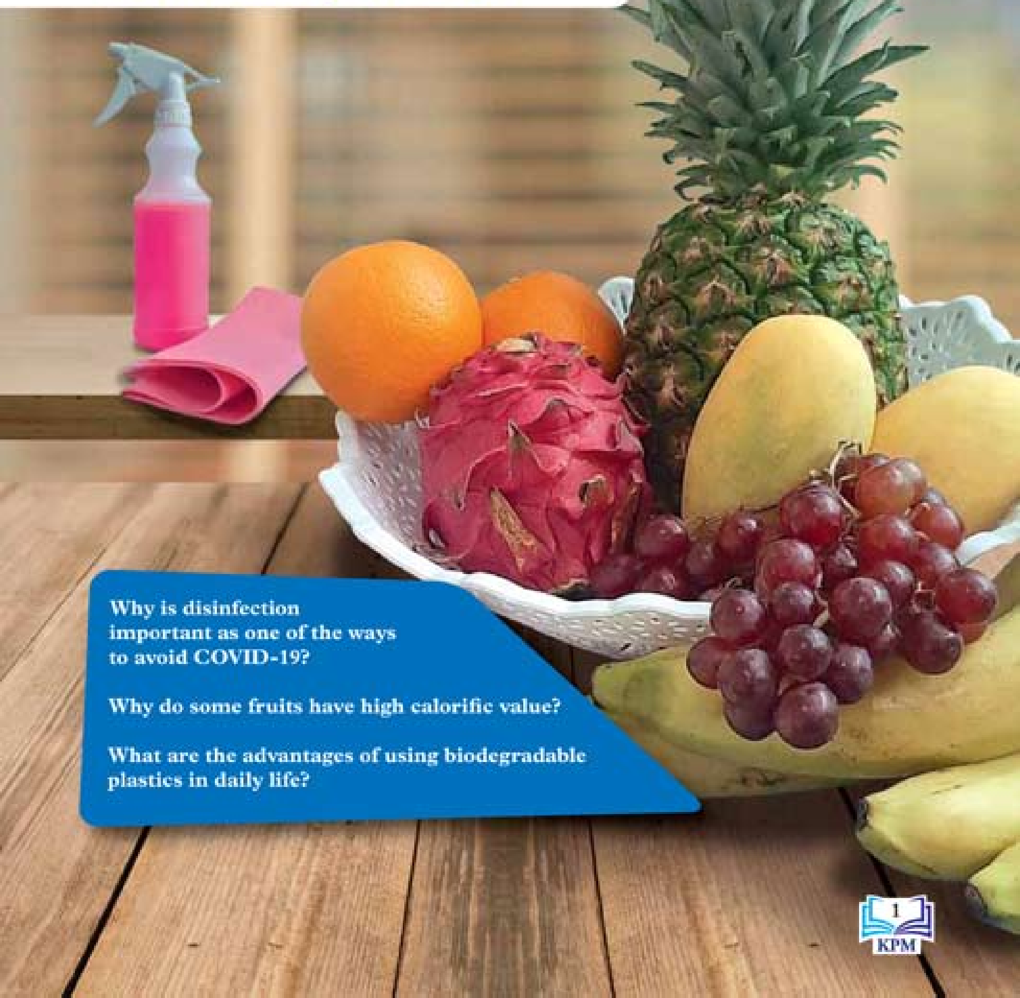
THEME 1

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?

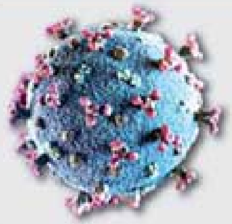
Why is 'prevention better than cure' for an illness caused by harmful microorganisms?

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**.

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.

