feeds at night on human blood.
- lice, ticks and fleas are blood sucking vectors which sometimes also spread various pathogens. some of them do not transmit pathogens, they bite on the human skin which causes rashes and sores that may become infected.
- particles are very small parts of a substance that cannot be seen by the naked eye.
- solids have definite shape and volume because of the fixed position of particles, they are tightly packed.
- solids are rigid and hard because particles attract each other with a very strong force, hey cannot leave their positions.
- the force of attraction holds the particles at one particular place.
- vibration is the rapid back- and- forth motion of particles
- the spaces between particles are very small and they attract one another with strong force.

NOW DO PRACTICE EXERCISE 13 ON THE NEXT PAGE.

Practice Exercise 13

Answer the following questions.

1. What is a vector?

   _____

2. What are vector diseases?

   _____

3. What is the name of the microbe which cause malaria?

   _____

4. Apart from malaria, name two other diseases which can also be transmitted by mosquitoes.
   a. _____ b. _____

5. Which part of the mosquito's body carries the malaria parasite?

   _____

6. Beside the vectors listed, write in the names of the diseases they transmit to complete the table.

Name of vector	Diseases they transmit
flies	
cockroaches	
mosquitoes	
human fleas	
rats	
dogs	

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 3.

Answers to Activity

A. 1. Female anopheles mosquito
   2. Proboscis
   3. (a) Hairy body (b) feet (c) faeces *(in any order)*
   4. Under floors, in cracks, in walls, and generally in dark and dirty places.
   5. Rabies viruses.

B. 1 . FALSE 2. FALSE
   3. FALSE 4. TRUE 5. TRUE

Lesson 14: Airborne Diseases

Welcome to Lesson 14. In our last lesson we learned about the different types of animals called vectors that transmit diseases from one organism to another. We also learned the different types of diseases they transmit and their effects on human being.

Your Aims:

- describe airborne diseases.
- explain how airborne diseases are transmitted.
- describe symptoms of the diseases and the ways in which these diseases can be avoided.

Airborne Diseases and How They Are Transmitted

In this lesson we will learn about the diseases which are transmitted through the air. These diseases are called the airborne diseases. We will study the types of diseases which can be transmitted by pathogens that travel through the air current from one person to another. We will also learn the causes and symptoms of the common airborne diseases and look at ways to control and avoid them so that we are protected from these diseases

Airborne diseases are diseases that travel through the air by pathogenic microbes. Airborne diseases are those caused by pathogens and transmitted through the air as very small, or aerosolized particles.

Disease-causing pathogens are organisms that spread from an infected person to another through coughing, talking and sneezing - even breathing and laughing!

According to the U.S. Centers for Disease Control, flu droplets can travel up to six feet away!

When people breathe, laugh and talk, tiny droplets of moisture are carried into the air from their mouth. When people cough or sneeze, or through close personal contact, large number of droplets are aerosolized (sprayed) into the air. These droplets contain bacteria and viruses.

Smaller, lighter particles are suspended in the air longer than larger and heavier particles. The smaller the particle, the farther down in the respiratory tract that particle can travel. How long these organisms can survive outside the body depends on the type of organism and the conditions of the air, such as its humidity and temperature.

The larger drops may settle on food or utensils, but the tiny droplets carrying the pathogens usually remain suspended in the air and or are capable of travelling distances on air currents. The bacteria and viruses may then be breathed into the lungs through the nose or mouth.

There are three main types of organisms that can cause airborne diseases, including viruses, bacteria and fungi.

Types of airborne diseases

There are many other infections which can spread by airborne transmission. In this lesson we will learn about the diseases that are very common to us and which affect us most often.

1. **Caused by viruses**

Common cold or a typical **influenza** (flu) is the most common and minor air borne disease. It is caused by a highly contagious, constantly changing virus and typically affects people in the winter months Colds can spread rapidly in crowded and badly ventilated rooms. The level of infection varies from the very mild to very serious, and in some cases, may even result in death. Symptoms of the flu include a runny nose, a sore throat, muscle aches and fatigue.

Cold or flu can spread easily in overcrowded rooms

This happens more when the weather is cold, and for these reasons respiratory diseases are common in the Highlands.

Air borne diseases can spread easily in poorly ventilated rooms. These are rooms which are over crowded with many people, the air is warm and still. There is none or very little circulation of fresh air.

SARS and **bird flu** (avian flu)

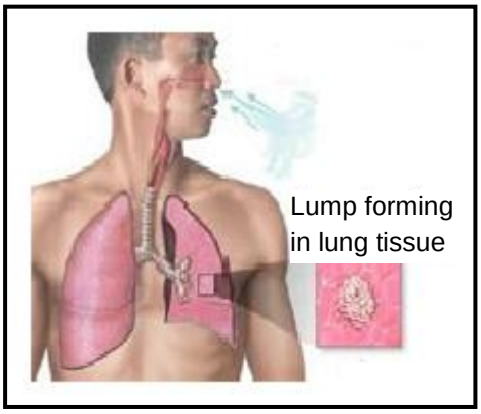
A member of the coronavirus group, first discovered in 2003, causes severe acute respiratory distress or SARS, a potentially fatal type of pneumonia. This is the same type of virus responsible for the common cold; once its droplets land, they can remain alive for up to six hours. Approximately 2-10 days after exposure, individuals typically experience chills, cough and fever; headaches and muscle aches are also symptoms of SARS.

SARS are well known modern airborne diseases which have more severe symptoms. People infected will start off with a high fever, and often headaches and body aches. They will develop a cough after two to seven days, and often develop pneumonia. These diseases are deadly and can kill many people if they are not treated as soon as possible.

2. **Caused by bacteria**

The bacteria, Mycobacterium tuberculosis causes **tuberculosis or TB**., which can be treated with prescription drugs. While it can infect any part of the body, it typically affects the lungs. In its latent form, the infected person carries, but shows no sign of disease. Latent TB can become infectious and passed onto others.

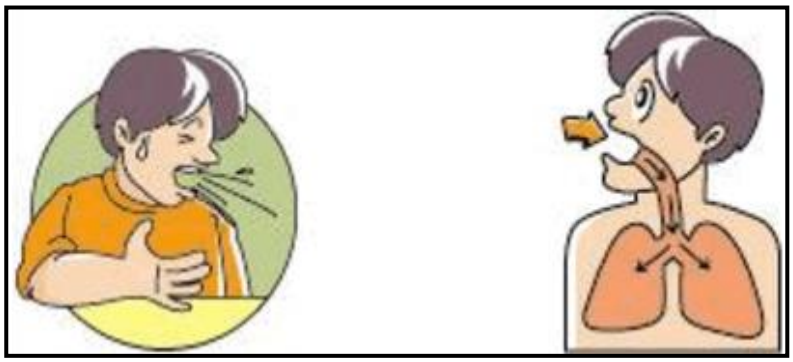
Tuberculosis (TB) typically attacks the lungs, but can also affect other parts of the body. It is spread through the air when people who have an active TB infection cough, sneeze, or otherwise transmit their saliva through the air.



Tuberculosis can be contracted from inhaling droplets from a cough or sneeze by an infected person.

TB has symptoms that include weight loss, poor appetite, fever, night sweats, energy loss and a productive cough with blood-stained sputum.

These symptoms are easy to mistake for other problems, so it is essential to have a qualified doctor or nurse check over the person in question. Other symptoms include chest pain, chills, and cough, as well as fever and fatigue.



TB germ is spread by an infectious patient through air droplets

Person becomes infected

3. **Caused by fungi**

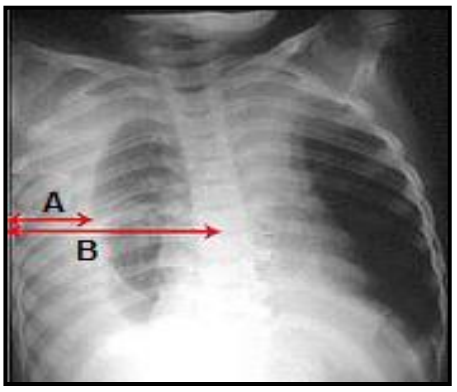
Fungal spores inhaled into the lungs cause coccidioidomycosis or **valley fever**. They are typically found in the deserts of the Southwestern United States, where spores can disperse into the air with construction dust. Some individuals can inhale the spores but never get the disease; those infected may recover on their own, or with the help of an antifungal medication. Extreme cases of valley fever can be fatal. Symptoms of valley fever include fever, cough, fatigue and headache. At-risk groups include pregnant women and patients undergoing cancer treatments; African Americana and Filipinos may be especially to valley fever

Pneumonia is an infection that takes root in one or both of the lungs. It is often caused by fungi, bacteria, or viruses. Pneumonia can be contracted from sneezing, coughing, or even just poor living conditions.Typical symptoms include a cough, chest pain, fever, and difficulty breathing.

People who have recently had lung or heart diseases or viral infections have high risk of catching pneumonia. People who over-use drugs and alcohol are also more at risk of being attacked by pneumonia.

Most other airborne diseases also develop into pneumonia. The microbes make their way into one or both lungs and infect them. The infection causes the alveoli (air sacs) in the lungs to fill with a fluid which makes it difficult for the lung to carry out normal gas exchange. This causes the lung containing the fluid to reduce in size.

Other cases of airborne diseases include**; Chickenpox, smallpox, whooping cough, measles diphtheria** and **plague,**



A chest x-ray photograph of a pneumonia patient. The **A** arrow indicates fluid layering in the right chest. The **B** arrow indicates the width of the right lung. The volume of the right lung is reduced because of the collection of fluid around the lung.

The photographs below show symptoms of children suffering from chicken fox, diphtheria and whooping cough, which are all airborne diseases.

Chicken pox

Diphtheria

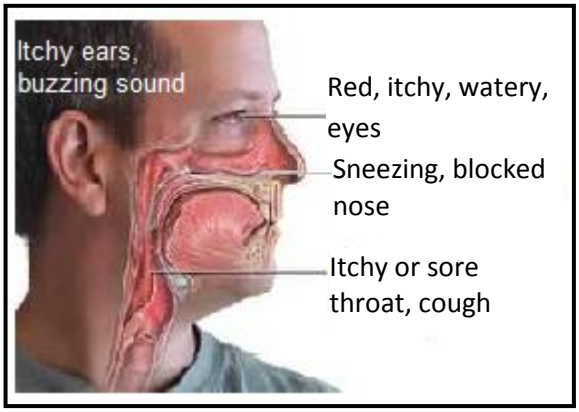
Whooping cough

Effects and symptoms of airborne diseases in the human body

Often, airborne **pathogens** or **allergens** cause **inflammation** in the nose, throat, and the lungs. This is caused by the inhalation of these pathogens that affect a person's respiratory system or even the rest of the body.

Airborne diseases can be identified by the symptoms that the infected person displays. Symptoms would include; coughing, sneezing, sinus congestion (blockage of the nose cavity with mucous), itchy and watery eyes and nose, sore throat, and fatigue (tiredness of the body).

These are caused by inflammation of the upper respiratory air way due to these airborne agents.



Common symptoms displayed in a person when the upper respiratory system is inflamed by airborne agents.

Causes and prevention of airborne diseases

Apart from bacteria and viruses there are some substances in the air that the body dislikes and they are the allergens. When **allergens** are inhaled into the lungs they cause airborne diseases

Airborne diseases are most commonly seen in unclean household conditions and overcrowded areas with less air circulation. Also, these diseases increase in area that lack proper hygienic conditions.

Covering up when coughing or sneezing can prevent the spread of airborne diseases.

The best way to prevent attracting airborne diseases is to stay away from anyone who is affected, washing hands regularly, and covering up sneezes and coughs. This will reduce the risk of bacteria and pathogenic microbial agents entering the body through the air.

Proper ventilation and filtration in buildings can greatly reduce the spread of airborne diseases, but can't completely eliminate them. Mold and allergens can also become problems in a poorly ventilated building.

Moulds are some form of fungi that grow rapidly in moist warm conditions. As they mature they release their spores (powdery seeds) into the air which are allergens for airborne diseases.

Mould growing in the house can make you sick. Inset: mould produces spores as they flower - (enlarged).

Activity: **Now test yourself by doing this activity.**

A. Match the airborne diseases listed in column A with their correct symptoms in column B by inserting the matching letters in the empty boxes.

Disease		Symptom	
1	Pneumonia		Rashes (sores) on the skin
2	Influenza		cough with blood- stained sputum
3	SARS		watery eyes and nose
4	Chicken pox		Head and body aches with high fever
5	Tuberculosis		Chest pain, difficulty with breathing

B. Choose the correct words from the readings and write them beside each definition given below.

	Words	Definitions
A		Disease which causes the lung to reduce in size.
B		A substance that the body dislikes and when breathed in it can cause airborne diseases.
C		Organ of our body which we use to breathe air into.
D		Circulation of air.
E		Tiredness of the body

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 14.

Summary

You have come to the end of lesson 14. In this lesson you have learnt that:

- airborne diseases are caused by microbes that are transmitted through the air
- the microbes can be carried in the air with droplets and with dust.
- tuberculosis and pneumonia are two airborne diseases which damage the lungs
- tuberculosis causes the lungs to develop a growth of lump while pneumonia causes the air sacs in the lungs to fill with a fluid
- overcrowded and poorly ventilated living conditions help the spread of some airborne diseases
- sars and avian flu are two deadly modern airborne diseases which can kill many people if they are not treated immediately
- allergens are some substances which can cause airborne diseases if they are breathed into the lungs
- the best way to prevent the spread of airborne diseases is to:
    - stay away from people who are infected
    - keep homes and the surrounding hygienically clean
    - avoid overcrowding and allow proper ventilation and filtration in buildings.

NOW DO PRACTICE EXERCISE 14 ON THE NEXT PAGE.

Practice Exercise 14

Answer the following questions.

1. What are airborne diseases?.
   _____

2. Write down 4 ways in which pathogens in a person's mouth can be put into the air.
   (a) _____ (c) _____
   (b) _____ (d) _____

2. Name two substances that hold the microbes as they are suspended in the air.
   (a) _____(b) _____

4. What is the main cause of the spread of common cold or influenza?
   _____

5. Describe a poorly ventilated room.
   _____
   _____

6. What are allergens?
   _____
   _____

7. List down the symptoms of the tuberculosis disease.
   _____
   _____

8. List down the symptoms of pneumonia.
   _____
   _____

9. What happens to the infected lungs of a person suffering from pneumonia?
   _____
   _____

10. How do mould fungi contribute to airborne diseases?
    _____
    _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 3.

Answers to Activity

A.

1. Pneumonia – chest pain, difficulty with breathing.
2. Influenza – watery eyes and nose.
3. SARS – Head and body aches with high fever.
4. chicken fox – rashes on the skin
5. Tuberculosis – cough with blood stained sputum.

B.

A. Pneumonia
B. allergens
C. Lung
D. ventilation

Lesson 15: Food and water diseases

Welcome to lesson 15. In the previous lesson, we learnt about diseases that can be transmitted through the air through droplets and dust particles. These diseases spread very easily as they can be inhaled into the lungs which can make people sick.

Your Aims:

- describe how people are infected through water and food.
- identify diseases acquired through water and food.
- identify types of water that spread water diseases.

What are Food and Water diseases?

There are diseases which can be transmitted through the food and drinks we take every day. In this lesson you will learn about the pathogens which cause food borne illnesses. Food and drinks can be safe to take if they are prepared and handled correctly, otherwise pathogens can be transmitted easily through food and drinks and people who eat them will become sick.

Food and water diseases are known as **food borne** diseases. They are caused by eating food or drinking water and beverages contaminated with bacteria, parasites, or viruses. Harmful chemicals can also cause food borne illnesses if they have contaminated food during harvesting or processing.

Transmission of infections through water

Diseases that are transmitted through water are called **waterborne diseases**. These diseases are spread by contamination of drinking water systems with the urine and faeces of infected animal or people.

This is likely to occur where public and private drinking water systems get their water from surface waters such as rain, creeks, rivers, lakes etc., which can be contaminated by infected animals or people.

Contamination of surface water can be caused by water which runoff from landfills, septic fields, sewer pipes, and residential or industrial developments.

This has been the cause of many dramatic outbreaks of faecal-oral diseases such as **cholera** and **typhoid**.

When people wash in a river or when faeces and urine get into the river then pathogens can be carried downstream making the water unsafe to drink

However, there are many other ways in which faecal material can reach the mouth, for instance on the hands or on contaminated food..

Types of waterborne diseases and how they are transmitted
The pathogens that cause diseases such as diarrhoea, amoebic dysentery, typhoid and cholera are often spread by water. All of these diseases affect the digestive system and are known as **gastro intestinal diseases**. When these microbes reproduce in the stomach or intestine, spores or the microbes themselves are carried out with the faeces. The germs in the faeces can cause the diseases by even slight contact and transfer.

If faeces or urine containing these pathogens are deposited directly in water that is used for drinking, the pathogens may then infect large numbers of people. If infected faeces are left on the ground, or if a pit toilet is too close to a river or well, the disease organisms may be washed or carried into the water supply and contaminate it. In this way, one person who is suffering from an intestinal disease, such as typhoid or cholera, can infect hundreds of other people.

Moving water can quickly spread microbes over large distances. For example, rivers can spread pathogens down streams. Flooding often means that faeces from toilets get carried to places which do not normally receive water which contains pathogens.

Ways in which waterborne diseases can be prevented
It is important that people in towns and villages make sure that their faeces and other wastes are disposed of properly so that water supplies cannot be contaminated.

Clean water is a requirement for reducing the spread of water-borne diseases. It is well recognised that the occurrence of water-borne diseases can be greatly reduced by provision of clean drinking water and safe disposal of faeces.

In the urban centres of Papua New Guinea the water supply system is treated with substances such as chlorine and chlorine dioxide to disinfect it.

Treatment of water
Water can be disinfected to kill any pathogens that may be present in the water supply and to prevent them from growing again in the distribution systems. Disinfection is the process to prevent the growth of pathogenic organisms and to protect the general public.

