KURIKULUM STANDARD SEKOLAH MENENGAH

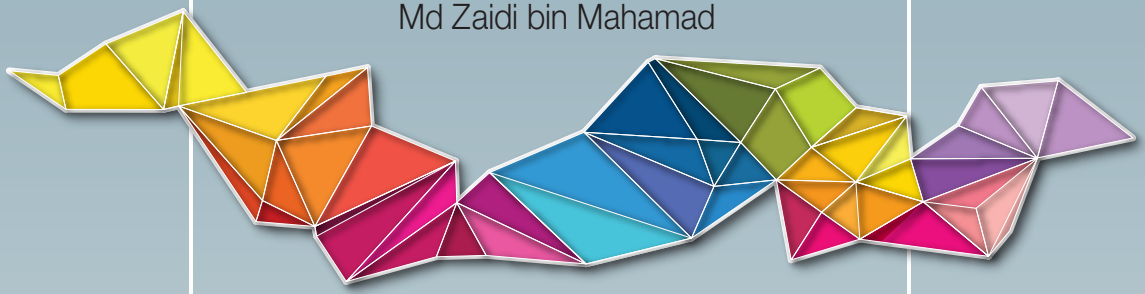
SCIENCE

FORM 3

Writers
Tho Lai Hoong
Che Ahamad bin Daud

Translators
Thum Lai Chun
Tho Lai Hoong

Editors
Yusri bin Ramly
Tengku Mohd Fozi bin Tengku Mohd Noor
Md Zaidi bin Mahamad



Designers
Engku Ismail bin Engku Ibrahim
Mohd Nabil bin Nakim

Illustrator
Yusmafazali bin Mohd Yusop

SASBADI SDN. BHD. (139288-X)
(Wholly-owned subsidiary of Sasbadi Holdings Berhad (1022660-T))

2018

KEMENTERIAN PENDIDIKAN MALAYSIA

Serial Book No.: XXXX

KPM 2018 ISBN xxx–xxx-xx-xxxx-x

First Published 2018

Published for Ministry of Education Malaysia by:
Sasbadi Sdn. Bhd. (139288-X)
(Wholly-owned subsidiary of Sasbadi Holdings Berhad (1022660-T))
Lot 12, Jalan Teknologi 3/4,
Taman Sains Selangor 1, Kota Damansara,
47810 Petaling Jaya,
Selangor Darul Ehsan, Malaysia.
Tel: +603-6145 1188 Fax: +603-6145 1199
Website: www.sasbadisb.com
E-mail: enquiry@sasbadi.com

Design and typesetting by:
Sasbadi Sdn. Bhd. (139288-X)

Font style: Minion Pro
Font size: 11 point

Printed by:
XXXX, XXXXXXXX,
XXXXXXX.

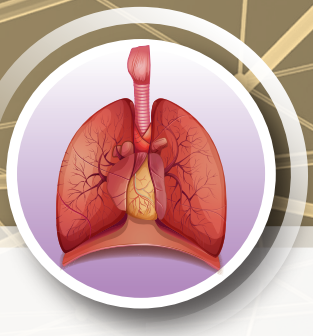
ACKNOWLEDGEMENT

The publisher and the authors would like to thank the following organisations and individuals for their invaluable assistance and cooperation in publishing this book.

- Committee members of Quality Control, Textbook Division, Ministry of Education Malaysia
- Curriculum Development Division, Ministry of Education Malaysia
- English Language Teaching Centre (ELTC), Teacher Education Division, Ministry of Education Malaysia
- Shah Alam Hospital, Selangor
- Sekolah Menengah Kebangsaan Seksyen 8, Kota Damansara
- Dato' Dr. Sheikh Muszaphar Shukor Al Masrie Sheikh Mustapha
- Individuals, groups and related agencies for their contributions in terms of ideas and materials, directly or indirectly

Some of the websites referred to in this book contain materials that can be used by the public. The information may be updated from time to time. The publisher and the authors will not take any responsibility for the content in these websites.

Contents



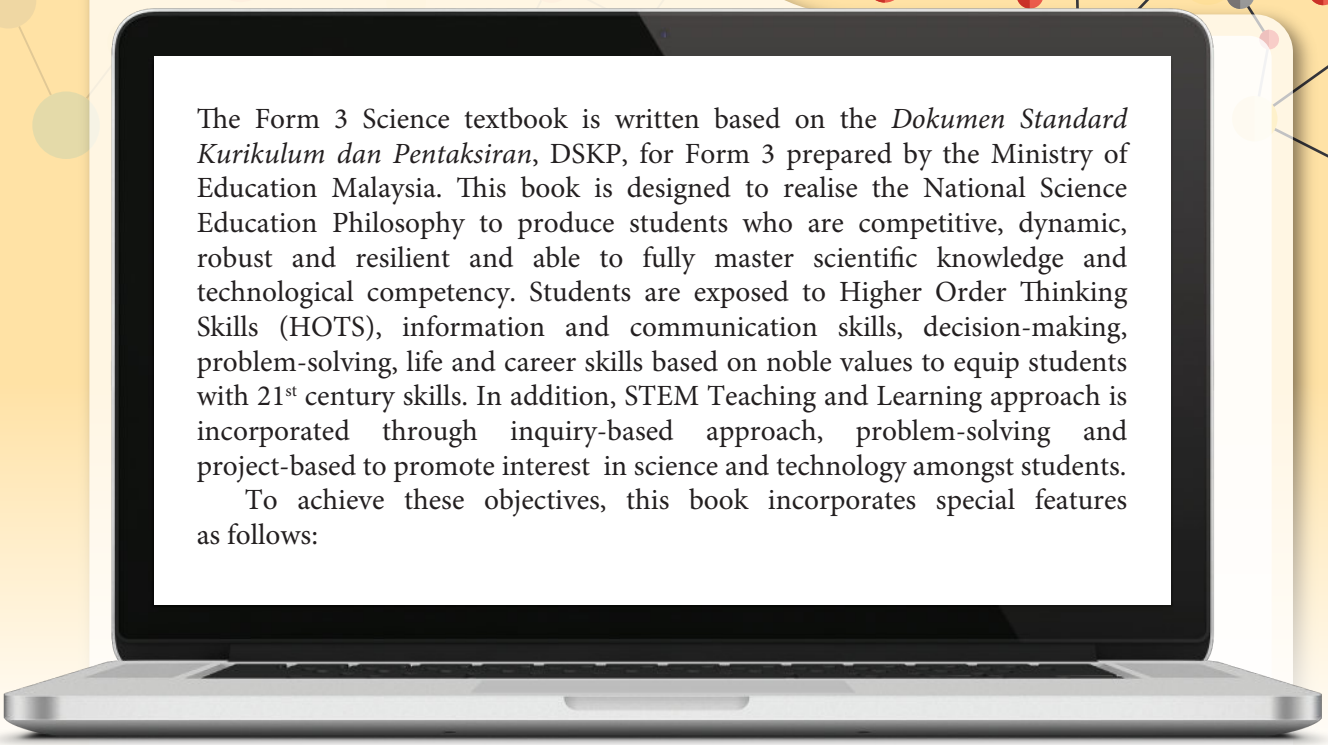
Theme 3: Energy and Sustainability of Life

Theme 4: Earth and Space Exploration

Introduction

The Form 3 Science textbook is written based on the *Dokumen Standard Kurikulum dan Pentaksiran*, DSKP, for Form 3 prepared by the Ministry of Education Malaysia. This book is designed to realise the National Science Education Philosophy to produce students who are competitive, dynamic, robust and resilient and able to fully master scientific knowledge and technological competency. Students are exposed to Higher Order Thinking Skills (HOTS), information and communication skills, decision-making, problem-solving, life and career skills based on noble values to equip students with 21st century skills. In addition, STEM Teaching and Learning approach is incorporated through inquiry-based approach, problem-solving and project-based to promote interest in science and technology amongst students.

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



1.2.2 — Learning Standards based on the Standard Curriculum and Assessment Document for teachers' reference

SCIENCE INFO — Additional information related to a topic

I CAN REMEMBER! — Formulae or important information for students to remember

BRAIN TEASER — Questions that challenge students' thinking

STEM - Science, Technology, Engineering, Mathematics — Questions and information related to the developments in Science, Technology, Engineering and Mathematics

MARVELS OF SCIENCE — Appreciating the marvels of science

My World of Science — Applications of science in daily life

My Malaysia — Latest information on the achievements in the fields of science and technology in Malaysia

Today in history — Information on scientific developments and science-related events in the past

Websites — Information from websites on the Internet

VIDEO — Video links to help students understand a topic

KPM

Science Careers

Careers in the field of Science, Technology, Engineering and Mathematics (STEM)

CAUTION!

Emphasis on matters that could bring danger in daily life and during scientific investigations

21st Century Skills

21st Century Skills
- Critical Thinking and Problem-solving Skills (CPS)
- Interpersonal and Self-reliance Skills (ISS)
- Information and Communication Skills (ICS)
- STEM

Safety Precaution

Steps that students need to take to obtain accurate results and to avoid any accidents during scientific investigations

Formative Practice 2.1

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

Students are notified of websites that can be accessed to further assist in the understanding of a certain topic. Apart from website addresses (URL), students can also browse the related websites using the QR code displayed.

Students are required to take the following steps:

Step 1

Choose and download the QR code reader application that is compatible with the student's smart mobile device either from the App Store or Play Store for free.

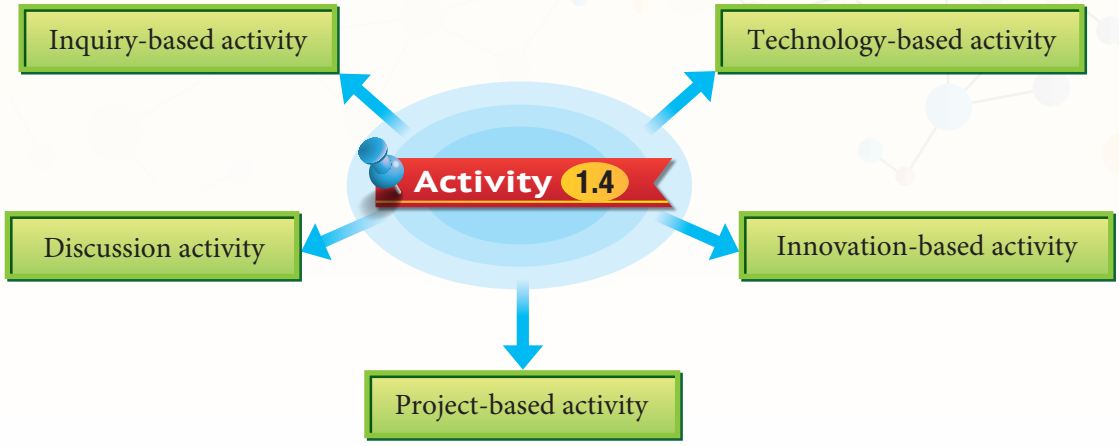
Step 2

Activate the QR code reader application and then scan the QR code using the camera in the student's smart mobile device.

Step 3

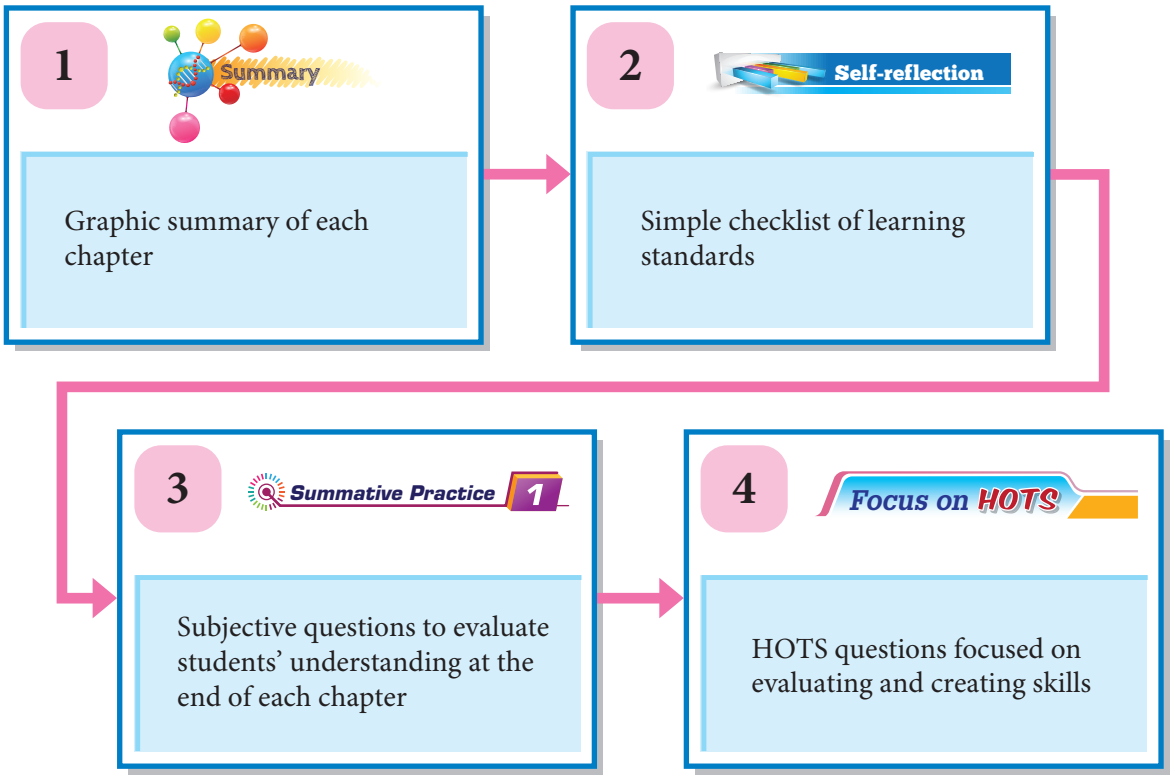
The student should be able to access the website.

Types of activities in this book:



Experiment 2.1 Scientific investigation through guided experiments.

Components at the end of a chapter:



HOTS questions – applying, analysing, evaluating, creating

Components of mobile application:

This textbook includes a mobile application, that is BT Science F3 2018. This application contains interesting multimedia materials which can optimise the teaching and learning process. Multimedia materials such as Augmented Reality (AR), videos, interactive activity and animation can be activated through the following steps:

Step 1

Scan this QR code with a smart mobile device to download the BT Science F3 2018 application.

Step 2

Take note of this icon that can be seen on certain pages in this book. It indicates that the page contains multimedia materials. The following table shows the contents of the multimedia materials.

Multimedia materials	Pages
AR (Augmented Reality)	4, 86, 260
Interactive activity	135
Animation	138
Videos	10, 34, 47, 60, 85, 89, 90, 109, 130, 132, 134, 171, 216, 260

Step 3

Activate the BT Science F3 2018 application and scan the entire page.

Step 4

Users do not need to close and reactivate the BT Science F3 2018 application to scan the following pages.

THEME 1

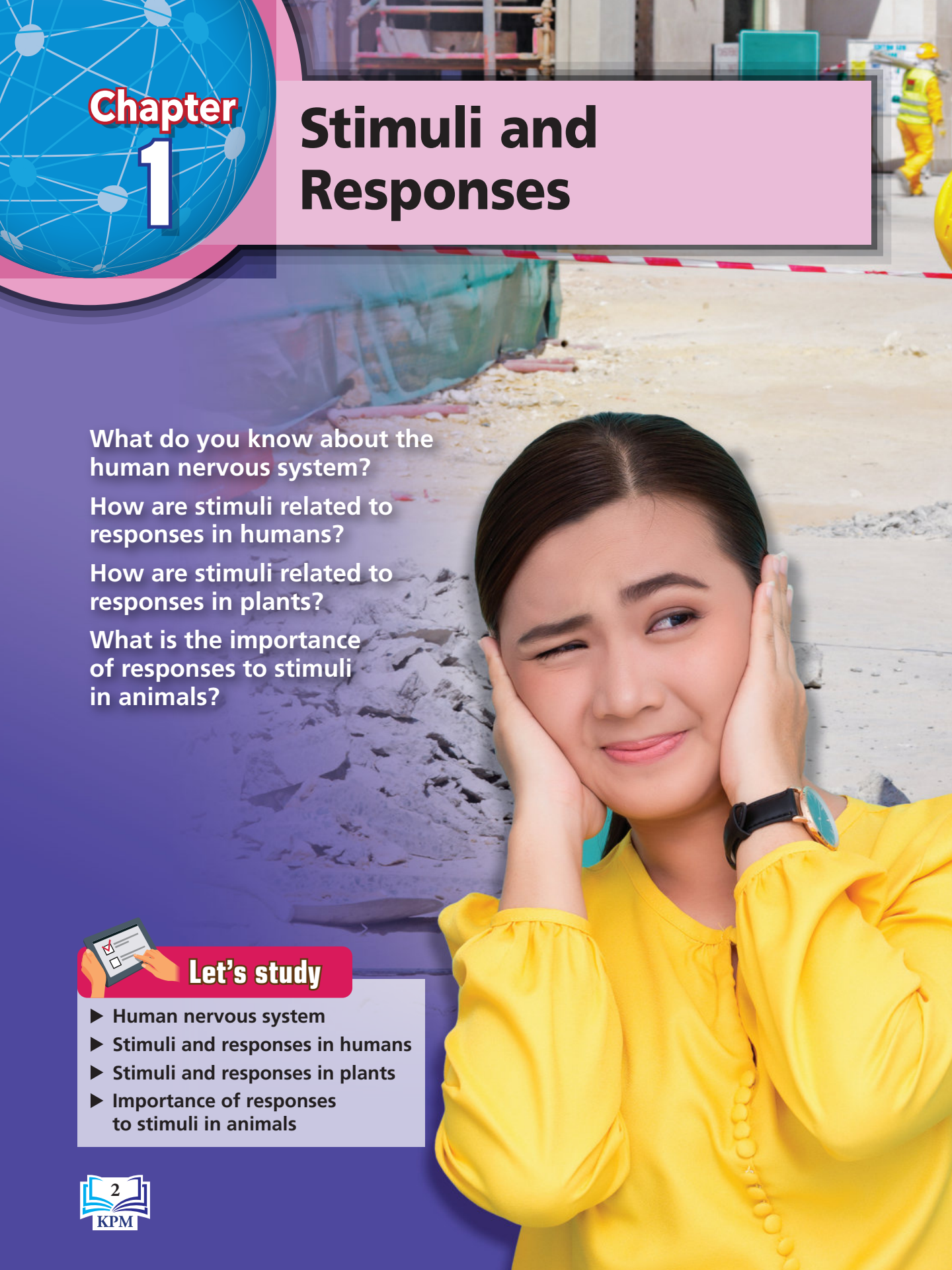
Maintenance and Continuity of Life

Humans, animals and plants depend on stimuli and responses for survival. Name the organs or parts involved in the stimuli and responses based on the photographs shown.

Why is it healthier for us to exercise during the day than at night?

Chapter 1

Stimuli and Responses



What do you know about the human nervous system?

How are stimuli related to responses in humans?

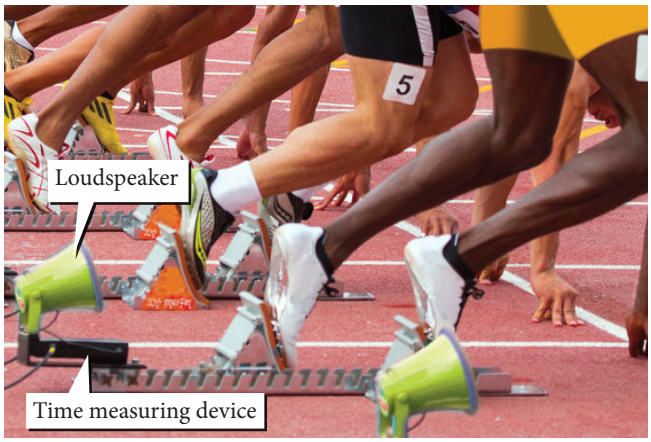
How are stimuli related to responses in plants?

What is the importance of responses to stimuli in animals?

Let's study

- Human nervous system
- Stimuli and responses in humans
- Stimuli and responses in plants
- Importance of responses to stimuli in animals

Science Gallery



The sprint event in international sports competitions such as the Olympics uses loudspeakers and time measuring devices as shown in the above photograph. The time measuring device measures the time interval between the sound from the loudspeaker and the first push exerted by the runner's foot against the time measuring device. This time interval is known as the reaction time.

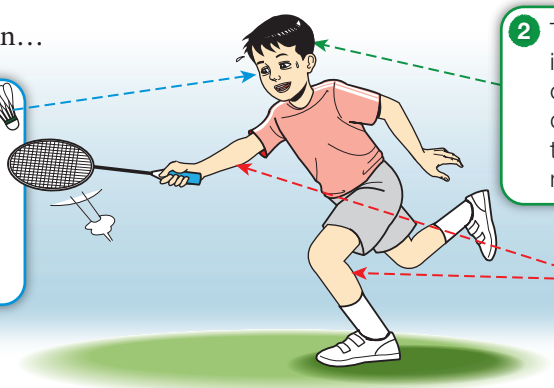
In the 100 m sprint event at the 2016 Olympics, the reaction time of the gold medal winner, Usain Bolt, was 0.155 s. If the measured reaction time of a runner is less than 0.1 s, the runner will be disqualified from competing. Why?

Keywords

- Stimulus
- Response
- Spinal cord
- Peripheral nerve
- Affector
- Effector
- Voluntary action
- Involuntary action
- Photoreceptor
- Taste bud
- Optical illusion
- Geotropism
- Hydrotropism
- Thigmotropism
- Nastic movement
- Stereoscopic vision
- Monocular vision
- Stereophonic hearing

1.1 Human Nervous System

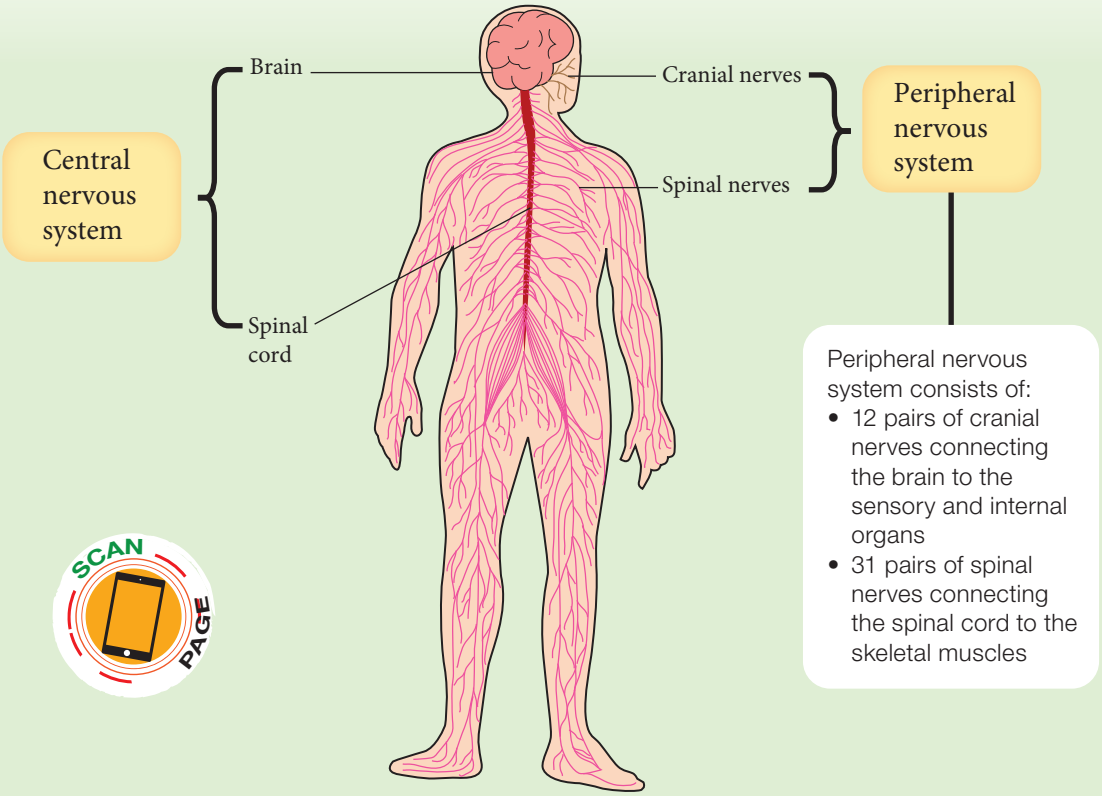
In a game of badminton…



The **human nervous system** is an important control system in body coordination. Other than sight, thinking and body movement, the human nervous system also controls and coordinates organ functions in the body and maintains a balanced internal environment through a process. What is this process?

Structure of the Human Nervous System

Look at Figure 1.1. The human nervous system consists of:



SCAN PAGE

Figure 1.1 *Human nervous system*

Functions of the Human Nervous System

The human nervous system **controls** and **coordinates** organs and parts of the body. The human nervous system:

- detects **stimuli**
- sends **information** in the form of impulses
- interprets **impulses**
- produces appropriate **responses**

Photographs 1.1, 1.2 and 1.3 show examples of daily activities that involve detection of stimuli and production of responses to the stimuli detected. State the stimulus and response in each of the daily activities shown.

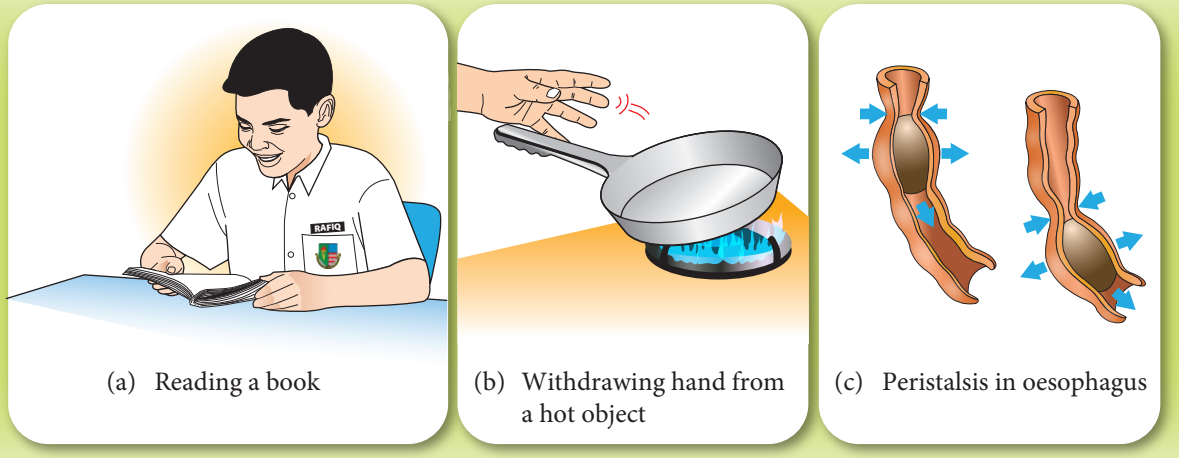
Photograph 1.1 *Collecting garbage*

Photograph 1.2 *Sneezing*

Photograph 1.3 *Surfing the Internet*

Voluntary and Involuntary Actions

The responses of the human body to stimuli can be divided into **voluntary actions** and **involuntary actions**. Observe the examples of responses of the human body in Figure 1.2.



(a) Reading a book

(b) Withdrawing hand from a hot object

(c) Peristalsis in oesophagus

Figure 1.2 *Examples of responses of the human body*

Based on Figure 1.2, which response is a voluntary action and which is an involuntary action?

Voluntary Actions

Voluntary actions are conscious actions and conducted under one's will. All voluntary actions are controlled by the **brain**. Examples of voluntary actions include reading, writing, speaking, eating, drinking, walking, running and exercising. Figure 1.3 shows the pathway of impulse in a voluntary action.

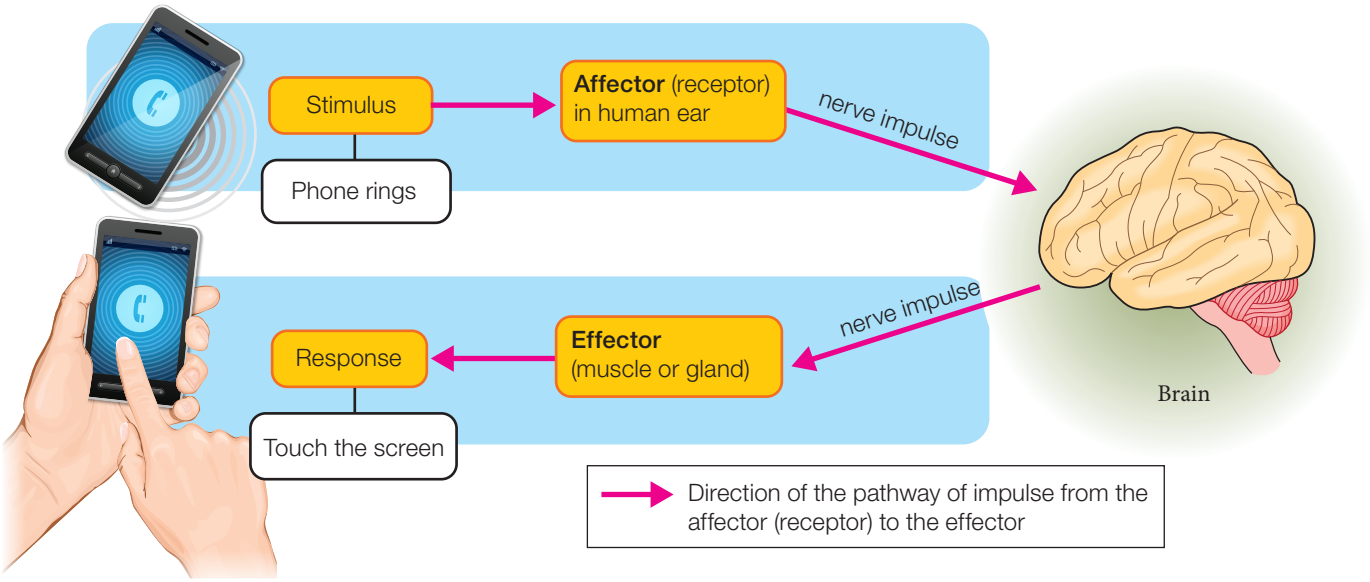


Figure 1.3 *Pathway of impulse in a voluntary action*

Let us learn more on voluntary actions by carrying out Activity 1.1 on page 7.

Activity 1.1

Inquiry-based activity

Measuring the reaction time by catching a free-falling ruler (voluntary action)

Aim: To measure reaction time

Apparatus
Half metre rule

Instructions
1. Work with a partner.
2. Ask your partner to hold the end of a half metre rule as shown in Figure 1.4.

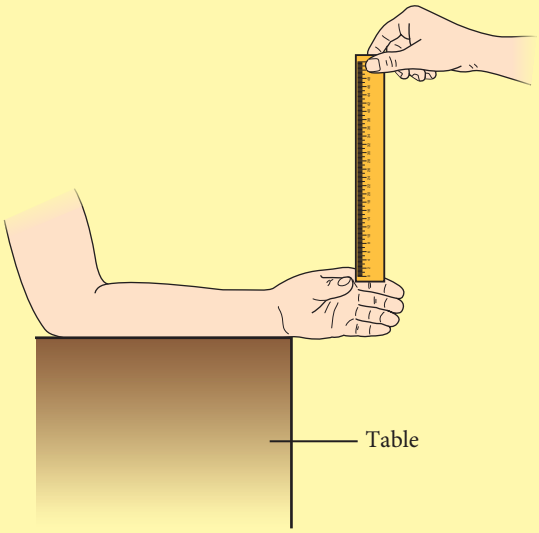


Figure 1.4

Safety Precautions
- Make sure that the hand used to catch the ruler remains stationary on the table.
- Be careful when releasing or catching the ruler.

3. Place your hand at the end of the ruler close to the zero mark without touching it as shown in Figure 1.4.
4. Your partner will release the ruler without warning and you must try to catch the ruler as quickly as possible.
5. Record the distance the ruler fell, x, that is, the scale on the ruler when you catch it. The distance, x, is the measurement of your reaction time.
6. Repeat this activity four times. Then, calculate the average distance, $x_{average}$.

Questions
1. In this activity, state the stimulus and its response. Is the response a voluntary action or an involuntary action? Explain.
2. Why is the distance the ruler fell considered as the reaction time?
3. Explain the difference in the reaction time among the students in the class.
4. What is the importance of reaction time in our daily life?

Conclusion
Make a conclusion on the reaction time of the students in your class.

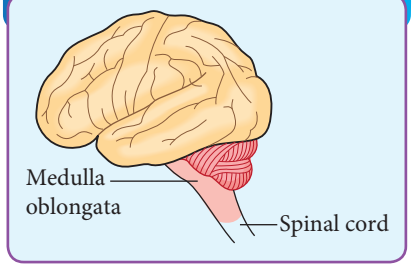
Involuntary Actions

Involuntary actions are actions that occur immediately **without conscious control** or **prior thoughts**. Involuntary actions can be classified into two.

Involuntary actions

Involving medulla oblongata	Involving spinal cord (reflex actions)
• Heartbeat	• Withdrawing hand when it accidentally touches a hot object
• Breathing	• Withdrawing foot when it accidentally steps on a sharp object
• Peristalsis	• Sneezing when dust enters the nose
• Secretion of saliva	

SCIENCE INFO



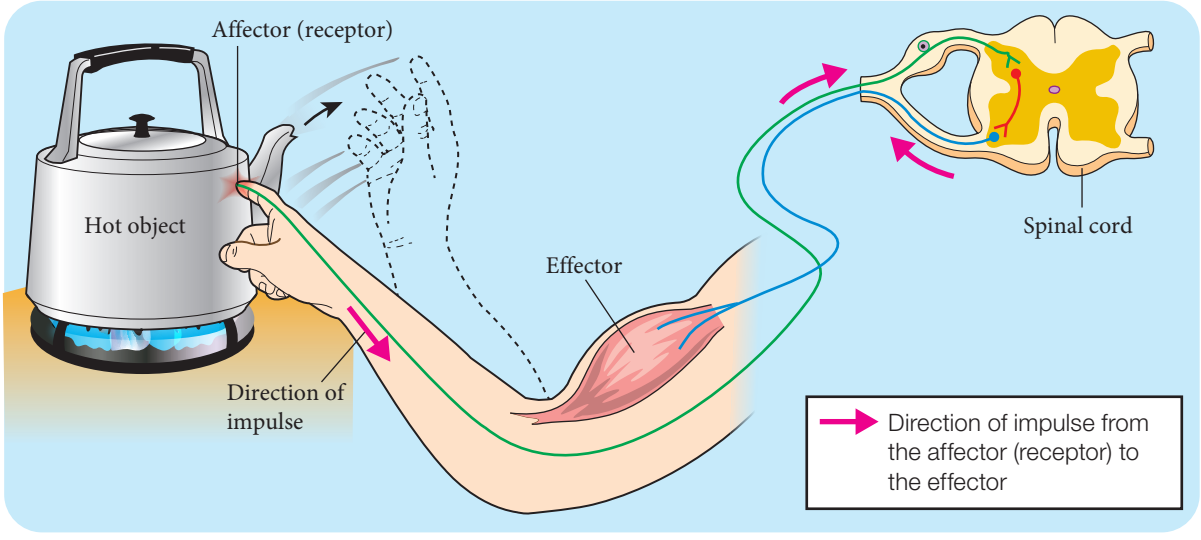


Figure 1.5 *Pathway of impulse in an involuntary action (reflex action)*

Let us learn more on involuntary actions by carrying out Activity 1.3 on page 9.

Activity 1.2

21st Century Skills
- ICS
- Innovation-based activity

Create a presentation on:
- the parts involved in the transmission of impulse from the affector to the effector
- the pathway of impulses in voluntary and involuntary actions

Instructions
1. Work in groups.
2. Each group is required to create a presentation to illustrate the following:
   - The parts involved in the transmission of impulse from the affector to the effector
   - The pathway of impulses in voluntary and involuntary actions

Activity 1.3

Inquiry-based activity

Detecting changes in the size of the pupil in the eye towards light intensity (involuntary action)

Aim: To observe changes in the size of the pupil of the eye towards different light intensities

Apparatus
Mirror and lamp

Instructions
1. Identify the pupil of the eye in Figure 1.6.

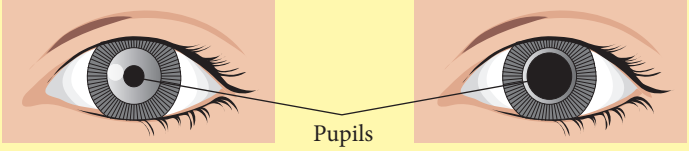


Figure 1.6

2. Observe the pupil using a mirror in bright light. Sketch the size of the pupil.
3. Observe the pupil in dim light. Sketch the size of the pupil.
4. Compare and contrast the size of the pupils in bright and dim lights.

Questions
1. In this activity, state the stimulus and its response. Is the response a voluntary or an involuntary action? Explain.
2. What is the relationship between the size of the pupil and light intensity?
3. What is the importance of this response?

Conclusion
Make a conclusion about the changes in the size of the pupil towards light intensity.

SCIENCE INFO

The pupil in the human eye is circular. Is the pupil in other animals' eye circular as well?

(a) Goat: Rectangular

(b) Stingray: Crescent

(c) Crocodile: Vertical slit

(d) Squid: W-shaped

BRAIN TEASER

Other than the nervous system, what other body systems help in body and internal organ movements?

STEM
- Science, Technology, Engineering, Mathematics

Humanoid robot

SCAN PAGE

Importance of the Network of Human Nervous System in Daily Life

The network of the human nervous system controls and coordinates the organs and parts of the body to carry out processes in the body such as breathing and body movements.

A damaged nervous system normally causes a person to become temporarily, partially or completely paralysed. For example, if the nerves in the muscles of a leg or hand are injured, the person will face difficulty in moving his leg or hand. In the case of a more serious problem, he might have to depend on machines to carry out his physiological processes such as breathing or heart beating.

Humans are blessed with a nervous system, so they should use and take good care of it.

Photograph 1.4 *Partially-paralysed individual*

Photograph 1.5 *Patient using a breathing machine*

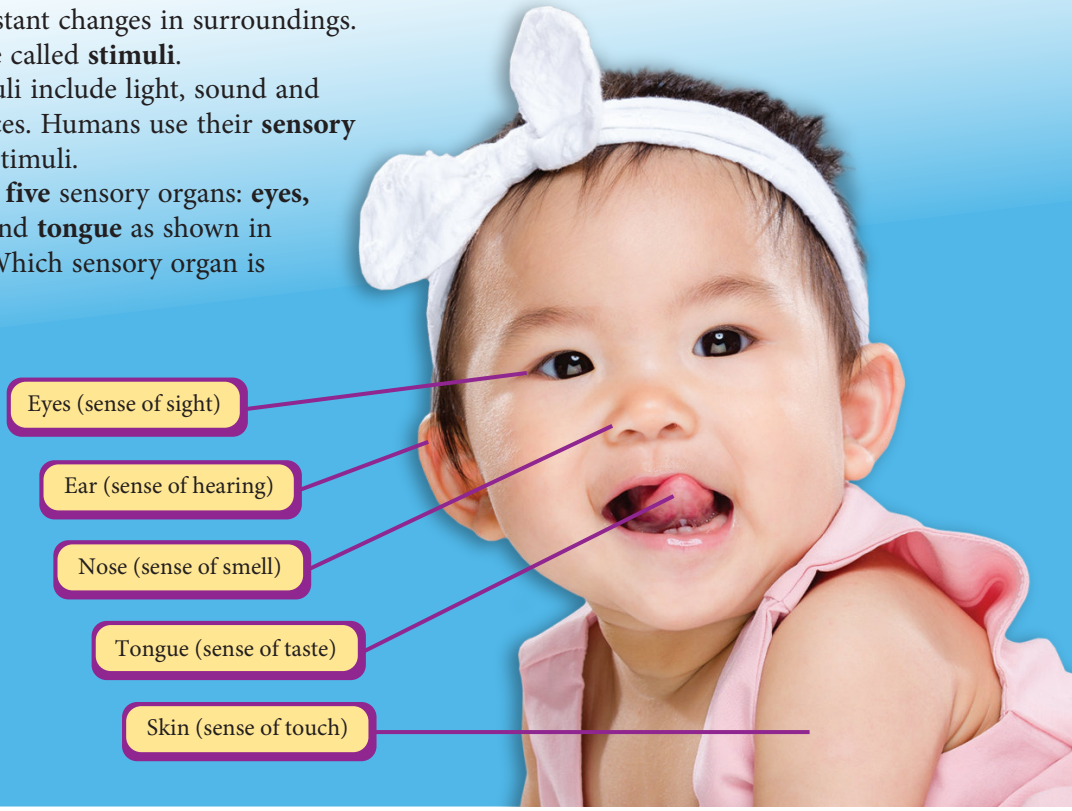
Formative Practice 1.1

1. State **two** main parts of the human nervous system.
2. (a) What is voluntary action? Give **one** example of a voluntary action.
   (b) What is involuntary action? Give **one** example of an involuntary action.
3. What happens if a person has brain injury?
4. What is the importance of the network of human nervous system in life?

1.2 Stimuli and Responses in Humans

Humans face constant changes in surroundings. These changes are called **stimuli**. Examples of stimuli include light, sound and chemical substances. Humans use their **sensory organs** to detect stimuli.

Humans have **five** sensory organs: **eyes, ears, nose, skin** and **tongue** as shown in Photograph 1.6. Which sensory organ is the largest?



Photograph 1.6 *Human sensory organs*

Eye

Study Figure 1.7. Can you identify the parts of the eye? Let us learn more on the parts of the eye by referring to Figure 1.8 on page 12.

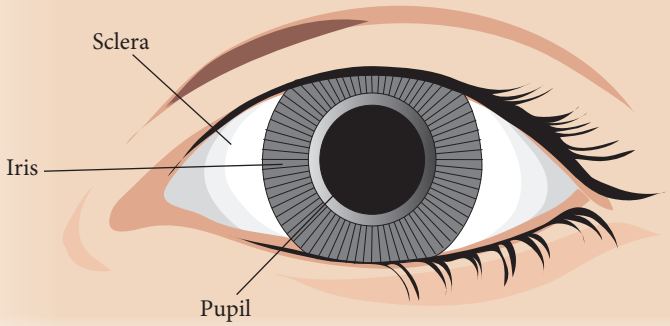


Figure 1.7 *Front view of the eye*

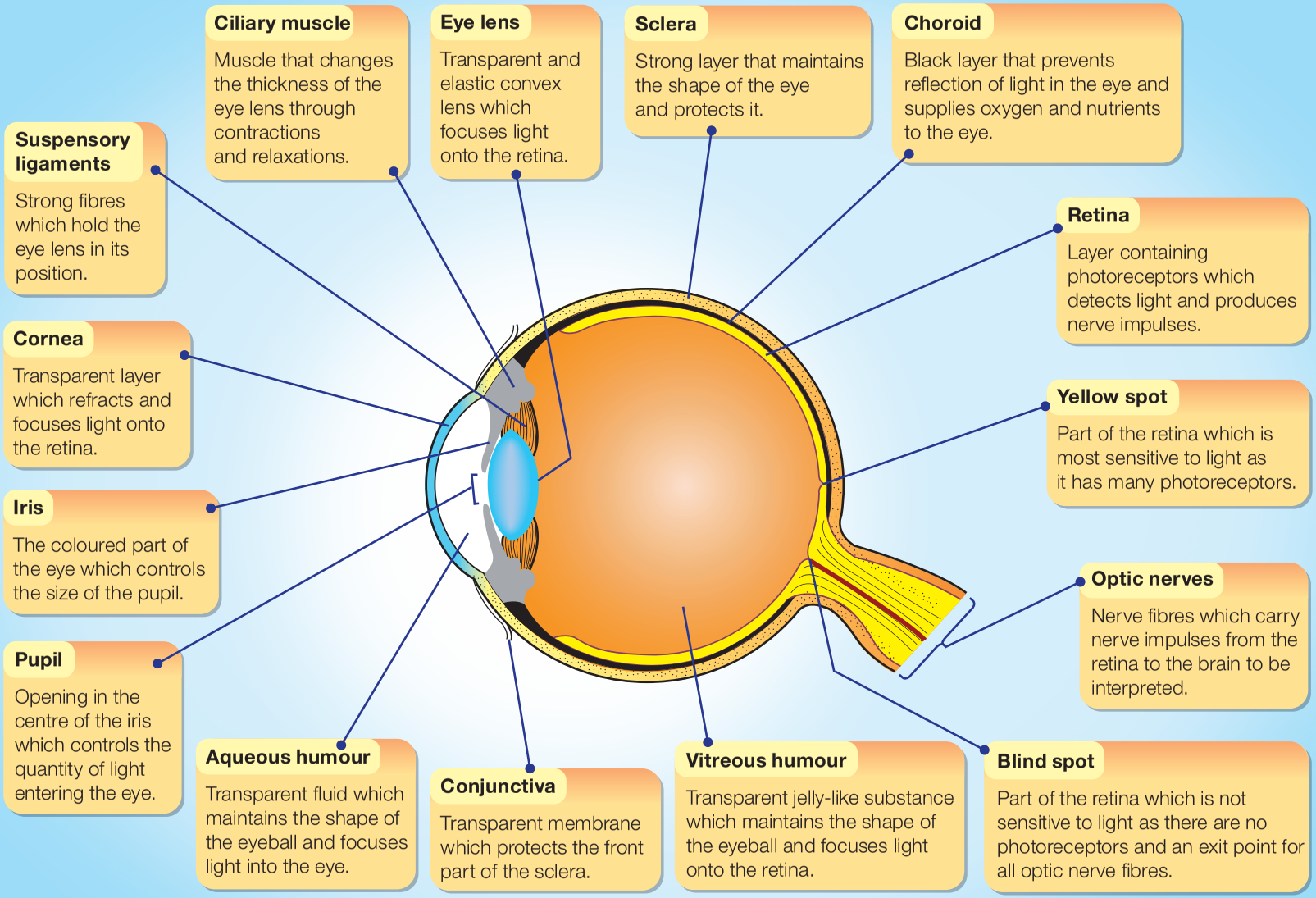


Figure 1.8 *Parts of the human eye and their functions*

What is the Colour of the Object Seen?

The retina has two types of photoreceptors: **rod cells** and **cone cells** as shown in Figure 1.9.

Rod cells are sensitive to different light **intensities** including faint light but are not sensitive to the colours of light.

Cone cells are sensitive to the **colours of light** under bright conditions. There are **three** different types of cone cells, with each is sensitive to **red** light, **green** light and **blue** light.

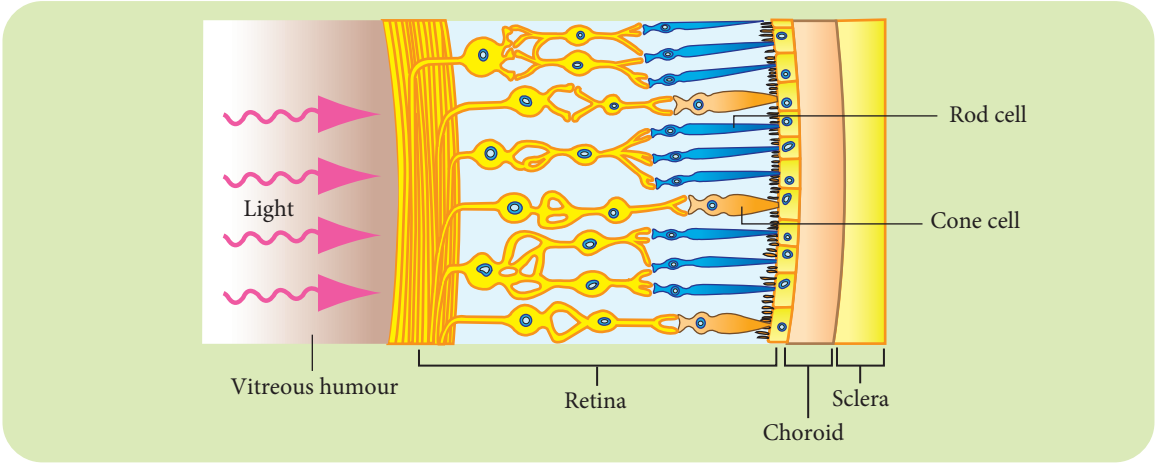


Figure 1.9 *Photoreceptors – rod and cone cells*

Ear

What are the parts of the ear and their functions? Study Figure 1.10 and Table 1.1 on page 14.

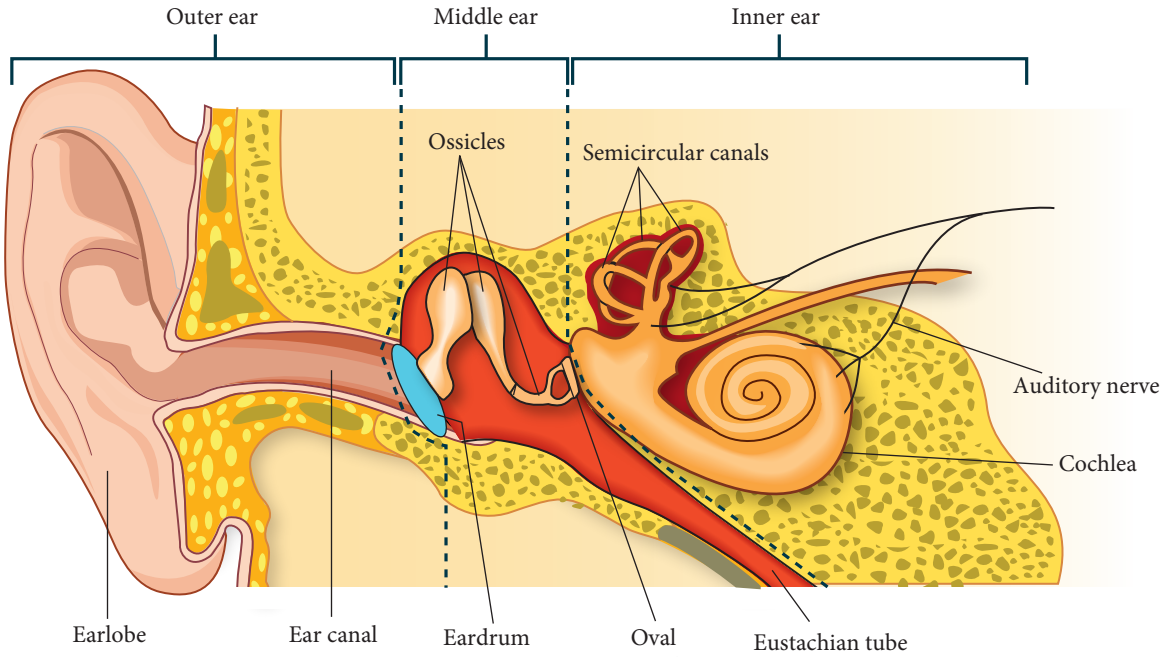


Figure 1.10 *Parts of the human ear*

Table 1.1 *Functions of the parts of the human ear*

Part of ear	Structure of ear	Functions
Outer ear	Earlobe	Collects and directs **sound waves** into the ear canal
	Ear canal	Directs **sound waves** to the eardrum
Middle ear	Eardrum (thin membrane)	Vibrates according to the frequency of the sound waves received and transfers the **vibrations** to the ossicles
	Ossicles (made up of three small bones)	Amplify **sound vibrations** and transfer them to the oval window
	Oval window	Collects and transfers **sound vibrations** from the ossicles to the cochlea
	Eustachian tube	Balances the air pressure on both sides of the eardrum
Inner ear	Cochlea (contains fluid)	Detects and converts sound vibrations into **nerve impulses**
	Semicircular canals (contain fluid)	Detect the position of the head and help to balance the body
	Auditory nerve	Sends **nerve impulses** from the cochlea to the brain to be interpreted

Nose

What are the parts of the nose? Study Figure 1.11.