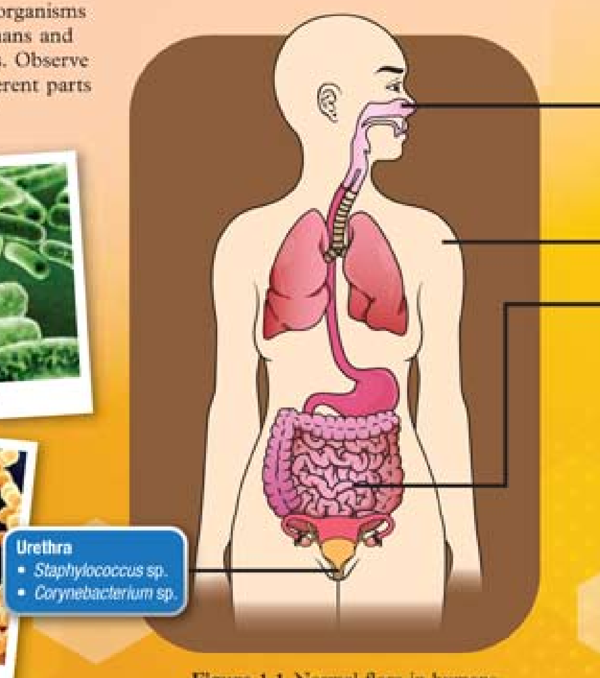


Figure 1.1 Normal flora in humans

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).

Microorganisms
- Fungi
- Algae
- Protozoa
- Bacteria
- Viruses

Figure 1.2 Classification of microorganisms

1.1.1

Fungi

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).

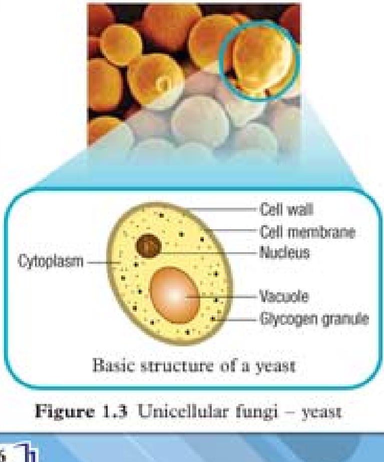


Figure 1.3 Unicellular fungi – yeast

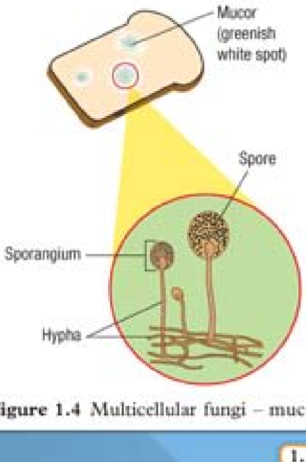


Figure 1.4 Multicellular fungi – mucor

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.

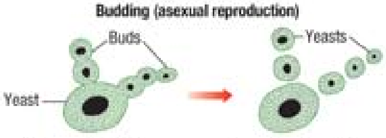


Figure 1.5 Yeast reproduces by budding

Conjugation (sexual reproduction)

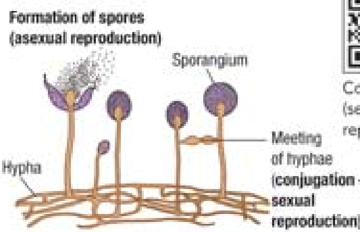


Figure 1.6 Asexual and sexual reproduction in mucor

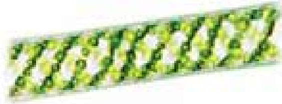
1.1.1

Algae

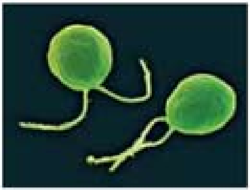
Size

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.

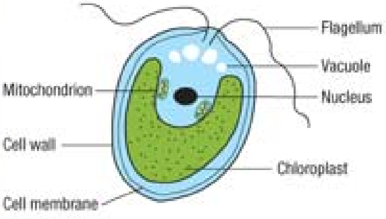


(c) *Chlamydomonas* sp.

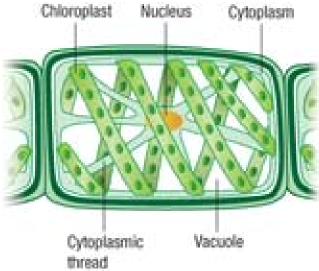
Photograph 1.3 Various types of algae

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**.