Drinking water which has already been treated to make it safe for drinking can become contaminated if there are breaks or leaks in pipes which allow pathogens to enter the system.

Pollution can also occur at reservoirs where water is stored.
The only way to break the continued transmission is to improve the people's hygienic behaviour and **to** provide them with certain basic needs: drinking water, washing and bathing facilities and sanitation.

Activity 1: Now test yourself by doing this activity

Write T if the statement is true and F if false on the space provided.

_____ 1. Waterborne diseases can be transmitted through urine and faeces.
_____ 2. When rivers and lakes are contaminated they can be easily treated to destroy the microbes.
_____ 3. Chlorination is the most common method of treating water systems in Papua New Guinea.
_____ 4. Waterborne diseases affect the human excretory system.
_____ 5. Having pit toilets built near a river or well does not contaminate the water.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 14.

Transmission of infections through food

Many of the microbes transmitted in water are also carried in food. Washing food in contaminated water, or leaving food uncovered may attract flies to spread pathogens Food can also be contaminated when handled by people with dirty hands, sick or from poisoned or infected wounds. **Foodborne disease** is caused by consuming contaminated food or drink.

What are the causes of food borne diseases?

Foodborne illness is caused by consuming contaminated foods or beverages. Many different disease-causing microbes or pathogens can contaminate foods, so there are many different types of foodborne illnesses.

There are more than 250 known foodborne diseases. The majority are infectious and are caused by bacteria, viruses, and parasites. Other foodborne diseases are essentially poisonings caused by toxins, chemicals contaminating the food. All foodborne microbes and toxins enter the body through the gastrointestinal tract and often cause the first symptoms there. Nausea, vomiting, abdominal cramps and diarrhea are frequent in foodborne diseases.

Other diseases are poisonings caused by harmful toxins or chemicals that have contaminated food. Of note many foodborne pathogens also can be acquired through recreational or drinking water, from contact with animals or their environment, or through person-to-person spread.

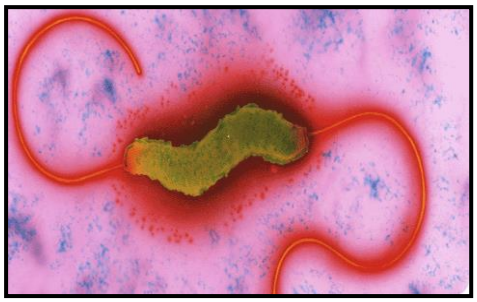
After going to the toilet it is likely that there will be small amounts of faeces or urine on a person's hand. If the person touches food or utensils such as saucepans, plates, knives, spoons, the faeces, or urine, or any microbes they may come in contain may be transferred. If another person touches the same utensils the microbes will be transferred also. For this reason it is wise and healthy l to wash hands after visiting the toilet and before touching food.

People who prepare food for others must be particularly careful about washing hands and keeping clean.

Food borne illnesses can cause symptoms that range from an upset stomach to more serious symptoms, including diarrhea, fever, vomiting, abdominal cramps, and dehydration.

Harmful bacteria are the most common cause of food borne illnesses. The most common foodborne infections are caused by three bacteria -- Campylobacter, Salmonella, and E. coli O157:H7 -- and by a group of viruses called calicivirus, better known as Norwalk-like virus:

1. **Campylobacter** is the most common bacterial cause of diarrheal illness in the world. The bacteria live in the intestines of healthy birds, and most raw poultry meat has Campylobacter on it. Eating undercooked chicken or other food that has been contaminated with juices dripping from raw chicken is the most frequent source of this infection. Aside from diarrhea, common symptoms include causes fever, diarrhea, and abdominal cramps.

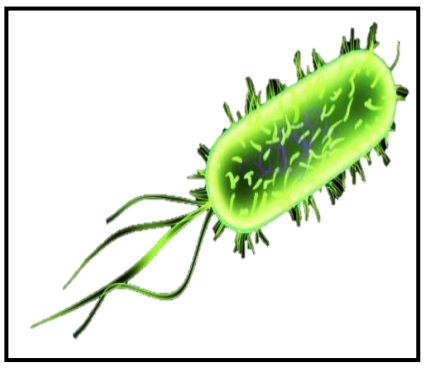


Electron micrograph of *Campylobacter jejuni*

3. **Salmonella** is widespread in the intestines of birds, reptiles and mammals. People can acquire the bacteria via a variety of different foods of animal origin. The illness it causes is called **salmonellosis** and typically includes fever, diarrhea and abdominal cramps. In persons with poor underlying health or weakened immune systems, Salmonella can invade the bloodstream and cause life-threatening infections, typhoid and food poisoning. One in 10,000 eggs may be contaminated with Salmonella inside the egg shell. Produce such as spinach, lettuce, tomatoes, sprouts, and melons can become contaminated with bacteria. Contamination can occur during growing, harvesting, processing, storing, shipping, or final preparation and distribution.

Color enhanced scanning electron micrograph showing *Salmonella typhimurium* (red) invading cultured human cells

4. **Escherichia coli** (O157:H7) has a reservoir in cattle and other similar animals. Illness typically follows consumption of food or water that has been contaminated with microscopic amounts of **cow feces**. The illness it causes is often a severe and bloody diarrhea and painful abdominal cramps, without much fever. But in 3 to 5% of cases, a life threatening complication called the **hemolytic uremic syndrome (HUS)*** can occur several weeks after the initial symptoms, resulting in anemia, profuse bleeding, and kidney failure.

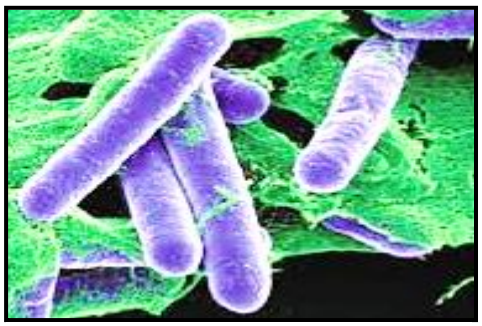


Escherichia coli

Bottle-fed babies are sometimes at risk from diseases that spread very quickly. It is important that bottles are properly sterilised, that the milk is made properly and not allowed to remain at room temperature, otherwise bacteria will rapidly grow.

Milk and eggs should be stored away at the right temperature to avoid contamination by bacteria.

Some bacteria may be present on foods when you purchase them. Raw foods are the most common source of food borne illnesses because they are not sterile; examples include raw meat and poultry that may have become contaminated during slaughter. Seafood may become contaminated during harvest or through processing. Another bacteria that reproduce in raw meat, cooked meat and milk is **Clostridium** that cause a deadly kind of food poisoning known as **botulism**.



Colorized scanning electron micrograph of *Clostridium botulinum*

Contamination may also occur during food preparation in a restaurant or a home kitchen. When food is cooked and left out for more than 2 hours at room temperature, bacteria can multiply quickly. Most bacteria grow undetected because they do not produce a bad odour or change the colour or texture of the food.

Freezing food slows or stops bacteria's growth but does not destroy the bacteria. The microbes can become reactivated when the food is defrosted. Refrigeration also can slow the growth of some bacteria. Thorough cooking is needed to destroy the bacteria.

Bacteria which cause food poisoning can reproduce easily in raw meat.

What are the symptoms of food borne illnesses?

In most cases of food borne illnesses, symptoms resemble intestinal infection and may last a few hours or even several days. Symptoms can range from mild to serious and may include;

- abdominal cramps
- nausea
- vomiting
- diarrhoea, which is sometimes bloody
- fever
- dehydration (loss of water)

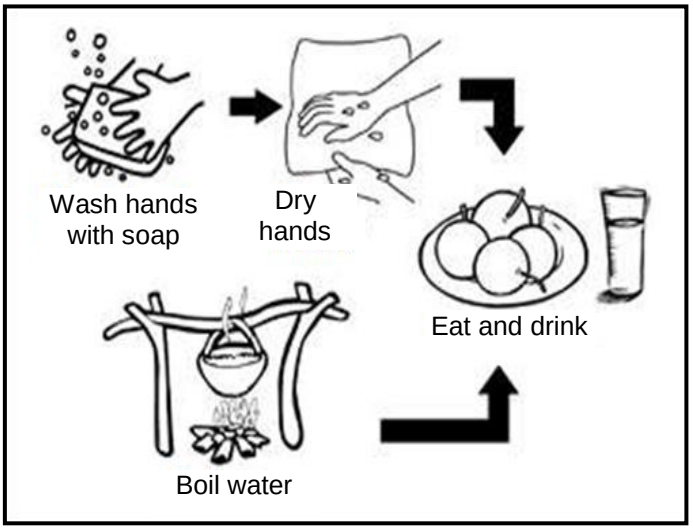
Diarrhoea and vomiting are signs of food borne illnesses

What are the risk factors of food borne illnesses?

Some people are at greater risk for bacterial infections because of their age or an unhealthy immune system. Young children, pregnant women and their unborn babies, and older adults are at greatest risk.

What are the more serious complications of food borne illnesses?
If a person has any of the following symptoms with diarrhoea, he should see a doctor right away:

- High fever—temperature over 101.5°, measured orally
- Blood in the stools
- Diarrhoea that lasts more than 3 days
- Prolonged vomiting that prevents keeping liquid down and can lead to dehydration
- Signs of severe dehydration, such as dry mouth, sticky saliva, decreased urination, dizziness, *fatigue* (weakness), sunken eyes, low blood pressure, or increased heart rate and breathing rate
- Signs of shock, such as weak or rapid pulse or shallow breathing
- Confusion or difficulty reasoning



Washing of hands and boiling water can prevent food borne illnesses.

How are food borne illnesses prevented?
Most causes of food borne illnesses can be prevented through proper cooking or processing of food, which kills bacteria.

Below are some tips to prevent harmful bacteria from growing in food:

- Refrigerate foods immediately. If prepared food stands at room temperature for more than 2 hours, it may not be safe to eat. Foods are properly cooked only when they are heated long enough and at a high enough temperature to kill the harmful bacteria that cause illnesses.
- Handle food properly. Always wash your hands for at least 20 seconds with warm, soapy water before and after handling raw meat, poultry, fish, shellfish, produce, or eggs. Wash your hands after using the bathroom, changing diapers, or touching animals.
- Wash utensils and surfaces before and after use with hot, soapy water. Better still, sanitize them with diluted bleach.
- Never defrost food on the kitchen counter. Use the refrigerator, cold running water, or the microwave oven. .Never let food marinate at room temperature—refrigerate it.
- Wash all unpackaged fruits and vegetables, and those packaged and not marked “pre-washed,” under running water just before eating, cutting, or cooking. Scrub firm produce such as melons and cucumbers with a clean produce brush. Dry all produce with a paper towel to further reduce any possible bacteria.
- Do not pack the refrigerator. Cool air must circulate to keep food safe.

Activity 2: Now test yourself by doing this activity

Fill in the blanks to complete the sentences.

1. Wash hands with soap for at least _____.

2. Signs of sck in a sick person are _____.

3. The two common food borne bacteria are (a) _____ and (b) _____. Both of these bacteria can reproduce in (c) _____ (d) _____ and (e) _____.

4. Milk for babies should be prepared in a _____ bottle.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 15.

Summary

You have come to the end of lesson 15. In this lesson you have learnt that:

- food borne diseases result from eating food or drinking beverages that are contaminated with bacteria, viruses, or parasites.
- waterborne diseases affect the digestive system therefore they are known as the gastro intestinal diseases.
- people at greater risk for food borne illnesses include young children, pregnant women and their unborn babies, older adults, and people with lowered immunity.
- most of the waterborne diseases are transmitted through urine and faeces therefore urine and faeces should be disposed of in proper toilets.
- symptoms usually begin with vomiting and diarrhoea due to intestinal flu. see a doctor immediately if you have more serious problems or do not seem to be improving as expected.
- you can prevent food borne illnesses by taking the following precautions:
    - wash your hands with warm, soapy water before and after preparing food and after using the bathroom or changing diapers
    - keep raw meat, poultry, seafood, and their juices away from ready-to-eat foods.
    - cook foods properly and at a high enough temperature to kill harmful bacteria.
    - refrigerate foods within 2 hours or less after cooking because cold temperatures will help keep harmful bacteria from growing and multiplying.
    - clean surfaces well before and after using them to prepare food.

NOW DO PRACTICE EXERCISE 15 ON THE NEXT PAGE.

Practice Exercise 15

Answer the following questions.

1. What are food borne diseases?
   _____

2. Raw food such as meat can be contaminated with pathogens. What should be done to make them safe to eat?
   _____

3. List down at least 4 ways in which people can make food and drinks become contaminated with pathogens.
   (a) _____
   (b) _____
   (c) _____
   (d) _____

4. What happens to the bacteria in the food when it is frozen?
   _____

5. Name the common bacteria that cause typhoid and food poisoning.
   _____

6. Which people are at a greater risk of getting infected easily by the bacteria that causes food borne illnesses?
   _____
   _____

7. Describe how surface water can be contaminated and made unsafe to use.
   _____
   _____

8. When a person is infected with a food borne bacteria, he suffers two symptoms which cause him to dehydrate. What are those symptoms?
   _____ and _____.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 3.

Answers to Activities

Activity 1

1. T
2. F
3. T
4. F
5. F

Activity 2

1. Twenty seconds
2. Weak or rapid pulse or shallow breathing
3. (a) salmonella
   (b) botulism
   (c) raw meat
   (d) cooked meat
   (e) milk
4. sterilized

Answers to Practice Exercises 12 – 15

Practice Exercise 12

1. Pathogens are organisms that cause diseases.

2. Utensils, breath droplets, water supplies, food and others.

3. (a) Bacteria (b) protozoa (c) viruses

4. Mouth, nose, urinary passage, anus, vagina (any four)

5. Granulocyte and monocyte

6. (a) They surround and swallow the microbes, 'eat' then and digest them.
   (b) They combine with the antigens and either destroy them, make them harmless or make them easily caught by phagocytes.

7. Lymphocytes produce antibodies.

8. They are proteins which are produced by lymphocytes.

Practice Exercise 13

1. Vectors are animals that carry diseases from one organism to another.

2. Diseases which are caused by the vector animals.

3. Protozoan Plasmodium

4. (a) elephantiasis (b) dengue fever

5. In their salivary glands.

6.

Name of vector	Diseases they transmit
(a) flies	Intestinal diseases such as cholera and dysentery.
(b) cockroaches	Intestinal diseases, poliomyelitis.
(c) mosquitoes	Malaria, elephantiasis, dengue fever
(d) human fleas	Bubonic plaque and tapeworms.
(e) rats	Food poisoning, bubonic plaque.
(f) dog	Rabies

Practice Exercise 14

1. Any diseases that are caused by pathogenic microbes that are transmitted through the air.

2. Coughing, sneezing, talking, laughing, spitting, breathing. (any 4)

3. Water droplets and dust.

4. Overcrowding and poor ventilation.

5. Overcrowded with people, air is warm and no ventilation.

6. Substances that the body dislikes, when inhaled it irritates the nose and throat and make people develop airborne disease.

7. Weight loss, poor appetite, fever, night sweats, energy loss and a productive cough with blood-stained mucous.

8. Cough, chest pain, fever and difficulty breathing.

9. Gets filled with a fluid.

10. They produce spores as they flower, which are allergens to human bodies.

Practice Exercise 15

1. Food borne diseases are caused by eating food or drinking water and beverages contaminated with harmful microbes.

2. They can be cooked long enough at high temperature to kill the pathogens.

3. (a) Washing food with contaminated water.
   (b) Toughing food with dirty and infected hands.
   (c) Leaving food uncovered so flies can walk over them.
   (d) Leaving food at room temperature for more than two hours.

4. Freezing only slows down or stops the bacteria from growing, it doesn't destroy them.

5. Salmonella

6 Children, pregnant mothers and their unborn babies, older adults.

7. Surface water can be contaminated by water which runoff from landfills, septic fields, and sewer pipes, and residential or industrial developments.

8. Diarrhoea and vomiting.

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

REVIEW OF TOPIC 3: HARMFUL MICROBES

Now, revise all lessons in this Topic and then do **ASSIGNMENT 2.** Here are the main points to help you revise.

Lesson 12: Pathogens

- Organisms that cause disease are called pathogens.
- All viruses, some bacteria and a few fungi and protozoa are pathogens.
- Pathogens can enter the body through the natural openings such as the nose, mouth and sex organs.
- Unbroken skin forms a natural barrier to most microbes. cuts, wounds and bites allow pathogens to enter the body.
- The body has external defenses which make it difficult for microbes to enter the body.
- The body has internal defenses which destroy microbes inside the body or make them harmless. These defenses make use of phagocytes and antibodies.

Lesson 13: Vector Diseases

- Animals that carry pathogens and spread them from one organism to another are known as vectors.
- Most vectors are insects and arachnids, and they belong to a group of animals called arthropods.
- Vectors which suck on human flesh such as the mosquitoes, and ticks transmit pathogens directly into the bloodstream.
- Some vectors such as the houseflies and rats carry pathogens on their body parts and in their urine and faeces. These pathogens are responsible for intestinal diseases and food poisoning. The microbes are spread on food as they move around from place to place.
- Pathogens for malaria and the elephantiasis diseases are carried by the anopheles mosquito that feeds at night on human blood.
- Lice, ticks and fleas are blood sucking vectors which sometimes also spread various pathogens. some of them do not transmit pathogens, they bite on the human skin which causes rashes and sores that may become infected.

Lesson 14: Airborne Diseases

- Airborne diseases are caused by microbes that are transmitted through the air.
- The microbes can be carried in the air with droplets and with dust.
- Tuberculosis and pneumonia are two airborne diseases which damage the lungs.
- Tuberculosis causes the lungs to develop a growth of lump while pneumonia causes the air sacs in the lungs to fill with a fluid.
- Overcrowded and poorly ventilated living conditions help the spread of some airborne diseases.
- Sars and avian flu are two deadly modern airborne diseases which can kill many people if they are not treated immediately.
- Allergens are some substances which can cause airborne diseases if they are breathed into the lungs.
- The best way to prevent the spread of airborne diseases is to;

- Stay away from people who are infected.
- Keep homes and the surrounding hygienically clean;
- Avoid overcrowding and allow proper ventilation and filtration in buildings.