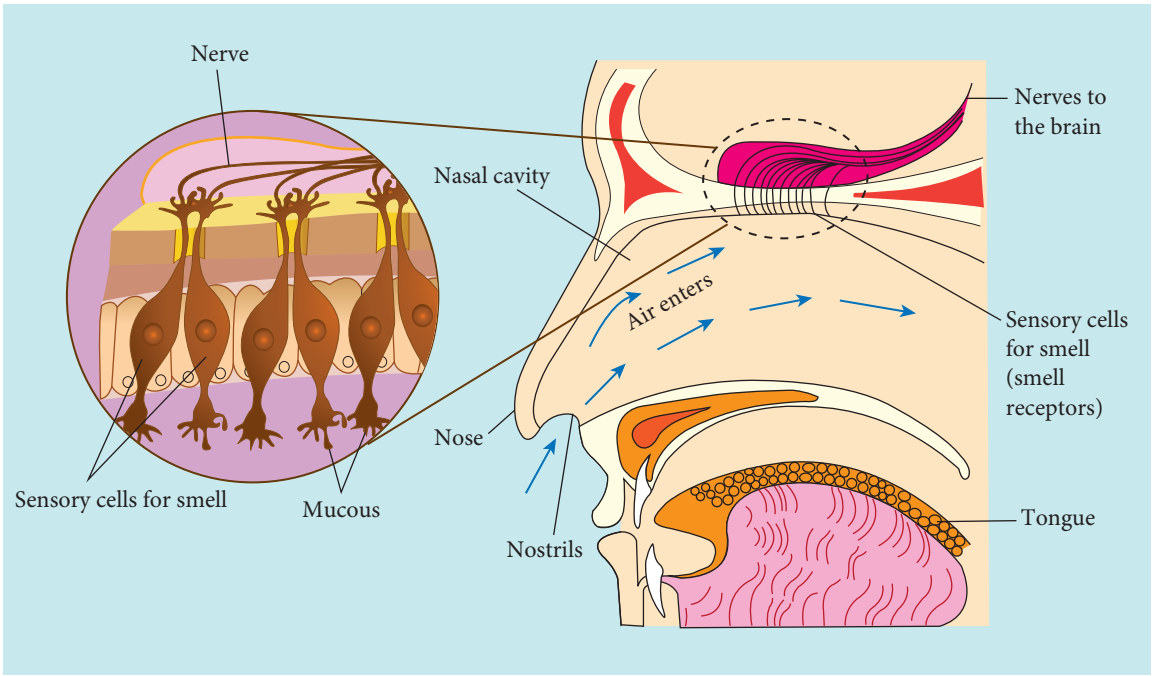


Figure 1.11 *Parts of the human nose*

Structure of the Nose

The **nose** is the sensory organ of smell. **Smells** are chemical substances present in the air. About 10 million **sensory cells for smell** are located at the roof of the nasal cavity as shown in Figure 1.11.

BRAIN TEASER

Why is a person suffering from flu normally unable to detect smells?

Function of Sensory Cells for Smell

Sensory cells for smell are tiny and covered with a layer of **mucous**. Chemical substances in the air will dissolve in this layer of mucous and stimulate the cells to produce **nerve impulses**. The nerve impulses are then sent to the brain to be interpreted to determine the type of smell.

Tongue

What are the parts of the tongue? Study Figure 1.12.

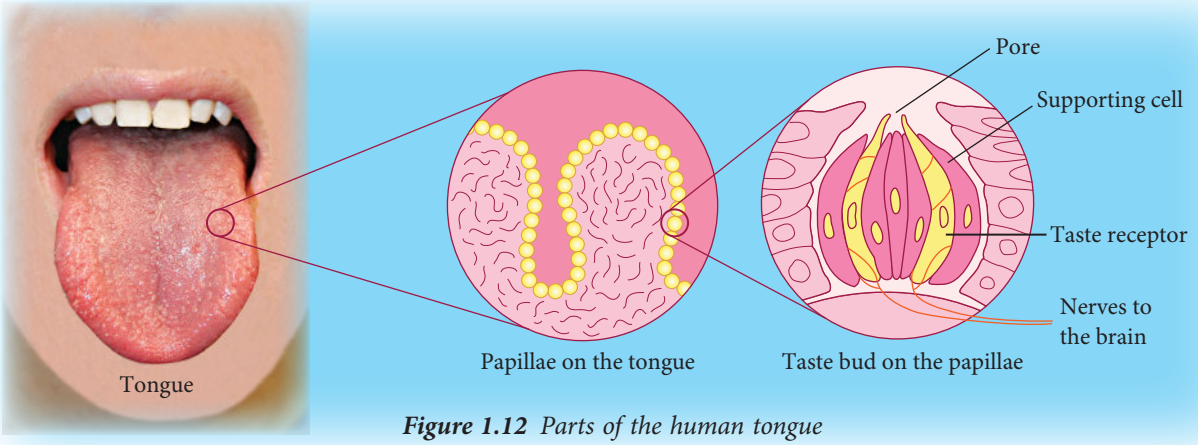


Figure 1.12 *Parts of the human tongue*

Structure of the Tongue

The **tongue** is the sensory organ of taste. Observe the surface of your tongue using a mirror. There are tiny nodules known as **papillae** on the surface of the tongue. The surface of a papillae is covered by hundreds of **taste buds**. Each taste bud contains 10 to 50 taste receptors. These **taste receptors** can detect **five** types of basic tastes which are **sweet, salty, sour, bitter** and **umami**.

SCIENCE INFO

Umami is classified as a basic taste because there are taste receptors that can only detect umami taste. This is the same as other basic tastes such as sweet, salty, sour and bitter. Umami taste is related to delicious tastes such as the taste of meat in soups or the taste of fermented foods such as cheese and mushrooms or monosodium glutamate (MSG).

Function of Taste Buds

When food is chewed, part or all the chemical substances in the food dissolve in the **saliva**. These dissolved chemical substances will diffuse into the **taste buds** through their pores and stimulate the **taste receptors** in them to produce **nerve impulses**. These nerve impulses are then sent to the brain to be interpreted as **sweet, salty, sour, bitter, umami** tastes or a combination of the basic tastes.

Skin

What are parts of the skin? There are five types of receptors found in the skin. What are their functions? Study Figure 1.13.

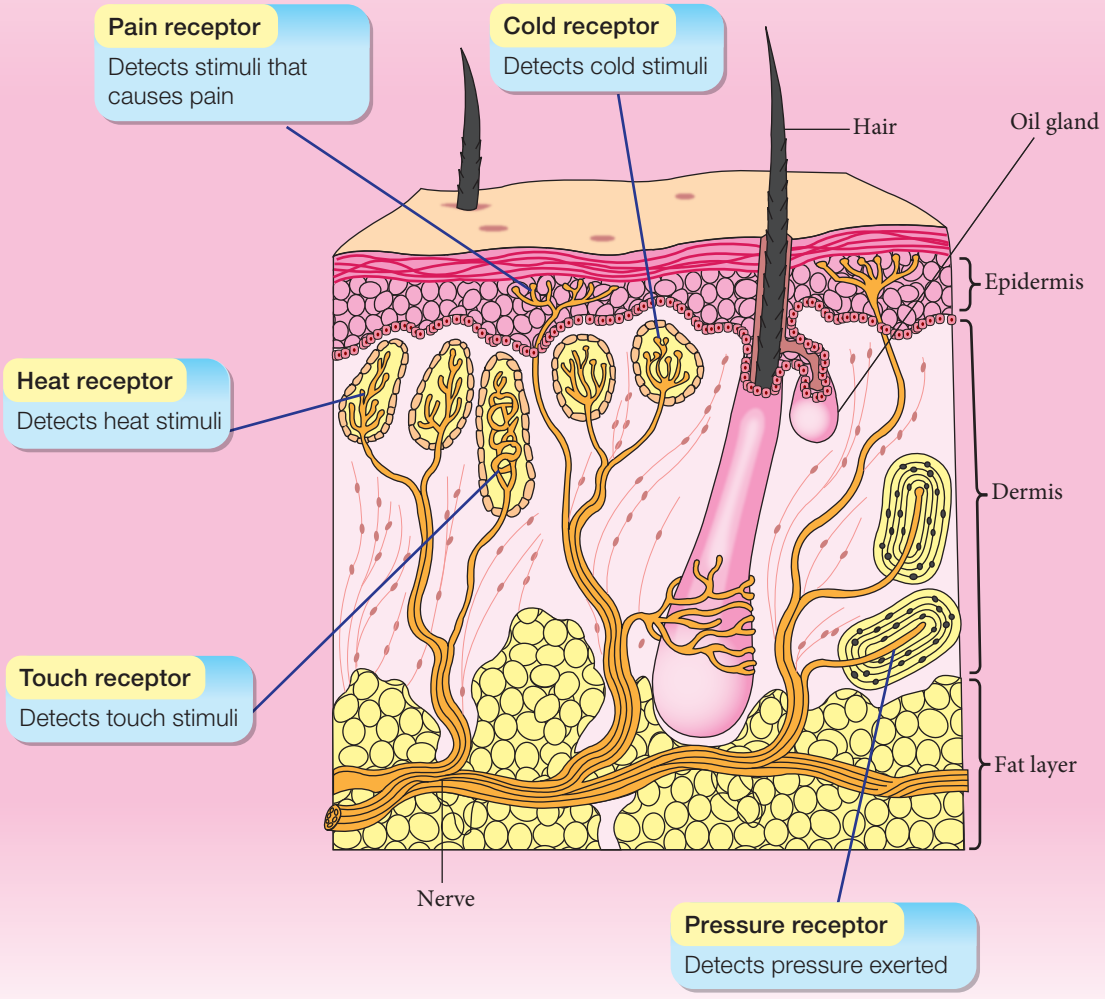


Figure 1.13 *Parts of the human skin*

The **skin** is the **largest sensory organ** in the human body. The human skin is made up of a thin outer layer known as **epidermis** and an inner layer known as **dermis**.

The skin has **five** types of receptors at different positions to detect different stimuli as shown in Figure 1.13. State the five types of stimuli which can be detected by the receptors in the skin.

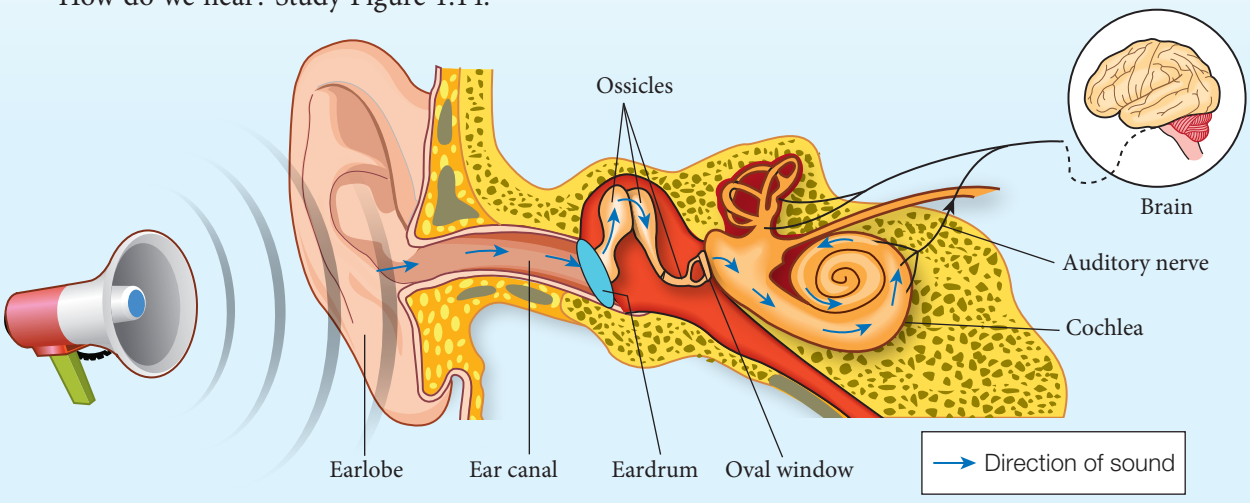
When the receptor in the skin is stimulated, **nerve impulses** are produced and sent through the nervous system to the brain to be interpreted and to produce an appropriate response.

BRAIN TEASER

How does the skin function as a sense of 'sight' for the blind?

Mechanism of Hearing

How do we hear? Study Figure 1.14.



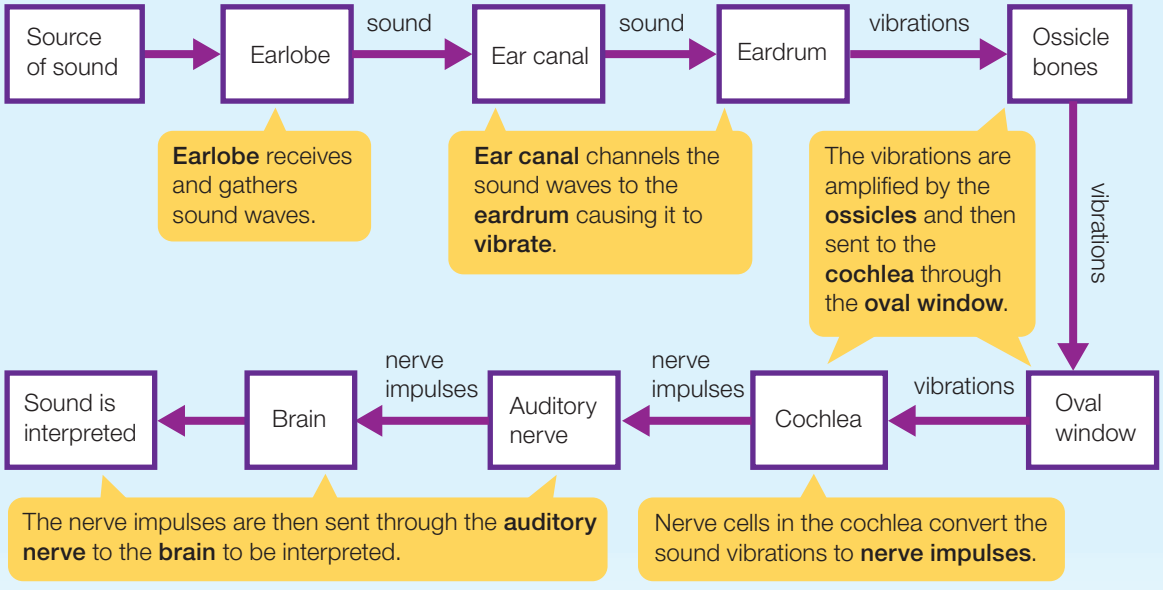


Figure 1.14 *Mechanism of hearing in humans*

Activity 1.4

21st Century Skills
- CPS, ICS
- Innovation-based activity

To study the mechanism of hearing using a model

Instructions

1. Work in groups.
2. Each group is required to present the mechanism of hearing using a model prepared by the teacher.
3. Construct a flow chart that shows the direction of sound in the mechanism of hearing.

Mechanism of Sight

How do we see? Study Figure 1.15.

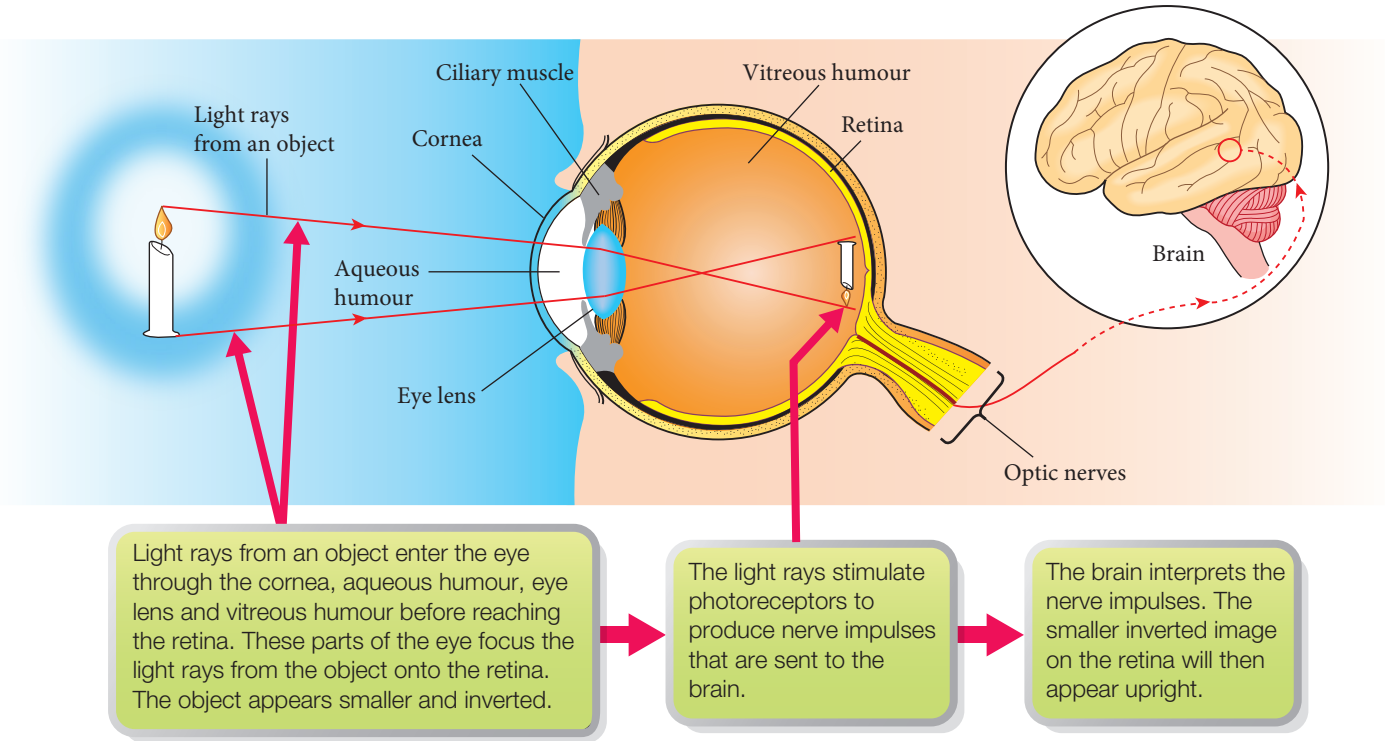


Figure 1.15 *Mechanism of sight in humans*

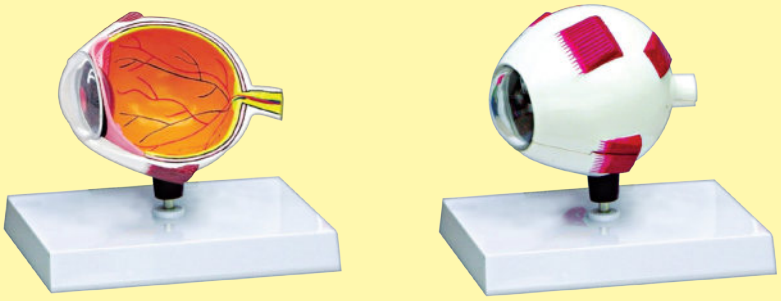
Activity 1.5

21st Century Skills
- CPS, ICS
- Innovation-based activity

To study the mechanism of sight using a model

Instructions

1. Work in groups.
2. Each group is required to present the mechanism of sight using a model prepared by the teacher.
3. Construct a flow chart that shows the direction of light in the mechanism of sight.



Photograph 1.7 *A human eye model*

Sensitivity of the Skin on Different Parts of the Body towards Stimuli

Photograph 1.8 shows a few examples of daily activities of humans which make use of the sensitivity of skin on different parts of the body towards different stimuli.

Photograph 1.8 *Sensitivity of the skin on different parts of the body*

Why are the daily activities shown in Photograph 1.8 carried out on different parts of the body? Let us investigate this in Activity 1.6.

Activity 1.6

Inquiry-based activity

To investigate the sensitivity of the skin on different parts of the body towards the touch stimulus

Material

Cellophane tape

Apparatus

Ruler (30 cm), toothpick and handkerchief (or blindfold)

Instructions

1. Work in pairs.
2. Set up the apparatus as shown in Figure 1.16.

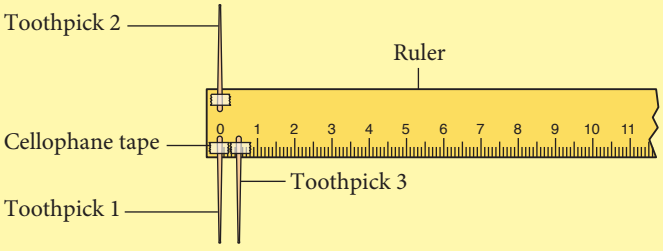


Figure 1.16

Using the cellophane tape, attach:

- Toothpick 1 on the 0 mark of the ruler.
- Toothpick 2 opposite the first toothpick on the ruler.
- Toothpick 3 on the 0.5 cm mark of the ruler.

3. Cover your partner's eyes with a handkerchief.
4. Prick the back of your partner's hand with one or two toothpicks as shown in Figure 1.17.

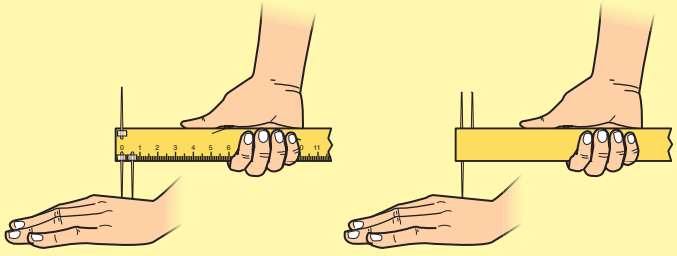


Figure 1.17

CAUTION!

- Hold the sharp end of the toothpick with care.
- Do not press the sharp end of the toothpick too hard onto the skin.
- Throw away all used toothpicks into the rubbish bin.

Ask your partner if he or she feels it as one or two toothpicks.

5. Mark '✓' if the answer is correct and '×' if the answer is wrong in the table below.
6. Repeat steps 4 and 5 three times.
7. Repeat steps 4 to 6 on different parts of the body such as the tip of the index finger, elbow and arm.

Part of Body	Touch stimulus by using					
	one toothpick			two toothpicks		
	1st attempt	2nd attempt	3rd attempt	1st attempt	2nd attempt	3rd attempt
Back of the hand						
Tip of the index finger						
Elbow						
Arm						

Questions

1. At which part or parts of the body is the skin most sensitive to touch stimulus? Explain your observation.
2. At which part or parts of the body is the skin least sensitive to touch stimulus? Explain your observation.
3. Which type of receptor is stimulated in this activity?
4. State **two** factors that affect the sensitivity of skin on different parts of the body towards touch stimulus.

The sensitivity of skin towards stimuli depends on **the number of receptors** and **the thickness of the skin epidermis**. For example, the tip of the finger is very sensitive towards touch because at the tip of the finger, there is a large number of touch receptors and the epidermis is thin. The tongue, nose and lips are also very sensitive to touch. The elbow, the sole of the foot and the back of the body are less sensitive to touch. Why?

Sensitivity of the Tongue towards Different Taste Stimuli

The tongue can detect **five** types of tastes which are **sweet**, **salty**, **sour**, **bitter** and **umami**. Each type of taste is detected by a different receptor. Let us investigate the areas of the tongue that detect different tastes in Activity 1.7.

Activity 1.7

Inquiry-based activity

To show that the sensitivity of the tongue towards taste stimuli is related to the number of receptors

CAUTION!

Do not taste any chemical substance in the laboratory without your teacher's permission.

Materials

Sugar solution (sweet), salt solution (salty), lime juice (sour), strong coffee without sugar (bitter), mushroom soup (umami) and distilled water

Apparatus

Drinking straw, handkerchief (or blindfold) and six cups

Photograph 1.9

Instructions

1. Work in pairs. Your teacher will provide each pair of students with five solutions of different tastes which are sweet, salty, sour, bitter and umami, in different cups.
2. Cover your partner's eyes with a handkerchief.
3. Ask your partner to gargle with distilled water.
4. Using a drinking straw, place a drop of sugar solution on part A of his tongue as shown in Figure 1.18.
5. Ask your partner to identify the taste of the solution without pulling the tongue back into the mouth.
6. Mark '✓' if your partner correctly identifies the taste of the solution and '✗' if your partner incorrectly or fails to identify the taste of the solution in a table as shown below.
7. Repeat steps 3 to 6 on parts B, C, D and E.
8. Repeat steps 3 to 7 using the four other solutions provided.

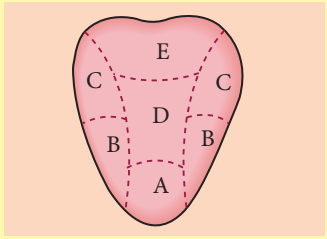


Figure 1.18

Part of the tongue	Type of taste				
	Sweet	Salty	Sour	Bitter	Umami
A					
B					

Questions

1. Why does your partner have to gargle each time before tasting the solutions?
2. Which part of the tongue is able to identify all the tastes of the solutions?
3. Which part of the tongue is most sensitive to taste? Explain your observation.
4. Which part of the tongue is least sensitive to taste? Explain your observation.
5. What conclusion can you make from this activity?

Different Areas of the Tongue are More Sensitive to Specific Taste

Areas of the tongue are sensitive to all five tastes. However, different areas of the tongue have different sensitivities towards specific taste. For example, the area in front of the tongue is more sensitive to **sweet** taste whereas the sides are more sensitive to **sour** and **salty** tastes. The area at the back of the tongue is more sensitive to **bitter** taste. The area at the centre of the tongue, however is more sensitive to **umami** taste. Study Figure 1.19.

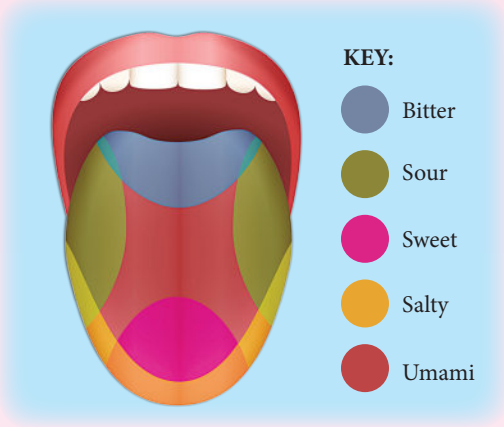


Figure 1.19 *Different areas of the tongue are more sensitive to specific taste*

BRAIN TEASER

Nowadays, there is a toothbrush equipped with a tongue cleaner. Does the use of the tongue cleaner reduce the sensitivity of the tongue?

Combination of the Sense of Taste and the Sense of Smell

Look at Photograph 1.10. Can the child enjoy the fried chicken? Does the sense of smell play a role when a person tastes food? Let us investigate this matter in Activity 1.8.

Photograph 1.10 *Food eaten without smelling*

Activity 1.8

Inquiry-based activity

To investigate the relationship between sense of taste and sense of smell

Materials

Cordial drinks of different flavours (grape, orange, mango, strawberry) and distilled water

Apparatus

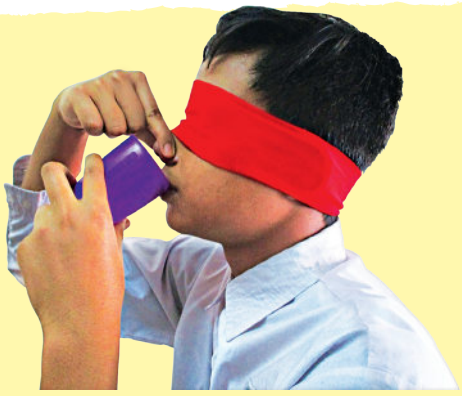
Handkerchief (or blindfold) and cups

Instructions

1. Work in pairs. Your teacher will provide each pair of students with cordial drinks of different flavours such as grape, orange, mango and strawberry in different cups.
2. Cover the eyes of your partner with a handkerchief and ask him to pinch the nose as shown in Photograph 1.11.
3. Give your partner a cup of distilled water and ask him to gargle.

4. Give your partner a cup of grape-flavoured cordial drink and ask him to identify and state the flavour of the cordial in the given cup.
5. Mark '✓' if your partner answers correctly and '×' if your partner is unable or fails to answer correctly in a table as shown below.
6. Repeat steps 3 to 5 using cordial drink of other flavours.
7. Repeat steps 2 to 6 without pinching the nose.

Condition of the nose	Flavour of cordial drink			
	Grape	Orange	Mango	Strawberry
Pinched				
Without being pinched				



Photograph 1.11

CAUTION!

Make sure your partner is not allergic to all the flavours of the cordial drinks investigated.

Questions

1. Under what condition is your partner able to identify the flavours of the cordial drinks more easily, with his nose pinched or not being pinched?
2. State **one** inference based on your answer.
3. Why should your partner's eyes be covered in this activity?
4. Why does hot food taste better?

Case Study

1. The judges in a cooking competition as shown in Photograph 1.12 use several types of senses.
   (a) State the types of senses used by the judges to carry out their evaluation.
   (b) What sensory organs are related to the sense of taste?

Photograph 1.12

2. Have you ever carried out the daily activity as shown in Photograph 1.13?
   (a) What is the combination of senses used in this activity?
   (b) What is the importance of the combination of sensory organs in carrying out this activity?

Photograph 1.13

How do Limitation of Senses, Defect in Sensory Organs and Ageing Affect Human Hearing and Sight?

Audio visual which combines the senses of hearing and sight, plays an important role in daily life. Let us investigate how limitation of senses, defect in sensory organs and ageing affect the sensitivity of hearing and sight of humans.

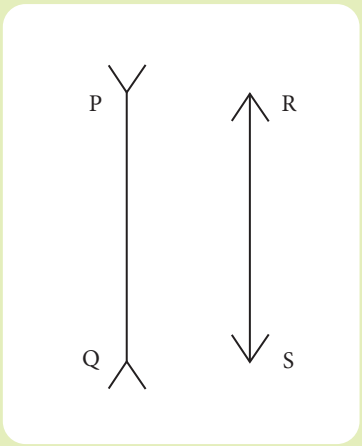
SCIENCE INFO

Audio visual refers to the use of two components, sound component (**audio**) and graphic component (**visual**).

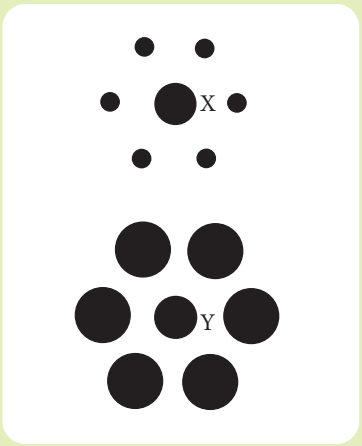
Limitations of Sight

Limitation of sight is the limitation in the ability of the eye to see objects. We **cannot see very tiny** objects such as microorganisms as well as **very distant** objects such as planet Jupiter. Limitations of sight include **optical illusions** and **blind spot**.

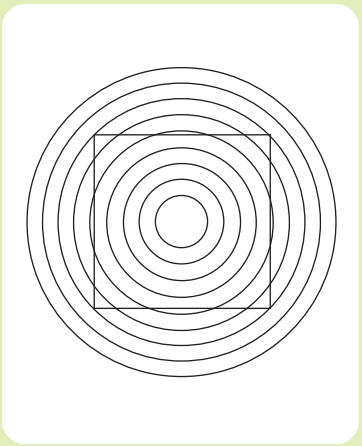
Optical Illusions



(a) Which line is longer?



(b) Which spot in the centre is larger?



(c) Are the sides of the square straight or curved?

Figure 1.20 *Optical illusions*

Look at Figure 1.20 and answer the questions given. Check your answer using a straight ruler. Is your answer correct or wrong? Why?

Optical illusion occurs when an object that is seen differs from its actual state. Optical illusion occurs because the brain is unable to accurately interpret the object seen by the eye due to distractions around the object. Look at Figure 1.21.

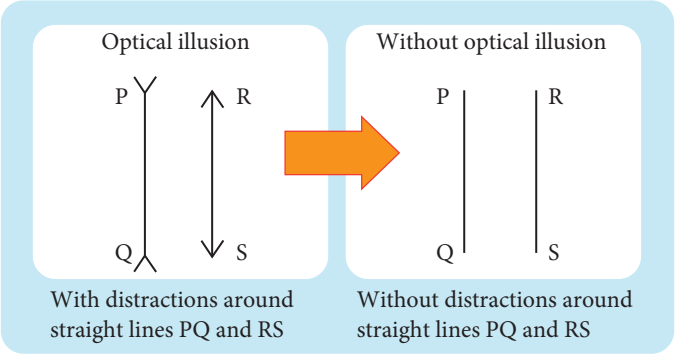


Figure 1.21 *Factor causing an optical illusion*

Blind Spot

Refer to the blind spot shown in Figure 1.8 on page 12. Why are images that fall on the blind spot invisible?

We are unaware of the presence of the blind spot in the eye because it is not possible for the image of the same object to fall on the blind spots of both eyes simultaneously. Carry out the following simple activity to investigate the blind spot.

Figure 1.22 *Investigating the blind spot*

Instructions

1. Hold this book with your right hand and straighten your arm.
2. Cover your left eye and look at the cat in Figure 1.22 with your right eye.
3. Move this book slowly towards your eyes. Does the bird disappear from your sight at a certain position? Why?

Photograph 1.14 shows examples of various devices used to overcome the limitations of sight. Name these devices. Gather information on the use of these devices from the Internet, magazines, books, newspapers and other sources. Discuss the information gathered. Present the findings of your discussions collaboratively using multimedia presentation.

Scanning electron microscope

Binoculars

Light microscope

Ultrasound machine

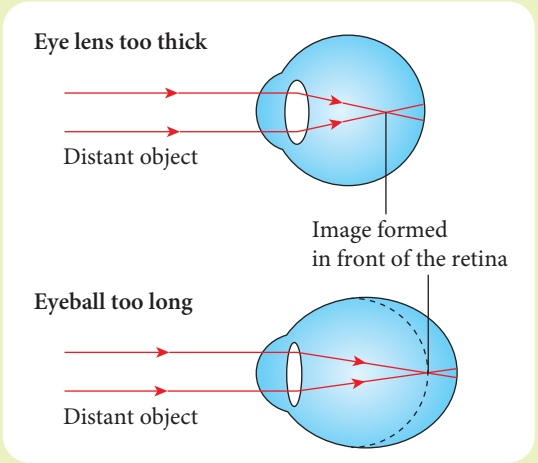
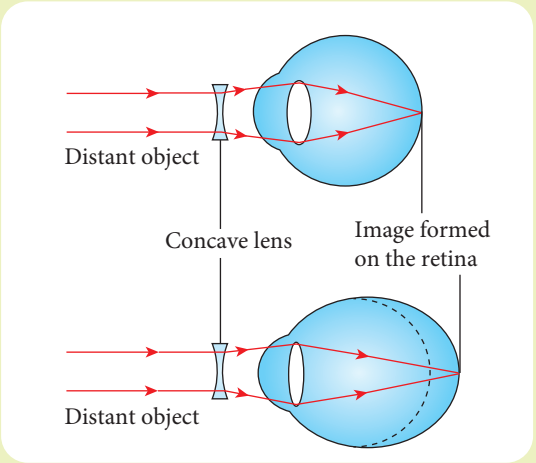
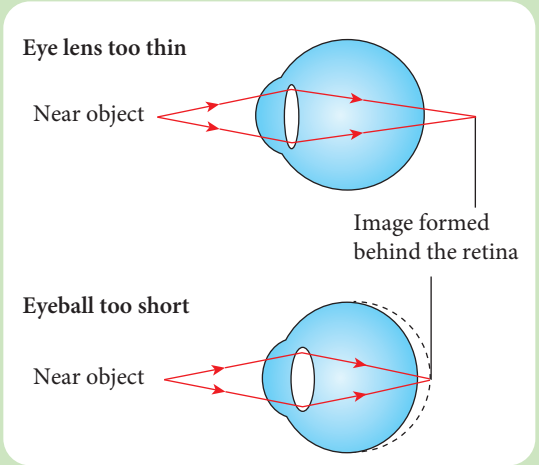
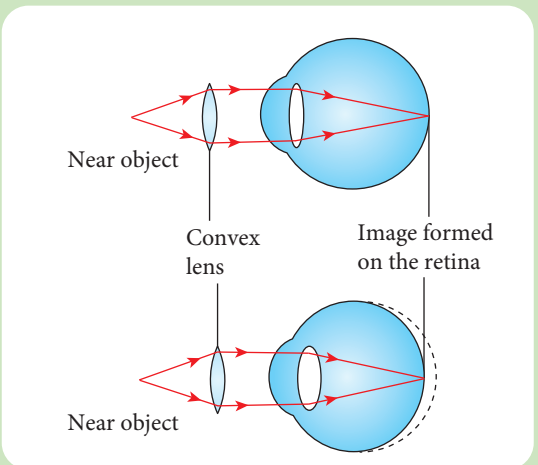
X-ray machine

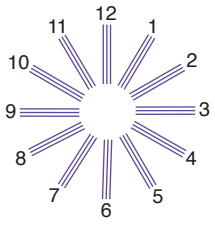
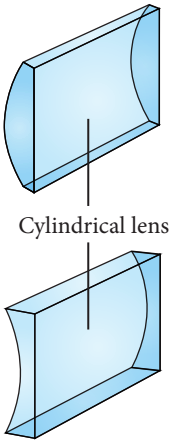
Photograph 1.14 *Examples of devices to overcome limitations of sight*

Defects of Sight and Ways to Correct Them

Defects of sight include **short-sightedness, long-sightedness** and **astigmatism**. How can these defects of sight be corrected? Study Table 1.2.

Table 1.2 *Defects of sight and ways to correct them*

Defect of sight	How it is corrected
Short-sightedness (a) Inability to see distant objects clearly. (b) Distant objects appear blurry because the image is focused **in front of the retina**. (c) This defect is caused by the eye lens being too thick or the eyeball being too long.	Short-sightedness can be corrected using **concave lens**.
	
Long-sightedness (a) Inability to see near objects clearly. (b) Near objects appear blurry because the image is focused **behind the retina**. (c) This defect is caused by the eye lens being too thin or the eyeball being too short.	Long-sightedness can be corrected using **convex lens**.
	

Defect of sight	How it is corrected
Astigmatism (a) Seeing part of an object clearer than the rest of the object (b) This defect is caused by the uneven curvature of the cornea or eye lens.  *Figure 1.23* Test your eyes by looking at Figure 1.23. Can you see all the lines clearly? If you cannot, you have astigmatism.	Astigmatism can be corrected using **cylindrical lenses**. 

Limitations of Hearing

Limitations of hearing are limitations in the ability of the ear to hear sound. We can only hear sounds of frequencies between the range of 20 Hz to 20 000 Hz. The ears are unable to detect sounds which lie outside this frequency range. The **frequency range of hearing** of every individual is different. When a person gets older, the frequency range of his hearing gets narrower as his eardrum becomes less elastic. Examples of devices invented and used to overcome the limitations of hearing are shown in Photograph 1.15.

Today in history

The first stethoscope made of wood was invented by Rene Laennec at Necker-Enfants Malades Hospital, Paris in 1816.

Stethoscope helps us to listen to the heartbeats.

A loudspeaker amplifies sound so that it can be heard from far away.

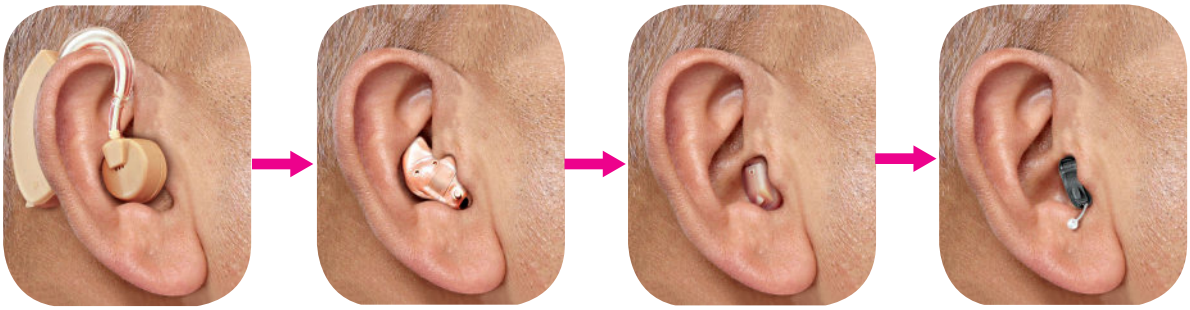
Photograph 1.15 *Examples of equipment used to overcome limitations of hearing*

Defects of Hearing and Ways to Correct Them

Defects of hearing occur when the sense of hearing of a person does not function well. Defects of hearing are normally caused by damage to the ear due to infection by microorganisms, injury, ageing process or continuous exposure to loud sounds.

Damages to the **outer ear** and **middle ear** can be corrected easily. For example, the clearing of foreign objects in the ear canal. Punctured eardrum and damaged ossicles can also be corrected using medicine or surgery. Damage to the **inner ear** is more difficult to correct. A damaged cochlea can be corrected using a cochlear implant but a damaged auditory nerve cannot be corrected using medicine or surgery.

Photograph 1.16 shows how innovation and technology are applied to invent smaller and more sophisticated hearing aids.



Photograph 1.16 *Advancements in hearing aids*

The Five Senses – a Gift

The five senses is a gift from God that we should appreciate. However, unhealthy lifestyles and high risk careers can affect the sensitivity of the sensory organs.

Based on Photographs 1.17 and 1.18,

- name the sensory organ whereby the sensitivity is affected in each situation.
- describe how each situation can affect the sensitivity of the sensory organ.
- what are the devices or safety measures taken to maintain the safety and health of the sensory organ in each situation?

Photograph 1.17 *Unhealthy lifestyle*

Photograph 1.18 *High risk careers*

Activity 1.9

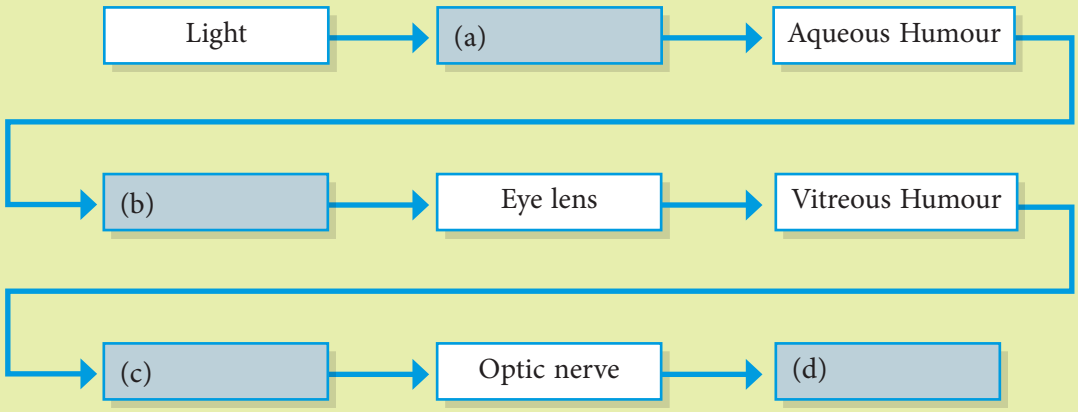
21st Century Skills
- CPS, ISS, ICS
- Technology-based activity

Instructions

1. Work collaboratively in groups.
2. Each group is assigned by your teacher to create a multimedia presentation such as MS PowerPoint or animation on one of the following topics:
   - Optical illusion and blind spot
   - Various types of audio visual defects such as short-sightedness, long-sightedness, astigmatism and defects of hearing
   - Correction of audio visual defects using concave lenses, convex lenses and hearing aids
   - Examples and effects of unhealthy lifestyles or high risk careers that can affect the sensitivity of the sensory organs
   - The five senses – a gift and the importance of practising safety and healthcare of the sensory organs

Formative Practice 1.2

1. Complete the following mechanism of sight.



2. Which structure of the ear, if damaged, will not influence the mechanism of hearing?

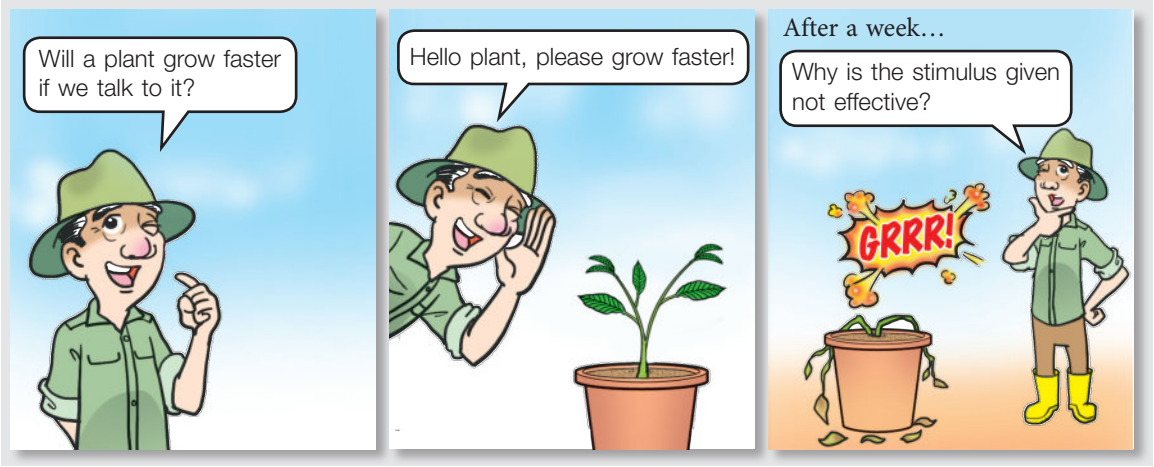
3. Where is the sensory cell for smell located?

4. State the **five** tastes that can be detected by the tongue.

5. State **two** factors that influence the sensitivity of the skin to stimuli.

6. (a) State the type of stimulus that can be detected by the tongue.
(b) Explain how the stimulus in question **6** (a) can be detected.

1.3 Stimuli and Responses in Plants



Like humans and animals, **plants** can also **detect stimuli** and **respond** to them. The stimuli that can be detected by plants include **light, water, gravity** and **touch**. The responses of plants can be divided into two as shown in Figure 1.24.

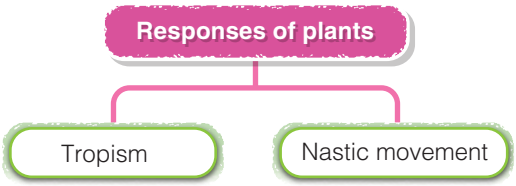


Figure 1.24 *Responses of plants to stimuli*

Tropism

Tropism is a directional **response of plants** to **stimuli** such as light, water, gravity and touch coming from a certain direction. A certain part of a plant will grow towards or move away from the detected stimulus. The part of a plant which grows towards a stimulus is known as **positive tropism** whereas the part of a plant which grows away from a stimulus is known as **negative tropism**. The directional response of plants normally occurs slowly and less significantly. Let us carry out Experiment 1.1 to determine the direction of response of plants to light, water, gravity and touch.

Experiment 1.1

A Response of plants towards light or phototropism

Aim: To study the response of plants to light

Problem Statement: Which part of plants responds to light?

Hypothesis: Shoots of plants grow in the direction of light.

Variables

(a) manipulated variable : Direction of light towards the shoots of the seedlings
(b) responding variable : Direction of growth of the shoots of the seedlings
(c) constant variables : Seedlings of the same type and height, volume of water

Materials
Green pea seedlings, soil, water and three boxes (one box with an opening at the top and two other boxes with openings at the side)

Apparatus
Three beakers

Procedure

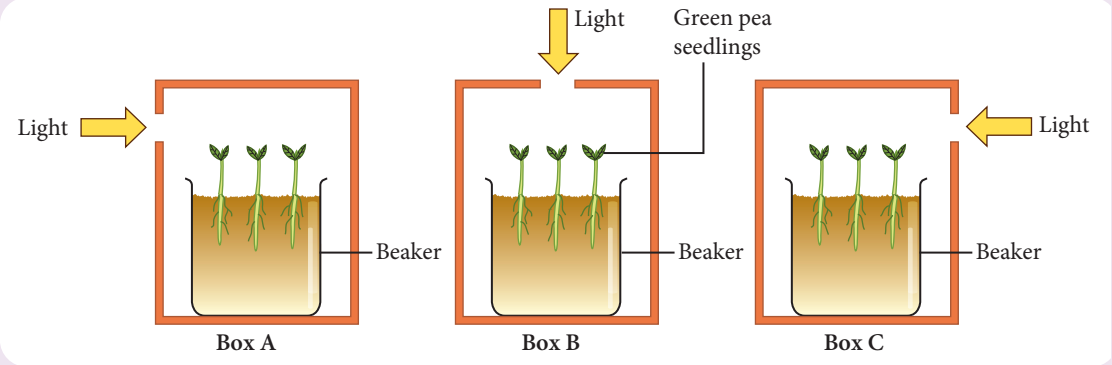


Figure 1.25

1. Set up the apparatus as shown in Figure 1.25.
2. Observe and sketch the positions of the shoots of the seedlings in boxes A, B and C.
3. Keep all three boxes in the laboratory for five days. Keep the soil moist by watering it with the same amount of water daily.
4. After five days, observe and sketch the positions of the shoots of the seedlings in boxes A, B and C.

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

Questions
1. What is the stimulus used in this experiment?
2. State the part of the plant that responds to the stimulus.
3. Does the part of the plant in question 2 show positive or negative phototropism? Explain your answer.

B Response of plants to gravity or geotropism

Aim: To study the response of plants to gravity

Problem statement: Which part of plants responds to gravity?

Hypotheses: (a) Roots of plants grow in the direction of gravity.
(b) Shoots of plants grow in the opposite direction of gravity.

Variables
(a) manipulated variable : Position of the seedlings relative to the direction of gravity
(b) responding variable : Direction of growth of the roots and shoots of the seedlings
(c) constant variables : Presence of water, absence of light, seedlings with straight roots and shoots

Materials
Green pea seedlings with straight roots and shoots, moist cotton wool and plasticine

Apparatus
Petri dish

Procedure
1. Set up the apparatus as shown in Figure 1.26. Make sure that the green pea seedlings are arranged in different positions in the Petri dish.
2. Observe and sketch the position of the shoots and roots of the seedlings in the Petri dish.
3. Keep the apparatus in a dark cupboard for two days.
4. After two days, observe and sketch the position of the shoots and roots of the seedlings in the Petri dish.