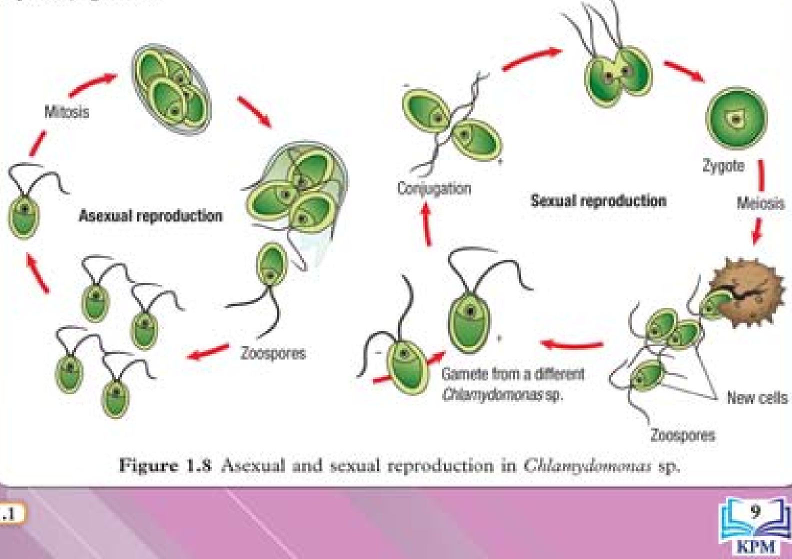


Figure 1.8 Asexual and sexual reproduction in *Chlamydomonas* sp.

1.1.1

Protozoa

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.

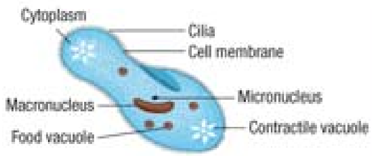


Figure 1.9 Basic structure of *Paramecium* sp.

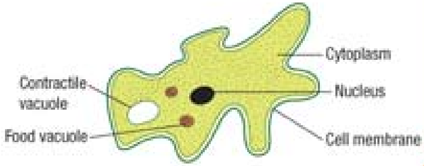


Figure 1.10 Basic structure of *Amoeba* sp.

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).

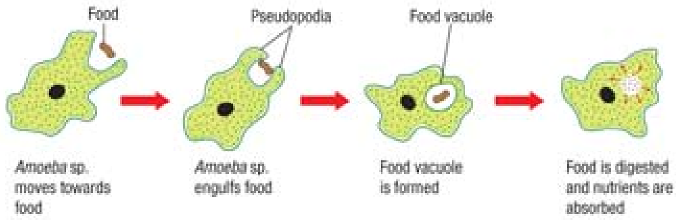


Figure 1.11 Phagocytosis in *Amoeba* sp.

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).

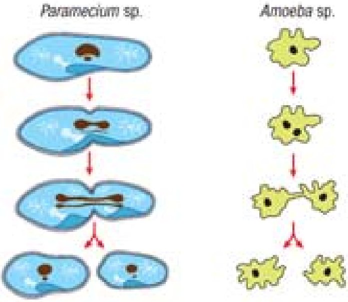


Figure 1.12 Binary fission of *Paramecium* sp. and *Amoeba* sp.

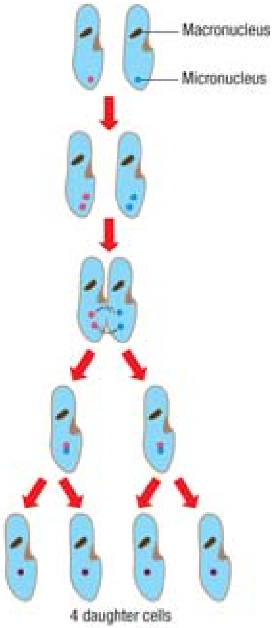


Figure 1.13 Sexual reproduction of *Paramecium* sp. by conjugation

Characteristics of protozoa

Habitat

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

1.1.1

Bacteria

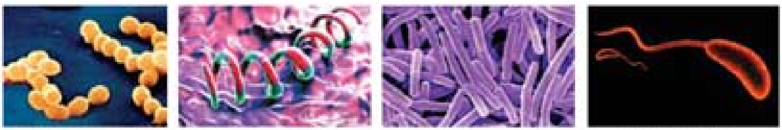
Size

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.

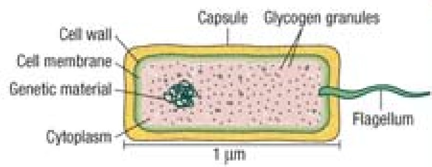


Figure 1.14 Basic structure of bacterium

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).

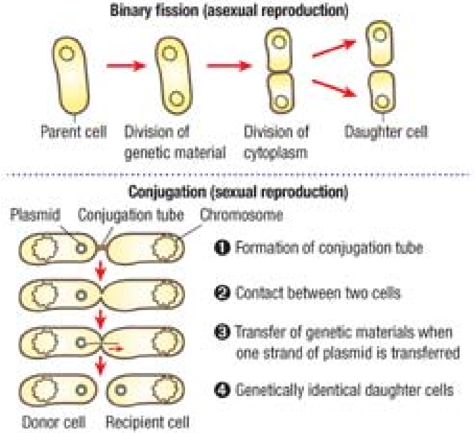


Figure 1.15 Asexual and sexual reproduction of bacteria

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.