Lesson 15: Food and water diseases

- Food borne illnesses result from eating food or drinking beverages that are contaminated with bacteria, viruses, or parasites.
- Waterborne diseases affect the digestive system therefore they are known as the gastro intestinal diseases.
- People at greater risk for food borne illnesses include young children, pregnant women and their unborn babies, older adults, and people with lowered immunity.
- Most of the waterborne diseases are transmitted through urine and faeces therefore urine and faeces should be disposed of in proper toilets.
- Symptoms usually begin with vomiting and diarrhoea due to intestinal flu. see a doctor immediately if you have more serious problems or do not seem to be improving as expected.
- You can prevent food borne illnesses by taking the following precautions:
    - wash your hands with warm, soapy water before and after preparing food and after using the bathroom or changing diapers
    - keep raw meat, poultry, seafood, and their juices away from ready-to-eat foods.
    - cook foods properly and at a high enough temperature to kill harmful bacteria.
    - refrigerate foods within 2 hours or less after cooking because cold temperatures will help keep harmful bacteria from growing and multiplying.
    - clean surfaces well before and after using them to prepare food.

NOW DO TOPIC TEST 3 IN YOUR ASSIGNMENT 6.

TOPIC 4

PREVENTION OF DISEASES

In this topic you will learn about:

- **microbes in food spoilage**
- **control and elimination of malaria**
- **blood**
- **immunity and vaccination**

INTRODUCTION TO TOPIC 4: PREVENTION OF DISEASES

In the previous topic we have learned different diseases that affect organisms and can even cause one's death. In this topic we will be learning on how diseases can be prevented.

Prevention can be defined as inhibiting the introduction of disease into an area, herd, or individual. Prevention is aimed at maintaining a healthy population that is preventing the occurrence of disease.

Humans evolved an immune system because the world is teeming with these disease causing organisms. Many of them do not bother us; the bacteria that normally live in your digestive tract are, in fact, beneficial. But other microbes break into and take up residence in your body, using your warmth, nutrients, and tissues to survive and reproduce—and doing you great harm in the process.

Chances are you never had diphtheria. You probably don't know anyone who has suffered from this disease, either. In fact, you may not know what diphtheria is, exactly.

Similarly, diseases like whooping cough (pertussis), measles, mumps, and German measles (rubella) may be unfamiliar to you. The names of these diseases were frightening household words. Today, they are all but forgotten. That change happened largely because of vaccines.

Vaccines protect against infectious diseases caused by microbes. Vaccines take advantage of your body's natural ability to learn how to eliminate almost any disease-causing germ, or microbe, that attacks it. What's more, your body "remembers" how to protect itself from the microbes it has encountered before. Collectively, the parts of your body that recall and repel microbes are called the immune system. We will take a closer look at the immune system in this topic and how vaccines work. Without the immune system, the simplest illness—even the common cold—could quickly turn deadly.

Topic 4 will help you answer the following questions:

- What are the causes and treatment of malaria?
- How white blood cells protect us from diseases?
- What is active and passive immunity?

In this Topic, you will find the answers to these questions and all other questions relating to the prevention of diseases.

Lesson 16: Microbes in Food Spoilage

Welcome to Lesson 16. Most microbes are useful, but only few microbes are harmful. Organisms that cause diseases are known as pathogens. One of the most common ways that infectious diseases are spread about is by food. Most disease-causing microbes must be destroyed, and the few that remain must not be allowed to grow. The food must also remain pleasant to taste and still contain needed vitamins and other nutrients. The oxygen from the air must be kept out. There are number of methods of food preservation methods in use today.

Your Aims

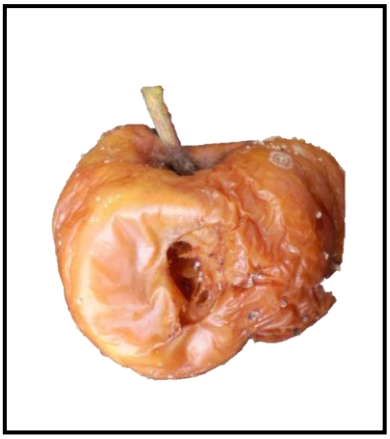
- explain canning and pasteurisation
- explain microbes in food spoilage
- state two of food preservation methods

What is Food Spoilage?

Food spoilage means the original nutritional value, texture, flavour of the food are damaged and the food become harmful to people and unsuitable to eat**.**

Food spoilage is the process in which food deteriorates to the point that it is not edible to humans or its quality of edibility becomes reduced .Various external forces are responsible for the spoilage of food. Food that is capable of spoiling is referred to as **perishable food**.

Some spoiled foods are harmless to eat, and may simply be diminished in quality. But foods exhibiting certain types of spoilage may be harmful to consume. Uncooked or under-cooked animal flesh that spoils is typically quite toxic, and consumption can result in serious illness or death. The toxic effects from consuming spoiled food are known colloquially as "food poisoning", and more properly as "foodborne illness. "



This apple has decomposed to the point that it is unappealing for humans to eat.

Damage or injuries that make food undesirable for human consumption can be the result of:

a. insect damage
b. physical injury
c. enzymatic degradation
d. microbial activity

Basic types of food spoilage

1. Appearance: when a food “looks bad,” what is this referring to?
   a. Microbial growth mycelia or colonies visible on surface development of cloudiness in liquids
   b. Changes in food color due to heme or chlorophyll breakdown colony pigments, growth of mycelia .
2. Textural changes

a. Slime formation due primarily to surface accumulation of microbial cells
also be a manifestation of tissue degradation.
b. Tissue softening due to enzymatic degradation (example soft rot in veggies)

3. Changes in taste and odor
Development of:
1. nitrogenous compounds (ammonia, amines, others.)
2. sulfides
3. organic acids

Black bread mold (Rhizopus stolonifer) on bread

Microbes in food spoilage

There are three types of micro-organisms that cause food spoilage yeasts, moulds and bacteria.

1. **Yeasts** growth causes fermentation which is the result of yeast metabolism.

There are two types of yeasts **true yeast** and **false yeast.**

True yeast metabolizes sugar producing alcohol and carbon dioxide gas. This is known as fermentation Yeasts can be responsible for the decomposition of food with high sugar content. The same effect is useful in the production of various types of food and beverages, such as bread, yogurt, cider, and alcoholic beverages.

False yeast grows as a dry film on a food surface such as on pickle brine. False yeast occurs in foods that have a high sugar or high acid environment.

Signs of food spoilage may include an appearance different from the food in its fresh form, such as a change in colour, a change in texture, an unpleasant odor, or an undesirable taste. The item may become softer than normal.

4. Various **bacteria** can be responsible for the spoilage of food. When bacteria breaks down the food, acids and other waste products are created in the process. While the bacteria itself may or may not be harmful, the waste products may be unpleasant to taste or may even be harmful to one's health.

5. If mould occurs, it is often visible externally on the item. Moulds grow in filaments forming a tough mass which is visible as " mould growth". Moulds form spores which when dry float through the air to find suitable conditions where they can start the growth cycle again.

Mould can cause illness, especially if the person is allergic to moulds. Usually though, the main symptoms from eating mouldy food will be nausea or vomiting from the taste and smell of the mouldy food.

Both yeasts and moulds can thrive in high acid foods like fruit, tomatoes, jams, jellies and pickles. Both

These strawberries have a nice growth of Botrytis cinerea on them
(the "Grey mould")

are easily destroyed by heat. Processing high acid foods at a temperature of 100°C (212°F) in a boiling water canner for the appropriate length of time destroys yeasts and moulds.

Some key changes brought about by spoilage microbes

1. **Changes in colour** due to the microbe itself:

Moulds
Many moulds have coloured spores, especially blue- green or black Rhizopus produces black spore heads (sporangia) on bread.

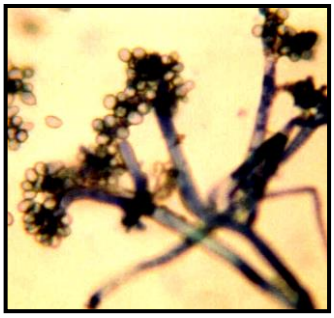
Many Penicillium spp. are blue-green. Other moulds have coloured hyphae eg red or black. Fusarium is red/pink

Browning of apples caused by Monilia sp

Some bacteria are also coloured:
Purple coloration due to *Halobacterium salinarum* in salted fish (Halobacterium is a member of an interesting group of microbes called Archaea, which are distinct from the true bacteria or Eubacteria)

2. Production of pigments

A number of microbes produce coloured pigments during growth. *Pseudomonas fluorescens* greening of eggs and bacon



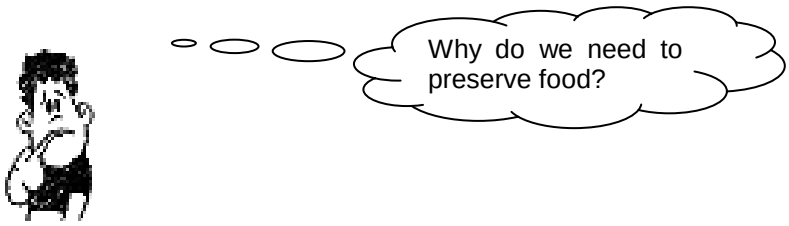
Botrytis cinerea spore head and hyphae (lactophenol cotton-blue preparation

Some microbes induce colour changes in the food.
Production of brown colour in apples caused by the enzyme phenol oxidase produced by fungi example the filamentous Monilia

3. **Odour and flavour changes**
Many microbes produce chemicals during growth. These are by-products of their metabolism (use of nutrients) Amines and hydrogen sulphide from breakdown of proteins. Fatty acids (rancid smell) from fat degradation Acids (acetic, lactic) and gas from carbohydrates

4. **Texture change**
Soft rot or maceration of plant tissue caused by the bacterium *Erwinia carotovora* in potatoes and carrots.
The filamentous *fungus Penicillium citrinum* in citrus fruit.The bacterium *Pseudomonas fluorescens i*n fish and meat.Note different enzymes are needed for plant and animal tissues. In plants pectinases are important; in meat / fish proteases are the key enzymes.
Ropiness in milk and beer is caused by the bacteria (example the Bacillus and Leuconostoc respectively)

Soft rot of a tomato caused by Erwinia carotovora



Canning and Pasteurisation

How do pasteurization and canning help preserve food?
Most fresh fruits, vegetables and animal products spoil quickly without refrigeration, dehydration or preservation. Food preservation is essential because it extends the length of time during which the food is nutritionally viable and safe to eat.

Food preservation works because the preserving agents prevent bacteria, old and other potentially harmful organisms from growing on the food.

The most popular and effective preserving techniques employ salt, sugar, vinegar or brine.

Dry preserving techniques, such as packing food in salt, draws water out of the food, making it an inhospitable environment for microorganisms.

Wet-preserved foods undergo heat processing that kills microorganisms, and the vacuum seal created by proper canning prevents life-sustaining oxygen from entering the container.

Most bacterial and fungal spores cannot live without oxygen and do not survive prolonged immersion in boiling water. A notable exception is the bacterium Clostridium botulinum, which causes a dangerous and potentially fatal disease called botulism.

Clostridium botulinum is unusually hardy and thrives in anoxic environments; oxygen is toxic to it. It also survives boiling temperatures that kill most other bacteria. However, it cannot survive acidic environments such as pickle brine.

Non-acidic preserves such as unpickled vegetables, soup stock and all wet meat preserves do not contain sufficient acid to kill Clostridium botulinum.

The only safe technique for making these preserves is to process the jars in a pressure **canner,** which subjects them to temperatures much higher than boiling water

Canning or heat sterilization
Most food can be canned – meat, fish, fruits, vegetables, and others. Food is packed into cans, liquids added, and the cans sealed and then heated to sterilize, before cooling rapidly.

Food is heated to 90^{o}C, which destroys all microbes.so that the food is sterilized. The hot, sterile food is then placed inside a sterile can of tin plate which has been coated with a substance to stop the food changing colour. After sealing and cooling, the contents contract and partial vacuum develops, which further protects the food. As long as the can remains sealed and undamaged, the food will not spoil.

Pasteurisation

This process was first developed by Louis Pasteur as a way of preserving beer. Today the most important use of this process is in the preservation of milk. Milk cannot be safely marketed raw because of the possibility that it may be a carrier of gastroenteritis, tuberculosis, diphtheria and typhoid. Almost all fresh fluid milks are pasteurized.

Pasteurized milk has been heated to a high temperature below boiling by one of the two methods: the flash method or the holding method. In the flash method, the milk is brought to 160 ^{0} F (71^{0} C) and held there for less than 15 seconds. In the holding method, the milk is brought to a temperature not lower than 143 ^{0} F (62 ^{0} C) and held there for not less than 30 minutes.

Both methods destroy disease-producing bacteria and keep less harmful strains of bacteria to a minimum. The lower boiling temperatures eliminates the undesirable flavour milk acquires when it is boiled.

What is the importance of food safety and sanitation?

Food safety is essential in protecting individuals from bacteria and parasites that can be passed through food consumption.

By practicing hygiene prior to handling food and ensuring that all utensils and surfaces are clean, food contamination can be prevented. Food safety also requires that food is cooked to and stored at a safe temperature. The best way to ensure that food is safely stored is to allow food to thaw in a refrigerator. Cross contamination is also a common cause of food contamination. By always using clean utensils and surfaces that have not touched other food items, the risk of cross contamination can be greatly reduced. By practicing safe food handling, illnesses and fatalities can be prevented

---

Activity 1: **Now test yourself by doing this activity.**

Answer the following questions.

1. Write at least five types of food that are canned.

_____
_____

---

2. Explain why the raw milk cannot be marketed.

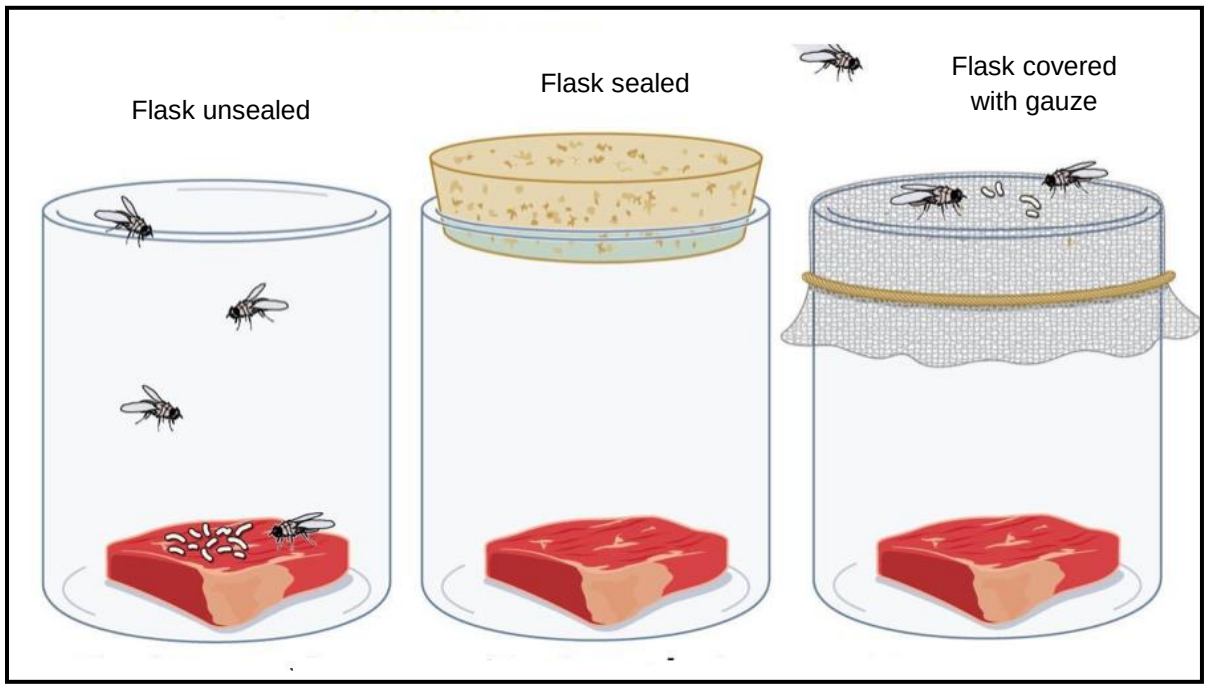
_____
_____

The r

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 16.

Many microbes transmitted in water are also carried on or in food. Washing food in contaminated water, or leaving food uncovered so that the flies can walk on it may lead to the spread of pathogens. Spontaneous generation was the idea that living things could arise from non-living matter.

When a piece of meat is left lying about, maggots (that later changed into flies) would appear on the meat. People thought that the rotting meats produced the maggots. However, in 1668 the Italian Franceso Redi (1626-97) tested this idea as shown below. He placed meat in some containers. Half the containers were left uncovered, while the ther half was covered with gauze.



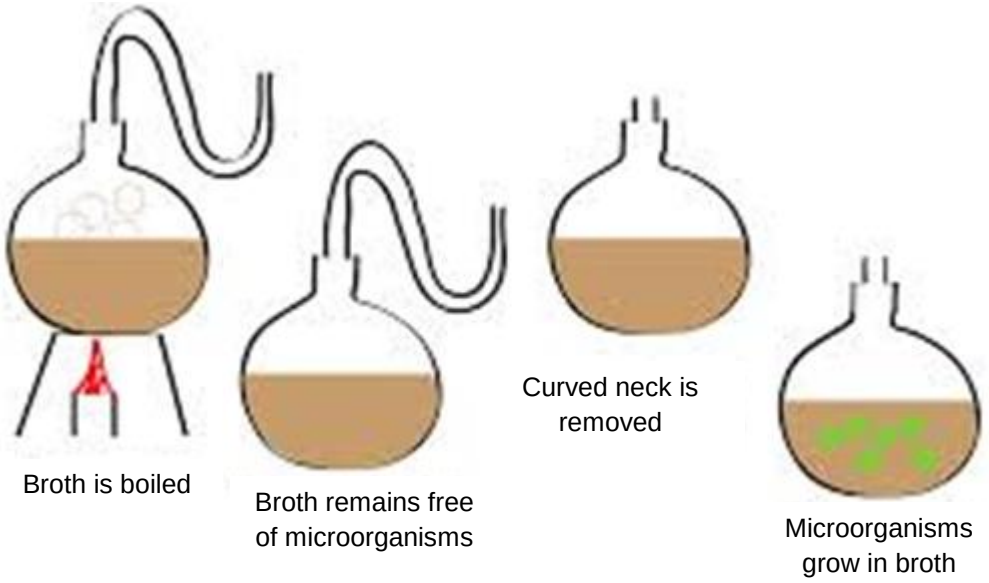
Redi's experiment: The diagram above shows that the meat in both containers began to decay and smell. But maggots were found only on the uncovered.