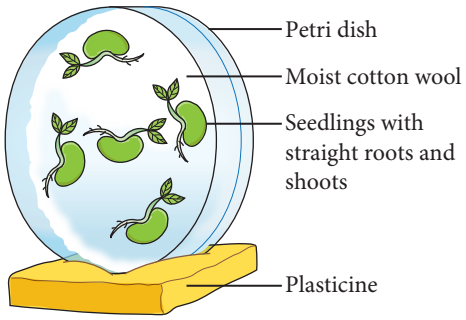


Figure 1.26

Conclusion
Are the hypotheses accepted? What is the conclusion of this experiment?

Questions
1. Why is the apparatus kept in a dark cupboard?
2. Based on your observations, state the direction of growth of the:
   (a) shoots of the seedlings
   (b) roots of the seedlings
3. Do plants show positive geotropism or negative geotropism? Explain your answer.

C Response of plants to water or hydrotropism

Aim: To study the response of plants to water

Problem statement: Which part of plants responds to water?

Hypothesis: Roots of plants grow in the direction of water.

Variables
(a) manipulated variable : Presence of a source of water
(b) responding variable : Direction of growth of roots of seedlings
(c) constant variables : Gravity, absence of light and seedlings with straight roots

Materials
Green pea seedlings with straight roots, moist cotton wool and anhydrous calcium chloride

Apparatus
Rough wire gauze and two beakers

Procedure
1. Set up the apparatus as shown in Figure 1.27.
2. Observe and sketch the positions of the roots of the seedlings in beakers X and Y.
3. Keep both beakers X and Y in a dark cupboard.
4. After two days, observe and sketch the positions of the roots of the seedlings in beakers X and Y.

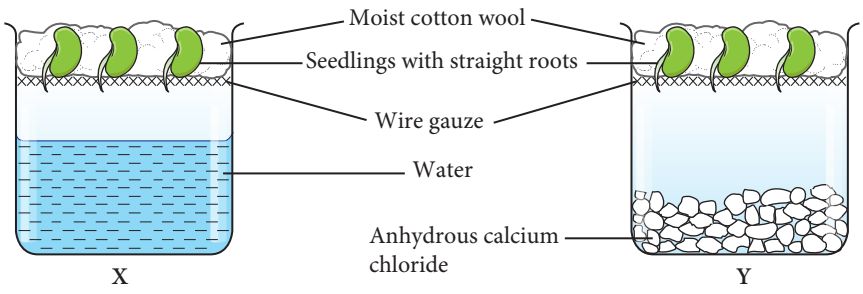


Figure 1.27

Conclusion

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

Questions

1. What is the stimulus used in this experiment?
2. State the part of the plant that responds to the stimulus.
3. What is the function of the anhydrous calcium chloride in beaker Y?
4. Does the part of the plant in question 2 show positive or negative hydrotropism? Explain your answer.

Plants need to be responsive towards stimuli such as light, gravity and water so that they can respond appropriately to ensure their sustainability and survival. Why do plants need light and water? Name one stimulus that can be detected by plants but not investigated in Experiment 1.1.

Phototropism

Phototropism is the response of plants towards **light**. **Shoots of plants** show **positive phototropism** which is growth towards the direction of light (Photograph 1.19). As plants need light to carry out photosynthesis, positive phototropism ensures that shoots and leaves of plants obtain enough sunlight to make food through photosynthesis.

Photograph 1.19 *Shoots of plants show positive phototropism*

Hydrotropism

Hydrotropism is the response of plants towards **water**. **Roots of plants** show **positive hydrotropism** which is growth towards the direction of water (Figure 1.28). Positive hydrotropism allows roots of plants to obtain water to carry out photosynthesis and absorb dissolved mineral salts to stay alive.

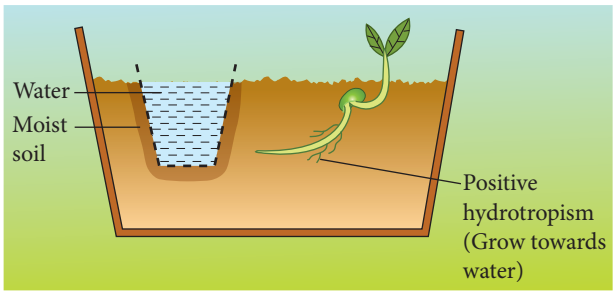


Figure 1.28 *Roots showing positive hydrotropism*

1.3.1 1.3.2 1.3.3

Geotropism

Geotropism is the response of plants towards **gravity**. **Roots of plants** show **positive geotropism** which is downward growth towards the direction of gravity. Positive geotropism allows the roots of plants to grow deep into the ground to grip and stabilise the position of the plant in the ground. On the other hand, **shoots of plants** show **negative geotropism** which is upward growth in the opposite direction of gravity. Negative geotropism allows the shoots and leaves of plants to grow upwards to obtain sunlight for photosynthesis (Figure 1.29).

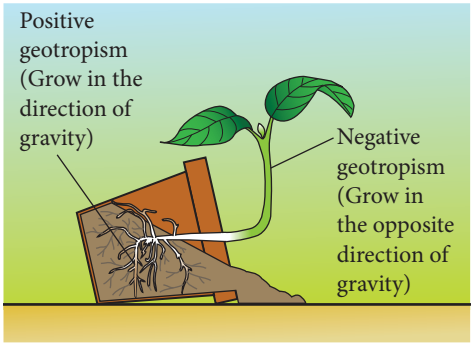


Figure 1.29 *Roots show positive geotropism whereas shoots show negative geotropism*

Thigmotropism

Thigmotropism is the response towards **touch**. **Tendrils** or **twining stems** show positive thigmotropism when they cling onto whatever objects or other plants they come into contact (Photograph 1.20). This response enables plants to grow upwards to obtain sunlight and grip objects to obtain support. Roots show negative thigmotropism since they avoid any object that obstructs their search for water.

(a) Cucumber plant has tendrils that twine around objects in contact with it

(b) Morning glory plant has stems that twine around objects in contact with it

Photograph 1.20 *Tendrils and stems which twine around objects show positive thigmotropism*

Nastic Movement

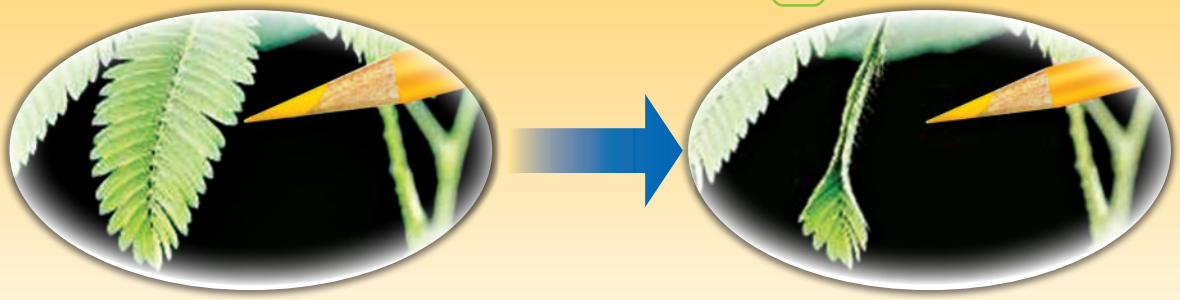
Nastic movement is the response towards a stimulus such as **touch** but does not depend on the direction of the stimulus. What are other stimuli that can cause nastic movement? Why is nastic movement not a type of tropism?

Nastic movement occurs **more rapidly** than tropism. For example, the *Mimosa* sp. responds to touch by folding its leaves inwards when touched as shown in Photograph 1.21. This nastic movement serves as a **defence** of the *Mimosa* sp. against its enemies and strong wind.

VIDEO

Nastic movement of the *Mimosa* sp.

SCAN PAGE



Photograph 1.21 *Nastic movement of a leaf of Mimosa sp.*

Activity 1.10

21st Century Skills
- CPS
- Inquiry-based activity

To investigate responses of plants in different situations

The responses of plants towards the earth's gravity and the period of exposure to sunlight in a day influence the growth of shoots and roots of plants. These ensure the sustainability and survival of the plants.

At the International Space Station (ISS), scientists investigate the growth of plants in the following situations:
(a) no gravity
(b) period of exposure to sunlight

Photograph 1.22 *A scientist carrying out investigations at the ISS*

Instructions

1. Work in groups.
2. Gather information on the results of the investigations of the scientists on the growth pattern of shoots and roots of plants towards stimuli (gravity and sunlight).
3. Present the outcome of the discussion of each group using multimedia presentation.

Formative Practice 1.3

1. (a) What is tropism?
(b) State the type of tropism towards the following stimuli:
(i) Touch
(ii) Gravity
(iii) Light

2. (a) Which parts of a plant show:
(i) positive phototropism?
(ii) positive geotropism?
(iii) positive thigmotropism?
(b) What is the importance of hydrotropism to plants?

3. State **one** similarity and **one** difference between the responses of tropism and nastic movement.

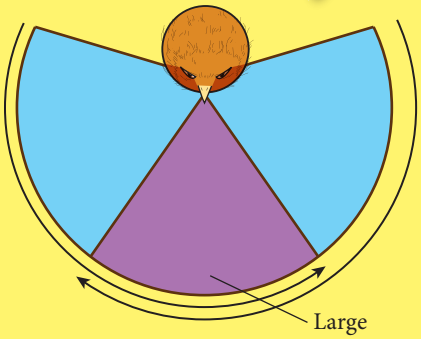
1.3.1 1.3.2 1.3.3

1.4 Importance of Responses to Stimuli in Animals

Stereoscopic and Monocular Visions

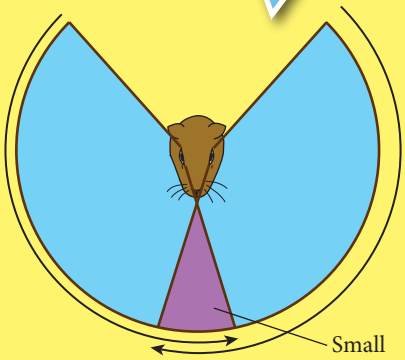
Study Figure 1.30 to understand stereoscopic and monocular visions. Table 1.3 shows the characteristics and importance of stereoscopic and monocular visions in animals.

- Humans and animals such as cats and owls have a pair of eyes located **in front of their head**.
- They have **stereoscopic vision**.



(a) Stereoscopic vision

- Animals such as rats, chickens and rabbits have a pair of eyes located on opposite **sides of their head**.
- They have **monocular vision**.



(b) Monocular vision

Figure 1.30 *Stereoscopic and monocular visions*

Table 1.3 *Differences between stereoscopic and monocular vision*

Stereoscopic vision	Monocular vision
Both eyes located in **front of** the **head**.	Both eyes located at the **sides of** the **head**.
A **narrow** field of vision.	A **wide** field of vision.
Fields of vision overlap to a great extent. Overlapping fields of vision produce vision in three dimensions.	Fields of vision do not overlap or overlap only **slightly**.
Three dimensional images formed in the overlapping fields of vision allow the distance, size and depth of objects to be estimated accurately.	**Two dimensional images** formed in the non-overlapping fields of vision prevent the distance, size and depth of objects from being estimated accurately.
The ability to estimate distance accurately helps animals to hunt.	A wide field of vision helps animals to detect their enemies coming from any direction.
Humans and most **predators** have stereoscopic vision.	Most **prey** have monocular vision.

Stereophonic Hearing

What is the importance of having a pair of ears to humans and animals? **Stereophonic hearing** is hearing using **both ears**. Stereophonic hearing allows us to **determine the direction of the sound** accurately. Look at Figure 1.31.

The importance of stereophonic hearing to humans is to determine the **location** of a source of sound. Stereophonic hearing helps predators to determine the location of their prey. Conversely, stereophonic hearing also helps prey to determine the location of their predators and to escape from them.

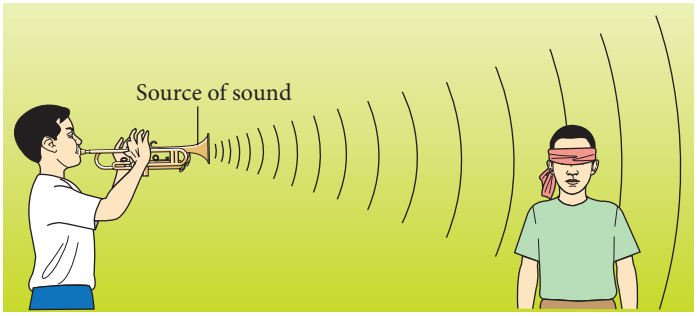
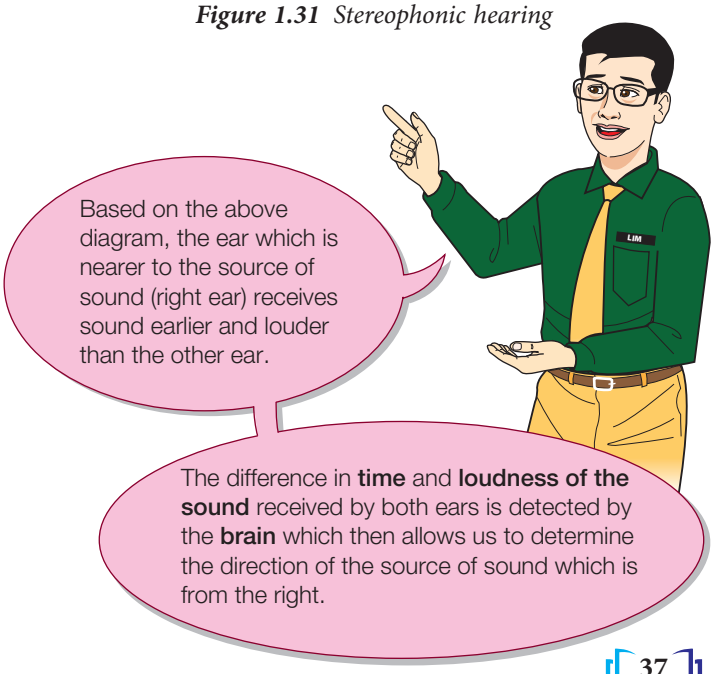


Figure 1.31 *Stereophonic hearing*



BRAIN TEASER

How does the ear function as a sense of 'sight' for the blind?

Hearing Frequencies of Animals

Different animals can hear sounds of different frequencies as shown in Figure 1.32.

I CAN REMEMBER!

Frequencies of sounds that can be detected by the human ear are limited to the range of 20 Hz to 20 000 Hz.

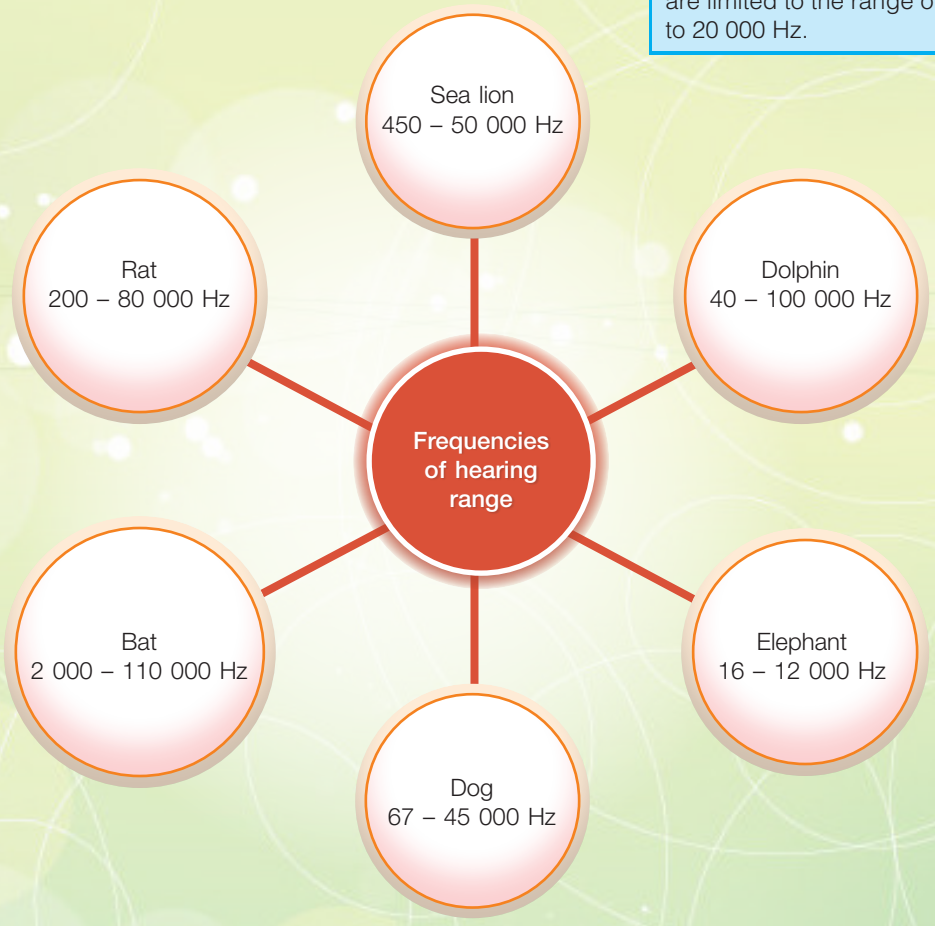


Figure 1.32 *Frequencies of hearing range of different animals*

Activity 1.11

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

Instructions

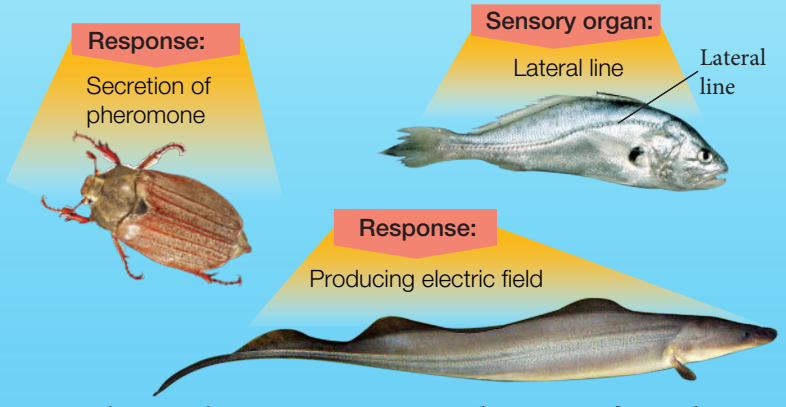
1. Work collaboratively in groups.
2. Each group will be assigned by your teacher to create a multimedia presentation such as MS PowerPoint or animation on one of the following topics:
   (a) Stereoscopic and monocular visions in animals
   (b) Stereophonic hearing
   (c) Different hearing frequencies for different animals

Sensory Organs Ensure the Survival of Animals on Earth

Responses to stimuli ensure the survival of animals on Earth. The sensory organs and responses of several animals are shown in Photograph 1.23. Carry out Activity 1.12 to investigate the sensory organs and responses of several other animals.

MARVELS OF SCIENCE

Animals such as ants, snakes, frogs and birds are believed to be able to predict earthquakes. Scientists are investigating the types of stimuli detected by these animals before earthquakes occur.



Photograph 1.23 *Sensory organs and responses of animals*

Websites

Electric field of an electric eel
http://links.and117.com/BT_Science_39

Activity 1.12

To explain the sensory organs and responses of other animals on Earth

21st Century Skills
- ICS
- Discussion activity

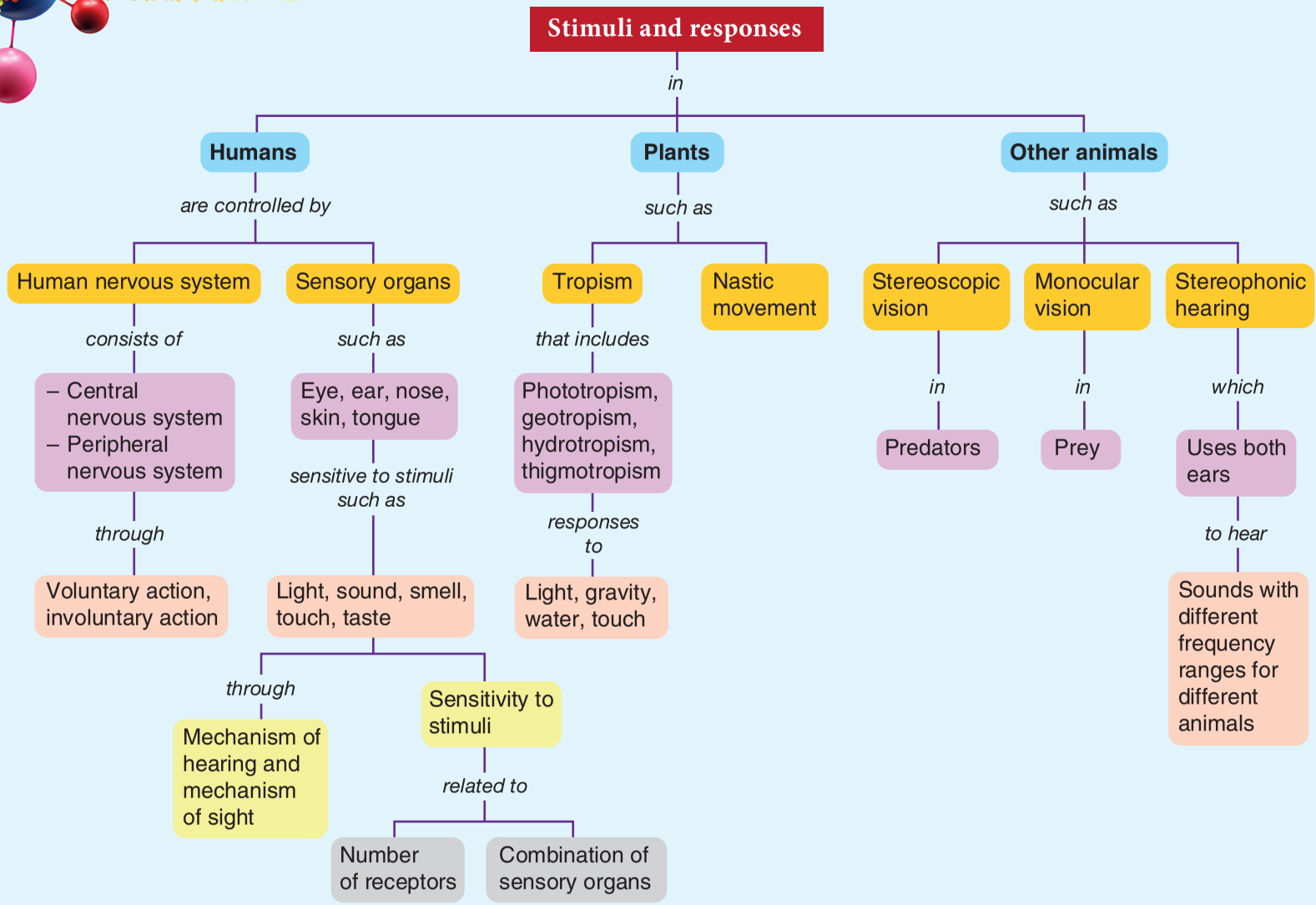
Instructions

1. Work in groups.
2. Each group is required to gather information on how responses of animals in Photograph 1.23 are able to ensure their survival on Earth.
3. Discuss the information gathered.
4. Present the outcome of the discussion of each group in class using multimedia presentation.

Formative Practice 1.4

1. State **two** types of vision of animals.
2. State the factor that determines the type of vision of animals.
3. What is the type of vision of a primary consumer? Give your reasons.
4. What is the importance of stereophonic hearing?
5. In the dark, Azman can determine the location of a mewing cat. Explain how Azman is able to determine the location of the cat.

Summary


Stimuli and responses
in
Humans
are controlled by
Human nervous system
consists of
– Central nervous system
– Peripheral nervous system
through
Voluntary action, involuntary action
Sensory organs
such as
Eye, ear, nose, skin, tongue
sensitive to stimuli such as
Light, sound, smell, touch, taste
through
Mechanism of hearing and mechanism of sight
Sensitivity to stimuli
related to
Number of receptors
Combination of sensory organs
Plants
such as
Tropism
that includes
Phototropism, geotropism, hydrotropism, thigmotropism
responses to
Light, gravity, water, touch
Nastic movement
Other animals
such as
Stereoscopic vision
in
Predators
Monocular vision
in
Prey
Stereophonic hearing
which
Uses both ears
to hear
Sounds with different frequency ranges for different animals

Self-reflection

After studying this chapter, you are able to:

1.1 Human Nervous System

- ☐ Describe the structures and functions of human nervous system through drawings.
- ☐ Make a sequence to show the pathway of impulses in voluntary and involuntary actions.
- ☐ Justify the importance of human nervous system in life.

1.2 Stimuli and Responses in Human

- ☐ Draw the structures of sensory organs and explain their functions and sensitivities towards stimuli.
- ☐ Explain the mechanism of hearing and sight through drawing.
- ☐ Relate human sensory organs to the sensitivity towards various combination of stimuli.
- ☐ Explain through examples how the limitation of senses, defect in sensory organs and ageing affect human hearing and sight.
- ☐ Justify how innovations and technologies can improve the ability to sense in sensory organs.

1.3 Stimuli and Responses in Plants

- ☐ Describe the parts of a plant that are sensitive towards stimuli.
- ☐ Justify how responses in plants ensure their sustainability and survival.
- ☐ Carry out experiments to study responses in plants towards various stimuli.

1.4 Importance of Responses to Stimuli in Animals

- ☐ Explain with examples the types of sight and hearing in animals.
- ☐ Communicate how sensory organs ensure the survival of animals on Earth.

Summative Practice 1

Answer the following questions:

1. Mark '✓' the correct statement and '×' the incorrect statement about the human nervous system.

(a) The peripheral nervous system is made up of nerves connecting the brain with the spinal cord.	
(b) Without a functioning brain, voluntary actions cannot be carried out.	
(c) Playing badminton is an involuntary action.	
(d) Impulses can only be interpreted by the brain.	

2. Figure 1 shows structures P, Q and R of the human nervous system.

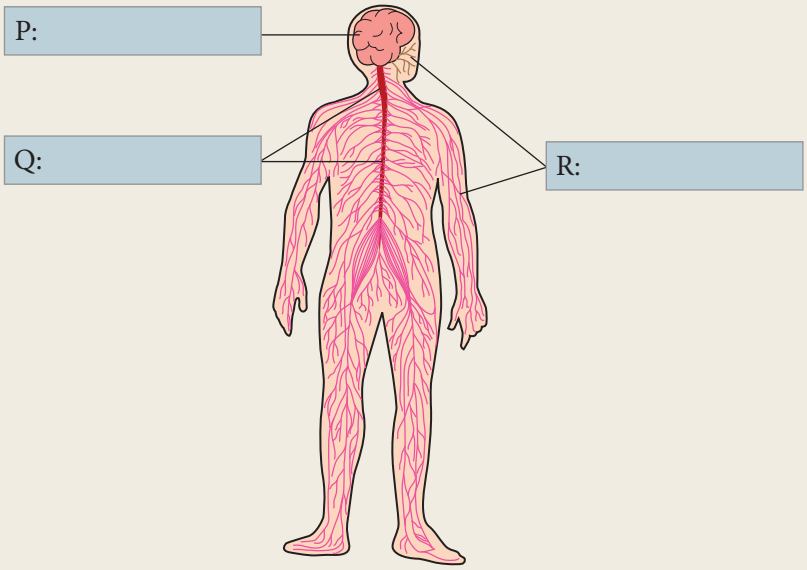
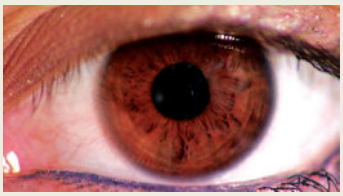


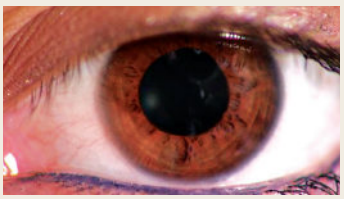
Figure 1

Label P, Q and R in Figure 1.

3. Figure 2 shows responses A and B of the eye.



Response A



Response B

Figure 2

(a) State the responses shown in Figure 2.
(b) State the stimuli that cause these responses.
(c) How do the stimuli cause these responses?
(d) These responses protect the eye especially the retina by preventing light of excessive intensity from entering the eye. During the solar eclipse, explain why we should observe this event on the water surface in a basin of water.

4. In a science class, Azura studies the mechanisms of hearing and sight.
(a) Draw **one** flow chart that shows the pathway of sound from a source of sound entering the ear.
(b) Draw **one** flow chart that shows the pathway of light from an object entering the eye.

5. Figure 3 shows the structure of the human skin.

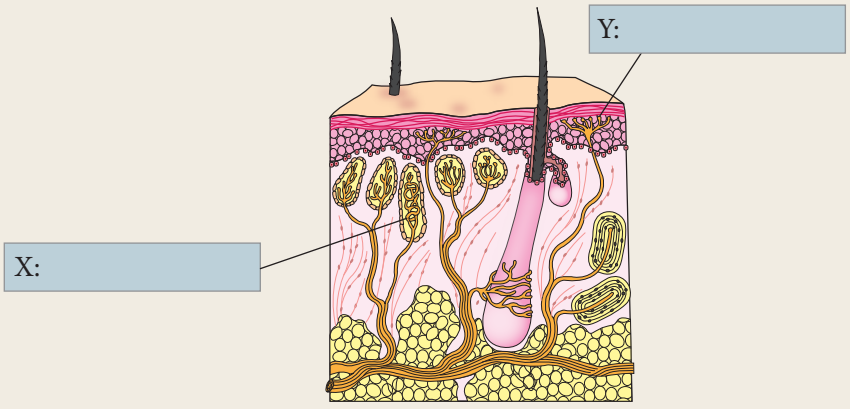


Figure 3

(a) Label X and Y in Figure 3.

(b) Explain why the fingertip and not the palm of the hand is used to detect Braille symbols.

(c) Mazlan classifies the tongue as skin that possesses taste receptors. Do you agree with the classification of the tongue as skin? Explain your answer.

6. (a) What is the importance of the sense of smell when we are in the science laboratory? Give **one** example.

(b) Why are dogs in police units trained to detect the presence of drugs kept in bags?

7. (a) State **two** responses in plants that help photosynthesis.

(b) How do the two responses of plants in question **7** (a) help photosynthesis?

8. (a) Name the type of vision of an eagle.

(b) What is the importance of the type of vision in question **8** (a) to the survival of the eagle?

Focus on HOTS

9. Pak Dollah who is long-sighted forgot to bring his glasses during breakfast in a restaurant. You are required to invent a lens to enable Pak Dollah to read the newspaper. Your invention must make use of the materials shown in Figure 4.

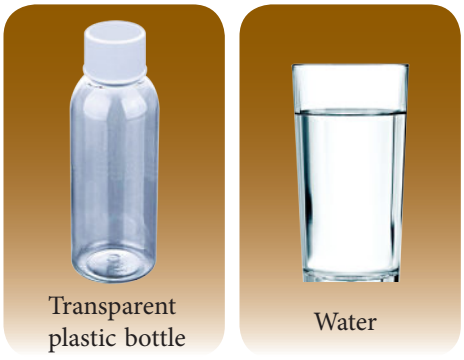
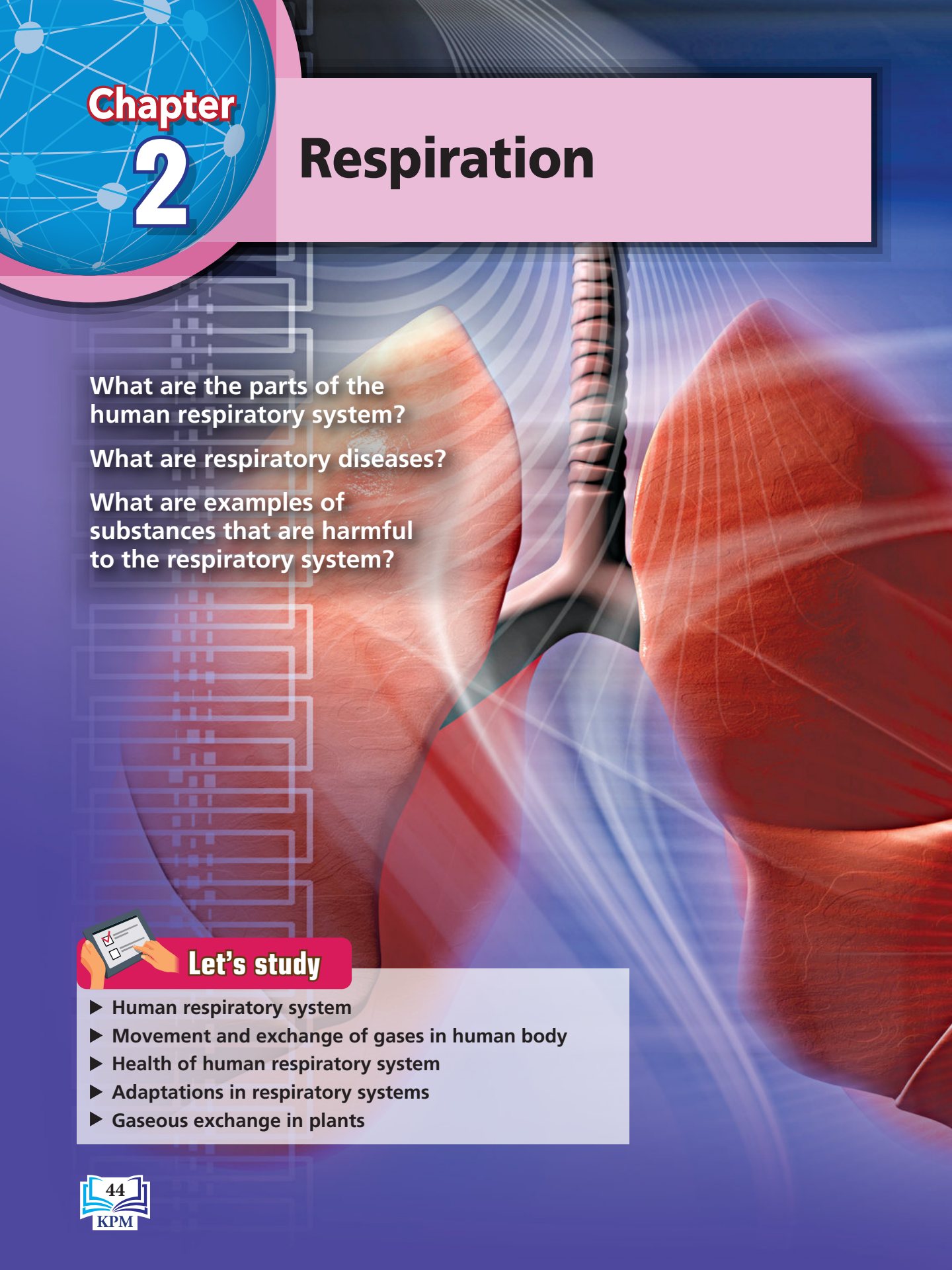


Figure 4

Chapter 2

Respiration



What are the parts of the human respiratory system?

What are respiratory diseases?

What are examples of substances that are harmful to the respiratory system?

Let's study

- Human respiratory system
- Movement and exchange of gases in human body
- Health of human respiratory system
- Adaptations in respiratory systems
- Gaseous exchange in plants

Science Gallery

(a) Running at high altitude

(b) Running in a hypoxic training room

How can the above two locations increase the efficiency of an athlete's respiration?

The higher the altitude, the lower the concentration of oxygen in the air. Therefore, less oxygen is transported to the cells in the body. Shortage of oxygen in these cells will stimulate the body to respond by:

- releasing red blood cells stored in the spleen
- increasing the production rate of red blood cells
- facilitating the decomposition of oxyhaemoglobin to release oxygen

All these responses will increase the efficiency of respiration. What is the importance of this adaptation in human survival?

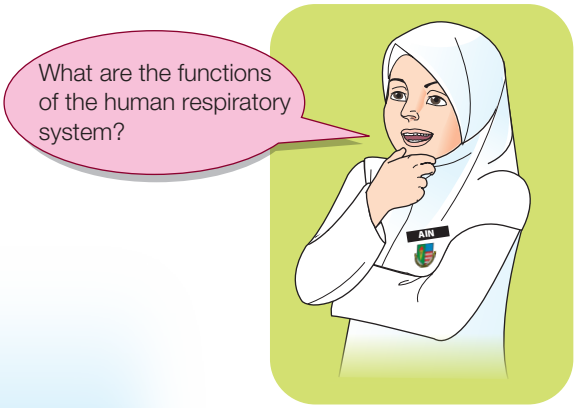
Keywords

- Intercostal muscles
- Trachea
- Bronchus
- Bronchiole
- Alveolus
- Diaphragm
- Oxyhaemoglobin
- Diffusion
- Cell respiration
- Emphysema
- Lung cancer
- Bronchitis
- Asthma
- Stoma
- Osmosis
- Guard cell

2.1 Human Respiratory System

Human Respiratory System

Breathing is the process of inhaling and exhaling air by the lungs. The system in the body that helps us to breathe is known as the **human respiratory system**. The structure of the human respiratory system is shown in Figure 2.1.



I CAN REMEMBER!

The human respiratory system functions to supply oxygen and removes carbon dioxide from the body cells.

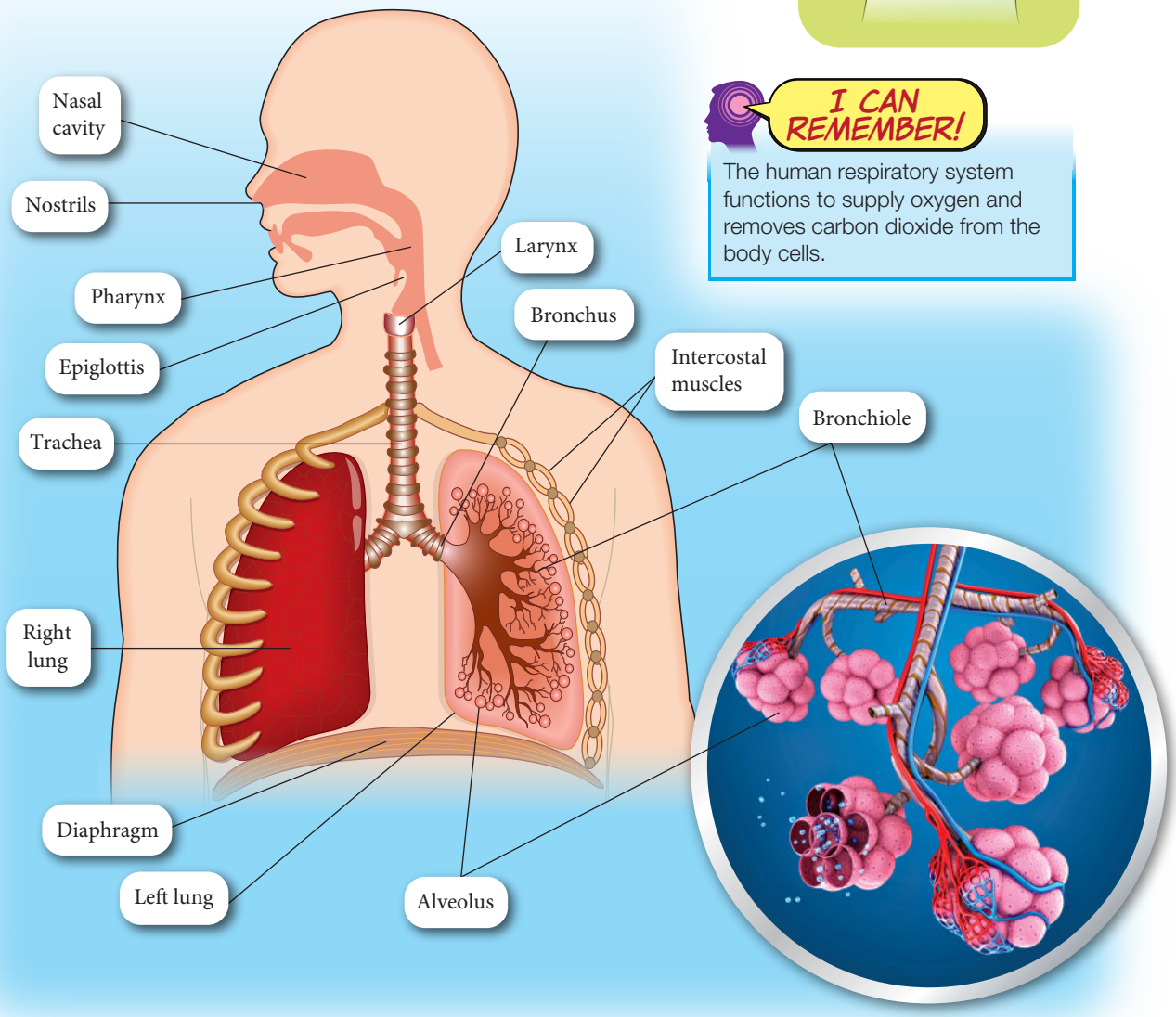


Figure 2.1 *Human respiratory system*

Activity 2.1

To explain the structure of the human respiratory system

Instructions

1. Work in groups.
2. Search the Internet for the structures of the human respiratory system.
3. Create a multimedia presentation from the results of your search.

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

Breathing Mechanism

Inhale and exhale. Can you feel the air entering and leaving through your nose? Place your hand on your chest. Do you realise that your chest rises and falls during breathing? The direction of air from the nose to the lungs is as shown in Figure 2.2.

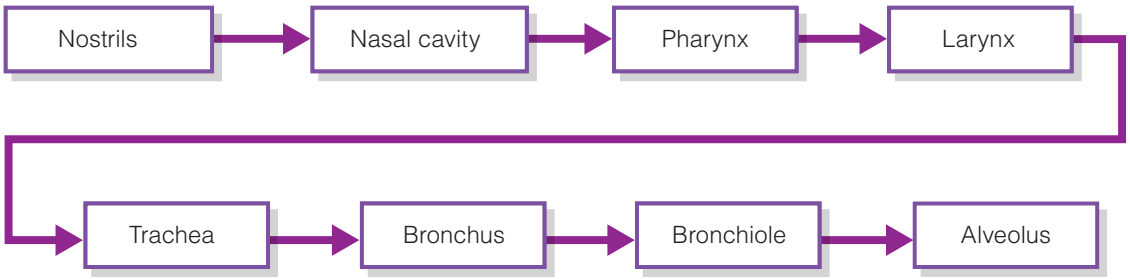


Figure 2.2 *Direction of air in breathing mechanism*

SCIENCE INFO

Most people take breathing for granted to the extent of not realising that they are breathing right now! Are you breathing? In this active world, the correct technique of breathing plays an important role to ensure the physical and mental health of humans. Correct breathing technique will improve the performance during exercise or sports events such as weightlifting.

VIDEO

Inhalation and exhalation

SCAN PAGE

Inhalation

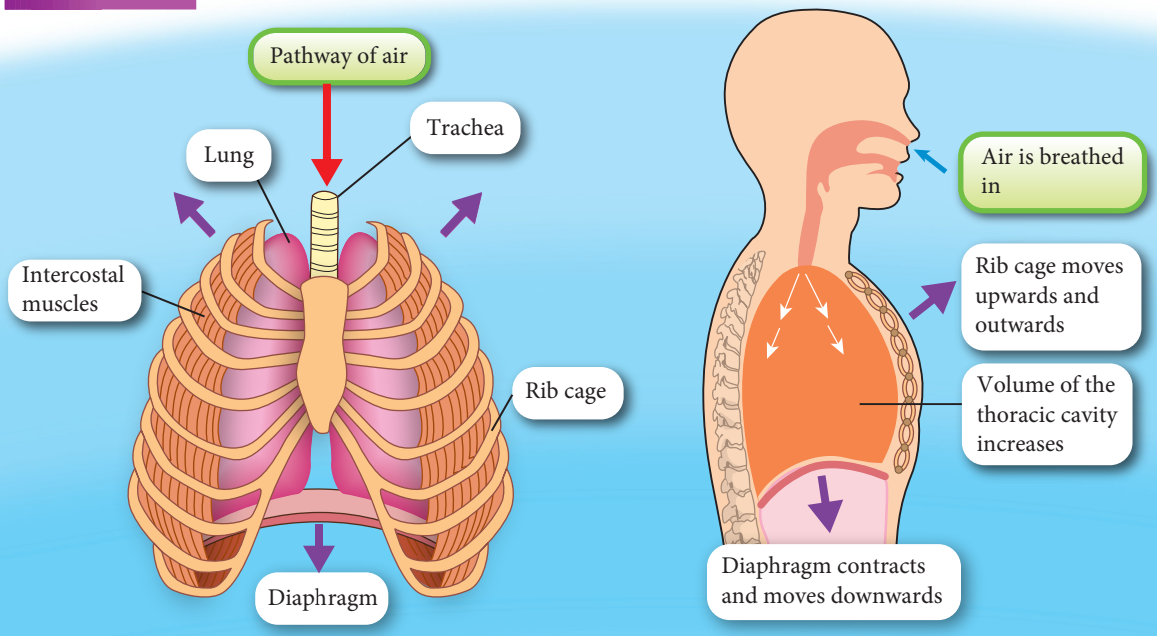


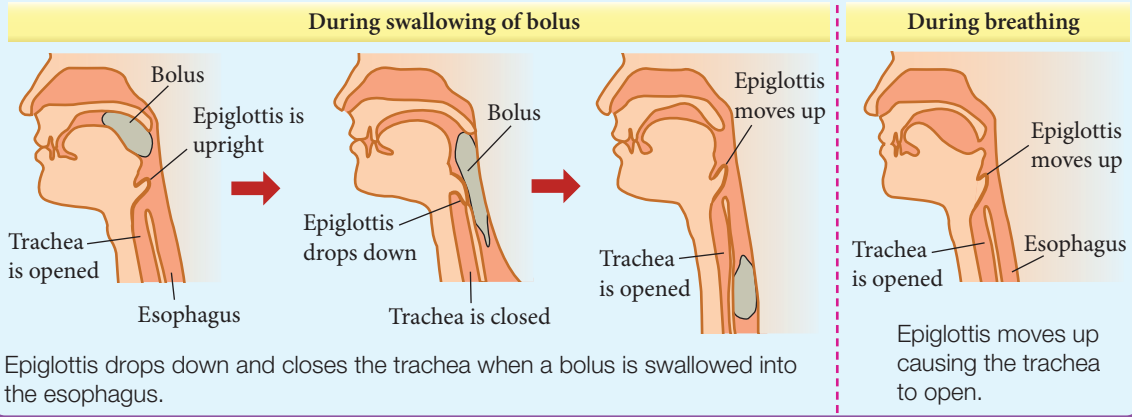
Figure 2.3 *Inhalation*

When you **inhale**,

- **intercostal muscles** contract and pull the **rib cage** upwards and outwards as shown in Figure 2.3.
- **diaphragm muscles** contract and pull the diaphragm to descend and become flat.
- movements of the rib cage and diaphragm make the **thoracic cavity** bigger and cause **air pressure** in the thoracic cavity to decrease.
- the higher **air pressure** outside forces air to enter the lungs as shown in Figure 2.3 (b).

SCIENCE INFO

The action of epiglottis during swallowing of bolus and breathing



Exhalation

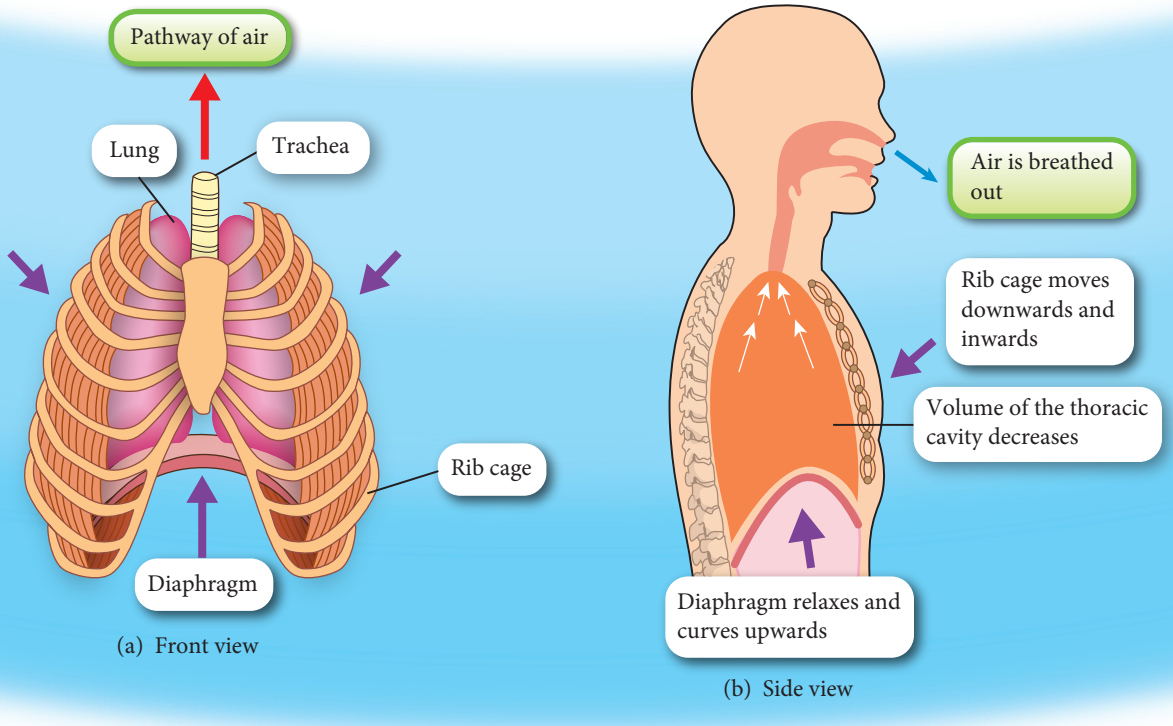


Figure 2.4 *Exhalation*

When you **exhale**,

- **intercostal muscles** relax and the **rib cage** moves downwards and inwards as shown in Figure 2.4.
- **diaphragm muscles** relax and curve upwards.
- movements of the rib cage and diaphragm make the **thoracic cavity** smaller and cause the **air pressure** in the thoracic cavity to increase.
- the higher **air pressure** in the lungs pushes the air out as shown in Figure 2.4 (b).

Activity 2.2

21st Century Skills
- ICS, ISS
- Innovation-based activity

To create a model or simulation to describe the breathing mechanism

Instructions

1. Work in groups.
2. Create a model or multimedia simulation to describe the actions of the diaphragm, intercostal muscles, movement of the rib cage, changes in the volume and air pressure in the thoracic cavity during inhalation and exhalation.
3. Present the breathing mechanism based on the model or simulation created.

Experiment 2.1

A Percentage of oxygen in inhaled and exhaled air

Aim

To study the difference in the percentage of oxygen in inhaled and exhaled air

Problem statement

What is the difference in the percentage of oxygen in inhaled and exhaled air?

Hypothesis

The percentage of oxygen in inhaled air is higher than the percentage of oxygen in exhaled air.