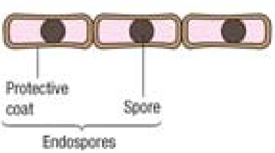


Figure 1.16 Endospores of *Bacillus anthracis*

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).

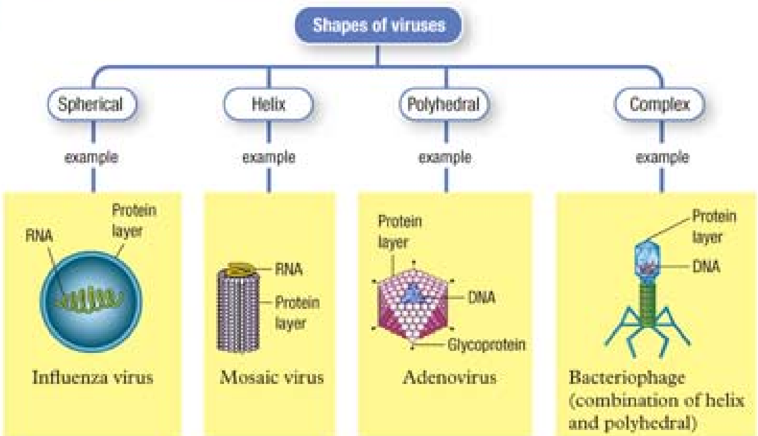


Figure 1.17 Shapes of viruses

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.

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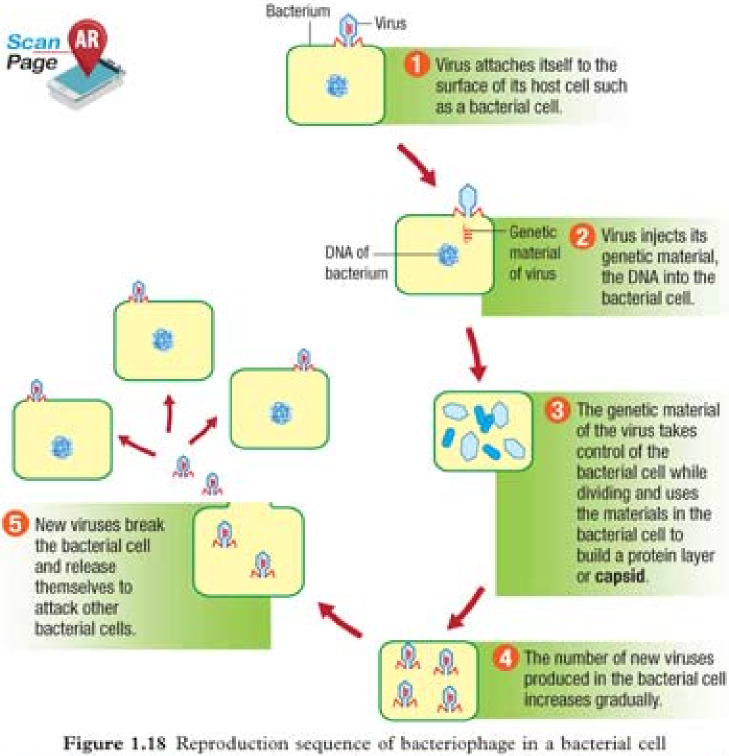


Figure 1.18 Reproduction sequence of bacteriophage in a bacterial cell

1.1.1

Activity 1.1

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

21st Century Skills
- ICS
- Inquiry-based activity

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.

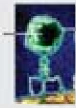
Answer: Alga

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

1.1.1

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.

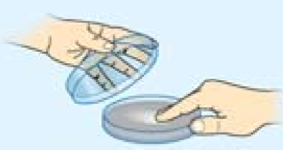


Figure 1.20

(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

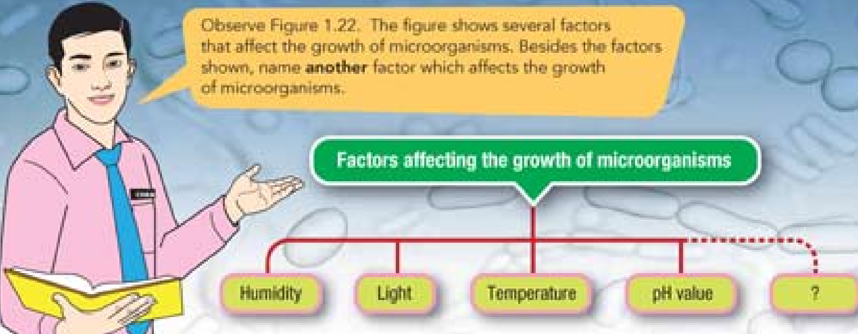


Figure 1.22 Factors that affect the growth of microorganisms

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

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).