The meat in both containers went bad and smelled terrible, thus attracting flies. But only the uncovered meat had maggots grow on it. The gauze stopped the flies laying eggs on the meat in the container.

The discovery of microbes by van Leeuwenhoek in 1675 started people using the idea of spontaneous generation again. If a broth (soup) was allowed to stand, it soon went bad and began to smell.

Van Leeuwenhoek found that it contained huge numbers of tiny bacteria. Some people believed the bacteria had spontaneously generated in the soup.

These people were shown wrong by Louis Pasteur (1822-95) in 1860. He boiled some soup in a container that allowed air to enter through an S-shaped neck as shown overleaf.



Pasteur's Test of Spontaneous Generation

The diagram above shows Pasteur's boiled broth that did not go bad**.**

Even though open to the air, Pasteur's boiled soup did not go bad. The curved tube caught any microbes in the air as they try to enter. Two examples of pathogens that are carried by food are the bacteria Salmonella and Clostridium. Salmonella causes typhoid and food poisoning, and Clostridium causes a deadly kind of food poisoning called botulism. Both of these bacteria are able to reproduce in raw meat, cooked meat and milk.

Activity 2: Now test yourself by doing this activity.

Answer the following questions.

1. Refer to Redi's experiment on page 3; explain why maggots were not found on the covered meat.
   _____
   _____

2. Why are flies carriers of some diseases?
   _____
   _____

3. Explain why Pasteur's broth (soup) did not go bad.
   _____
   _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 16.

Methods of Preserving Food

It is well known that when steps are not taken to preserve food it spoils very quickly. This occurs because the same microbes that cause the decay of faeces and dead plants and animals can also cause the decay of food. This is not surprising because all our food comes from plants and animals, and naturally contains microbes. When food is left uncovered, more microbes will settle on it and reproduce so that when the food is eaten, harmful microbes may enter the body. For hundreds of years people have been preserving food so that it can be used later. In all communities there are both traditional and modern processes that are used to stop or slow down the decay of food by microbes. Two of these methods described make the environment unsuitable for microbes to survive.

Cooking

Some food, for example meat which has been cooked, will spoil more slowly than been cooked, as long as the cooking process destroys all the microbes present. This means that all parts of the food must be heated to a high enough temperature for a long enough time to kill any bacteria present. For example, boiling chicken for 20 minutes. Food that has been partly cooked may contain more bacteria than uncooked food.

Dehydration

Microbes need water to grow. Removal of the water prevents them from growing and reproducing. Water can be removed in the food in the following ways.

1. **Air drying**: This method uses heat from the sun and the air movement of the wind. This is used to dry coconuts, coffee and chillies.

2. **Smoking**: In this method food is supported above smoking fire. This has the added advantages that it also flavours the food. Smoking is used traditionally in Papua New Guinea for preserving fish and flying foxes.

3. **Vacuum drying**: When air pressure is reduced, water evaporates more quickly and at lower temperatures. This can be used to remove water from food. Some sausages and coffee are packed in this way.

4. **Freeze drying:** The food is first quick frozen and then placed under reduced pressure so that the ice changes directly into water vapour.

5. **Curing and salting:** Salt draws water from the food and from any bacteria present, which kills them. Sodium nitrate salts can also be added to the salt solution, which also kills bacteria. Nitrate salts combine with the meat proteins to form a red substance, and the food is said to be cured. Bacon is red because of this curing process.

Summary

You have come to the end of lesson 16. In this lesson you have learnt that:

- microbes can cause food to spoil or decay.
- food should be kept covered and cool in order to avoid spoilage
- different ways of preserving food are cooking, refrigeration, freezing, dehydrating, pickling, sugaring, pasteurization, canning and, addition of artificial preservations.
- different ways of dehydrating are air drying, smoking, vacuum drying, freeze drying, and curing and salting.
- organisms that cause disease are called pathogens.
- all viruses, some bacteria and a few fungi and protozoa are pathogens.
- food poisoning can be caused by salmonella or clostridium, which are transmitted into food.
- insects also spread pathogens. for example, houseflies and cockroaches can spread gastro-intestinal diseases, while mosquitoes can spread malaria.

NOW DO PRACTICE EXERCISE 16 ON THE NEXT PAGE.

Practice Exercise 16

Answer the following questions.

1. Explain the following words.

   a. Canning:
   _____
   _____

   b. Pasteurisation:
   _____
   _____

2. Explain why food is heated before canned.
   _____
   _____

3. Explain what would happen to milk that is left out of a fridge on a hot summer's day.
   _____
   _____

4. What is spontaneous generation?
   _____
   _____

5. How was this idea (spontaneous generation) shown to be wrong?
   _____
   _____

---

6. Explain what would happen to Pasteur's broth if the S-shaped tube was broken off?
   _____
   _____
   _____

7. Explain why food can easily be spoiled by microbes.
   _____
   _____
   _____

8. What are two things that people can do to prevent cooked food being spoiled by microbes?

   (a) _____
   (b) _____

9. List the method of food preserving which

   (a) destroys microbes:_____
   (b) prevent the growth of microbes:_____

10. Briefly explain why dehydration is a good method of food preservation.
    _____
    _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 4.

Answers to Activities

Activity 1

1. Canned meat, canned tin fish, canned pineapple, canned luncheon meat, canned steak and onion.
2. The raw milk cannot be marketed because of the possibility that it may be a carrier of gastroenteritis, tuberculosis, diphtheria and typhoid.

Activity 2

1. Maggots were not found on the covered meats because the flies (which are carriers of the maggots) did not enter the container.
2. Flies are carriers of some diseases because they sit on decayed organisms and faeces.
3. Pasteur's broth did not go bad because all the microbes were caught at the swan neck and did not go right through into the broth.

Lesson 17: Control and Elimination of Malaria

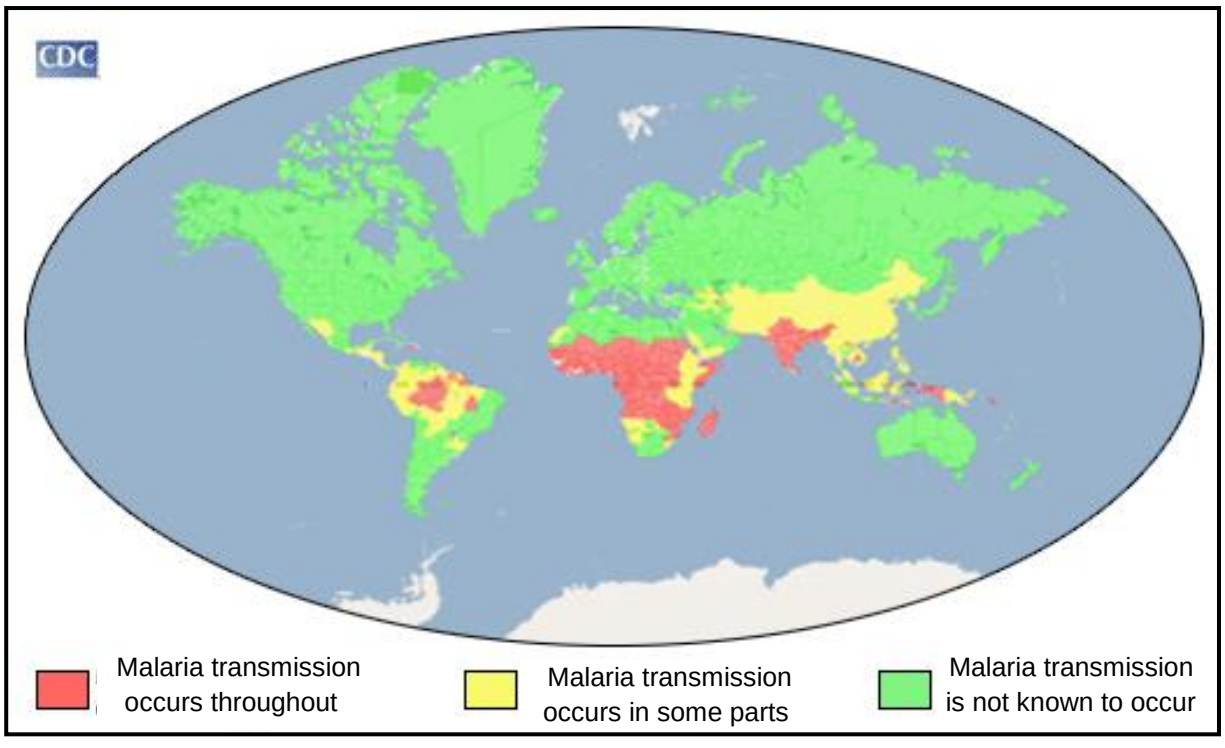
Welcome to Lesson 17. Malaria is one of the greatest health problems in the world and affects one-third of the world's population. Malaria is the second deadly disease in Papua New Guinea, after respiratory disease such as pneumonia. In this lesson we will learn on what are the causes and how to prevent and eliminate malaria.

Your aims:

- state the cause and effects of malaria.
- identify types of malarial causing parasite.
- explain the transmission of malaria
- describe control and elimination of malaria.
- identify the treatment of malaria.
- explain the importance of the community and different organisations in controlling and eliminating malaria.

World distribution of Malaria

About 25 000 people are admitted to the hospital each year suffering from malaria and about 400 die from the disease. Malaria is endemic to Papua New Guinea. This means that the disease is always present, and the number of malaria cases each year is high. This is true for most coastal and lowland areas. The only places normally free from malaria are those Highlands areas above 1500 metres.



The Worldwide distribution of malaria

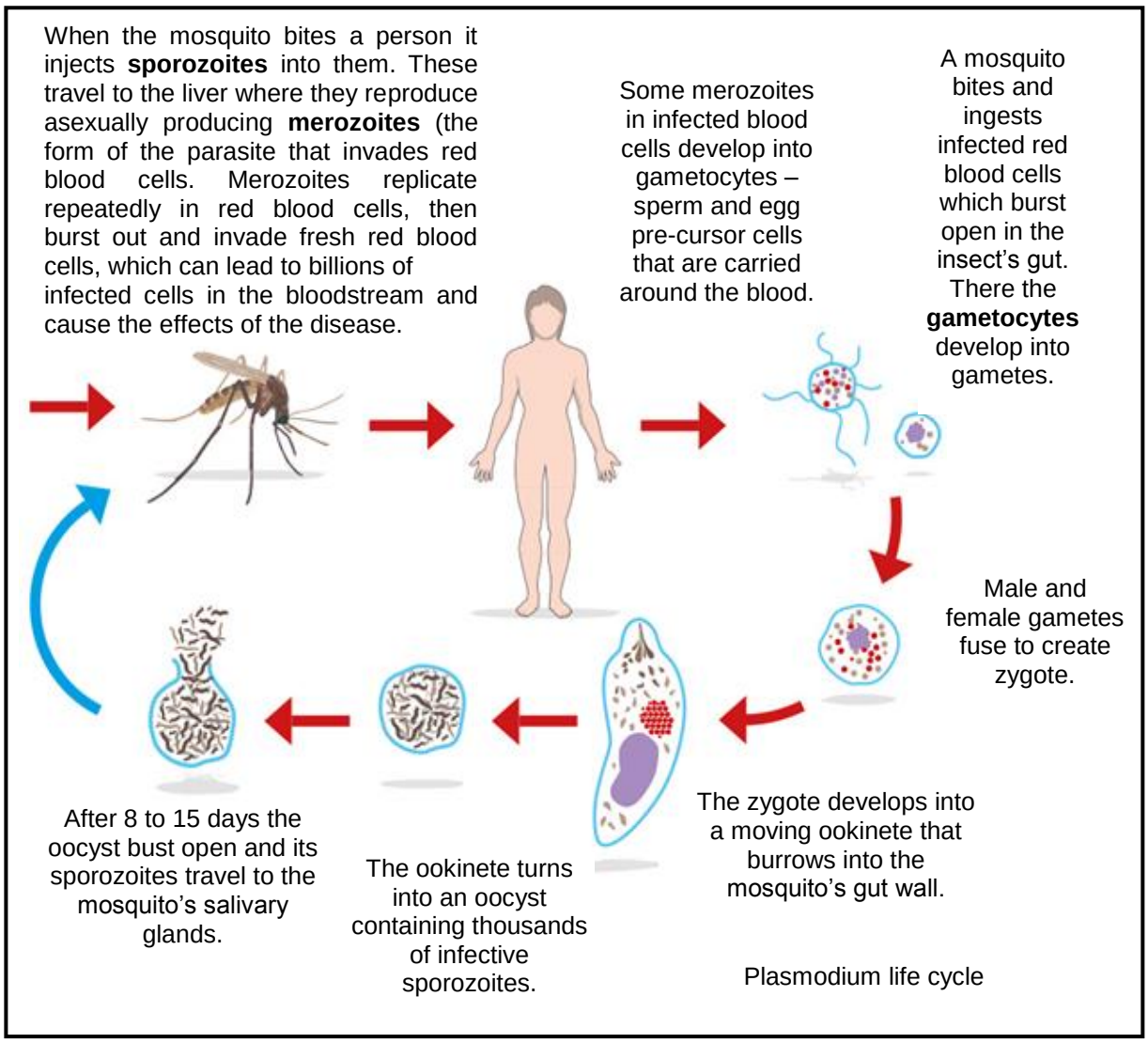
The causes and effects of malaria, and the type of malarial causing parasites

Malaria causes

Malaria is caused by parasitic protozoan of the genus **Plasmodium** which lives in the liver and bloodstream, and is transmitted to humans by mosquitoes. The history of malaria shows that it was difficult to determine the disease's mode of transmission. When some cultures reviewed the facts available to them, they concluded that malaria was caused by bad air without realizing that the same swamps that created foul-smelling air also were excellent breeding grounds for mosquitoes. In 1880, the parasite was identified in an infected patient's blood.

There are several stages in the life cycle of Plasmodium, including sporozoites, merozoites, and gametocytes. The bite of an infected mosquito transmits the sporozoite stage of the organism to humans. The parasite travels into the bloodstream and eventually makes its way to the liver, where it begins to multiply by producing merozoites. The merozoites leave the liver and enter red blood cells to reproduce. Soon, young parasites burst out in search of new red blood cells to infect.

Sometimes, the reproducing Plasmodia will create a form known as a gametocyte in the human bloodstream. If a mosquito takes a blood meal when gametocytes are present, the parasite begins to reproduce in the insect and create sporozoites that are infectious to people, completing the life cycle.



Plasmodium life cycle

There are five species of Plasmodium that infect humans:

1. **Plasmodium vivax**
   This species is most commonly found in Asia, Latin America, and parts of Africa. Infections can sometimes lead to life-threatening rupture of the spleen. This type of malaria can hide in the liver (this is called the "hepatic phase" of the life cycle). It may then return later to cause a relapse years after the first infection. Special medications are used to eradicate P. vivax from the liver.
2. **Plasmodium ovale**
   This species is rarely found outside Africa or the western Pacific islands. Symptoms are similar to those of P. vivax. Like P. vivax, P. ovale can hide in the liver for years before bursting out again and causing symptoms.
3. **Plasmodium malariae**
   It is found worldwide but is less common than the other forms. This form of malaria is hard to diagnose because there are usually very few parasites in the blood. If untreated, the infection can last many years.
4. **Plasmodium falciparum**
   This is the most life-threatening species of malaria. Although present throughout much of the tropical and subtropical world, it is particularly common in sub-Saharan Africa. P. falciparum is resistant to many of the older drugs used to treat or prevent malaria. Unlike P. vivax and P. ovale, this species does not hide in the liver.
5. **Plasmodium knowlesi**
   Found predominantly in Malaysia, this species can also cause high levels of parasites in the blood, leading to organ failure or death.

The main effects of the disease are as follows:

1. Anaemia due to the destruction of millions of red blood cells. People with anaemia feel weak and look pale.
2. Fever due to the release of poisons called toxins that are produced by the parasite.
3. An enlarged spleen due to the accumulation there of the destroyed red blood cells.

Plasmodium also lives in the salivary glands of female anopheles mosquitoes. The mosquitoes themselves are not affected by these parasites, but they carry the disease from one person to another.

Activity 1: Now test yourself by doing this activity.

Answer the following questions.

1. What is the name of the microbe that causes malaria?
   _____
2. What type of microbe is it?
   _____
3. How is the disease transmitted?
   _____
   _____

4. What are the three main effects of malaria on a person?

(i) _____
_____

(ii) _____
_____

(iii) _____
_____

(iv) _____
_____

(v) _____
_____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 17.

Is malaria contagious?

Fortunately, malaria is not contagious except in rare situations. It is not spread directly from person to person with the following exceptions. A few cases have occurred in other countries through blood transfusion, intravenous drug abuse with shared needles, or organ transplantation.

An infected mother can spread malaria through the placenta to her unborn child. Except for these rare situations, transmission only occurs when a person is bitten by an infected mosquito. The infected person is not contagious to other individuals, and there is no need to isolate or quarantine the person to protect others from direct transmission.