Variables

(a) manipulated variable : Type of air in gas jar
(b) responding variable : Final water level in gas jar
(c) constant variables : Air temperature and air pressure, volume of gas jar

Safety Precaution

Gas jar filled with exhaled air should be covered with a gas jar cover while being transferred to be inverted over a candle.

Materials

Candle, plasticine, matches, permanent marker, water, inhaled air and exhaled air

Apparatus

Glass basin, gas jar, gas jar cover and gas jar stand

Procedure

1. Set up the apparatus as shown in Figure 2.5 (a) and (b).

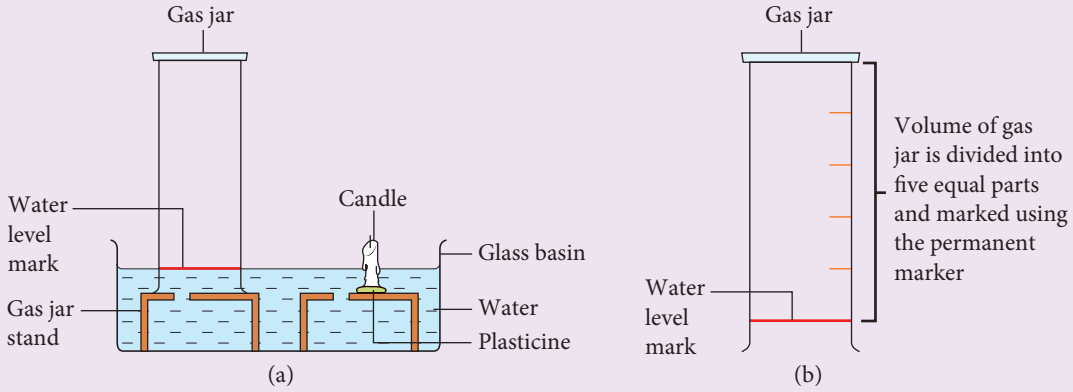


Figure 2.5

2. Light a candle and invert the gas jar filled with air over the candle as shown in Figure 2.6.
3. Observe and record the final water level (in units of the number of equal parts marked on the gas jar) after the candle flame extinguishes. Estimate the percentage of oxygen in the air in the gas jar.

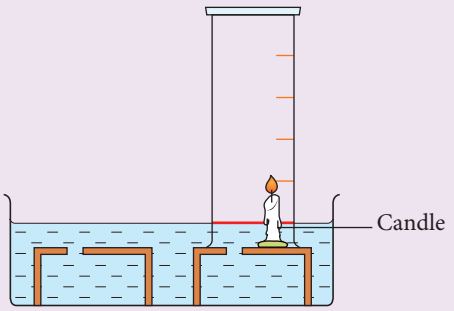


Figure 2.6

4. Set up the apparatus as shown in Figure 2.7 to collect exhaled air until the water level mark.
5. Repeat steps 2 and 3.

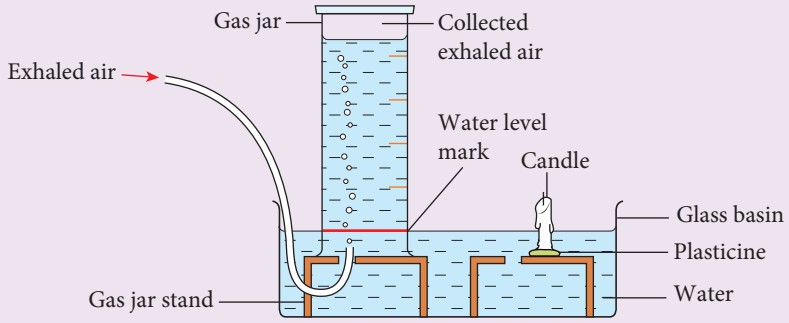


Figure 2.7

Results

Type of air in gas jar	Final water level in gas jar (number of parts)	Percentage of oxygen in the air
Inhaled air		
Exhaled air		

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

Question
In which gas jar does the water level rise higher? Explain your observation.

B Concentration of carbon dioxide in inhaled and exhaled air

Aim
To study the difference in concentration of carbon dioxide in inhaled and exhaled air

Problem statement
What is the difference in concentration of carbon dioxide in inhaled and exhaled air?

Hypothesis
Concentration of carbon dioxide in exhaled air is higher than concentration of carbon dioxide in inhaled air.

Variables
(a) manipulated variable : Type of air passed through limewater
(b) responding variable : Condition of limewater
(c) constant variables : Concentration of limewater, volume of conical flask

Materials
Limewater, inhaled air and exhaled air

Apparatus
Conical flask, connecting tube, rubber tubing, glass tube and rubber stopper

Procedure

1. Set up the apparatus as shown in Figure 2.8.
2. Close clip A. Inhale and hold your breath. Then, close clip B and open clip A. After that, exhale.

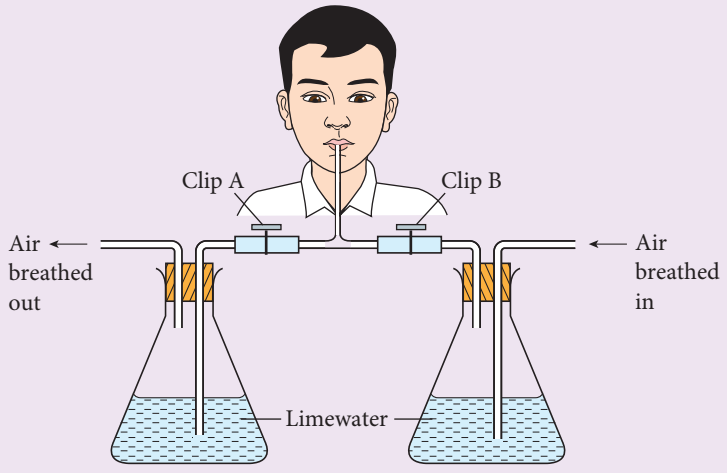


Figure 2.8

3. Observe and record if the limewater in the conical flasks where inhaled and exhaled air passes through appears clear or cloudy.

Results

Type of air that passes through limewater	Condition of limewater
Inhaled air	
Exhaled air	

Conclusion

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

Question

In which conical flask does the limewater become cloudy? Explain your observation.

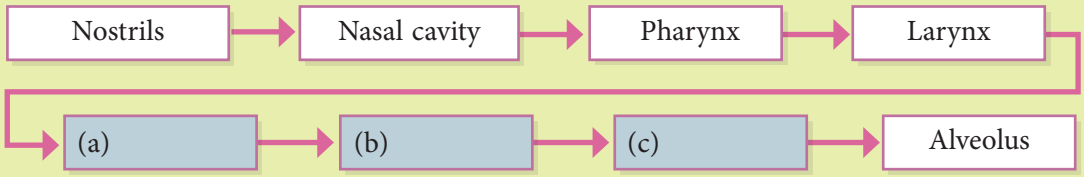
In theory,

Percentage/Concentration	Inhaled air	Exhaled air
Oxygen	Higher	Lower
Carbon dioxide	Lower	Higher

Do the results of Experiment 2.1 support this theory? Explain your answer.

Formative Practice 2.1

1. Complete the flow chart below which describes the direction of air during inhalation.



2. Mark '✓' for the correct statements and '×' for the incorrect statements on breathing.

(a) Epiglottis is the structure that opens or closes the trachea.	
(b) Exchange of gases in the body cells occurs in the bronchioles.	
(c) The diaphragm moves downwards and flattens during exhalation.	
(d) The percentage of carbon dioxide in exhaled air is less than inhaled air.	

3. What is the importance of good ventilation in a class with many students?

4. Figure 1 shows a simple model used to show the breathing mechanism.

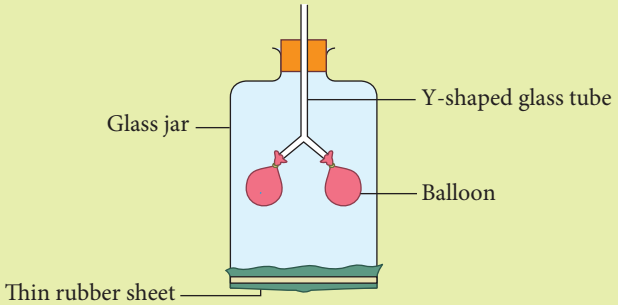


Figure 1

(a) Name the parts of the human respiratory system represented by the following parts:
- (i) Glass jar
- (ii) Thin rubber sheet
- (iii) Y-shaped glass tube
- (iv) Balloon

(b) Why is a thin rubber sheet used in the above model instead of a thick rubber sheet?

(c) Name the breathing processes shown by the following actions performed on the thin rubber sheet:
- (i) Pulling the thin rubber sheet downwards.
- (ii) Pushing the thin rubber sheet upwards.

(d) Why does the glass jar fail to function as a rib cage in the breathing mechanism using the above model?

2.2 Movement and Exchange of Gases in the Human Body

Movement and Exchange of Oxygen and Carbon Dioxide in the Human Body

Have you ever wondered about the process of movement of particles such as oxygen and carbon dioxide molecules from an area of higher concentration to an area of lower concentration? What is this process?

Observe the movement and exchange of oxygen and carbon dioxide in the alveolus and blood capillaries as shown in Figure 2.9.

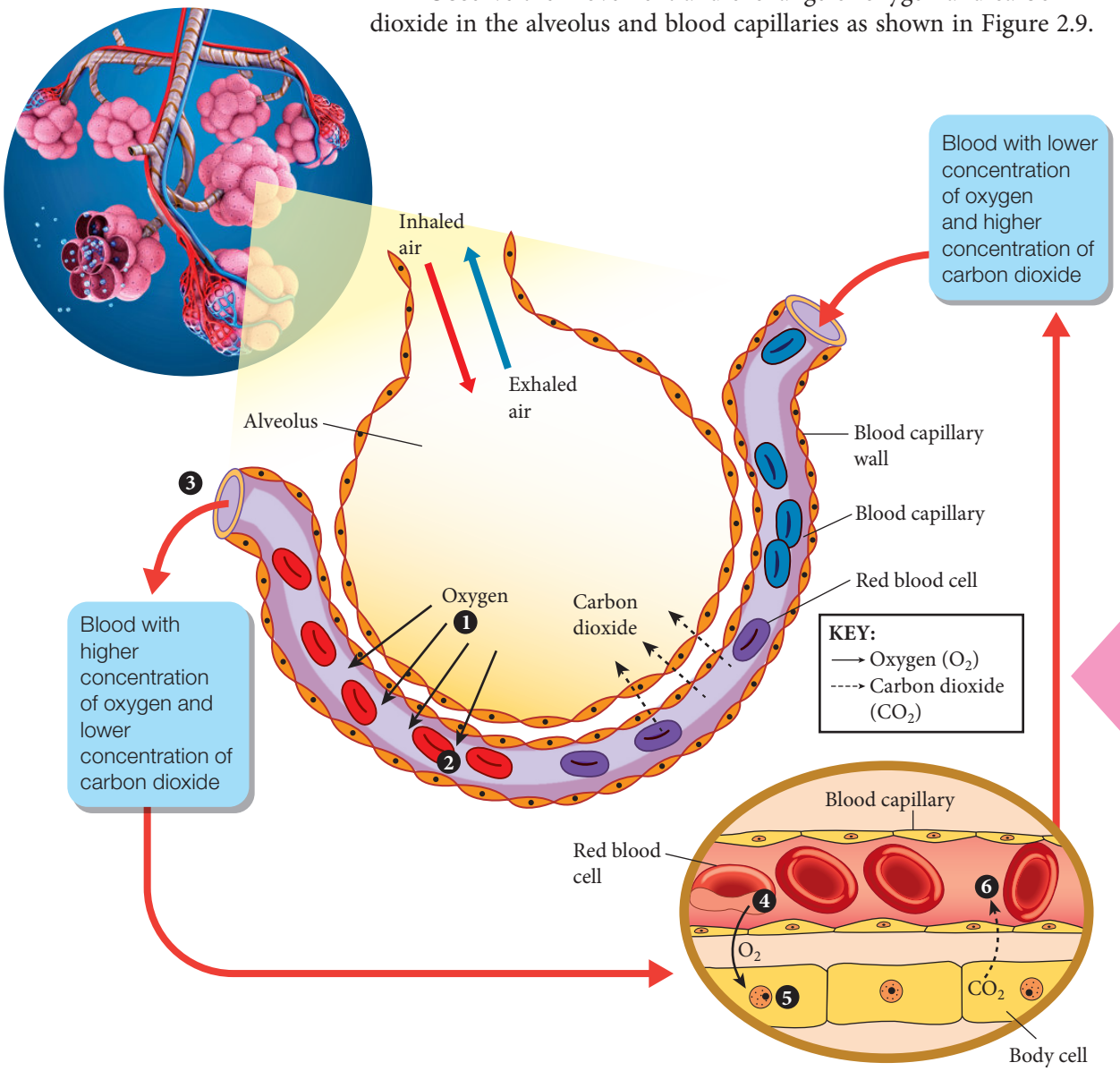


Figure 2.9 *Movement and exchange of oxygen and carbon dioxide in the human body*

Activity 2.3

21st Century Skills
- ISS
- Innovation-based activity

To create a presentation to show the movement and exchange of gases in the human body

Instructions

1. Work in groups.
2. Each group needs to create a presentation showing the following:
   - Exchange of oxygen and carbon dioxide due to the difference in concentration in the alveolus and blood capillaries
   - Process of diffusion of oxygen from the alveolus into the blood capillaries
   - Formation of an unstable compound, that is oxyhaemoglobin
   - Release of oxygen into the body cells
   - Process of oxidation of food, that is, cellular respiration to produce energy
   - Diffusion of carbon dioxide from the body cells into the blood capillaries and then into the alveolus

1 The air inhaled into the alveolus has a higher concentration of oxygen compared to the concentration of oxygen in the blood. Therefore, oxygen will diffuse through the wall of the alveolus into the walls of the capillaries and into the blood.

2 In red blood cells, there is a dark red-coloured compound known as **haemoglobin**. Haemoglobin will combine with oxygen to form **oxyhaemoglobin** which is an unstable compound and bright red in colour.

Haemoglobin + oxygen $\rightleftharpoons$ oxyhaemoglobin

3 Blood with oxyhaemoglobin is transported from the lungs to the heart and pumped to the other parts of the body.

4 When the blood reaches the area around the body cells that has a low concentration of oxygen, the oxyhaemoglobin being an **unstable compound** will decompose to release oxygen molecules and change back into haemoglobin.

Oxyhaemoglobin → haemoglobin + oxygen

5 In the body cells, the diffused oxygen oxidises glucose molecules into carbon dioxide, water and energy through the process of **cellular respiration** as summarised in the following chemical equation.

Glucose + oxygen → carbon dioxide + water + energy

6 Carbon dioxide released by the cells diffuses into the blood capillaries and is transported to the alveolus to be removed during exhalation.

Importance of the Adaptations of the Alveolar Structure

The adaptations of the alveolar structure increase the efficiency and maximise the exchange of gases in the human body. Among the adaptations of the alveolar structure are as shown in Figure 2.10.

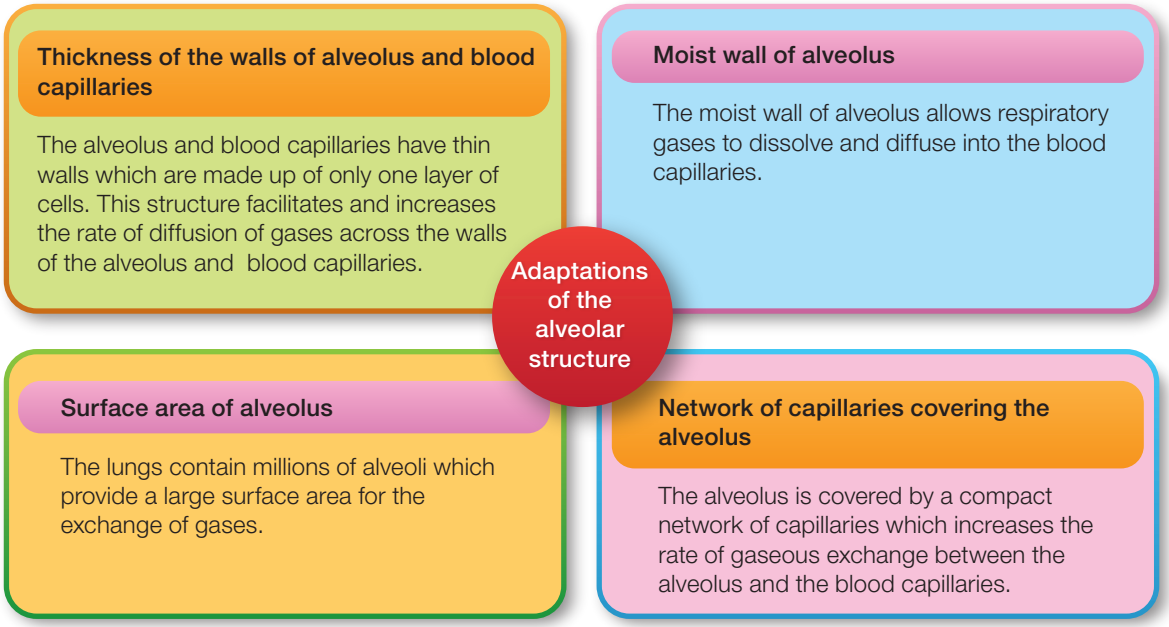


Figure 2.10 *Adaptations of the alveolar structure to increase efficiency in the exchange of gases*

SCIENCE INFO

Other than the alveolar structure, another factor that can increase the exchange of gases in the human body is the difference in concentration of gases in the alveoli and blood capillaries. The greater the difference in concentration of a gas in the alveoli and blood capillaries, the higher the rate of diffusion of the gas between the alveoli and the blood capillaries.

Formative Practice 2.2

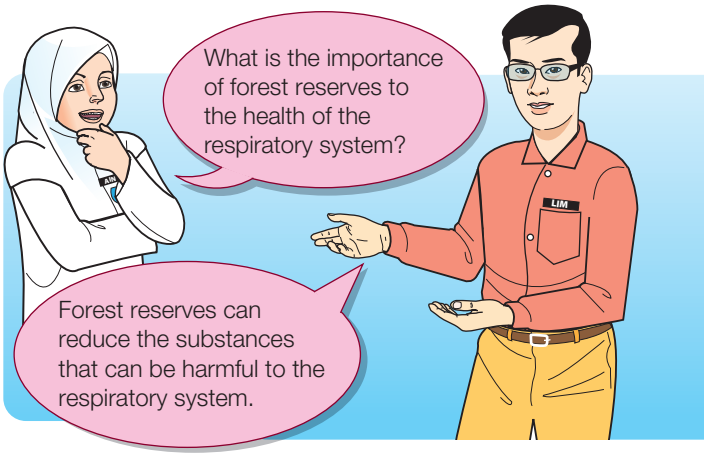
1. What factor determines the rate of exchange of oxygen between the alveolus and blood capillaries?
2. Describe the conditions in the following processes:
   (a) Haemoglobin changes into oxyhaemoglobin
   (b) Oxyhaemoglobin decomposes into haemoglobin
3. Write a chemical equation to describe cellular respiration
4. What happens to the efficiency of the exchange of oxygen in the human body at a high altitude? Explain your answer
5. State **four** adaptations that influence the efficiency of the alveolus to maximise the exchange of gases in the body

2.3 Health of Human Respiratory System

Substances that are Harmful to the Human Respiratory System

The air that we inhale during breathing may contain substances that can be harmful to the respiratory system. Examples of such substances are as follow:

- Cigarette tar
- Carbon monoxide
- Sulphur dioxide
- Nitrogen dioxide
- Haze, dust and pollen



BRAIN TEASER

Why are forests commonly known as 'green lungs'?

SCIENCE INFO

Cigarette tar and tar used in making roads are different substances. Cigarette tar is normally labelled as **'tar'** which is the acronym for '**t**otal **a**erosol **r**esidue'.

Cigarette Tar

Cigarette tar is one of the toxic substances found in cigarette smoke. Cigarette tar in inhaled air sticks to and kills cells in the air passage such as the thorax, pharynx, epiglottis, larynx, bronchi, bronchioles and alveoli. Cigarette tar also increases the production of mucus and phlegm in the lungs. Why do smokers often cough or have flu?

Based on the data of lung cancer patients, most of them are **smokers**. Cigarette tar is an example of a substance in cigarette smoke that can cause lung cancer.

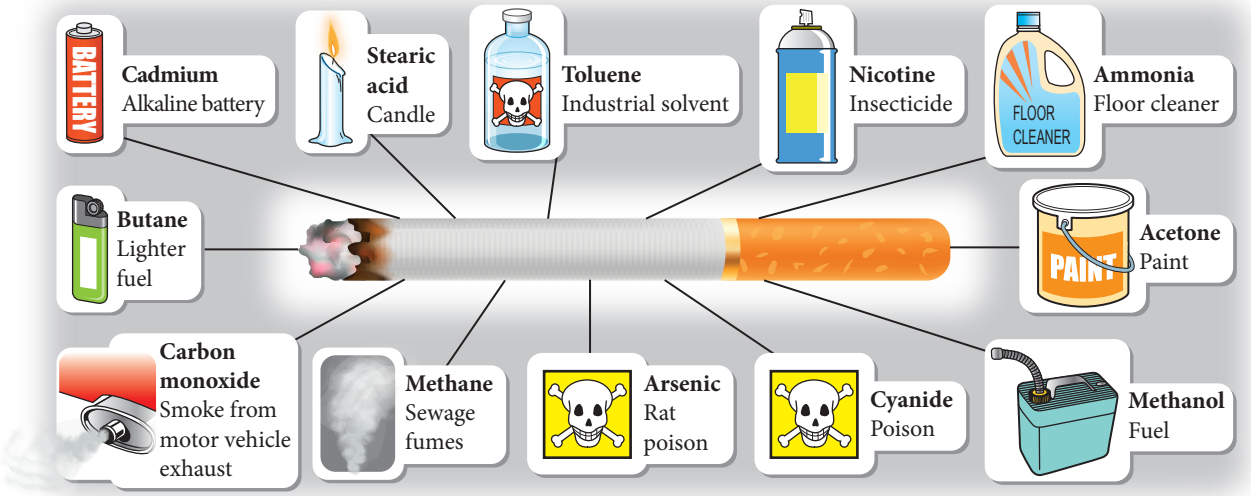


Figure 2.11 *Harmful substances found in cigarette smoke*

Carbon Monoxide

Carbon monoxide is usually found in **cigarette smoke** and **exhaust gases of motor vehicles**. **Carbon monoxide** is a colourless and odourless gas. When carbon monoxide diffuses from the alveoli into the blood capillaries, it will combine chemically with haemoglobin to form **carboxyhaemoglobin** which is a stable compound.

Carbon monoxide + haemoglobin ⟶ carboxyhaemoglobin

This causes a shortage of oxyhaemoglobin in blood that transports oxygen to the body cells. Due to this shortage, the body cells are unable to produce the required amount of energy through cellular respiration. Can body cells live without energy?

Sulphur Dioxide

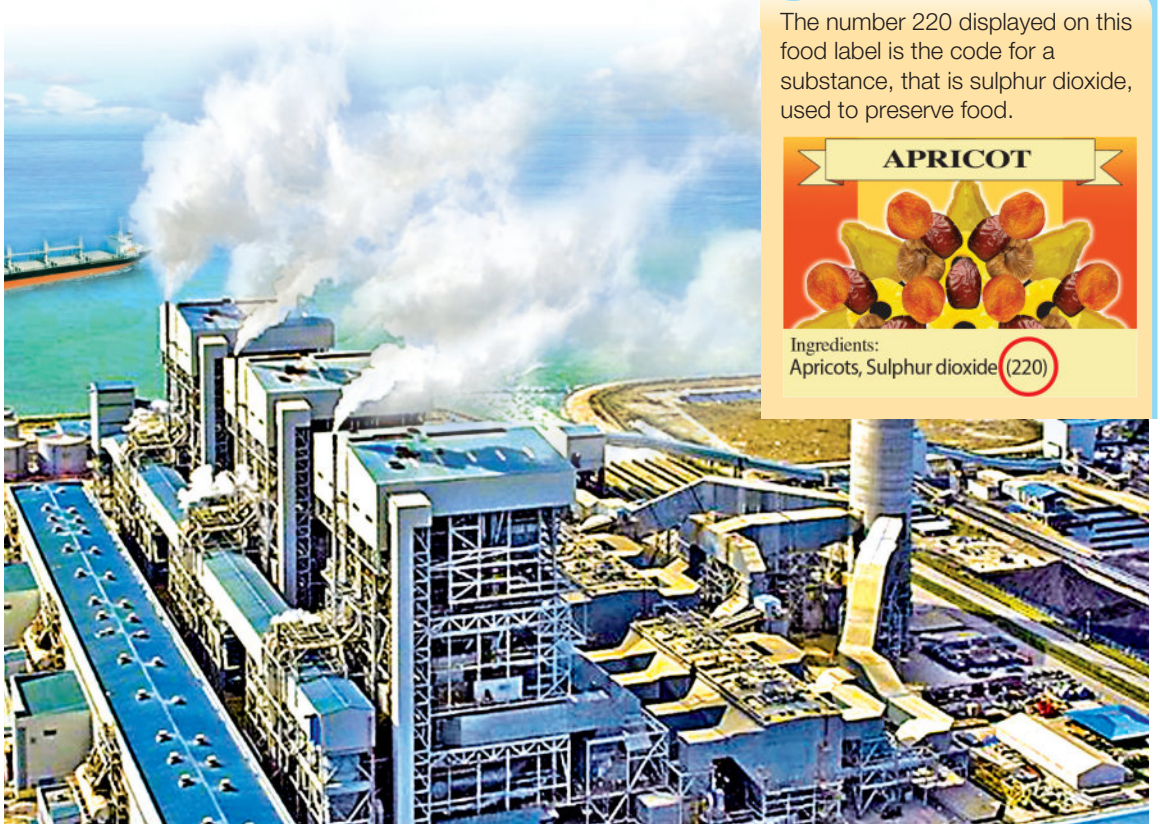
Sulphur dioxide that is released into the air is normally produced by the **combustion of coal** from power stations as shown in Photograph 2.1. **Sulphur dioxide** is a colourless gas with a pungent smell. It irritates the air passage causing cough, difficulty in breathing, bronchitis and lung cancer.

BRAIN TEASER

Why should we support 'SAY NO TO SMOKING' campaigns?

My World of Science

The number 220 displayed on this food label is the code for a substance, that is sulphur dioxide, used to preserve food.



Photograph 2.1 *Smoke released from a power station*

Nitrogen Dioxide

Nitrogen dioxide that is released into the air is normally produced by the **combustion of fuels** such as petrol and diesel in motor vehicles as shown in Photograph 2.2. **Nitrogen dioxide** is a brown-coloured gas with a pungent smell. This gas irritates the air passage and causes cough, difficulty in breathing and asthma.

Photograph 2.2 *Motor vehicles*

Haze, Dust and Pollen

Haze, dust and pollen are solid particles which are fine, light and suspended in the air. The smoke from motor vehicle exhaust, open burning and forest fires produces haze and dust (Photograph 2.3). Pollen released from anthers into the air is carried by the wind over long distances in all directions. Haze, dust and pollen irritate the respiratory system and cause respiratory diseases such as asthma.

Photograph 2.3 *Condition of the surroundings during haze*

BRAIN TEASER

How does the use of electric buses conserve the human respiratory system?

SCIENCE INFO

On 23 June 2013, the **Air Pollutant Index (API)** in Muar, Johor rose up to 746 at 7.00 a.m. far above the minimum hazardous level of 300. This situation caused the government to declare a state of emergency in Muar and Ledang (which was subsequently withdrawn on the morning of 25 June 2013).

My Malaysia

Health Education Division, Ministry of Health Malaysia
http://links.and17.com/BT_Science_59

Respiratory Diseases and their Symptoms

Asthma

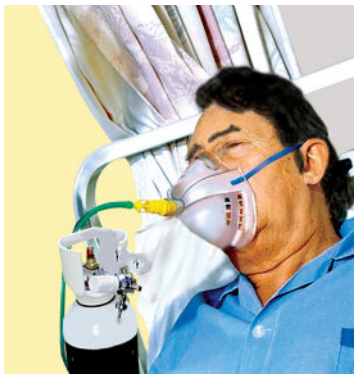
Asthma is triggered by the presence of dust, pollen, haze, smoke from cigarette and motor vehicle exhaust, open burning and forest fires. Symptoms of asthma include shortness of breath, wheezing and coughing.

Bronchitis

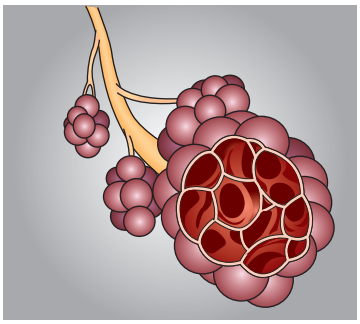
Bronchitis is an inflammation of the bronchus caused by tar and irritants in cigarette smoke. Symptoms of bronchitis include shortness of breath, persistent coughing and insomnia.

Emphysema

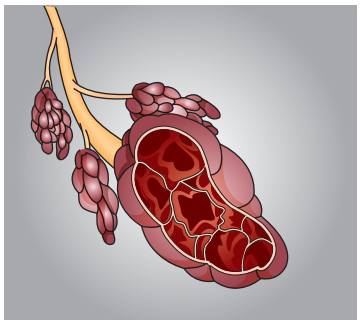
Emphysema is the condition of the alveoli in the lungs which are damaged by harmful substances in the air such as irritants in cigarette smoke. Symptoms of emphysema include shortness of breath, pain when breathing and feeling tired from doing even a light task. Emphysema patients cannot be cured but the symptoms of this disease can be controlled (Photograph 2.4).



Photograph 2.4 *Emphysema patients need oxygen supply even while at rest*



(a) Healthy alveoli



(b) Damaged alveoli due to emphysema

Figure 2.12 *Difference between healthy alveoli and damaged alveoli*

VIDEO

Symptoms and ways to treat asthma

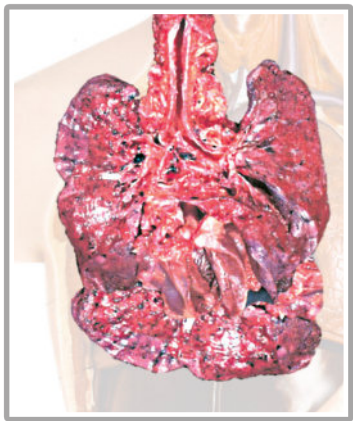
SCAN PAGE

Websites

- Is this flu, bronchitis or inflammation of the lungs? *http://links.and117.com/BT_Science_60_2*
- Emphysema, symptoms and ways to treat it *http://links.and117.com/BT_Science_60_3*

Lung Cancer

Lung cancer is caused by cancer causing chemical substances known as **carcinogens**. These chemical substances are inhaled during breathing. Cigarette smoke contains various carcinogens, for example tar that causes lung cancer. Symptoms of lung cancer include persistent coughing, blood in the phlegm and feeling pain when breathing. Observe the difference between healthy lungs and the lungs of a cancer patient shown in Photograph 2.5.



(a) Lungs of a healthy person

(b) Lungs of a cancer patient

Photograph 2.5 *Difference between healthy and cancerous lungs*

Today in history

World Cancer Day is celebrated on 4 February every year since 2000.

My Malaysia

National Cancer Institute

Screening test for lung cancer is provided free of charge to Malaysians between the ages of 50 and 70.

http://links.and17.com/BT_Science_61

Activity 2.4

21st Century Skills
- ICS
- Discussion activity

To gather and analyse data on respiratory diseases

Instructions

1. Work in groups.
2. Gather and analyse information based on data obtained from the Ministry of Health Malaysia or from other countries on respiratory diseases such as asthma, bronchitis, emphysema and lung cancer.

http://links.and17.com/BT_Science_61_2

http://links.and17.com/BT_Science_61_3

3. Discuss the analysed information.
4. Present the outcome of your group's discussion in class in the form of multimedia presentation.

Effects of Smoking on the Lungs

Smoking is not only harmful to the respiratory system of smokers but also to the respiratory system of other people in the vicinity of the smokers. A person who does not smoke but inhales cigarette smoke is known as a **passive smoker**. The harmful effects of cigarette smoke to the human respiratory system do not only happen in the body of the smoker but also in the body of the passive smoker.

Photograph 2.6 *Signboards at the hospital related to smoking*

Experiment 2.2 (Demonstration by teacher)

Aim
To study the effects of smoking on the lungs

Problem statement
What are the effects of smoking on the lungs?

Hypothesis
Cigarette smoke contains cigarette tar (brown-coloured substance) and acidic gases that damage the lungs.

Safety Precautions

- Carry out this experiment in a fume chamber.
- Avoid inhaling cigarette smoke.
- U-tube and conical flask are fragile. Be careful when handling these apparatus.

Variables

(a) manipulated variable : Presence of cigarette smoke
(b) responding variables : Colour of cotton wool and litmus solution at the end of the experiment
(c) constant variable : Rate of suction of air using the filter pump

Materials
Cigarette, cotton wool, litmus solution and matches or lighter

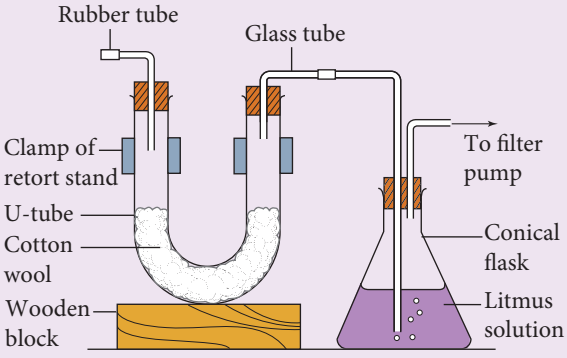


Figure 2.13 (a)

Apparatus
U-tube, conical flask, rubber stopper, filter pump, rubber tube, glass tube, retort stand with clamps and wooden block

Procedure

1. Set up the apparatus as shown in Figure 2.13 (a).
2. Observe and record the colour of the cotton wool and litmus solution.
3. Switch on the filter pump for 10 minutes.
4. Switch off the filter pump.
5. Observe and record the change in colour of the cotton wool (if any) and litmus solution in a table.
6. Repeat steps 1 to 5 with a lighted cigarette as shown in Figure 2.13 (b).

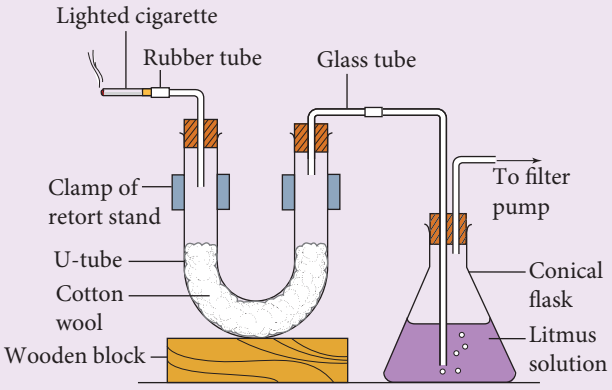


Figure 2.13 (b)

Observation

Presence of cigarette smoke	Colour of cotton wool		Colour of litmus solution	
	beginning of experiment	end of experiment	beginning of experiment	end of experiment
No				
Yes				

Conclusion

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

Questions

1. Name the substance in cigarette smoke that is deposited on the cotton wool.
2. Is cigarette smoke acidic or alkaline? Explain your answer.
3. Name **three** other harmful substances found in cigarette smoke.

Formative Practice 2.3

1. (a) Name **four** examples of solids in the air that are harmful to the human respiratory system.
(b) Name **three** examples of gases in the air that are harmful to the human respiratory system.

2. Name **one** substance released by plants that is harmful to the human respiratory system.

3. State **one** symptom of each of the following respiratory diseases:
(a) Emphysema
(b) Lung cancer
(c) Bronchitis
(d) Asthma

4. Name **two** types of respiratory diseases that are caused by harmful substances in cigarette smoke.

5. What is meant by passive smoker?

2.4 Adaptations in Respiratory Systems

How the Respiratory System Adapts in Different Surroundings

The respiratory structures of most organisms including humans have **three features** to ensure an efficient gaseous exchange with the surroundings. These three features are as follows:

Moist surface of respiratory structures such as the moist surface of alveoli.

Thin respiratory structures such as the walls of alveolus and blood capillaries which are one cell thick.

Large surface area of respiratory structures such as the surface area of millions of alveoli.

Different organisms have different respiratory systems and adapt to maximise the rate of gaseous exchange in different surroundings. The respiratory structures which adapt in different surroundings include **moist outer skin**, **gills** and **trachea**.

Moist Outer Skin

Amphibians such as frogs are organisms which can live on land and in water. The respiratory structure of frogs can adapt to increase the efficiency of gaseous exchange while they are on land (Figure 2.14). Name **one** respiratory structure of frogs which can adapt for gaseous exchange while they are on land.

Other than **lungs**, frogs usually use their **moist outer skin** for gaseous exchange. The skin of frogs is thin and very permeable to gas. The skin of frogs is also always moist because it is covered by a layer of mucus which causes the respiratory gases to dissolve and diffuse easily.
Under the layers of skin is a dense network of blood capillaries to increase the diffusion rate of gases between the skin and the blood capillaries.

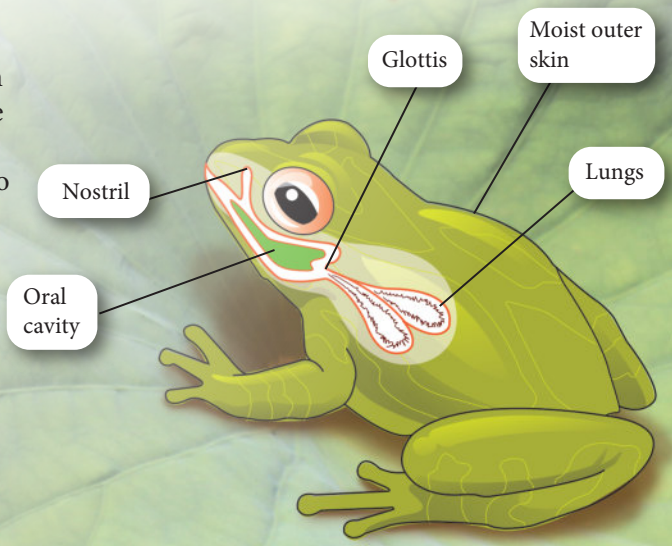


Figure 2.14 *Respiratory system of a frog*

Gills

Fish is an organism that can only live in water. Therefore, the respiratory structure of fish, namely **gills** can adapt to increase the efficiency of gaseous exchange in water.

Gills are made up of two rows of fine **filaments** that have many thin and flat projections known as **lamellae** as shown in Figure 2.15. The number of filaments and lamellae produces a large surface area to facilitate gaseous exchange. Since fish live in water, their gills are surrounded by water and this causes the respiratory gases to dissolve and diffuse easily.

SCIENCE INFO

Mudskippers are classified as amphibious fish because they breathe through their gills like fish and also through their moist outer skin like amphibians.

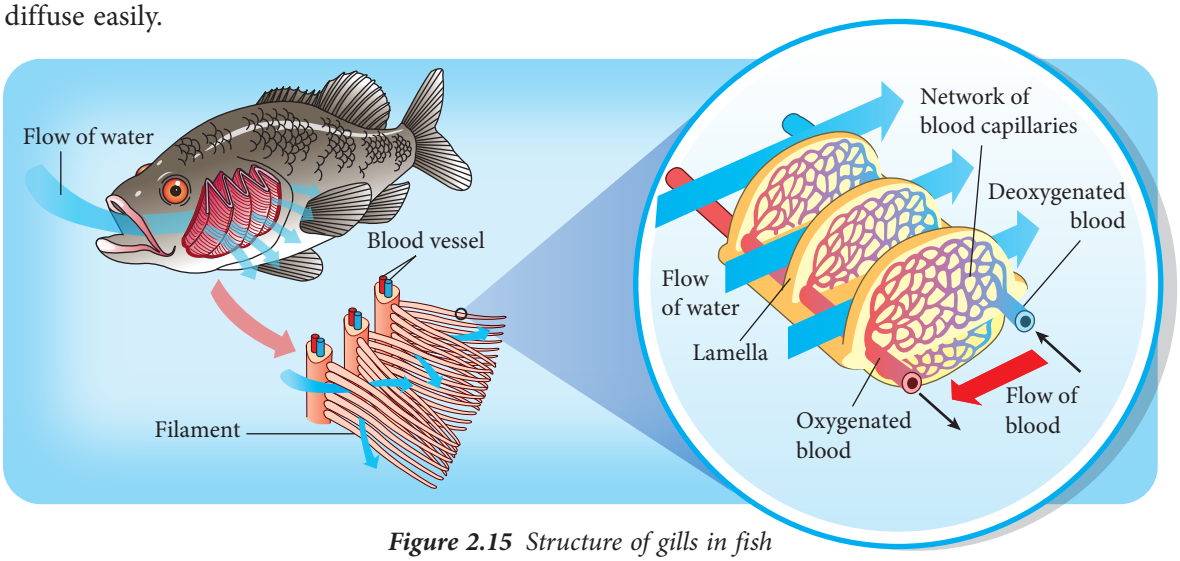


Figure 2.15 *Structure of gills in fish*

Trachea

The respiratory system of insects is the **trachea system** made up of air tubes known as **trachea** as shown in Figure 2.16. Air enters or leaves the trachea through breathing pores known as **spiracles**. The opening and closing of spiracles are controlled by **valves** which allow air to leave and enter the body.

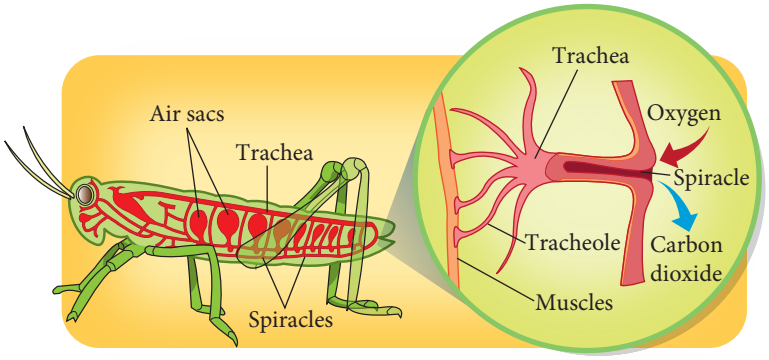


Figure 2.16 *Trachea system of grasshopper*

Trachea is divided into fine branches known as **tracheoles**. Tracheoles have thin and moist walls to increase the efficiency of gaseous exchange. The large number of tracheoles also provides a large surface area to facilitate gaseous exchange through diffusion directly into the cells. Some insects such as grasshoppers have **air sacs** in their trachea system. These sacs are filled with air to increase the rate of exchange of respiratory gases between tissues and the surroundings during energetic activities.

Activity 2.5

21st Century Skills
- ISS
- Inovation-based activity

To create a presentation showing how respiratory system adapts in different surroundings

Instructions

1. Work in groups.
2. Each group is required to create a presentation explaining how other organisms carry out respiration through respiratory systems that can adapt in different surroundings through:
   (a) moist outer skin (b) gills (c) trachea

Activity 2.6

21st Century Skills
- CPS

Active reading on the adaptation and ability of the human respiratory system

Instructions

Carry out active reading on adaptation and ability of the human respiratory system in the following contexts:

(a) Different altitudes (at the bottom of the sea and in mountainous regions). *Flashback: Refer to Science Gallery on page 45*

(b) Sports activities and lifestyles (athlete and swimmer). *Refer Info 1.*

(c) Sickle cell anaemia. *Refer Info 2.*

Active reading strategy
http://links.and117.com/BT_Science_66_5

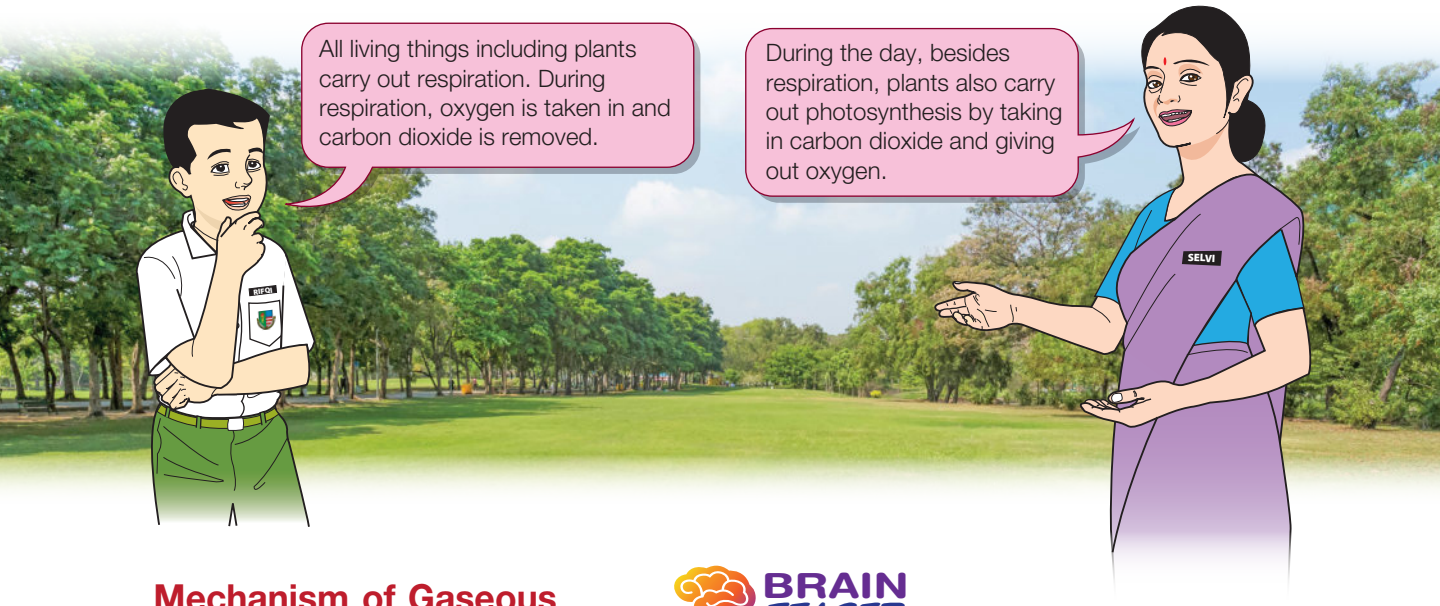
Info 1
The adaptation and ability of the human respiratory system during exercise
http://links.and117.com/BT_Science_66_3

Info 2
Sickle cell anaemia
http://links.and117.com/BT_Science_66_4

Formative Practice 2.4

1. Name the respiratory structure in the following animals:
   (a) Fish (b) Insects (c) Amphibians
2. State **two** adaptations in the outer skin of frogs that facilitate quick and efficient gaseous exchange between the outer skin and the surroundings.
3. Why is the circulatory system of insects not involved in the respiratory mechanism of insects?
4. What is the importance of exercise in maintaining a healthy respiratory system?
5. Choosing a healthy lifestyle is important for respiration. State **two** examples of healthy lifestyles.

2.5 Gaseous Exchange in Plants



Mechanism of Gaseous Exchange in Plants

Most plants carry out the process of gaseous exchange with their surroundings through their **leaves**, **stems** and **roots**. These three parts provide a **large surface area** for gaseous exchange. Gaseous exchange in plants is shown in Figure 2.17.

BRAIN TEASER

State **one** function of the aerial roots of mangrove plants as shown in the photograph on the right.

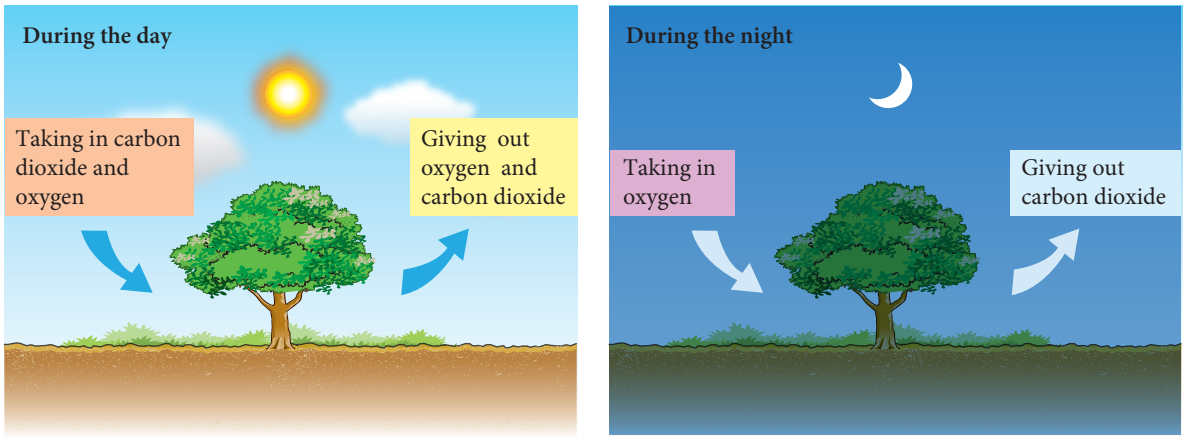
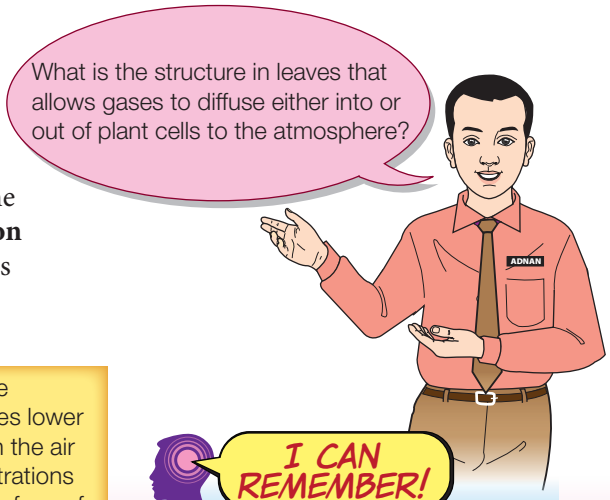


Figure 2.17 *Gaseous exchange in plants*

Diffusion of Carbon Dioxide

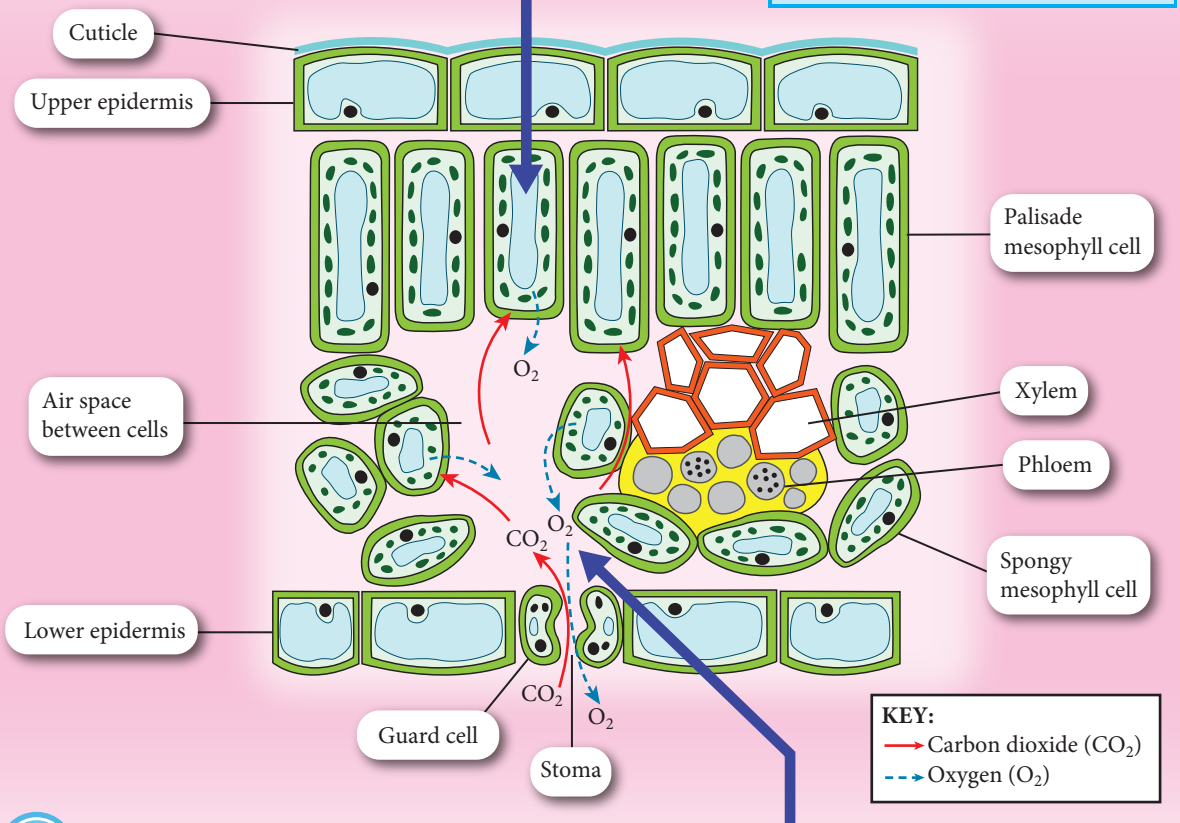
The structure in leaves that shows the pathway of gaseous exchange is as shown in Figure 2.18. The diffusion of carbon dioxide occurs through the **stoma** according to the **difference in concentration of carbon dioxide** in the cells and in the air spaces between the cells during photosynthesis.