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.

1.1.3

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).

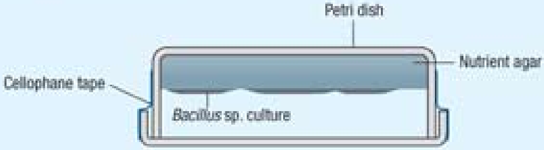


Figure 1.27 Inverted Petri dish

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.

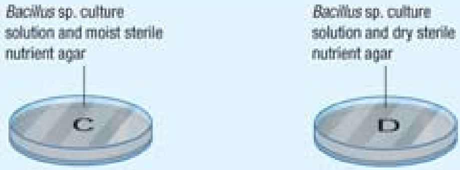


Figure 1.28

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

1.1.3

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).

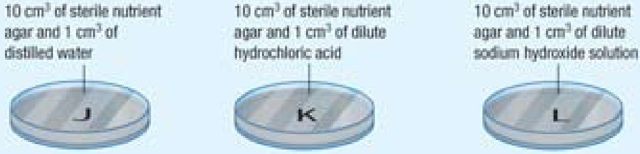


Figure 1.31

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).

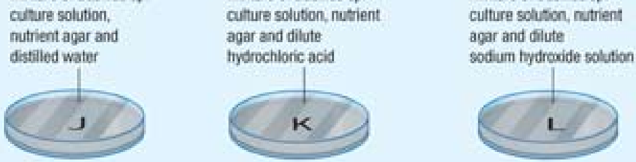


Figure 1.32

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.

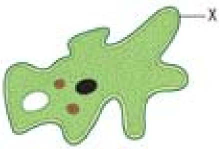


Figure 1

   (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.

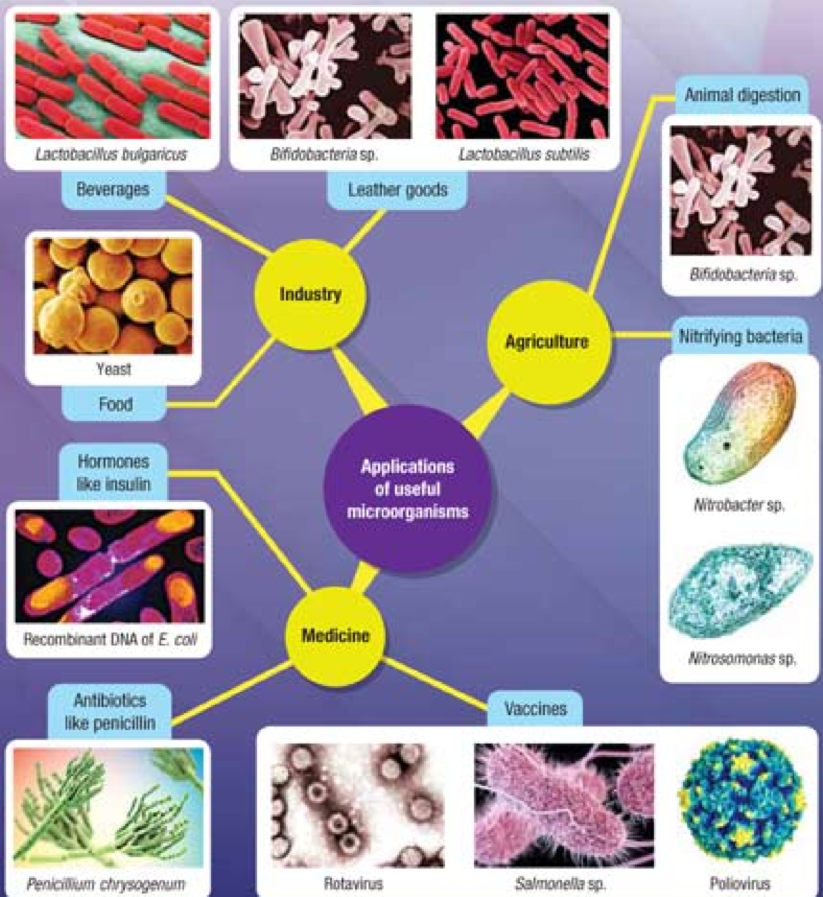


Figure 1.33 Applications of useful microorganisms in medicine, agriculture and industry

1.2.1

Activity 1.2

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

21st Century Skills
- ICS
- Discussion

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

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

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

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.