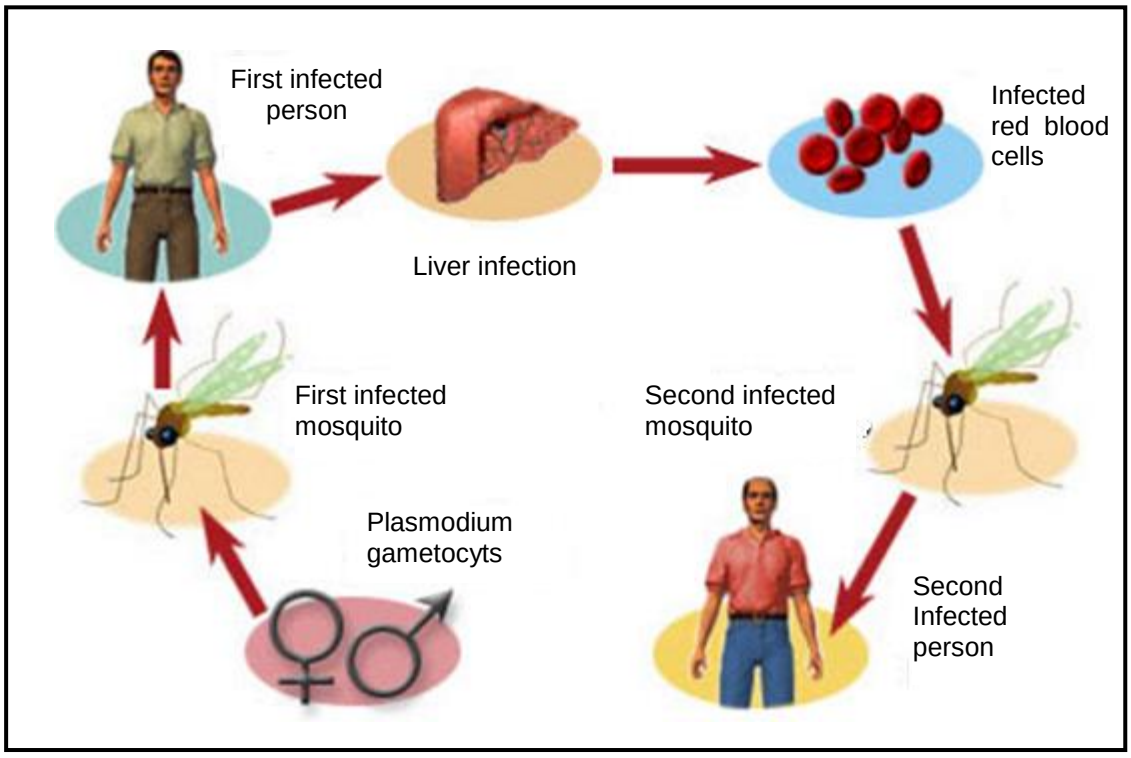
However, depending on the local public-health situation, an infected traveler returning home may be asked to stay indoors until well. Some areas may have mosquitoes that are able to transmit malaria, and transmission of malaria from a returning traveler by local mosquitoes has been reported. Public-health authorities may increase mosquito-control measures in the area, as well, to reduce this risk.

Transmission of malaria

Male mosquitoes feed on plant juices, while female mosquitoes feed on blood. When a female **Anopheles** mosquito bites a person who has malaria, the malarial parasites in the blood are drawn into the mosquito's stomach, where they reproduce.

After about two weeks they move to the salivary glands in the mosquito's mouth, where they accumulate in large numbers. When this mosquito bites a healthy person, saliva containing hundreds of parasites is injected into the person's bloodstream.

From here they pass to the liver where they enter the liver cells and rapidly multiply, forming many more parasites. These burst out of the liver cells and enter new red blood cells, where they again grow and multiply to form many new parasites. When thousands of red blood cells burst at the same time, the person suffers from a fever. The cycle repeats itself continually so that increasing numbers of red blood cells are destroyed.



Malaria transmission cycle

Activity 2: **Now test yourself by doing this activity.**

Answer the following questions.

1. What do the female mosquitoes feed on?

   _____

2. What is the name of the female mosquito?

   _____

3. What does the female mosquito draws when it bites a person who has malaria?

   _____

   _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 17.

Control and Elimination of Malaria

The disease can be controlled by removing the parasite-carrying mosquito and by reducing the number of malarial parasites.

The spread of the disease can be greatly reduced if the number of Anopheles mosquitos are reduced and prevented from coming in contact with humans.

This can be done in the following ways:

1. Sleeping and sitting under mosquito nets that are treated with insecticide and putting fly-wire on houses.
2. Removing any rubbish that might collect water, such as old tins, bottles and coconut shells. This removes the places where mosquitoes breed.
3. Draining swamps and making drainage, channels, which again reduce the places where mosquitoes breed.
4. Adding fish that feed on mosquito larva to ponds and lakes.
5. Using chemical insect repellents on the skin.
6. Spraying all surfaces on which mosquitoes settle with insecticide, such as **DDT***, that kills them. Houses can remain free of mosquitoes for several months if this is done.
7. Spraying oil or mixed oil with insecticide on the surface of all stagnant water such as lakes, ponds, drains and gutters.

Treatment for Malaria

Several drugs are available to people which control malaria by either killing Plasmodium or stopping it from reproducing. In Papua New Guinea the most common one is chloroquine.

Chloroquine can be used as a prophylactic, which means that it can be used to protect someone getting very sick with the disease.

If a person takes two tablets of chloroquine on the same day each week, the symptoms of malaria will not develop, even the person is beaten by mosquitoes carrying Plasmodium.

Chloroquine can also be used as a treatment for people who have already become sick with malaria. The number of chloroquine tablets that should be taken depends on the weight of the person.

With all kinds of medicine, it is dangerous to take more than the dose recommended by the health worker. Chloroquine is the first treatment for most malaria, and usually the person will get better.

However, sometimes a patient may be very sick from the start or the Plasmodium becomes resistant to chloroquine. This is sometimes called resistant chloroquine malaria and can be controlled by **quinine** and **Fansidar**.

An example of this type is the malaria caused by Plasmodium falciparum. In this type of malaria some of the parasites are carried to the brain, where they cerebral malaria which can cause death.

Importance of the Community and different Organisations in Controlling and Eliminating Malaria.

As a result of continual contact with malaria over many years, most coastal people have developed a natural immunity, or resistance, to the disease without the need for drugs. However, children, young people, adults who are weak or sick and even stronger, healthy people can still get malaria.

The Department of Health recommends that at night people sit and sleep under treated mosquito nets. These are ordinary mosquito nets that have been soaked in an insecticide and then allowed to dry. These nets work in two ways.

Firstly, they help to prevent insects from reaching people. Secondly, any insects which come into contact with the net will be killed by the insecticide on the net. Another way that malaria can be controlled is through spraying. Buildings are sprayed with the insecticide DDT which kills mosquitoes that settle on walls after feeding on blood.

This means that the mosquito will not bite a second person. However, because DDT is a poison it can affect other animals as well as mosquitoes. Once DDT has got into the food chain, it is passed on and will accumulate in the animals further along the food chain.

For this reason some countries do not allow DDT to be used. For many years up to the time of independence, spraying took place in many provinces, but this has been very much reduced in recent years.

In Port Moresby a special machine is used on the back of a truck. This blows out the special smoke or fog of DDT that kills mosquitoes. Another problem is that DDT is becoming less effective as an insecticide.

The mosquitoes of today can withstand higher concentrations of insecticides than when spraying began years ago. The mosquito population are becoming resistant to the chemicals. For this reason, larger and larger concentrations of DDT are needed to kill the mosquitoes.

The Effect of Malaria on the Population

The main effects of malaria on individuals and communities are:

1. People with the disease may die, especially young children if not treated immediately.
2. People are more likely to get other diseases because malaria weakens their bodies.
3. Students are unable to study properly and may not do well at school.
4. Women may find it hard to become pregnant. If a pregnant woman has malaria it can cause the death of her baby before it is born.
5. People are unable to work properly, so the development in their area is slow.
6. People may be unable to go to certain places because they know that they will get sick if they go into those areas.

Summary

You have come to the end of lesson 17. In this lesson you have learnt that:

- malaria is one of the most significant sickness in the world and is endemic to Papua New Guinea.
- malaria is caused by the parasitic protozoan plasmodium.
- malaria makes people very sick and causes anaemia, fever and an enlarged spleen. It can also cause death.
- malaria is caused by the female anopheles mosquito that feeds at night on human blood.
- malaria can be controlled by getting rid of the mosquitoes that carry the disease and by killing or stopping the reproduction of the parasite that causes the disease.
- mosquitoes can be controlled by removing breeding places, sleeping under mosquito nets treated with an insecticide, screening houses, adding fish to ponds and using insecticides.
- chloroquine can be used as a prophylactic to prevent malaria, and also as a treatment for malaria.
- malaria parasites that do not respond to chloroquine can be treated with quinine and fansidar.
- many people in Papua New Guinea have a natural immunity to malaria.
- people can die or have other health problems and be unable to work properly because of malaria.

NOW DO PRACTICE EXERCISE 17 ON THE NEXT PAGE

Practice Exercise 17

_____

Answer the following questions.

1. One particular type of malarial parasite is more dangerous than the others.

   a. What is the name of this parasite?
   _____

   b. Why is it very dangerous?
   _____
   _____

2. Explain in your own words how a person gets malaria.
   _____
   _____

3. What are the two main ways in which malaria can be controlled?

   a. _____

   b. _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 4.

Answers to Activities

Activity 1

1. The name of the microbe that cause malaria is called Plasmodium
2. Plasmodium is a parasitic protozoan.
3. The disease is transmitted through a malaria carrying parasite.
4. The three main effects of malaria on a person:
   (i) Anaemia due to the destruction of red blood cells
   (ii) Fever due to release of poisons called toxins
   (iii) An enlarged spleen due to the accumulation there of the destroyed red blood cells.

Activity 2

1. The female mosquito feeds on blood
2. The name of the female mosquito is called the anopheles
3. The female mosquito draws malarial parasites when it bites a person who has malaria.

Lesson 18: Blood

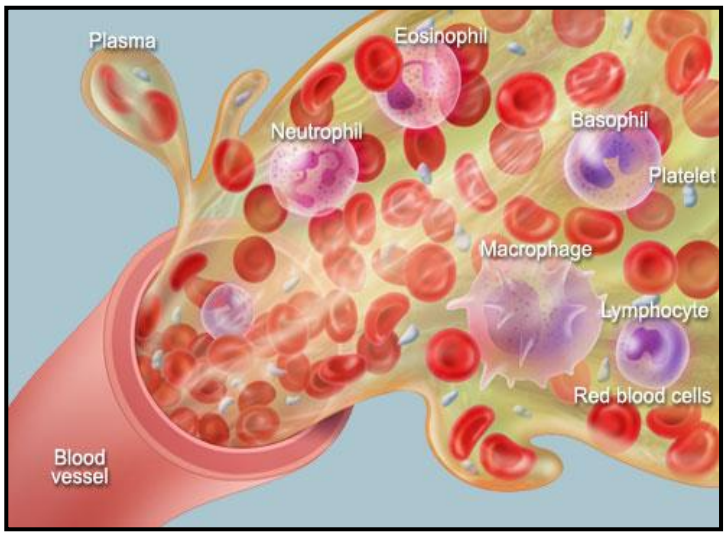
Welcome to lesson 18. Under the microscope, blood is seen to be made of three types of cells - red blood cells, white blood cells and platelets. When blood is centrifuged it is also found to contain clear but yellowish liquid called **plasma**. Blood flows around the body. As it does this, it carries things from one place to another.

Your aims:

- define blood
- identify the blood groups
- describe red blood cells, white blood cells, plasma and platelets
- state the importance of the blood in prevention of diseases

Blood

Blood is made up of liquid, called plasma, and various different types of cells. An average-sized man has about 5-6 litres of blood in his body; a woman has slightly less.



Blood flowing from the blood vessel showing the different blood cells

Where is blood found?

Blood is found in blood vessels, such as arteries, arterioles, capillaries, venules and veins. They take blood to and from every part of your body. Blood is pumped through blood vessels by your heart.

Blood and blood vessels

The main function of blood vessels is to transport blood around the body. Blood vessels are found throughout the body.

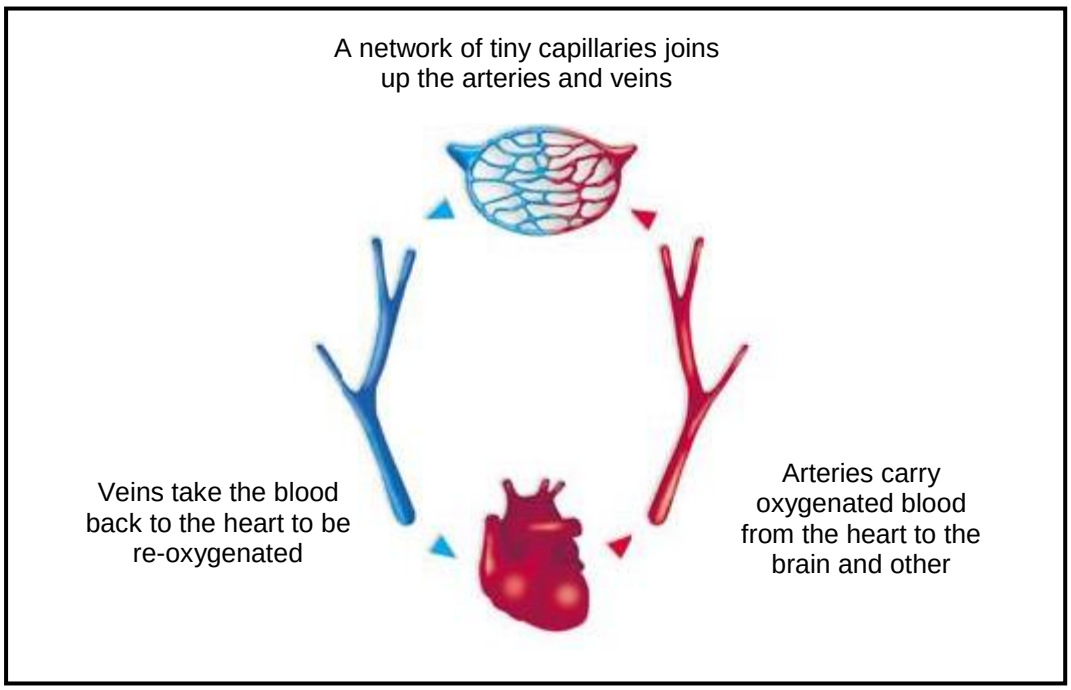
There are five main types of blood vessels: arteries, arterioles, capillaries, venules and veins.

1. **Arteries** carry blood away from the heart to other organs. They can vary in size.
2. **Arterioles** are the smallest arteries in the body. They deliver blood to capillaries. Arterioles are also capable of constricting or dilating and by doing this they control how much blood enters the capillaries.
3. **Capillaries** are tiny vessels that connect arterioles to venules. They have very thin walls which allow nutrients from the blood to pass into the body tissues.

Waste products from body tissues can also pass into the capillaries. For this reason capillaries are known as exchange vessels.

4. Groups of capillaries within a tissue reunite to form small veins called **venules.** Venules collect blood from capillaries and drain into veins.

5. **Veins** are the blood vessels that carry blood back to the heart. They may contain valves which stop blood flowing away from the heart.



Transport of blood through the blood vessels

What does blood do?
Blood has a variety of different functions. These include:

1**.** **Transport system** for the body.
- Blood carries **food** (from the digestive system) and **oxygen** (from the lungs) to the body's cells as it travels around the body. The cells need blood and oxygen to stay alive.
- Blood takes **oxygen** from the lungs to the cells of the body. It takes carbon dioxide from the body's cells to the lungs where it is breathed out. Blood carries nutrients, hormones and waste products around the body.
- Blood carries **heat** around the body. Cells which are using up food quickly give out lots of heat. If the heat is not carried away, the body temperature will rise, this is called **homeostasis**.
- Blood carries **waste materials** away from the cells. These waste materials are made when the cells use up food. They must be carried away before they poison the cells.

2. **Regulation**
Blood helps to keep the acid-alkali balance of the body in check. It also plays a part in regulating body temperature. Increasing the amount of blood flowing close to the skin helps the body to lose heat.

3. **Protection**
White blood cells attack and destroy invading bacteria and other pathogens. Blood clots, which protects the body from losing too much blood after injury.

What is normal blood made up of?

A. **Blood cells**, which can be seen under a microscope, make up about 40% of the blood's volume. Blood cells are divided into three main types:

1. **Red blood cells or erythrocytes**
Human red blood cells are shaped like biconcave discs with the flat sides curved inwards with no nucleus (as shown by the picture below).

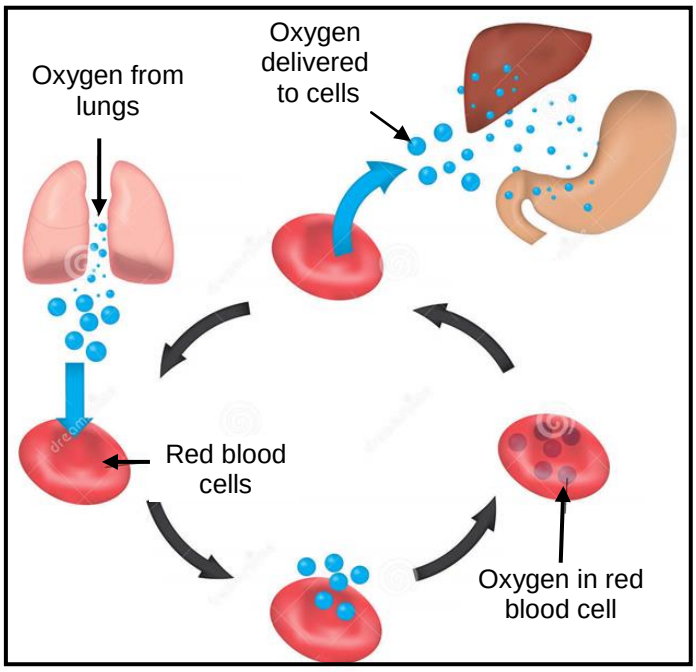
These cells are easy to bend, as much squeezing is needed to get them through smallest blood vessels. Red blood cells live only for about 120 days.