1 When carbon dioxide is used in photosynthesis, the concentration of carbon dioxide in the cells becomes lower compared to the concentration of carbon dioxide in the air space between the cells. This difference in concentrations allows the dissolved carbon dioxide in the moist surface of cells to diffuse from the air space between the cells into the cells.

I CAN REMEMBER!

Diffusion is the process of movement of particles from a region of high concentration to a region of low concentration.

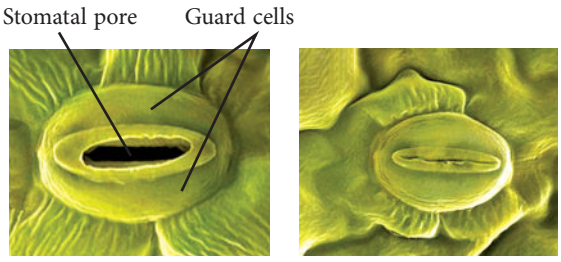


2 This causes the concentration of carbon dioxide in the air space between the cells to become lower compared to the concentration of carbon dioxide in the air outside the stoma. This difference in concentrations causes the diffusion of carbon dioxide from the atmosphere into the air space between the cells through the stoma which is open.

Figure 2.18 *Pathway of gaseous exchange in leaves during photosynthesis*

Stomatal Pore and Guard Cells

Stoma is made up of a **stomatal pore** bounded by a pair of **guard cells**. Guard cells contain **chloroplasts** to carry out photosynthesis. Stomata of plants **open** during photosynthesis when there is **light** and **close** when it gets **dark** or when the plant **loses a lot of water** on a hot day as shown in Photograph 2.7.



(a) Open stoma (b) Closed stoma

Photograph 2.7 *Open and closed stoma*

SCIENCE INFO

Stoma – singular
Stomata – plural

Process of Osmosis Affects the Stoma

Concept of Osmosis

Osmosis is the process of movement of **water molecules** from a region of **high concentration** of water molecules (solution with a low concentration of solutes) to a region of **low concentration** of water molecules (solution with a high concentration of solutes) through a **semipermeable membrane** (Figure 2.19). This membrane is permeable to water but not permeable to some solutes such as sucrose molecules.

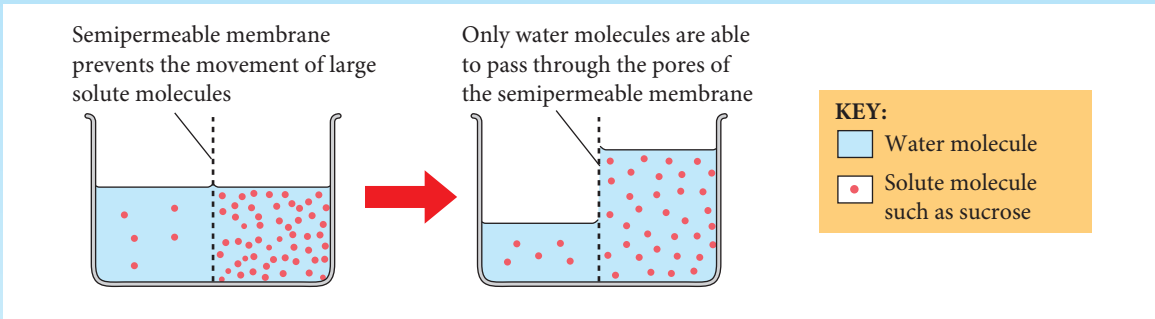


Figure 2.19 *Osmosis*

Process of Osmosis in Guard Cells

When there is light, guard cells carry out photosynthesis to produce glucose. The concentration of glucose in guard cells increases and causes water from surrounding cells to diffuse into the guard cells through **osmosis**. Hence, the guard cells become **turgid** and **curved** as shown in Figure 2.20. Conversely, at night or on a hot day, water diffuses out of the guard cells also through osmosis and causes the guard cells to become **flaccid** and **straight**.

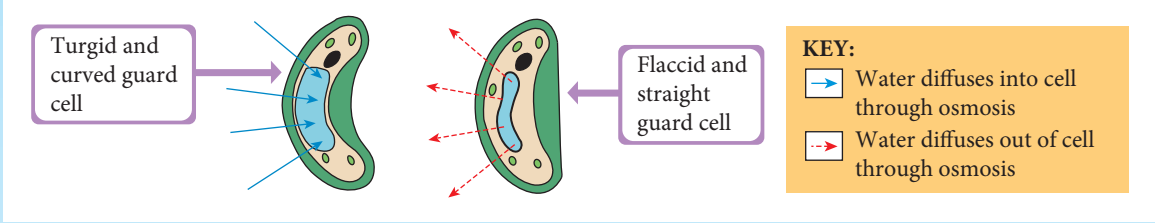


Figure 2.20 *Change in shape of guard cells caused by osmosis*

Effects of Osmosis on Stoma

The process shown in Figure 2.20 explains how during the day, water diffuses into the guard cells through osmosis and causes both the guard cells to curve and open the stoma as shown in Figure 2.21.

At night or on a hot day, water diffuses out of the guard cells through osmosis and causes both the guard cells to become straight and close the stoma as shown in Figure 2.22.

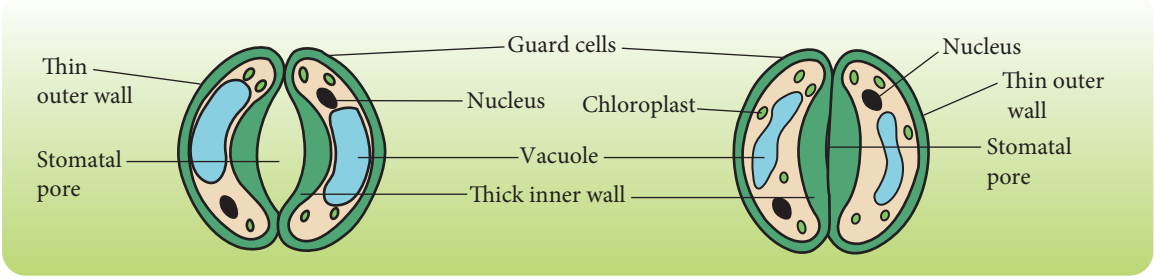


Figure 2.21 *Open stoma*

Figure 2.22 *Closed stoma*

Activity 2.7

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

To show the mechanism of gaseous exchange in plants

Instructions

1. Work in groups.
2. Create a multimedia presentation to show the following:
   - Stomatal pore is controlled by two guard cells
   - During the day, water diffuses into the guard cells through osmosis and causes both the guard cells to curve and open the stoma
   - Diffusion of carbon dioxide occurs in the stoma due to the difference in concentration
   - At night, water diffuses out of the guard cells through osmosis and causes the stoma to close

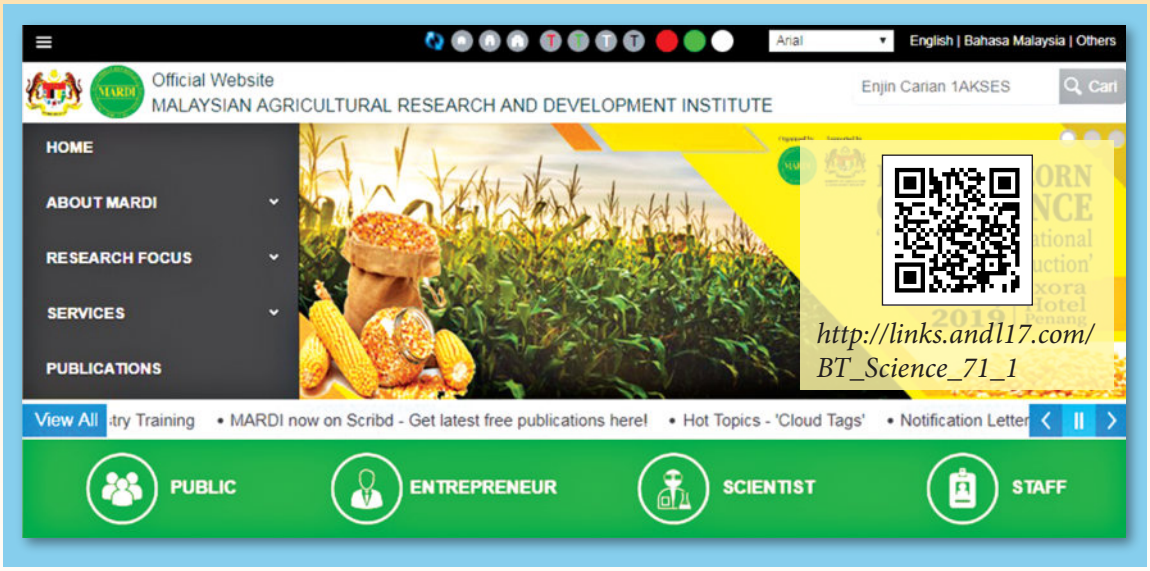
Importance of Unpolluted Environment for the Survival of Plants

The environment, especially unpolluted air, is very important to ensure the growth and survival of plants.

Effects of Haze and Dust on the Survival of Plants

If the surrounding is hazy and dusty, the polluted air will be harmful to the growth and survival of plants as shown in the article on page 71. Visit the website and study the article published.

Other than reducing sunlight from reaching the plants and reducing the rate of photosynthesis, haze and dust that settle on stomata prevent gaseous exchange between plants and their surrounding. What will happen to a plant if its stomata are clogged with dust?



Photograph 2.8 *Official website of MARDI*

Effects of Acidic Gases in the Air on the Survival of Plants

Air pollutant gases which are acidic such as sulphur dioxide and nitrogen dioxide dissolve in rainwater to produce **acid rain**. Acid rain kills plant cells and causes soil to be acidic and less fertile. Most plants cannot live in highly acidic soil. This will reduce agricultural produce and cause food shortage.

Among the preventive measures against the effects of pollution on plants in the local and global context are as follows:

- Ban open burning in Indonesia and Malaysia
- Limit the number of motor vehicles on the road in Beijing, China
- Encourage the use of alternative energy such as solar energy

BRAIN TEASER

Why do efforts to prevent air pollution require the cooperation of the global society?

Examples of research and information gathered by scientists on the effects of acid rain and steps taken to prevent air pollution in this region are as follows:

Effects of acid rain in Asia
http://links.andl17.com/BT_Science_71_3

ASEAN – Haze preventive measures
http://links.andl17.com/BT_Science_71_2

Activity 2.8

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

To create a multimedia presentation on the effects of pollution on plants and the preventive measures against pollution in local or global context

Instructions

1. Work in groups.
2. Gather and analyse further information on the following:
   - Effects of pollution on plants
   - Preventive measures against pollution in the local or global context
3. Discuss the information analysed.
4. Present the findings of each group in the form of multimedia presentation.

Formative Practice 2.5

1. Figure 1 shows mangrove plants.

Figure 1

Name **three** parts of a mangrove plant where gaseous exchange occurs.

2. Figure 2 shows a structure found in a leaf.

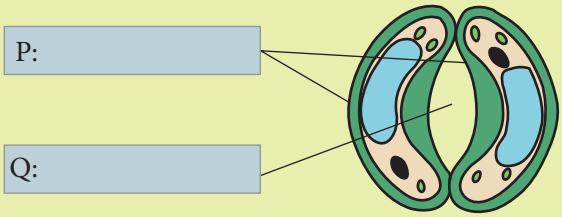


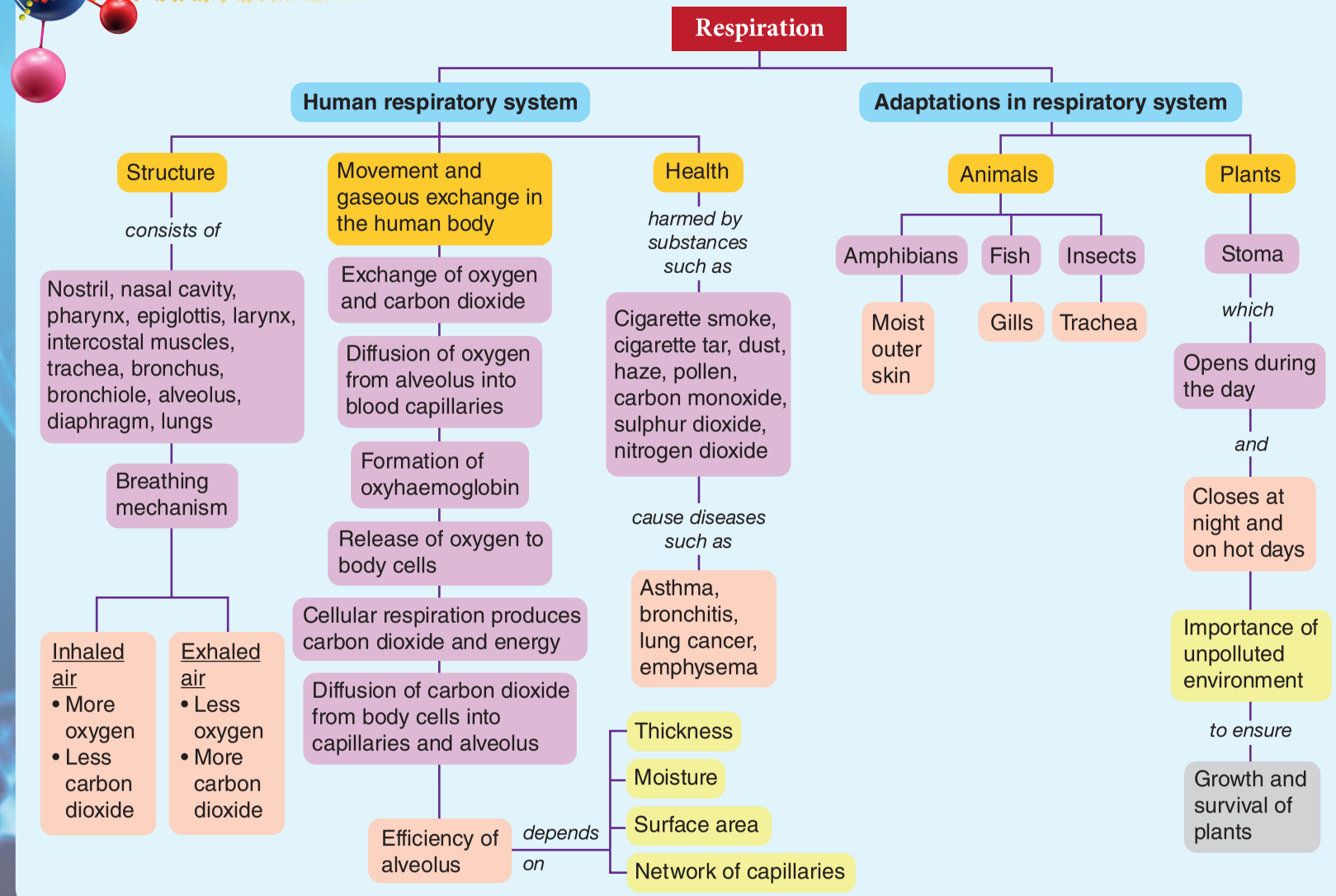
Figure 2

Label parts P and Q.

3. (a) Are stomata open or closed during the day? Explain.
(b) Are stomata open or closed at night? Explain.
(c) Why are stomata closed on hot days?

4. What are the effects of polluted air on the growth and survival of plants?

Summary


Respiration
Human respiratory system
Adaptations in respiratory system
Structure
consists of
Nostril, nasal cavity, pharynx, epiglottis, larynx, intercostal muscles, trachea, bronchus, bronchiole, alveolus, diaphragm, lungs
Breathing mechanism
Inhaled air
• More oxygen
• Less carbon dioxide
Exhaled air
• Less oxygen
• More carbon dioxide
Movement and gaseous exchange in the human body
Exchange of oxygen and carbon dioxide
Diffusion of oxygen from alveolus into blood capillaries
Formation of oxyhaemoglobin
Release of oxygen to body cells
Cellular respiration produces carbon dioxide and energy
Diffusion of carbon dioxide from body cells into capillaries and alveolus
Efficiency of alveolus
depends on
Thickness
Moisture
Surface area
Network of capillaries
Health
harmed by substances such as
Cigarette smoke, cigarette tar, dust, haze, pollen, carbon monoxide, sulphur dioxide, nitrogen dioxide
cause diseases such as
Asthma, bronchitis, lung cancer, emphysema
Animals
Amphibians
Moist outer skin
Fish
Gills
Insects
Trachea
Plants
Stoma
which
Opens during the day
and
Closes at night and on hot days
Importance of unpolluted environment
to ensure
Growth and survival of plants

Self-reflection

After studying this chapter, you are able to:

2.1 Human Respiratory System

- ☐ Draw and label the internal structures of the human respiratory system and describe the breathing mechanism.
- ☐ Carry out experiments to investigate the differences in the content of gases in inhaled and exhaled air.

2.2 Movement and Exchange of Gases in the Human Body

- ☐ Describe the movement and exchange of oxygen and carbon dioxide in the human body.
- ☐ Justify the importance of adaptations of the alveolar structure to increase efficiency of gaseous exchange in the human body.

2.3 Health of Human Respiratory System

- ☐ Communicate about substances that are harmful to the respiratory system as well as diseases and their symptoms.
- ☐ Carry out an experiment to show the effects of smoking on the lungs.

2.4 Adaptations in Respiratory System

- ☐ Justify how the respiratory system adapts in different situations.

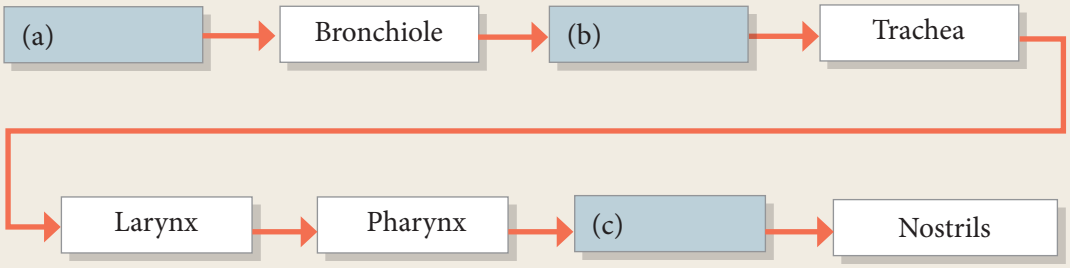
2.5 Gaseous Exchange in Plants

- ☐ Explain the mechanism of gaseous exchange in plants.
- ☐ Communicate to justify the importance of an unpolluted environment for the growth and survival of plants.

Summative Practice 2

Answer the following questions:

1. Complete the following flow chart to show the direction of air that is breathed out from the lungs.



2. Figure 1 shows the human respiratory system.

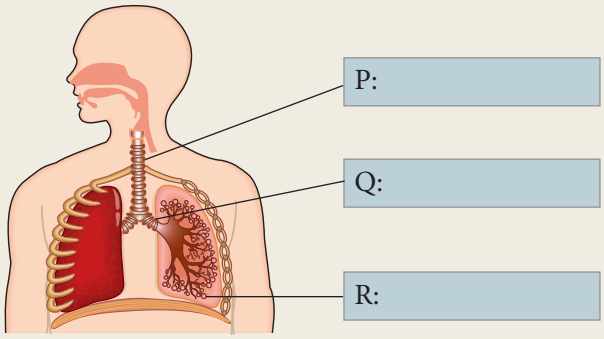


Figure 1

Label P, Q and R in Figure 1 using the following words:

Alveolus	Bronchiole	Bronchus	Trachea

3. Figure 2 shows the breathing mechanism during exhalation.

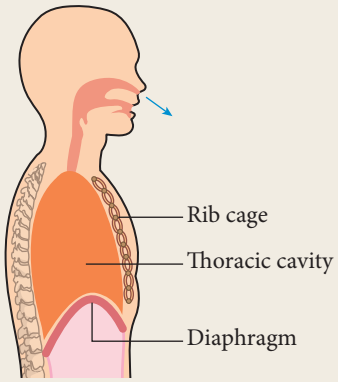


Figure 2

Mark '✓' for the correct statements, about the mechanism.

(a) Air leaves the lungs when the diaphragm moves upwards.	
(b) When exhaling, the rib cage moves downwards.	
(c) Air pressure is lower in the lungs.	
(d) Volume of thoracic cavity decreases.	

4. Underline the correct answers.

(a) Percentage of oxygen in inhaled air is (higher/lower) than in exhaled air.

(b) Percentage of carbon dioxide in inhaled air is (higher/lower) than in exhaled air.

5. (a) What is the function of haemoglobin in the human respiratory system?

(b) What is the importance of the characteristic of oxyhaemoglobin as an unstable compound in gaseous exchange in the body?

6. Azura is an asthma patient.

(a) Why does the doctor advise Azura to reduce her visits to botanical gardens during Spring?

(b) Other than the botanical gardens, state **two** other locations that should be avoided by Azura. Explain your answer.

7. (a) State **four** factors that affect the efficiency of the alveolus to maximise gaseous exchange in the human body.

(b) State **one** symptom of each of the following respiratory diseases. What causes the symptom?

(i) **Asthma**

Symptom :

Cause :

(ii) **Bronchitis**

Symptom :

Cause :

(iii) **Emphysema**

Symptom :

Cause :

8. Describe **three** ways to maintain the health of the respiratory system.

9. Why should waiting areas for public transport such as LRT stations and bus stands be designated as non-smoking areas?

10. (a) Give **one** similarity in the gaseous exchange between insects and plants.

(b) Is the insect respiratory system more or less effective compared to the human respiratory system?

(c) Explain your answer in **10** (b).

11. (a) Gas X is harmful to the human respiratory system. Gas X can diffuse into a stationary car with its air conditioning on, windows closed and engine running. Name gas X.

(b) Explain the effects of the gas in the situation in **11** (a).

Focus on HOTS

12. Changes in the volume of air in the lungs of runners X and Y are as shown in Figures 3 (a) and 3 (b).

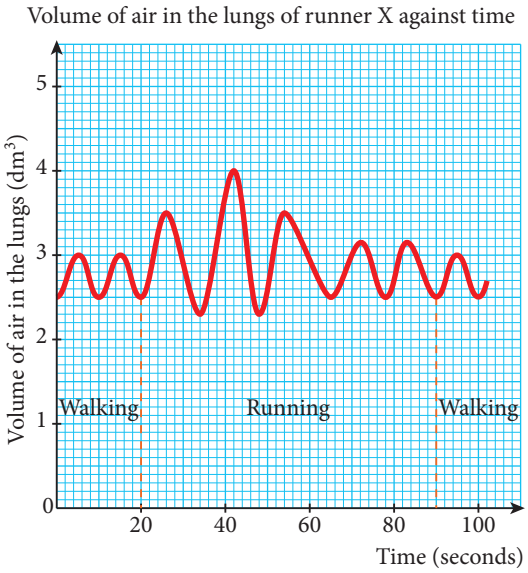


Figure 3 (a)

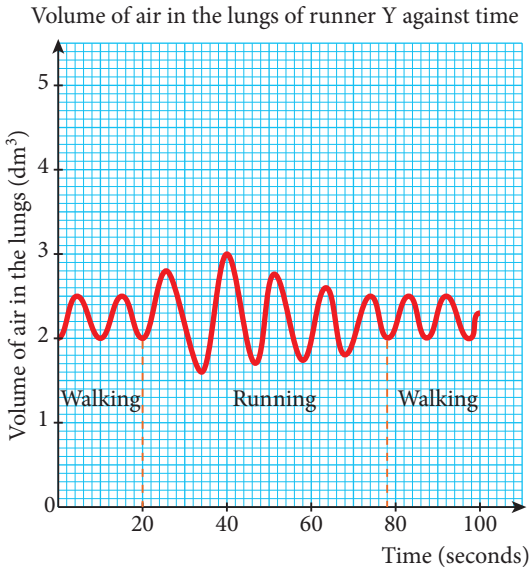


Figure 3 (b)

(a) State the maximum volume of air in the lungs of the following runners while walking.
  (i) Runner X
  (ii) Runner Y

(b) State the maximum volume of air in the lungs of the following runners:
  (i) Runner X
  (ii) Runner Y

(c) From the graphs in Figures 3 (a) and 3 (b), state the relationship between the types of activity performed and the maximum volume of lungs of each runner. Explain.

(d) If one of the runners X or Y is a smoker, which one is the smoker? Explain.

(e) How does the increase in the maximum volume of the lungs affect the respiration rate? Explain.

Chapter 3

Transportation

What is the transport system in organisms?

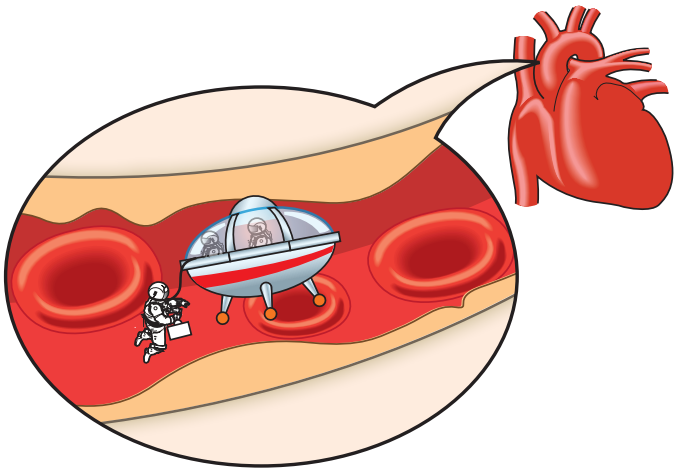
What are the components, constituents and blood groups of humans?

What factors affect the rate of transpiration in plants?

Let's study

- Transport system in organisms
- Blood circulatory system
- Human blood
- Transport system in plants
- Blood circulatory system in animals and transport system in plants

Science Gallery



In 1966, a science fiction film 'Fantastic Voyage' attracted the interest of many viewers including scientists!

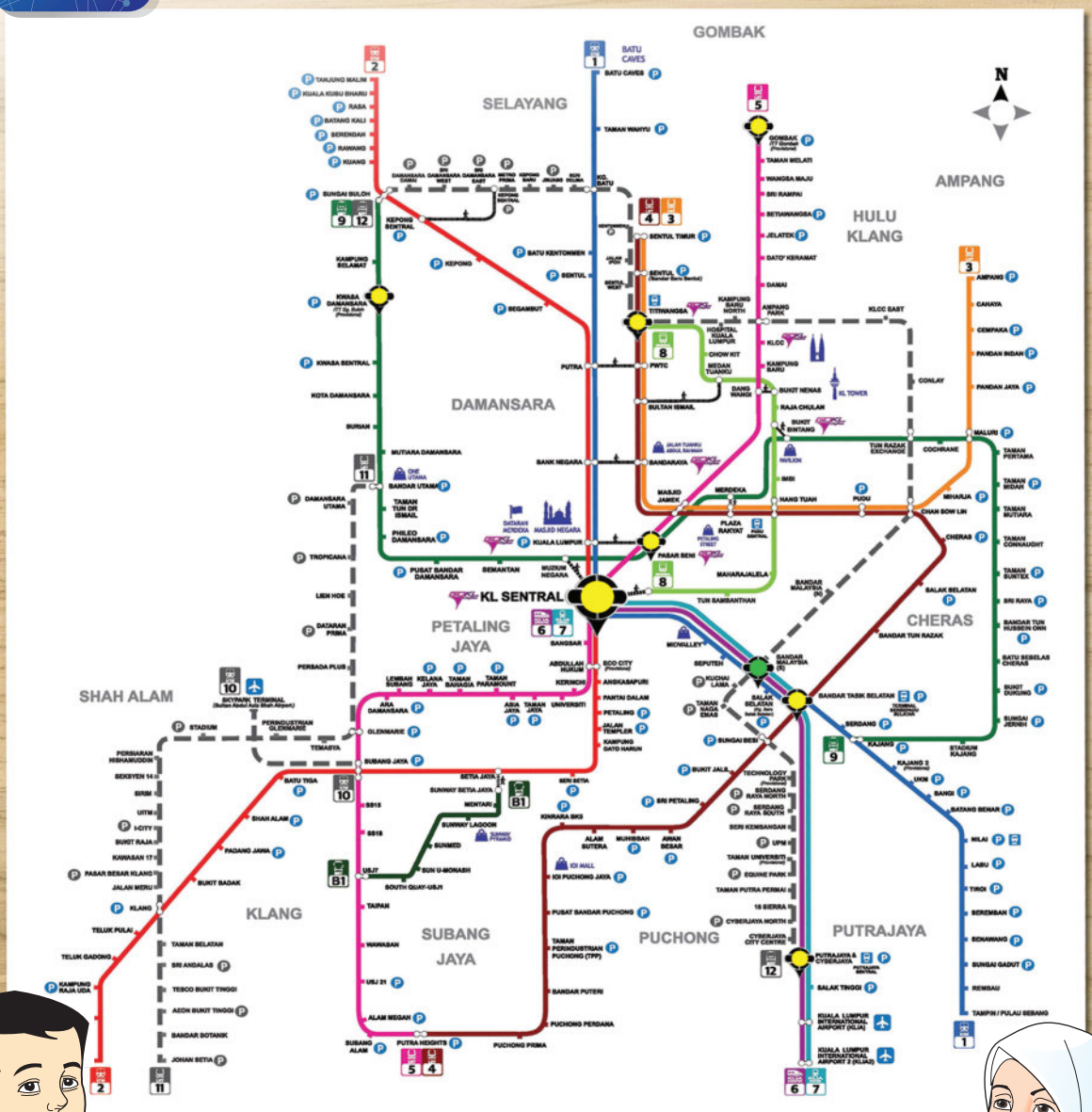
In this film, a team of medical personnel is put into a submarine which is reduced to microscopic size (size of a red blood cell) for an hour using the technological creation of scientist, Jan Benes. This submarine is then injected into the blood circulatory system in Jan Benes's body to eliminate a blood clot in his brain using laser.

The submarine in Jan Benes's blood circulatory system needs to travel through the heart, lungs and other parts of the body before reaching the blood clot in his brain. Can the blood clot be eliminated using laser in one hour? Is there a possibility of this film being classified as a science documentary film in the future? Why?

Keywords

- Heart
- Artery
- Vein
- Capillary
- Antigen
- Antibody
- Transpiration
- Guttation
- Xylem
- Phloem

3.1 Transport System in Organisms



Photograph 3.1 *Klang Valley Rail Transit Map*

Have you ever used the Klang Valley Rail Transit Map as shown in Photograph 3.1 to plan your trip?

What is the importance of a transit route network in the public transport system?

Why is KL Sentral known as the 'heart' of the transit route network?

Compare and contrast the public transport system with the transport system in organisms.

Need for Transport System in Organisms

Every cell needs oxygen for cell respiration and nutrients to obtain energy. At the same time, carbon dioxide and other waste products produced by cells need to be eliminated to the external environment. The process of carrying oxygen, nutrients and other useful substances from the external environment into the cells is through **diffusion.** The process of eliminating waste products from the cells is also through diffusion. What is the system that carries useful substances to all parts of the body of an organism and eliminates waste products from the body?

Transport System in Simple Organisms

Simple organisms such as unicellular organisms (Photograph 3.2) do **not** have a specialised transport system. Substances needed by cells such as oxygen and nutrients enter directly into cells via diffusion through the cell membrane. Waste products such as carbon dioxide are also eliminated from cells to the external environment via diffusion through the cell membrane.

Photograph 3.2 *Examples of unicellular organisms*

Transport System in Complex Organisms

Complex organisms such as humans, vertebrates and multicellular plants have a **specialised transport system** as shown in Figure 3.1.

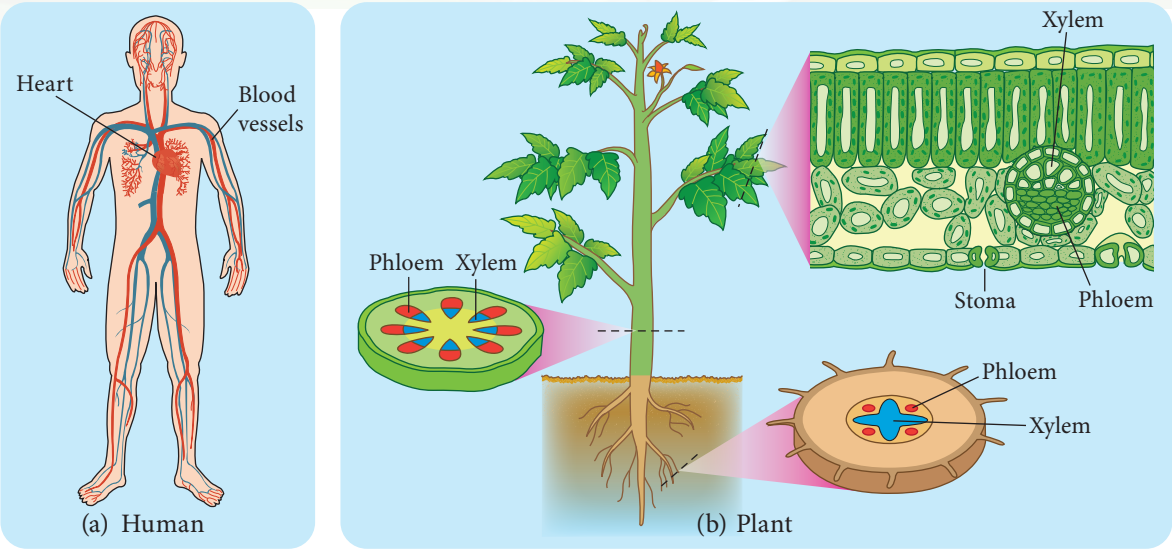


Figure 3.1 *Examples of complex organisms with specialised transport system*

The process of exchange of substances needed by cells and waste products between complex organisms and the external environment (via diffusion) occurs slowly and not comprehensively because complex organisms have a large volume. Therefore, complex organisms need to have a **specialised transport system**. Through this specialised transport system, oxygen and nutrients can be carried to all the body cells in complex organisms and waste products can be eliminated from all the body cells to the external environment.

3.1.1 3.1.2

Importance of the Function of Transport System in Organisms

The importance of the function and impact of transport system in organisms is as shown in Figure 3.2.

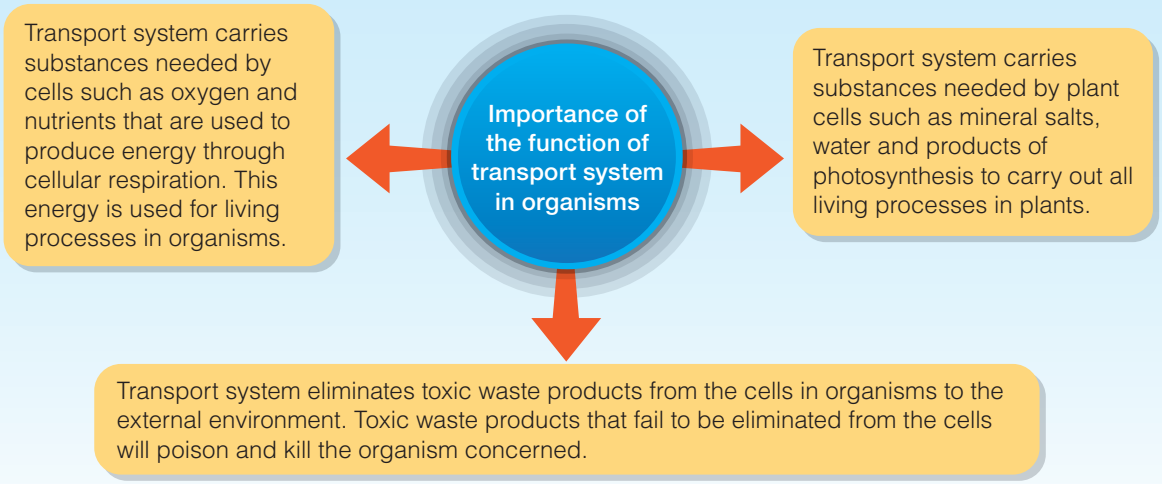


Figure 3.2 *Importance of the function of transport system in organisms*

Activity 3.1

21st Century Skills
- ICS
- Discussion activity

To gather and share information on the need, function, importance and impact of transport system in organisms

Instructions

1. Work in groups.
2. Gather and share information on the following:
   (a) Need for transport system in organisms
   (b) Function of transport system in organisms
   (c) Importance of transport system in organisms
   (d) The impact if transport system cannot function well
3. Discuss the shared information.
4. Present the findings of your group's discussion using multimedia presentation such as MS PowerPoint.

Formative Practice 3.1

1. What is the function of the transport system in organisms?
2. State **two** examples of substances needed by cells and **two** examples of waste products that are eliminated from cells.
3. What is the importance of the function of transport system in organisms?
4. Explain the impact on organisms if the transport system in the organisms cannot function well.

3.2 Blood Circulatory System

Blood Circulatory System in Vertebrates

Humans and all vertebrates such as mammals, reptiles, amphibians, birds and fish (complex organisms) have a specialised transport system, that is the **blood circulatory system**. In the blood circulatory system of all vertebrates, blood flows continuously in **blood vessels** to all parts of the body in one complete cycle through the **heart**. However, there are significant **differences** in the blood circulatory system among mammals, reptiles, amphibians, birds and fish. How many times does the blood flow through the heart of mammals, reptiles, amphibians, birds and fish in one complete cycle to all parts of the body? What is the number of atria and ventricles in the heart of mammals, reptiles, amphibians, birds and fish? Carry out Activity 3.2 to find out the differences.

Activity 3.2

21st Century Skills
- CPS
- Discussion activity

Compare and contrast the blood circulatory system in vertebrates

Instructions

1. Carry out active reading to compare and contrast the blood circulatory system in vertebrates such as mammals, reptiles, amphibians, birds and fish as shown in Figures 3.3 and 3.4.

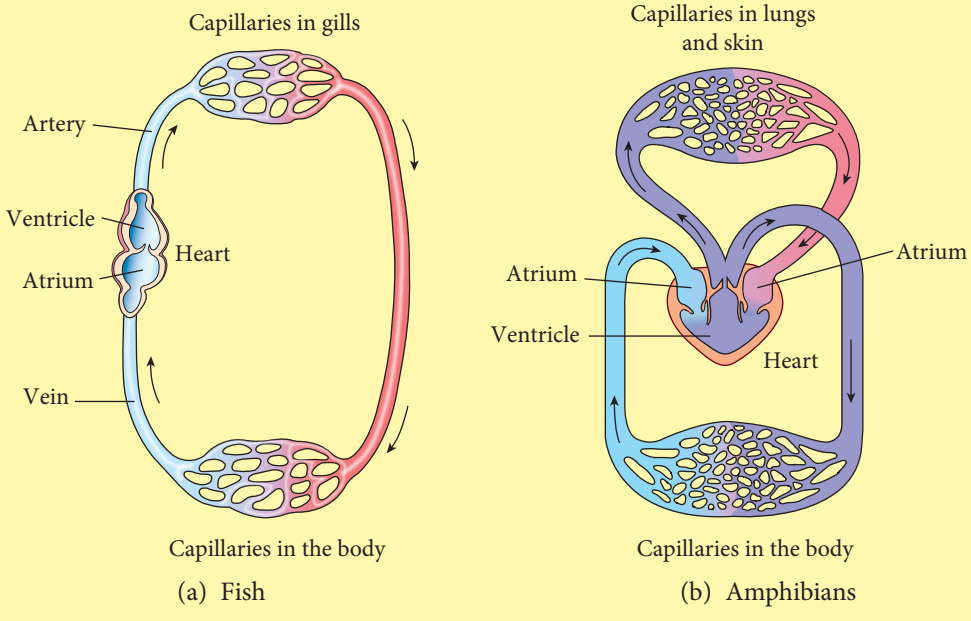


Figure 3.3

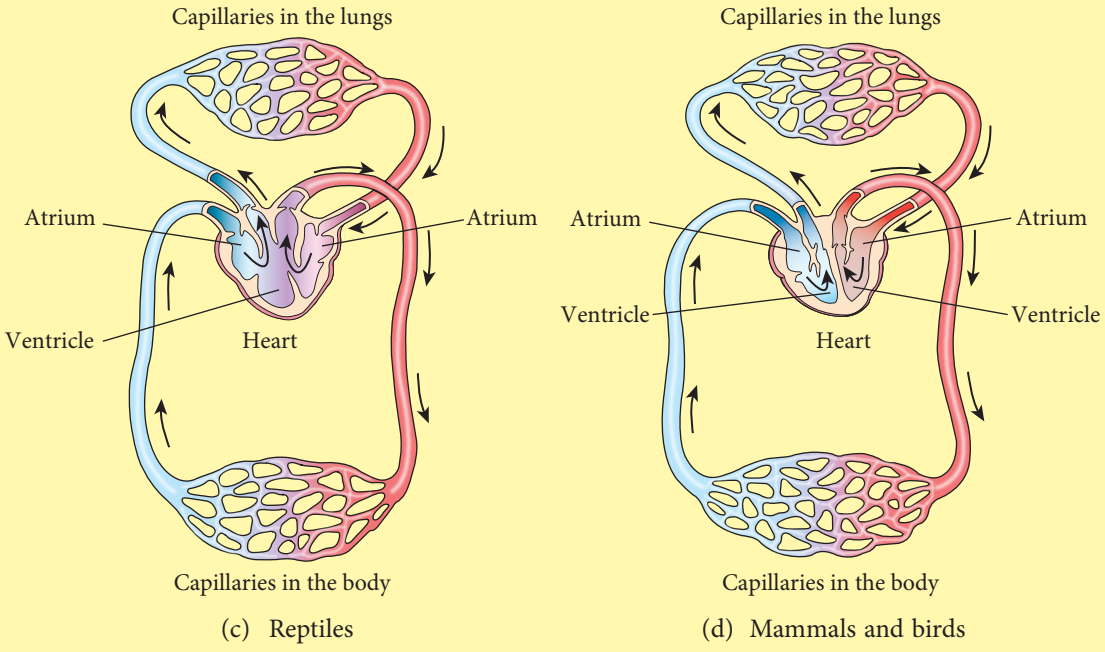


Figure 3.4

2. Complete the chart which shows a comparison of the blood circulatory systems of vertebrates such as mammals, reptiles, amphibians, birds and fish.

Blood circulatory system of vertebrates

Similarities

Made up of a system that allows blood to continuously flow in blood vessels through the heart which pumps blood to the whole body and back to the heart.

Differences

Fish	Amphibians	Reptiles	Mammals and birds

Blood Circulatory System in Humans

The **human blood circulatory system** involves the circulation of blood which is pumped from an organ known as the **heart** to all parts of the body and specialised blood vessels, namely **arteries**, **capillaries** and **veins** as shown in Figure 3.5.

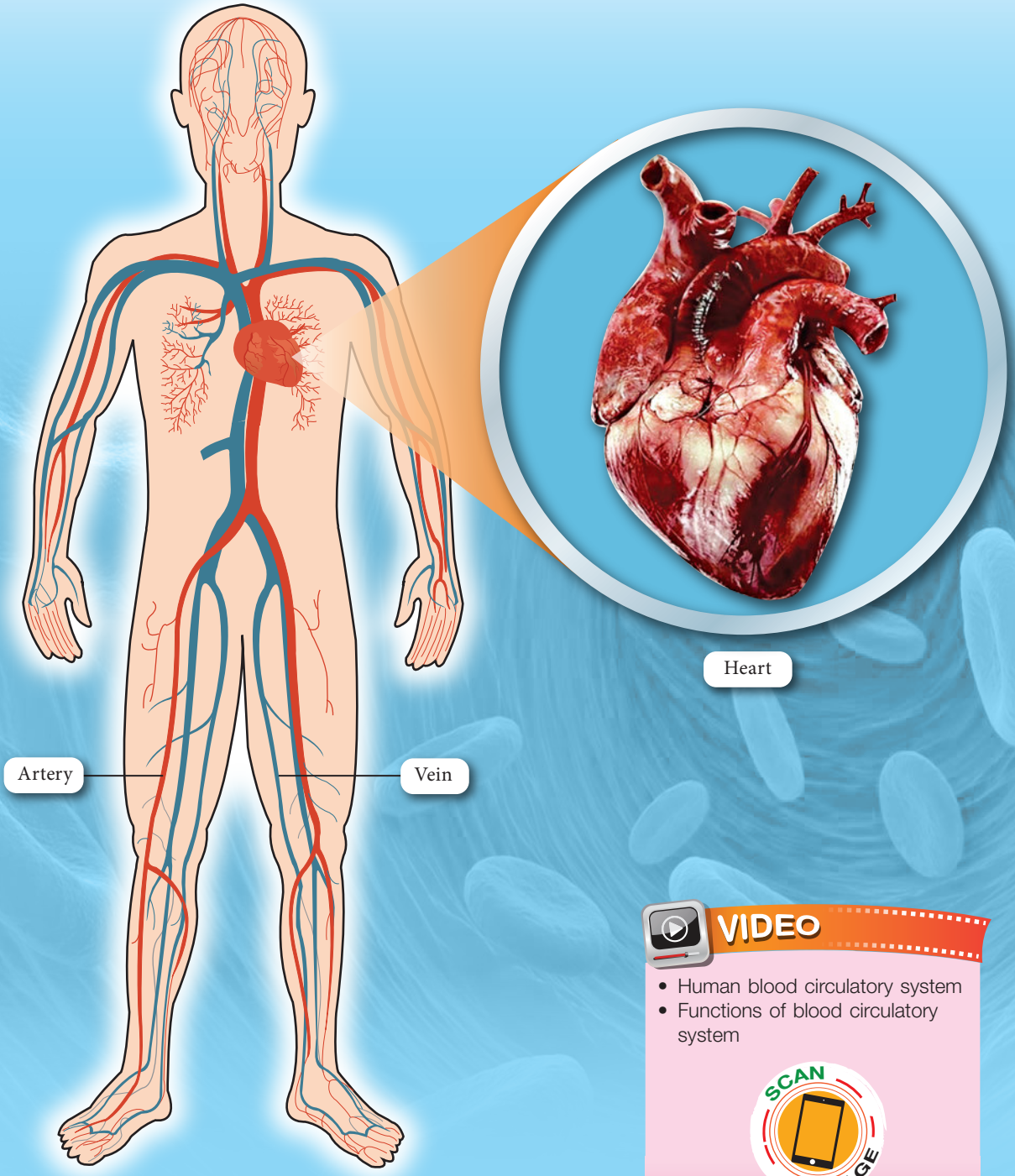


Figure 3.5 *Human blood circulatory system*

VIDEO

- Human blood circulatory system
- Functions of blood circulatory system

SCAN PAGE

3.2.1 3.2.2

Structure and Functions of the Human Heart

The human heart has **four chambers**, that is **two atria** and **two ventricles** as shown in Figures 3.6 and 3.7.

