
KSSM
KURIKULUM STANDARD SEKOLAH MENENGAH
KEMENTERIAN PENDIDIKAN MALAYSIA
DUAL LANGUAGE PROGRAMME
SCIENCE
FORM 5
KEMENTERIAN PENDIDIKAN MALAYSIA

RUKUN NEGARA

Bahawasanya Negara Kita Malaysia
mendukung cita-cita hendak:

Mencapai perpaduan yang lebih erat dalam kalangan
seluruh masyarakatnya;

Memelihara satu cara hidup demokrasi;

Mencipta satu masyarakat yang adil di mana kemakmuran negara
akan dapat dinikmati bersama secara adil dan saksama;

Menjamin satu cara yang liberal terhadap
tradisi-tradisi kebudayaannya yang kaya dan pelbagai corak;

Membina satu masyarakat progresif yang akan menggunakan
sains dan teknologi moden;

MAKA KAMI, rakyat Malaysia,
berikrar akan menumpukan
seluruh tenaga dan usaha kami untuk mencapai cita-cita tersebut
berdasarkan prinsip-prinsip yang berikut:

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KESETIAAN KEPADA RAJA DAN NEGARA
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KEDAULATAN UNDANG-UNDANG
KESOPANAN DAN KESUSILAAN

(Sumber: Jabatan Penerangan, Kementerian Komunikasi dan Multimedia Malaysia)

KURIKULUM STANDARD SEKOLAH MENENGAH

DUAL LANGUAGE PROGRAMME

SCIENCE

FORM 5

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Contents

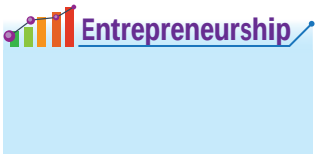
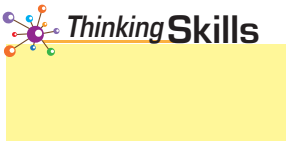
Introduction

The **Form 5 Science** *Kurikulum Standard Sekolah Menengah* (KSSM) textbook is written for Form 5 students based on the *Dokumen Standard Kurikulum dan Pentaksiran Tingkatan 5* developed by the Ministry of Education Malaysia. This textbook is based on a holistic approach that aims to produce students who are intelligent, creative, innovative, critical and possess noble values in line with the National Education Philosophy.

This book is written with emphasis on Lower Order Thinking Skills (LOTS) and Higher Order Thinking Skills (HOTS), scientific skills, communication skills, decision-making and problem-solving skills in daily life so that students can master the skills needed in the 21st century. In addition, the Science, Technology, Engineering and Mathematics (STEM) teaching and learning approach is also incorporated through activities and projects so that students become interested and involved in science and technology.

To achieve these objectives, this book incorporates special features as follows:

1.1.1	Learning Standards based on the *Dokumen Standard Kurikulum dan Pentaksiran* (DSKP) *Sains Tingkatan 5* for teachers' reference
Science Info	Additional information related to a topic that stimulates students' interest in the topic
BRAIN TEASER	Questions that challenge students' thinking
My Malaysia	Latest information on Malaysia's achievements in the field of science and technology
Today in history	Information on scientific developments and science-related historical events
Click@Web	Additional information on topics from websites

	Recalling acquired information
	Video links to help students understand a topic
	Information on the knowledge, understanding and application of entrepreneurship concepts
	In-depth investigation of topics by gathering information from the Internet, print media and other electronic media to support it
	Steps that students need to take to obtain accurate results and to avoid any accidents during scientific investigations
	Emphasis on matters that could be potentially harmful during scientific investigations
	21st Century Skills • Thinking and Problem-solving Skills (TPS) • Interpersonal and Self-reliance Skills (ISS) • Information and Communication Skills (ICS) • STEM

Students are notified of websites, additional information and videos that can be accessed for an in-depth understanding of a certain topic. Apart from website addresses (URLs), students can also access websites, additional information and videos using the QR code displayed. Students only need to follow these steps:

Step1

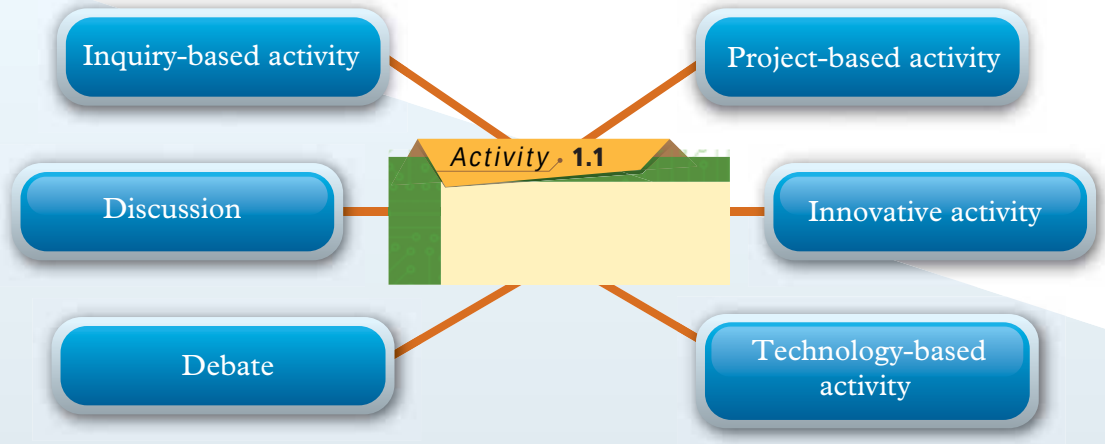
Choose and download a QR code reader application that is compatible with the smart device either from the App Store or Play Store for free

Step 2

Activate the QR code reader application and then scan the QR code using the camera in the smart device

Relevant websites, additional information or videos will be available

Types of activities in this book:



Experiment 1.1

Scientific investigation through guided experiments

Formative Practice 2.1

Questions at the end of each subtopic to test students' understanding

Components at the end of a chapter:

Summary	Graphic summary of concepts
Self-Reflection	Simple checklist of Learning Standards for students' reference
Summative Practice 2	Subjective questions to test students' understanding
Quiz http://buku-teks.com/sc5043	Interactive multiple-choice questions to test students' understanding
Enrichment Practice	HOTS questions focused on evaluating and creating skills
	HOTS questions – applying, analysing, evaluating, creating

Components of mobile application:

Scan AR Page

This textbook includes a mobile application, that is *BT Sains T5*. This application contains interesting AR (Augmented Reality) materials which can optimise the teaching and learning process. AR materials can be downloaded and activated through the following steps:

Step 1

Scan the QR code on the right with a smart device and download the *BT Sains T5* application

Step 2

Find this icon on pages:

Scan AR Page

15, 210, 225, 226, 239

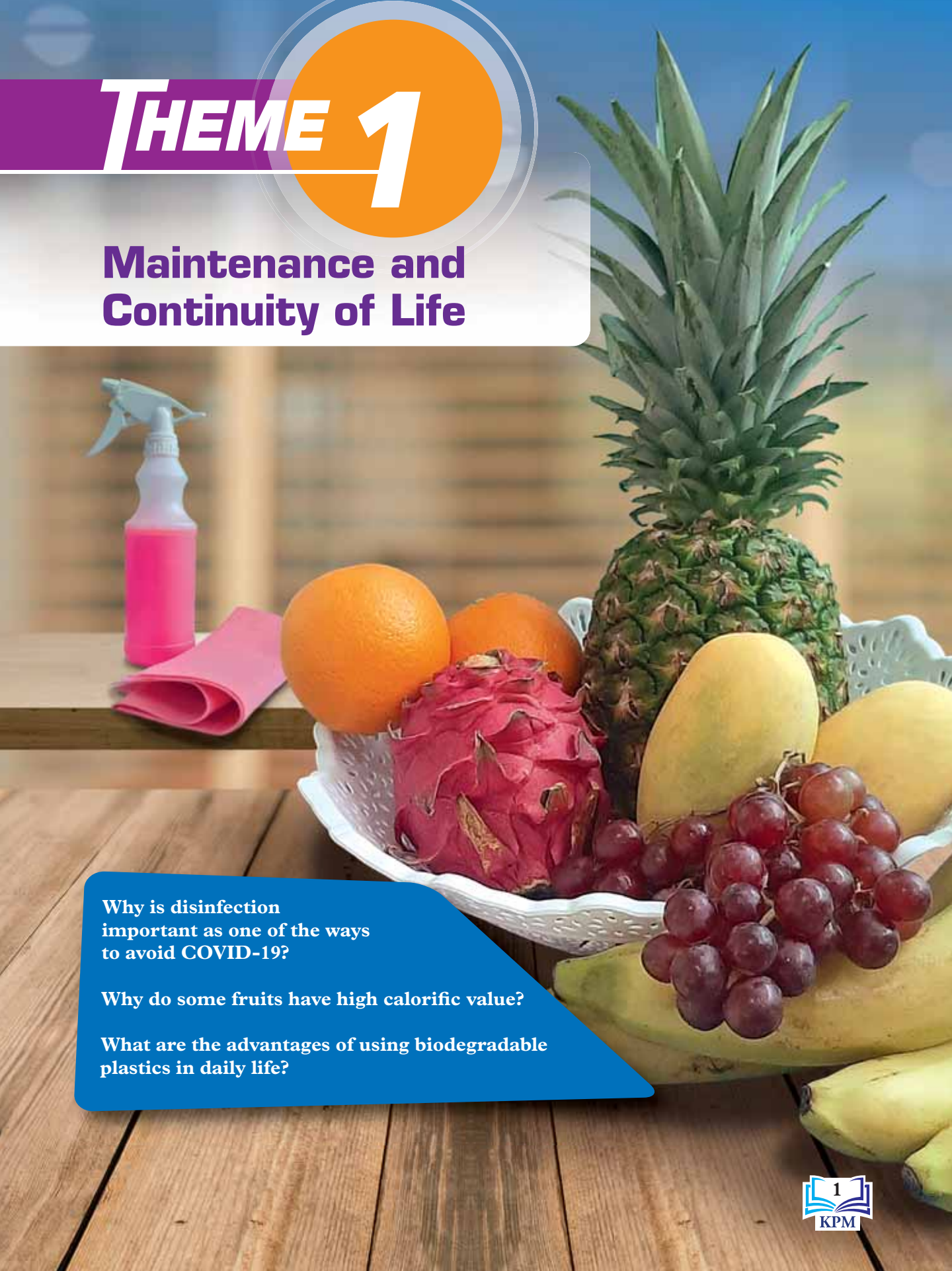
Step 3

Activate the *BT Sains T5* application and scan the entire page

Users do not need to close and reactivate the *BT Sains T5* application to scan subsequent pages

THEME 1

Maintenance and Continuity of Life



Why is disinfection important as one of the ways to avoid COVID-19?

Why do some fruits have high calorific value?

What are the advantages of using biodegradable plastics in daily life?

CHAPTER 1

MICROORGANISMS

Why were microorganisms not discovered before the invention of the microscope?

What are the roles of useful microorganisms in the fields of medicine, agriculture and industry?

Why is 'prevention better than cure' for an illness caused by harmful microorganisms?

Let's study

- World of microorganisms
- Useful microorganisms
- Prevention and treatment of diseases caused by microorganisms

Science Bulletin

Coronavirus disease or COVID-19 is an infectious disease first detected and identified in Wuhan, China. Due to the outbreak of COVID-19 worldwide, it has been categorised as a pandemic by the World Health Organisation (WHO).

Coronavirus

Keywords

- Microorganism
- Fungus
- Alga
- Protozoan
- Bacterium
- Virus
- Normal flora
- Vaccine
- Eco enzyme
- Pathogen
- Aseptic
- Sterilisation
- Antiseptic
- Disinfectant
- Antibiotic
- Antifungal
- Antiviral

1.1 World of Microorganisms

Microorganisms are minute organisms that cannot be seen with the naked eye. Microorganisms can only be seen with the help of a **microscope**.

The number of body cells in a human body is approximately 3.0×10^{13}. Can you estimate the number of microorganisms in your body?

Click@Web

Is the number of microorganisms larger than the number of body cells in the human body?
http://buku-teks.com/sc5004

Normal Flora

Normal flora refers to the microorganisms found in organisms including humans and animals which do not cause illness. Observe the normal flora found in the different parts of the human body in Figure 1.1.

Lactobacillus sp.

Streptococcus sp.

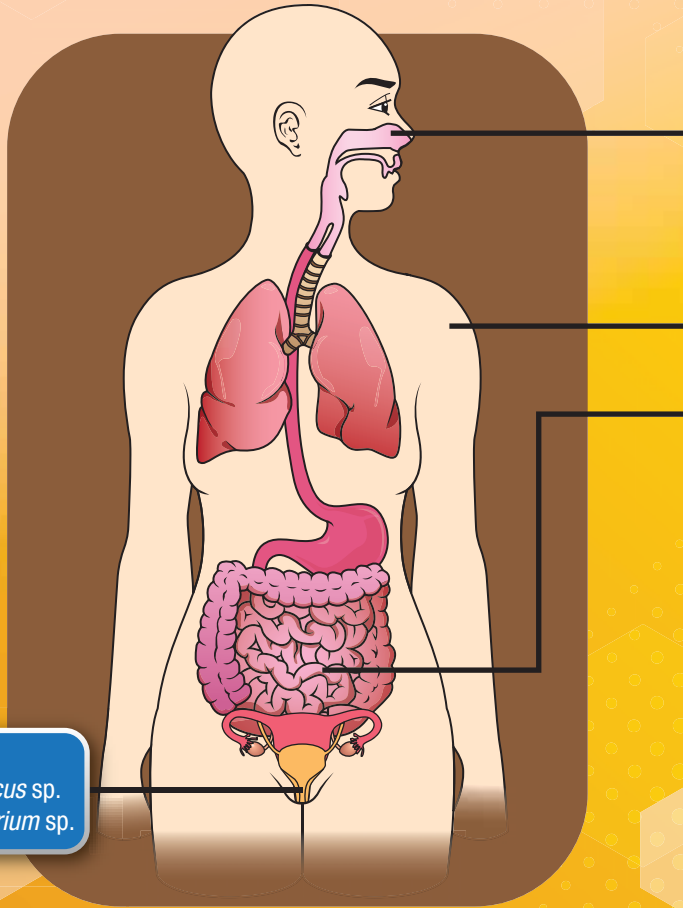


Figure 1.1 Normal flora in humans

1.1.1

Staphylococcus sp.

Corynebacterium sp.

Escherichia coli

Upper part of respiratory tract
- *Staphylococcus* sp.
- *Streptococcus* sp.

Skin
- *Staphylococcus* sp.
- *Corynebacterium* sp.

Small intestine
- *Escherichia coli*
- *Lactobacillus* sp.
- *Streptococcus* sp.

Science Info

The importance of normal flora for human health are as follows:
- normal flora competes with pathogens to obtain nutrients and prevent the formation of colonies of pathogens
- normal flora consists of bacteria that synthesise vitamin B_{12} and vitamin K
- normal flora stimulates the growth of body tissues such as colon tissues and tissues in the digestive tract
- normal flora stimulates the production of antibodies that fight pathogens and diseases

Classification of Microorganisms

Microorganisms are normally classified into **five** groups (Figure 1.2).

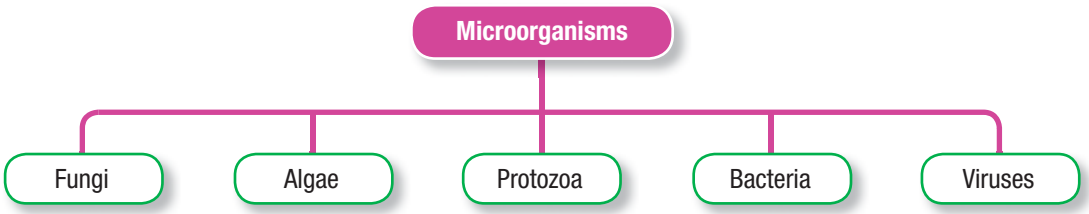


Figure 1.2 Classification of microorganisms

Size

The sizes of fungi **vary** (Photograph 1.1). There are **macroscopic fungi** such as mushrooms which can be seen with the naked eye and **microscopic fungi** such as yeast and mucor which measure **10 µm – 100 µm**. Microscopic fungi can only be seen with the help of a microscope. Fungi like mucor normally exist in **colonies** or groups.

BRAIN TEASER

If mucor is microscopic, then why can mucor on bread be seen with the naked eye?

(a) Mushroom

(b) Yeast (under an electron microscope)

(c) Mucor

Photograph 1.1 Various types of fungi

Shape

Unicellular fungi such as **yeast** are shaped like **small spheres** (Figure 1.3). **Multicellular** fungi such as **mucor** are normally made up of **sporangium** which is **spherical** and **hypha** which is **filamentous** (Figure 1.4).

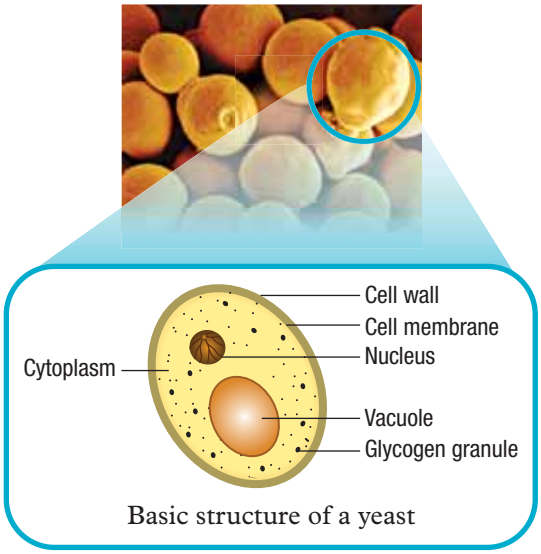


Figure 1.3 Unicellular fungi – yeast

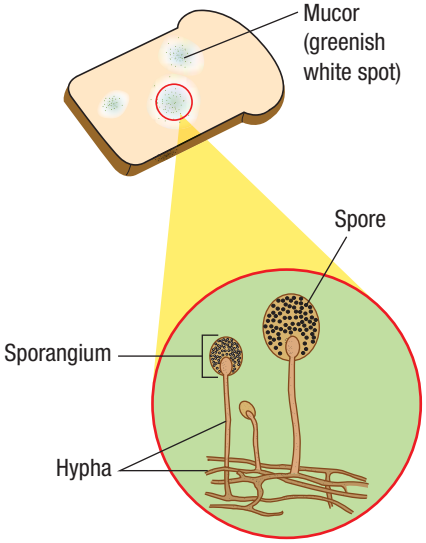


Figure 1.4 Multicellular fungi – mucor

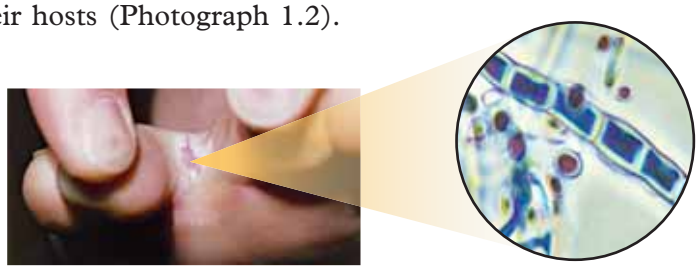
Characteristics of fungi

Nutrition

Why are fungi cells unable to make their own food? Some fungi are **saprophytes** which obtain nutrients from dead and decaying organisms, and some are **parasites** which obtain nutrients from their hosts (Photograph 1.2).

Flashback

What is the importance of saprophytic fungi in the nitrogen cycle, carbon cycle and oxygen cycle?



Photograph 1.2 *Trichophyton rubrum*, a parasitic fungus

Habitat

The habitat of a microorganism is normally related to its **nutrition**. Therefore, fungi normally live in places which contain a lot of decaying matter, faeces, animal skin and food. Fungi also grow well in dark and moist places. State one example of habitat for *Trichophyton rubrum*.

Methods of reproduction

Unicellular fungi such as **yeast** reproduce **asexually** by **budding** (Figure 1.5). **Multicellular** fungi such as **mucor** reproduce **asexually** by **spore formation** or **sexually** by **conjugation** (Figure 1.6).

Spores are microscopic cells released by a sporangium. When the very fine and light spores are carried by wind to a favourable environment, the spores will germinate without fertilisation. In the **conjugation** process, the meeting of hyphae occurs, gametes are produced and the fertilisation of gametes produces new mucor.

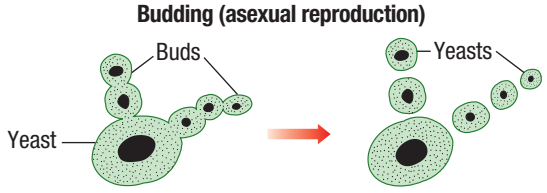
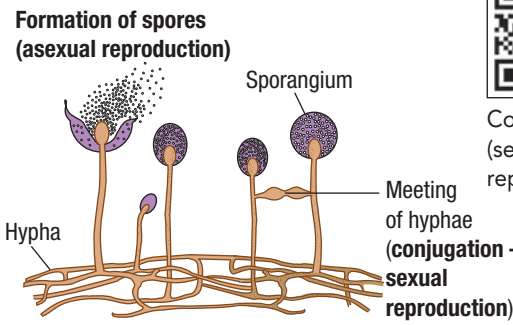


Figure 1.5 Yeast reproduces by budding



Conjugation (sexual reproduction)

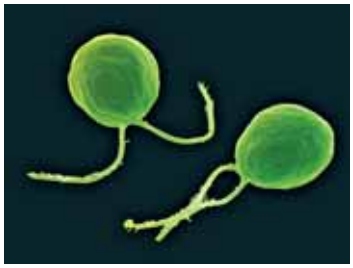
Figure 1.6 Asexual and sexual reproduction in mucor

Size

Algae have different sizes. There are **macroscopic algae** such as sea algae which can be seen with the naked eye and **microscopic algae** such as *Chlamydomonas* sp. and *Spirogyra* sp. which measure from **1 µm** to **hundreds of µm** (Photograph 1.3).

(a) Sea algae

(b) *Spirogyra* sp.

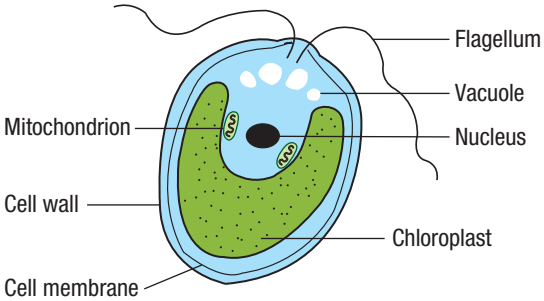


(c) *Chlamydomonas* sp.

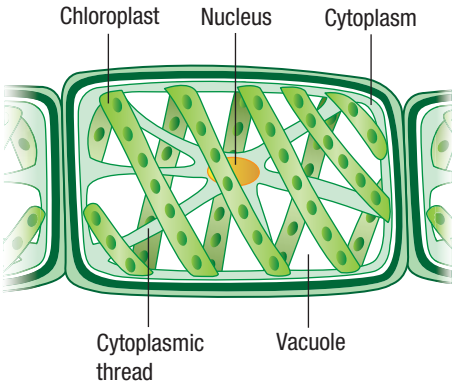
Photograph 1.3 Various types of algae

Basic shape or structure

Unicellular algae such as *Chlamydomonas* sp. and **multicellular** algae such as *Spirogyra* sp. have chloroplasts which contain **chlorophyll** (Figure 1.7).



(a) *Chlamydomonas* sp.



(b) *Spirogyra* sp.

Figure 1.7 Examples of unicellular and multicellular algae

Characteristics of algae

Nutrition

Most algae are green in colour because of the presence of **chlorophyll** in their cells. This also differentiates microscopic algae from other microorganisms. **Chlorophyll** enables algae to carry out **photosynthesis** to produce their own food.

BRAIN TEASER

Why are algae not found at the bottom of the ocean?

Habitat

The habitats of algae are fresh water, salt water, moist soil and tree barks that are exposed to sunlight.

Methods of reproduction

Algae such as *Chlamydomonas* sp. normally reproduce **asexually** by **binary fission** and **sexually** by **conjugation**. Algae such as *Spirogyra* sp. reproduce **sexually** by **conjugation**.

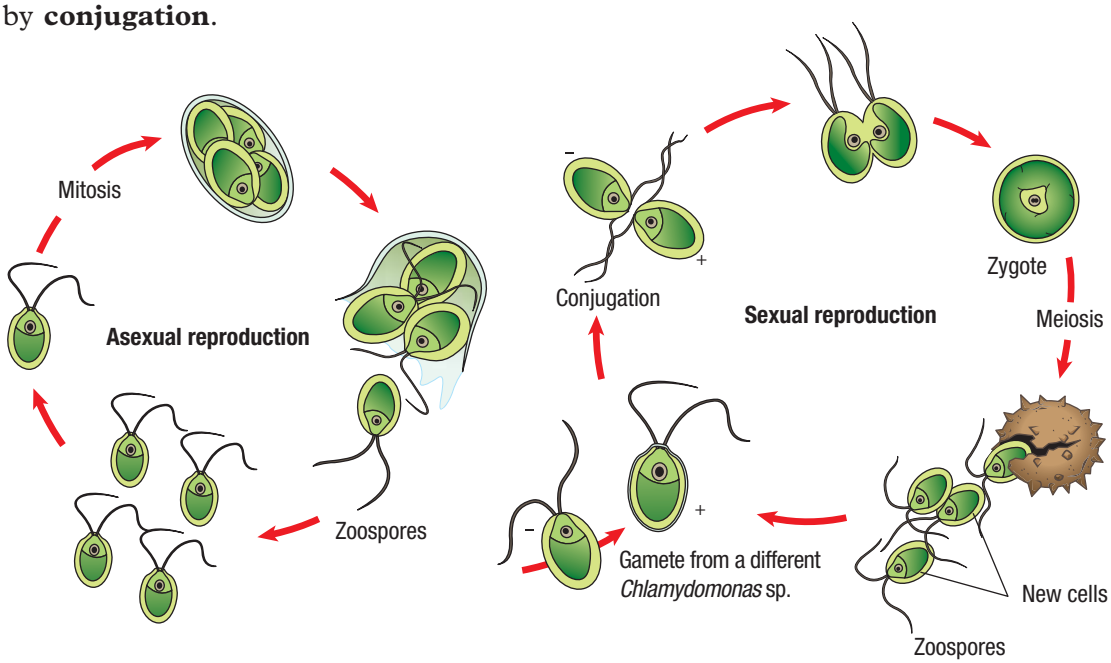


Figure 1.8 Asexual and sexual reproduction in *Chlamydomonas* sp.

Size

Most **protozoa** are **unicellular microorganisms** measuring **5 µm – 250 µm** and can be seen under the low powers of a light microscope. Protozoa normally exist in colonies.

Shape

Protozoa have various shapes. Observe the structures in *Paramecium* sp. and *Amoeba* sp. (Figures 1.9 and 1.10).

***Paramecium* sp.** is **slipper-shaped** and has structures such as micronucleus, macronucleus, cytoplasm, food vacuoles, contractile vacuoles, cell membrane and tiny hairs known as **cilia**.

***Amoeba* sp.** does not have a fixed shape. It **keeps changing its shape** while moving. It has structures like nucleus, cytoplasm, food vacuoles, contractile vacuoles and cell membrane.

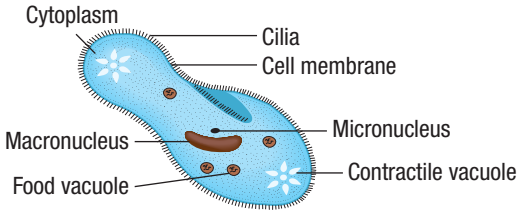


Figure 1.9 Basic structure of *Paramecium* sp.

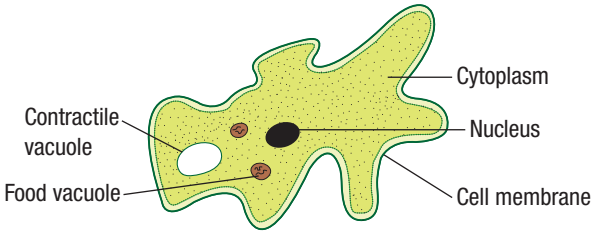


Figure 1.10 Basic structure of *Amoeba* sp.

Nutrition

Protozoa practise different types of nutrition. *Euglena* sp. carries out photosynthesis. *Plasmodium* sp. is a parasitic protozoa. *Amoeba* sp. obtains nutrients through phagocytosis. *Amoeba* sp. uses projections of its cytoplasm known as **pseudopodia** or 'false feet' to move and engulf food during phagocytosis (Figure 1.11).