These make blood a red colour. One drop of blood contains about five million red cells. A constant new supply of red blood cells is needed to replace old cells that break down. Millions of red blood cells are made each day.

Red Blood Cells

Red blood cells are packed with the complex chemical called **haemoglobin** which gives the red blood cells red colour. This binds to oxygen, and takes oxygen from the lungs to all parts of the body. Haemoglobin also helps carry some waste carbon dioxide from the cells back to the lungs

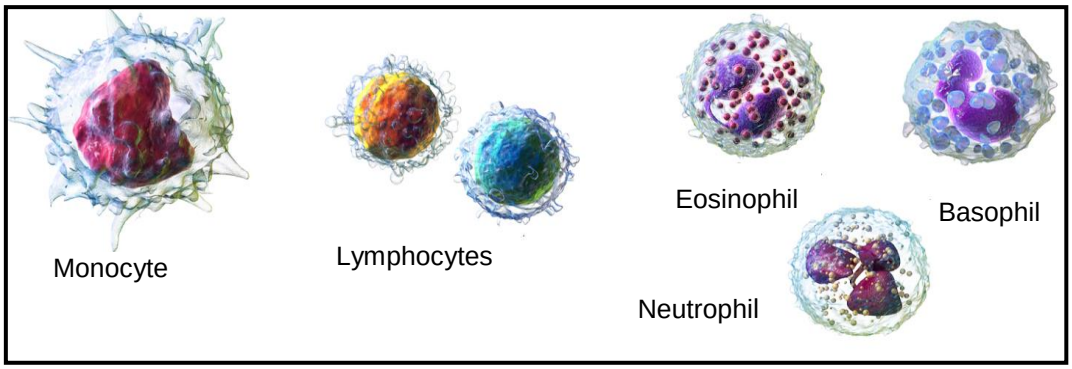
a. The red cells pick up oxygen as blood is pumped through the lungs
b. The oxygen and haemoglobin join to form oxyhaemoglobin. This is bright red.
c. As the blood passes around the body, the oxyhaemoglobin breaks down and release oxygen to the body cells.
d. Without oxygen blood is dull red. It is pumped back to the lungs for more oxygen.



2. **White cells or leukocytes**

The white blood cells are larger, nearly colourless, and have a nucleus. They can be found in both the blood stream and out in the cells nearby.

There are different types of white cells which are called neutrophils (polymorphs), lymphocytes, eosinophils, monocytes, and basophils. They are part of the immune system. Their main role is to defend the body against infection.



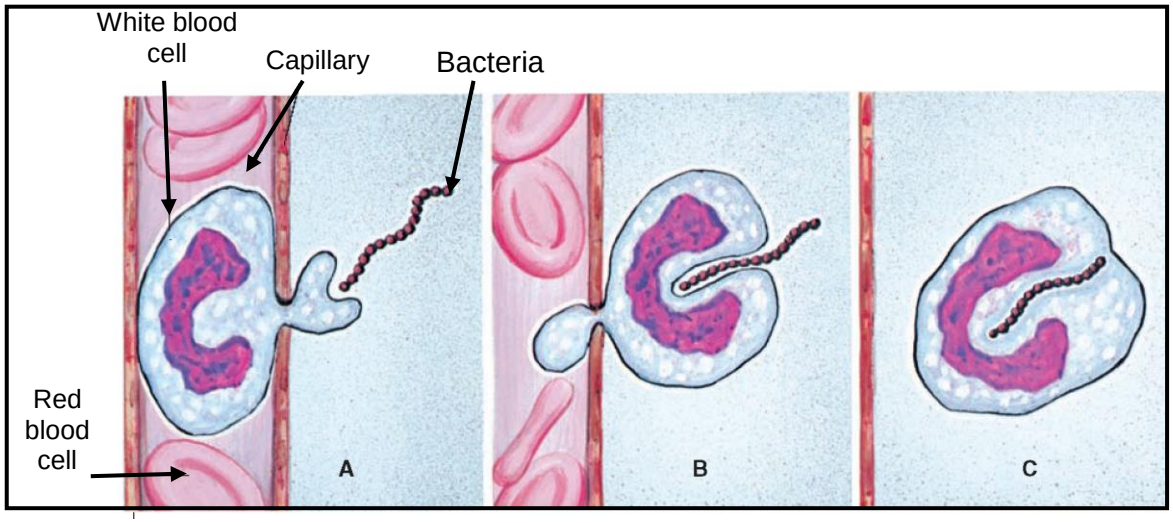
White blood cells

- **Neutrophils** engulf bacteria and destroy them with special chemicals.
- **Eosinophils** and **monocytes** also work by swallowing up foreign particles in the body.
- **Basophils** help to intensify inflammation. Inflammation makes blood vessels leaky. This helps specialised white blood cells get to where they are needed.
- **Lymphocytes** have a variety of different functions. They attack viruses and other pathogens (germs). They also make antibodies which help to destroy pathogens.

Role of white blood cells

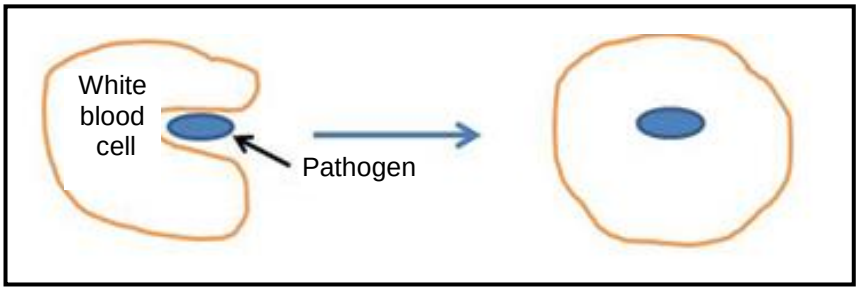
The white blood cells are called **phagocytes** move around like this to protect us from foreign invaders such as bacteria and viruses. They (phagocytes) eat up the germs that cause disease. White blood cells also remove worn out cells.

- Phagocytes can squeeze through capillary walls as shown below.
- They move towards germs and surround them. Then they digest them.

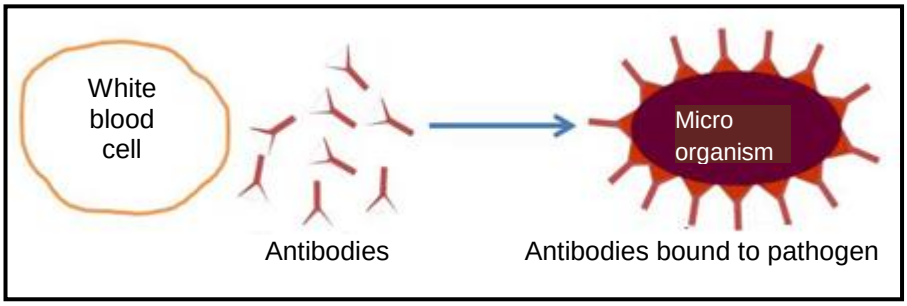


How white blood cells protect us from diseases?
White blood cells protect us from diseases in three different roles.

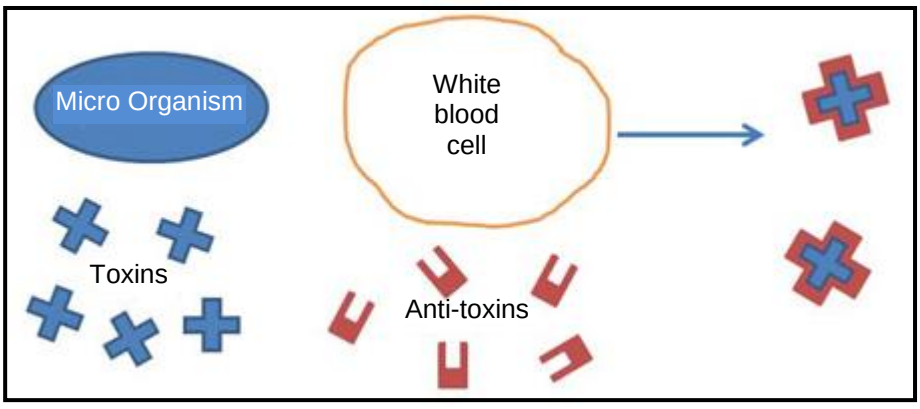
- **Ingesting microorganisms**
  Some white blood cells ingest (take in) pathogens, destroying them and preventing them from causing disease.



- **Producing antibodies**
  Some white blood cells produce special chemicals called **antibodies**. These target or bind with particular bacteria or viruses and destroy them. These chemicals destroy germs that get into the body by making them stick together, or by destroying them. Each type of pathogen needs a unique antibody. Once your white blood cells have made the unique antibody they can make them very quickly next time the pathogen enters the body.

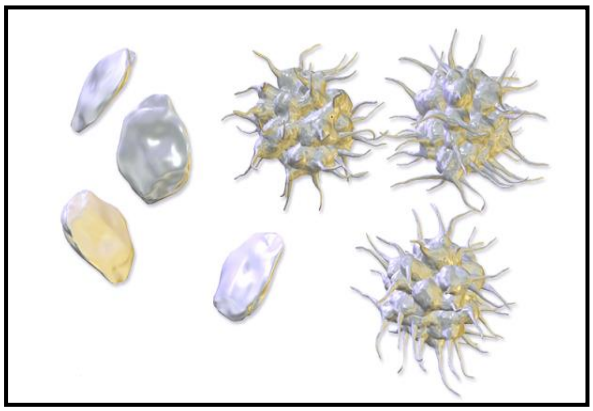


- **Producing antitoxins**
  Some white blood cells produce the **antitoxins** which bind and counteract the toxins produced by the pathogen. They destroy toxins (poisons) that germs make. There is a different antitoxin for each kind.
  .



3. **Platelets**

Platelets are fragments of cells in bone marrow. Their job is to help stop bleed from cuts. They do not have a nucleus. These are tiny and help the blood to clot if we cut ourselves.



Platelets

How does blood clot?

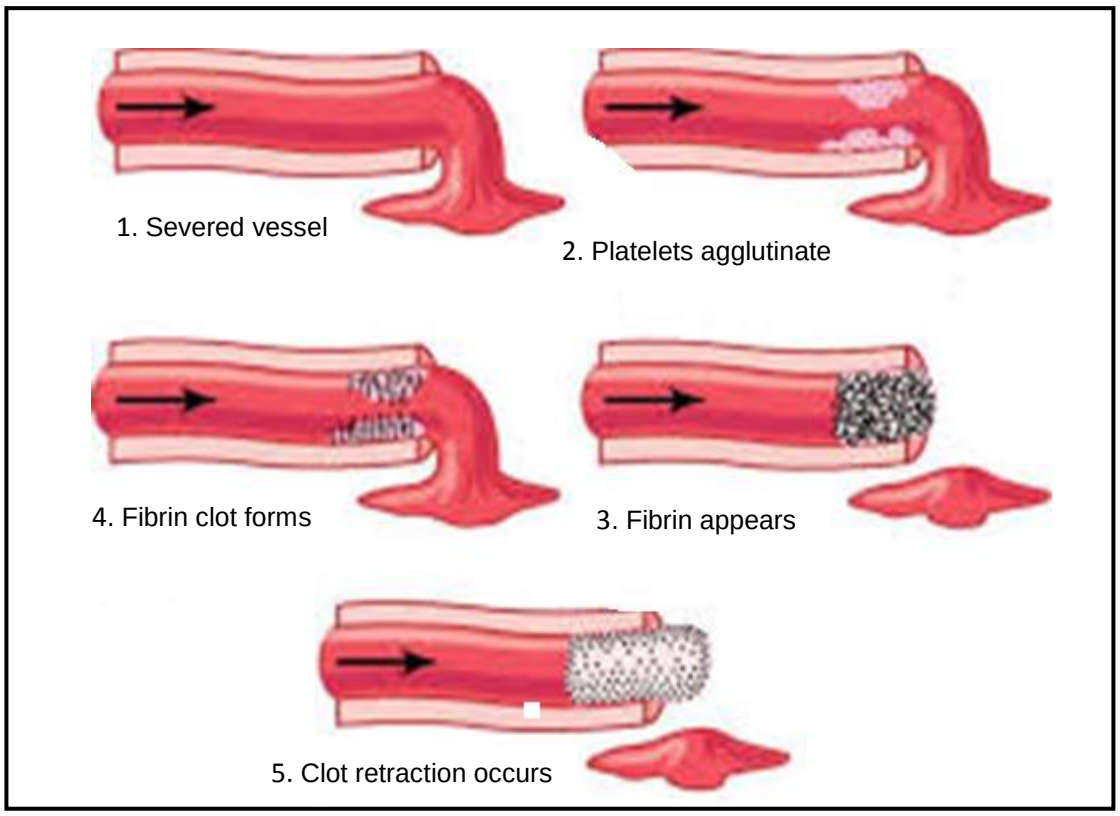
Within seconds of cutting a blood vessel, the damaged tissue causes platelets to become sticky and clump together around the cut.

These activated platelets, and the damaged tissue, release chemicals which react with other chemicals and proteins in the plasma, called **fibrinogen,** a soluble protein.

1. Bleeding washes out dirt and germs from the cut. Then the platelets produce tiny fibres. Red cells get trapped in these fibres and the blood changes into a thick red jelly called a blood clot (refer to the two pictures below).

2. The clot hardens to a scab. This keeps the wound clean while new skin grows. Then the skin breaks off.

The final step of this chemical reaction is to convert fibrinogen into thin strands of a solid protein called fibrin. The strands of fibrin form a meshwork, and trap blood cells and platelets so that a solid clot is formed.



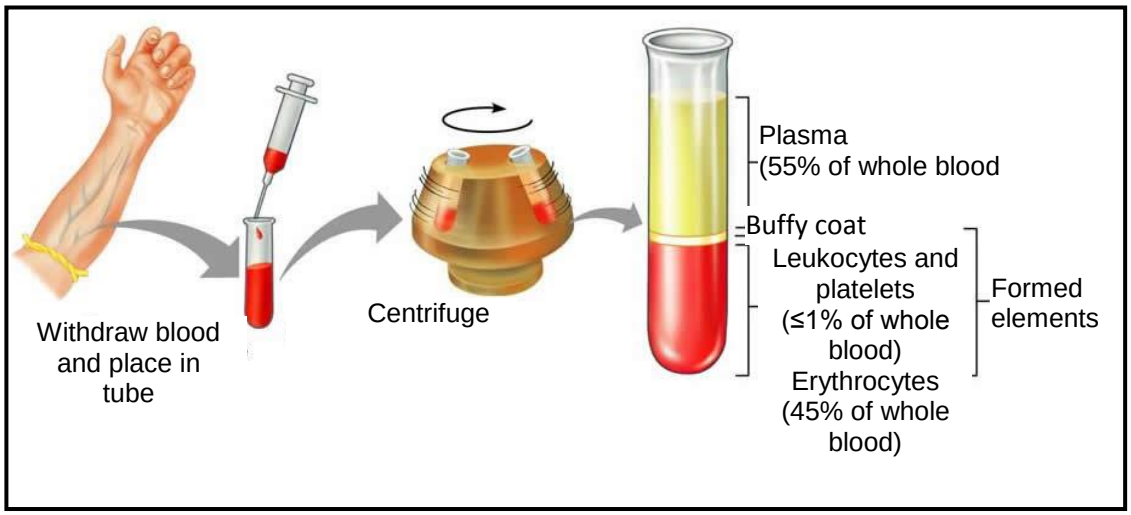
If a blood clot forms within a healthy blood vessel it can cause serious problems. So, there are also chemicals in the blood which prevent clots from forming, and chemicals which dissolve clots. So, there is a balance between forming clots and preventing clots. Normally, unless a blood vessel is damaged or cut, the balance tips in favour of preventing clots forming within blood vessels.

B. **Plasma**

The yellowish-coloured clear liquid left after cells are removed from the blood is called plasma. It is the liquid part of blood and makes up about 55% of the blood's volume

. Plasma is mainly made from water, but also contains many different proteins and other chemicals such as hormones, antibodies, enzymes, glucose, fat particles, salts and others products of digestion

The plasma also carries waste such as carbon dioxide and urea. Among the proteins are many blood-clotting chemicals. When these clotting proteins are removed from the plasma, serum (the clear fluid of the blood, with blood cells and substances that cause blood clotting removed) is produced.



When blood spills from your body (or a blood sample is taken into a plain glass tube) the cells and certain plasma proteins clump together to form a clot. The remaining clear fluid is called serum.

Activity: **Now test yourself by doing this activity.**

Answer the following questions.

1. What is the important job done by blood?

   _____

2. a) What does blood carry to and from the cells?

   _____

   b) How much blood in your body?