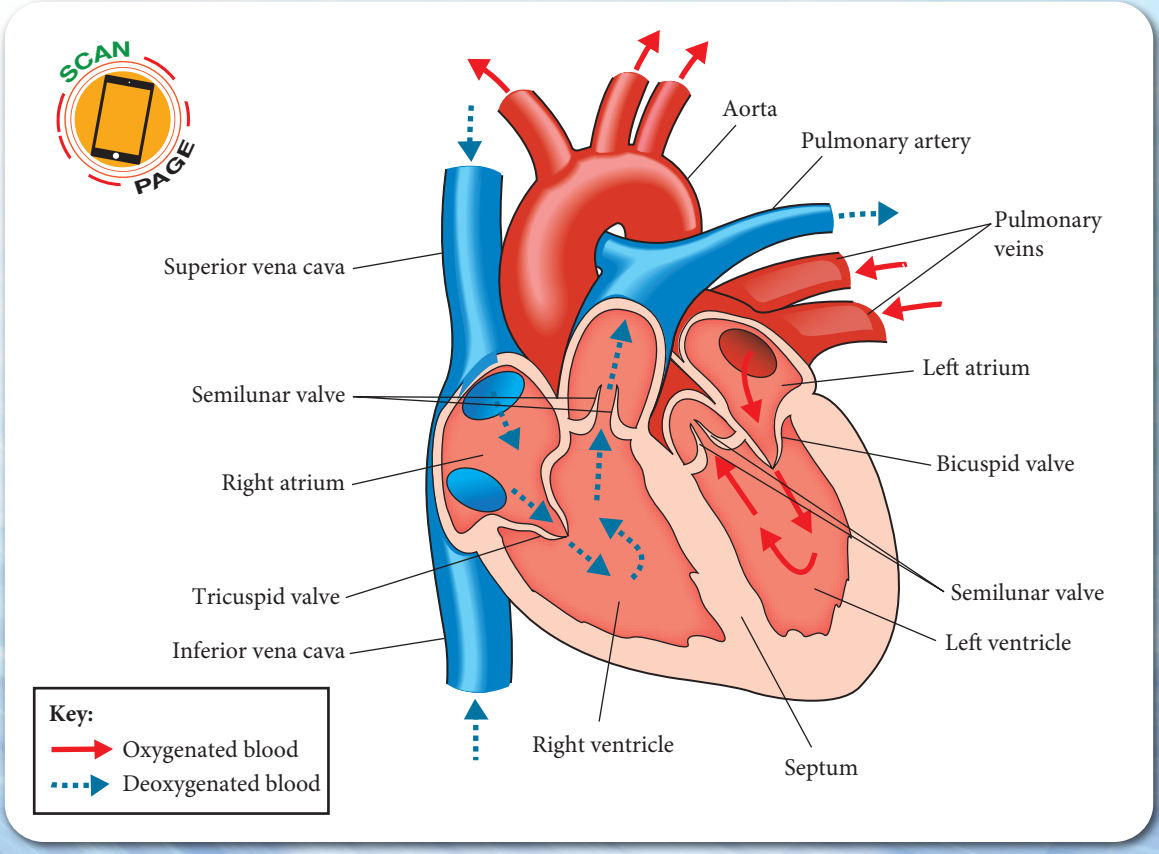


Figure 3.6 *Longitudinal section of the human heart*

Right atrium has thin muscular **wall**.
Functions:

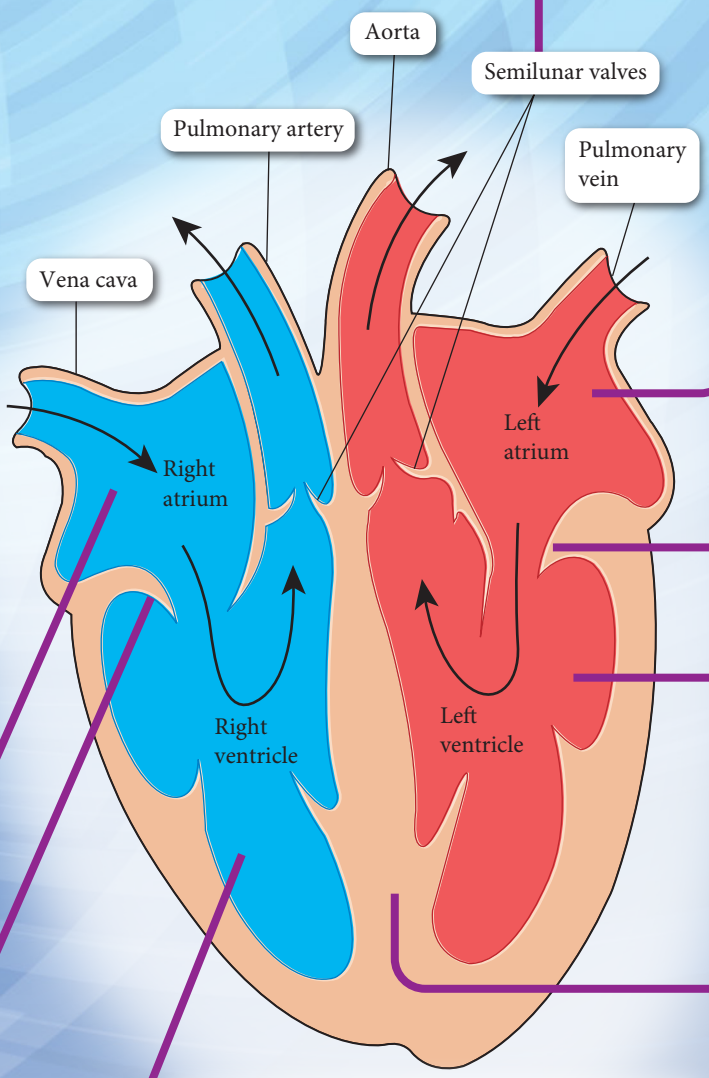
- **Deoxygenated blood** from the whole body except the lungs enters the **right atrium** through the **superior** and **inferior vena cava**.
- When the **right atrium contracts**, **deoxygenated blood** is forced to **flow** into the chamber below it, namely the **right ventricle**.

Tricuspid valve
Function:
Allows the flow of blood in only one direction from the **right atrium** to the **right ventricle**.

Right ventricle has thick muscular wall.
Function:
When the right ventricle contracts, deoxygenated blood is forced to flow out into the **pulmonary artery** to be carried to the **lungs**.

SCIENCE INFO

The period of time for blood to make one complete circulation from the heart to all parts of the body including the lungs and back to the heart is approximately 1 minute!



Semilunar valves
Function:
Semilunar valves at the pulmonary artery and aorta ensure that blood flows only in one direction and not back into the ventricles.

Left atrium has thin muscular wall.
Functions:
- **Oxygenated blood** from the **lungs** enters the left atrium through the **pulmonary vein**.
- When the left atrium contracts, oxygenated blood is forced to flow into the chamber below it, namely the **left ventricle**.

Bicuspid valve
Function:
Allows the flow of blood in only one direction from the **left atrium** into the **left ventricle**.

Left ventricle has the thickest muscular wall.
Function:
When the left ventricle contracts, oxygenated blood is forced to flow out into the aorta to be carried to all parts of the body except the lungs.

Septum is the muscular wall which separates the left side of the heart from the right side of the heart.
Function:
Prevents oxygenated blood from mixing with deoxygenated blood.

Figure 3.7 *Simple structure of the human heart and circulation of blood through the heart*

Structure and Functions of Main Blood Vessels

There are three human blood vessels, namely **arteries, capillaries** and **veins**. Figure 3.8 shows the relationship between the artery, capillary and vein. Observe the direction of the blood circulation through the artery, capillary and vein as shown in the figure.

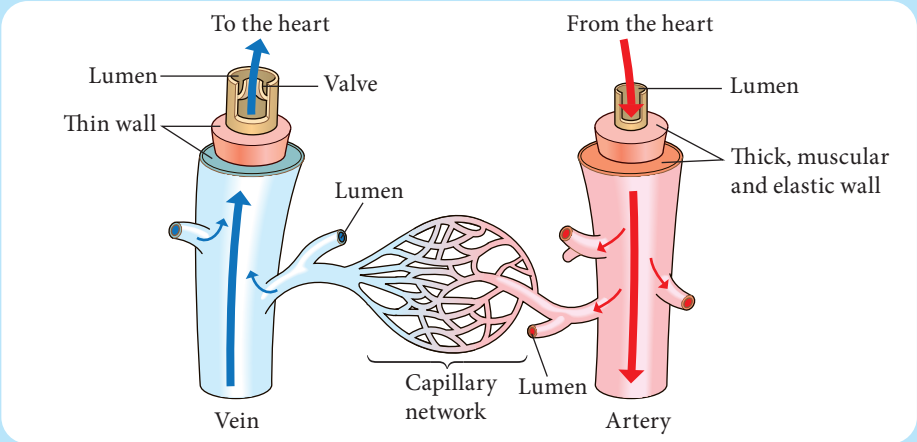
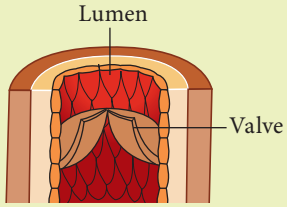
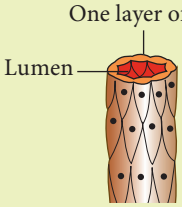
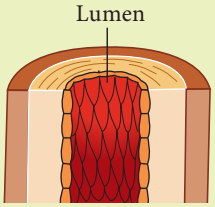


Figure 3.8 *Relationship between the artery, capillary and vein*

Table 3.1 *Structure and functions of the artery, capillary and vein*

Type of blood vessel	Vein	Capillary	Artery
Structure	 • **Thin**, less muscular and less elastic wall to facilitate blood flow under low blood pressure • **Has** valves • **Large** lumen	 • **Thinnest** wall which is one cell thick without any muscle or elastic tissue • **No** valves • **Smallest** lumen	 • **Thick** and muscular wall with a lot of elastic tissues to withstand high blood pressure • **No** valves • **Small** lumen
Functions	• Transports **deoxygenated blood** back to the heart from the whole body except the lungs • Pulmonary vein transports **oxygenated blood** from the lungs to the heart	• Allows the **exchange of gases**, **food** and **waste products** between the blood and body cells via diffusion through the thin wall of the capillary	• Transports **oxygenated blood** from the heart to the whole body except the lungs • Pulmonary artery transports **deoxygenated blood** from the heart to the lungs
Circulation of blood	• **Slow** blood flow under **low** blood pressure • **No** pulse	• **Slow** blood flow under decreasing blood pressure • **No** pulse	• **Rapid** blood flow under **high** blood pressure • Pulse **detected**

'Double' Blood Circulatory System

Humans and other mammals have a 'double' blood circulatory system that is made up of the **pulmonary circulatory system** and **systemic circulatory system**. Carry out active reading to compare and contrast the pulmonary circulatory system and systemic circulatory system as shown in Figure 3.9.

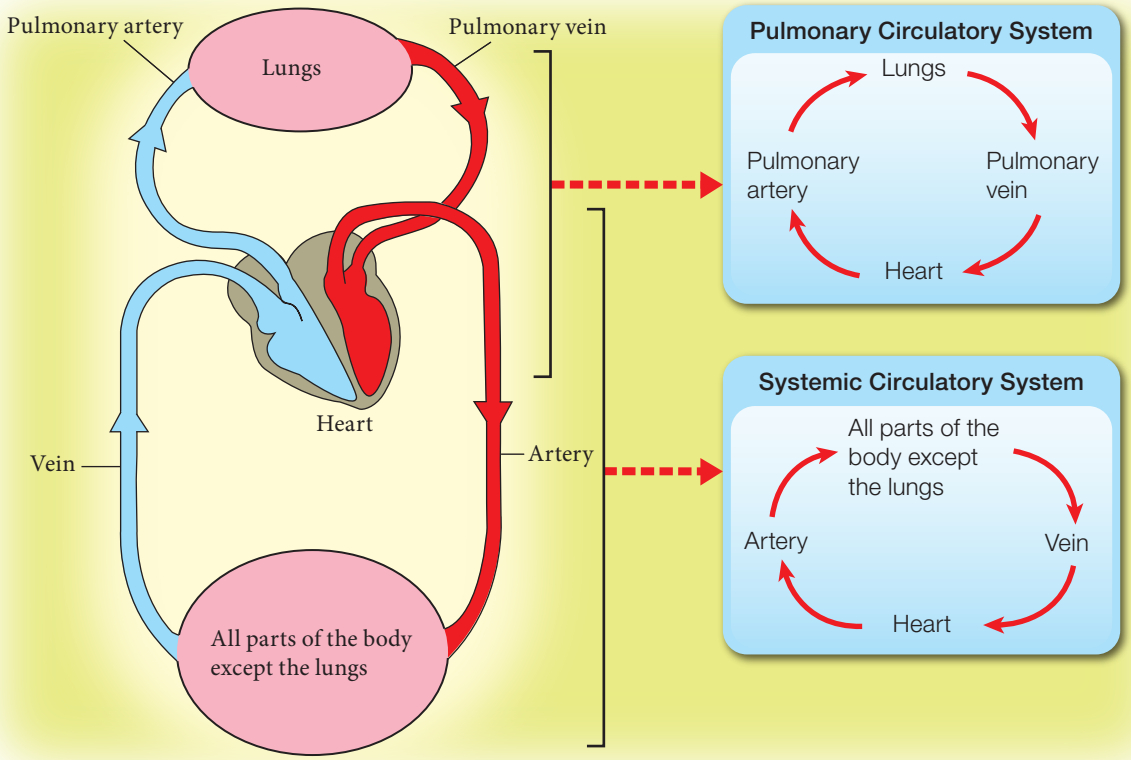


Figure 3.9 *Pulmonary circulatory system and systemic circulatory system*

Activity 3.3

21st Century Skills
- ICS
- Active reading activity

Create a multimedia presentation based on research of a sheep's heart and, explain its structures and functions

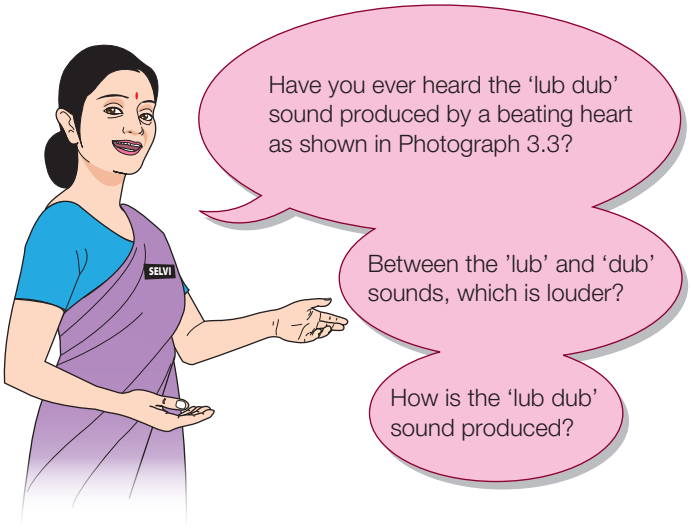
Instructions

1. Work in groups.
2. Each group is required to create a presentation on the research of the heart of a sheep to explain its structures and functions.

Example:
Video on the dissection of a sheep's heart

SCAN PAGE

Heartbeat



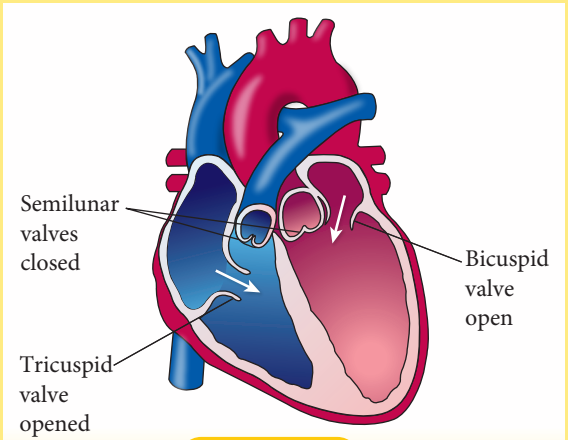
Photograph 3.3 *Hearing the 'lub dub' sound when the heart is beating*

Figure 3.10 shows the sequence of the opening and closing of the valves in the heart during heartbeats.

VIDEO

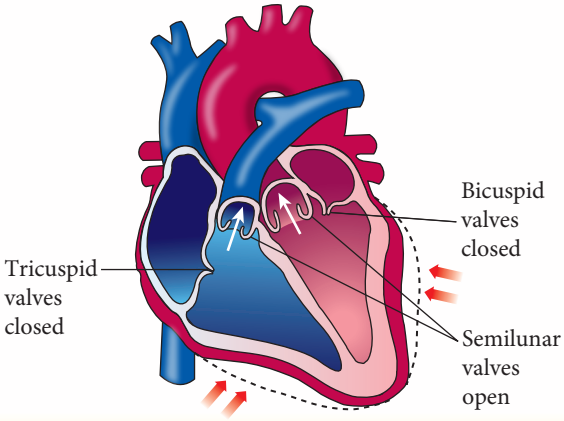
Watch this video to understand the process of diastole and systole

SCAN PAGE



DIASTOLE

The 'dub' sound is produced by the closure of the semilunar valves at the aorta and pulmonary artery when relaxation of the ventricles occurs. This condition is known as **diastole**. The pressure reading of blood flowing into and filling the heart is called the **diastolic** pressure reading.



SYSTOLE

The 'lub' sound is produced by the closure of the tricuspid and bicuspid valves between the atria and the ventricles when contraction of the ventricles occurs. This condition is known as **systole**. The pressure reading of blood flowing out of the heart is called the **systolic** pressure reading.

Figure 3.10 *Diastole and systole*

Measurement of Blood Pressure

Blood pressure is usually measured using a sphygmomanometer as shown in Photograph 3.4.

Photograph 3.4 *Measuring blood pressure*

SCIENCE INFO

Taking of diastolic and systolic pressure readings from a sphygmomanometer is based on listening to the sounds produced by the blood circulation when diastole and systole occur. Due to this, the use of sphygmomanometer to take readings of diastolic and systolic pressures is usually done by an experienced doctor.

The systolic pressure reading of a youth is normally 120 mm Hg and the diastolic pressure reading is 75 mm Hg. Hence, this blood pressure reading is normally written as 120/75 mm Hg. Measure and read your blood pressure (systolic and diastolic) using a sphygmomanometer.

BRAIN TEASER

Why is the reading of systolic pressure higher than the reading of diastolic pressure?

Pulse Rate

Photograph 3.5 shows one of the medical examination activities that is normally carried out by a doctor on a patient. What is the quantity measured as shown in the photograph?

Pulse is produced by the contraction and relaxation of the muscular artery wall. Is your pulse rate constant? Give **two** examples of conditions in your daily life that increase the pulse rate. Let us carry out Experiment 3.1 to study the factors that influence the pulse rate.

Photograph 3.5 *Detecting pulse*

Experiment 3.1

Aim
To study the factors that influence the pulse rate

Problem statement
How does the intensity of a physical activity influence the pulse rate?

Hypothesis
The more vigorous a physical activity, the higher the pulse rate.

Variables
(a) manipulated variable : Type of activity
(b) responding variable : Pulse rate
(c) constant variable : Duration of activity

Apparatus
Watch

Procedure
1. Rest for 5 minutes. Then, locate your pulse as shown in Figure 3.11.
2. Count and record the number of pulses over a period of 10 seconds in a table. Calculate the pulse rate in number of pulses per minute.
3. Repeat steps 1 and 2 after carrying out each of the following types of activities over a period of 5 minutes.
   (a) Walking slowly
   (b) Running

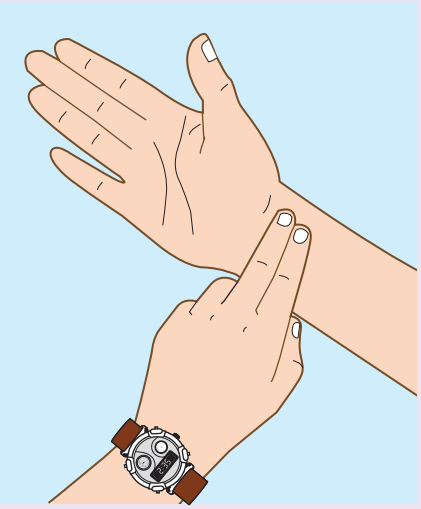


Figure 3.11

Type of activity	Number of pulses over a period of 10 seconds	Pulse rate (number of pulses per minute)
Resting		
Walking slowly		
Running		

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

Questions
1. How does the type of activity influence the pulse rate?
2. How is the increase in pulse rate while carrying out vigorous activities related to the rate of oxygen intake and release of carbon dioxide?

Other Factors that Influence the Pulse Rate

Apart from physical activities, other factors which influence the pulse rate are as follows:

Photograph 3.6 *A modern blood pressure and pulse rate measuring device*

A Gender

The average pulse rate of an adult male is between 70 to 72 beats per minute and the average pulse rate of an adult female is between 78 to 82 beats per minute. The difference in pulse rate between males and females is caused by the difference in the size of the heart. The heart of females which is normally of smaller size pumps less blood for each heartbeat and needs to beat at a much higher rate compared to the heart of males.

B Age

Look at Table 3.2. As the age of a person increases, the person's pulse rate becomes lower.

Table 3.2 *Average maximum pulse rate based on age*

Age (years)	Average maximum pulse rate (pulse per minute)
20	200
25	195
30	190
35	185
40	180
45	175
50	170
55	165
60	160
65	155
70	150

(Source: https://healthyforgood.heart.org/move-more/articles/target-heart-rates)

C Body health

The pulse rate of a less healthy individual is normally higher or lower than the normal pulse rate. A pulse rate that is too high or too low is dangerous and can be life-threatening.

Importance of Maintaining a Healthy Heart

The health of a heart should be given attention since its functions are very important in the continuity of human life. How are we able to enhance the knowledge and understanding of the health of the heart among Malaysians? Carry out Activity 3.4.

Activity 3.4

21st Century Skills
- ICS, ISS, CPS, STEM
- Project-based activity

To enhance the knowledge and understanding of the health of the heart through project-based learning using STEM approach

Aim

To study the relationship between dietary habits and lifestyle with health of the heart among the locals

Materials

Printed materials and the Internet

Instructions

1. Work in groups of five to six.
2. Study the following problem statement:

   > Since 2005, heart disease remains as one of the main causes of death among Malaysians. This problem is closely related to their dietary habits and lifestyles.

3. Gather information related to the given problem statement as follows:
   (a) Types of heart diseases
   (b) Causes of heart diseases
   (c) Ways to avoid heart diseases
   (d) Ways to prevent heart diseases
   (e) Other related matters
4. Discuss the information required to complete a K-W-L Chart as a guide to prepare a questionnaire.
5. The K-W-L Chart is prepared for a "Gallery Walk" session.
6. Prepare a questionnaire related to the topic of the study.
7. Carry out the study (at least 30 respondents) and analyse the findings of the study.
8. Present the analysis of each item in the questionnaire using chart papers or MS PowerPoint software.
9. Present the analysis of the study in the form of graphs using MS PowerPoint software.

10. After the presentation and discussion sessions, carry out the following activities in groups under the supervision of your teacher:
    (a) Presentation of the findings of your study in the school assembly
    (b) Health talk programme entitled "LET US TAKE CARE OF OUR HEART" as a co-curricular activity
    (c) Poster competition: Care for Our Heart
    (d) Produce infographics brochure on the health care of the heart related to dietary habits and lifestyles

Note:
What is the K-W-L Chart Strategy?

The K-W-L Chart Strategy is an active reading strategy. It prepares students to predict what is read and is able to get other students to participate in the content of the topic discussed.

K-W-L Chart Strategy		
K – What we know	W – What we want to know	L – What we learn

My Malaysia!

In July 2017, heart specialists at the *Institut Jantung Negara* (IJN) successfully replaced the damaged aorta of a heart patient with synthetic aorta. Gather further information on this at the following website:
http://links.andl17.com/BT_Science_95_1

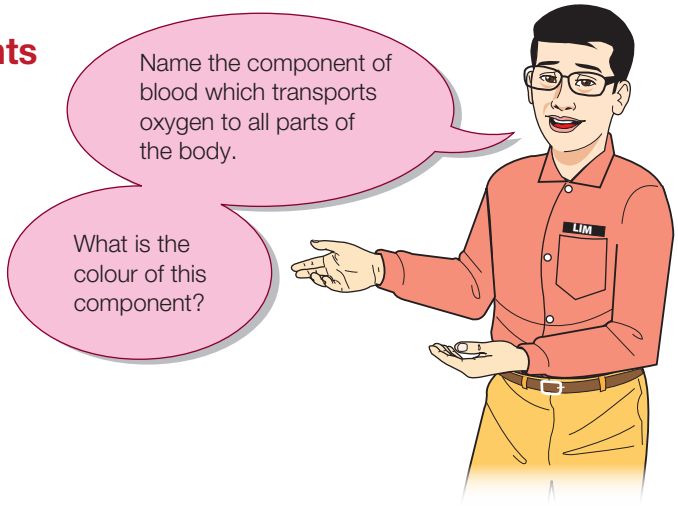
Formative Practice 3.2

1. What is blood circulatory system?
2. Differentiate the functions of the artery, capillary and vein.
3. State **four** factors that influence the pulse rate.
4. What is the importance of taking care of the heart?

3.3 Human Blood

Components and Constituents of Human Blood

Blood transports oxygen and nutrients to the body cells. Blood also transports waste products from the body cells.

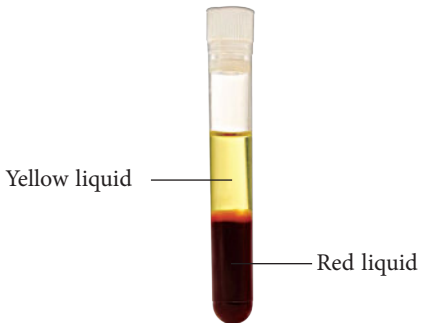


Science Careers

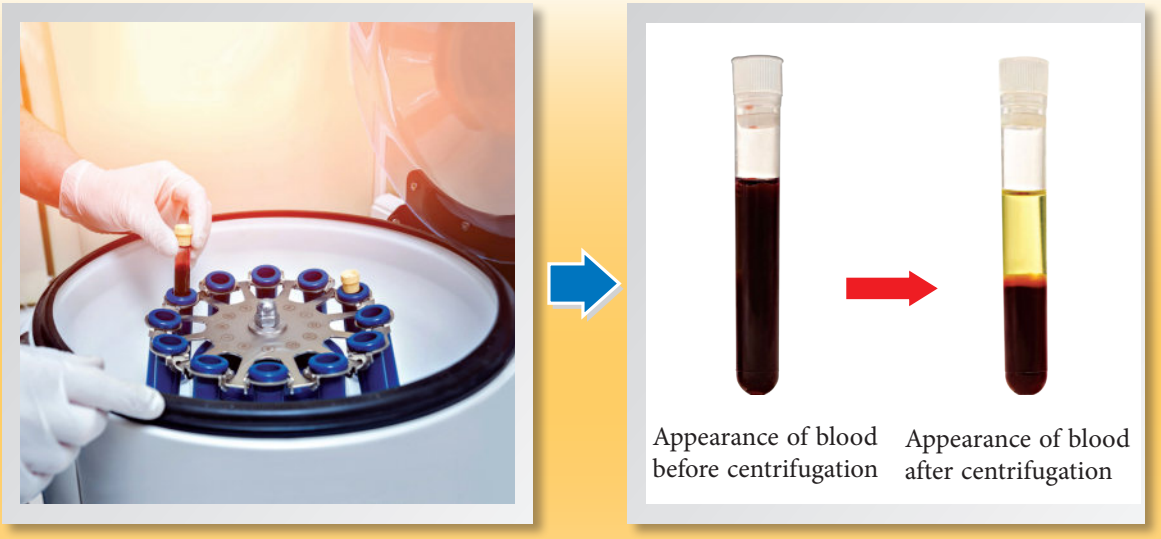
Haematologists are medical specialists who study the components, constituents and diseases related to human blood.

Blood is a type of **mixture** because it can be separated into two components, a **yellow liquid** floating on top of a **red liquid** as shown in Photograph 3.7.

The components of blood are normally separated using the **centrifugal method**. The mixture of blood is rapidly spun in a centrifuge as shown in Photograph 3.8.



Photograph 3.7 *Two components of blood*



Photograph 3.8 *Separation of the components of blood using centrifugal method*

Components of Blood

Blood consists of a suspension of **red blood cells, white blood cells, platelets** and **blood plasma** as shown in Figure 3.12.

Blood plasma is made up of approximately 90% water and 10% dissolved substances flowing to all parts of the body. These dissolved substances include nutrients, carbon dioxide, enzymes, hormones and waste products. Let us carry out Activity 3.5 to study the substances transported by blood.

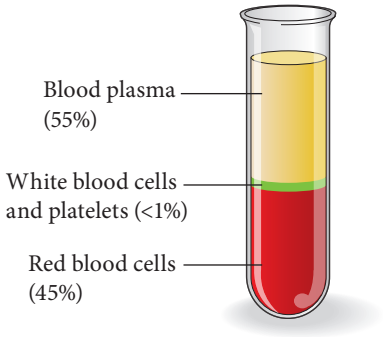


Figure 3.12 *Components of human blood*

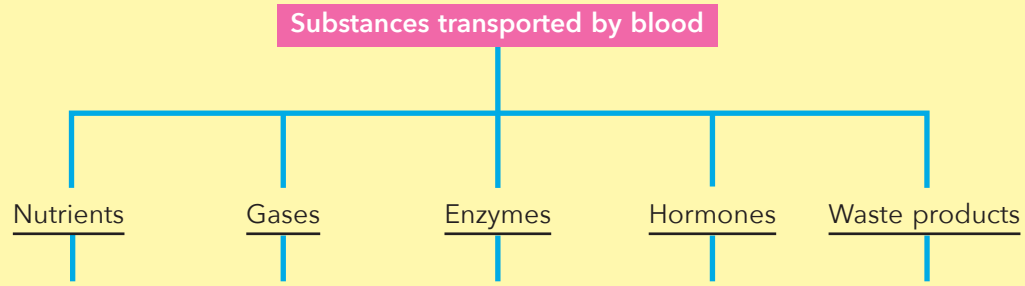
Activity 3.5

21st Century Skills
- CPS
- Discussion activity

To study the substances transported by blood

Instructions

1. Work in groups to gather information on the substances transported by blood, namely nutrients, gases, enzymes, hormones and waste products.
2. Carry out active reading on the gathered information.
3. Discuss the information gathered and present the findings of your group's discussion.
4. Complete the following tree map to show the substances transported by blood and the characteristics of the substances.



Human Blood Groups

Antigens on Red Blood Cells

Human blood can be classified into four blood groups, namely **A, B, AB** and **O** according to the type of antigen, if any, present on the red blood cells. The type of antigen present on red blood cells is **A antigen** or **B antigen**. The classification of blood groups A, B, AB and O is shown in Figure 3.13.

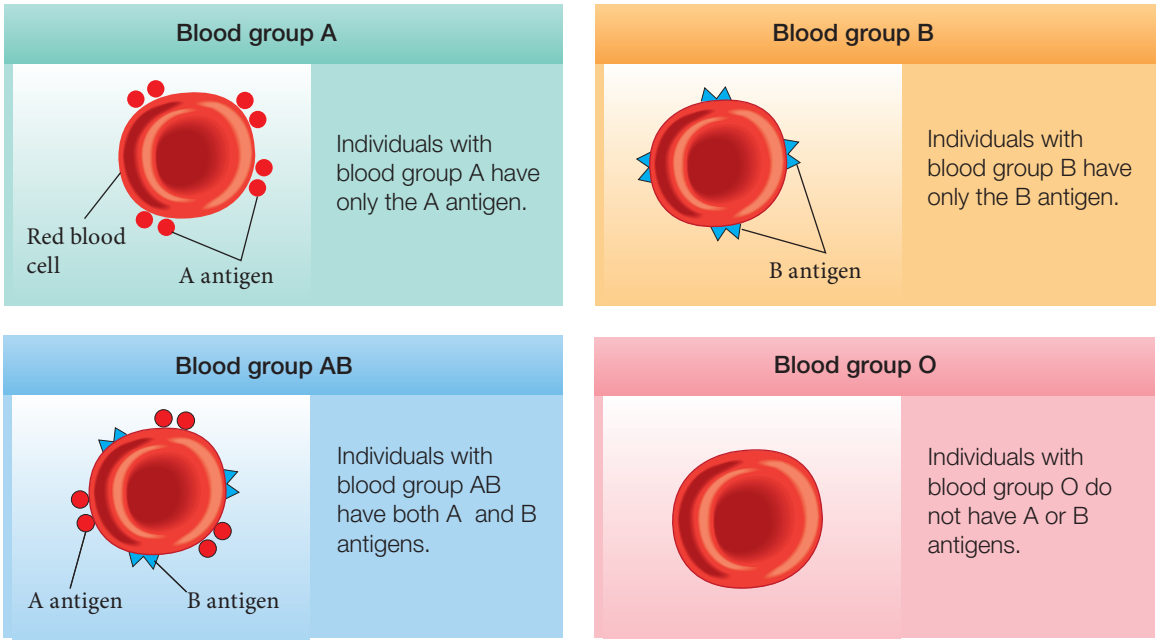


Figure 3.13 *Classification of human blood groups*

Antibodies in Blood Plasma

Blood plasma contains antibodies. The types of antibodies present in blood plasma are **Anti-A** and **Anti-B** antibodies. The types of blood, antigens and antibodies are as shown in Table 3.3.

Table 3.3 *Types of blood, antigens and antibodies*

Type of blood	Types of antigens (On the surface of red blood cells)	Types of antibodies (In blood plasma)
A	A	Anti-B
B	B	Anti-A
AB	A and B	–
O	–	Anti-A and Anti-B

An antibody will attack its corresponding antigen and cause the **coagulation** of blood to occur. This may cause **death**. For example, **Anti-A** antibody will coagulate with A antigen and **Anti-B** antibody will coagulate with B antigen.

Summary based on Table 3.3

- An individual who has **Anti-A antibodies** (type B blood) cannot receive types **A** and **AB** blood because these two blood types contain A antigen.
- An individual who has **Anti-B antibodies** (type A blood) cannot receive types **B** and **AB** blood because these two blood types contain B antigen.
- An individual who has type **AB** blood is free to receive all types of blood because there are no antibodies in his blood (universal recipient).
- On the other hand, an individual who has type **O** blood cannot receive any other blood type because of the presence of Anti-A and Anti-B antibodies in his blood plasma.

Therefore, whether a person can receive blood or not depends on the presence of **antibodies** in his blood plasma.

BRAIN TEASER

Why is an individual who has type O blood known as the universal donor?

Compatibility of Blood Groups of Donors and Recipients

Before blood transfusion, we need to know that the blood groups of the donor and the recipient must be **compatible** as shown in Table 3.4. Otherwise, blood will coagulate. This situation can cause the death of the recipient.

Table 3.4 *Compatibility of blood groups of donors and recipients*

Blood group of donor	Blood group of recipient			
	A	B	AB	O
A	✓	×	✓	×
B	×	✓	✓	×
AB	×	×	✓	×
O	✓	✓	✓	✓

Note: Compatibility of blood for transfusion (✓: compatible ×: not compatible)

Importance of Blood Donation

Take note of the facts shown in Figure 3.14.

Do you agree with the efforts to justify the importance of blood donation in the context of daily life? Carry out project-based learning using the STEM approach on the importance of blood donation through Activity 3.6.

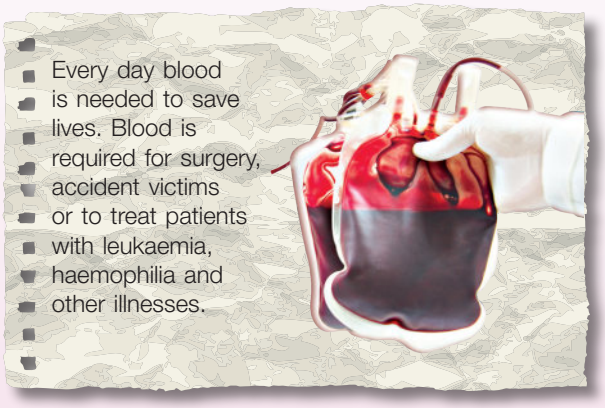


Figure 3.14 *The importance of blood donation*

Activity 3.6

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

To understand and solve issues related to blood donation in the context of daily life based on projects using the STEM approach

Instructions

1. Work in groups to study the following statement:

> Every day blood is needed to save lives. Blood is required for surgery, accident victims or to treat patients with leukaemia, haemophilia and other illnesses.

2. Prepare a project using the STEM approach to find creative and innovative solutions for the following issues:
   - Importance of blood donation
   - Criteria to be a blood donor
   - Issues related to blood donation
   - Methods of handling and storing the donated blood
3. Gather the information or existing solutions from the relevant and reliable government or private agencies as follows:

National Blood Centre	Ministry of Health Malaysia	Malaysian Red Crescent
http://links.and117.com/BT_Science_100_1	*http://links.and117.com/BT_Science_100_2*	*http://links.and117.com/BT_Science_100_3*

4. Discuss the solutions obtained.
   Present the findings of your group's discussion.

SCIENCE INFO

A healthy individual with a mass of more than 45 kg and between 18 to 60 years old can donate blood. A donor can donate up to 0.5 litres of blood at any one time as shown in Photograph 3.9.

When an individual donates blood, the total red blood cells in his body reduces. This forces the bone marrow to produce new cells. The individual will become more energised and able to function better.

Photograph 3.9 *Blood donation campaign*

Formative Practice 3.3

1. State **four** components of human blood.

2. State the largest component of human blood.

3. Mark '✓' for blood groups of donor and recipient that are compatible and '×' for the blood groups of donor and recipient that are not compatible.

Blood group of donor	Blood group of recipient			
	A	B	AB	O
A				
B				
AB				
O				

4. (a) What is the importance of blood donation?
   (b) State **two** examples of diseases that can be treated through blood transfusion.

5. (a) Why is a blood donor with blood group O known as a universal donor?
   (b) Why is a blood recipient with blood group AB known as a universal recipient?
   (c) Why is the blood storage centre known as the blood bank?

6. (a) State **two** public places where people can donate blood.
   (b) Give **one** situation that requires a large amount of donated blood.

7. Figure 1 shows a bag filled with a donor's blood that has been tested.

Figure 1

   (a) Based on Figure 1, state the blood group of the donor concerned.
   (b) Other than blood group, what else is tested in the blood sample of the donor?
   (c) The blood bag contains several chemical substances such as sodium citrate. What is the function of sodium citrate?

3.4 Transport System in Plants

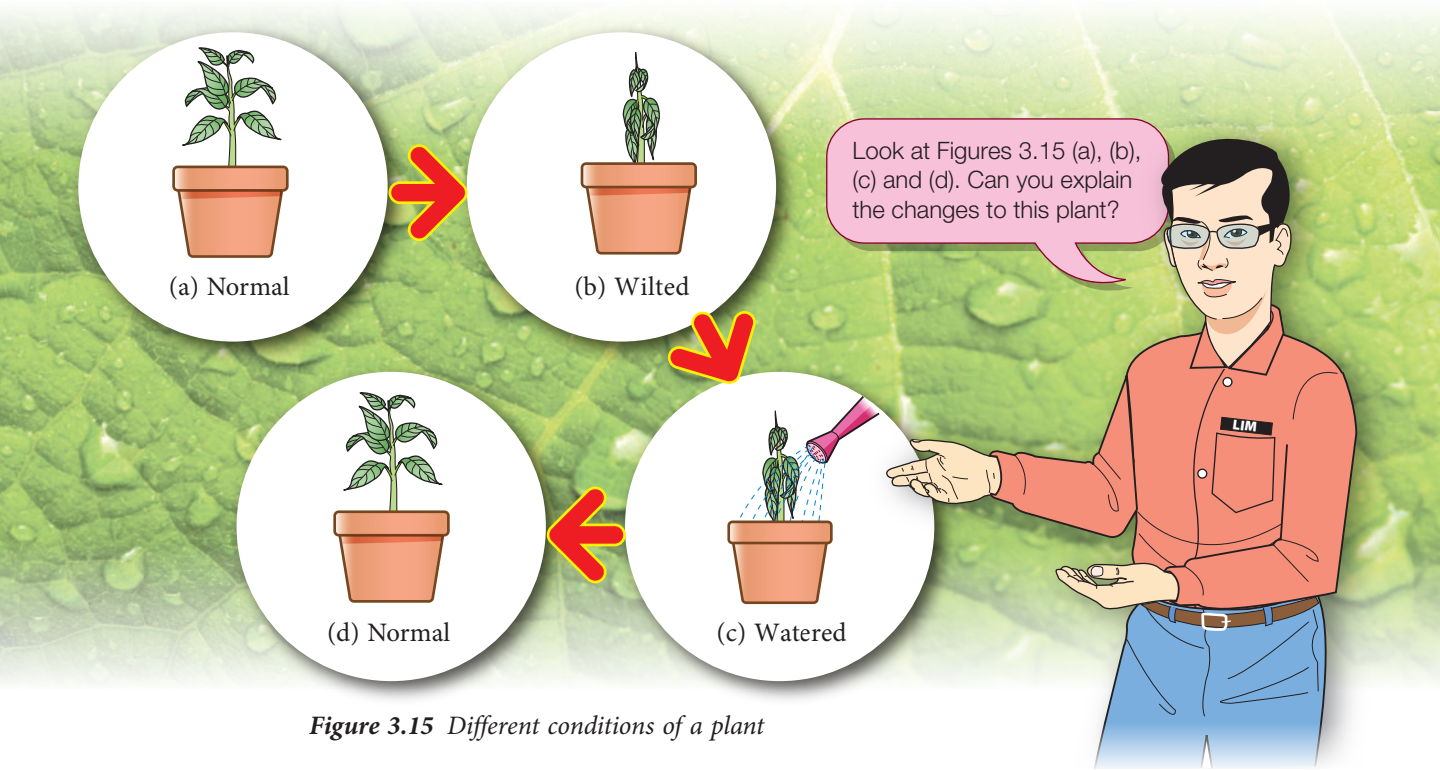


Figure 3.15 *Different conditions of a plant*

Transpiration

Transpiration is a process of **water loss** in the form of water vapour from the surface of leaves to the air through **evaporation**. Study Figure 3.16. **Leaves** are part of a plant where most water loss occurs through transpiration.

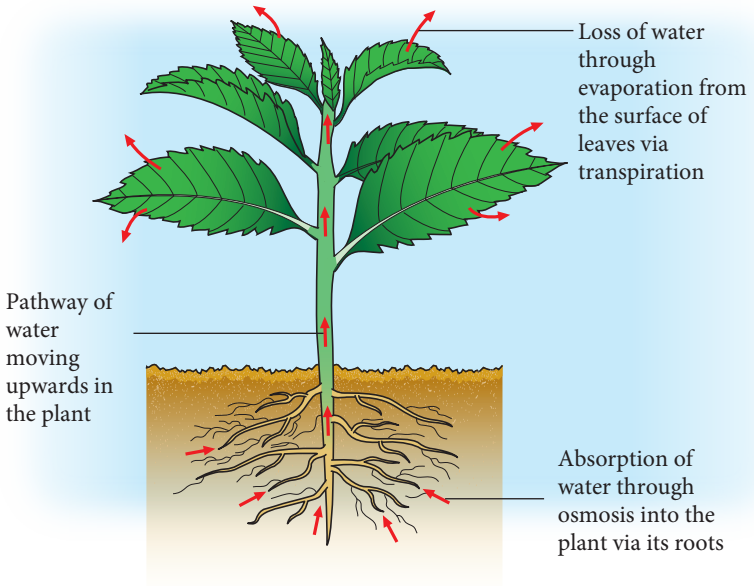


Figure 3.16 *Transpiration and absorption of water in a plant*

Cross Section of a Leaf

The epidermis of a leaf is made up of a single layer of epidermal cells covering both the upper and lower surfaces of the leaf, namely **upper epidermis** and **lower epidermis** as shown in Figure 3.17. Epidermal cells secrete a **waxy cuticle** which covers the outer surface of the leaf to reduce water loss during transpiration.

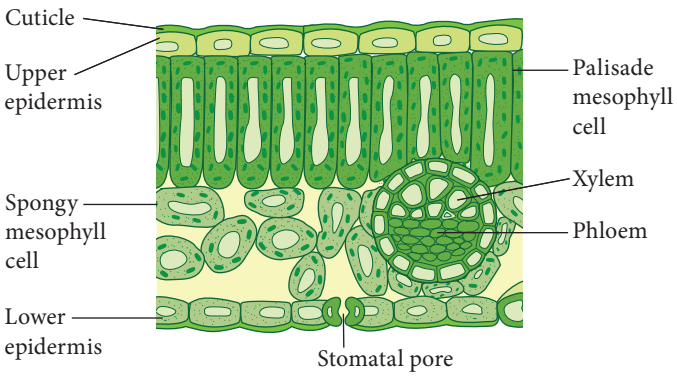


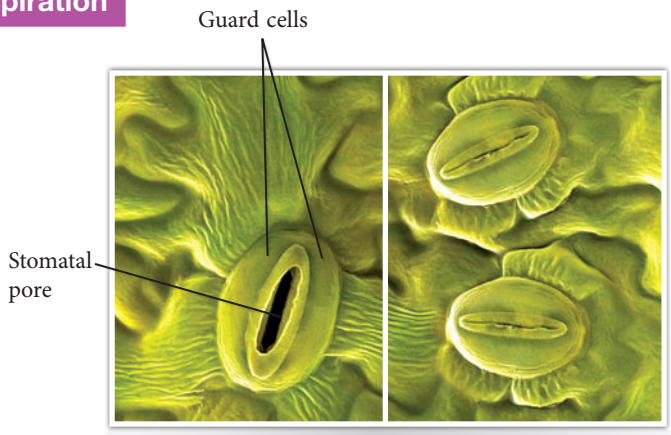
Figure 3.17 *Cross section of a leaf*

Function of Stoma during Transpiration

Most of the water lost during transpiration in plants occurs through the **stomatal pores** found in the epidermis of the leaf as shown in Photograph 3.10.

When photosynthesis takes place during the day, the stoma is usually open as shown in Photograph 3.10 (a). What enters the guard cells that causes the stoma to open?

Opening of stoma also causes the plant to lose water through transpiration. Photograph 3.10 (b) shows closed stoma to reduce the loss of water through transpiration.



(a) Open stoma (b) Closed stoma

Photograph 3.10 Open and closed stoma

Exudation (Guttation)

Other than water loss from plants through transpiration, water is also lost from plants through **exudation** or **guttation**. Exudation or guttation is the water loss from plants in liquid form through **hydathodes** that are always open at the edges of the leaves. Guttation usually occurs at night or when the air humidity is high. What is the name of the water droplets that come out of leaves as shown in Photograph 3.11? Carry out Activity 3.7 to learn more about transpiration and exudation (guttation).

SCIENCE INFO

Guttation is different from dew drops. Dew drops are formed from the condensation process of water vapour in the atmosphere into water.

Photograph 3.11
Exudation (guttation)

Activity 3.7

To make observations and create presentations to study the processes of transpiration and exudation (guttation) in plants

21st Century Skills
- ICS
- Innovation-based activity

Instructions

1. Work in groups.
2. Each group is required to create a presentation to study the processes of transpiration and exudation (guttation) in plants.

Rate of Transpiration

Transpiration occurs mainly through the stomata. Due to this, the **number of stomata** affects the rate of transpiration in plants. Transpiration is faster if the plant has more stomata. Other factors affecting the rate of transpiration are as shown in Figure 3.18. Carry out Experiments 3.2, 3.3, 3.4 and 3.5 to study the factors affecting the rate of transpiration.

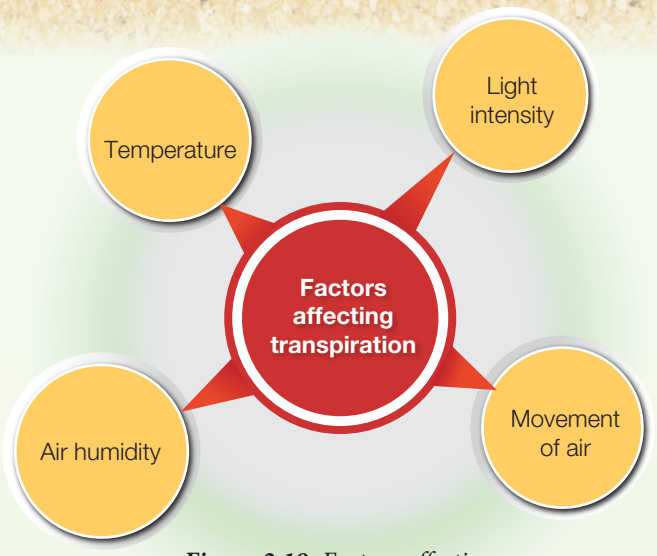
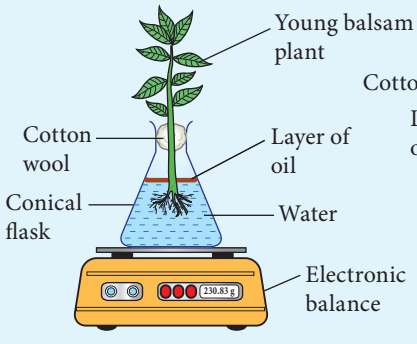


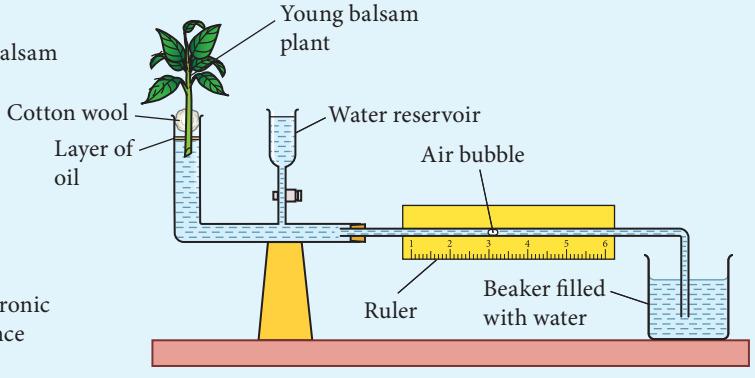
Figure 3.18 *Factors affecting the rate of transpiration*

SCIENCE INFO

The rate of transpiration of plants is normally estimated using a potometer as shown in Figures (a) and (b) below.



(a) Mass potometer



(b) Bubble potometer

Mass potometer measures the rate of transpiration of a plant according to the rate of mass of water absorbed by the plant. **Bubble potometer** measures the rate of transpiration of a plant according to the rate of volume of water absorbed by the plant.

Experiment 3.2

Aim
To study the effect of light intensity on the rate of transpiration

Problem statement
What is the effect of light intensity on the rate of transpiration?

Hypothesis
Increase in light intensity increases the rate of transpiration.

Variables
(a) manipulated variable : Light intensity
(b) responding variable : Rate of transpiration
(c) constant variables : Size and type of plant, air humidity, air movement, temperature and time

Materials
Young balsam plant, water, cotton wool and oil

Apparatus
Electronic balance, conical flask, clock and source of light such as sunlight or lamp

Procedure
1. Set up the apparatus as shown in Figures 3.19 and 3.20.
2. Measure the mass of both apparatus set-ups and record your observation in a table.
3. After 3 hours, measure the mass of both apparatus set-ups once again and record your observation in the table.
4. Calculate the rate of transpiration of the young balsam plant that is exposed to a light source and also the one kept in the dark in a cupboard using the following formula:

$$\text{Rate of transpiration} = \frac{\text{change in the mass of the potometer}}{\text{time taken}}$$

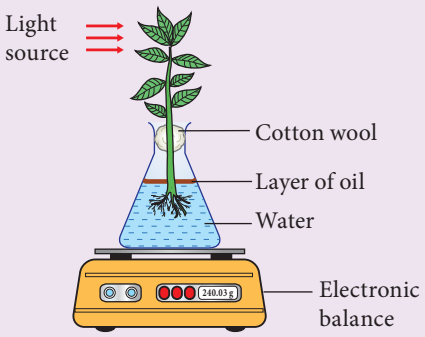


Figure 3.19

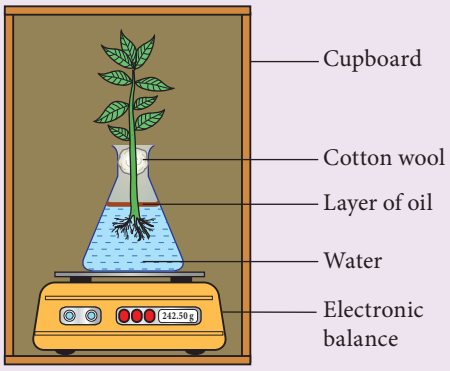


Figure 3.20

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

Experiment 3.3

Aim
To study the effect of air humidity on the rate of transpiration

Problem statement
What is the effect of air humidity on the rate of transpiration?

Hypothesis
Increase in air humidity decreases the rate of transpiration.