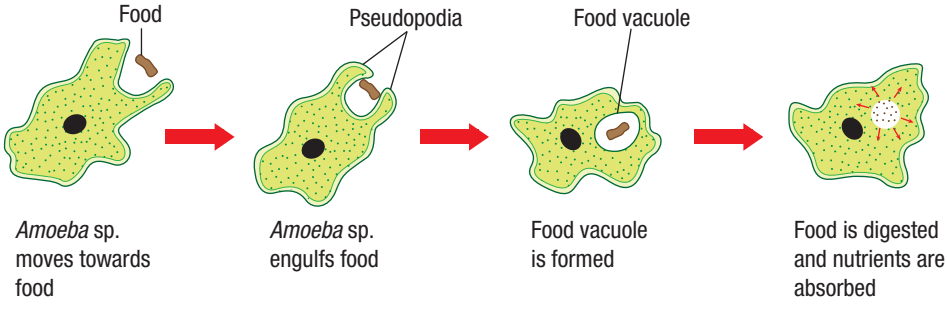


Figure 1.11 Phagocytosis in *Amoeba* sp.

Characteristics of protozoa

Methods of reproduction

Binary fission starts with the division of the nucleus followed by the division of the cytoplasm (Figure 1.12). *Paramecium* sp. and *Amoeba* sp. reproduce **asexually** by **binary fission**. The parent cell divides into two to form two daughter cells which have similar genetic materials as the parent.

Paramecium sp. also reproduces **sexually** by **conjugation**. Two *Paramecium* sp. unite and the exchange of genetic materials occurs (Figure 1.13).

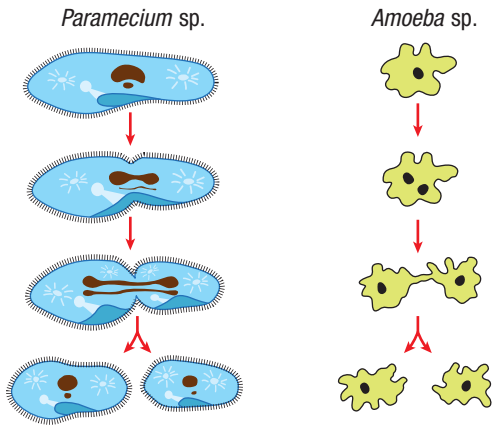


Figure 1.12 Binary fission of *Paramecium* sp. and *Amoeba* sp.

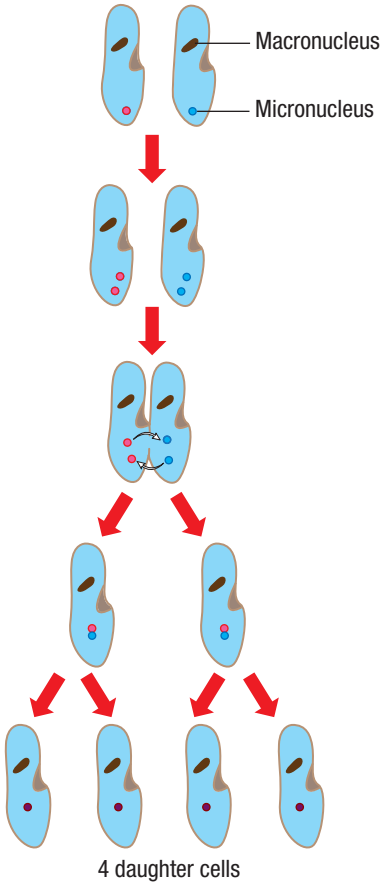


Figure 1.13 Sexual reproduction of *Paramecium* sp. by conjugation

Habitat

The habitat of *Paramecium* sp. is fresh water. The habitat of *Amoeba* sp. includes moist soil, fresh water, seawater and its host.

Bacteria

Size

Bacteria are **unicellular** microorganisms measuring **0.2 µm – 10 µm**. Bacteria can be seen under the high powers of a light microscope.

Shape

The naming and classification of bacteria are based on the basic shape of the bacteria, which are **spherical (coccus)**, **spiral (spirillum)**, **rod (bacillus)** and **comma (vibrio)** (Photograph 1.4).

BRAIN TEASER

What is the shape of the bacterium known as diplococcus?

Streptococcus sp. (coccus)

Treponema pallidum (spirillum)

Bacillus anthracis (bacillus)

Vibrio cholerae (vibrio)

Photograph 1.4 Classification of bacteria

Basic structures

Observe the basic structure of a bacterium in Figure 1.14. Most bacteria have a firm **cell wall** that gives **shape** and support to the bacteria. The cell wall of a bacterium is not made of cellulose but is made of **amino acids** and **polysaccharides**. Some bacteria have **capsules** which protect the cell wall. Some have fine hair structures known as **pili** which enable the bacteria to attach to certain surfaces. Others have a structure shaped like a tail known as **flagellum** to help in their movement.

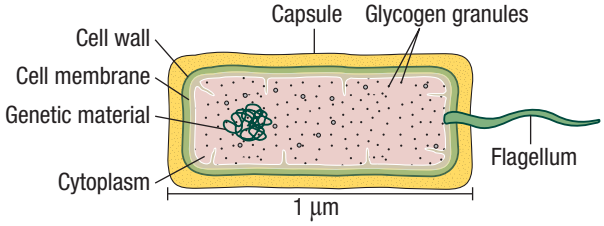


Figure 1.14 Basic structure of bacterium

Nutrition

Bacteria obtain food in various ways. Bacteria which have **chlorophyll** produce their own food. Some bacteria are **parasitic** in which they obtain nutrients from their hosts. There are also **saprophytic** bacteria which obtain nutrients from dead organisms.

Characteristics of bacteria

Habitat

Bacteria can be found in air, water, soil and all decaying organisms and materials.

Methods of reproduction

Bacteria **reproduce asexually**, that is by **binary fission** and also **sexually** by **conjugation** (Figure 1.15).

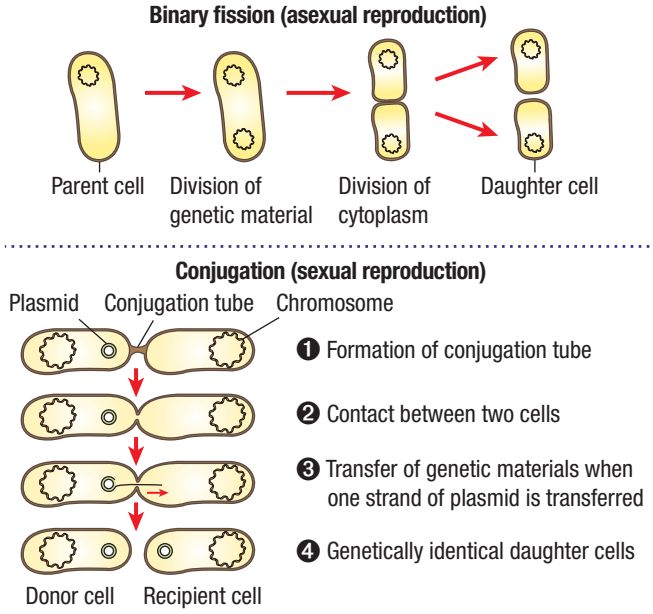


Figure 1.15 Asexual and sexual reproduction of bacteria

Science Info

Plasmid resembles a small circular chromosome that can replicate independently and is responsible for transferring genetic materials during conjugation in bacteria.

Special characteristics

Bacteria such as *Bacillus anthracis* form endospores (Figure 1.16) to withstand extreme surroundings such as very hot or cold places, drought and food shortage.

Endospores are spores formed in bacterial cells and have a strong protective coat. This protective coat will rupture when the surroundings of the endospores become favourable for growth. This allows germination to form new bacteria.

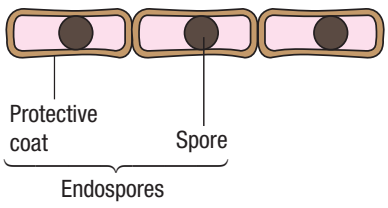


Figure 1.16 Endospores of *Bacillus anthracis*

Viruses

Photograph 1.5 Electron microscope

Size

Viruses are the **smallest microorganisms** with a size of less than **0.5 µm**. Viruses can only be seen under an **electron microscope** (Photograph 1.5).

Shape

Different viruses have **different shapes** such as spherical, helix, polyhedral and complex (combination of helix and polyhedral) (Figure 1.17).

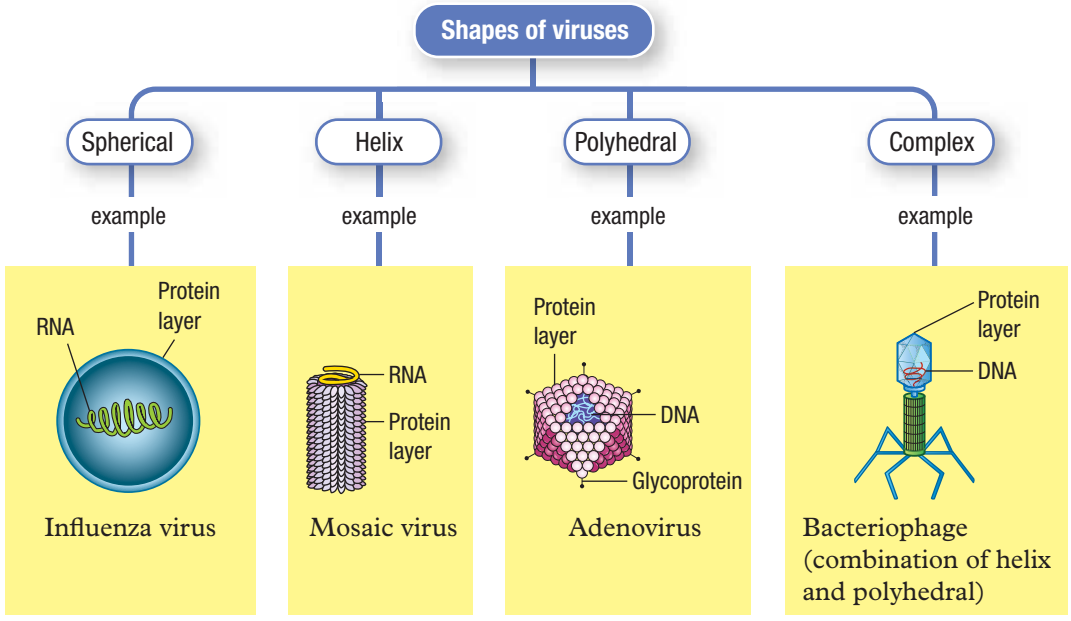


Figure 1.17 Shapes of viruses

Basic structures

Viruses are made up of **nucleic acid threads** (**deoxyribonucleic acid (DNA)** or **ribonucleic acid (RNA)**) which are protected by a **protein layer**. This protein layer known as **capsid** determines the **shape** of the **virus** (Figure 1.17).

Characteristics of viruses

Special characteristics

Unlike other organisms, viruses do not have living characteristics outside their host because they do not respire, excrete, grow and respond towards stimulus. Viruses only **reproduce** by infecting the **cells of their hosts** such as bacteria, animals and plants. Figure 1.18 shows the reproduction sequence of a bacteriophage by infecting its host cell, which is a bacterium.

Scan AR Page

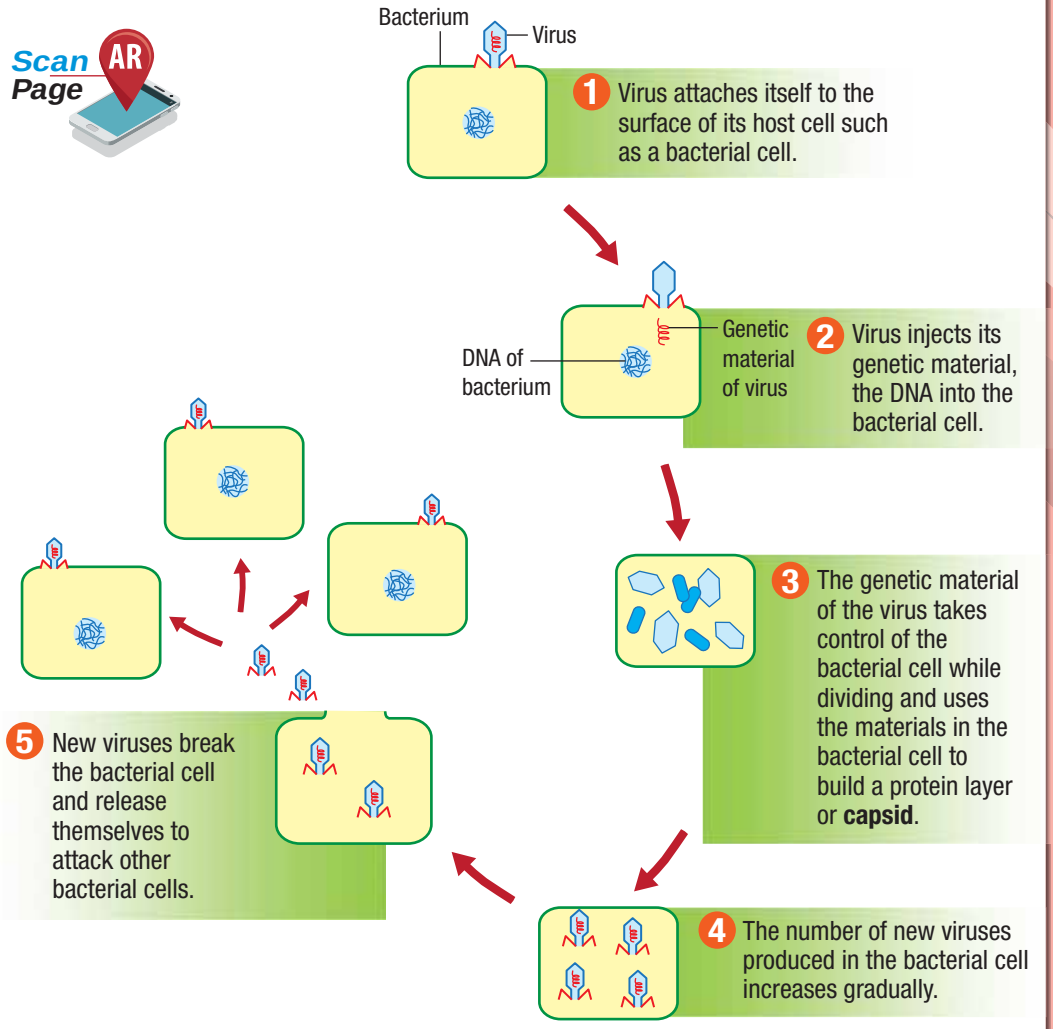


Figure 1.18 Reproduction sequence of bacteriophage in a bacterial cell

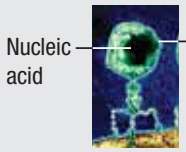
Activity 1.1

21st Century Skills
- ICS
- Inquiry-based activity

To classify microorganisms into fungi, algae, protozoa, bacteria and viruses based on size, shape, methods of reproduction, nutrition and habitat

Instructions

1. Carry out this activity in groups.
2. Prepare 10 quiz cards which contain one characteristic of microorganism based on size, shape, habitat, methods of reproduction or nutrition.
   Examples of quiz cards:

Characteristic of microorganism: Lives in bright areas Name the type of microorganism. Answer: Alga	Characteristic of microorganism: Only reproduces in the host cell Name the type of microorganism. Answer: Virus	Characteristic of microorganism:  Name the type of microorganism. Answer: Virus

3. Carry out the quiz in class.

The Presence of Microorganisms

How many times do you wash your hands each day? What is the importance of washing your hands with soap or handwash? Study and discuss Photograph 1.6. Why should awareness of hand hygiene be emphasised in all daily activities especially when handling food?

BRAIN TEASER

During a cholera epidemic, water that is used to wash hands is normally boiled water. Why?

Photograph 1.6 Awareness of hand hygiene in all daily activities

Experiment 1.1

Aim:
To compare the growth of bacteria on sterile nutrient agar that has been streaked with:
(a) unwashed fingers
(b) fingers that have been washed with water only
(c) fingers that have been washed with soap and water

Problem statement:
How does the cleanliness level of the fingers which streak the surface of the sterile nutrient agar affect the rate of bacterial growth on the surface of the sterile nutrient agar?

Hypothesis:
When the cleanliness level of the fingers which streak the surface of the sterile nutrient agar increases, the bacterial growth on the surface of the sterile nutrient agar will decrease.

Variables:
(a) manipulated : Cleanliness of the fingers which streak the sterile nutrient agar
(b) responding : Number of bacterial colonies on the sterile nutrient agar
(c) constant : Surrounding temperature

Materials:
Sterile nutrient agar, cellophane tape and marker pen

Apparatus:
Four sterile Petri dishes with lids labelled A, B, C and D, and sterile measuring cylinder (10 cm^3)

Safety Precautions

1. Wash your hands with soap and water after the experiment.
2. Sterilise all waste before disposal.
3. Immerse all used apparatus in disinfectant after the experiment.

Procedure:

1. Prepare the apparatus set-up (Figure 1.19).

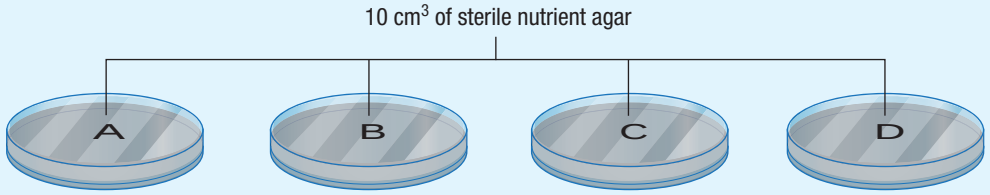


Figure 1.19

2. Carry out the following steps:
   (a) Streak the entire surface of the sterile nutrient agar in Petri dish A with unwashed fingers (Figure 1.20).
   (b) Wash your hands with water and repeat step 2(a) by replacing Petri dish A with Petri dish B.

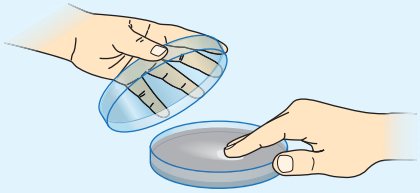


Figure 1.20

(c) Wash your hands with soap and water and repeat step 2(a) by replacing Petri dish A with Petri dish C.
(d) The sterile nutrient agar in Petri dish D is not streaked with fingers.

3. Cover Petri dishes A, B, C and D, and seal the lids with cellophane tape. Invert every Petri dish (Figure 1.21).

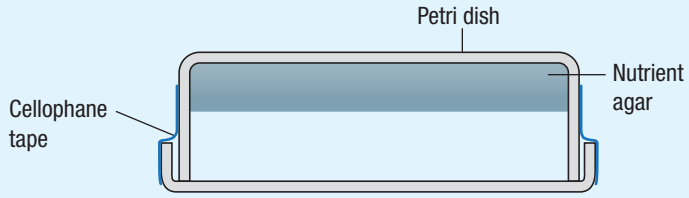


Figure 1.21 Inverted Petri dish

4. Keep the inverted Petri dishes A, B, C and D at room temperature for three days in a dark cupboard.
5. After three days, remove the Petri dishes A, B, C and D from the cupboard.
6. Observe the number of bacterial colonies in each Petri dish. Record your observations in a table. State in the table whether there are no colonies, a few colonies or many colonies in each Petri dish.

Observation:

Petri dish	Surface of nutrient agar	Number of bacterial colonies
A	Streaked with unwashed fingers	
B	Streaked with fingers that have been washed with water only	
C	Streaked with fingers that have been washed with soap and water	
D	Not streaked with any fingers	

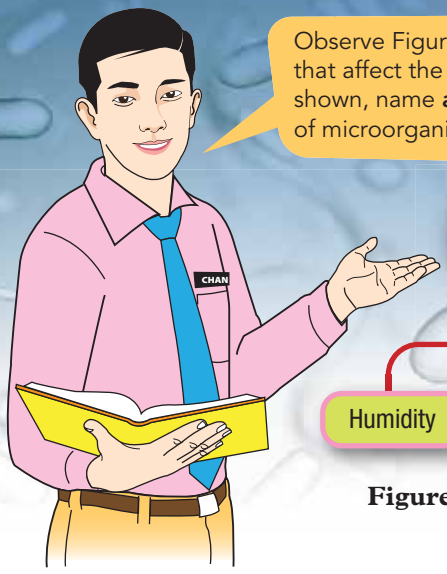
Conclusion:

Is the hypothesis accepted? What is the conclusion for this experiment?

Questions:

1. Why are the nutrient agar and Petri dishes sterilised?
2. Explain why the Petri dishes are kept in these conditions:
   (a) covered and the lids are sealed with cellophane tape
   (b) inverted
   (c) kept in a dark cupboard
3. (a) Which of the following Petri dishes, A, B or C, has the highest number of bacterial colonies? Give a reason.
   (b) Which of the following Petri dishes, A, B or C, has the lowest number of bacterial colonies? Give a reason.
4. What is the function of the sterile nutrient agar in Petri dish D?
5. Are there any colonies of bacteria growing on the nutrient agar in Petri dish D? Give a reason.

Factors that Affect the Growth of Microorganisms



Observe Figure 1.22. The figure shows several factors that affect the growth of microorganisms. Besides the factors shown, name **another** factor which affects the growth of microorganisms.

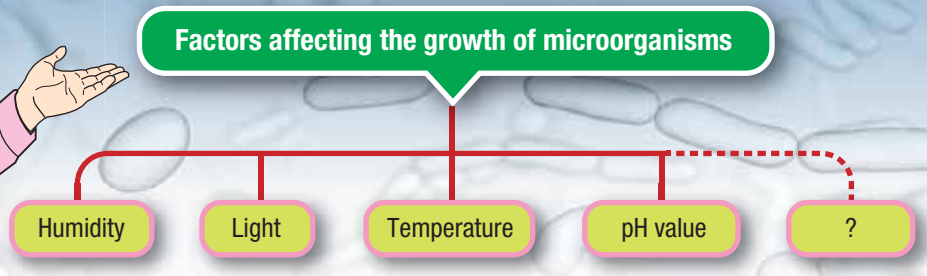


Figure 1.22 Factors that affect the growth of microorganisms

There are several factors that affect the growth of microorganisms. These factors are as follows:

Humidity

- Damp conditions promote the growth and reproduction of microorganisms
- Dry conditions cause microorganisms to become less active and retard their growth

Light

- Microorganisms which possess chlorophyll require light to carry out photosynthesis
- Microorganisms such as fungi and bacteria grow better in the dark
- Exposure to ultraviolet light can kill microorganisms

Temperature

- Temperatures of 35°C – 40°C are the optimum temperatures for the growth of microorganisms
- Low temperatures such as in a refrigerator retard the growth of microorganisms
- Temperatures which are too high can kill microorganisms

pH Value

- pH 7 (neutral pH) is the optimum pH value for the growth of most microorganisms
- There are certain microorganisms that can live in slightly acidic or alkaline environments

Nutrients

- The growth rate of microorganisms increases with the presence of sufficient nutrients
- The growth rate of microorganisms will be retarded even with the presence of nutrients when other factors such as humidity, light, temperature and pH value are limiting

Let us carry out Experiment 1.2 to investigate the factors that affect the growth of microorganisms.

Experiment 1.2

Cooperative learning – problem-solving activity in groups

The students in the class are divided into five groups. Each group is assigned to investigate one different factor that affects the growth of microorganisms (*Bacillus* sp.).

A Effect of nutrients on the growth of *Bacillus* sp.

Aim: To study the effect of nutrients on the growth of *Bacillus* sp.

Problem statement: What is the effect of nutrients on the growth of *Bacillus* sp.?

Hypothesis: *Bacillus* sp. needs nutrients for its growth.

Variables:
(a) manipulated : Presence of nutrients
(b) responding : Number of colonies of *Bacillus* sp.
(c) constant : Volume of *Bacillus* sp. culture solution and surrounding temperature

Materials: *Bacillus* sp. culture solution, sterile nutrient agar, sterile non-nutrient agar and cellophane tape

Apparatus: Two Petri dishes with lids labelled A and B, and wire loop

Procedure:

1. Prepare a Petri dish that contains 10 cm^3 of sterile nutrient agar and label it as A. Prepare another Petri dish that contains 10 cm^3 of sterile non-nutrient agar and label it as B.
2. Sterilise the wire loop by heating it over a Bunsen burner flame until it glows (Figure 1.23).

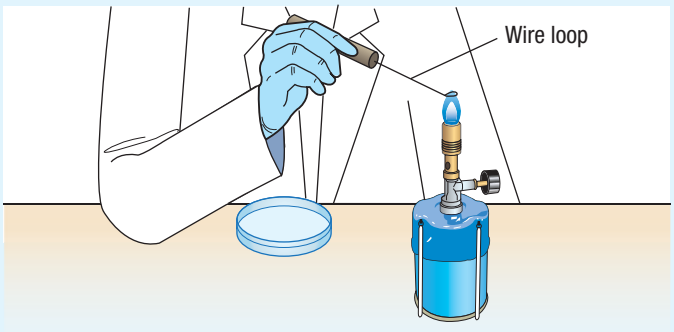


Figure 1.23

Safety Precautions

1. Wash your hands with soap and water before and after the experiment.
2. Wear gloves during the experiment.
3. Sterilise all waste before disposal.
4. Immerse all used apparatus in disinfectant after the experiment.

3. After sterilising the wire loop, remove it from the Bunsen burner flame and allow it to cool to room temperature.
4. Insert the end of the wire loop into the *Bacillus* sp. culture solution (Figure 1.24).

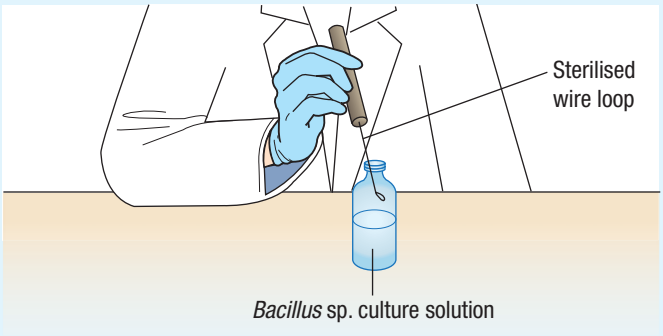


Figure 1.24

5. Use the end of the wire loop to smear the bacteria culture in a zigzag pattern onto the surface of the nutrient agar in Petri dish A (Figure 1.25).

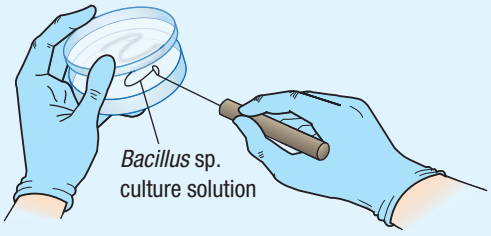


Figure 1.25

6. Repeat steps 2 to 5 for Petri dish B.
7. Cover Petri dishes A and B, and seal the lids with cellophane tape (Figure 1.26).

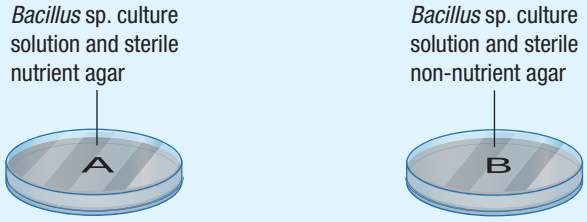


Figure 1.26

8. Invert both Petri dishes (Figure 1.27).

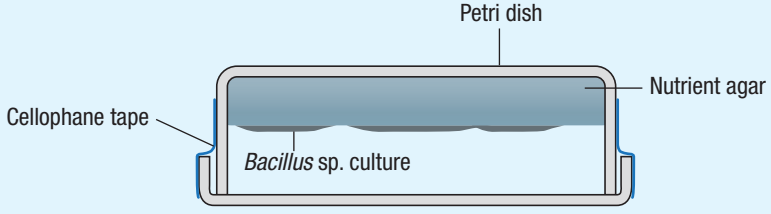


Figure 1.27 Inverted Petri dish

9. Keep the inverted Petri dishes at room temperature for three days in a dark cupboard.

10. After three days, remove the Petri dishes from the cupboard.
11. Observe the number of bacterial colonies in each Petri dish. Record your observations in a table. State in the table whether there are no colonies, a few colonies or many colonies in each Petri dish.

Observation:

Petri dish	Presence of nutrient in agar	Number of bacterial colonies
A	Yes	
B	No	

Conclusion:

Is the hypothesis accepted? What is the conclusion for this experiment?

Questions:

1. How is the number of bacterial colonies related to the growth of bacteria?
2. What is the function of the nutrient agar in this experiment?

B Effect of humidity on the growth of *Bacillus* sp.

Aim: To study the effect of humidity on the growth of *Bacillus* sp.

Problem statement: What is the effect of humidity on the growth of *Bacillus* sp.?

Hypothesis: Low humidity retards the growth of *Bacillus* sp..

Variables:
(a) manipulated : Moisture content of nutrient agar
(b) responding : Number of colonies of *Bacillus* sp.
(c) constant : Volume of *Bacillus* sp. culture solution and surrounding temperature

Materials: *Bacillus* sp. culture solution, moist sterile nutrient agar and cellophane tape

Apparatus: Two sterile Petri dishes with lids labelled C and D, wire loop and oven

Procedure:

1. Prepare two Petri dishes that contain 10 cm^3 of sterile nutrient agar and label them as C and D.
2. Heat Petri dish D in an oven until the nutrient agar becomes dry. Remove the Petri dish from the oven and let it cool to room temperature.
3. Repeat steps 2 to 5 (Experiment 1.2 A) by replacing Petri dishes A and B with Petri dishes C and D.
4. Cover Petri dishes C and D, and seal their lids with cellophane tape (Figure 1.28).