1.2.2

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?

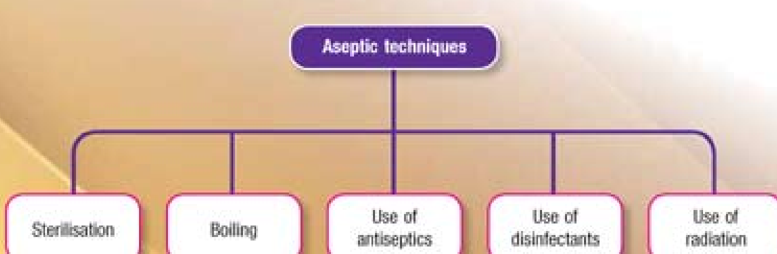


Figure 1.35 Aseptic techniques

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.

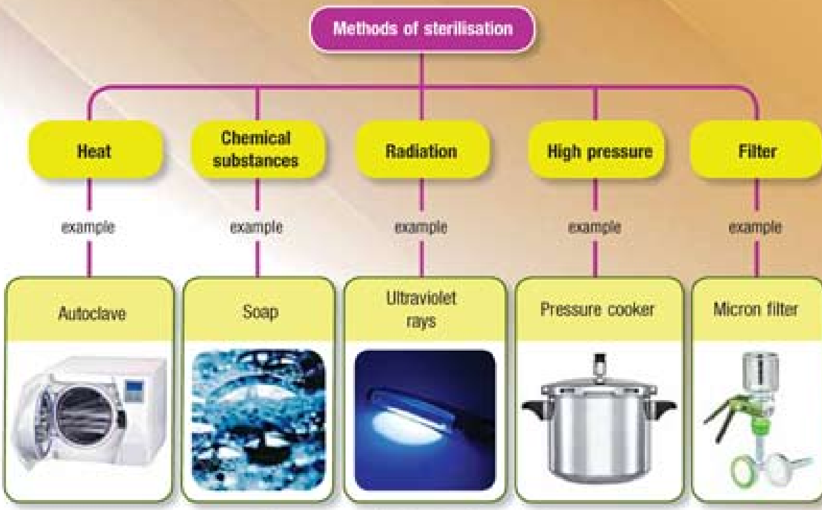


Figure 1.36 Methods of sterilisation

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.

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.

Photograph 1.10 Boiling milk bottles

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).

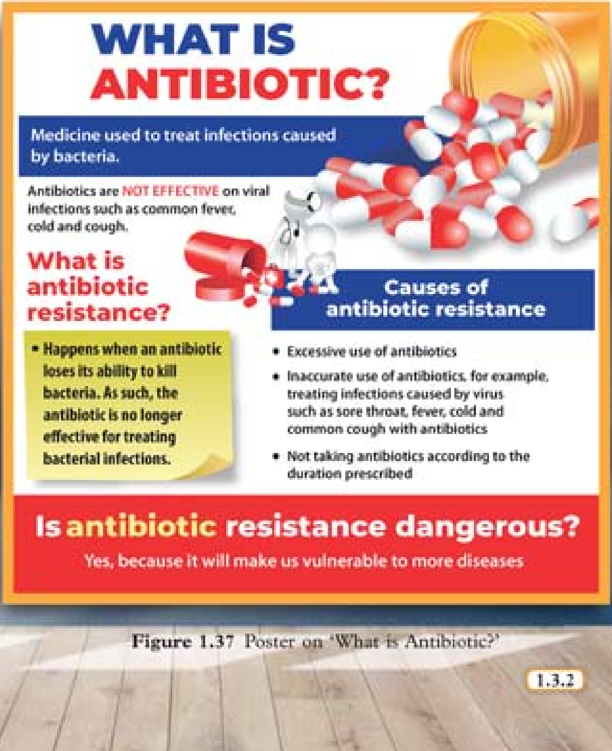


Figure 1.37 Poster on 'What is Antibiotic?'