Variables
(a) manipulated variable : Air humidity
(b) responding variable : Rate of transpiration
(c) constant variables : Size and type of plant, light intensity, air movement, temperature and time

Materials
Young balsam plant, anhydrous calcium chloride, water, cotton wool and oil

Apparatus
Electronic balance, conical flask, plastic bag, clock and source of light such as sunlight or lamp

Procedure
1. Set up the apparatus as shown in Figures 3.21 and 3.22.
2. Measure the mass of both apparatus set-ups and record your observation in a table.
3. After 3 hours, measure the mass of both apparatus set-ups once again and record your observation in the table.
4. Calculate the rate of transpiration in both apparatus set-ups.

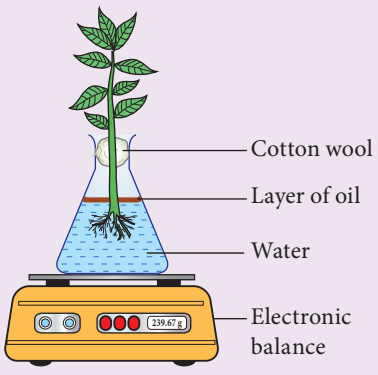


Figure 3.21

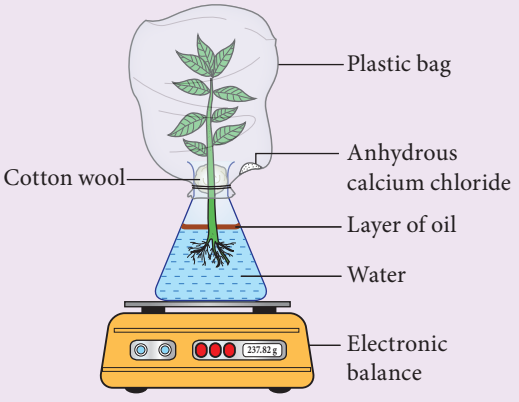


Figure 3.22

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

Experiment 3.4

Aim
To study the effect of air movement on the rate of transpiration

Problem statement
What is the effect of air movement on the rate of transpiration?

Hypothesis
Increase in air movement increases the rate of transpiration.

Variables
(a) manipulated variable : Air movement
(b) responding variable : Rate of transpiration
(c) constant variables : Size and type of plant, light intensity, air humidity, temperature and time

Materials
Young balsam plant, water, cotton wool and oil

Apparatus
Electronic balance, fan, conical flask and clock

Procedure
1. Set up the apparatus as shown in Figures 3.23 and 3.24.
2. Measure the mass of both apparatus set-ups and record your observation in a table.
3. After 3 hours, measure the mass of both apparatus set-ups once again and record your observation in the table.
4. Calculate the rate of transpiration in both apparatus set-ups.

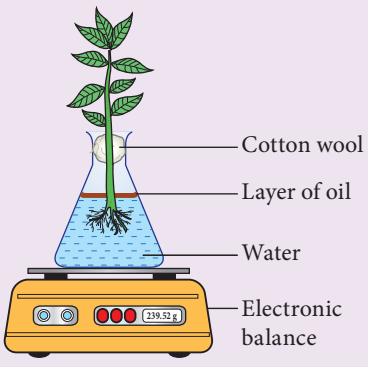


Figure 3.23

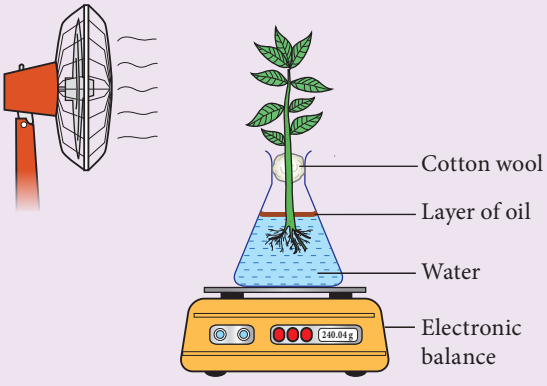


Figure 3.24

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

Experiment 3.5

Aim
To study the effect of temperature on the rate of transpiration

Problem statement
What is the effect of temperature on the rate of transpiration?

Hypothesis
Increase in temperature increases the rate of transpiration.

Variables
(a) manipulated variable : Temperature
(b) responding variable : Rate of transpiration
(c) constant variables : Size and type of plant, light intensity, air humidity, air movement and time

Materials
Young balsam plant, water, cotton wool and oil

Apparatus
Electronic balance, conical flask and clock

Procedure
1. Set up the apparatus as shown in Figures 3.25 and 3.26.
2. Measure the mass of both apparatus set-ups and record your observation in a table.
3. After 3 hours, measure the mass of both apparatus set-ups once again and record your observation in the table.
4. Calculate the rate of transpiration in both apparatus set-ups.

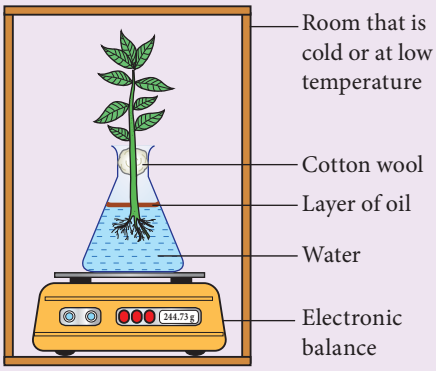


Figure 3.25

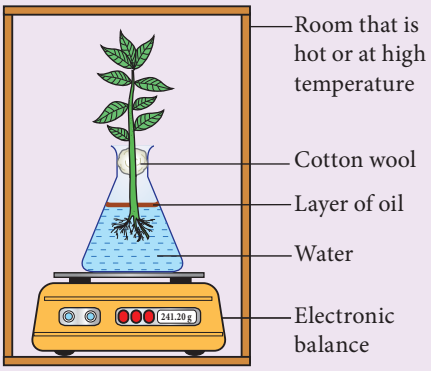
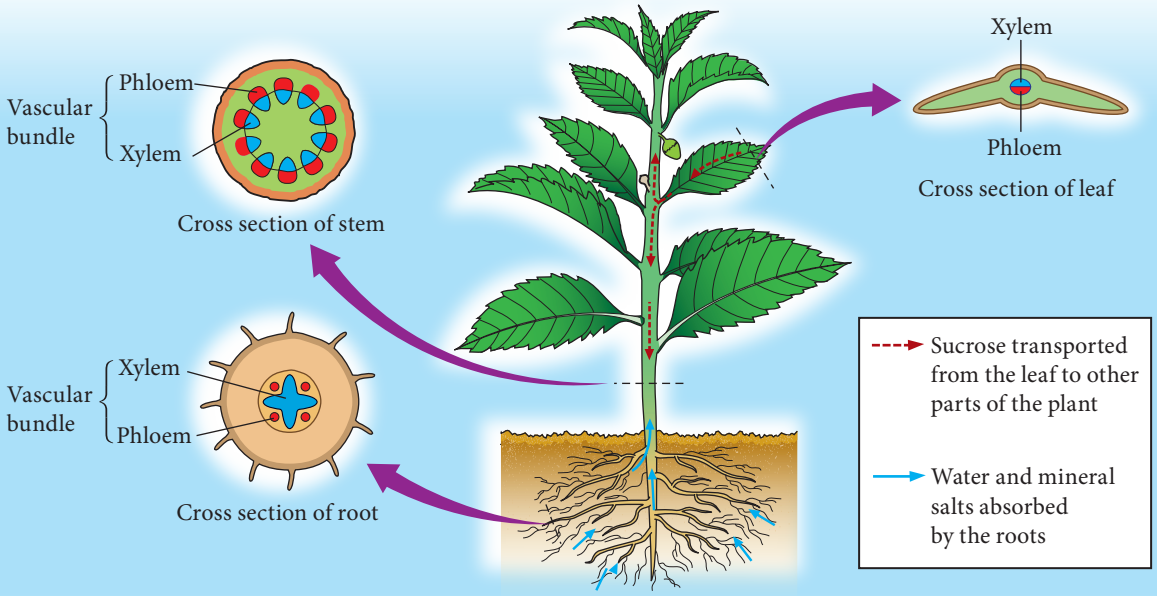


Figure 3.26

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

Structures and Functions of the Components in Vascular Bundles of Plants

Transpiration facilitates the transportation of water and mineral salts in plants. During transpiration, water and dissolved mineral salts diffuse into plants through the roots to the stem and leaves as shown in Figure 3.27.



- **Xylem** transports water and dissolved mineral salts from the roots to the leaves through the stem to carry out photosynthesis and to replace water lost during transpiration.
- **Phloem** transports sucrose produced by leaves during photosynthesis to other parts of the plant.

Figure 3.27 *Transport system in a flowering plant and distribution of vascular bundles in the leaves, stem and roots*

The transport system in flowering plants is made up of two transport tissues, namely **xylem** and **phloem**, which are found in a group of vessels known as **vascular bundles**. Observe the formation pattern of the vascular bundles in the root, stem and leaf as shown in Figure 3.27. Is the formation pattern of vascular bundles in the root, stem and leaf the same or different?

Visit the following websites and watch the video to find out the position and structure of the xylem and phloem in a vascular bundle.

Info 1

http://links.andl17.com/BT_Science_109_2

Info 2

http://links.andl17.com/BT_Science_109_3

Video

SCAN PAGE

Direction of Water and Food in the Transport System of Plants

In Activity 3.8 and Activity 3.9, we will investigate the functions of the xylem and phloem.

Activity 3.8

Inquiry-based activity

Studying the direction of water in plants

Aim: To study the direction of water in a plant

Materials
Balsam plant and eosin solution (red dye)

Apparatus
Conical flask, glass cover, folding knife, microscope and slide

Instructions
1. Wash the roots of the balsam plant carefully with water.
2. Immerse the roots of the balsam plant in a conical flask filled with eosin solution as shown in Figure 3.28.

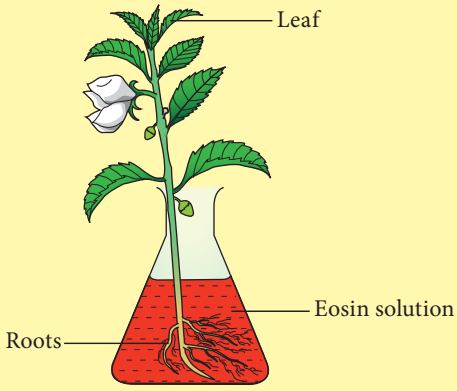


Figure 3.28

Safety Precautions

- Avoid coming in contact with the eosin solution as it will stain your clothes.
- Be careful when using a folding knife.

3. After 30 minutes, make thin cross-sections of the leaf, stem and root of the plant using a folding knife.
4. Examine each of the sections under a microscope.
5. Draw a labelled diagram for each section that has been observed. Identify and label the tissues that have been coloured red by the eosin solution.

Questions
1. Is the eosin solution spread evenly or does it have a specific pattern in the leaf, stem and root of the plant?
2. Name the part which is coloured red in the cross-sections of the leaf, root and stem in this activity.
3. What is the conclusion from this activity?

Activity 3.9

Inquiry-based activity

Studying the direction of food in plants

Aim: To investigate the direction of food in a plant

Material
Woody plant

Apparatus
Scalpel

Safety Precaution
Handle the scalpel with care.

Instructions
1. Choose a healthy branch of a woody plant.
2. Cut a complete ring out of the bark of the plant including the phloem as shown in Figure 3.29.

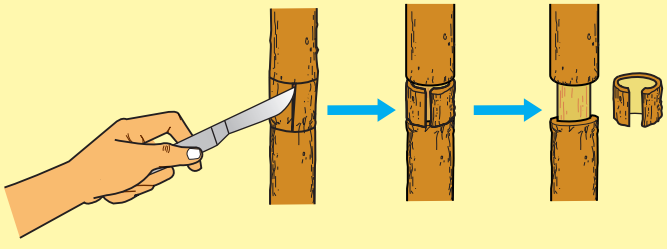


Figure 3.29

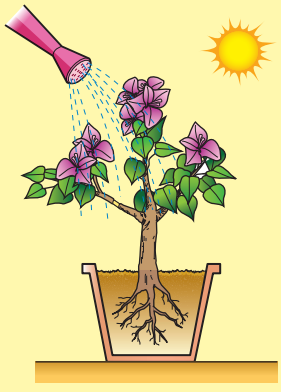
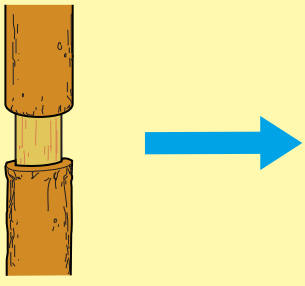


Figure 3.30

3. Water the plant every day and expose it to enough light so that the plant can carry out photosynthesis as shown in Figure 3.30.
4. Observe and sketch the changes, if any, in the branch of the woody plant with its bark removed after two to three months.

Questions
1. Sketch the changes in the part of the branch with its bark removed after two to three months.



(a) Beginning of activity

(b) End of activity

2. What is the conclusion from this activity?

Case Study

Based on your understanding of the transport system in plants, discuss examples of hypothetical situations such as when there are no xylem or phloem vessels in the following context:

Propose and discuss:
- ways to transport water and dissolved mineral salts in plants without xylem
- ways to transport sucrose from leaves to all parts of plants without phloem
- adaptations in the transport system to replace xylem and phloem vessels in plants

Formative Practice 3.4

1. What is the meaning of transpiration?
2. Underline the correct answer on the transport system in plants.
   (a) Loss of water from plants through transpiration is in the form of (liquid/vapour) while loss of water through exudation is in the form of (liquid/vapour).
   (b) The tissue that transports water in plants is (phloem/xylem) while the tissue that transports sucrose is (phloem/xylem).
3. State **four** factors that affect the rate of transpiration in plants.
4. Why is dye used to investigate the direction of water in xylem?
5. Figure 1 shows the structure of xylem and phloem in vascular bundles in different parts of a plant.

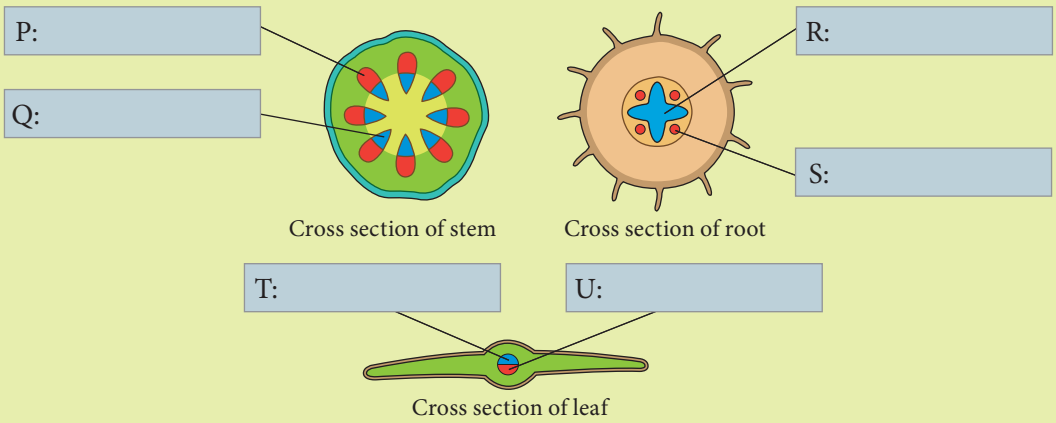


Figure 1

Label P, Q, R, S, T and U using the following words:

Xylem Phloem

3.5 Blood Circulatory System in Animals and Transport System in Plants

Studies on the blood circulatory system in animals and transport system in plants have made us aware of the uniqueness of circulatory systems to the continuity of life of organisms created by God. What are the similarities and differences between the blood circulatory system in animals and the transport system in plants? Study Figure 3.31.

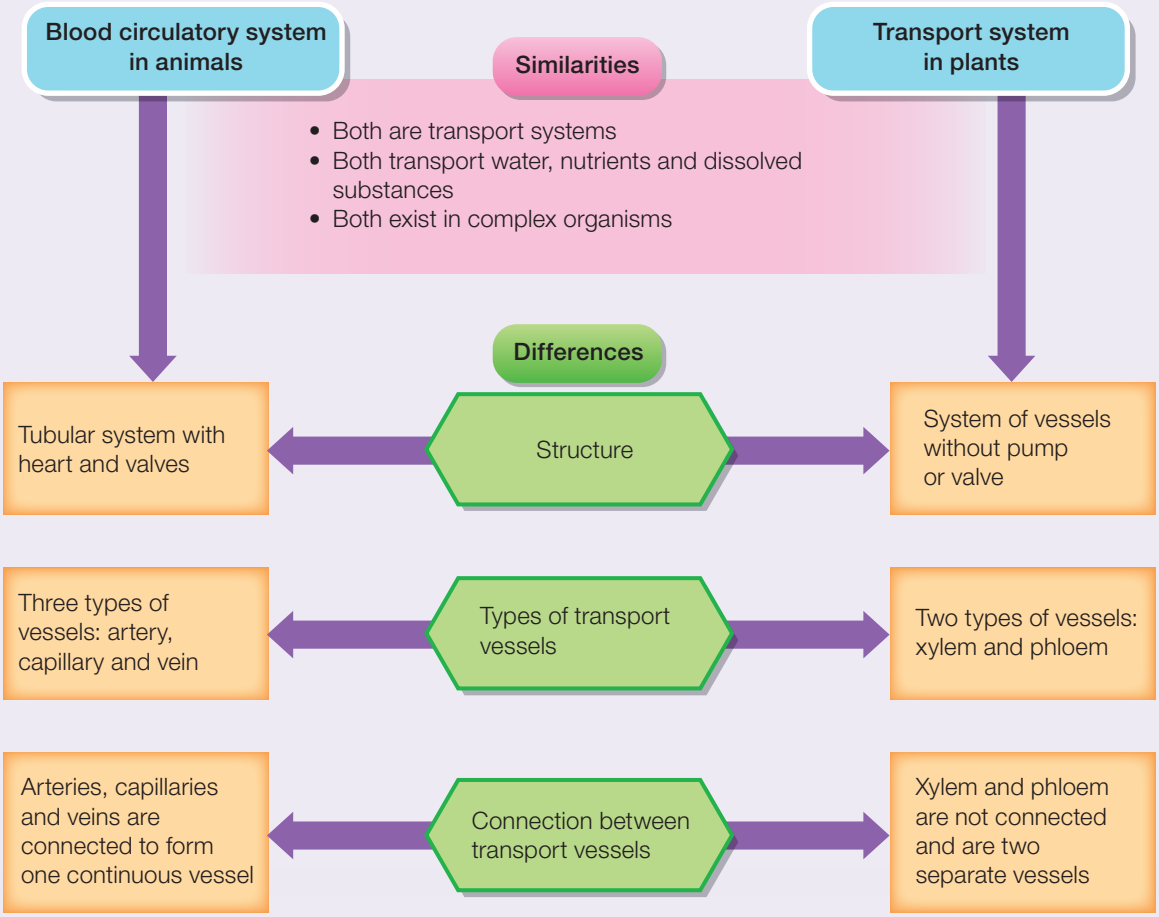
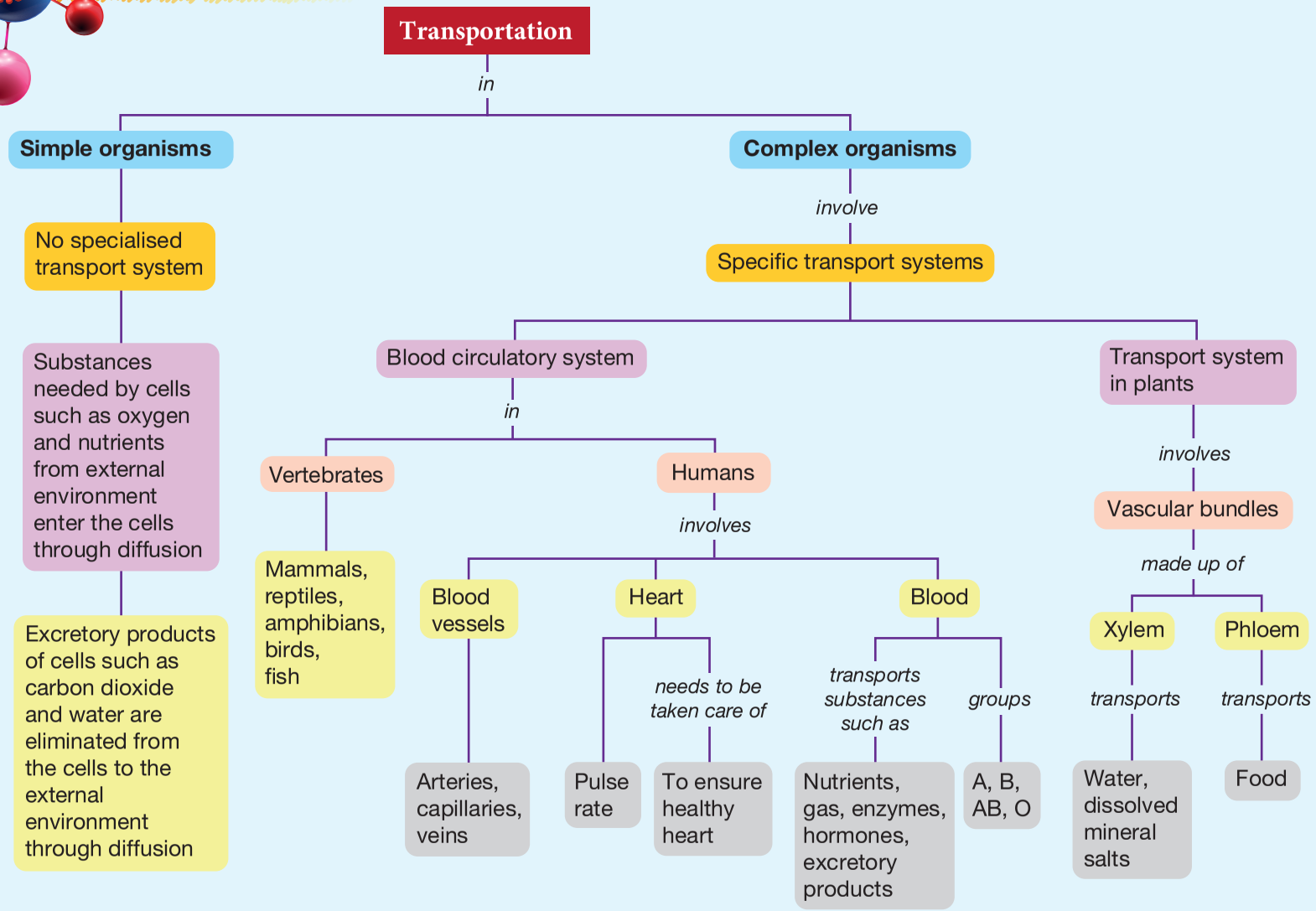


Figure 3.31 *Comparison between blood circulatory system in animals and transport system in plants*

Formative Practice 3.5

1. Give **one** similarity and **one** difference between the blood circulatory system in animals and the transport system in plants.
2. Why should we be thankful for the uniqueness of the circulatory system to the continuity of life of organisms?

Summary


Transportation
in
Simple organisms
Complex organisms
No specialised transport system
Substances needed by cells such as oxygen and nutrients from external environment enter the cells through diffusion
Excretory products of cells such as carbon dioxide and water are eliminated from the cells to the external environment through diffusion
involve
Specific transport systems
Blood circulatory system
in
Vertebrates
Mammals, reptiles, amphibians, birds, fish
Humans
involves
Blood vessels
Arteries, capillaries, veins
Heart
needs to be taken care of
Pulse rate
To ensure healthy heart
Blood
transports substances such as
Nutrients, gas, enzymes, hormones, excretory products
groups
A, B, AB, O
Transport system in plants
involves
Vascular bundles
made up of
Xylem
transports
Water, dissolved mineral salts
Phloem
transports
Food

Self-reflection

After studying this chapter, you are able to:

3.1 Transport System in Organisms

- ☐ Describe the function of transport systems in complex and simple organisms.
- ☐ Compare and contrast the functions of transport systems in complex and simple organisms.
- ☐ Justify the importance of the function of transport system in organisms.

3.2 Blood Circulatory System

- ☐ Generalise the meaning of blood circulatory system in animals.
- ☐ Communicate to explain the structure and functions of a heart and blood vessels in human blood circulatory system.
- ☐ Carry out experiments to study factors that affect pulse rate.
- ☐ Justify the importance of maintaining a heathy heart.

3.3 Human Blood

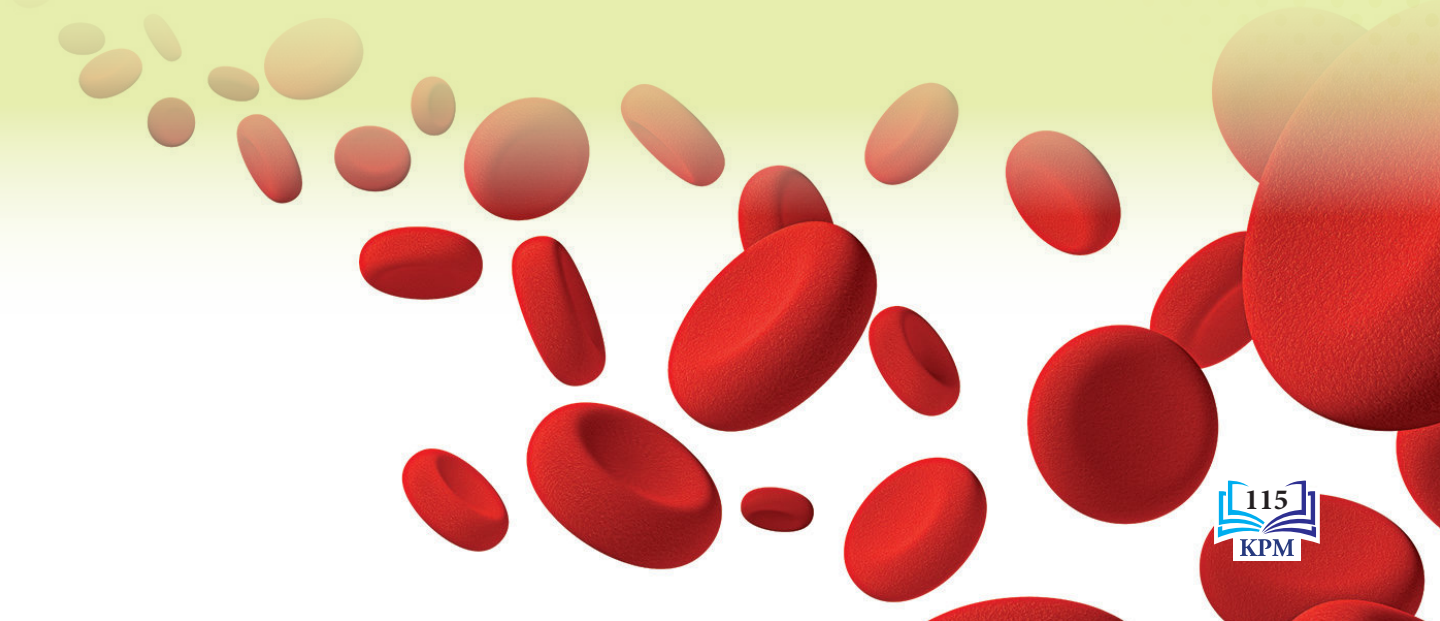
- ☐ Separate the components and constituents of human blood.
- ☐ Identify blood groups and the effects of receiving incompatible blood groups.
- ☐ Communicate about the importance of blood donation in context of daily life.

3.4 Transport System in Plants

- ☐ Describe transpiration in plants
- ☐ Carry out experiments to investigate the factors affecting the rate of transpiration.
- ☐ Differentiate between the structures and functions of components in a vascular bundle of a plant.

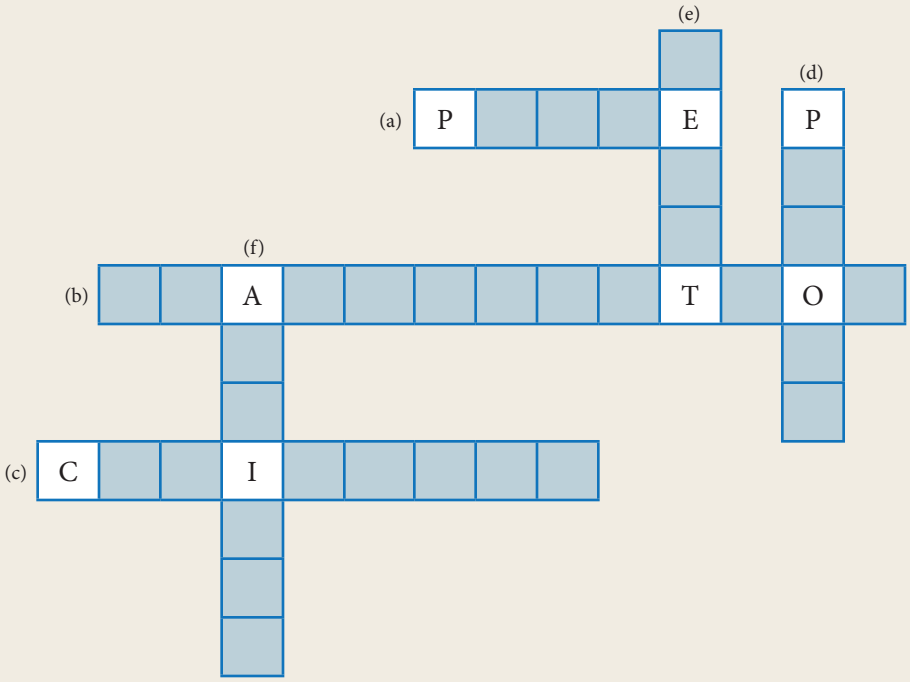
3.5 Blood Circulatory System in Animals and Transport System in Plants

- ☐ Compare blood circulatory system in animals with transport sytem in plants.



Answer the following questions:

1. Solve the crossword puzzle below with the correct answers.



Across

(a) Carrying out vigorous activities increases the rate of _____.
(b) Loss of water from plants occurs through the process of _____.
(c) Blood vessel with the thinnest wall is the _____.

Down

(d) Sucrose is transported by the _____.
(e) The organ which pumps blood is the _____.
(f) Blood group A has one type of _____.

2. Mark '✓' for the correct statement and '×' for the incorrect statement on transport in organisms.

(a) *Amoeba* sp. does not have a specific transport system.	
(b) The function of transport system is only to carry useful substances to all parts of the body of an organism.	
(c) In a systemic circulatory system, blood flows from the heart to the lungs and returns to the heart.	
(d) Coagulation of the blood is an effect from the action of receiving a compatible blood group.	

3. Figure 1 shows three types of blood vessels in the human body.

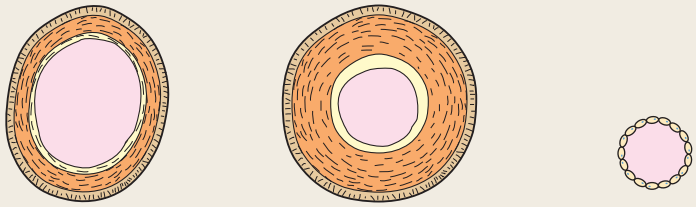


Figure 1

(a) Name the structure in blood vessel P that is not shown in Figure 1.

(b) State the function of blood vessel Q.

(c) Explain the adaptations in the structure of the following blood vessels:
(i) Blood vessel Q
(ii) Blood vessel R

4. (a) State **five** substances that are transported in the human body.

(b) State **three** substances that diffuse through the membrane or wall of plant cells and are transported in plants.

(c) Why do plant cells not need a supply of oxygen from outside during the day?

5. (a) Underline the correct answer.
(i) The ('lub'/'dub') sound is produced by the closure of the valves at the aorta and pulmonary artery.
(ii) The ('lub'/'dub') sound is produced by the closure of the valves between the atria and ventricles.
(iii) The pressure reading of blood flowing out of the heart is known as (diastolic/systolic).
(iv) The pressure reading of blood flowing into and filling the heart is known as (diastolic/systolic).

(b) Between diastolic and systolic pressure readings, which is higher? Explain your answer.

6. (a) Table 1 shows four blood donors from different blood groups.

Table 1

Blood donor	Blood group
Dollah	A
Eric	B
Sita	AB
Roy	O

A road accident victim lost a lot of blood. He is confirmed to have blood from group B.

(i) Which blood donor is suitable to donate blood to the victim?

(ii) Explain the effect to the victim if he receives blood from Sita.

(b) The Red Crescent Society launched a 'Let's Donate Blood' campaign to replenish the blood bank. Three individuals are interested to take part in the campaign. Table 2 shows their age, gender and body mass.

Table 2

Individual	Age (years)	Gender	Body mass (kg)
1	15	Male	62
2	30	Female	70
3	61	Male	66

(i) Based on Table 2, which individual is most suitable to donate blood? Explain your answer.

(ii) What is the special additional condition for blood donors with regard to their suitability to donate blood?

7. Figure 2 shows a cross section of the stem of a plant.

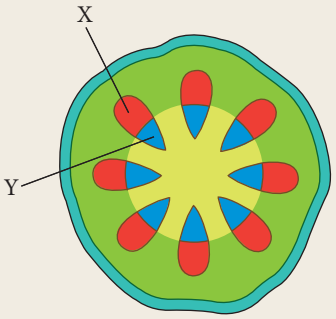


Figure 2

(a) State **one** function of X.

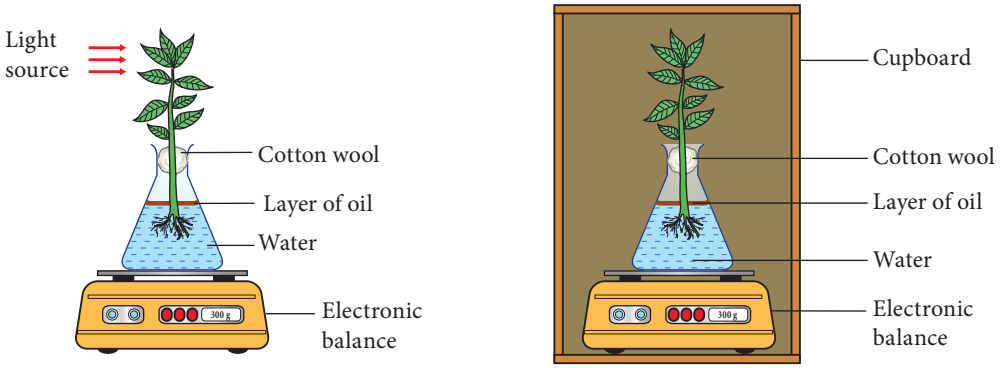
(b) State the structure in the stem of the plant that transports water from the roots to the leaves.

(c) (i) What will happen to the plant if a ring of its bark and X are removed? Explain your answer.

(ii) What will happen to the plant if X and Y are removed?

Focus on HOTS

8. Figure 3 shows the apparatus set-up of an investigation to study the factors that affect the rate of transpiration of a plant and the results after three hours.



Results:

Set	Initial mass (g)	Final mass (g)	Rate of transpiration (g/min)
A	300	246	
B	300	264	

Figure 3

Calculate the rate of transpiration in this investigation.

9. Three students, Badrul, Azizah and Murad carried out a fitness activity to investigate the health of their heart. Table 3 shows the pulse rates for the three of them before and after the fitness activity.

Table 3

Condition	Pulse rate (number of beats per minute)		
	Badrul	Azizah	Murad
Before the activity	63	70	65
Immediately after the activity	130	95	94
15 minutes after the activity	75	71	75

(a) Name the student who is most at risk of having heart disease.
Explain your answer.

(b) Name the student who has the healthiest heart.
Explain your answer.

10. All the members of the Science Club in your school have agreed to carry out a project to plant herbs in school. Herbs that are to be planted will grow well when the rate of transpiration is moderate and the exposure to sunlight is sufficient to carry out photosynthesis. Figure 4 shows three areas:

- area A, inside a dark laboratory
- area B, in a shaded bright area
- area C, in a hot school field under the sun

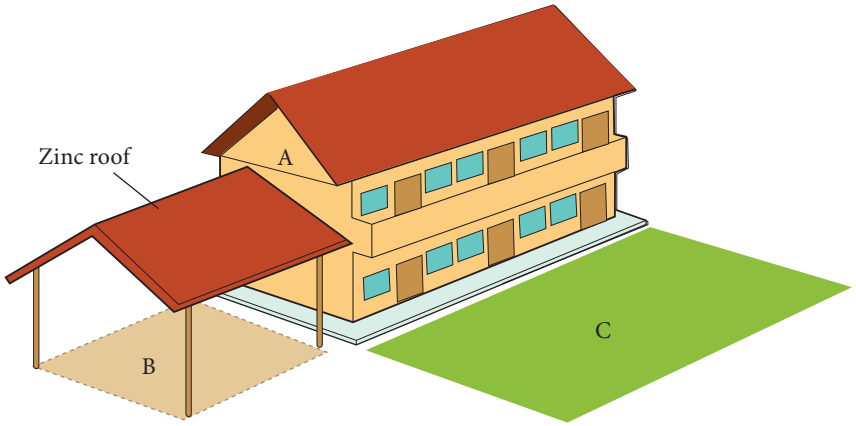


Figure 4

(a) Based on Figure 4, which is the most suitable area for the project site? Explain your answer.

(b) Construct the most suitable model to make this project a success. The model is a glasshouse or greenhouse in which the air humidity and light intensity can be controlled. The construction of the model requires the use of the following materials:

A transparent umbrella

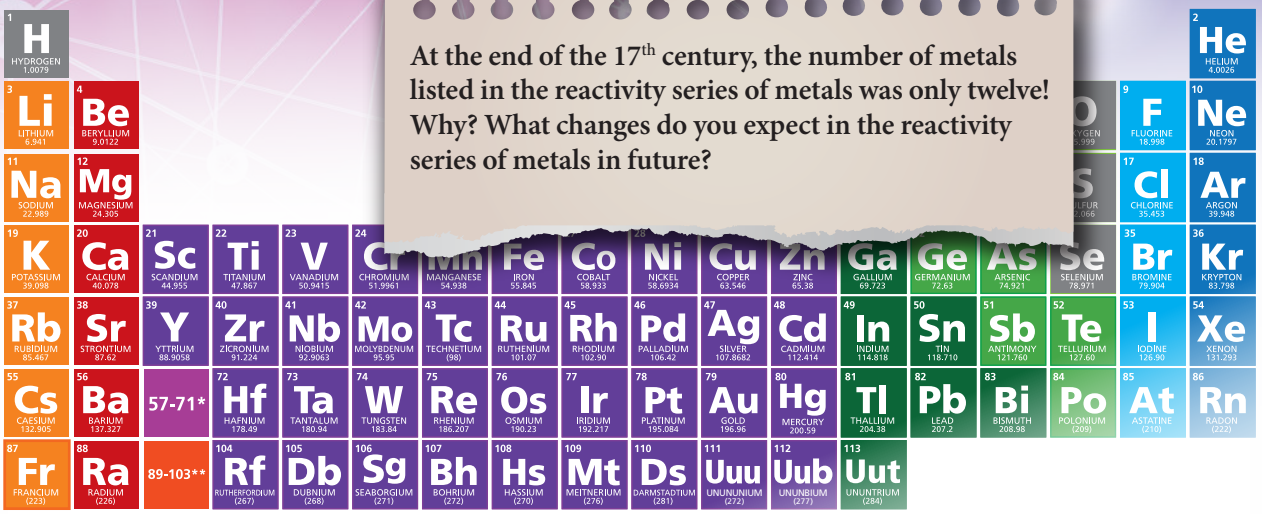
Container and a roll of tissue

Water

THEME 2

Exploration of Elements in Nature

At the end of the 17th century, the number of metals listed in the reactivity series of metals was only twelve! Why? What changes do you expect in the reactivity series of metals in future?



Colourful fireworks display is one of the applications of thermochemistry. Does the chemical reaction of the fireworks display release or absorb heat? What is the use of heat in the fireworks display ?

Chapter 4

Reactivity of Metals

What are minerals?

What are the uses of minerals in daily life?

What is the reactivity series of metals?

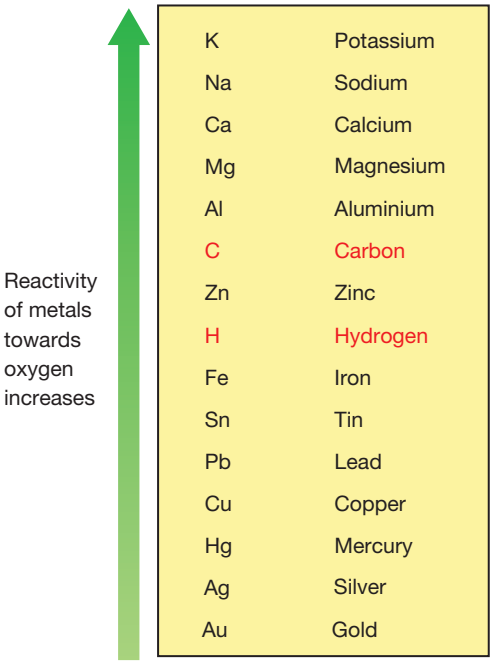
How is the process of tin extraction carried out in Malaysia?

Let's study

- Variety of minerals
- Reactivity series of metals
- Extraction of metals from their ores

Science Gallery

According to existing records, the first metal used by humans is gold. Gold was discovered in its mineral element form in a cave in Spain in 40 000 BC. Due to the importance of various metals used in daily life, scientists have constructed a reactivity series of metals to understand the order of metals according to their reactivity towards oxygen as shown in the figure below.



Based on this reactivity series of metals, we can determine the properties of metals such as the reactions of metals with oxygen, acid or water. We can also understand how the extraction of a metal from its ore is carried out. The mining issues of metals can also be highlighted to increase awareness on the importance of sustainable management and development of the environment.

Keywords

- Mineral
- Natural compound
- Element
- Earth's crust
- Reactivity series of metals
- Extraction of metal
- Mining issues
- Physical characteristic
- Chemical characteristic
- Blast furnace
- Slag

4.1 Variety of Minerals

Look at Photograph 4.1. This photograph shows various types of ores found in the Earth's crust. Each type of ore is different in terms of colour, structure, shape and texture because the ores contain different minerals.

Photograph 4.1 *Various types of ores found in the Earth's crust*

Try to guess, how many minerals exist on this Earth! Then, compare your guess with the number of minerals listed in the following website:

http://links.and17.com/BT_Science_124 and click "Recent new minerals"

Is your guess close to the number of minerals listed by the International Mineralogical Association, IMA?

SCIENCE INFO

Mineralogy or the study of minerals is an active field of science because the number and properties of minerals keep increasing.

My World of Science

Soon, all cars using petrol or diesel will be replaced with electric cars. This can be realised with the discovery of two minerals which can produce long lasting batteries. These two minerals are **lithium** and **cobalt**.

Various Forms of Minerals in the Earth's Crust

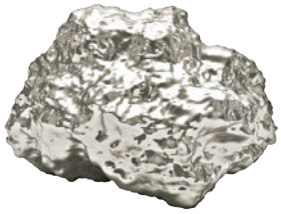
Minerals are solid elements or compounds present naturally with definite crystalline structures and chemical compositions. Various minerals are contained in rocks found in the Earth's crust.

Minerals that can be found in the Earth's crust are made up of the following:

A **Elements** such as gold, diamond and silver


Gold

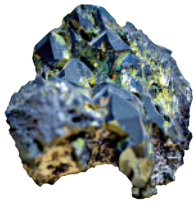

Diamond


Silver

Photograph 4.2 *Gold, diamond and silver*

B **Compounds** such as bauxite, hematite, galena and cassiterite


Bauxite


Hematite


Galena


Cassiterite

Photograph 4.3 *Bauxite, hematite, galena and cassiterite*

The common and scientific names of natural compounds and the combination of their elements are shown in Table 4.1.

Table 4.1 *Natural compounds and their elements*

Common name	Scientific name	Combination of elements
Hematite	Ferrum(III) oxide	Iron, oxygen
Cassiterite	Stanum(IV) oxide	Tin, oxygen
Quartz	Silicon dioxide	Silicon, oxygen
Bauxite (aluminium ore)	Aluminium oxide	Aluminium, oxygen
Galena (lead ore)	Plumbum(II) sulphide	Lead, sulphur
Pyrite	Ferrum(II) sulphide	Iron, sulphur
Calcite	Calcium carbonate	Calcium, carbon, oxygen

Natural Compounds are the Combination of Several Elements

Photograph 4.4 *Limestone quarry*

BRAIN TEASER

The compound shown in this photograph has a common name, that is bauxite or aluminium ore. Its scientific name is aluminium oxide. Who normally uses the common and scientific names for this compound?

My World of Science

Calcium silicate is a natural compound that can be used as an additive in human food.

Limestone is a mineral that has many uses in daily life such as in the construction of roads and buildings, and for table tops. Is limestone a natural compound made up of a combination of several elements? Let us investigate this by carrying out Activity 4.1. Then, carry out Activity 4.2 to create a multimedia presentation on examples of properties of natural minerals and their uses in daily life.

Activity 4.1

Inquiry-based activity

A natural compound is a combination of several elements

Aim: To show that a natural compound is a combination of several elements

Materials

Calcium carbonate powder, clear limewater and dilute hydrochloric acid

Apparatus

Boiling tube labelled P, boiling tube labelled Q, spatula, test tube, Bunsen burner, rubber stopper with delivery tube, filter funnel and retort stand with clamp

Instructions

1. Put a spatula of calcium carbonate into boiling tubes P and Q.
2. Pour 10 ml of dilute hydrochloric acid into boiling tube P.
3. Set up the apparatus to test the property of the gas released by passing it through limewater as shown in Figure 4.1.

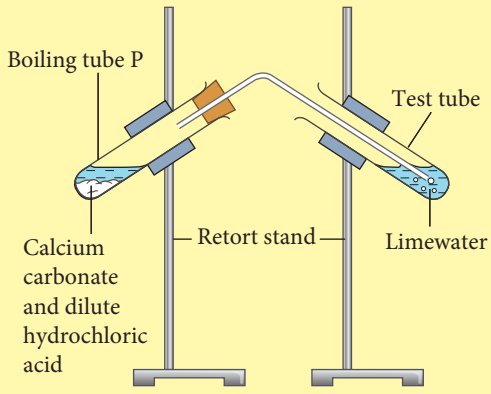


Figure 4.1 *Apparatus set-up to test gas released*

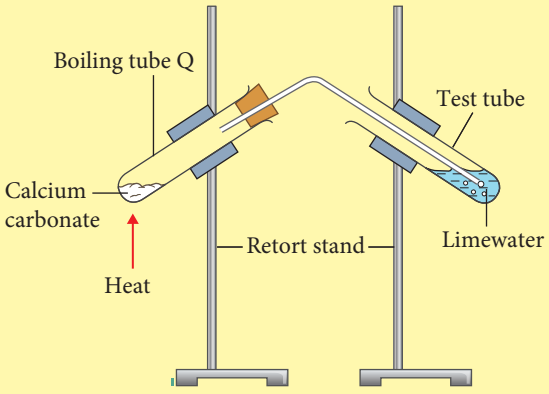


Figure 4.2 *Apparatus set-up to heat calcium carbonate*

4. Observe and record the changes in the limewater, if any, in a table.
5. Set up the apparatus as shown in Figure 4.2. Heat the calcium carbonate in boiling tube Q strongly until gas is released.
6. Observe and record the changes in the limewater, if any, in the table.

Safety Precaution

Do not point the mouth of the boiling tube that is being heated at yourself or others.

Observation

Action on calcium carbonate	Condition of limewater	
	before gas passes through	after gas passes through
Calcium carbonate mixed with dilute hydrochloric acid		
Calcium carbonate heated strongly		

Questions

1. Name the gas that is tested using limewater.
2. How is the test for the gas carried out? Explain.
3. Name the gas released when calcium carbonate:
   (a) reacts with dilute hydrochloric acid
   (b) is heated strongly
4. Complete the word equation for each reaction in question 3.
   (a) Calcium carbonate + hydrochloric acid ⟶ ____ + ____ + ____
   (b) Calcium carbonate $\xrightarrow{\text{heated}}$ ____ + ____
5. Name **three** elements that are combined in calcium carbonate.

SCIENCE INFO

Calcium carbonate is a natural compound that exists in various forms, colours and textures such as calcite, limestone, marble, chalk, coral reefs and shells of marine animals.


Limestone


Marble


Chalk


Calcite

Activity 4.2

21st Century Skills
- Technology-based activity

To create a multimedia presentation on examples of properties of natural minerals and their uses in daily life

Instructions

1. Work in groups.
2. Gather and discuss information on examples of properties of natural minerals and their uses in daily life. Then, fill in the information in the table as follows:

Natural mineral	Physical characteristics	Chemical characteristics	Uses in daily life

3. Present the findings of your group's discussion in class.

Formative Practice 4.1

1. What are minerals?
2. Name **one** example of a mineral in the form of:
   (a) element
   (b) natural compound
3. State **two** examples of minerals, their chemical or physical characteristics and their uses in daily life.

4.2 Reactivity Series of Metals

Compare and contrast the reactions of metals with oxygen in the air as shown in Photograph 4.5.

(a) Magnesium burning in air

(b) Iron exposed to air

Photograph 4.5 *Reactions between metals and oxygen*

Is the vigour of the reactions of different metals such as magnesium and iron with oxygen the same or different?

In a **vigorous reaction** between a more reactive metal such as magnesium and oxygen, a bright flame is observed as shown in Photograph 4.5 (a).

In a **less vigorous reaction** between a less reactive metal such as iron and oxygen, only a glow or slow change in colour is observed as shown in Photograph 4.5 (b).

Constructing Reactivity Series of Metals

Different metals have different reactivities towards oxygen. Metals that are **more reactive** towards oxygen react **more vigorously** with oxygen. **Reactivity series of metals** is a list of metals arranged in order of their reactivity towards oxygen as shown in Figure 4.3.

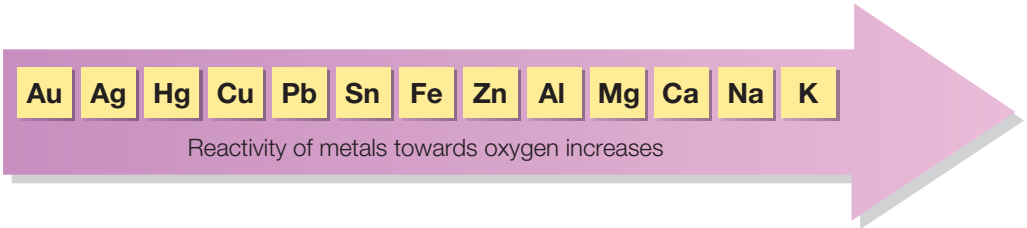


Figure 4.3 *Reactivity series of metals towards oxygen*

Let us carry out Activity 4.3 to compare and contrast the reactivity of several different metals towards oxygen.