Safety Precautions

1. Wash your hands with soap and water before and after the experiment.
2. Wear gloves during the experiment.
3. Sterilise all waste before disposal.
4. Immerse all used apparatus in disinfectant after the experiment.

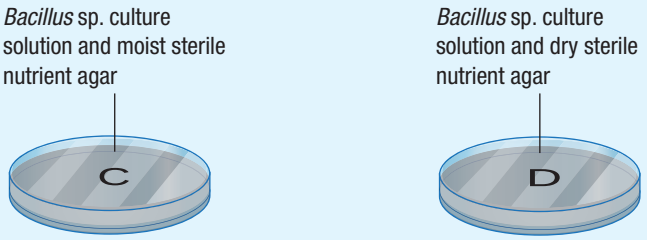


Figure 1.28

5. Invert Petri dishes C and D and keep them at room temperature for three days in a dark cupboard.
6. After three days, remove the Petri dishes from the cupboard.
7. Observe the number of bacterial colonies in each Petri dish. Record your observations in a table. State in the table whether there are no colonies, a few colonies or many colonies in each Petri dish.

Observation:

Petri dish	Moisture content of nutrient agar	Number of bacterial colonies
C	High	
D	Low	

Conclusion:

Is the hypothesis accepted? What is the conclusion for this experiment?

Question:

Why should the nutrient agar that is removed from the oven be cooled first before *Bacillus* sp. culture solution is smeared onto it?

C Effect of light on the growth of *Bacillus* sp.

Aim: To study the effect of light on the growth of *Bacillus* sp.

Problem statement: What is the effect of light on the growth of *Bacillus* sp.?

Hypothesis: Light retards the growth of *Bacillus* sp..

Variables:
(a) manipulated : Presence of light
(b) responding : Number of colonies of *Bacillus* sp.
(c) constant : Volume of *Bacillus* sp. culture solution and surrounding temperature

Materials: *Bacillus* sp. culture solution, sterile nutrient agar and cellophane tape

Apparatus: Two sterile Petri dishes with lids labelled E and F, and wire loop

Procedure:

1. Prepare two Petri dishes that contain 10 cm^3 of sterile nutrient agar and label them as E and F.
2. Repeat steps 2 to 5 (Experiment 1.2 A) by replacing Petri dishes A and B with Petri dishes E and F.
3. Cover Petri dishes E and F, and seal their lids with cellophane tape.
4. Keep Petri dish E (inverted) in a dark cupboard and Petri dish F (inverted) in a bright area such as near a window for three days (Figure 1.29).

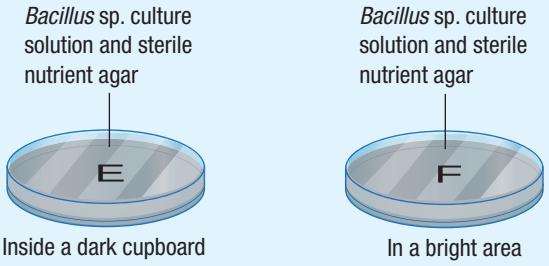


Figure 1.29

5. After three days, remove Petri dish E from the cupboard and Petri dish F from its place near the window.
6. Observe the number of bacterial colonies in each Petri dish. Record your observations in a table. State in the table whether there are no colonies, a few colonies or many colonies in each Petri dish.

Safety Precautions

1. Wash your hands with soap and water before and after the experiment.
2. Wear gloves during the experiment.
3. Sterilise all waste before disposal.
4. Immerse all used apparatus in disinfectant after the experiment.

Observation:

Petri dish	Presence of light	Number of bacterial colonies
E	Absent	
F	Present	

Conclusion:

Is the hypothesis accepted? What is the conclusion for this experiment?

Question:

Why is Petri dish F not placed under direct sunlight?

D Effect of temperature on the growth of *Bacillus* sp.

Aim: To study the effect of temperature on the growth of *Bacillus* sp.

Problem statement: What is the effect of temperature on the growth of *Bacillus* sp.?

Hypothesis: The growth of *Bacillus* sp. is the highest at room temperature.

Variables:
(a) manipulated : Temperature
(b) responding : Number of colonies of *Bacillus* sp.
(c) constant : Volume of *Bacillus* sp. culture solution

Materials:
Bacillus sp. culture solution, sterile nutrient agar and cellophane tape

Apparatus:
Three sterile Petri dishes with lids labelled G, H and I, wire loop, refrigerator, incubator and thermometer

Procedure:

1. Prepare three Petri dishes that contain 10 cm^3 of sterile nutrient agar and label them as G, H and I.
2. Repeat steps 2 to 5 (Experiment 1.2 A) by replacing Petri dishes A and B with Petri dishes G, H and I.
3. Cover Petri dishes G, H and I, and seal their lids with cellophane tape.
4. Keep Petri dish G (inverted) in a dark cupboard at room temperature, Petri dish H (inverted) in a refrigerator at 5°C and Petri dish I (inverted) in an incubator at 70°C for three days (Figure 1.30).

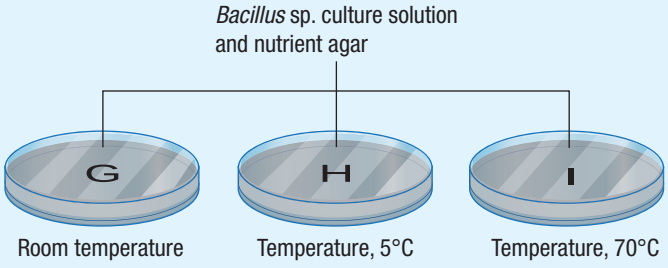


Figure 1.30

Safety Precautions

1. Wash your hands with soap and water before and after the experiment.
2. Wear gloves during the experiment.
3. Sterilise all waste before disposal.
4. Immerse all used apparatus in disinfectant after the experiment.

5. After three days, remove Petri dish G from the dark cupboard, Petri dish H from the refrigerator and Petri dish I from the incubator.
6. Observe the number of bacterial colonies in each Petri dish. Record your observations in a table. State in the table whether there are no colonies, a few colonies or many colonies in each Petri dish.

Observation:

Petri dish	Temperature (°C)	Number of bacterial colonies
G	Room temperature	
H	5	
I	70	

Conclusion:
Is the hypothesis accepted? What is the conclusion for this experiment?

Question:
Why is *Bacillus* sp. kept in an incubator at a high temperature?

E Effect of pH value on the growth of *Bacillus* sp.

Aim: To study the effect of pH value on the growth of *Bacillus* sp.

Problem statement: What is the effect of pH value on the growth of *Bacillus* sp.?

Hypothesis: The growth of *Bacillus* sp. is most rapid at pH 7.

Variables:
(a) manipulated : pH value
(b) responding : Number of colonies of *Bacillus* sp.
(c) constant : Volume of *Bacillus* sp. culture solution and surrounding temperature

Materials: *Bacillus* sp. culture solution, moist sterile nutrient agar, dilute hydrochloric acid, dilute sodium hydroxide solution, distilled water and cellophane tape

Apparatus: Three sterile Petri dishes with lids labelled J, K and L, three beakers, three wire loops and three syringes

Safety Precautions

1. Wash your hands with soap and water before and after the experiment.
2. Wear gloves during the experiment.
3. Sterilise all waste before disposal.
4. Immerse all used apparatus in disinfectant after the experiment.

Procedure:

1. Prepare the apparatus set-up (Figure 1.31).

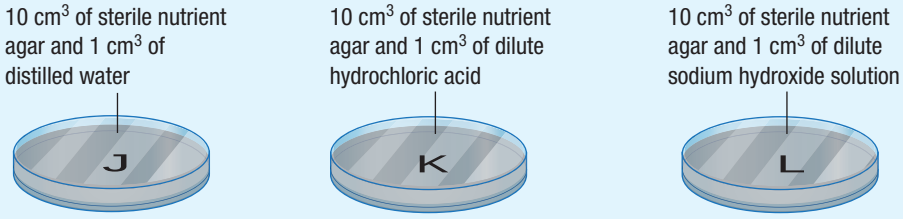


Figure 1.31

2. Repeat steps 2 to 5 (Experiment 1.2 A) by replacing Petri dishes A and B with Petri dishes J, K and L.
3. Cover Petri dishes J, K and L, and seal the lids with cellophane tape (Figure 1.32).

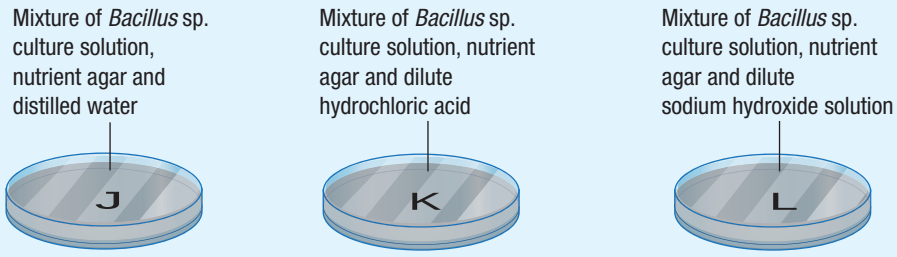


Figure 1.32

4. Invert Petri dishes J, K and L and keep them in a dark cupboard at room temperature for three days.
5. After three days, remove the Petri dishes from the cupboard.
6. Observe the number of bacterial colonies in each Petri dish. Record your observations in a table. State in the table whether there are no colonies, a few colonies or many colonies in each Petri dish.

Observation:

Petri dish	pH value	Number of bacterial colonies
J	7	
K	Less than 7	
L	More than 7	

Conclusion:

Is the hypothesis accepted? What is the conclusion for this experiment?

Question:

State **one** daily activity that applies the effect of pH value on bacteria. Explain your answer.

Formative Practice 1.1

1. What are microorganisms?

2. (a) Name **five** groups of microorganisms.
(b) What are the characteristics used to classify microorganisms into five groups?

3. Name the group of microorganisms that reproduces asexually through the formation of spores.

4. State **two** basic structures that make up a virus.

5. State **five** factors that affect the growth of microorganisms.

6. Figure 1 shows a type of microorganism.

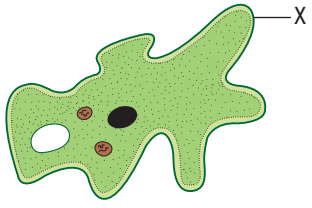


Figure 1

(a) What is the group of the microorganism shown above?
(b) (i) What is the structure labelled X?
(ii) State the function of this structure.

1.2 Useful Microorganisms

Applications of Useful Microorganisms in Daily Life

Figure 1.33 shows some applications of useful microorganisms in our daily life.

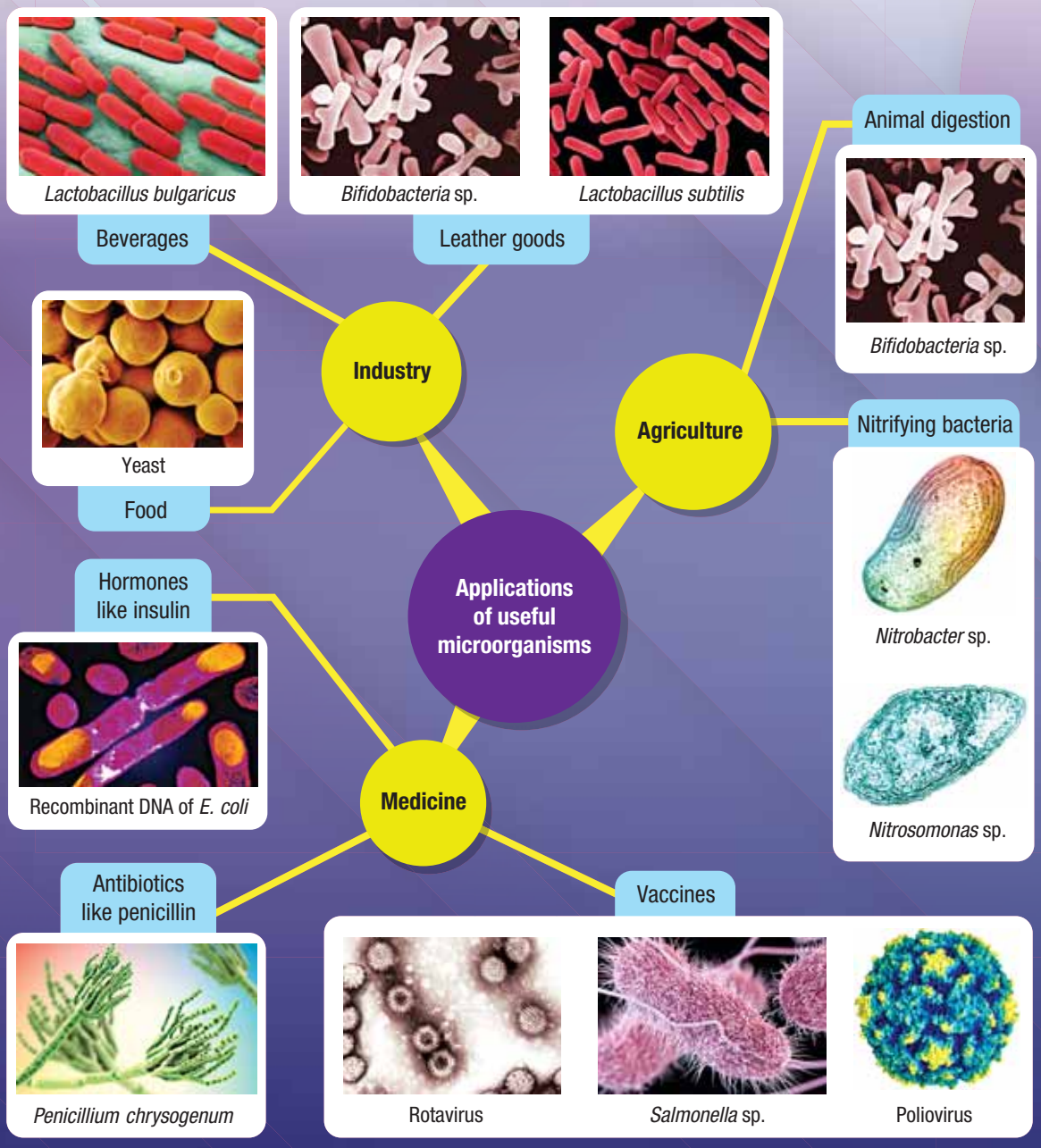


Figure 1.33 Applications of useful microorganisms in medicine, agriculture and industry

Activity 1.2

21st Century Skills
- ICS
- Discussion

To explain the role of microorganisms in medicine, agriculture and industry

Instructions

1. Carry out this activity in groups.
2. Gather information on the roles of microorganisms in the following fields (refer to Figure 1.33):
   (a) medicine
   (b) agriculture
   (c) industry
3. Discuss the information gathered.
4. Present the outcome of your group discussion to the class using a multimedia presentation.

Activity 1.3

21st Century Skills
- TPS, ISS, ICS
- Inquiry-based activity

To understand the process of food production or other industrial products that use microorganisms

Instructions

1. Carry out this activity in groups.
2. Visit any factory that manufactures food or other industrial products in your neighbourhood which uses microorganisms in their manufacturing process.
3. Gather information related to the process of producing food or other industrial products using microorganisms.
4. Identify the elements of entrepreneurship practised in the industry you visited.
5. Discuss the information gathered including the elements of entrepreneurship that can be inculcated and practised from your visit.
6. Present the outcome of your group discussion to the class using a multimedia presentation.

Click@Web

Yoghurt – an accidental discovery that has become a global commercial product
http://buku-teks.com/sc5029

Potential Use of Microorganisms in Biotechnology and Sustainability of the Environment

The advancements and developments in biotechnology especially green biotechnology have generated and made possible the potential idea of using microorganisms to treat sewage and to produce **eco enzymes** from agricultural waste fermentation.

1.2.1 1.2.2

Eco Enzyme Cleaning Solution

Eco enzyme is a natural product obtained from the **fermentation** of agricultural waste such as fruit or vegetable waste.

Photograph 1.7 shows an eco enzyme cleaning solution and a chemical cleaning substance.

My Malaysia

The use of eco enzyme as a cleaning solution for oily substances is a Green Technology application in the Waste and Wastewater Management Sector.

(a) Eco enzyme cleaning solution (b) Chemical cleaning substance

Photograph 1.7 Eco enzyme cleaning solution and chemical cleaning substance

The differences between eco enzyme cleaning solutions and chemical cleaning substances are shown in Table 1.1.

Table 1.1 Differences between eco enzyme cleaning solution and chemical cleaning substance

Aspects	Type of cleaner	
	Eco enzyme cleaning solution	Chemical cleaning substance
Production process	Fermentation of agricultural waste	Use of chemical substances
Action on fat and grease	Enzymes in the eco enzyme decompose fat and grease into smaller molecules	Surfactants in chemical cleaning substances emulsify fat and grease into foam
Ease of use	Need not scrub as fat and grease are easily removed	Need to scrub hard
Clog drainage	The small molecules produced by enzymes do not clog drainage	Foam produced by surfactants clogs drainage
Cost	Low	High
Waste production	Less	More
Environment	Environmentally friendly	Pollutes the environment

Click@Web

Making an eco enzyme cleaning solution
http://buku-teks.com/sc5030

Lactobacillus sp. Bacterial Serum

***Lactobacillus* sp. bacterial serum** is used to treat wastewater and sludge in drainage systems. Why should we use *Lactobacillus* sp. bacterial serum instead of chemical substances to remove pollutants in drainage systems?

Some uses of *Lactobacillus* sp. bacterial serum are shown in Figure 1.34.

Click@Web

Lactobacillus sp. bacterial serum
http://buku-teks.com/sc5031

Photograph 1.8
Lactobacillus sp. bacterial serum

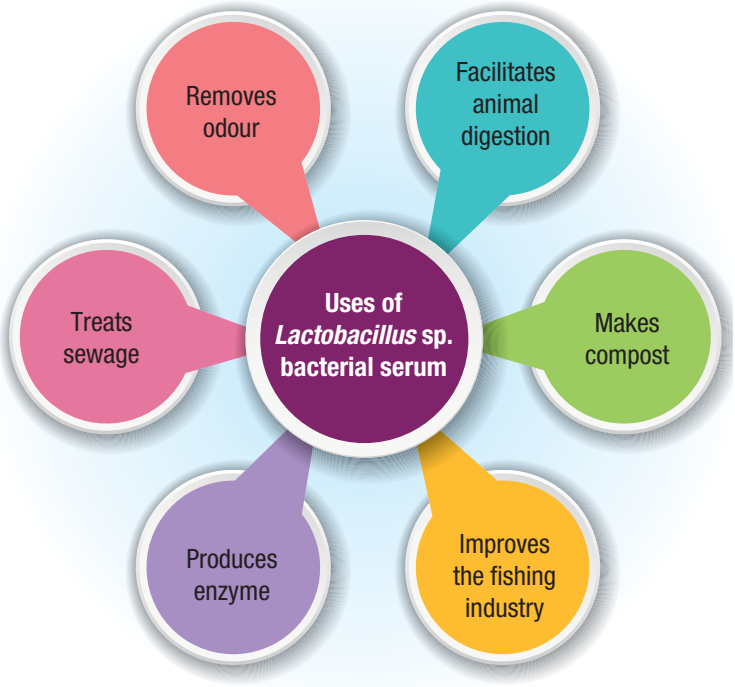


Figure 1.34 Uses of *Lactobacillus* sp. bacterial serum

Activity 1.4

21st Century Skills
- TPS
- Active reading
- Discussion

To do active reading on the potential uses of microorganisms

Instructions

1. Carry out this activity in groups.
2. Do active reading on the potential uses of microorganisms as follows:
   (a) producing enzymes from agricultural waste products such as fruit and vegetable waste using microorganisms (refer to Info 1 on page 32)
   (b) treating sewage using microorganisms (refer to Info 2 on page 32)
3. Discuss the information gathered.
4. Present the outcome of your group discussion to the class using a multimedia presentation.

Active reading strategy
http://buku-teks.com/sc5032a

Info 1
Modul Teknologi Hijau Biologi, CETREE USM
Title: *Enzim Teknologi Hijau*
pages 56 – 65
http://buku-teks.com/sc5032b

Info 2
Modul Teknologi Hijau Biologi, CETREE USM
Title: *Memahami impak mikroorganisma terhadap sisa untuk kehidupan lestari*
pages 40 – 55
http://buku-teks.com/sc5032d

Fruit and vegetable wastes: bioactive compound, extraction and uses
http://buku-teks.com/sc5032e

Note: *Modul Teknologi Hijau*, prepared by CETREE USM, is only available in *bahasa Melayu*.

Formative Practice 1.2

1. Name **two** examples of useful microorganisms in each of the following fields:
   (a) medicine
   (b) agriculture
   (c) industry

2. State **two** examples of foods that use microorganisms and name the microorganisms.

3. (a) What is eco enzyme?
   (b) Give **two** uses of eco enzyme.

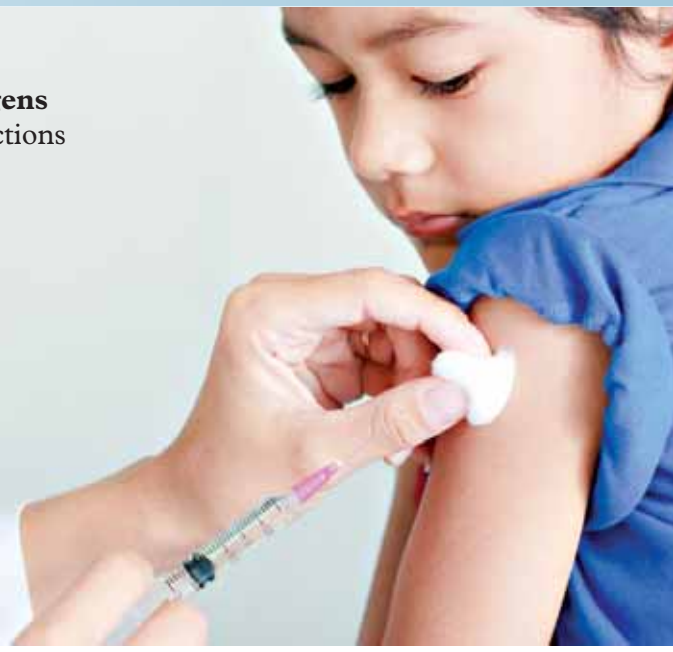
4. (a) Figure 1 shows a type of bacterium. Name this type of bacterium.
   (b) Give **three** uses of the serum derived from the bacterium mentioned in question 4(a).

Figure 1

1.3 Prevention and Treatment of Diseases Caused by Microorganisms

Besides useful microorganisms, there are also harmful microorganisms known as **pathogens** which can cause diseases. Can we prevent infections caused by these pathogens?

Observe the activity in Photograph 1.9. What is the use of antiseptic in the activity shown in the photograph? Name the technique applied in this activity.



Photograph 1.9 The use of antiseptics such as alcohol swabs on a body part before an injection is given

Aseptic Technique

Aseptic technique refers to the healthcare procedure carried out to prevent infections caused by pathogens or to remove existing pathogens. As such, the aseptic technique is in line with the phrase '**prevention is better than cure**'. This means preventing someone from being infected with pathogens is better than treating someone who has been infected by the pathogens. Based on Figure 1.35, which aseptic techniques have you used before? What was your purpose for using them?

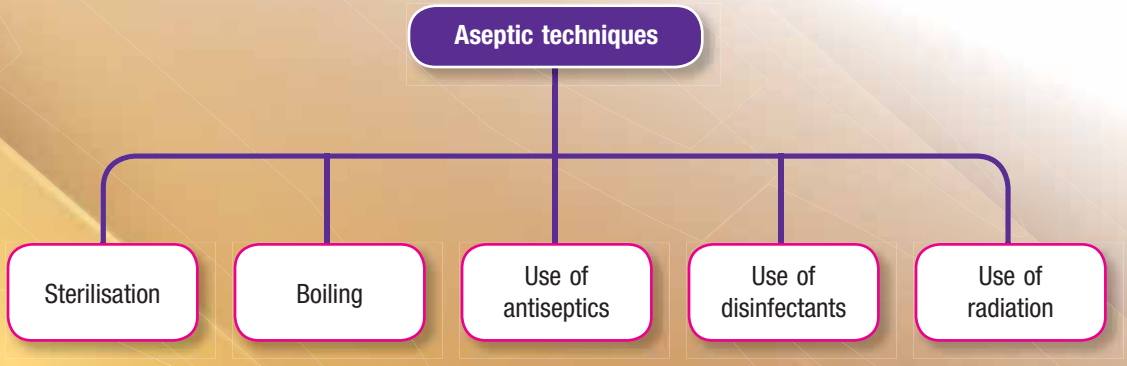


Figure 1.35 Aseptic techniques

1.3.1 1.3.2

Sterilisation

Sterilisation is the process of killing or eliminating microorganisms from an object or a particular surrounding. Methods of sterilisation are shown in Figure 1.36.

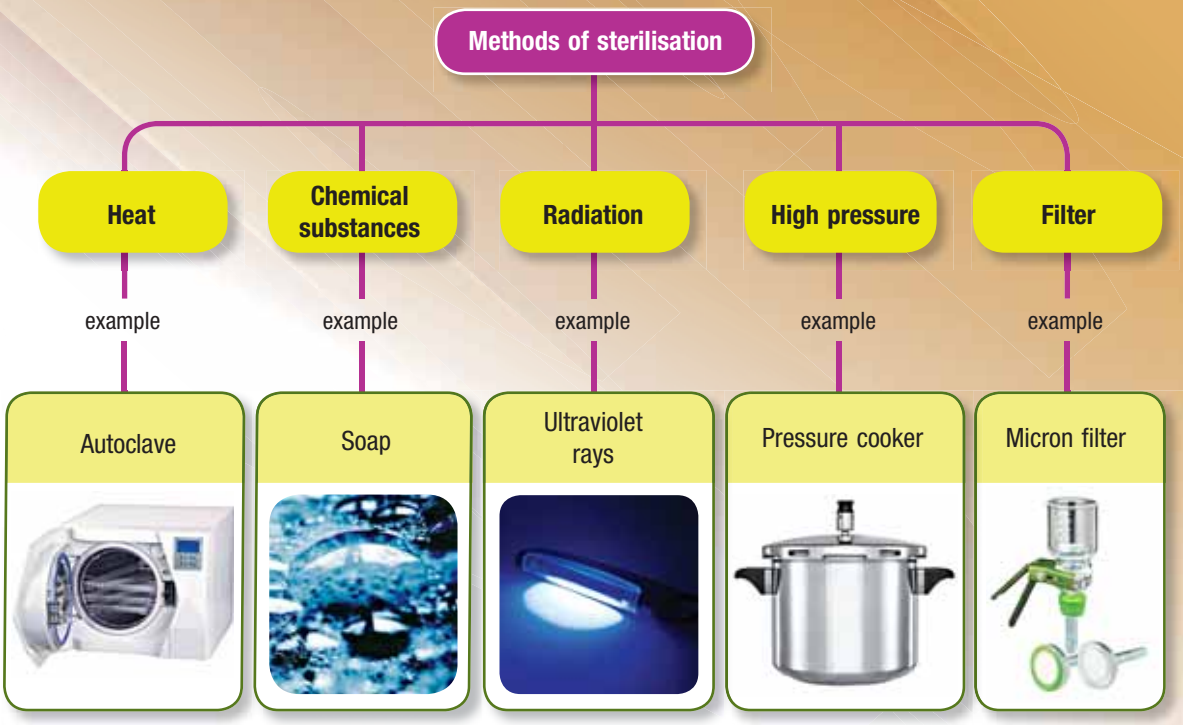


Figure 1.36 Methods of sterilisation

The method of sterilisation depends on the type of microorganism to be killed or eliminated. For instance, a temperature above 130°C in an autoclave can kill microorganisms and their spores. Micron filter, on the other hand, is used to filter fine particles and microorganisms (0.1 μm – 10 μm) from water or liquids.

Photograph 1.10 Boiling milk bottles

Boiling

Boiling water at a temperature of 100°C is normally used to kill microorganisms on everyday objects such as milk bottles (Photograph 1.10), injection needles and dental equipment.

Antiseptic

Antiseptic is a chemical substance that can be applied on human skin or wounds to prevent pathogenic infections. Examples of antiseptics are acriflavine (yellow medicine), povidone and 70% isopropyl alcohol (IPA) (Photograph 1.11).

(a) Acriflavine (yellow medicine)

(b) Povidone

(c) 70% isopropyl alcohol

Photograph 1.11 Types of antiseptics

Some antiseptics such as acriflavine and povidone can kill microorganisms while other antiseptics such as proflavine blocks or prevents the growth of microorganisms. 70% isopropyl alcohol can be used as an antiseptic and sterilising agent.

Disinfectant

Disinfectant is a chemical substance used on non-living things such as bed sheets, toilets and swimming pools to kill microorganisms especially pathogens. Disinfectants are not suitable to be used on skin or wounds. Examples of disinfectants commonly used in daily life include bleach, hydrogen peroxide and liquid chlorine (Photograph 1.12).