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

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

Procedure:

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

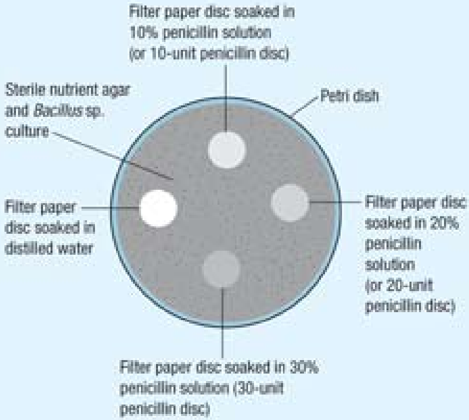


Figure 1.38

   (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.

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.

1.3.3

Observation:

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

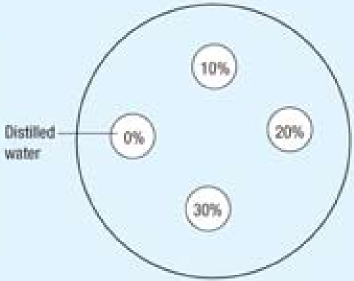


Figure 1.40

Conclusion:

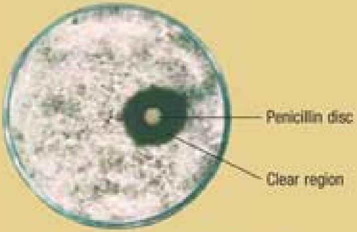
Is the hypothesis accepted? What is the conclusion for this experiment?

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.

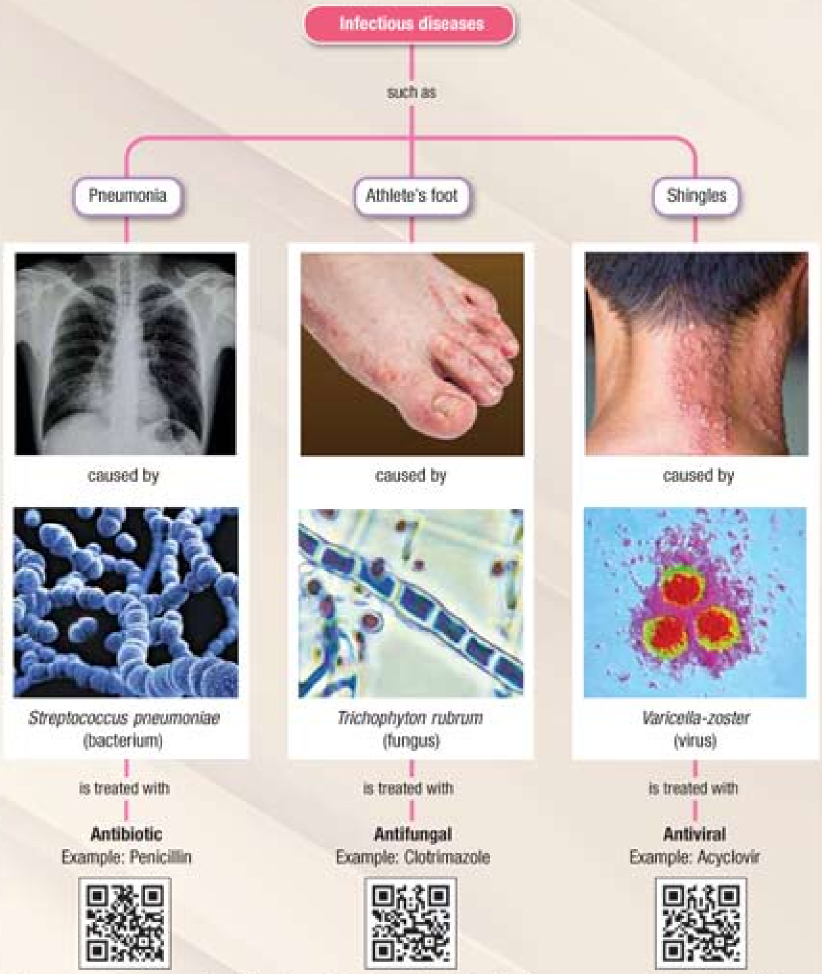


Figure 1.41 The use of antibiotic, antifungal and antiviral in the treatment of infectious diseases

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.