   _____

4. Explain how white blood cells protect us from diseases?

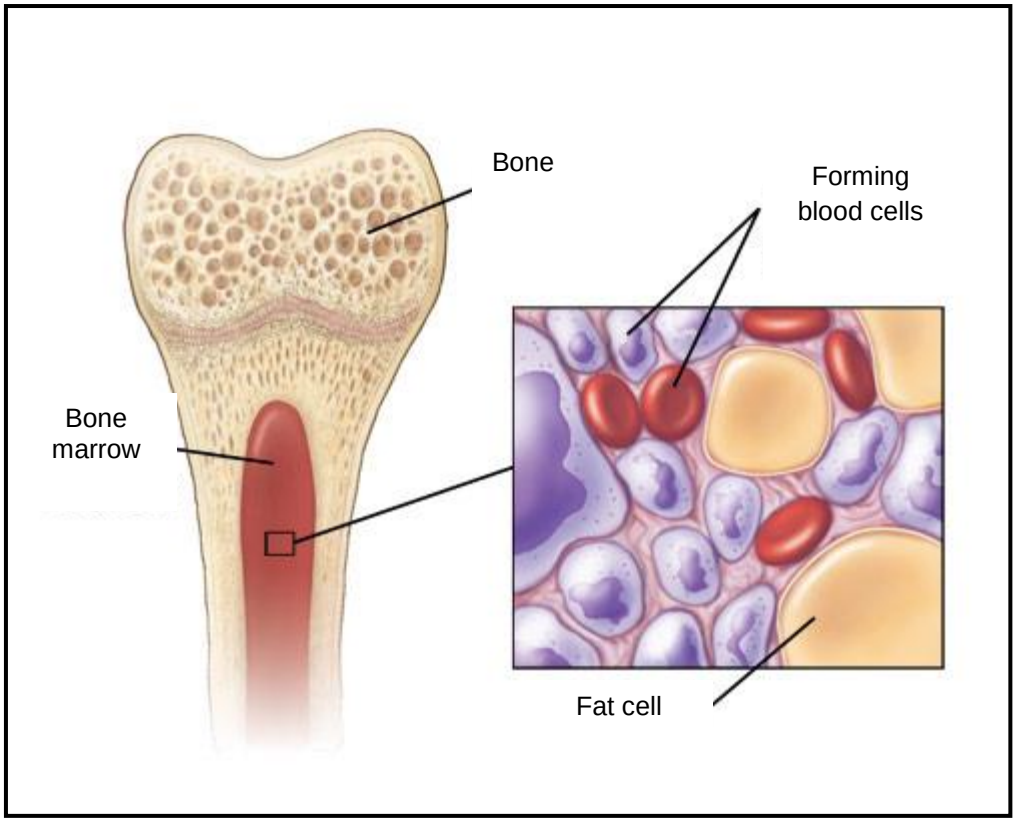
_____
_____
_____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 17.

The bone marrow, stem cells and blood cell production

Bone marrow

Blood cells are made in the bone marrow by stem cells. The bone marrow is the soft spongy-like material in the centre of bones. The large flat bones such as the pelvis and breastbone (sternum) contain the most bone marrow. To make blood cells constantly you need a healthy bone marrow. You also need nutrients from your diet, including iron and certain vitamins.



Bone marrow producing blood cells

Stem cells

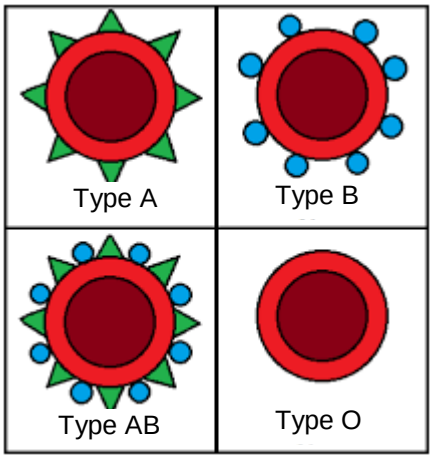
Stem cells are primitive (immature) cells. Stem cells constantly divide and produce new cells. Some new cells remain as stem cells and others go through a series of maturing stages (precursor or blast cells) before forming into mature blood cells. Mature blood cells are released from the bone marrow into the bloodstream.

Blood Groups

What is a blood group?

Red blood cells have certain proteins on their surface, called **antigens**. Also, your plasma contains **antibodies** which will attack certain antigens if they are present. There are various types of red blood cell antigens.

Your blood group depends on which antigens occur on the surface of your red blood cells .The most important blood groups are called A, B, AB and O.

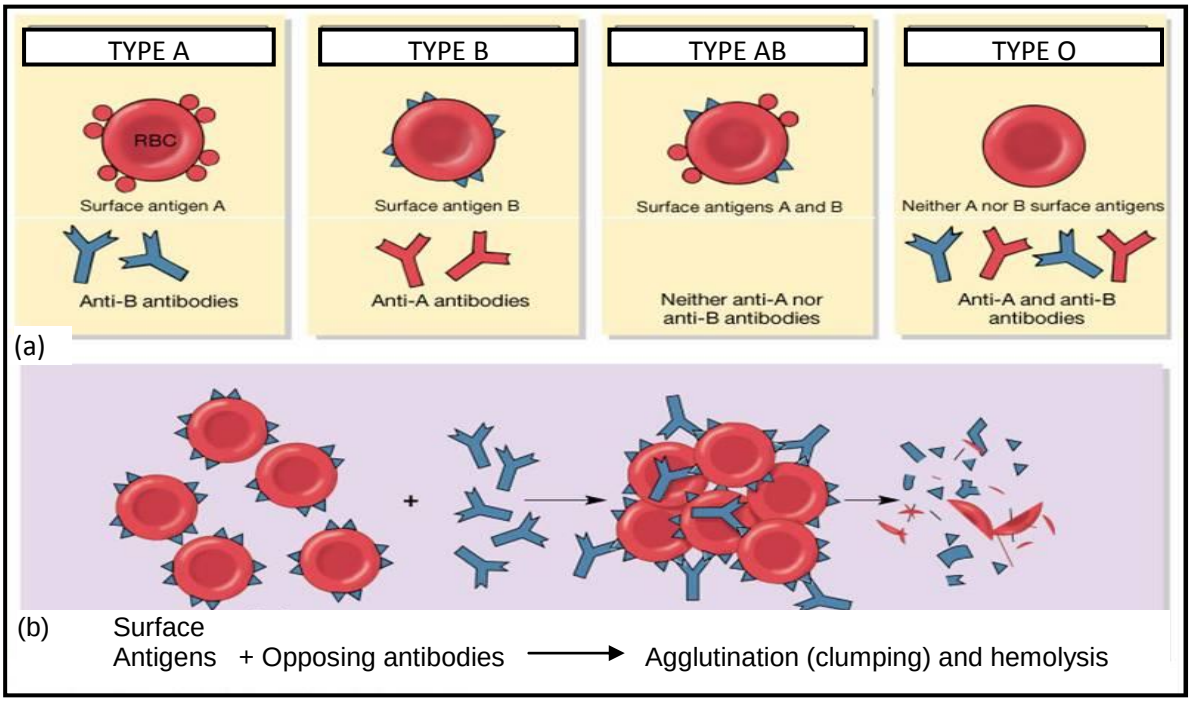


Problems with blood groups

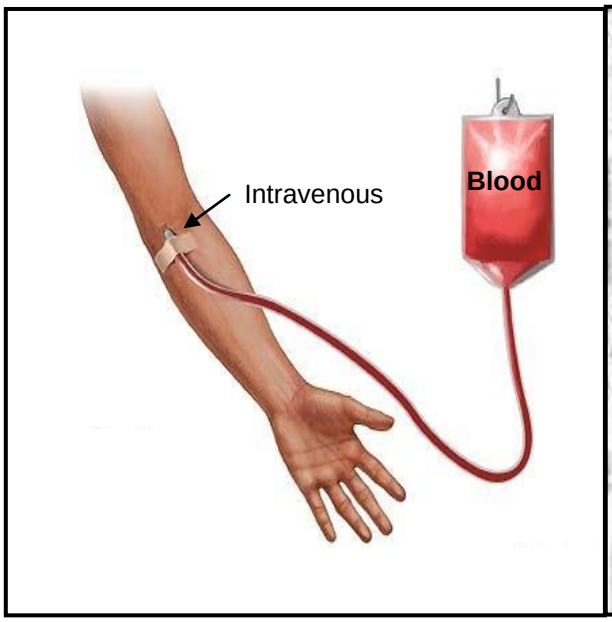
If blood from different groups is mixed, the proteins can make the red blood cells stick together. This can cause the blood to clot inside the blood vessels, leading to the death of a person. If someone needs a blood transfusion, the blood group of the donor must be compatible with the blood group of the recipient.

It is vital that the blood you receive is compatible with your own. For example, if you receive blood from a person who is A positive and you are B positive, then the anti-A antibodies in your plasma will attack the red blood cells of the donated blood. This causes the red cells of the donated blood to clump together. This can cause a serious or even fatal reaction in your body.

So, before a blood transfusion is done, a donor bag of blood is selected with the same blood group as yourself. Then, to make sure there is no incompatibility, a sample of your blood is mixed with a sample of the donor blood. After a short time the mixed blood is looked at under a microscope to see if there has been any clumping of blood. If there is no clumping, then it is safe to transfuse the blood.



Often ill people need blood transfusion. The blood may come directly from the donor or sent to the hospitals in plastic packs as shown in the diagrams below.



Blood transfusion

Giving blood to save life

Summary

You have come to the end of lesson 18. In this lesson you have learnt that:

- blood is seen to be made of three types of cells – red blood cells, white blood cells and platelets under the microscope. however, blood also contains yellowish liquid called plasma when it (blood) is centrifuged.
- blood carries things from one place to another as it flows around the body.
- blood carries food and oxygen to the body's cells as it travels around.
- the cells need food and oxygen to stay alive.
- the waste materials from the food are carried away from the cells.
- blood carries heat around the body.
- blood is the transport system for the body.
- the most important blood groups are called a, b, ab and o.
- if someone needs a blood transfusion, the blood group of the donor
- must be compatible to the blood group of the recipient.
- red blood cells are packed with haemoglobin which carries all the oxygen from the lungs to the cells.
- the white blood cells called phagocytes move around the body to protect us from foreign bacteria and viruses that invades our body.
- platelets' job is to stop any bleeding from cuts.

NOW DO PRACTICE EXERCISE 18 ON THE NEXT PAGE.

Practice Exercise 18

Choose the letter of the correct answer.

1. Most of the volume of normal human blood is composed of _____.

   A. plasma B. red cells

   C. hemoglobin D. white cells

2. Erythrocyte is another name for _____.

   A. platelet B. red cell

   C. white cell D. antibody

3. Which of the following blood components provide the major defence for our bodies against invading bacteria and viruses?

   A. Platelets B. Red cells

   C. White cells D. Antigens

4. The relatively clear liquid medium which carries the other cells of blood is called _____.

   A. lipid B. plasma

   C. antibody D. antigen

5. Which of these cell types should not be grouped with the others?

   A. Veins B. Arteries

   C. Capillaries D. Neutrophil

6. Red blood cells survive around _____ days.

.

   A. 10 B. 120

   C. 240 D. 360

7. Select the statement about red blood cells that is incorrect.

   A. Mature red blood cells lack nuclei.
   B. Deoxyhemoglobin carries oxygen.
   C. Red blood cells lack mitochondria.
   D. Red blood cells contain hemoglobin.

8. When blood clumps or forms visible islands in the still liquid plasma, it is called _____.

A. clotting B. agglutination

C. intravenous D. blood transfusion

9. Which of the following are likely to increase in quantities when the body is under attack from bacteria?

A. Platelets B. Antigens

C. Leukocytes D. Erythrocytes

10 _____ are the smallest arteries in the body. They deliver blood to capillaries.

A. Veins B. Arteries

C. Arterioles D. Capillaries

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 4.

Answers to Activity

1. The blood acts as the transport system for the whole body.
2. The blood carries food from the digestive system to the cells, oxygen from the lungs to the cells, waste materials away from the cells, and, heat round the body.
3. There is about 5.5 litres of blood in the body.
4. White blood cells protect us from diseases by ingesting microorganisms, producing antibodies and antitoxins that counteract and destroy the pathogens that cause diseases.

Lesson 19: Immunity and Vaccination

Welcome to Lesson 19. In your previous lessons 16 and 17 you have learnt that microbes such as bacteria cause some diseases. These include tuberculosis, some type of pneumonia, gonorrhea, typhoid, fever, diphtheria and whooping cough. These diseases can be prevented from occurring, therefore in this lesson we will learn how vaccination and immunity help prevent many of these diseases.

Your aims:

- define immunity and vaccination, natural immunity and acquired immunity.
- discuss the history of natural vaccination
- explain how vaccination works
- discuss passive immunity and active immunity
- describe immunization in PNG

Immunity and Vaccination

From the day you were born you are able to resist some diseases. This is known as **natural immunity.** However, the effectiveness of natural immunity varies from one person to another.

When pathogens invade the body and cause disease, antibodies are produced to fight that disease. When the person recovers, the ability to make these antibodies remains and they become effective if the person is infected for a second time.

In this way the person does not develop the symptoms of the disease a second time because he or she is now immune to it. This is called **acquired immunity** and is more effective than natural immunity.

However it should be noted that pathogens can change so that the person is no longer immune to them.

Example, the virus that causes the common cold is an example of a pathogen that can change.

It is also possible to produce immunity by introducing the pathogen into the body deliberately, causing the body to make antibodies. This process is called **vaccination or immunization.**

Vaccination is the process whereby any substance made from bacteria or viruses that is injected (or otherwise administered) so that the body will develop immunity to that bacteria or virus. The material in the vaccine causes the body to produce antibodies against the pathogen.

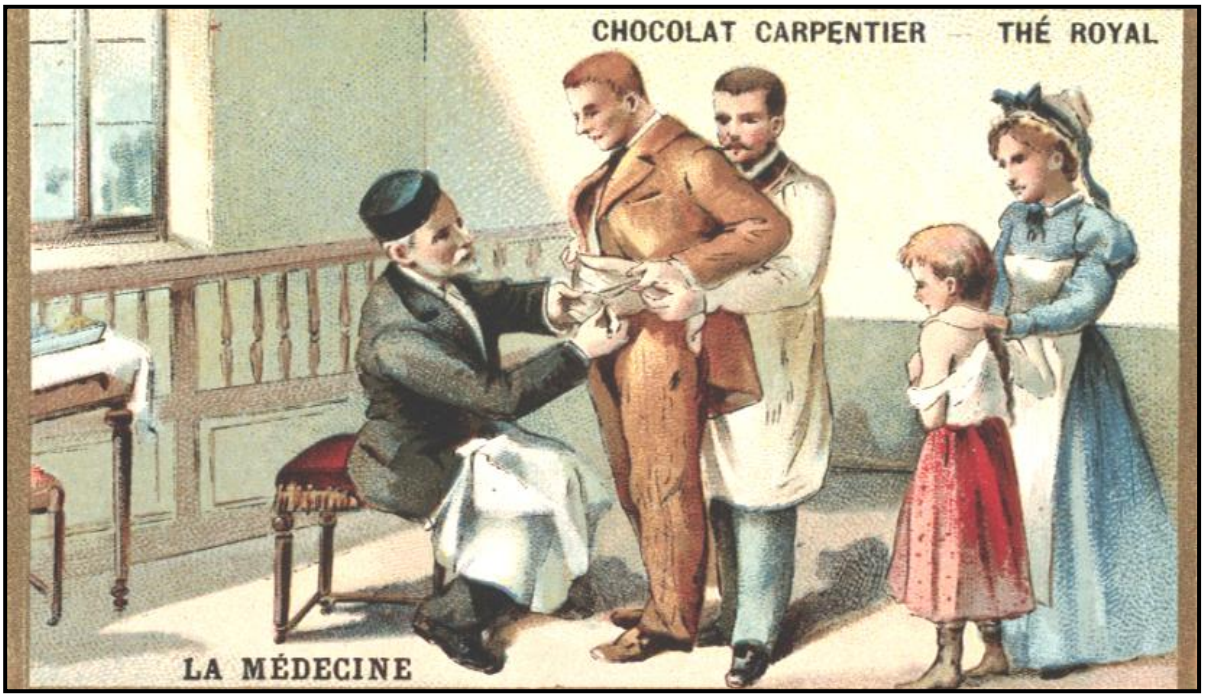
The first person to do this was Edward Jenner who was a doctor who lived in England 200 years ago. At that time small pox was very common disease in England and killed many people. Jenner noticed that people who had suffered from cowpox, a similar but much milder disease, were able to resist infection from small pox.

Jenner took some material from the hands of a girl who used to milk cows and who was suffering from cowpox. He then scratched this material into the skin of a completely healthy boy. The boy developed cowpox in his hands, but was otherwise healthy. Jenner then exposed the same boy to material from the skin of a small pox sufferer. Fortunately the boy did not develop small pox because he was immune to the disease.

The test was repeated some time later, but the boy still remained immune to smallpox. Jenner repeated these tests on a number of different people and the results were all the same. People who had been exposed to cowpox were immune to smallpox.

Jenner was the first person to scientifically demonstrate by these experiments that the techniques of vaccination could protect against a disease. Although Jenner's vaccination worked, he did not know why vaccination with cowpox protected against smallpox.

A hundred years later a French scientist named Louis Pasteur showed exactly how vaccines work to prevent disease from developing.



Pasteur inoculating a man with the rabies virus

How vaccines work

Active immunity

Vaccination is a technique which stimulated the body to develop antibodies which act as a natural defence to a particular disease. It the disease causing microbes later enter the body, they are destroyed by the antibodies before any harm is done.

The vaccine is first introduced into the bloodstream, usually by injection. The presence of the antigens from the vaccine material causes the body's own defence system to produce antibodies that attack the antigens. This results into **artificial immunity.**

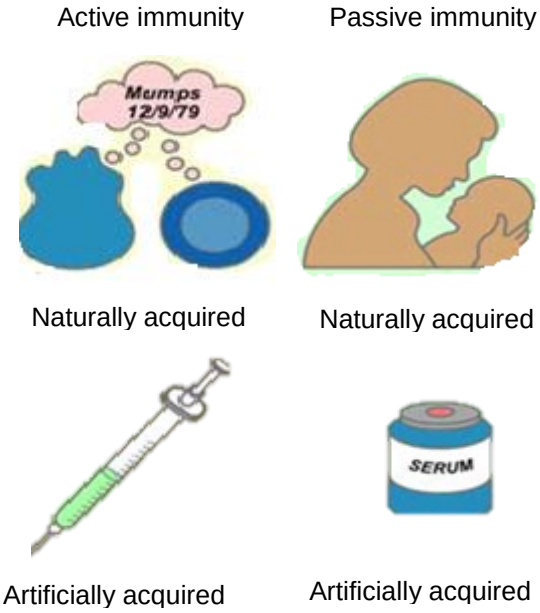
Passive immunity
When ready-made antibodies are transferred to non-immune people then they automatically acquire immunity.