Give one example of an object or a place where disinfectants are used.

(a) Bleach (b) Hydrogen peroxide (c) Liquid chlorine

Photograph 1.12 Various types of disinfectants

Photograph 1.13 Ultraviolet rays from ultraviolet lamps used as an aseptic technique

Radiation

Ionising **radiation** such as ultraviolet ray, X-ray and gamma ray can be used to kill microorganisms. These rays penetrate into the microorganisms' cells and destroy them. For example, ultraviolet rays are used to kill microorganisms in operating theatres (Photograph 1.13).

Antibiotic

Have you ever been given antibiotics by doctors to treat infectious diseases?

Study the meaning of antibiotics and antibiotic resistance from the poster (Figure 1.37).

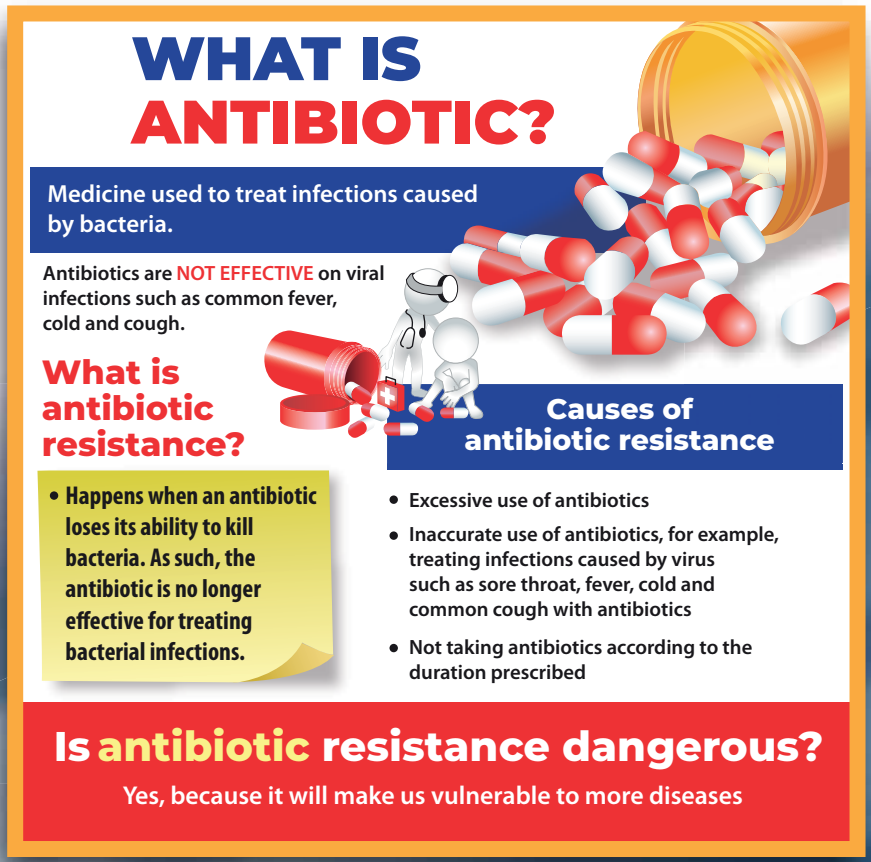


Figure 1.37 Poster on 'What is Antibiotic?'

Activity 1.5

To gather information on antibiotics

21st Century Skills
- ICS, TPS, ISS
- Discussion

Instructions

1. Use the link given to read the articles provided to gather information on antibiotics.
2. Use the information gathered to answer the following questions:
   (a) What is antibiotic?
   (b) What will happen to a patient who does not take the prescribed antibiotics according to time or does not complete the antibiotic course?
   (c) What is antibiotic resistance?

Click@Web

Read the following article about antibiotics
http://buku-teks.com/sc5037
(Medium: *bahasa Melayu*)

Carry out Experiment 1.3 to study the effect of concentration of antibiotic (penicillin) on the growth of bacteria (*Bacillus* sp.).

Experiment 1.3

Aim: To study the effect of concentration of antibiotic (penicillin) on the growth of bacteria (*Bacillus* sp.)

Problem statement: What is the effect of concentration of antibiotic on the growth of bacteria?

Hypothesis: The higher the concentration of antibiotic, the lower the growth of bacteria.

Variables:
(a) manipulated : Concentration of antibiotic
(b) responding : Area of clear region
(c) constant : Type of bacteria (*Bacillus* sp.)

Materials: *Bacillus* sp. culture solution, sterile nutrient agar, four filter paper discs of 6 mm in diameter, penicillin solutions of different concentrations such as 10%, 20% and 30% (or filter paper discs of 6 mm diameter and three penicillin discs of different concentrations such as 10, 20 and 30 units of penicillin), distilled water, marker pen and cellophane tape

1.3.2 1.3.3

Apparatus: Petri dish with lid, syringe, sterile forceps and transparent grid sheet

Procedure:

1. Prepare the apparatus set-up (Figure 1.38).

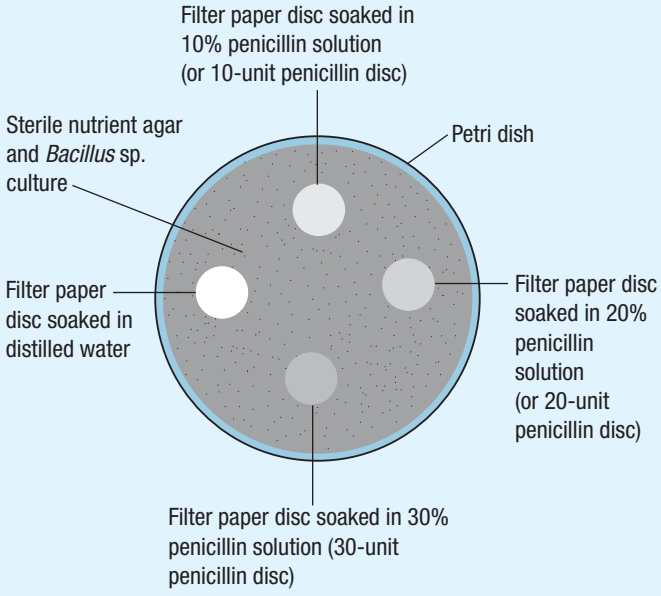


Figure 1.38

Safety Precautions

1. Wash your hands with soap and water before and after the experiment.
2. Wear gloves during the experiment.
3. Sterilise all waste before disposal.
4. Immerse all used apparatus in disinfectant after the experiment.

   (a) Pour 1 cm^3 of *Bacillus* sp. culture solution on top of sterile nutrient agar in a Petri dish.
   (b) Use sterile forceps to place the filter paper discs soaked in distilled water and penicillin solution of concentrations 10%, 20% and 30% on top of the nutrient agar and *Bacillus* sp. culture in the Petri dish (Figure 1.38).
2. Cover the Petri dish and seal its lid with cellophane tape (Figure 1.39).

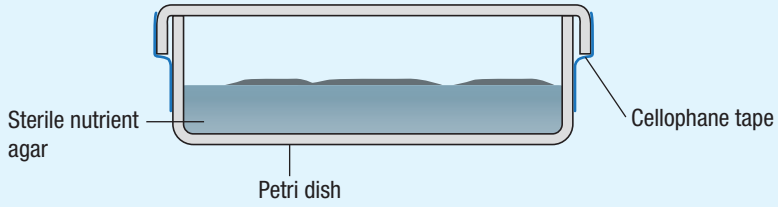


Figure 1.39

3. Keep the Petri dish in a dark cupboard at room temperature for three days.
4. After three days, remove the Petri dish from the cupboard.
5. Observe the clear region around every filter paper disc in the Petri dish. Sketch your observation (refer to Figure 1.40).
6. Measure the area of the clear regions by using a transparent grid sheet.

Observation:

Concentration of antibiotic (% or unit)	Area of clear region (cm^2)
0	
10	
20	
30	

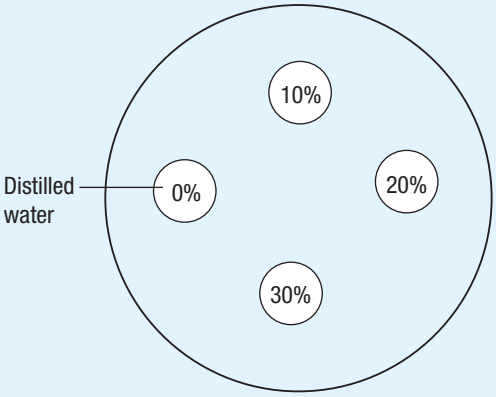


Figure 1.40

Conclusion:

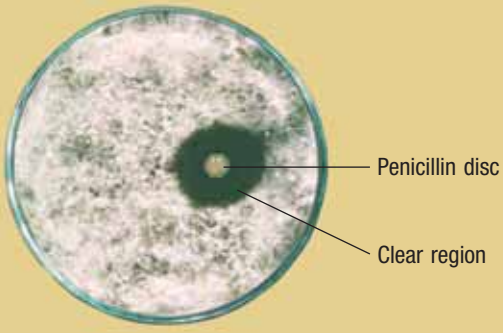
Is the hypothesis accepted? What is the conclusion for this experiment?

Questions:

1. What is the purpose of using a filter paper disc soaked in distilled water in this experiment?
2. How does the clear region on the surface of the nutrient agar show the action of penicillin on bacterial growth?
3. Explain your observations. Give reasons.

Today in history

Sir Alexander Fleming studied the action of the *Penicillium* sp. fungus on the bacterial growth on sterile nutrient agar, similar to Experiment 1.3 which you carried out. Sir Alexander Fleming was the first person to discover antibiotics.



Clear region surrounding the penicillin disc

Alexander Fleming studied the action of the *Penicillium* sp. fungus on bacterial growth

Methods of Treating Infectious Diseases

Recall the infectious diseases you studied in Form 2. Observe examples of infectious diseases and the pathogens that cause them in Figure 1.41.

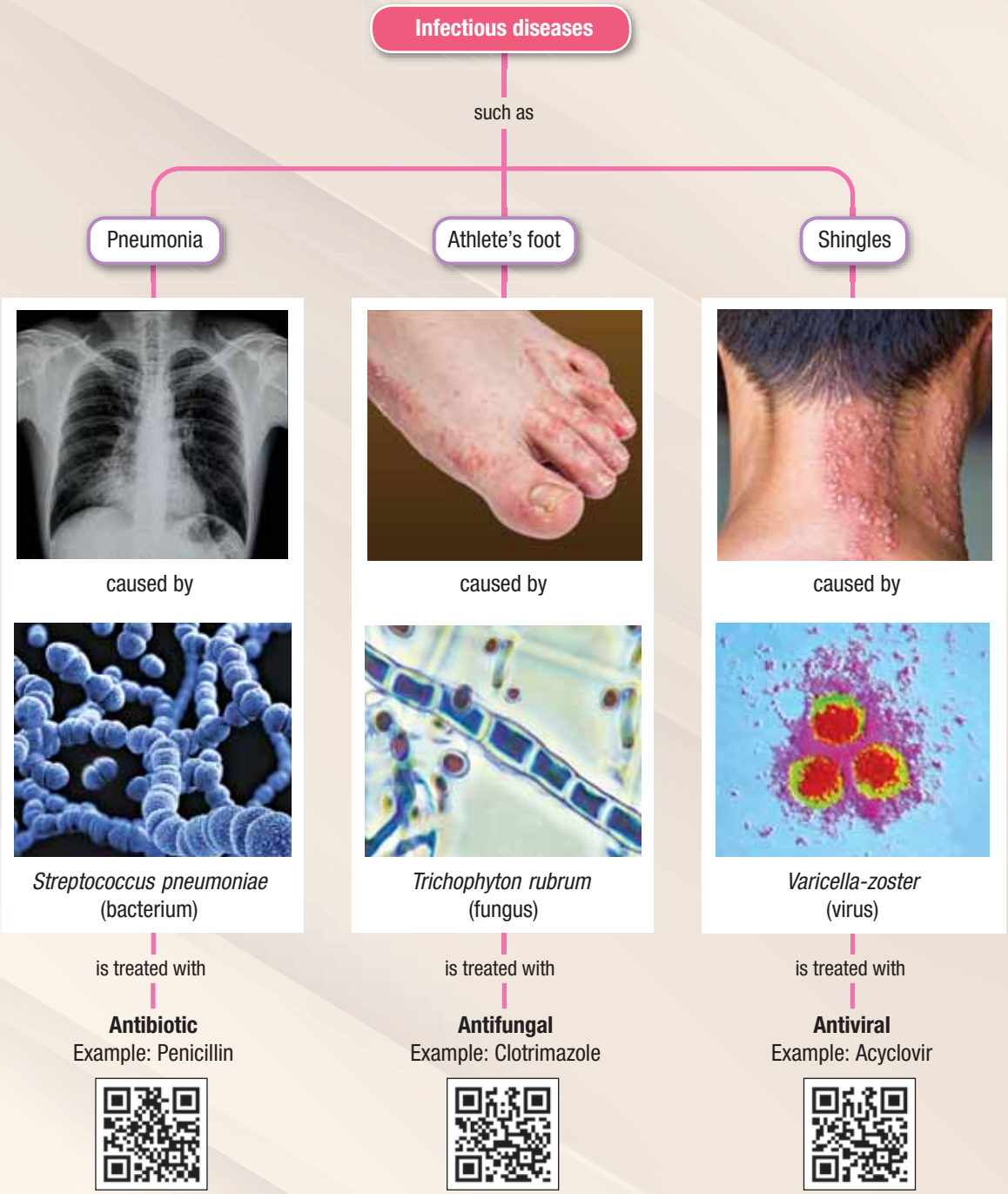


Figure 1.41 The use of antibiotic, antifungal and antiviral in the treatment of infectious diseases

BRAIN TEASER

What are superbugs? How can superbugs be prevented?

Activity 1.6

21st Century Skills
- ICS
- Discussion

To compare and contrast the use of antibiotic, antifungal and antiviral in the treatment of infectious diseases

Instructions

1. Carry out this activity in groups.
2. Search for information. Then, compare and contrast the use of antibiotic, antifungal and antiviral in the treatment of infectious diseases as follows:
   (a) using antibiotic to treat lung infections and other diseases
   (b) using antifungal to treat athlete's foot and other diseases
   (c) using antiviral to treat shingles and other diseases
3. Present the outcome of your group discussion to the class in the form of a multimedia presentation.

BRAIN TEASER

How do vaccine and antiviral act on virus?

Formative Practice 1.3

1. State **five** examples of aseptic techniques used to control the spread of pathogens.

2. How is the aseptic technique related to the phrase 'prevention is better than cure'?

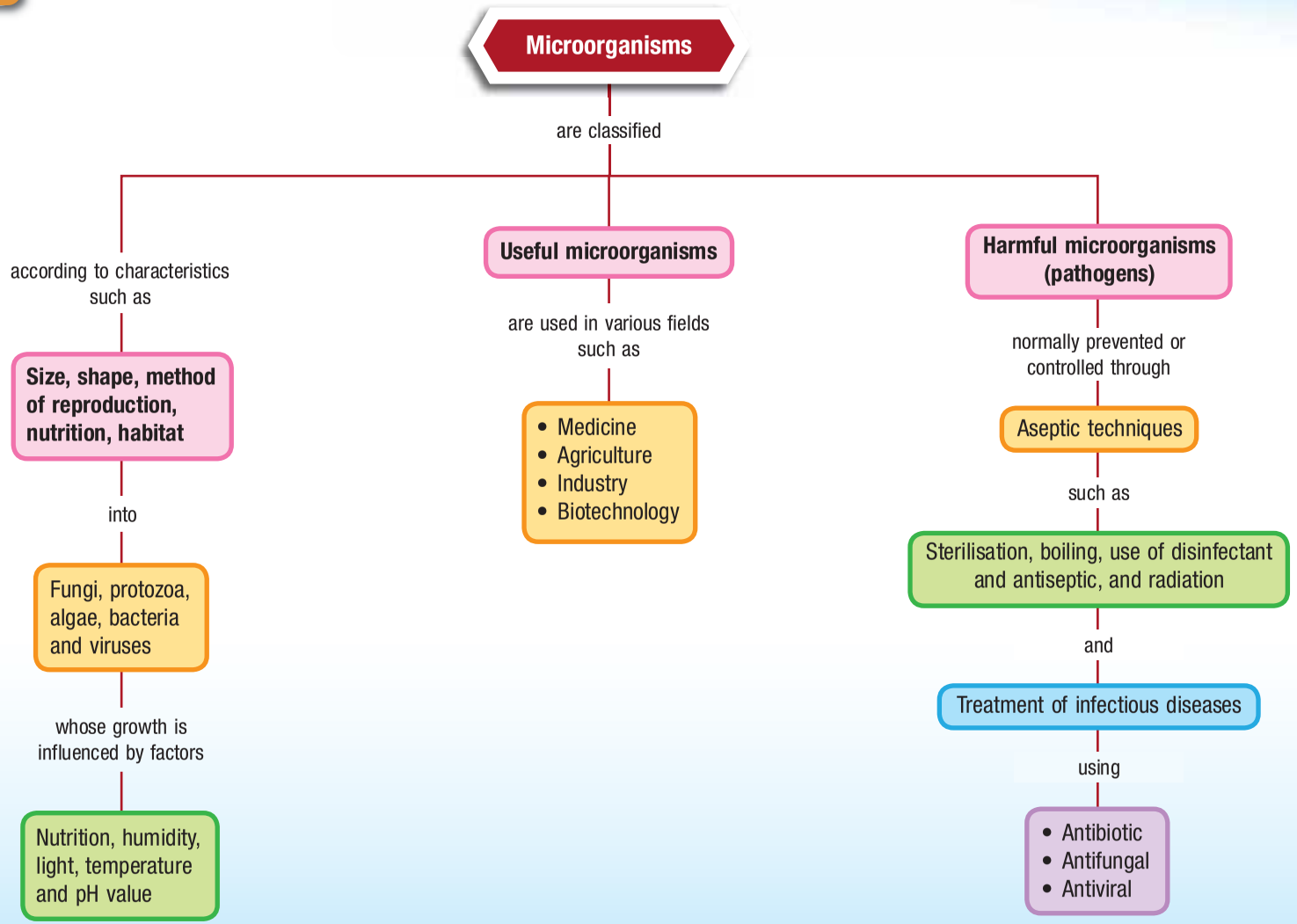
3. (a) What is sterilisation?
(b) How is sterilisation carried out?
(c) Why is the use of autoclave more effective in the prevention of microorganisms compared to boiling water?

4. State **one** similarity and **one** difference between antiseptics and disinfectants.

5. Name **three** examples of ionising radiation used in the aseptic technique.

6. State the type of substance that is used to treat the following infectious diseases:
(a) athlete's foot
(b) pneumonia
(c) shingles

Summary


Microorganisms
are classified
according to characteristics such as
Size, shape, method of reproduction, nutrition, habitat
into
Fungi, protozoa, algae, bacteria and viruses
whose growth is influenced by factors
Nutrition, humidity, light, temperature and pH value
Useful microorganisms
are used in various fields such as
• Medicine
• Agriculture
• Industry
• Biotechnology
Harmful microorganisms (pathogens)
normally prevented or controlled through
Aseptic techniques
such as
Sterilisation, boiling, use of disinfectant and antiseptic, and radiation
and
Treatment of infectious diseases
using
• Antibiotic
• Antifungal
• Antiviral

Self-Reflection

After studying this chapter, you are able to:

1.1 World of Microorganisms

- ☐ Communicate about microorganisms.
- ☐ Conduct an experiment to show the presence of microorganisms.
- ☐ Conduct experiments to investigate factors that affect the growth of microorganisms.

1.2 Useful Microorganisms

- ☐ Justify the applications of useful microorganisms in life.
- ☐ Generate ideas on the potential use of microorganisms in biotechnology and sustainability of the environment.

1.3 Prevention and Treatment of Diseases Caused by Microorganisms

- ☐ Explain the phrase 'prevention is better than cure' for diseases caused by microorganisms.
- ☐ Explain the aseptic techniques to control the spread of microorganisms.
- ☐ Conduct an experiment to study the effect of antibiotic on bacterial growth.
- ☐ Communicate about methods of treatment of infectious diseases.

Summative Practice 1

Quiz
http://buku-teks.com/sc5043

Answer the following questions:

1. Figure 1 shows the results of an experiment to study the effect of different antibiotic concentrations on the growth of bacteria.

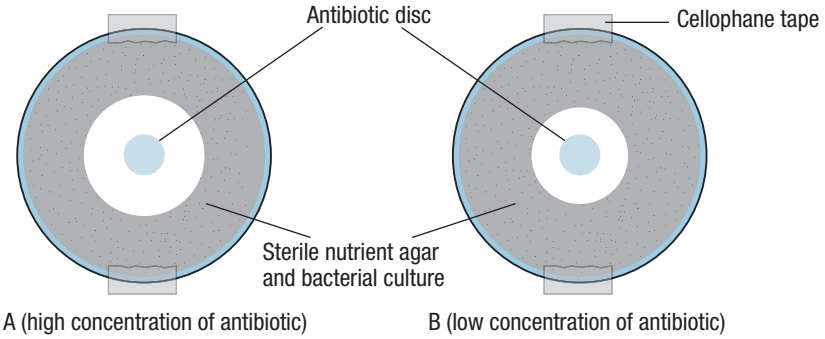


Figure 1

(a) State **one** hypothesis for this experiment.

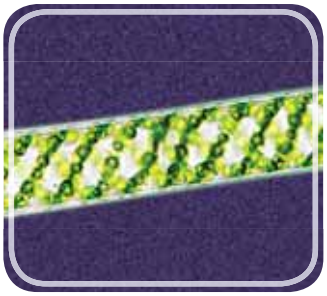
(b) State the variables in this experiment.
  (i) Constant variable
  (ii) Manipulated variable

(c) What is the effect of antibiotics based on this experiment?

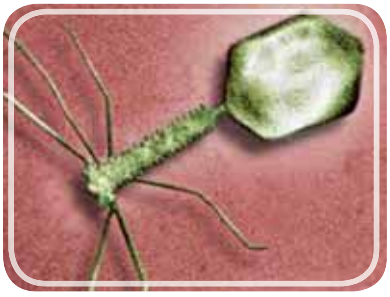
2. Figure 2 shows microorganisms P, Q, R, S and T.

P

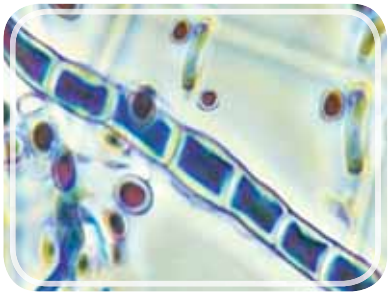
Q



R



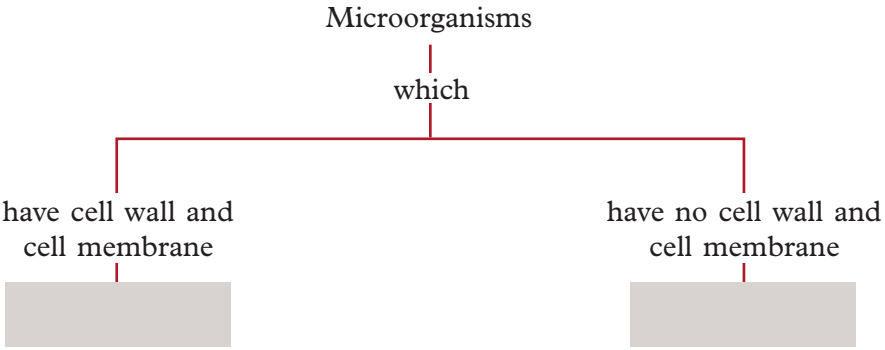
S



T

Figure 2

(a) Classify P, Q, R, S and T based on the following characteristics:
(i) have cell wall and cell membrane
(ii) have no cell wall and cell membrane



(b) Name the group of microorganisms that has no cell wall and cell membrane.

(c) (i) Name microorganism P.
(ii) Is microorganism P a useful microorganism or a pathogen? Explain your answer.

3. Figure 3 shows an experiment to study the effect of temperature on the growth of *Bacillus* sp.

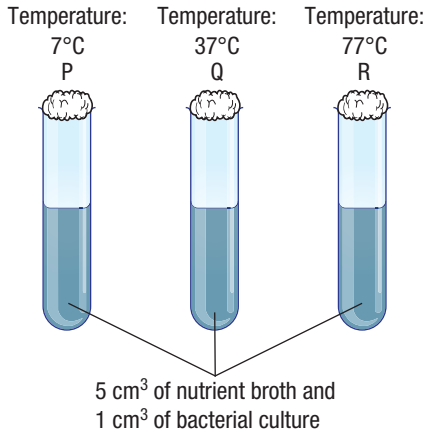


Figure 3

The condition of the nutrient broth in test tubes P, Q and R is observed after three days. The results of the experiment are recorded in Table 1.

Table 1

Test tube	Temperature (°C)	Condition of nutrient broth after three days
P	7	Slightly cloudy
Q	37	Cloudy
R	77	Slightly cloudy

(a) State **one** observation of the nutrient broth that was kept at a temperature of 37°C for three days.

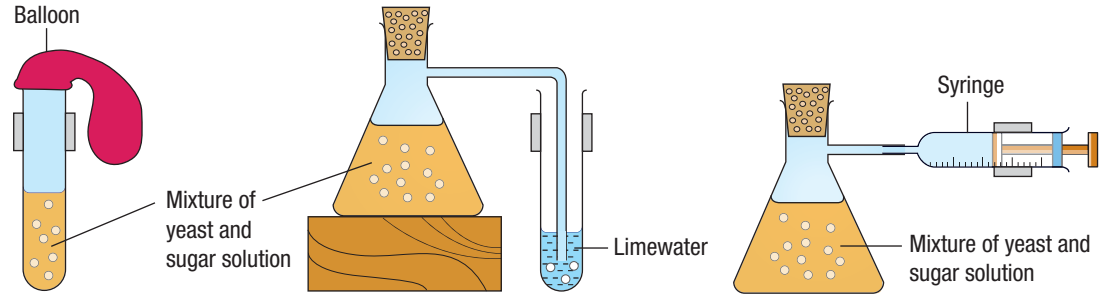
(b) State the hypothesis for this experiment.

(c) State the variables in this experiment.
(i) Manipulated variable
(ii) Responding variable

(d) State **one** inference that can be made based on the observation of this experiment.

Enrichment Practice

4. By using the apparatus set-up in Figure 4, suggest **five** different ways to measure the rate of carbon dioxide production from the action of yeast in sugar solutions at different temperatures.



Apparatus set-up X | Apparatus set-up Y | Apparatus set-up Z

Figure 4

CHAPTER 2

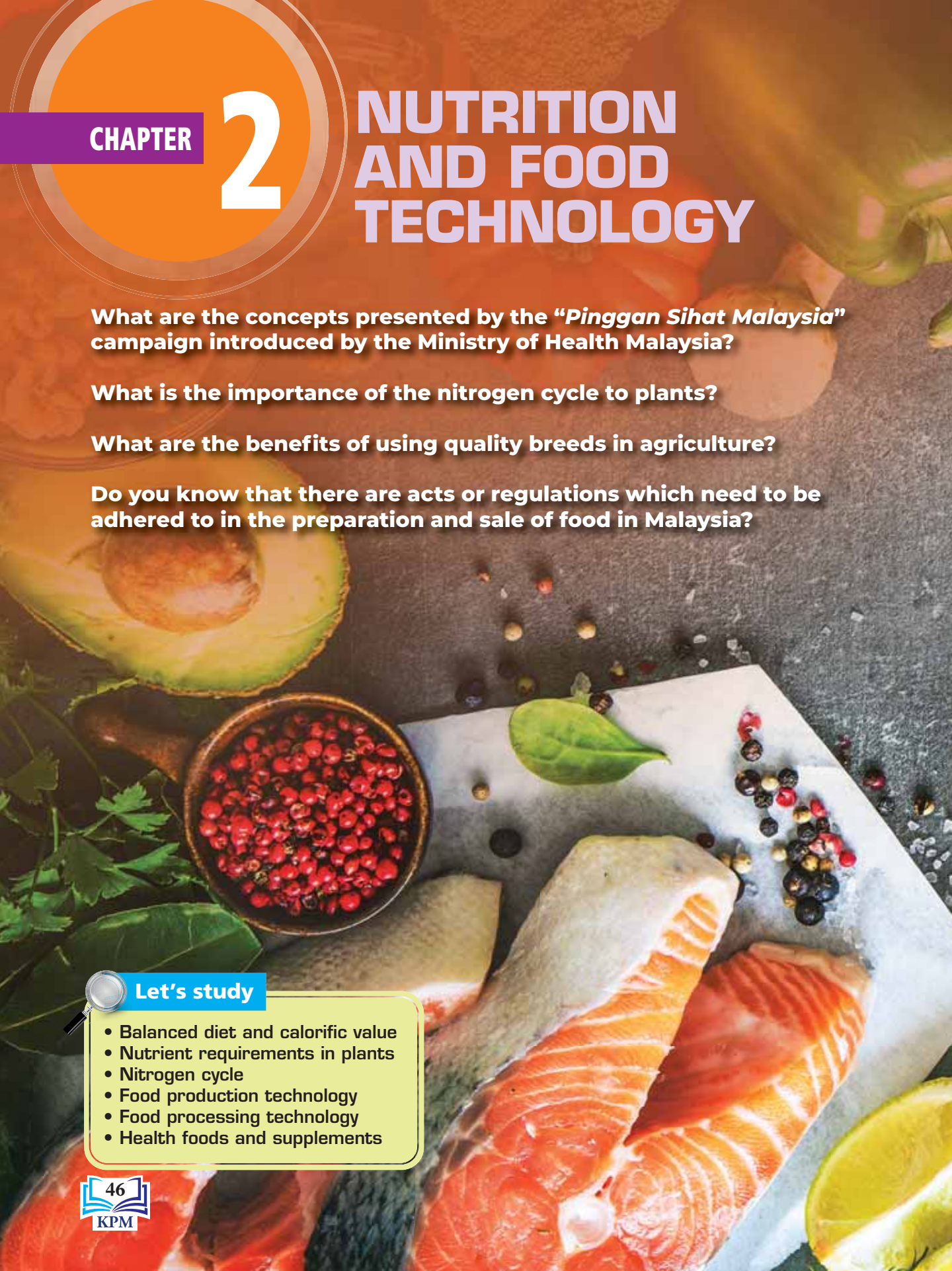
NUTRITION AND FOOD TECHNOLOGY

What are the concepts presented by the "*Pinggan Sihat Malaysia*" campaign introduced by the Ministry of Health Malaysia?