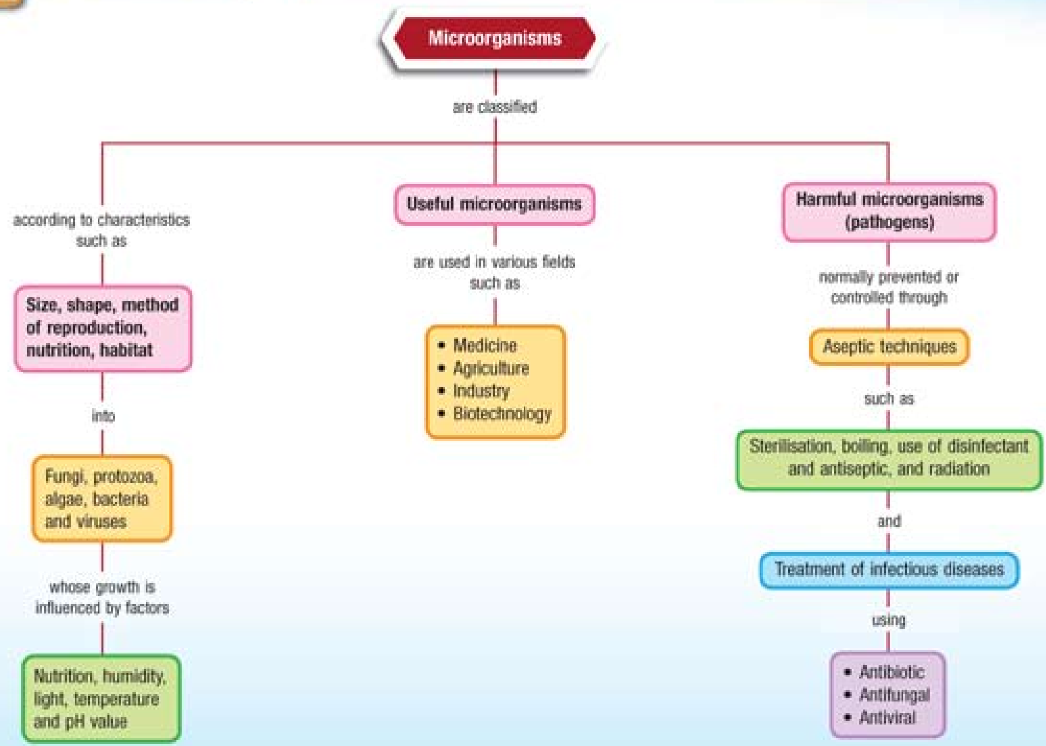
BRAIN TEASER

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.

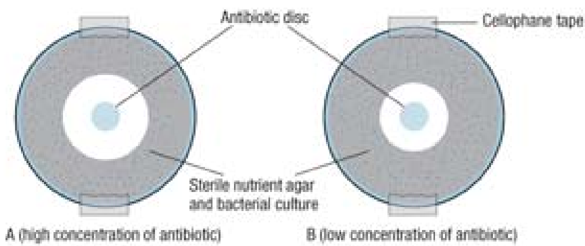


Figure 1

(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.

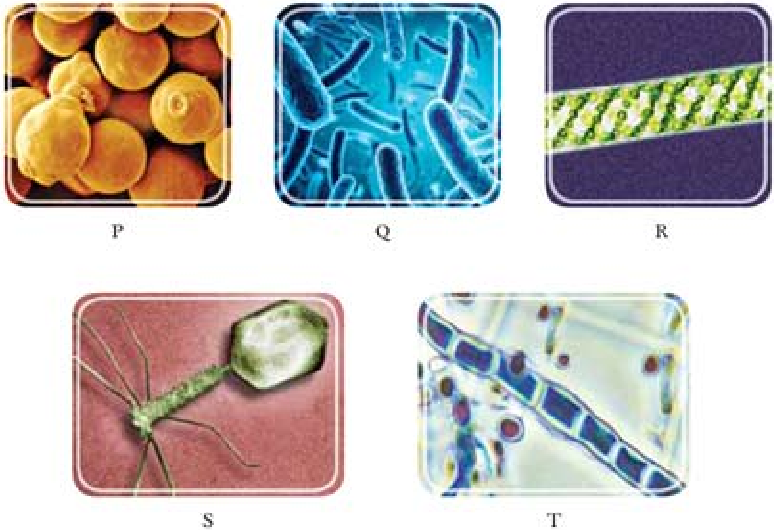


Figure 2

(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

Microorganisms

which

have cell wall and cell membrane | 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.