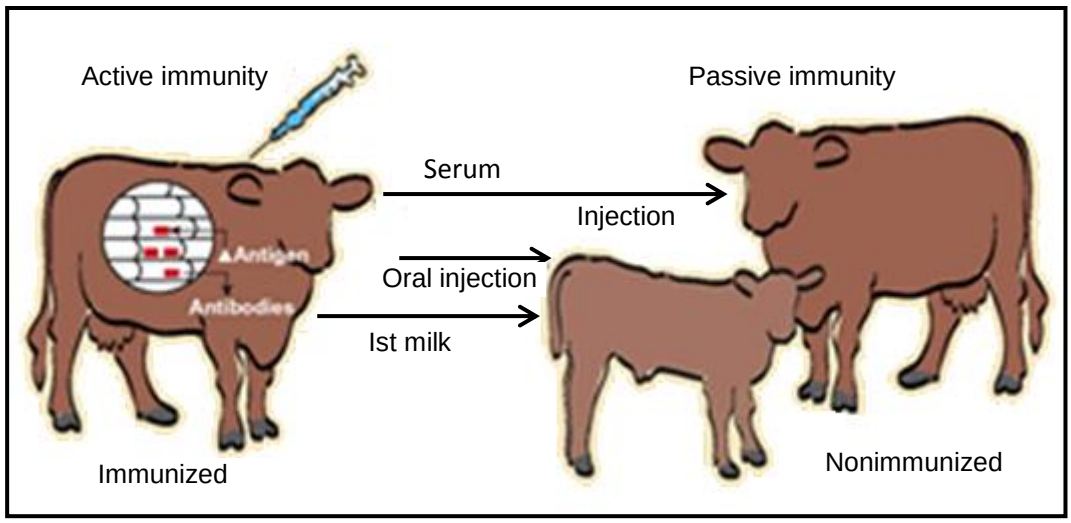
However, since no antigens are introduced, the body does not "learn" how to produce the required antibodies and so the immunity is described as **passive.**

Passive immunity can be acquired in the following ways:

1. The antibodies present in the blood plasma of pregnant woman diffuse through the placenta into the foetus. This means that at birth the baby has immunity to the same diseases as the mother. Antibodies are also passed to the baby in breast milk, which is another good reason for breast feeding.

2. The injection into the body of a serum containing ready – made antibodies. This is known as immune serum and can be used as a precaution against disease such as infective hepatitis.





In both these cases the antibodies do not last long and are eventually eliminated from the body. Injection of antibodies does not stimulate the body to form more antibodies. For these reasons injections with the hepatitis vaccine have to be repeated every year. The different ways in which immunity can be acquired are summarized in the table on the next page.

DIFFERENT WAYS THAT THE IMMUNITY CAN BE ACQUIRED

Active immunity (the body makes its own antibodies)	**Passive immunity** (the body is given antibiotics
Reaction to infection (natural) Immunisation with a vaccine (used to prevent a person from getting disease(artificial) **Active immunity usually lasts a long time**	Antibodies passed to developing baby through the placenta. Injection with a serum containing antibodies (used to cure a person who already has a disease) **Passive immunity only lasts a short time**

The immune system of your body is a defence system against invading organisms and is organized like a highly specialized army.

Immunization in Papua New Guinea

Vaccines are available free of charge to protect people against several disease. The Department of Health encourages parents to have their children immunized. Soon after a baby is born the parents should take the baby to the clinic to have a BCG vaccination, which protects against **tuberculosis.** At about two months, four months and six months of age, parents should again take their baby to the clinic for a **triple antigen** injection, which protects against whooping cough, diphtheria and tetanus. Babies living in town areas also need Sabin which protects against poliomyelitis. Sabin is an oral vaccine, which means it is taken through the mouth. When parents find that their baby has missed an injection, they should still go to the clinic, since it is never too late for children to be immunized.

The immunization programme for children and adults which is carried out by the Department of Health is shown in the table below.

AGE	VACCINE
Soon after birth	BCG
2 months old	Sabin (town areas)
4 months old	Triple antigen & Sabin (in town areas)
6 months old	Triple antigen & Sabin (in town areas)
7 years old	Tetanus toxoid
13 years old	BCG & Tetanus toxoid
First pregnancy	Tetanus toxoid
Fourth pregnancy	Tetanus toxoid

Summary

You have come to the end of lesson 19. In this lesson you have learnt that:

- the body's defence system provides an inborn or natural immunity to invading pathogens from the time a person is born.
- when some pathogens invade the human body, immunity can be acquired against the second attack of that pathogen, as the body develops certain antibodies as a result of the disease.
- pathogens can be introduced into the body artificially, causing the body to make antibodies. this process is called vaccination or immunization and can prevent a person from getting a disease.
- when the body makes its own antibodies it produces passive immunity which does not last for a long time
- injection with a serum containing antibodies can be used to cure a person who already has a disease.
- all people should be immunized against certain common disease.

NOW DO PRACTICE EXERCISE 19 ON THE NEXT PAGE.

Practice Exercise 19

Answer the following questions.

1. What is meant by natural immunity?

   _____
   _____

2. How can vaccination prevent a person from getting a disease?

   _____
   _____

3. Explain the difference between active and passive immunity.

   Active: _____
   Passive: _____

4. In what ways is a new –born baby protected from disease?

   _____
   _____

5. How can a person who is sick be treated with an injection which gives immunity?

   _____
   _____
   _____

6. A. Briefly describe the work of Edward Jenner in demonstrating the importance of vaccination.

   _____
   _____

   B. Was it alright for Jenner to put the life of the young boy at risk when he did his experiment? Give reasons for your answer.

   _____
   _____
   _____

7. Which diseases should young people be immunized against?

   _____
   _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 4.

Answers to Practice Exercises 16 - 19

Practice Exercise 16

1. (a) Canning is the method of food preservation where the food is first heated out of contact with air to kill bacteria present and to destroy enzymes. Then the lid is sealed to keep out oxygen and stop microbes from entering.
   (b) Pasteurisation is the method of food (milk) preservation whereby milk is heated to about 71^{0} C for at least 15 seconds and quickly canned and bottled. This kills the disease-causing bacteria.

2. The food is heated before canned in order to destroy any bacteria present in the food.

3. The milk that is left open on a hot summer's day will be spoiled because of the microbes which enter into it.

4. Spontaneous generation is the idea that living things will develop from non-living things.

5. The idea of spontaneous generation was shown wrong by Louis Pasteur where he boiled some broth in the container that allowed air to enter through an S-shaped neck. Even though the soup was exposed to the air, it did not go bad because the microbes did not reach the soup. This shows that the microbes enter the food from the outside of the food and not the food that slowly generates them.

6. Pasteur's soup would have gone bad since the microbes would have gone right into the soup.

7. Food can easily be destroyed by microbes because they sit on dirty things like the faeces and decayed organisms.

8. a) Cover the food to stop entry of microbes onto the food.
   b) Keep the food in a dry, warm place to keep away the microbes.

9. a) cooking
   b) dehydrating

10. Dehydrating is a good way of food preservation because it does not remove the nutrients from the food.

Practice Exercise 17

1. a) The female anopheles mosquito
   b) Because it feeds on blood.

2. When a female Anopheles mosquito bites a person who has malaria, the malarial parasites in the blood are drawn into the mosquito's stomach, where they reproduce.

After about two weeks they move to the salivary glands in the mosquito's mouth, where they accumulate in large numbers. When this mosquito bites a healthy person, saliva containing hundreds of parasites is injected into the person's bloodstream.

From here they pass to the liver and rapidly multiply, forming many more parasites. These burst out of the liver cells and enter new red blood cells, where they again grow and multiply to form many new parasites. When thousands of red blood cells all burst at the same time, the person suffers from a fever. The cycle repeats itself continually so that increasing numbers of red blood cells are destroyed.

3. a) Controlling the Anopheles mosquito
   b) Recording the numbers of the malarial parasite

Practice Exercise 18

1.	A	6.	B
2.	B	7.	B
3.	C	8.	A
4.	B	9.	C
5.	D	10.	C

Practice Exercise 19

1. Natural immunity is the production of antibodies naturally by the body to fight diseases when pathogens invade the body.

2. Vaccination can prevent a person from getting a disease by introducing the pathogen into the body deliberately, causing the body to make antibodies

3. Active immunity is the immunity in which vaccine is introduced into the bloodstream and the presence of the antigens from the vaccine material causes the body's own defence system to produce antibodies that attack the antigen.
   Passive immunity is the immunity in which read-made antibodies are transferred to non-immune people and they automatically a acquire immunity.

4. A new born baby is protected from disease by taking the child to the clinic to be immunized soon after the baby is born, at about two months, four months and six months of age.

5. Injection with a serum containing antibodies can be used to cure a person who already has a disease.

6. A. Jenner took some material from the hands of a girl who used to milk cows and who was suffering from the cowpox. He then scratched this material to the skin of a completely healthy boy. The boy developed cowpox on his hands, but was otherwise healthy. Jenner then exposed the same boy to the material

from the skin of a smallpox sufferer. Fortunately the boy did not develop smallpox because he was immune to the disease.

B. It was all right for Jenner to put the life of the young boy at risk because he was a doctor and so whatever should happen after all, he would be able to handle the situation accordingly. Otherwise h confidently knew what he was doing.

7. The young people should be immunized against tuberculosis, whooping cough, diphtheria, tetanus and poliomyelitis.

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

REVIEW OF TOPIC 4: Prevention of Diseases

Now, revise all lessons in this Topic and then do **ASSIGNMENT 2.** Here are the main points to help you revise.

Lesson 16: Microbes in Food Spoilage

- Microbes can cause food to spoil or decay
- Food should be kept covered and cool in order to avoid spoilage
- Different ways of preserving food are cooking, refrigeration, freezing, dehydrating, pickling, sugaring, pasteurization, canning and, addition of artificial preservations.
- Different ways of dehydrating are air drying, smoking, vacuum drying, freeze drying, and curing and salting.
- Organisms that cause disease are called pathogens
- All viruses, some bacteria and a few fungi and protozoa are pathogens
- Food poisoning can be caused by salmonella or clostridium, which are transmitted into food.
- Insects also spread pathogens. for example, houseflies and cockroaches can spread gastro-intestinal diseases, while mosquitoes can spread malaria

Lesson 17: Control and Elimination of Malaria

- Malaria is one of the most significant sicknesses in the world and is endemic to Papua New Guinea.
- Malaria is caused by the parasitic protozoan plasmodium.
- Malaria makes people very sick and causes anaemia, fever and an enlarged spleen. it can also cause death.
- Malaria is caused by the female anopheles mosquito that feeds at night on human blood.
- Malaria can be controlled by getting rid of the mosquitoes that carry the disease and by killing or stopping the reproduction of the parasite that causes the disease.
- Mosquitoes can be controlled by removing breeding places, sleeping under mosquito nets treated with an insecticide, screening houses, adding fish to ponds and using insecticides.
- Chloroquine can be used as a prophylactic to prevent malaria, and also as a treatment for malaria.
- Malaria parasites that do not respond to chloroquine can be treated with quinine and fansidar.
- Many people in Papua New Guinea have a natural immunity to malaria.
- People can die or have other health problems and be unable to work properly because of malaria.

Lesson 18: Blood

- Blood is seen to be made of three types of cells – red blood cells, white blood cells and platelets under the microscope. however, blood also contains yellowish liquid called plasma when it (blood) is centrifuged.
- Blood carries things from one place to another as it flows around the body.
- Blood carries food and oxygen to the body's cells as it travels around.
- The cells need food and oxygen to stay alive.
- The waste materials from the food are carried away from the cells.
- Blood carries heat around the body.

- Blood is the transport system for the body.
- The most important blood groups are called a, b, ab and o. if someone needs a blood transfusion, the blood group of the donor must be compatible to the blood group of the recipient
- Red blood cells are packed with haemoglobin which carries all the oxygen from the lungs to the cells.
- The white blood cells called phagocytes move around the body to protect us from foreign bacteria and viruses that invades our body.
- Platelets' job is to stop any bleeding from cuts.

Lesson 19: Immunity and Vaccination

- The body's defence system provides an inborn or natural immunity to invading pathogens from the time a person is born.
- When some pathogens invade the human body, immunity can be acquired against the second attack of that pathogen, as the body develops certain antibodies as a result of the disease.
- Pathogens can be introduced into the body artificially, causing the body to make antibodies. This process is called vaccination or immunization and can prevent a person from getting a disease.
- When the body makes its own antibodies it produces passive immunity which does not last for a long time
- Injection with a serum containing antibodies can be used to cure a person who already has a disease.
- All people should be immunized against certain common disease.

NOW DO TOPIC TEST 4 TO COMPLETE YOUR ASSIGNMENT 2.

RETURN IT TO THE PROVINCIAL COORDINATOR.

GLOSSARY

A

AIDS
Stands for Acquired Immune Deficiency Syndrome.A disease in which there is a severe loss of the body's cellular immunity, greatly lowering the resistance to infection and malignancy.

Absorption
The act or process of absorbing or assimilating.The process of absorbing or assimilating substances into cells or across the tissues and organs through diffusion or osmosis, as in absorption of nutrients by the digestive system, or absorption of drugs into the bloodstream.

Alcohol
A colourless volatile flammable liquid which is the intoxicating constituent of wine, beer, spirits, and other drinks, and is also used as an industrial solvent and as fuel.

Animalcule
("little animal", from Latin animal + the diminutive suffix -culum) is an older term for a microscopic animal or protozoan.

Autotrophic
Relating to an organism that manufactures its own food from inorganic substances, such as carbon dioxide and nitrogen, using light or ATP for energy. All green plants and algae, and some bacteria and protists, are autotrophs.

B

Botulism
Food poisoning caused by a bacterium growing on improperly sterilized tinned meats and other preserved foods.

C

Casein
The main protein present in milk and (in coagulated form) in cheese. It is used in processed foods and in adhesives, paints, and other industrial products.

Chitin
A nitrogen-containing polysaccharide, related chemically to cellulose that forms a semitransparent horny substance and is a principal constituent of the hard parts such as exoskeleton, or outer covering, of insects, crustaceans, and arachnids.

Chlorophyll
A green pigment, present in all green plants, algae and in cyanobacteria, which is responsible for the absorption of light to provide energy for photosynthesis.

Cellulose
A carbohydrate that is a polymer composed of glucose units and that is the main component of the cell walls of most plants. It is insoluble in water and is used to make paper, cellophane, textiles, explosives, and other products

Colonies
Visible masses of microorganisms all originating from a single mother cell, therefore a colony constitutes a clone of bacteria all genetically alike

D

Decay
The state or process of rotting or decomposition**.**

Decomposition
The process of decaying or rotting

DDT **(**dichlorodiphenyltrichloroethane)
A colorless, crystalline, tasteless and almost odorless organochloride known for its insecticidal properties.

Dinoflagellates
Single-celled organisms with two flagella, occurring in large numbers in marine plankton and also found in fresh water. Some produce toxins that can accumulate in shellfish, resulting in poisoning when eaten.

E
Enzymes
Substances produced by a living organism which acts as a catalyst to bring about a specific biochemical reaction

F
Flagellae
Threadlike appendages, especially a whip like extension of certain cells or organisms that functions as an organ of locomotion**.**

G
Gametes
Mature haploid reproductive cells (male or female sex cells) that unite in sexual reproduction to form a new cell called zygote.

Gasohol
A mixture of petrol and ethanol used as fuel in internal-combustion engines.
"gasohol cars"

Granulocytes
White blood cells with secretory granules in its cytoplasm, example. an eosinophil or a basophil.

Glycerol
A colourless, sweet, viscous liquid formed as a by-product in soap manufacture. It is used as an emollient and laxative, and for making explosives and antifreeze.

H
Haemolytic uremic syndrome (HUS)
Abbreviated HUS is a disease characterized by hemolytic anemia (anemia caused by destruction of red blood cells), acute kidney failure (uremia), and a low platelet count (thrombocytopenia).

Heterotrophic
Requiring complex organic compounds of nitrogen and carbon (as that obtained from plant or animal matter) for metabolic synthesis.

Hyphae (singular hypha)
Long, branching filamentous structures of a fungus, oomycete, or actinobacterium. In most fungi, hyphae are the main mode of vegetative growth, and are collectively called a mycelium. Yeasts are unicellular fungi that do not grow as hyphae.

L
Lactate
A product of fermentation and is produced during cellular respiration as glucose is broken down

M
Manure
Any natural or artificial substance for fertilizing the soil.
Mitotic cell division

Mitosis is a process of nuclear division in eukaryotic cells that occurs when a parent cell divides to produce two identical daughter cells.

Monocytes
A large phagocytic white blood cell with a simple oval nucleus and clear, greyish cytoplasm.

Multicellular
Multicellular organisms are composed of many cells, which are integrated and independent to various degrees

P

Parasite
An organism that lives on or in an organism of another species, known as the host, from the body of which it obtains nutriment.

Parasitic
Definition of relating to or characteristic of organisms of parasites

Pathogenic
Causing or capable of causing disease.

R

Resistance
The natural or genetic ability of an organism to avoid or repel attack by biotic agents (pathogens, pests, parasites, etc.) or to withstand the effects of abiotic agents (chemicals, pesticides, salt, wind, heavy metals and others.

S

Saprophytes
Plant, fungi, or microorganisms that live on and derive their nourishment from dead or decaying organic matter.

Sexual reproduction
A mode of reproduction involving the fusion of female gamete (ovum) and male gamete (spermatozoon), which forms a zygote that potentially develops into genetically distinct offspring.

Sludge
Thick, soft, wet mud or a similar viscous mixture of liquid and solid components, especially the product of an industrial or refining process

Sporangia
A single-celled or many-celled structure in which spores are produced, especially in fungi, algae, mosses, and ferns. Also called spore case

Substrate
The molecule (or molecules) with which the enzyme bonds are referred to as the substrate

T

Toxoplasmosis parasite
A single-celled parasite called Toxoplasma gondii causes a disease known as toxoplasmosis

U

Unicellular
Unicellular organisms are made up of a single cell like most bacteria

V

Vats
A large tank or tub used to hold liquid, especially in industry.

Vectors
An insect or other organism that transmits a pathogenic fungus, virus, bacterium.

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FODE SUBJECTS AND COURSE PROGRAMMES

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

REMEMBER:

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

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

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

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

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

REMEMBER:

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