What is the importance of the nitrogen cycle to plants?

What are the benefits of using quality breeds in agriculture?

Do you know that there are acts or regulations which need to be adhered to in the preparation and sale of food in Malaysia?



Let's study

- Balanced diet and calorific value
- Nutrient requirements in plants
- Nitrogen cycle
- Food production technology
- Food processing technology
- Health foods and supplements

Science Bulletin

A smart consumer will always check the safety status of food products or health supplements. Are you a smart consumer?

A list of banned products is additional information prepared by the Pharmacy Enforcement Division, Ministry of Health (MOH) Malaysia. This list aims to inform traders, enforcement agencies as well as the public regarding health products, cosmetics and food products or beverages that are tainted with poison or prohibited chemical substances.

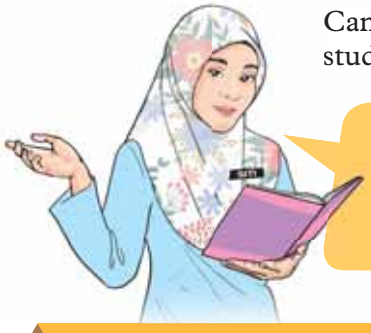
List of banned products
http://buku-teks.com/sc5047
(Medium: *bahasa Melayu*)

An example of label and QR code for a health supplement approved by MOH

Keywords

- Balanced diet
- Calorific requirements
- *Pinggan Sihat Malaysia*
- Food calorie
- Food Act 1983
- Bomb calorimeter
- Eating pattern
- Macronutrient
- Micronutrient
- Nitrogen cycle
- Food Regulations 1985
- Food production technology
- Food processing technology
- *Halal* status
- Malaysia Halal Certification Procedure

2.1 Balanced Diet and Calorific Value



Can you recall the meaning of a **balanced diet** studied in Form 2?

A balanced diet is a diet that includes all the classes of food in the right quantity according to the individual's body requirement.
Is this serving of *nasi lemak* an example of a balanced diet? Give your reasons.

Activity 2.1

21st Century Skills
- ICS
- Discussion

To gather information on balanced diet, factors that affect calorific requirements and the amount of energy needed by an individual

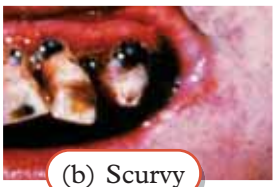
Instructions

1. Carry out this activity in groups.
2. Gather information on the following:
   (a) balanced diet and *Pinggan Sihat*
   (b) factors that affect calorific requirements
   (c) energy requirements for different individuals
3. Discuss the gathered information.
4. Present the outcome of your group discussion to the class using a multimedia presentation.

Malnutrition

A lack or an excess of any class of food can cause **malnutrition**. Several examples of health problems resulting from malnutrition are shown in Photograph 2.1. State the cause of each health problem.


(a) Goitre


(b) Scurvy


(e) Rickets


(c) Marasmus


(d) Kwashiorkor

Photograph 2.1 Several examples of health problems caused by malnutrition

Concept of *Pinggan Sihat Malaysia*

The Ministry of Health (MOH) Malaysia has introduced the concept of *Pinggan Sihat Malaysia* as shown in Figure 2.1.

Figure 2.1 The concept of *Pinggan Sihat Malaysia*

Applications of the Concept of *Pinggan Sihat Malaysia* in Daily Life

Applications of the concept of *Pinggan Sihat Malaysia* can be observed in daily life as shown in Figure 2.2.

Main Messages

- Eat 3 main healthy meals a day
- Eat 1 – 2 healthy snacks between meals if needed
- Eat more cereal foods
- Eat less fried food or food that contains coconut milk
- Eat home-cooked food more frequently

#SukuSukuSeparuh

Figure 2.2 Examples of *Pinggan Sihat Malaysia*

Calorific Value of Food

Calorific value (or **energy value**) of food is the amount of energy that is released from the complete oxidation or combustion of 1 g of that food.

Photograph 2.2 Apparatus set-up for measuring calorific value of food

Unit for Calorific Value

Energy that is released from the oxidation or combustion of food is normally measured in calorie (cal), kilocalorie (kcal), joule (J) or kilojoule (kJ). What is the S.I. unit for energy?

1 calorie (cal) = 4.2 joules (J)
1 kilocalorie (kcal) = 4 200 joules (J)
= 4.2 kilojoules (kJ)

The S.I. unit for calorific value is **joule per kilogram (J kg^{-1})**.

Measuring the Calorific Value of Food

The calorific value of food can be measured by using a special apparatus called **bomb calorimeter** (Photograph 2.3). Table 2.1 shows the calorific value of carbohydrate, fat and protein measured using a bomb calorimeter.

Table 2.1 Calorific values of carbohydrate, fat and protein

Class of food	Carbohydrate	Fat	Protein
Calorific value (kJ g^{-1})	16.7	37.6	16.7

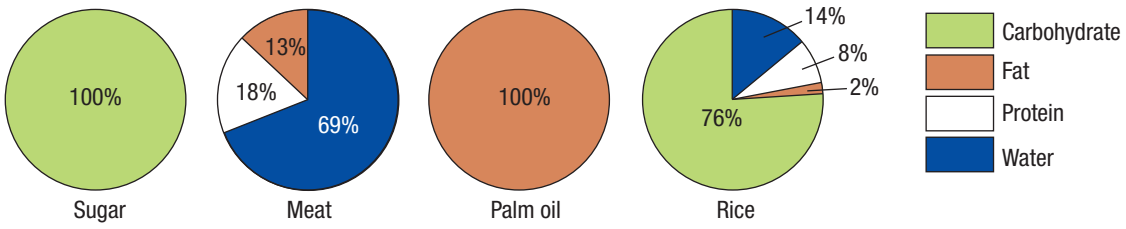
(*Source*: *Grosvenor and Smolin, 2000*)

Photograph 2.3 Bomb calorimeter

Different Kinds of Food and Estimation of Calorific Values

The calorific value of food is determined by the quantity of carbohydrate, protein and fat content in the food.

For example, observe Figure 2.3 and Table 2.2 which show several examples of food and their estimated calorific values.



(Source: Stone and Cozens, 1981)

Figure 2.3 Composition of carbohydrate, fat, protein and water in some food

Table 2.2 Different foods and their estimated calorific values

Class of food	Source	Calorific value (kJ g^{-1})
Carbohydrate	Rice	15.04
	White bread	10.60
	Coarse sugar	16.50
Fat	Palm oil	38.00
	Butter	31.20
Protein	Chicken	8.27
	Beef	13.11
Fibre	Cabbage	0.34
	Cucumber	0.55

(Source: Parkin, Simpkins, McCarthy and Reffin, 1996)

Thinking Skills

The table below shows the content of sandwiches A, B and C.

Sandwich	Content
A	• 2 pieces of white bread • 2 g of butter • 100 g of beef • 5 g of cucumber
B	• 2 pieces of white bread • 100 g of chicken • 5 g of cabbage
C	• 2 pieces of white bread • 2 g of butter • 100 g of chicken • 5 g of cabbage

Which of the sandwiches, A, B and C, is the healthiest choice? Explain your answer.

Experiment 2.1

Aim: To estimate the calorific value of several samples of food using a calorimeter

Problem statement: Which food sample has the highest calorific value?

Hypothesis: The calorific value of groundnuts is higher than that of bread and anchovies.

Variables:
(a) manipulated : Type of food sample
(b) responding : Change in temperature/calorific value of food
(c) constant : Mass of water

Materials: 1 g of groundnuts, 1 g of bread, 1 g of anchovies, cotton wool and distilled water

Apparatus: Retort stand, boiling tube, thermometer, shield, plasticine and needle

Procedure:

1. Prepare the apparatus set-up (Figure 2.4).

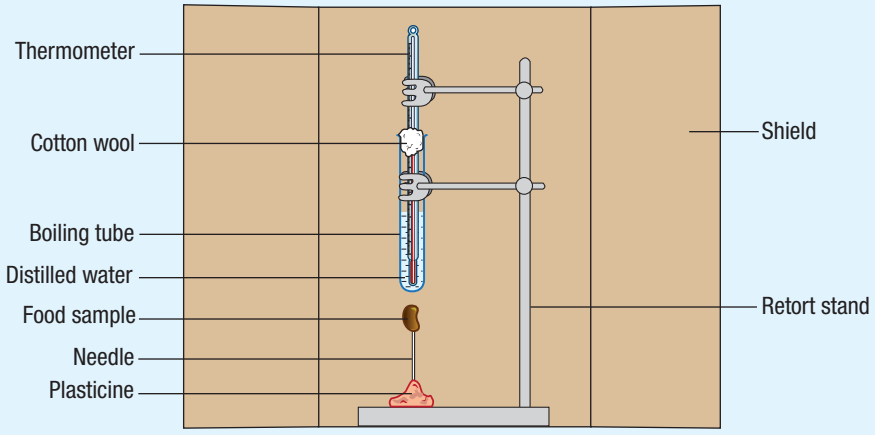


Figure 2.4

2. Record in the table the type of food sample and its mass, mass of water in the calorimeter and initial temperature, T_1, on the thermometer.
3. Use a lighter to set the food sample alight.
4. Observe and record the final temperature, T_2, after the food sample has been completely burnt.

Result:

Food sample	Groundnut	Anchovies	Bread
Mass of food sample (g)	1	1	1
Mass of water (g)	10	10	10
Initial temperature, T_1 (°C)			
Final temperature, T_2 (°C)			
Change in temperature, $T_2 - T_1$ (°C)			

Data analysis:

Calculate and record the calorific value of each food sample using the following formula:

$$\text{Calorific value of food} = \frac{4.2 \text{ J g}^{-1} \text{ °C}^{-1} \times \text{Mass of water (g)} \times \text{Change in water temperature (°C)}}{\text{Mass of food sample (g)} \times 1\,000}$$

Food sample	Groundnut	Anchovies	Bread
Calorific value (kJ g^{-1})			

Conclusion:

Is the hypothesis accepted? What is the conclusion for this experiment?

Questions:

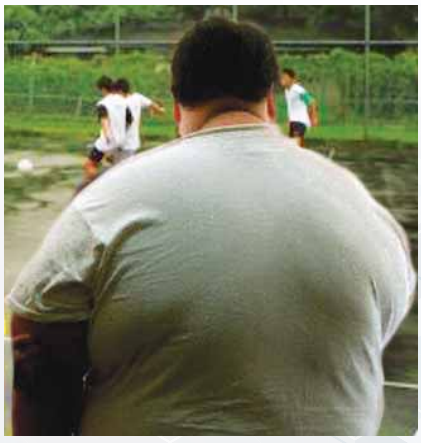
1. (a) Is the calorific value of the food sample determined using the calorimeter bigger or smaller than its actual calorific value?
   (b) Explain your answer.
2. Give **one** example of food sample used to estimate the calorific value for each of the following classes of food using a calorimeter:
   (a) carbohydrate
   (b) fat
   (c) protein
3. Name **one** class of food that has no calorific value. Give your reason.

Effects of Consuming Total Calories that Do Not Meet Individual Requirements

Besides a balanced diet, the total calories obtained from each meal should also meet the requirements of the individual to stay healthy. How does an individual determine whether the total calories consumed is sufficient, insufficient or in excess based on physical condition? How does the total calorie intake of an individual cause the effects shown in Photographs 2.4 (a) and (b)?

Unhealthy eating habits such as inappropriate mealtimes can cause problems such as malnutrition, obesity, anorexia nervosa, arteriosclerosis, diabetes mellitus, high blood pressure, thrombosis, stroke, heart attack and heart disease. Figure 2.5 shows the causes and effects of several health problems on individuals.

(a) Underweight



(b) Obese

Photograph 2.4 Examples of effects of total calorie intake which does not meet an individual's requirements

2.1.2 2.1.3

Figure 2.5 Causes and effects of several health problems

Eating Patterns of Malaysians and the Effects on their Health

The health of the human body is not only influenced by the total calorie intake which meets requirements but also depends on eating patterns such as mealtimes and types of food.

Photograph 2.5 Several local restaurants which operate 24 hours a day

In Malaysia, there are various types of restaurants especially fast food restaurants which operate 24 hours a day. Why do these restaurants operate 24 hours a day?

Can the calorie intake to meet your requirements be obtained from fast food and junk food?

BRAIN TEASER

Restaurants that operate 24 hours a day affect health negatively. Discuss.

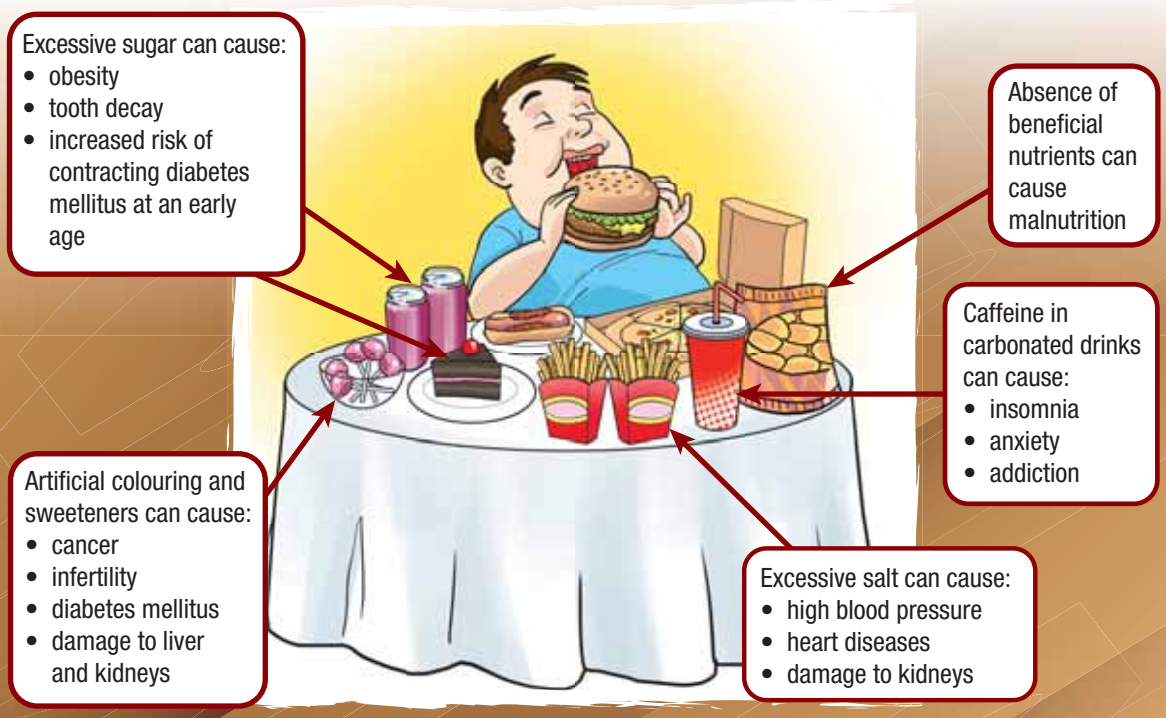


Figure 2.6 Effects of fast food and junk food

Click@Web

Info about obesity
http://buku-teks.com/sc5056a

Junk food retards growth of human body and IQ
http://buku-teks.com/sc5056b
(Medium: *bahasa Melayu*)

Activity 2.2

21st Century Skills
- ICS
- Discussion

To study the effects of insufficient or excessive total calorie intake

Instructions

1. Carry out this activity in groups.
2. Search for information on the following:
   (a) effects of insufficient or excessive total calorie intake
   (b) relationship between the lifestyle and eating patterns of Malaysians and the effects on health
   (c) effects of 24-hour restaurants, fast food restaurants and junk food advertisements on the eating patterns and health of Malaysians
3. Discuss the information gathered.
4. Present the outcome of your group discussion to the class in the form of a multimedia presentation.

Formative Practice 2.1

1. (a) What is the concept presented by *Pinggan Sihat Malaysia?* Explain the concept.
(b) What is the importance of the concept stated in question 1(a)?

2. (a) What is meant by the calorific value of a food?
(b) Name the device used to measure the calorific value of food.
(c) Write the formula for calculating the calorific value of a food sample using the device in question 2(b).

3. (a) State **one** effect of insufficient total calorie intake.
(b) State **one** effect of excessive total calorie intake.

4. Explain how the total calorie intake of an individual is influenced by the following:
(a) 24-hour restaurants
(b) fast food restaurants

2.2 Nutrient Requirements in Plants

Besides humans and animals, plants also require certain nutrients for growth, development and reproduction. Nutrients required by plants can be classified into **two** groups, namely **macronutrients** and **micronutrients** (Figure 2.7).

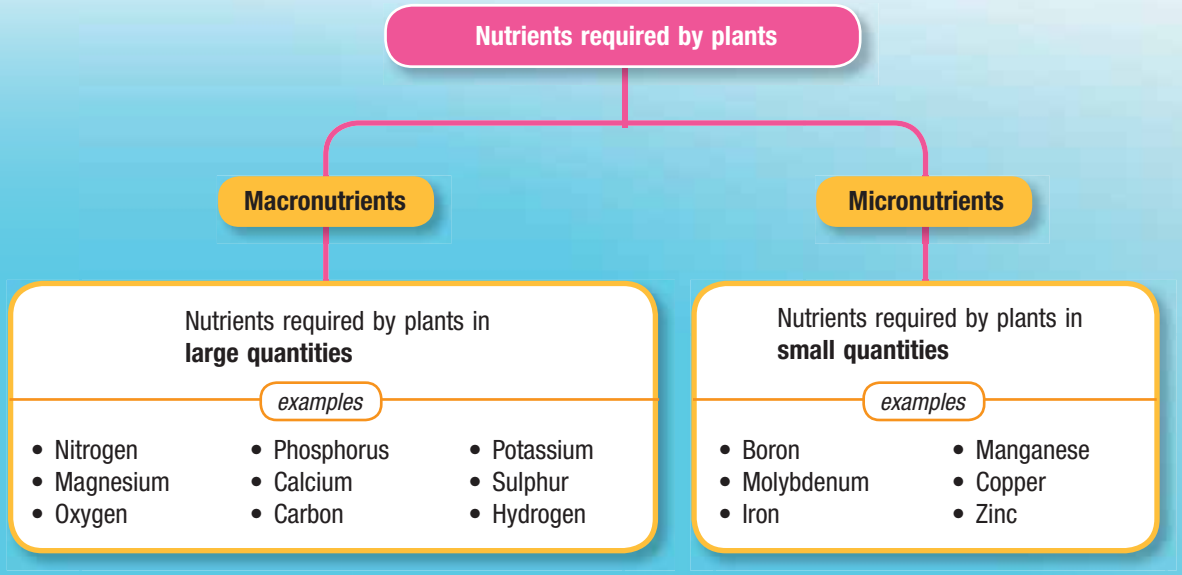


Figure 2.7 Classification of nutrients required by plants

Activity 2.3

21st Century Skills
- ICS
- Discussion

To gather information and classify the elements required by plants based on their quantities as well as functions

Instructions

1. Carry out this activity in groups.
2. Gather information from the Internet, print media and other electronic media about the classification of elements required by plants based on their quantities and functions.
3. Discuss the information gathered.
4. Present the outcome of your group discussion using a multimedia presentation.

Compare the outcome of your discussion from Activity 2.3 with the information given in Table 2.3 and Table 2.4 on page 58.

Macronutrients

Macronutrients are **elements** (or **minerals**) required by plants in **large** quantities.

Table 2.3 Examples of macronutrients and their functions

Macronutrient	Functions
Nitrogen	• Synthesises protein, chlorophyll, enzyme and nucleic acid • Helps the growth of branches and leaves • Increases the production of fruits and seeds
Phosphorus	• Synthesises protein and nucleic acid • Promotes cell division for the production of flowers and fruits
Potassium	• Synthesises protein • Promotes plant cell division • Strengthens resistance to infectious diseases
Magnesium	• Important component in chlorophyll
Calcium	• Synthesises spindle fibres during cell division • Helps growth of meristem at tips of shoots and roots
Sulphur	• Synthesises protein and chlorophyll • Helps development of fruits • Promotes plant cell division
Oxygen	• Involved in plant cell respiration to produce energy
Carbon Hydrogen	• Builds sugar or starch during photosynthesis • Builds cellulose

Micronutrients

Micronutrients are **elements** (or **minerals**) required by plants in **small** quantities.

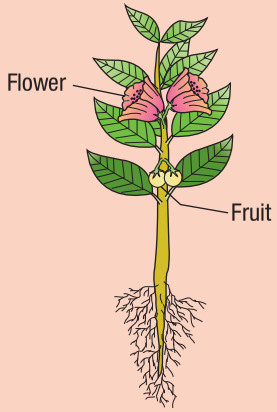
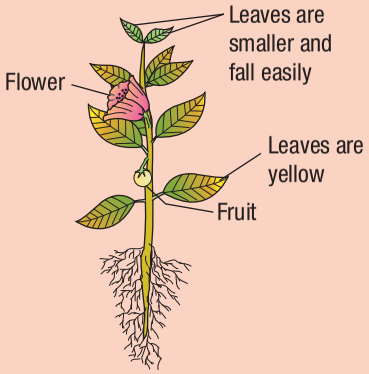
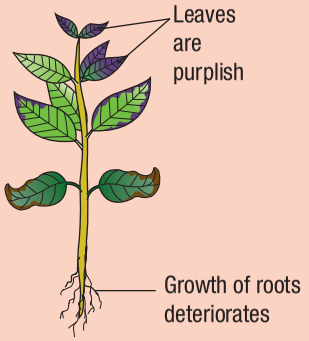
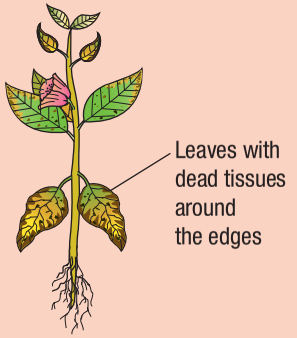
Table 2.4 Examples of micronutrients and their functions

Micronutrient	Functions
Boron	• Synthesises chlorophyll and cell wall • Helps the formation of fruits and seeds
Iron	• Helps growth of young tree parts • Helps cell respiration
Copper	• Involved in photosynthesis and respiration
Molybdenum	• Synthesises protein • Helps growth of plants
Manganese	• Involved in photosynthesis and respiration • Helps formation of amino acid
Zinc	• Helps synthesis of protein and formation of chlorophyll • Helps formation of leaves

Effects of Nitrogen, Phosphorus and Potassium Deficiency on Plant Growth

Table 2.5 shows the effects of nitrogen, phosphorus and potassium deficiency on plant growth compared to a plant that obtains all these nutrients.

Table 2.5 Effects of nitrogen, phosphorus and potassium deficiency on plant growth

Healthy plant	Plant with nitrogen deficiency	Plant with phosphorus deficiency	Plant with potassium deficiency
			
• Normal plant growth • Strong stem • Leaves at the top are small and light green • Leaves at the bottom are bigger and dark green • The production of flowers and fruits is normal • The growth of roots is normal	• Stunted plant growth • Weak stem • Leaves at the top are smaller and fall easily • Leaves at the bottom are pale green or yellow (lacking chlorophyll or chlorosis) • The production of flowers and fruits is stunted • The growth of roots is normal	• Stunted plant growth; slow to grow and mature • Weak stem • Leaves at the top are smaller and purplish • Leaves at the bottom are bluish green, curled and with brown edges • The production of flowers and fruits stops • The growth of roots deteriorates	• Stunted plant growth; dies before reaching maturity • Weak stem • Leaves at the top have brown spots, curled ends and chlorosis • Leaves at the bottom wilt and have dead tissues around the edges • The production of flowers is reduced and the production of fruit stops • The growth of roots is reduced

Experiment 2.2

Aim: To study the effects of macronutrient (nitrogen, phosphorus and potassium) deficiency on plant growth

Problem statement: What are the effects of macronutrient (nitrogen, phosphorus and potassium) deficiency on plant growth?

Hypothesis: Deficiency of macronutrients (nitrogen, phosphorus and potassium) stunts plant growth.

Variables:
(a) manipulated : Type of culture solution
(b) responding : Growth of plant
(c) constant : Volume of culture solution, size and type of seedlings, light and temperature

Materials: Distilled water, complete culture solution, culture solution without nitrogen, culture solution without phosphorus, culture solution without potassium, maize seedlings, black paper and cotton wool

Apparatus: Boiling tube, connecting tube, air pump and cork

Procedure:

1. Prepare the apparatus set-up (Figure 2.8).

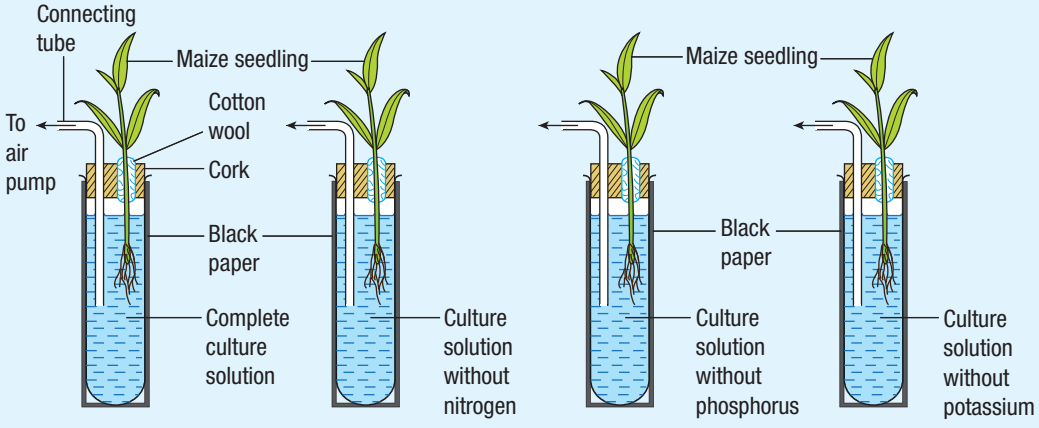


Figure 2.8

2. Place the apparatus set-up in a bright place such as near the laboratory window where there is sunlight.
3. Pump air into the culture solution in each boiling tube for 5 minutes every day.
4. The culture solution in each boiling tube is replaced once a week with the same type of culture solution.
5. After two weeks, observe and record the conditions of the seedlings in terms of size of plant, colour of leaves and growth of roots.

Observation:

Type of culture solution	Nutrient deficiency	Plant growth		
		Plant size	Colour of leaf	Root growth
Complete culture solution	None			
Culture solution without nitrogen	Nitrogen			
Culture solution without phosphorus	Phosphorus			
Culture solution without potassium	Potassium			

Conclusion:

Is the hypothesis accepted? What is the conclusion of this experiment?

Questions:

1. Why are the boiling tubes wrapped in black paper?
2. What is the importance of aerating the culture solutions every day?
3. Why is the culture solution in each boiling tube changed once a week with the same type of culture solutions?
4. State **one** factor, besides nutrient, that affects the growth of seedlings.

Formative Practice 2.2

1. (a) What is the meaning of macronutrient? Name **five** examples of macronutrients.
(b) What is the meaning of micronutrient? Name **five** examples of micronutrients.

2. What is the importance of macronutrients and micronutrients to plants?

3. Match the macronutrient with the effect of its deficiency on plant growth.

Macronutrient	Effect of macronutrient deficiency
(a) Phosphorus ▶	◀ Small leaves which fall easily
(b) Potassium ▶	◀ Stunted growth of roots
(c) Nitrogen ▶	◀ Brown spots on edges of leaves

2.3 Nitrogen Cycle

Nitrogen cycle is a **natural cycle** that recycles nitrogen between plants and animals, and the atmosphere, soil and water. Figure 2.9 shows the nitrogen cycle in an ecosystem.

Approximately 78% of air is made up of nitrogen. But plants cannot absorb nitrogen directly from the air. So how do plants obtain the nitrogen required for healthy growth?

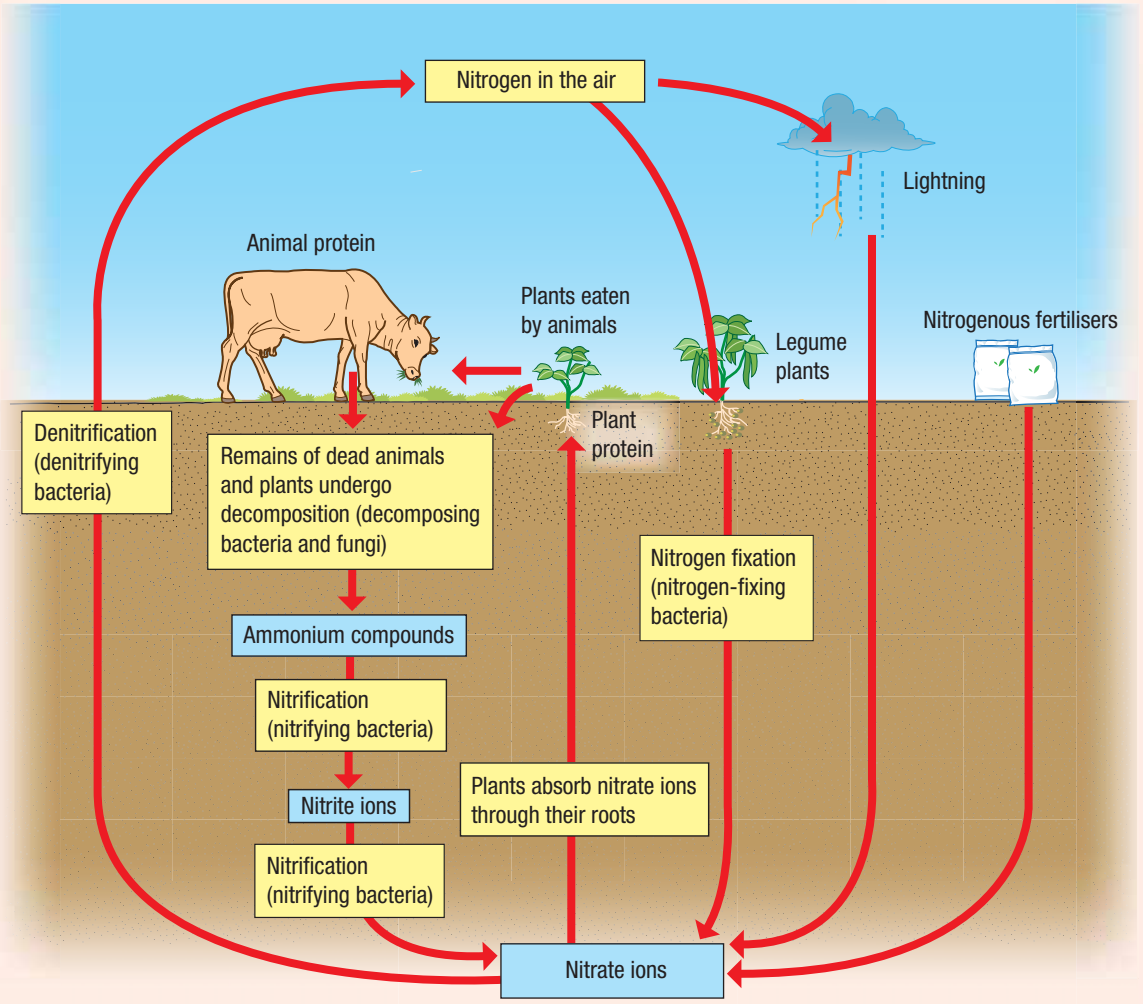


Figure 2.9 Nitrogen cycle

Plants can only absorb nitrogen in the form of nitrate ions from the soil through their roots. There are two processes in the nitrogen cycle, namely the **process of nitrate ion addition to the soil** and the **process of nitrate ion extraction from the soil** (Figure 2.10).

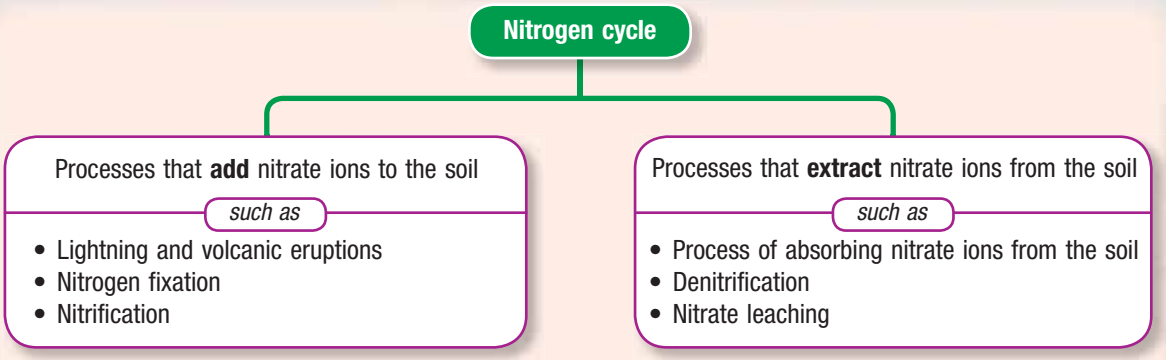


Figure 2.10 Processes in the nitrogen cycle

Processes that Add Nitrate Ions to the Soil

Lightning and Volcanic Eruptions

During lightning or volcanic eruptions, heat energy released at high temperatures oxidises nitrogen in the air to form nitrogen dioxide (Photographs 2.6 and 2.7).

When it rains, nitrogen dioxide in the air dissolves in the rainwater to form nitric acid which falls to the surface of the earth. This nitric acid seeps into the ground and reacts with minerals to form nitrate ions. As a result, the quantity of nitrate ions in the soil increases.

Photograph 2.6 Lightning

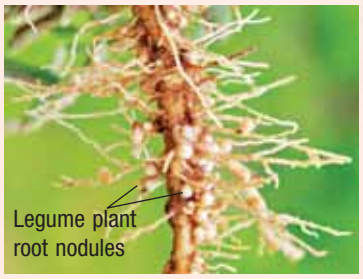
Photograph 2.7 Volcanic eruption

Nitrogen Fixation

Nitrogen-fixing bacteria in the soil, water or living symbiotically in legume plant root nodules (Photograph 2.8), convert nitrogen in the air into nitrate ions. The resulting action of nitrogen-fixing bacteria increases nitrate ions in the soil.

Nitrification

When animals and plants die, decomposing bacteria convert animal protein and plant protein into ammonium compounds through the process of decomposition. Then, nitrifying bacteria convert ammonium compounds into nitrite ions and then nitrate ions. The resulting action of nitrifying bacteria on ammonium compounds increases nitrate ions in the soil.



Photograph 2.8 Nitrogen-fixing bacteria in the root nodules of a legume plant

Processes that Extract Nitrate Ions from the Soil

Nitrate Ion Absorption from the Soil

Plants absorb nitrate ions from the soil to meet their nitrogen requirement. These ions are used to form plant protein. When animals eat plants, plant protein is transferred to the animals to form animal protein. What will happen to the protein in dead plants and animals?

Denitrification

There are also denitrifying bacteria in the soil which convert nitrate ions in the soil into nitrogen which then leaves the soil and returns to the air. This process is known as denitrification.

Nitrate Leaching

Nitrate leaching is a natural process. Through this process, nitrate ions in the soil dissolve in water and then flow into rivers or underground water. This process also removes nitrate ions from the soil.

Importance of Nitrogen Cycle

The nitrogen cycle maintains nature's balance by:

(a) **Maintaining nitrogen content in the air**
The nitrogen cycle helps to maintain the nitrogen content in the atmosphere by removing nitrogen from the air to form nitrate ions and returning it to the air by decomposing nitrate ions. Therefore, the concentration of nitrogen is maintained at 78% in the atmosphere to help ensure the continuity and sustainability of life on Earth.

(b) **Maintaining fertility of soil and increasing productivity of crops**
As you have learned in subtopic 2.2, nitrogen is an important macronutrient for plant growth and is obtained by plants in the form of nitrate ions absorbed from the soil. The removal of nitrate ions reduces the fertility of the soil. The problem of infertile soil can be solved through crop rotation and use of fertilisers (Photograph 2.9) to increase the content of nitrate ions in the soil again. As a result, plants become healthier. The productivity of crops rises and the income of farmers increases.

Photograph 2.9 Fertilisers that contain nitrate ions

(c) **Maintaining a continuous supply of plant proteins and animal proteins**
Nitrogen is an important component in the formation of protein. Protein is used to build new cells and repair damaged cells.
A continuous supply of protein is important to ensure the continuity and maintenance of life for all types of living things. Plants use nitrogen from the nitrate ions that are absorbed to form plant proteins. Animals obtain nitrogen by feeding on plants or other animals (Photograph 2.10).

Photograph 2.10 Examples of animal protein and plant protein

(d) **Reducing environmental pollution**
The remains of dead animals and plants undergo decay and decomposition to form ammonium compounds and then nitrate ions through bacterial and fungal actions. Processes in the nitrogen cycle such as **nitrification** help to reduce environmental pollution and are applied in green technology to produce compost (Photograph 2.11).

Photograph 2.11 Compost

Activity 2.4

21st Century Skills
- ICS, TPS
- Inquiry-based activity

To gather information on nitrogen cycle and its importance

Instructions

1. Carry out this activity in groups.
2. Gather information from the Internet, print media and electronic media on nitrogen cycle and its importance.
3. Discuss the gathered information.
4. Present the outcome of your group discussion to the class in the form of a multimedia presentation.

Formative Practice 2.3

1. What is nitrogen cycle?

2. (a) Name **three** processes in the nitrogen cycle which increase nitrate ions in the soil.
(b) Name **three** processes in the nitrogen cycle which remove nitrate ions from the soil.

3. How does the planting of legume plants increase the fertility of the soil?

4. What happens to the content of nitrate ions in the soil during rainy season? Explain your answer.

2.4 Food Production Technology

Food production technology is applied to solve the problem of global food shortage. The measures used in food production technology include:

- increasing food quality
- increasing the quantity of food production
- producing and using quality breeds
- using various types of modern technology

Ways to Increase the Quality and Quantity of National Food Production

There are efforts undertaken by various government and private agencies in Malaysia to increase food quality and quantity of national food production (Figure 2.11).

Figure 2.11 Ways to increase quality and quantity of national food production

Use of Quality Breeds

The use of quality breeds in Malaysia can diversify food sources, increase food quality and quantity of national food production (Photograph 2.12).

Tenera oil palm yields more fruits with larger kernel, thicker pulp, thinner shell and higher oil content

Mafriwal cow
A hybrid dairy cow that produces a lot of milk and can adapt to tropical areas

***Bintang Mas* starfruit** (MSTAR 1, MARDI) is golden yellow, sweet and crunchy

***Eksotika* papaya** is big and tastes sweet

***Akar Putra* chicken**
A hybrid chicken that grows rapidly and has the same meat texture as that of the *kampung* chicken

Photograph 2.12 Use of quality breeds to increase the yield of crops and livestock

Quality plant and livestock breeds are obtained through cloning techniques, cross-breeding, genetic engineering and mutagenesis technology. Characteristics of quality breeds are shown in Figure 2.12.

Figure 2.12 Characteristics of quality breeds

Use of Modern Technology

Modern technology is applied to increase the quality and quantity of food production (Figure 2.13).

Grinding machine and liquid filling machine speed up processing and manufacturing of food.

Cloning can retain good characteristics in crop and livestock breeds.

Modern technology

Figure 2.13 Various types of modern technology used to increase the quality and quantity of food production

Machinery such as tractors, bulldozers and harvesters speed up the rate of crop planting and harvesting.

Biotechnology such as embryo transfer, cloning and genetic engineering is used to increase the quality and quantity of food.

The use of the drone to spray pesticides can save time and reduce labour cost.

Education and Guidance for Farmers

Various agencies and institutions provide education and guidance to farmers to increase their knowledge and skills in the agricultural field in order to increase quality and quantity of national food production (Photograph 2.13).

Photograph 2.13 Oil palm farmers are given guidance and educated by the staff of Advanced Biotechnology and Breeding Centre (ABBC)

My Malaysia

Several agencies or institutions are tasked with providing education and guidance to farmers as follows:

- Ministry of Agriculture and Food Industries
  https://www.mafi.gov.my/alamat-jabatan-dan-agensi
- Malaysian Agricultural Research and Development Institute (MARDI)
  https://www.mardi.gov.my/
- Malaysian Palm Oil Board (MPOB)
  http://www.mpob.gov.my/

Click@Web

How does Advanced Biotechnology and Breeding Centre (ABBC) help farmers in agriculture especially food crops like oil palm?
http://buku-teks.com/sc5070

Research and Development

Research and development to increase food quality and quantity of food production is continuously conducted worldwide to overcome global food shortage. Name four examples of research and development agencies or institutions which increase the quality and quantity of food in Malaysia.

Several universities in Malaysia also conduct research and development to increase food quality and quantity of food production. Name these universities.

Photograph 2.14 An innovative product to tenderise meat (a research by the students of Faculty of Food Science and Technology, Universiti Putra Malaysia)

Optimal Use of Land and Water Resources

As suitable agricultural land and water resources are limited, the use of land and water resources need to be optimised to increase agricultural and livestock yields. Some of the ways to optimise the use of land and water resources are as follows:

- develop idle land into land suitable for agricultural or livestock activities
- fertilise barren land
- develop abandoned mining pools into areas suitable for freshwater aquaculture activities
- develop marshland that is easily flooded by seawater into areas suitable for marine aquaculture activities
- build dams and canals for agricultural or livestock land that experiences water shortage

Science Info

Two farming techniques, namely aeroponic and hydroponic do not require soil.

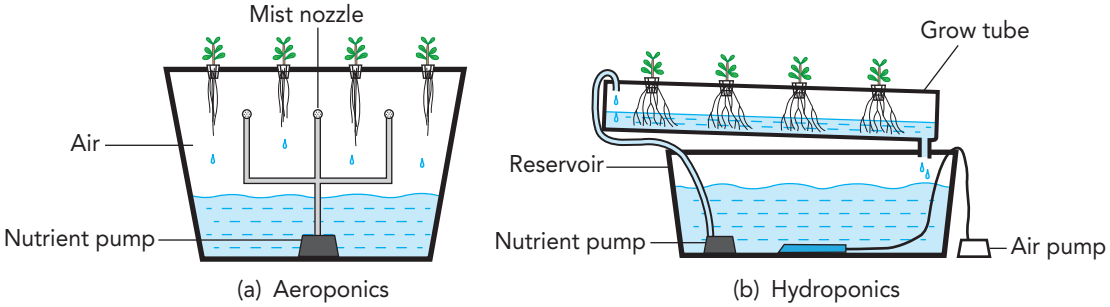


Figure 2.14 Two farming techniques without soil

My Malaysia

FELDA (Federal Land Development Authority) is responsible for restoring idle land into fertile land suitable for agriculture.

Efficient Land Management

Efficient land management involves the use of various approaches to:

- maintain land fertility
- increase quality of crop yield
- increase quantity of crop yield

Approaches for efficient land management are shown in Photograph 2.15.

Photograph 2.15 Various approaches for efficient land management

Activity 2.5

21st Century Skills
- ICS, TPS
- Discussion

To study the efforts of various agencies in diversifying food sources to increase food quality and quantity of national food production

Instructions

1. Carry out this activity in groups.
2. Gather information from the Internet, print media and electronic media on efforts to diversify food sources by various agencies or institutions to increase food quality and quantity of national food production as follows:
   (a) use of quality breeds
   (b) use of modern technology
   (c) education and guidance for farmers
   (d) research and development
   (e) optimal use of land and water resources
   (f) efficient land management
3. Discuss the information gathered.
4. Present the outcome of your group discussion to the class using a multimedia presentation.

Use of Insecticides

The elimination of crop pests plays an important role in ensuring the quality and quantity of crop yields. Photograph 2.16 shows several examples of crop pests.

Pesticides such as insecticides are easily used to control the population of crop pests (Photograph 2.17). However, the use of pesticides such as insecticides has side effects like polluting the environment, increasing the pesticide resistance of crop pests, killing earthworms and useful microorganisms in the soil, and contaminating the land and crop yields.

Photograph 2.16 Rat, grasshopper and snail are crop pests

Photograph 2.17 Spraying insecticides on crops

2.4.1 2.4.2

Biological Control

Apart from the use of pesticides, **biological control** is a method which applies the interaction between organisms such as prey-predator and parasitism in order to control crop pests in a habitat. Examples of biological control are shown in Photographs 2.18 and 2.19. Table 2.6 shows the advantages and disadvantages of biological control.

Photograph 2.18 Barn owl hunts rats for food (Type of interaction: Prey-predator)

Photograph 2.19 Wasps lay eggs in the eggs of butterflies and destroy them (Type of interaction: Parasitism)

Table 2.6 Advantages and disadvantages of biological control

Advantages of biological control	Disadvantages of biological control
• More environmental-friendly • Does not harm the health of other organisms except crop pests • Does not cause crop pests to become resistant • Cheaper	• Takes a longer time to control the population of crop pests • Difficult to predict the results of biological control which involves living organisms • Needs more detailed and effective planning and management • Disrupts the balance of ecosystem if populations of the predator species or parasite become uncontrollable

Biological control used without proper planning can cause various problems. For example, the use of mongoose (Photograph 2.20) to control the population of rats in sugarcane plantations on the islands of Hawaii failed because the mongoose is active during daytime while the rat is active at night. This resulted in the mongoose feeding on birds and turtle eggs.

Why does the biological control using barn owls to hunt rats in urban areas also fail? Give your reasons.

Photograph 2.20 Mongoose

Activity 2.6

21st Century Skills
- ICS, TPS
- Discussion

To evaluate the use of insecticides and biological control to increase the quality and quantity of national food production

Instructions

1. Carry out this activity in groups.
2. Discuss and evaluate the use of insecticides and biological control to increase the quality and quantity of national food production based on the following aspects:
   (a) advantages of using insecticides and biological control
   (b) disadvantages of using insecticides and biological control
3. Present the outcome of your group discussion to the class in the form of a multimedia presentation.

Click@Web

An integrated crop pest management system using Integrated Pest Management (IPM) by Sarawak Land Consolidated and Rehabilitation Authority (SALCRA).
http://buku-teks.com/sc5075

Formative Practice 2.4

1. State **four** characteristics of quality breeds.
2. How are quality breeds obtained using modern technology?
3. Name the agency which promotes the marketing of our country's crop yields.
4. State **three** ways of efficient land management.
5. What is biological control?

2.5 Food Processing Technology

According to nutritionists, fresh raw food is better as it is healthier for our body. However, not all raw food substances can be eaten fresh. As such, most raw food is converted into other forms using **food production technology**. Processed food lasts longer, is more delicious and attractive, and can be digested easily.

Food Processing Technology

The **methods** and **examples of food products** processed through **food processing technology** are shown on pages 76 to 79.

Cooking

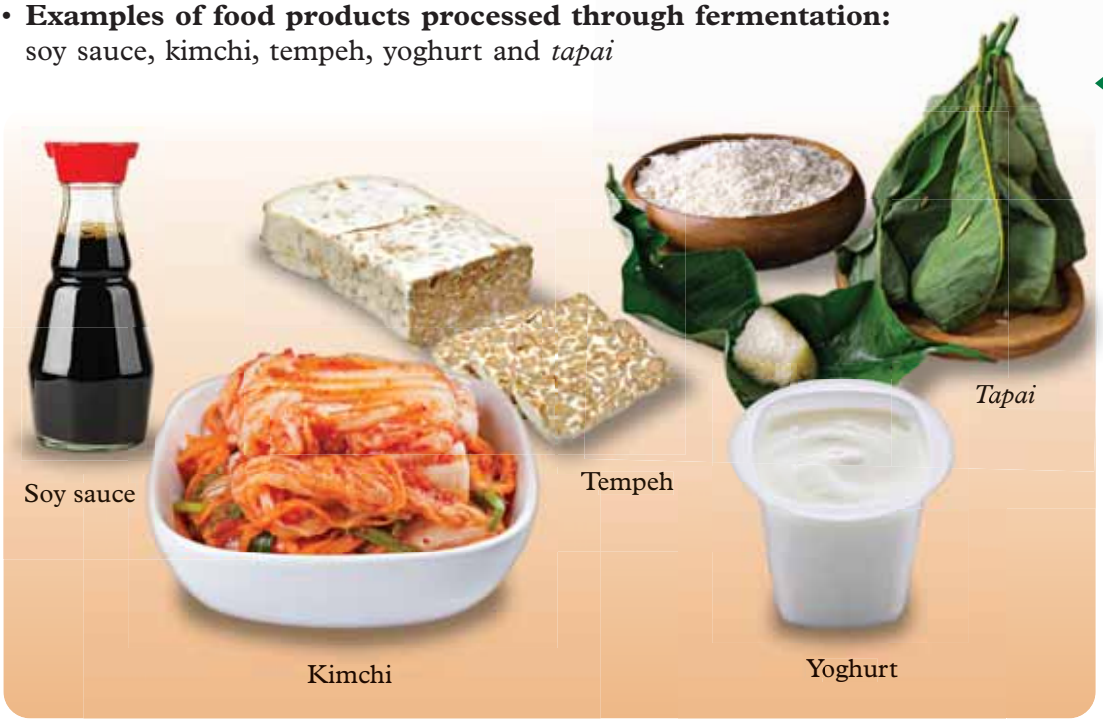
- **Method**
  Food is processed by heating food using techniques such as blanching, frying, grilling, smoking, braising, stir-frying, baking and steaming.
- **Examples of food products processed using cooking techniques:**
  chicken curry, fried fish, grilled chicken, rice, vegetables and cakes

Fermentation

- **Method**
  The breakdown of complex substances into simpler substances through the action of bacteria, yeast or other useful microorganisms. For example, the fermentation of glucose using yeast is used in the making of bread.

$$\text{Glucose} \xrightarrow{\textit{Yeast}} \text{Ethanol} + \text{Carbon dioxide}$$

- **Examples of food products processed through fermentation:**
  soy sauce, kimchi, tempeh, yoghurt and *tapai*

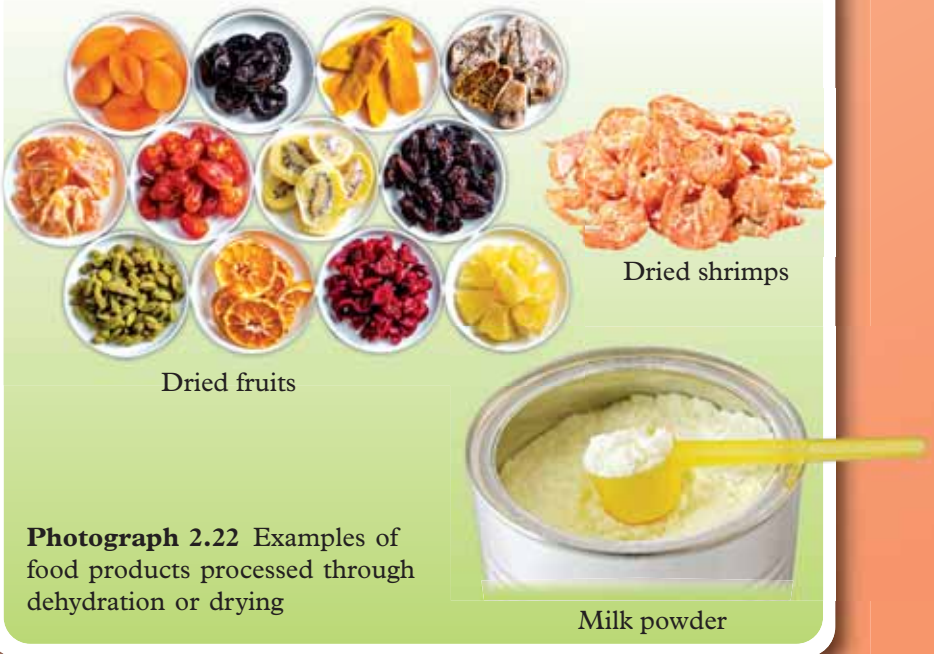


Photograph 2.21 Examples of food products processed through fermentation

Dehydration or Drying

- **Method**
  Water is removed from food through dehydration or evaporation by drying under the sun, using flame or smoke or in the oven.
- **Examples of food products processed through dehydration or drying:**
  dried shrimp, dried squid, dried fish, dried fruits, cereal, mushroom and milk powder

Food processing technology



Photograph 2.22 Examples of food products processed through dehydration or drying

Pasteurisation

- **Method**
  Liquid is heated to a temperature below its boiling point to kill pathogens and then cooled quickly. For example, fresh milk is heated to a temperature of 63°C for 30 minutes or to a temperature of 72°C for 15 seconds and then cooled immediately.
- **Examples of food products processed through pasteurisation:**
  milk, dairy products and fruit juices

Photograph 2.23 Examples of food products processed through pasteurisation

Canning

- **Method**
  Food is kept in cans which are sterilised and heated to a temperature exceeding 115°C under high pressure to kill microorganisms and their spores. The air in the can containing the sterilised food is removed before the can is sealed. The can is then heated again to kill any remaining microorganisms before being cooled quickly.
- **Examples of food products processed through canning:**
  meat, soup, beans, fish, fruits, sauce and canned milk

Lychee Milk Meat

Photograph 2.24 Examples of food products processed through canning

Freezing

- **Method**
  Food is kept at a temperature of 0°C or lower so that it can last longer. For example, meat is frozen at a temperature of –18°C to –24°C. At temperatures less than –18°C:
  - enzyme action stops
  - the growth and reproduction of microorganisms are inhibited
- **Examples of food products processed through freezing:**
  seafood, meat, chicken and fish

Photograph 2.25 Freezing of food

Food processing technology

Irradiation

- **Method**
  Food is exposed to ionising radiation such as gamma ray, ultraviolet ray and X-ray to kill microorganisms such as *Salmonella* sp. and *Campylobacter* sp. in raw meat, and insects such as weevils in rice, which spoil the food. Ionising radiation can also slow down seed germination, budding of root vegetables and ripening of fruits.
- **Examples of food products processed through irradiation:**
  vegetables, cereal and fruits

Photograph 2.26 An example of food product processed through irradiation

Vacuum Packaging

- **Method**
  Air is removed completely from the container or plastic bag used to pack the food before the package is sealed tight. The absence of air in the package prevents the growth of microorganisms in the package and stops food oxidation.
- **Examples of food products processed through vacuum packaging:**
  nuts, rice, durian and vegetables

Photograph 2.27 Examples of food products processed through vacuum packaging

Chemical Substances Used in Food Processing and their Impacts on Health

Chemical substances used in food processing are shown in Table 2.7.

Table 2.7 Chemical substances used in food processing

Chemical substance	Functions	Examples of chemical substance (natural or artificial)	Examples of food
Preservative	• Prevents growth and reproduction of microorganisms • Reduces food spoilage • Makes food last longer	Salt (natural)	Seafood, vegetables
		Sugar (natural)	Fruits
		Vinegar (natural/artificial)	Pickled food
		Sodium nitrite and sodium nitrate (artificial)	Meat, sausage
		Benzoic acid (artificial)	Fruit juice, ketchup
		Boric acid (artificial)	Noodles, fish ball
		Sulphur dioxide (artificial)	Fruit cordial
Colouring	• Adds colour to food • Makes food look more attractive	Pandan leaf, turmeric, milk, caramel, coconut milk (natural)	Cakes, drinks, candy, turmeric rice, ice cream
		Tartrazine (artificial)	Soft drinks, candy
		Sunset yellow (artificial)	Orange-coloured cordial
		Carmoisine (artificial)	Red-coloured cordial
Bleach	• Bleaches unwanted natural colour from food	Activated carbon (natural)	Palm oil, cane sugar
		Benzoyl peroxide (artificial)	Sugar, white rice, flour, rice noodle
Flavouring	• Improves the taste of food • Makes food more delicious and fragrant • Enhances the natural flavour of food	Sugar, salt, vinegar, pandan leaf, vanilla (natural)	Cakes, ice cream
		Monosodium glutamate (MSG) (artificial)	Instant noodle, soy sauce, potato chips
Stabiliser	• Prevents deposition of granules in liquid food • Improves texture and thickens food	Starch (natural)	Chilli sauce, ketchup
		Gelatine (natural)	Jelly
		Agar (natural)	Ice cream, instant soup, jelly
		Acacia gum (natural)	Ice cream, candy, jelly

Chemical substance	Functions	Examples of chemical substance (natural or artificial)	Examples of food
Sweetener	• Sweetens food and drinks	Sugar, palm sugar, honey (natural)	Cakes, drinks
		Aspartame (artificial)	Cordial, drinks, jam
		Sorbitol (artificial)	Food for diabetic patients
Antioxidant	• Slows down the oxidation of fatty food • Prevents fruits and vegetables from turning brown	Ascorbic acid, vitamin C (natural)	Cooking oil
		Tocopherol, vitamin E (natural)	Margarine, biscuit
		Butylated hydroxyanisole (artificial)	Vitamin pills
Emulsifier	• Emulsifies substances which do not mix such as fat and water in food • Improves homogeneity, stability and texture of food	Lecithin from egg yolk or soya beans (natural)	Ice cream, chocolate
		Pectin (natural)	Mayonnaise, pudding
		Fatty acid such as monoglyceride (natural), magnesium stearate (artificial)	Yoghurt, cheese

The impacts of excess chemical substances in food processing on human health are shown in Table 2.8.

Table 2.8 Impacts of excess chemical substances in food processing on human health

Chemical substance	Impacts on health	
Preservative	• Cancer • Disrupts the human digestive system • Allergy, rash and itchy skin	• Foetal defects in mother's womb • Damages liver and kidney
Colouring	• Cancer • Infertility	• Food poisoning • Damages liver and kidney
Bleach	• Cancer	• Food poisoning
Flavouring	• Cancer • High blood pressure • Heart diseases	• Mental retardation in children • Damages liver and kidney
Sweetener	• Cancer • Diabetes mellitus • Allergy, rash and itchy skin	• Obesity • Damages liver and kidney
Antioxidant	• Retards body growth • Damages liver and kidney	• Rash and itchy skin

Activity 2.7

21st Century Skills
- TPS, ISS, ICS
- Technology-based activity

To make a multimedia presentation on food processing methods, chemicals used in food processing and the impacts of using these chemical substances on human health

Instructions

1. Carry out this activity in groups.
2. Create a multimedia presentation on one of the following topics:
   (a) processing methods
   (b) chemical substances used in food processing with examples
   (c) the impacts of using chemical substances excessively in food processing on human health

Formative Practice 2.5

1. What is food processing?

2. State **four** purposes of processing food.

3. Name **four** methods of food processing.

4. Name the chemical substances used in processing the following food:
   (a) turmeric rice
   (b) chilli sauce
   (c) white rice

5. What is the use of activated carbon in the preparation of palm oil as cooking oil?

6. Figure 1 shows a method of food processing.

Figure 1

   (a) Name the food processing method.
   (b) Give **two** other examples of food that also use this food processing method for export purposes.
   (c) Give **one** reason for using this method of food processing.

2.6 Health Foods and Health Supplements

Health Foods

Health foods are natural food substances in a normal diet that maintain health and do not contain chemical substances.

Among the issues related to health foods are availability, high price, processing method and chemical substances used in food processing.

Photograph 2.28 Examples of health foods

Health Supplements

Health supplements are nutrients taken in the form of capsule, pill, liquid and powder in pre-determined doses.

Photograph 2.29
Examples of health supplements

Nutrients such as minerals, vitamins, carbohydrate and fibre found in health supplements are usually in small quantities but high in concentration. What is the importance of taking health supplements in recommended doses?

Among the issues related to health supplements is taking dosage according to health requirements. As individual body requirements vary, it is difficult to accurately determine the required dosage of health supplements. Consequently, taking insufficient or excessive health supplements frequently occurs and this may affect the user negatively.

BRAIN TEASER

If an individual experiences lack of red blood cells, what type of mineral in health supplements should be consumed? Give a reason.

National Food Safety Policy

The National Food Safety Policy is enforced by the Food Safety and Quality Division, Ministry of Health through food safety programmes. This policy is aimed at protecting the public from:

- risks of consuming food and drinks which endanger health
- fake health foods and health supplements

Furthermore, this policy promotes the local and global food trade.

The Drug Control Authority (DCA) is entrusted to register and monitor health supplements and traditional medicine before being marketed. Stickers with labels and QR codes will be affixed to bottles or boxes of health supplements and traditional medicine which have been approved and registered (Photograph 2.30).

In addition to the use of labels and QR codes, emphasis is also placed on efforts to raise public awareness through consumer education.

Advertisements and marketing methods on the quality of health foods and supplements are often confusing which makes it difficult for consumers to choose the right health food for their needs. To protect the welfare and facilitate the food selection process of consumers, the Malaysian government monitors food quality through the **Food Act 1983** and the **Food Regulations 1985**.

Photograph 2.30
Example of label and QR code for health supplements approved by MOH

Click@Web

National Pharmaceutical Regulatory Agency
http://buku-teks.com/sc5084a

Registration of health supplements
http://buku-teks.com/sc5084b

Food Act 1983

The **Food Act 1983** is a Malaysian legislation enforced by the government to protect the public from dangers of health and fraud related to the preparation, sale and use of food, as well as any matters related to them. In short, any parties found selling poisoned food or food that damages the health of users will be fined or jailed, or both if found guilty by the court of law.

Click@Web

Food Act 1983
http://buku-teks.com/sc5084c

Food Regulations 1985

Food Regulations 1985 are laws drafted under the **Food Act 1983** which are enforced by the Ministry of Health Malaysia and local authorities to help the public obtain food that is safe, of good quality, clean and free from any poisonous contaminants.

For example, according to Food Regulations 1985, the information on food labels should contain details as in Figure 2.15.

Click@Web

Food Regulations 1985, updated January 2018
http://buku-teks.com/sc5085

BRAIN TEASER

Why is Food Regulations 1985 frequently updated?

EXAMPLE OF FOOD LABEL

NUTRITIONAL QUALITY
Shows the nutritional quality of the product.

NAME OF FOOD
The name of food must be clear, accurate and not confusing.

NUTRITIONAL LABEL
Information about the nutritional content of the product.

LIST OF INGREDIENTS
Ingredients used in the product listed according to weight in descending order.

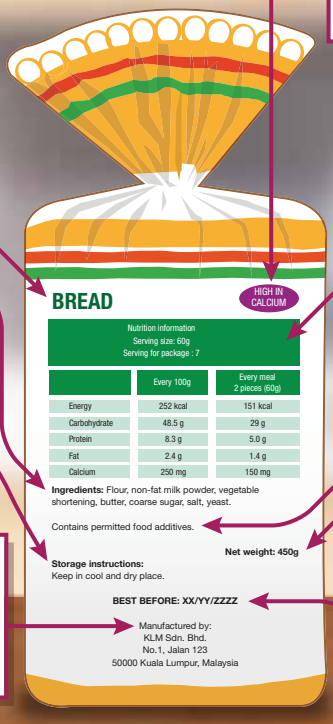
STATEMENT ON FOOD ADDITIVES
All permitted food additives such as preservatives, colouring, flavouring, additional flavours, antioxidants and conditioners should be stated.

STORING INSTRUCTIONS
Follow the recommended storing instructions.

STATEMENT ON QUANTITY/ WEIGHT/VOLUME
Statement on the net weight or volume or minimum quantity of contents.

MANUFACTURING INFORMATION
Name and address of manufacturer/packaging/agent (including imported product).

EXPIRY DATE
Make sure that the chosen food is not past its expiry date.



(Source: Food Safety and Quality Division, Ministry of Health Malaysia)

Figure 2.15 Food label

Halal Food Status

Recall eateries or food products which display the Halal Malaysia logo (Photograph 2.31). Eateries or food products which display the Halal Malaysia logo certify that the food sold in the eatery or the food product is *halal*.

Photograph 2.31 Halal Malaysia logo

My Malaysia

Malaysia's success and its global recognition in *halal* certification is well known amongst the *halal* industries. Why is *halal* certification important for Malaysia's economy?
http://buku-teks.com/sc5086a
(Medium: *bahasa Melayu*)

Click@Web

Definition of *halal*
http://buku-teks.com/sc5086b
(Medium: *bahasa Melayu*)

Activity 2.8

To gather information and discuss health foods, health supplements, Food Act 1983, Food Regulations 1985, *halal* food status and Malaysia Halal Certification

21st Century Skills
- ICS, ISS
- Discussion

Instructions

1. Carry out this activity in groups.
2. Gather information on health food, health supplements, Food Act 1983, Food Regulations 1985, *halal* food status and Malaysia Halal Certification from the Internet, print media and electronic media.
3. Discuss the information gathered.
4. Present the outcome of your group discussion using a multimedia presentation.

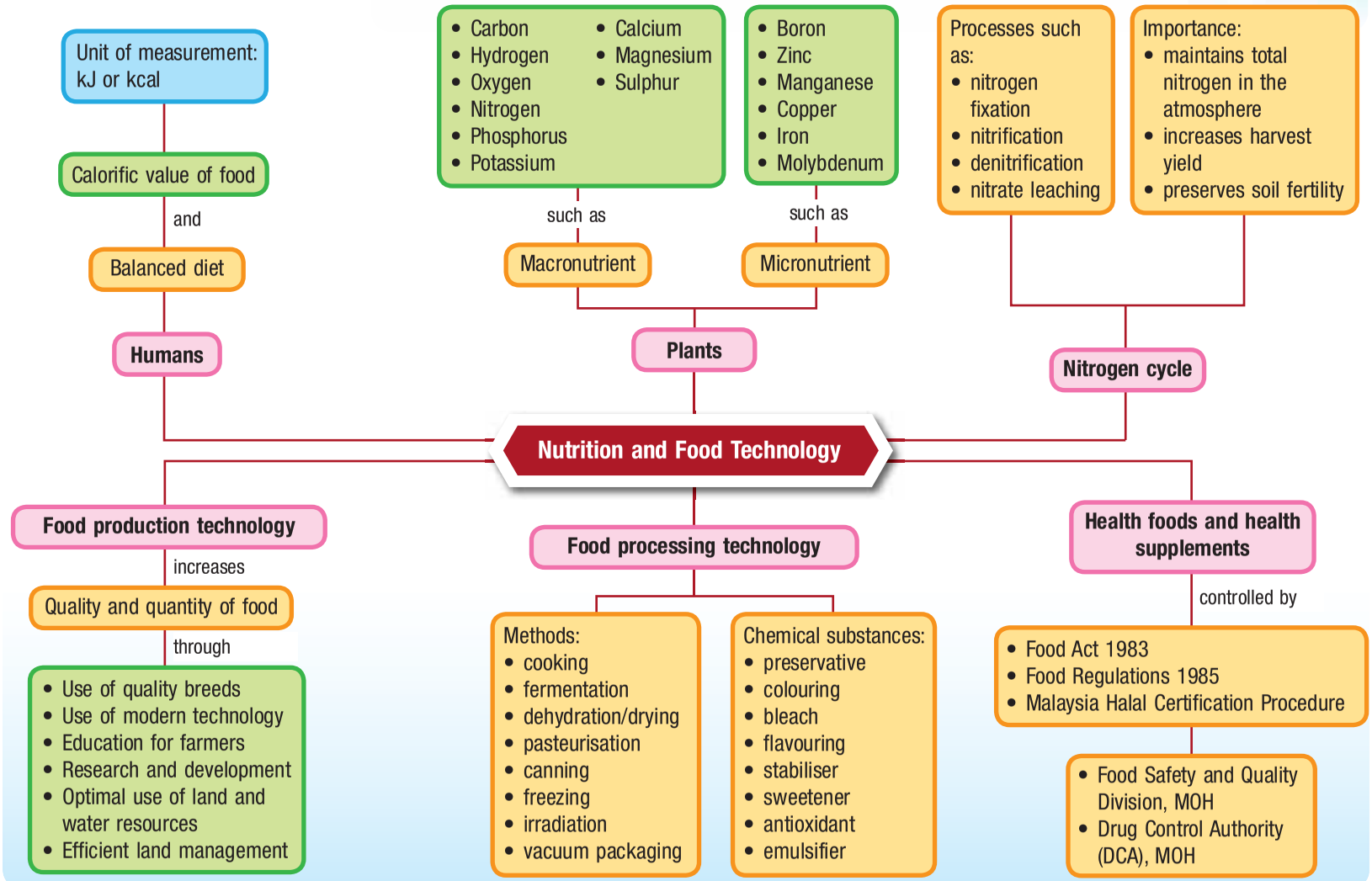
Click@Web

Malaysian Halal Certification Procedure Manual
http://buku-teks.com/sc5086c

Formative Practice 2.6

1. What is health food? Give **one** example of health food.
2. What is health supplement? Give **one** example of health supplement.
3. Name the body which monitors national food safety and approves the marketing of health supplements and traditional medicine in Malaysia.
4. What act was drafted in Malaysia to protect the welfare of users from dangers of health and fraud related to food?

Summary


Unit of measurement: kJ or kcal
Calorific value of food
and
Balanced diet
Humans
Carbon
Hydrogen
Oxygen
Nitrogen
Phosphorus
Potassium
Calcium
Magnesium
Sulphur
such as
Macronutrient
Boron
Zinc
Manganese
Copper
Iron
Molybdenum
such as
Micronutrient
Plants
Processes such as:
nitrogen fixation
nitrification
denitrification
nitrate leaching
Importance:
maintains total nitrogen in the atmosphere
increases harvest yield
preserves soil fertility
Nitrogen cycle
Nutrition and Food Technology
Food production technology
increases
Quality and quantity of food
through
Use of quality breeds
Use of modern technology
Education for farmers
Research and development
Optimal use of land and water resources
Efficient land management
Food processing technology
Methods:
cooking
fermentation
dehydration/drying
pasteurisation
canning
freezing
irradiation
vacuum packaging
Chemical substances:
preservative
colouring
bleach
flavouring
stabiliser
sweetener
antioxidant
emulsifier
Health foods and health supplements
controlled by
Food Act 1983
Food Regulations 1985
Malaysia Halal Certification Procedure
Food Safety and Quality Division, MOH
Drug Control Authority (DCA), MOH

Self-Reflection

After studying this chapter, you are able to:

2.1 Balanced Diet and Calorific Value

- ☐ Describe a balanced diet.
- ☐ Conduct an experiment to estimate the calorific value in food samples.
- ☐ Justify the effects of consuming calories that do not meet an individual's requirements.

2.2 Nutrient Requirements in Plants

- ☐ Explain with examples the functions of macronutrients and micronutrients in plants.
- ☐ Conduct an experiment to study the effects of macronutrient deficiency in plants.

2.3 Nitrogen Cycle

- ☐ Communicate about the nitrogen cycle and its importance.

2.4 Food Production Technology

- ☐ Communicate about ways to improve resources, food quality and quantity of food production.
- ☐ Evaluate the use of pesticides and biological control to increase the quality and quantity of food production.

2.5 Food Processing Technology

- ☐ Communicate about food processing technology.

2.6 Health Foods and Health Supplements

- ☐ Communicate about issues related to health foods and health supplements.
- ☐ Communicate about issues related to *halal* food status.

Summative Practice 2

Quiz
http://buku-teks.com/sc5088

Answer the following questions:

1. Study the following situation.

> The diet of Eskimos normally contains meat rich in fat such as whale meat. The consumption of whale meat can warm the body.

(a) Suggest **one** hypothesis to investigate the above situation.

(b) Based on the situation given, plan and describe an experiment to compare the calorific values of fat and another type of food such as carbohydrate and protein using a calorimeter.

Your description should contain the following aspects:

(i) aim of experiment
(ii) identification of variables
(iii) list of materials and apparatus
(iv) procedure or method
(v) tabulation of data

2. Table 1 shows the average daily energy requirements of females aged between 5 and 40 years old.

Table 1

Age (years)	Average daily energy requirement (kJ)
5	5 500
10	8 000
15	9 500
20	11 000
25	13 500
30	12 000
35	10 500
40	10 000

(a) Using the data in Table 1, draw a graph of average daily energy requirement against age.

(b) Based on the graph in question 2(a), state the average daily energy requirement for a 12-year-old individual.

(c) What is the relationship between average daily energy requirement and age between 30 and 40 years?

Enrichment Practice

3. Nowadays, Malaysia exports local durians to other countries like China and Singapore. The exported durians are processed using vacuum packaging to prevent the release of its strong smell into the air. Besides durian, other fruits such as jackfruit and *cempedak* also release strong smells into the air.

(a) Using the items shown in Figure 1, explain the vacuum packaging method for *cempedak*.

(b) Explain how the bicycle pump functions as a vacuum pump.

(c) How is the effectiveness of the vacuum packaging evaluated?

Cempedak

Bicycle pump

Plastic bag

Sealing machine for plastic bag

Figure 1

CHAPTER 3

SUSTAINABILITY OF THE ENVIRONMENT

Why do solar cells which do not release carbon dioxide into the atmosphere have carbon footprint?

Why are plastic bags being replaced with paper bags for environmental sustainability?

Are electric cars zero-emission vehicles?

What are the international organisations that play an important role in addressing environmental issues?

Let's study

- Product life cycle
- Environmental pollution
- Preservation and conservation of the environment

Science Bulletin

Upcycle is a recycling process to produce new products of higher value than the original product. The above photograph shows a sofa made from recycled waste paper. Is this sofa an upcycle product?

Keywords

- Upcycle
- Product life cycle
- Carbon footprint
- Carbon handprint
- Greenhouse gas
- Cradle-to-cradle life cycle of a product
- Cradle-to-grave life cycle of a product
- Microplastics
- Biochemical Oxygen Demand (BOD)
- Effective microorganism
- Negative Emission Technologies
- Zero carbon emission

3.1 Product Life Cycle

Carbon Footprint

Carbon footprint refers to the **total amount of carbon dioxide** released into the atmosphere as a result of the activities of an **individual, event, organisation, community** or **products** which are used in daily life.

Identify and discuss processes which influence **carbon footprint** (Figure 3.1). Name two processes in Figure 3.1 that can reduce carbon footprint.

The carbon footprint study of an individual begins by breaking down the products used in a day. As an example, the refrigerator represents a product that is used throughout the day in the life of an individual from the early hours of the morning until bedtime.

Figure 3.1 Carbon footprint

Figure 3.2 Energy efficiency labels

Science Info

Offset refers to processes that can reduce the release of greenhouse gases such as planting of green plants.

Study the energy efficiency labels in Figure 3.2. What is the relationship between the energy efficiency label on an electrical appliance with its carbon footprint?

Photograph 3.1 shows an example of a carbon footprint label on a food product. Based on the label, 900 g of carbon dioxide (CO_2) is released for every 500 ml.

Photograph 3.1 Example of carbon footprint label

Let us carry out Activity 3.1 to break down the products used in the daily life of an individual.

Activity 3.1

21st Century Skills
- ICS, TPS, ISS
- Inquiry-based activity

To break down the products used in the daily life of an individual

Instructions

1. Carry out this activity individually.
2. Choose an electrical lighting device (filament lamp, energy-saving lamp or LED lamp).
3. Observe and record in the table:
   - power of the electrical lighting device in kilowatts (kW)
   - frequency of its use in a day from wake-up until bedtime in hours (h)
4. Calculate and record the electrical energy used by the electrical lighting device in kilowatt-hours (kWh) (refer to the example given).
5. Calculate and record the mass of carbon dioxide released from using the electrical lighting device for one day by using the following formula:

$$\text{Amount of carbon dioxide released (g)} = \frac{\text{Electrical energy used (kWh)}}{50 \text{ kWh}} \times 39 \text{ g}$$

(Assumption: A usage of 50 kWh of electrical energy produces 39 g of carbon dioxide)

Observation

Example:

Electrical lighting device	LED lamp
Power of electrical lighting device (kW)	0.009
Frequency of use in one day (h)	5
Electrical energy used in one day (kWh)	0.045
Amount of carbon dioxide released into the air (g)	0.0351
Carbon footprint of the electrical lighting device used in a day (g)	0.0351

Discussion

1. Discuss the carbon footprint of the electrical lighting device you used with your classmates.
2. Discuss ways on how to reduce the carbon footprint of the device.

Besides carbon footprint, some questions that need to be considered regarding products used in daily life to preserve the sustainability of the environment include:

- Is the product environmentally friendly?
- What are the negative impacts of the manufacturing process of the product?
- Is the product safe to be used?
- How much waste is produced after the product is used?
- What other products can be produced from its waste (Photograph 3.2)?

Photograph 3.2 Coffee waste can be used as a fertiliser

Carbon Footprint and Carbon Handprint of a Product

The **carbon footprint** of a product refers to the **negative impacts** on environmental sustainability caused by the product throughout its **life cycle**.

The **carbon handprint** of a product refers to the **positive impacts** on environmental sustainability caused by the product throughout its **life cycle**.

Figure 3.3 Carbon footprint and handprint

The **carbon handprint** of a product is aimed at reducing its carbon footprint and increasing its positive impacts on environmental sustainability. Some of the **carbon handprint** steps to reduce greenhouse gas emissions throughout the life cycle of a product are as follows:

Use of materials with low carbon footprint in product manufacturing

Non-renewable building materials, which emit a lot of greenhouse gases are replaced with renewable building materials, which emit less greenhouse gases. As an example, cement is replaced with timber.

Cement

Timber

Photograph 3.3 Building materials

Extending the life cycle and increasing the efficiency of a product

Solar panels

Rechargeable batteries and solar panels are examples of products with extended life cycle and increased energy efficiency.

Rechargeable battery

Photograph 3.4 Products with extended life cycle and increased energy efficiency

Use of energy that emits less greenhouse gases and highly-efficient energy converters

Electrical energy is generated by power stations such as hydroelectric power stations which use renewable energy sources and do not emit greenhouse gases into the atmosphere. Is the use of electrical appliances carrying 5-star energy efficiency label a carbon handprint measure? Give your reasons.

Photograph 3.5
Bakun hydroelectric power station

Carbon handprint measures

Efficient management of waste towards environmental sustainability

The 5R (Refuse, Reduce, Recycle, Reuse, Rot) concept of waste management reduces waste by:

- refusing unnecessary products
- reducing the quantity of products used
- recycling products
- reusing products
- enabling the rotting of waste through composting

Photograph 3.6
Reuse of products

Elimination of greenhouse gases and storage of carbon dioxide in carbon sinks

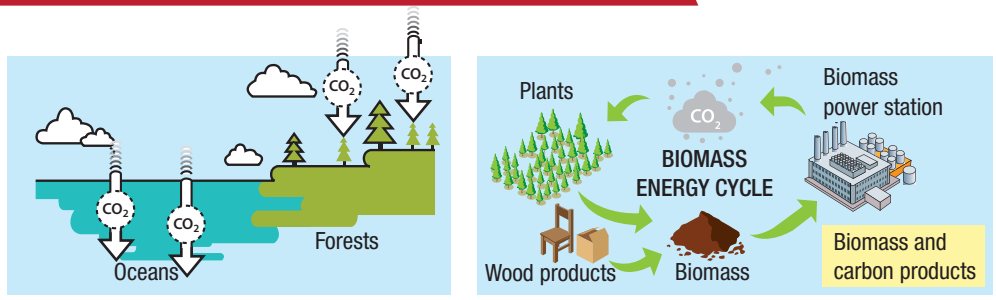


Figure 3.4 Elimination and storage of carbon dioxide in carbon sinks

Carbon sinks are natural places such as forests and oceans that remove carbon dioxide from the air. The reduction of carbon dioxide in the air occurs when carbon dioxide dissolves in seawater and when it is absorbed by green plants in the forests. Carbon accumulated in **biomass** can also help to reduce carbon dioxide in the air.

Video
Carbon sink
http://buku-teks.com/sc5095

Life Cycle of a Product

The common life cycle of a product starts from source to disposal either through recycling (cradle-to-cradle life cycle) or decay (cradle-to-grave life cycle) (Figure 3.5).

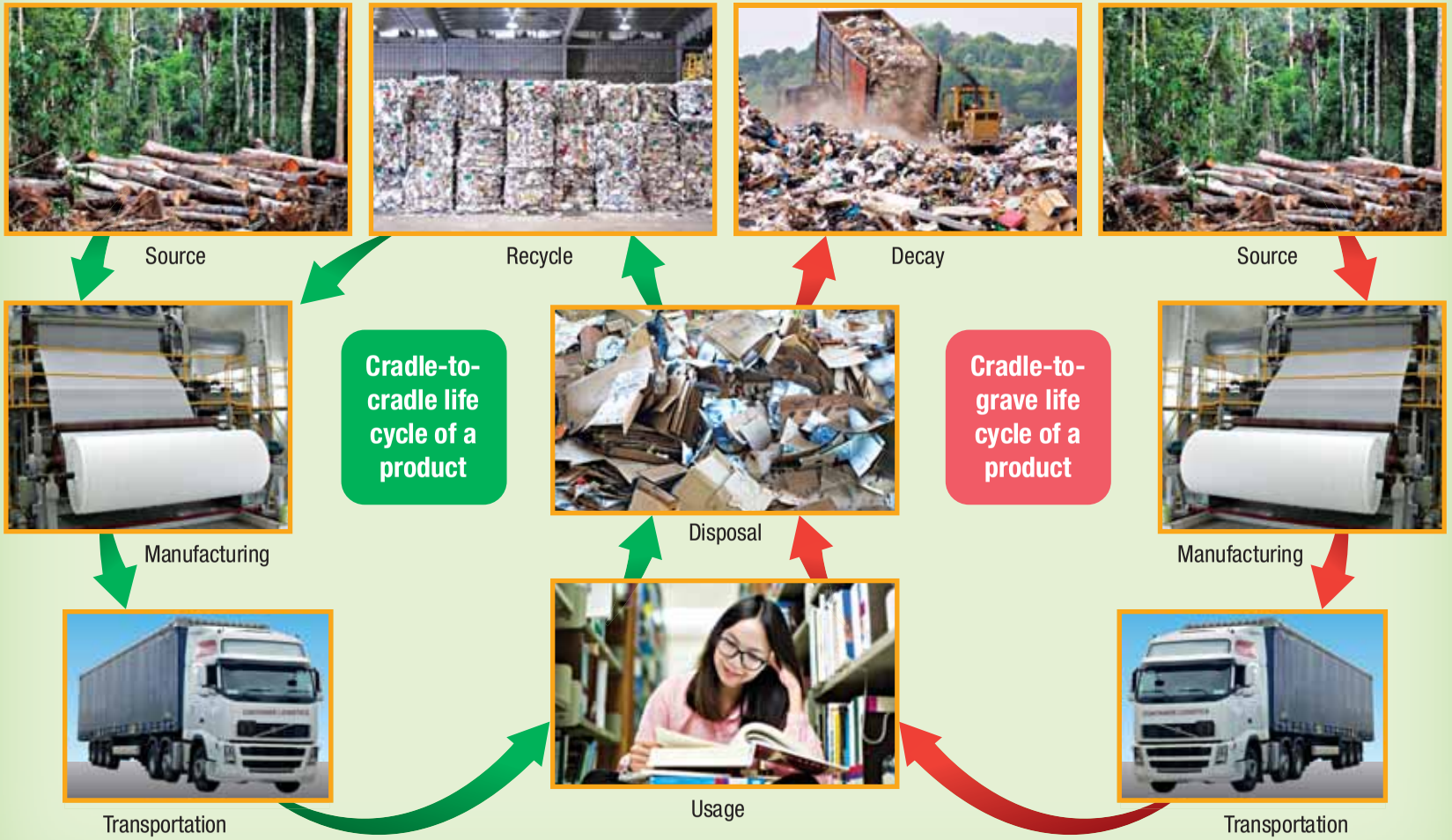


Figure 3.5 Life cycle of a product

Activity 3.2

21st Century Skills
- ICS, TPS
- Inquiry-based activity

To sketch the common life cycle of a product from source to disposal either through recycling or decay

Instructions

1. Carry out this activity in groups.
2. Gather and analyse information on the common life cycle of:
   (a) a product from source to disposal through recycling (cradle-to-cradle life cycle of a product)
   (b) a product from source to disposal through decay (cradle-to-grave life cycle of a product)
3. Discuss the information analysed and sketch the life cycles of both products.
4. Present the life cycle sketches of the chosen products to the class.
5. Conduct a 'Gallery Walk'.

Efficient Management of Plastic Waste towards Environmental Sustainability

In this modern era, our society must manage plastic waste using an efficient management idea towards environmental sustainability. For example, the recycling process, upcycle represents an efficient management idea that can be used to produce a new plastic product.

Photograph 3.7 shows a plastic broom as a new product of a higher value than its original product, used plastic bottles.

Photograph 3.7 Plastic broom made from used plastic bottles

3.1.4 3.1.5

Activity 3.3

21st Century Skills
- TPS, STEM
- Project-based activity

To generate ideas about efficient management of plastic waste towards environmental sustainability based on projects using the STEM approach

Instructions

1. Carry out this activity in groups in a safe area in your school or neighbourhood to study the following statement:

   > Plastic pollution is the accumulation of plastic products that has adverse effects on the environment, wildlife, their habitats and humans. Furthermore, the chemical structure of most plastics allows them to withstand the natural decomposition process and take a longer time to decompose.

2. Carry out a project using the STEM approach to generate ideas on the efficient management of plastic waste towards environmental sustainability through the following actions:
   (a) conduct a study on plastic pollution
   (b) gather data and run a campaign on the impact of plastic use to raise awareness in the school and local communities
3. Gather and analyse information or available solutions from relevant and reliable sources, for example:
   Modul Teknologi Hijau Kimia, CETREE USM.
   Title: *Melestarikan Polimer Mesra Alam* (Student's Activity) page 47
   http://buku-teks.com/sc5098
   Note: *Modul Teknologi Hijau*, prepared by CETREE USM, is only available in *bahasa Melayu*.
4. Discuss the creative and innovative ideas generated among your group members. Then, present the outcome of your group discussion to the class.

Microplastics in the Food Chain

According to the U.S. National Oceanic and Atmospheric Administration (NOAA), **microplastics** are plastic pieces, less than 5 mm in length, which can become hazardous if found inside the body of aquatic organisms. The main source of microplastics is plastic waste from various types of plastic products such as bottles, man-made textiles, paint and discarded electronic devices.

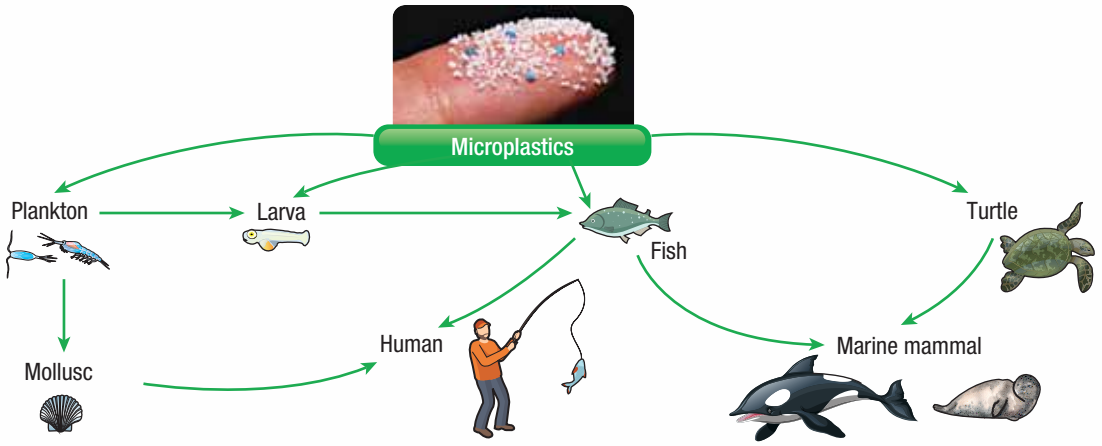


Figure 3.6 Microplastics in a food web

Figure 3.6 shows the transfer of microplastics between various types of organisms through the **food web** until they end up in humans and marine mammals.

The issue of microplastics in the food chain can be solved by reducing plastic waste and the use of plastic products. Do you agree that the use of plastic products such as plastic bags and plastic straws in supermarkets and restaurants should be stopped? Give your reasons.

Formative Practice 3.1

1. What is meant by carbon footprint?
2. State **seven** factors that normally influence the impact of a product that is used in an individual's daily life on environmental sustainability.
3. What is the difference between carbon footprint and carbon handprint of a product?
4. State **two** types of common life cycles of a product.
5. What is upcycle?
6. What is the issue of microplastics that is associated with the food web?

3.2 Environmental Pollution

Types and Sources of Environmental Pollution

Environmental pollution refers to the unwanted changes in the physical, chemical or biological characteristics of environmental components, that is, air, water and soil. Environmental pollution causes harm and discomfort to all life forms. Environmental pollution also causes environmental issues such as flash floods.

Observe the types of environmental pollution shown in Figure 3.7.

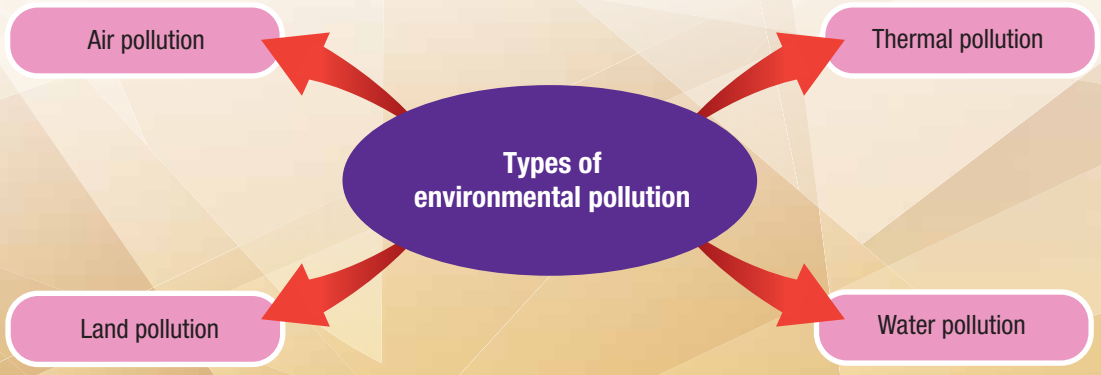


Figure 3.7 Types of environmental pollution

3.1.5 3.2.1

Observe and study the types and sources of environmental pollution in Table 3.1.
Do your own research and add other types and sources of environmental pollution, if any.

Table 3.1 Types and sources of environmental pollution

Type of environmental pollution	Sources of environmental pollution
Air pollution	• Burning of fossil and biomass fuels, automobile exhaust gases, decaying organic substances and waste which release greenhouse gases and various types of toxic gases such as sulphur dioxide into the air. • Natural air pollution – volcanic eruptions – forest fires – dust storms – decaying organic waste • Man-made air pollution – exhaust gases from motorised equipment or vehicles – blast furnaces – thermal power stations – industries and garbage disposal sites
Water pollution	• Waste – wastewater – domestic waste such as detergents and sewage – solid waste such as rubbish – industrial waste such as grease • Chemical substances used in agriculture such as chemical fertilisers and pesticides • Oil spills
Land pollution	• Excessive use of fertilisers and pesticides • Inappropriate management of solid waste • Acid rain • Nuclear waste • Electronic waste
Thermal pollution	• Deforestation • Industrial activities • Fuel combustion in vehicles or machines

Activity 3.4

To use a graphic organiser to show types and sources of environmental pollution

21st Century Skills
- TPS, ICS, ISS
- Innovative activity

Instructions

1. Carry out this activity in groups.
2. Use a graphic organiser to present in a creative and innovative way, the types and sources of environmental pollution shown in Table 3.1.
3. Discuss and improve on the graphic organiser of your group.
4. Present your group's graphic organiser to the class.

Level of Water Pollution from Domestic Waste

Air Pollutant Index (API) is the air pollution parameter which is measured to determine air pollution level while **Biochemical Oxygen Demand (BOD)** is the water pollution parameter which is measured to determine water pollution level.

Eutrophication is the ecosystem response towards an increase of phosphate ions and nitrate ions (from detergents, fertilisers and garbage) in an aquatic ecosystem. The rapid growth of algae in water bodies containing an excessive supply of nitrate ions is an example of eutrophication. The negative effects of eutrophication include reduced oxygen content in water that can cause the death of aquatic animals and plants.

Observe Photograph 3.8. Why are animals and plants unable to live in the lake shown in the photograph?

Photograph 3.8 Effects of eutrophication

3.2.1 3.2.2

Biochemical Oxygen Demand (BOD)

Biochemical Oxygen Demand (BOD) is the amount of dissolved oxygen needed by microorganisms such as bacteria to decompose organic substances in a water resource. The higher the BOD of a water sample, the more microorganisms can be found in it. What is the relationship between BOD and level of water pollution in a water sample?

The level of water pollution in a water sample can be determined by measuring the time taken for methylene blue solution to decolourise after being mixed with the water sample. When methylene blue solution is added to a contaminated water sample with a low concentration of dissolved oxygen, the blue colour of the solution will decolourise rapidly. The higher the level of water pollution, the shorter the time taken for the methylene blue solution to decolourise.

Activity 3.5

21st Century Skills
- TPS
- Inquiry-based activity

To determine the water pollution level in different water samples

Materials

0.1% methylene blue solution and four different water samples (200 cm^3 for each sample)

Apparatus

Four reagent bottles fitted with covers, syringe, watch and measuring cylinder

Safety Precautions

Make sure the needle of the syringe is placed under the surface of the water sample when adding the methylene blue solution.

Instructions

1. Prepare the apparatus set-up shown in Figure 3.8.

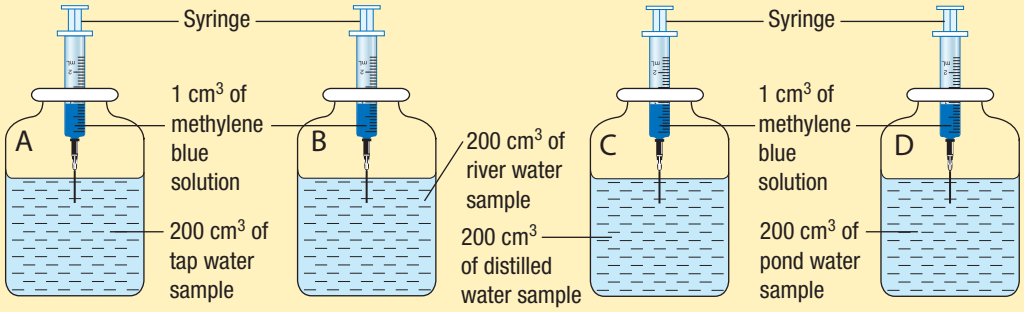


Figure 3.8

2. Add 1 cm^3 of methylene blue solution into each reagent bottle A, B, C and D, using a syringe and close all the reagent bottles.
3. Keep all the reagent bottles in a dark cupboard.
4. Observe the colour of the water samples every 30 minutes and record the time taken for the methylene blue solution to decolourise.

Observation

Reagent bottle	Type of water sample	Time taken for methylene blue solution to decolourise (minute)
A	Tap water	
B	River water	
C	Distilled water	
D	Pond water	

Questions

1. What is the use of methylene blue solution in this activity?
2. What is the relationship between the time taken for the methylene blue solution to decolourise and the amount of dissolved oxygen in the water sample?
3. Which water sample is the most polluted? Explain your answer.

Click@Web

Experiment to determine water pollution level by measuring the time taken for methylene blue solution to decolourise
http://buku-teks.com/sc5103
(Medium: *bahasa Melayu*)

Purification Method for Contaminated Water using Green Technology

Use of Effective Microorganism Mud Balls (EM Mud Balls)

Efforts to invent purification methods for contaminated water using Green Technology is a continual process in Malaysia. Among the Green Technology methods used to treat contaminated rivers in Malaysia include the use of effective microorganism mud balls (EM mud balls) as shown in Photograph 3.9.

Photograph 3.9 Effective microorganism mud balls (EM mud balls)

3.2.2 3.2.3

Science Info

Effective microorganisms (EM) are made up of the following **three** types of microorganisms:

Lactic acid bacteria such as *Lactobacillus casei*
Lactobacillus casei treats sewage, eliminates foul odour in water, stunts the growth of dangerous microorganisms, and facilitates the decay of organic substances.

Photosynthetic bacteria such as *Rhodopseudomonas palustris*
Photosynthetic bacteria use organic substances to synthesise useful substances such as amino acid and sugar for aquatic animals and plants to feed on.

Yeast (*Saccharomyces cerevisiae*)
Yeast produces substances needed for the growth of green plants.

Activity 3.6

21st Century Skills
- TPS
- Inquiry-based activity

To make EM mud balls to treat polluted water

Materials

1.4 kg of soil, 70 g of EM Bokashi or rice bran, 500 cm^3 of EM solution and newspaper

Apparatus

Tray, watering can and basin

Instructions

1. Carry out this activity in groups.
2. Prepare materials to make 10 EM mud balls according to the procedure shown in Figure 3.9.

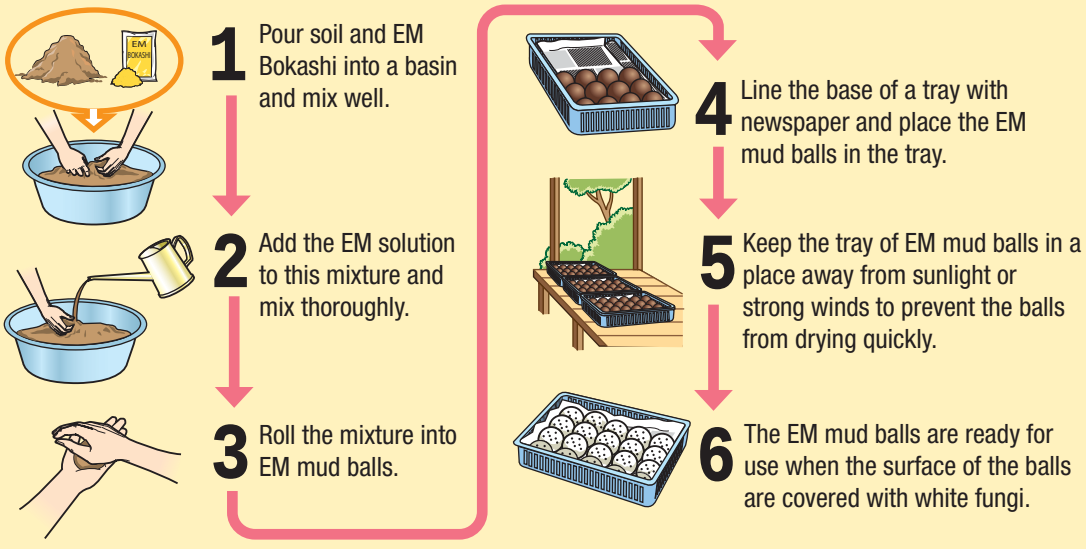


Figure 3.9

3. The EM mud balls can be used to treat polluted water resources.

Thinking Skills

"LOVE OUR RIVERS" CAMPAIGN
Gather and study information on the effectiveness of the "Love Our Rivers" campaign
http://buku-teks.com/sc5105
(Medium: *bahasa Melayu*)

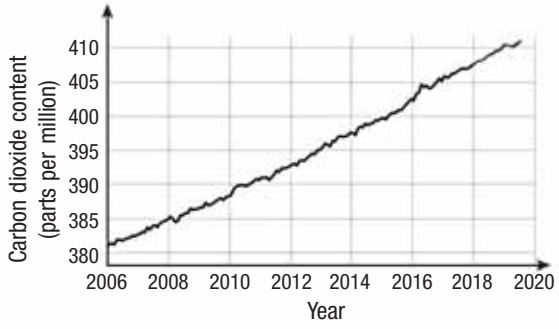
Formative Practice 3.2

1. Name **three** types of environmental pollution.
2. (a) What is eutrophication?
   (b) Name the type of pollution related to eutrophication.
3. Name **one** type of pollution which causes the following harmful effects:
   (a) greenhouse effect and global warming
   (b) climate change
4. (a) What is Biochemical Oxygen Demand (BOD)?
   (b) What is the relationship between BOD and the level of water pollution in a water sample?
5. How does methylene blue solution function as an indicator of the water pollution level in a water sample?
6. (a) Name the microorganisms used to make effective microorganism mud balls (EM mud balls).
   (b) How do effective microorganisms treat polluted water?

3.3 Preservation and Conservation of the Environment

Based on Figure 3.10, answer the following questions.

- What can be observed about the carbon dioxide content in the atmosphere from 2006 till 2019?
- What are the harmful effects of high carbon dioxide content in the atmosphere?
- Why does every individual need to play a role in reducing the content of carbon dioxide in the atmosphere?



Source: https://climate.nasa.gov/

Figure 3.10 Graph of carbon dioxide content in the atmosphere

3.2.3 3.3.1

Negative Emission Technologies

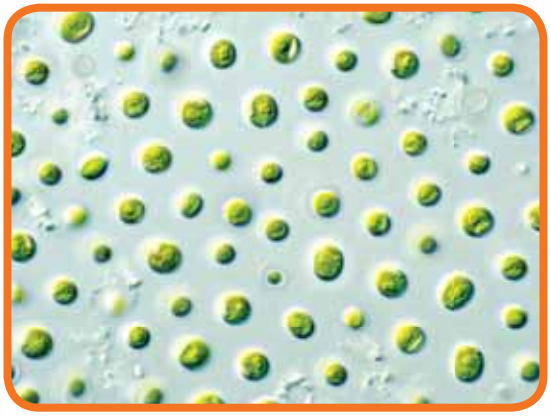
Negative Emission Technologies are technologies that remove the carbon dioxide content in the atmosphere.

One way is by using microalgae. What is the process carried out by microalgae that can help reduce the carbon dioxide content in the atmosphere?

The microalgae commonly used in Negative Emission Technologies are **marine microalgae**, that is, microscopic algae which live, grow and reproduce abundantly in seawater. Photograph 3.10 shows marine microalgae under an electron microscope. Marine microalgae are suitable for use in Negative Emission Technologies because these microalgae reduce the carbon dioxide content in the atmosphere through photosynthesis (Photograph 3.11).

Video

The use of microalgae in Negative Emission Technologies
http://buku-teks.com/sc5106a



Photograph 3.10 Marine microalgae under an electron microscope

Photograph 3.11 Microalgae plant used in Negative Emission Technologies

Science Info

Eco currency

The preservation and conservation of the environment requires global efforts to manage natural resources. As such, a type of universal currency known as eco currency has been proposed as a medium of exchange in transactions as one of the many efforts to maintain environmental balance.

Click@Web

Introduction of the term eco currency
http://buku-teks.com/sc5106b

Video

Importance of eco currency
http://buku-teks.com/sc5106c

Activity 3.7

21st Century Skills
- ICS, TPS
- Discussion

To discuss the use of Negative Emission Technologies and Green Technology in several sectors

Instructions

1. Carry out this activity in groups.
2. Gather and discuss information on the following:
   (a) use of Negative Emission Technologies to reduce the carbon dioxide content in the atmosphere
   (b) use of Green Technology in the following sectors:
      (i) solar technology
      (ii) green buildings
      (iii) zero carbon emission
      (iv) biodiesel
      (v) hybrid cars

References

Modul Teknologi Hijau Fizik, CETREE USM
Title: *Tenaga Solar dan Matahariku*

http://buku-teks.com/sc5107a
pages 42 – 51

http://buku-teks.com/sc5107b
pages 66 – 87

Modul Teknologi Hijau Fizik, CETREE USM
Title: *Bangunan Mesra Hijau*

http://buku-teks.com/sc5107a
pages 61 – 73

http://buku-teks.com/sc5107b
pages 107 – 131

Modul Teknologi Hijau Biologi, CETREE USM
Title: *Teknologi Penanaman Vertikal ke arah Pertanian Lestari*

http://buku-teks.com/sc5107c
pages 28 – 39

http://buku-teks.com/sc5107d
pages 31 – 59

Note: *Modul Teknologi Hijau*, prepared by CETREE USM, is only available in *bahasa Melayu*

3. Present the outcome of your group discussion in the form of a multimedia presentation.

The Role of United Nations (UN) in Addressing Global Environmental Issues

The United Nations (UN) plays an effective role in addressing global environmental issues. UN increases the cooperation and efforts of countries around the world to address global environmental issues through the following ways:

- finds solutions to address issues related to global climate change by sponsoring international conferences and agreements signed by the global community
- secures adequate supply of clean drinking water
- protects the ozone layer by banning the use of chlorofluorocarbon which causes the thinning of the ozone layer
- bans the use of toxic chemical substances such as DDT pesticides

Science Info

The international conferences and agreements sponsored by UN to promote cooperation and joint efforts among countries of the world include:

- the Rio Conference or United Nations Conference on Environment and Development (UNCED) in 1992, to address global environmental issues
- the Kyoto Protocol in 1997, to reduce the emission of greenhouse gases
- the Paris Agreement in 2016, to reduce the content and emission of greenhouse gases and limit the rise in global temperature by 1.5°C.

Activity 3.8

21st Century Skills
- ICS, ISS, TPS
- Debate

To debate on the role of the United Nations (UN) on the basis of conventions that have been held such as the Rio Conference, Kyoto Protocol and Paris Agreement

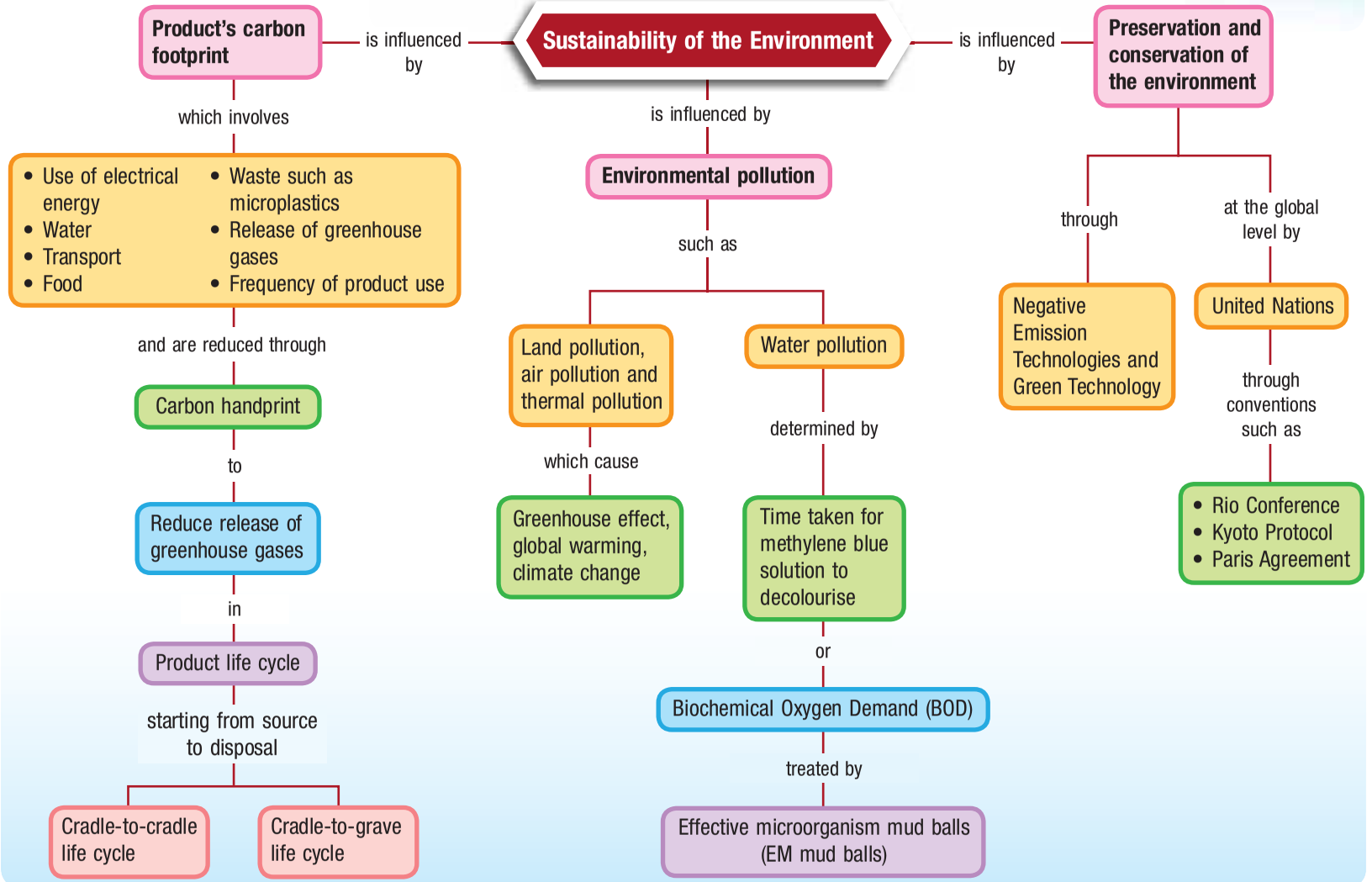
Instructions

1. Carry out this activity in groups.
2. Gather information from the Internet, print media and other electronic media on the role of the United Nations (UN) on the basis of conventions that have been held such as the Rio Conference, Kyoto Protocol and Paris Agreement.
3. Discuss the information gathered.
4. Conduct a debate.

Formative Practice 3.3

1. What are Negative Emission Technologies?
2. Give **one** example of microorganism used in Negative Emission Technologies.
3. What is the relationship between solar technology and zero carbon emission?
4. Why does the United Nations (UN) need to play an effective role in addressing environmental issues at the global level?

Summary


Sustainability of the Environment
is influenced by
Product's carbon footprint
which involves
• Use of electrical energy
• Water
• Transport
• Food
• Waste such as microplastics
• Release of greenhouse gases
• Frequency of product use
and are reduced through
Carbon handprint
to
Reduce release of greenhouse gases
in
Product life cycle
starting from source to disposal
Cradle-to-cradle life cycle
Cradle-to-grave life cycle
is influenced by
Environmental pollution
such as
Land pollution, air pollution and thermal pollution
which cause
Greenhouse effect, global warming, climate change
Water pollution
determined by
Time taken for methylene blue solution to decolourise
or
Biochemical Oxygen Demand (BOD)
treated by
Effective microorganism mud balls (EM mud balls)
is influenced by
Preservation and conservation of the environment
through
Negative Emission Technologies and Green Technology
at the global level by
United Nations
through conventions such as
• Rio Conference
• Kyoto Protocol
• Paris Agreement

Self-Reflection

After studying this chapter, you are able to:

3.1 Product Life Cycle

- ☐ Explain the meaning of carbon footprint.
- ☐ Break down the products used by an individual in a day.
- ☐ Justify the actions that need to be taken, that is, carbon handprint to reduce the greenhouse gas emissions in a day of one's life.
- ☐ Communicate about the life cycle of a product.
- ☐ Generate ideas about efficient management of plastic waste towards environmental sustainability.

3.2 Environmental Pollution

- ☐ Explain the types and sources of environmental pollution.
- ☐ Study the water pollution level from domestic waste.
- ☐ Create and design a purification method for contaminated water using Green Technology.

3.3 Preservation and Conservation of the Environment

- ☐ Justify the role of individuals in managing natural resources to maintain the balance in the environment.
- ☐ Debate on the role of the United Nations (UN) in addressing global environmental issues.

Summative Practice 3

Quiz
http://buku-teks.com/sc5110

Answer the following questions:

1. Figure 1 shows an experiment to study the level of water pollution in different water samples.

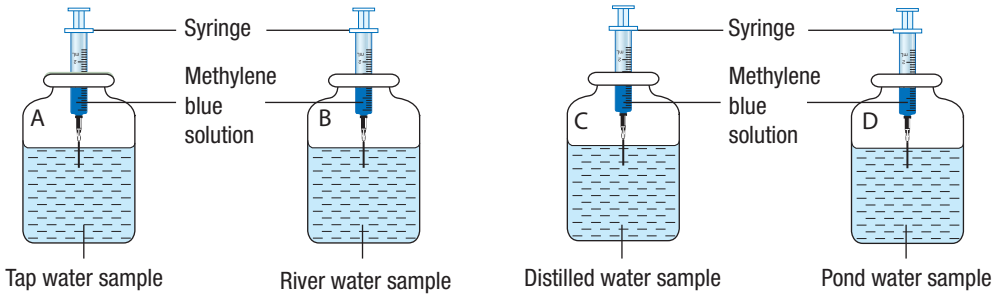


Figure 1

Table 1 shows the time taken for the methylene blue solution to decolourise in the different water samples in Figure 1.

Table 1

Reagent bottle	Type of water sample	Time taken for methylene blue solution to decolourise (hour)
A	Tap water	4
B	River water	1
C	Distilled water	The solution does not decolourise throughout the experiment
D	Pond water	2

(a) State **one** hypothesis for this experiment.

(b) State the variables in this experiment.
   (i) Constant variable
   (ii) Manipulated variable

(c) Based on Table 1, which water sample is the most polluted?

(d) Based on this experiment, state the relationship between the water pollution level and the time taken for methylene blue solution to decolourise.

2. Figure 2 shows two types of bags, which are, plastic bag and paper bag.

(a) Which of the bags shown in Figure 2 is more environmental-friendly?

(b) Give **one** reason for your answer in question 2(a).

(c) What is microplastic?

(d) Give **two** examples of plastic products which produce microplastic waste.

(e) State **one** difference between the carbon footprint and carbon handprint of a product.

Plastic bag Paper bag

Figure 2

3. (a) Figure 3 shows the symbol for carbon footprint. State **four** activities that can be related to carbon footprint.

Figure 3

(b) Figure 4 shows various types of environmental pollution.

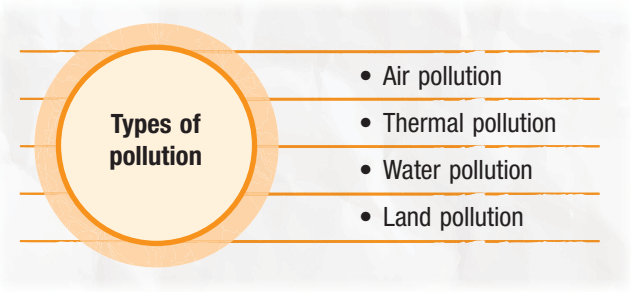


Figure 4

Study the information in Figure 4 and answer the following questions.
(i) Identify a type of pollution that is related to energy.
(ii) Name the type of pollution related to eutrophication.
(iii) Give **one** example of harmful effect of air pollution.
(iv) State the common characteristics of the pollution types shown in Figure 4.

Enrichment Practice

4. Air conditioners are electrical appliances that are widely used in our daily lives. Have you experienced the hot air emitted from the compressor of an air conditioner (Figure 5)?

Figure 5

(a) What is the type of environmental pollution caused by air conditioners?
(b) How can pollution caused by the usage of air conditioners be reduced?
(c) Suggest **one** creative way to use the heat released from the compressor of an air conditioner.