Activity 4.3

Inquiry-based activity

Reactivity of several metals towards oxygen

Aim: To study the reaction of heating metals such as magnesium, aluminium, zinc, iron and lead with oxygen

Materials
Potassium manganate(VII) crystals, magnesium powder, aluminium powder, zinc powder, iron powder, lead powder and glass wool

Apparatus
Boiling tube, retort stand with clamp, porcelain plate, spatula and Bunsen burner

Instructions

Safety Precautions

- Glass wool fibres are very dangerous. Use forceps to handle them. Make sure you wear safety glasses and cover your mouth and nose when handling glass wool. Do not allow glass wool to enter your body. Wash your hands after handling glass wool.
- Potassium manganate(VII) crystals and metal powder can explode if mixed during heating. Make sure both of these materials are always kept apart.
- Make sure you wear safety glasses and do not look directly at the flame caused by heating metal powder with oxygen.
- Use only a small amount of metal powder.

1. Put a spatula of potassium manganate(VII) crystals into a dry boiling tube. Use some glass wool to prevent it from coming out as shown in Figure 4.4.

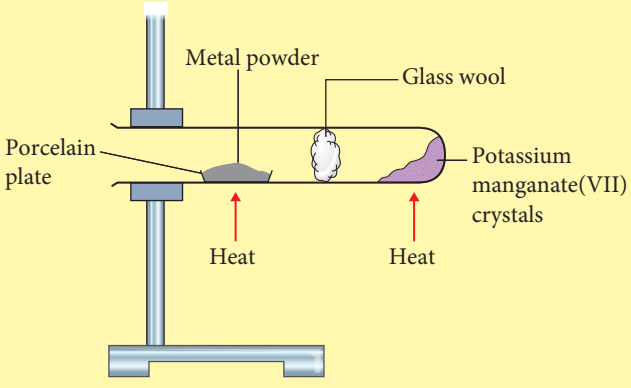


Figure 4.4

VIDEO

Reaction between metal and oxygen

SCAN PAGE

2. Clamp the boiling tube horizontally on to the retort stand as shown in Figure 4.4.
3. Put a spatula of magnesium powder on a small porcelain plate. Put the porcelain plate into the boiling tube as shown in Figure 4.4.

4. Heat the magnesium powder strongly. Then, heat the potassium manganate(VII) crystals.
5. Observe the vigour of the reaction.
6. Record your observations in a table. Take a video recording and/or photographs of the reaction.
7. Repeat steps 1 to 6 using the powdered form of the metals listed in the following table:

Observations

Metal	Observation				
	Metal burns very quickly and brightly	Metal burns quickly and brightly	Metal burns slowly	Metal glows brightly	Metal glows dimly
Magnesium					
Aluminium					
Zinc					
Iron					
Lead					

Questions

1. Complete the word equation for the reaction of each metal with oxygen.
   (a) Magnesium + oxygen → ____
   (b) Aluminium + oxygen → ____
   (c) Zinc + oxygen → ____
   (d) Iron + oxygen → ____
   (e) Lead + oxygen → ____
2. State the relationship between the vigour of the reactions and the reactivity of the metals towards oxygen.
3. Based on the results from this activity, complete the following sequence of metals according to their decreasing reactivity towards oxygen.
   ____ → ____ → ____ → ____ → ____

Position of Carbon in the Reactivity Series of Metals

The position of a metal in the reactivity series of metals depends on the reactivity of the metal when reacting with oxygen. Can the position of a non-metal such as **carbon** and **hydrogen** in the reactivity series of metals be determined according to the reactivity of carbon and hydrogen with oxygen?

Let us carry out Activity 4.4 to determine the position of carbon in the reactivity series of metals.

BRAIN TEASER

Write the word equation for the reaction between:
- carbon and oxygen
- hydrogen and oxygen

Activity 4.4

Inquiry-based activity

Determining the position of carbon in the reactivity series of metals

Aim: To determine the position of carbon in the reactivity series of metals by heating the following substances:
(a) Zinc oxide with carbon
(b) Aluminium oxide with carbon
(c) Lead(II) oxide with carbon

Materials

Carbon powder, zinc oxide, aluminium oxide and lead(II) oxide

Apparatus

Crucible, spatula, Bunsen burner, pipeclay triangle and tripod stand

Instructions

A Teacher's demonstration

Observe carefully when the teacher conducts a demonstration of steps 1 to 4 as follows:

1. Put a spatula of carbon powder and a spatula of zinc oxide powder into a dry crucible. Mix the powders evenly in the crucible.
2. Place the crucible on a pipeclay triangle on a tripod stand as shown in Figure 4.5.

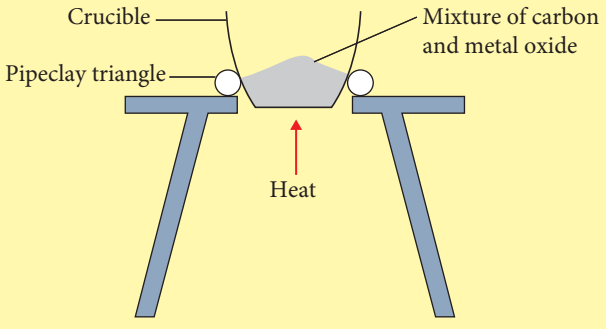


Figure 4.5

VIDEO

Position of carbon in the reactivity series of metals

SCAN PAGE

3. Heat the mixture in the crucible strongly.
4. Observe the changes that happen to the mixture. Record your observation in a table.

B Student's activity

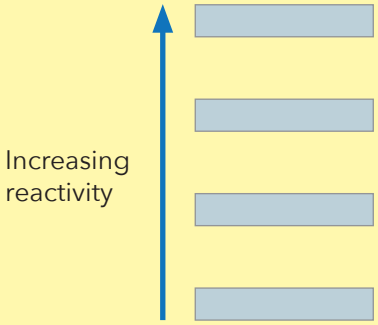
Repeat steps 1 to 4 replacing zinc oxide with aluminium oxide and lead(II) oxide.

Observations

Mixture	Observation	Reactivity of carbon
Zinc oxide and carbon		
Aluminium oxide and carbon		
Lead(II) oxide and carbon		

Questions

1. Complete the word equation for each reaction of metal oxide with carbon, if any.
   (a) Zinc oxide + carbon → _____
   (b) Aluminium oxide + carbon → _____
   (c) Lead(II) oxide + carbon → _____
2. Name the metal that is less reactive than carbon. Explain your answer.
3. Based on the results of this activity, complete the following sequence to show the arrangement of elements according to their increasing reactivity towards oxygen:



4. Give **one** application of the position of carbon in the reactivity series of metals for industrial use. Explain your answer.
5. Underline the correct answer for the following statements:
   (a) If carbon can remove oxygen from a metal oxide, it means carbon is (more/less) reactive than the metal.
   (b) If carbon cannot remove oxygen from a metal oxide, it means carbon is (more/less) reactive than the metal.

Position of Hydrogen in the Reactivity Series of Metals

The position of **hydrogen** in the reactivity series of metals can be determined through interpretation of the data based on Figure 4.6 and Table 4.2.

Figure 4.6 shows the apparatus set-up used to determine the position of hydrogen in the reactivity series of metals.

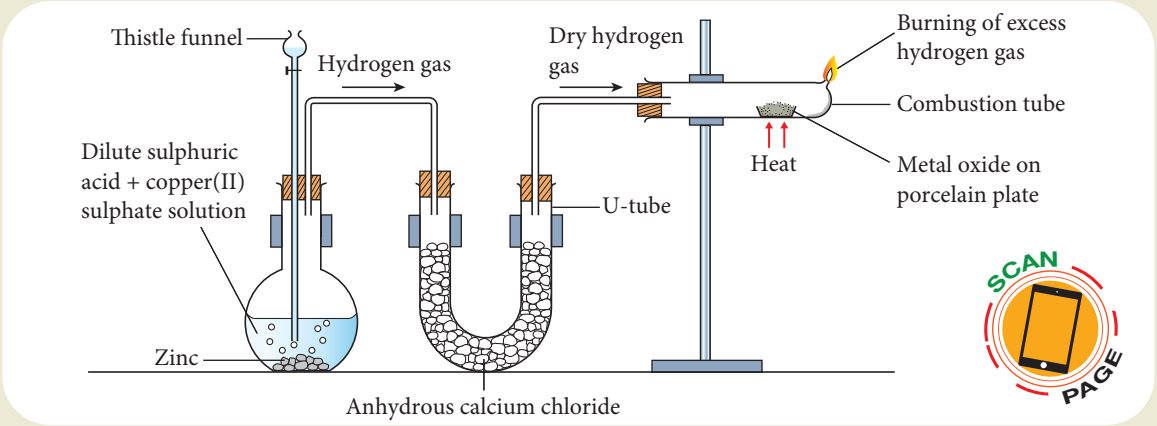


Figure 4.6 *Apparatus set-up to determine the position of hydrogen in the reactivity series of metals*

Table 4.2 shows the results from activities carried out by chemists to determine the position of hydrogen in the reactivity series of metals.

Table 4.2 *The results from activities to determine the position of hydrogen in the reactivity series of metals*

Mixture	Observation	Inference
Hydrogen and aluminium oxide	Aluminium oxide does not glow. Aluminium oxide is white in colour.	Hydrogen does not reduce aluminium oxide.
Hydrogen and zinc oxide	Zinc oxide does not glow. Zinc oxide turns yellow when hot and white on cooling.	Hydrogen does not reduce zinc oxide.
Hydrogen and iron(III) oxide	Iron(III) oxide burns brightly. Reddish brown powder turns shiny grey.	Iron is produced. Hydrogen reduces iron(III) oxide to iron.
Hydrogen and lead(II) oxide	Lead(II) oxide burns brightly. Yellow powder turns shiny grey.	Lead is produced. Hydrogen reduces lead(II) oxide to lead.
Hydrogen and copper(II) oxide	Copper(II) oxide burns very brightly. Black powder turns brown.	Copper is produced. Hydrogen reduces copper(II) oxide to copper.

Based on the results given in Table 4.2,

(a) Underline the correct answer about the reactivity of hydrogen.

(i) Hydrogen is (less/more) reactive than aluminium.

(ii) Hydrogen is (less/more) reactive than zinc.

(iii) Hydrogen is (less/more) reactive than iron.
(iv) Hydrogen is (less/more) reactive than copper.
(iv) Hydrogen is (less/more) reactive than lead.

(b) State the metals which are more reactive than hydrogen.

(c) State the metals which are less reactive than hydrogen.

Conclusion on the Position of Carbon and Hydrogen in the Reactivity Series of Metals

In Activity 4.3, you have arranged metals according to their reactivity towards oxygen. The arrangement you made is part of the reactivity series of metals. In Activity 4.4 and data interpretation in Table 4.2, you determined the position of **carbon** and **hydrogen** in the reactivity series of metals. Even though the **reactivity series of metals** is an arrangement of metals according to their reactivity towards oxygen, the position of non-metals such as carbon and hydrogen is also shown in the reactivity series of metals (Figure 4.7).

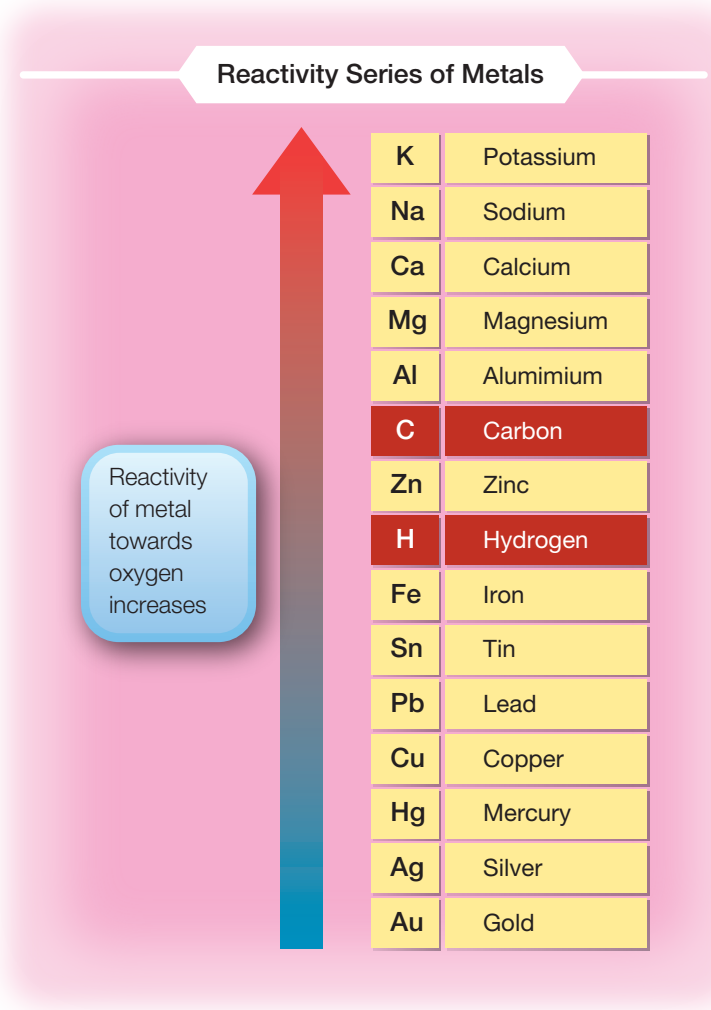


Figure 4.7 *Reactivity series of metals*

My World of Science

Lithium batteries will explode when heated. Due to this, passengers are not allowed to keep lithium batteries in their luggage placed in aircrafts.

SCIENCE INFO

Coal is one of the minerals found in Malaysia. About 80% of the coal is found in Sarawak, 19% in Sabah dan 1% in Peninsular Malaysia. The largest coal reserve is located in Merit Pila, Sarawak.

SCAN PAGE

Formative Practice 4.2

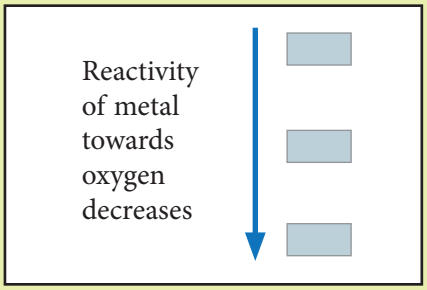
1. What is reactivity series of metals?
2. Figure 1 shows the reaction between metal X and oxygen in the air.

Figure 1

(a) Is metal X reactive towards oxygen? Explain your answer.

(b) Metal Y glows brightly when it reacts with oxygen. Is metal Y more or less reactive than metal X?

(c) If metal Z does not react with oxygen, arrange metals X, Y and Z in the reactivity series of metals based on their reactions.



3. Underline the correct answer.

(a) Metals are arranged in the reactivity series of metals based on the reaction of the metal towards (carbon/oxygen).

(b) The most reactive metal in the reactivity series of metals is (calcium/potassium).

(c) The reactivity series of metals is applied in the (melting/extraction) of metals from their ores.

4. (a) State the most reactive metal in the reactivity series of metals.

(b) State the least reactive metal in the reactivity series of metals.

5. (a) State **two** non-metal elements that are included in the reactivity series of metals.

(b) Why are these two non-metal elements included in the reactivity series of metals?

4.3 Extraction of Metals from their Ores

Extraction of Metals

Extraction of metals is the process to obtain metals from their ores. Observe the relationship between the position of carbon and hydrogen in the reactivity series of metals and the method used to extract metals from their ores as shown in Figure 4.8.

My Malaysia

The extraction of iron from its ore by a local company in Malaysia.
http://links.and17.com/BT_Science_137_2

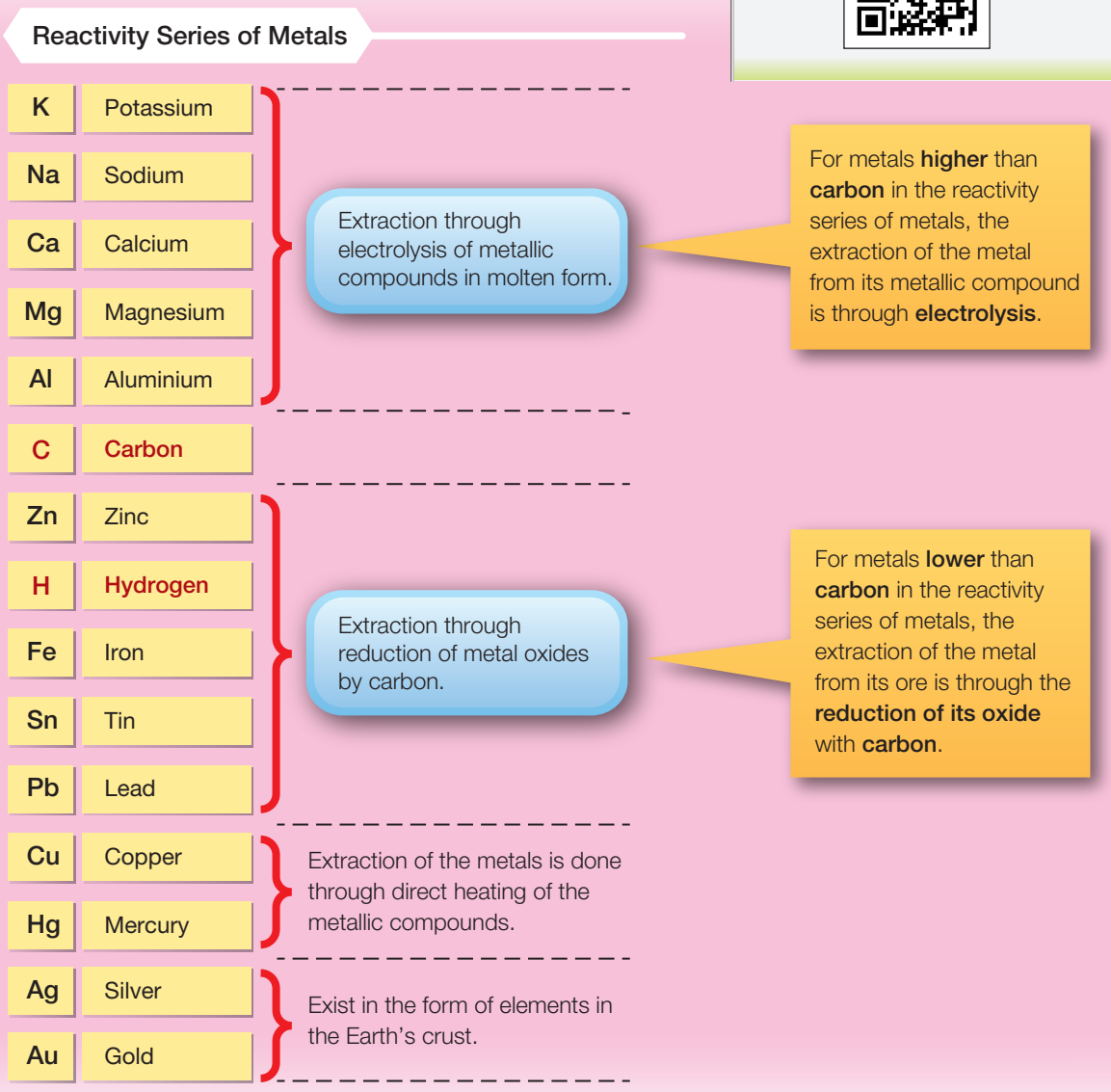


Figure 4.8 *Reactivity series of metals and methods of extracting metals from their ores*

Process of Iron Extraction

The extraction of iron from its ore is carried out in a **blast furnace** as shown in Figure 4.9.

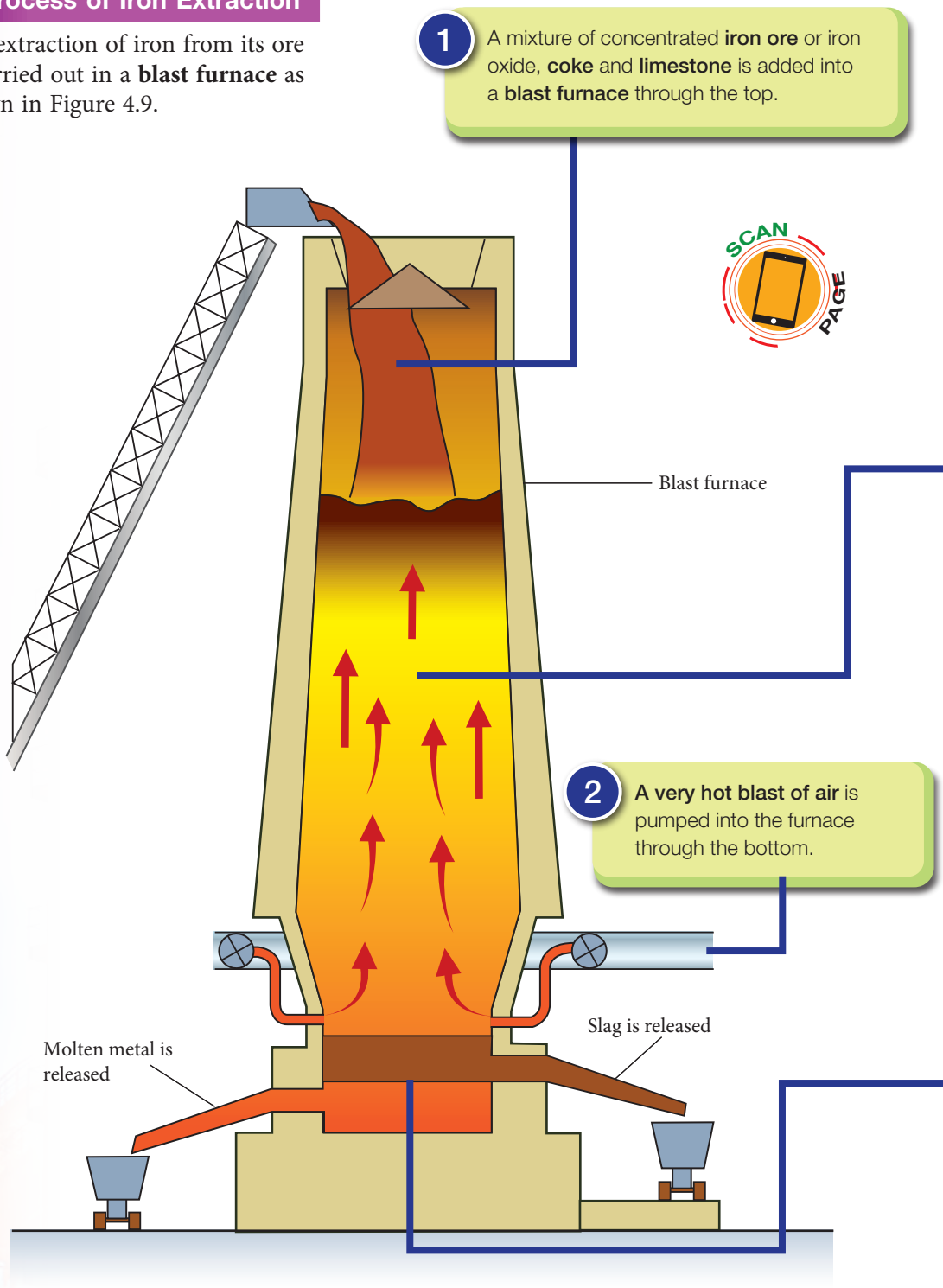


Figure 4.9 *Extraction of iron in a blast furnace*

3 Reactions that occur in the furnace at high temperature.

Production of iron

- Coke or carbon reacts with oxygen in the hot air to produce carbon dioxide and heat

Carbon + oxygen → carbon dioxide

- Carbon dioxide that is produced reacts with the rest of the hot coke to form carbon monoxide which is a strong reducing agent.

Carbon dioxide + carbon → carbon monoxide

- Carbon monoxide and carbon reduces iron oxide into iron.

Iron(III) oxide + carbon → iron + carbon dioxide
Iron(III) oxide + carbon monoxide → iron + carbon dioxide
Iron(II) oxide + carbon → iron + carbon dioxide
Iron(II) oxide + carbon monoxide → iron + carbon dioxide

Production of slag

- Limestone or calcium carbonate decomposes to form calcium oxide and carbon dioxide.

Calcium carbonate → calcium oxide + carbon dioxide

- Calcium oxide reacts with impurities such as sand or silicon dioxide in iron ore to form slag or calcium silicate.

Calcium oxide + silicon dioxide → calcium silicate

4 At high temperature in the furnace,

- **iron** that is produced will melt. This molten iron flows to the bottom part of the furnace. From time to time, the molten iron is tapped off and channelled into moulds and allowed to cool and freeze. The molten iron that has solidified is known as **cast iron**.
- **slag** that is produced will melt. This molten slag also flows to the bottom part of the furnace. Since molten slag is less dense than molten iron, the slag will float on top of the molten iron. From time to time, the molten slag is tapped off and used to make the base of buildings and roads.

Activity 4.5

21st Century Skills
- ICS
- Technology-based activity

To create a multimedia presentation explaining how metal extraction is carried out based on the processes of iron and tin extractions in Malaysia

Instructions

1. Work in groups.
2. Gather materials from various media on how metals are extracted in the mining sector in Malaysia.
3. Examples of websites are as follows:

- Source of minerals in Malaysia *http://links.and117.com/BT_Science_140*
- Process of tin extraction in Malaysia *http://links.and117.com/BT_Science_140_2*

4. Discuss the processes of iron and tin extractions from their ores.
5. Present the findings of your group's discussion using multimedia presentation such as MS PowerPoint.

Mining Issues in Malaysia

Mining issues in Malaysia and their impact on life in the local or global context are shown in Figure 4.10.

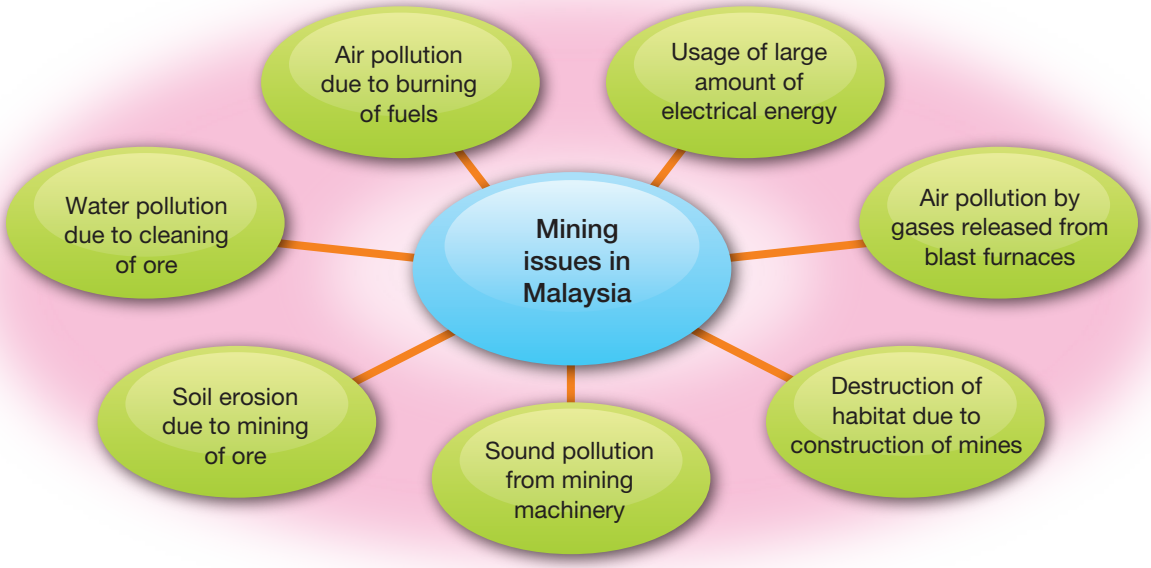


Figure 4.10 *Mining issues in Malaysia and their impact*

Let us carry out Activity 4.6 to study problems of mining issues in Malaysia shown in Figure 4.10.

Activity 4.6

21st Century Skills
- ICS
- Discussion/ project-based activity

To solve problems of mining issues in Malaysia

Instructions

1. Work in groups.
2. Gather information on issues of poorly planned mining activities in Malaysia and their impact on life in the local or global context.
3. Examples of websites are as follows:

- The Ministry of Human Resources *http://links.and117.com/BT_Science_141_1*
- Impact of bauxite mining in Kuantan, Pahang *http://links.and117.com/BT_Science_141_2*

4. Debate on the information gathered.
5. Generate ideas to solve problems of the adverse effects from mining activities that have been poorly planned to life on Earth.
6. Prepare posters for gallery walk on efforts to conserve mining areas towards sustainable development.
7. Display three of the best posters on the science bulletin board.

Formative Practice 4.3

1. State the extraction method of the following metals from their ore or metal oxides:
(a) Aluminium oxide
(b) Iron ore

2. Figure 1 shows a blast furnace used to extract iron.
(a) Name **one** example of a metal other than iron that is extracted using the blast furnace.
(b) Name the substance that is added into the blast furnace through the parts labelled:
(i) P (ii) Q
(c) Name the substance that is tapped off from the blast furnace through the parts labelled:
(i) R (ii) S

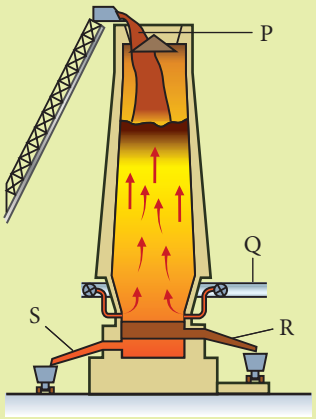
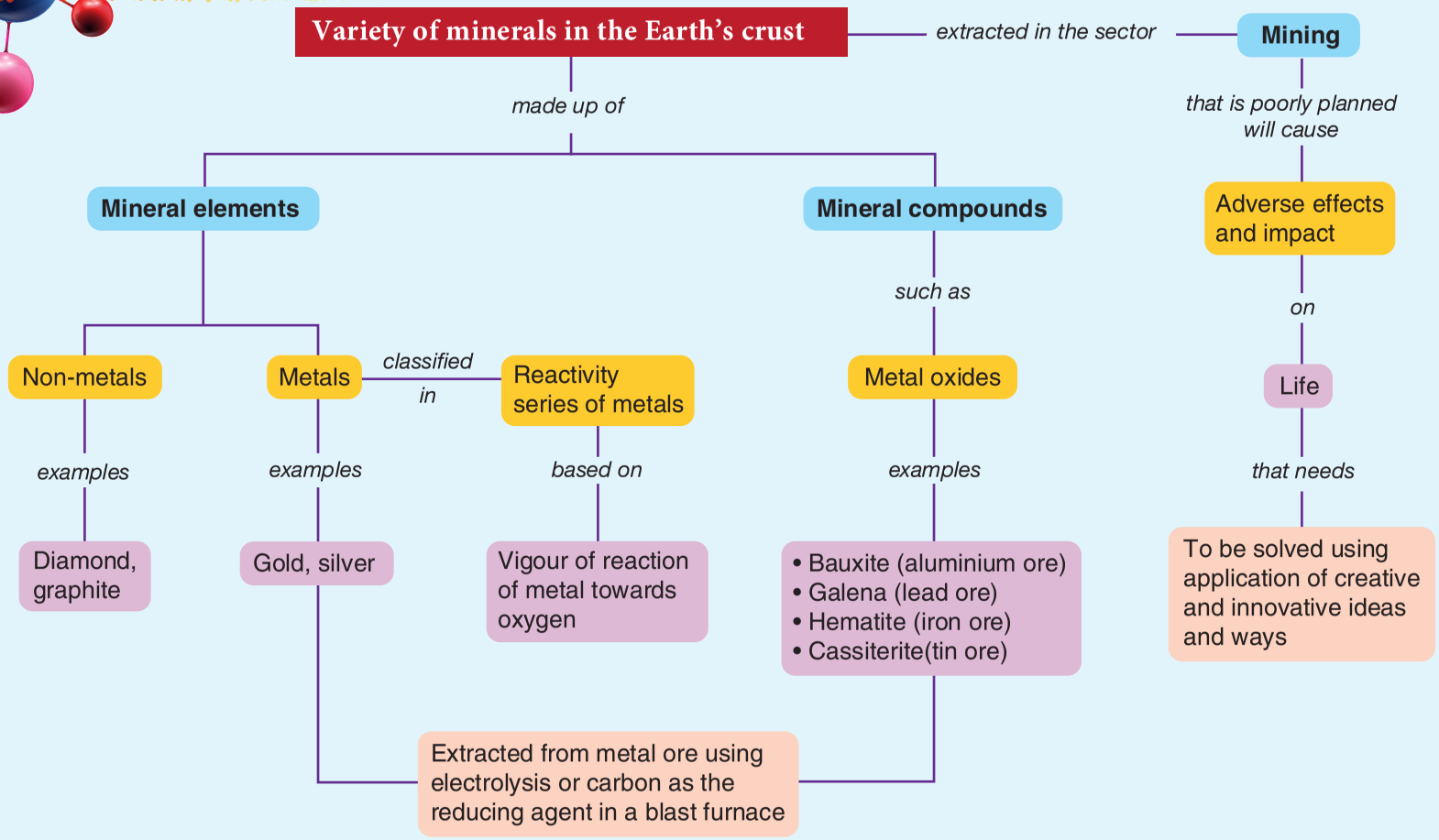


Figure 1

3. State **one** adverse effect from unplanned mining activities and ways to solve it in the following contexts:
(a) Local context
(b) Global context

Summary


Variety of minerals in the Earth's crust
extracted in the sector
Mining
made up of
that is poorly planned will cause
Adverse effects and impact
on
Life
that needs
To be solved using application of creative and innovative ideas and ways
Mineral elements
Mineral compounds
such as
Non-metals
Metals
classified in
Reactivity series of metals
Metal oxides
examples
examples
based on
examples
Diamond, graphite
Gold, silver
Vigour of reaction of metal towards oxygen
• Bauxite (aluminium ore)
• Galena (lead ore)
• Hematite (iron ore)
• Cassiterite(tin ore)
Extracted from metal ore using electrolysis or carbon as the reducing agent in a blast furnace

Self-reflection

After studying this chapter, you are able to:

4.1 Variety of Minerals

- ☐ Explain with examples minerals that are found in the Earth's crust.
- ☐ Identify elements found in natural compounds.
- ☐ Explain with examples the characteristics of natural minerals and its uses in daily life.

4.2 Reactivity Series of Metals

- ☐ Construct a reactivity series of metals based on its reactivity with oxygen and write the word equation for the reactions.
- ☐ Determine the position of carbon and hydrogen in the reactivity series of metals.

4.3 Extraction of Metals from their Ores

- ☐ Communicate about the extraction of metals from its ore by illustrations.
- ☐ Generate ideas on how to solve problems from unplanned mining activities to life on Earth.

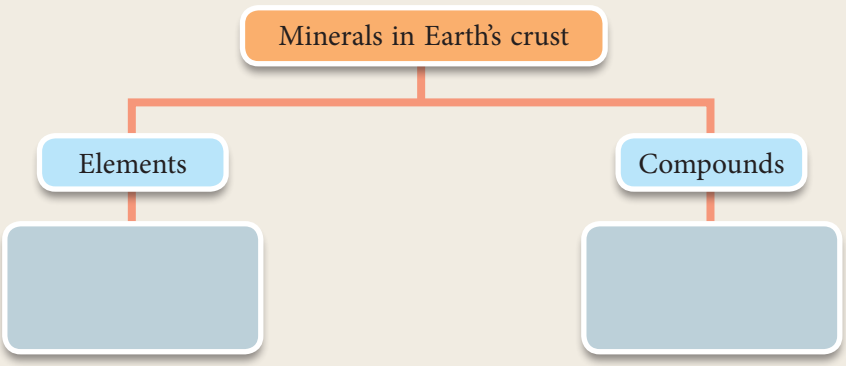
Summative Practice 4

Answer the following questions:

1. The following are some of the minerals found in the Earth's crust.

Iron	Quartz	Silver	Bauxite	Potassium
Galena	Tin	Hematite	Limestone	Diamond

(a) Classify the above minerals into two groups, namely elements and compounds.



(b) Give **one** example of metal ore and name the elements combined in the metal ore.

2. Figure 1 shows tin ore.

Figure 1

(a) What is the scientific name of tin ore?
(b) State the substance used to extract tin from tin ore.
(c) Write the word equation for the reaction between tin and oxygen.

3. Mark '✓' for the correct statement.

(a) The number of minerals in the Earth's crust is the same as the number of elements. ( )
(b) Aluminium ore is a mineral compound in the Earth's crust. ( )
(c) Calcium oxide that is used to reduce the acidity of soil is basic. ( )
(d) Carbon is used to form metal ores. ( )

4. (a) Name the substance that reacts with metals and is used to determine the position of the metals in the reactivity series of metals.
(b) Potassium and sodium are kept in dark reagent bottles filled with paraffin oil. Explain why.

5. Figure 2 shows the apparatus set-up of an activity to test the reaction of a metal towards gas X.

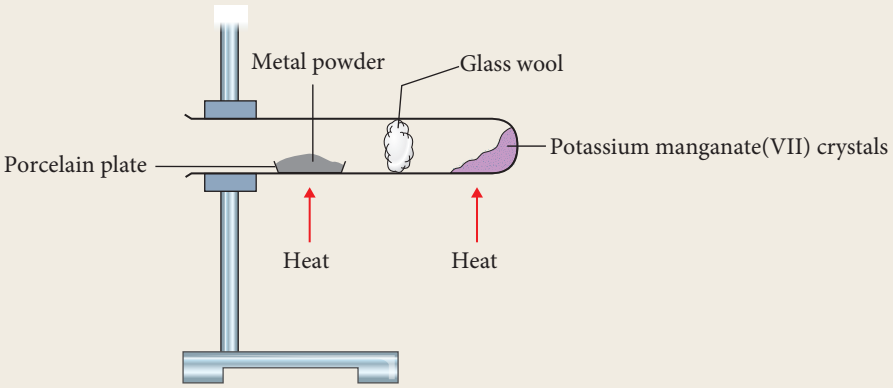


Figure 2

(a) Name gas X.
(b) What is the function of potassium manganate(VII) in this activity?
(c) Explain the steps of the correct heating procedure in this activity.
(d) State the aim of this activity.

6. How can the position of carbon in the reactivity series of metals determine the method of extraction of metals from their ores or metallic compounds?

Focus on HOTS

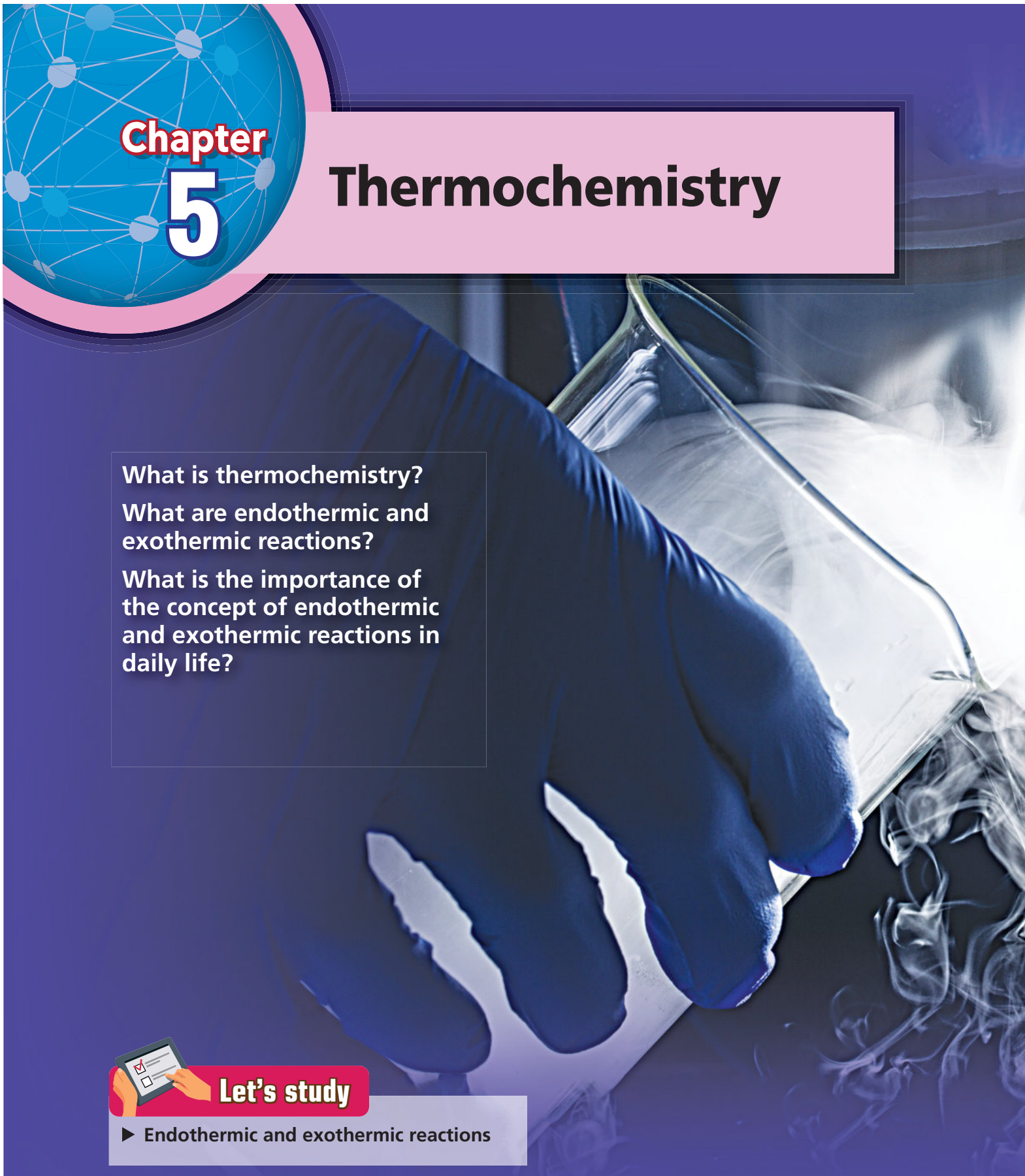
7. The construction of 3D (three dimensional) models are normally used in various fields. You are required to make a 3D model of a blast furnace using the following materials:

- Drinking straw
- Empty mineral water bottle
- Water
- Cooking oil
- Iron powder
- Coke
- Limestone powder
- Transparent plastic bag
- Motor
- Blade of fan
- Paper clips

Sketch your 3D model and explain.

Chapter 5

Thermochemistry



What is thermochemistry?

What are endothermic and exothermic reactions?

What is the importance of the concept of endothermic and exothermic reactions in daily life?

Let's study

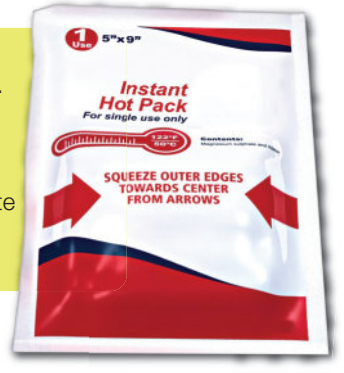
▶ Endothermic and exothermic reactions

Science Gallery

Every chemical reaction is followed by a change in the form of energy. When chemical reactions occur, chemical energy stored in the reactants is converted to heat energy and released into the surroundings.

Thermochemistry is the study of heat changes when chemical reactions occur. There are many applications of thermochemistry in our daily life which include instant hot packs and instant cold packs as shown in the photographs below.

Instant hot packs are used to release heat into the surroundings. The heat released by instant hot packs can relieve muscle cramp and increase the size of lumen in the blood capillaries so that the rate of blood circulation through these capillaries is increased.

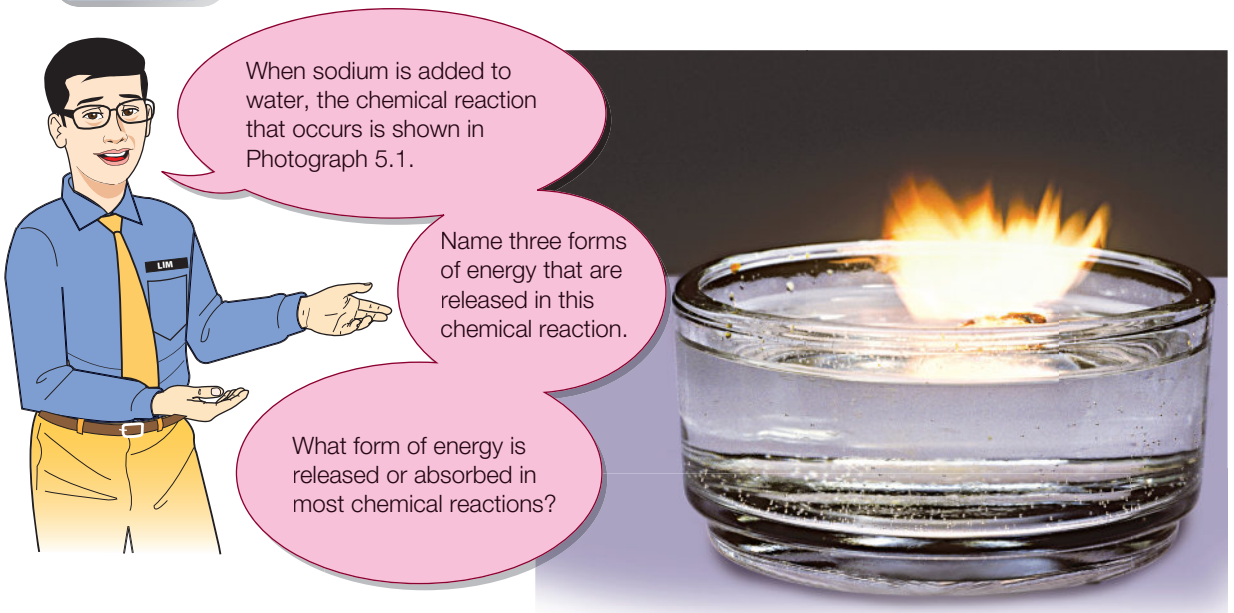


Instant cold packs are used to absorb heat from the surroundings. The heat absorbed by instant cold packs can reduce the swelling of wounds, get rid of heat from inflamed tissues or body organs and reduce the size of lumen in the blood capillaries so that the rate of blood circulation through these capillaries is reduced and this helps to stop bleeding.

Keywords

- Thermochemistry
- Endothermic reaction
- Exothermic reaction
- Thermal equilibrium
- Heat
- Temperature

5.1 Endothermic and Exothermic Reactions

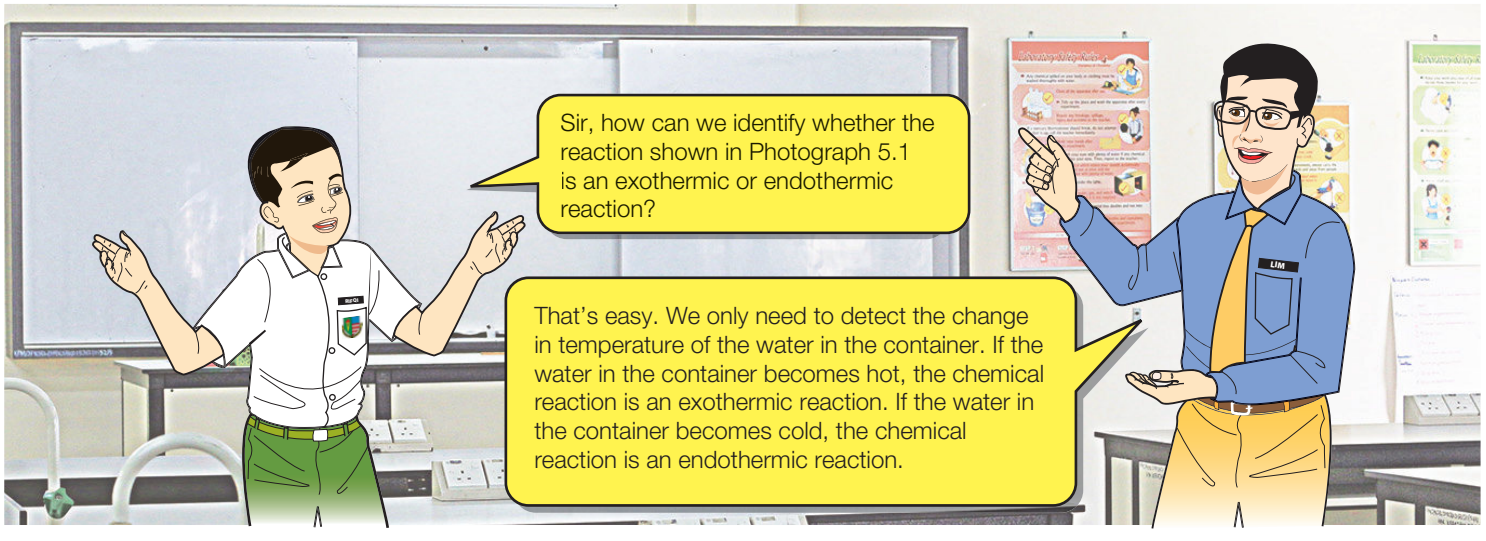


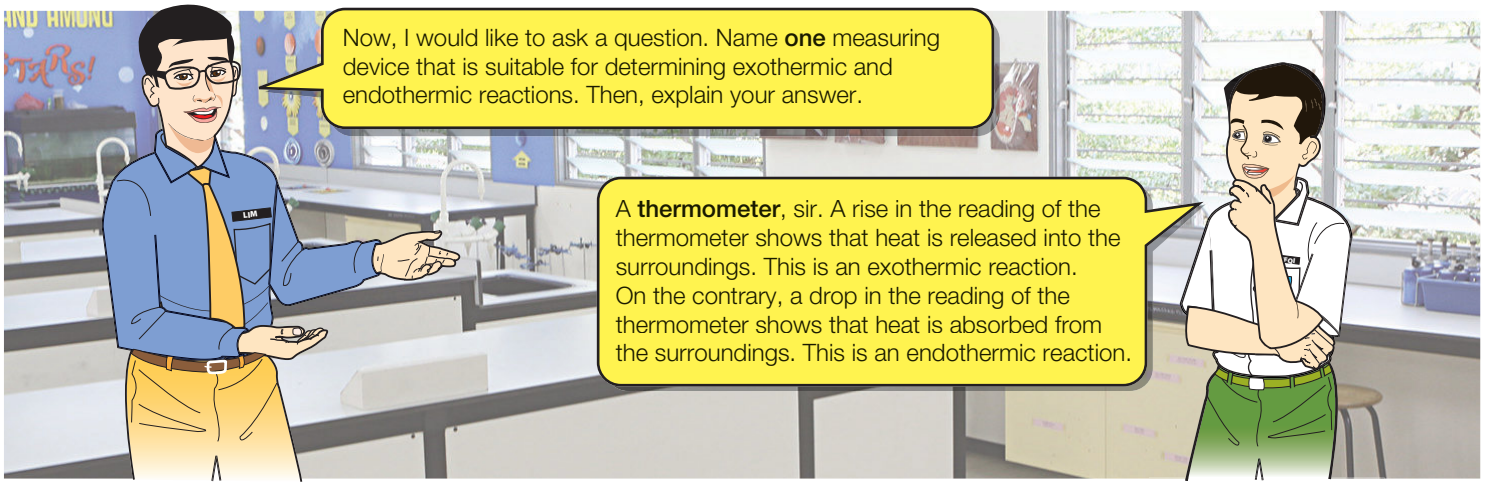
Photograph 5.1 *Reaction between sodium and water*

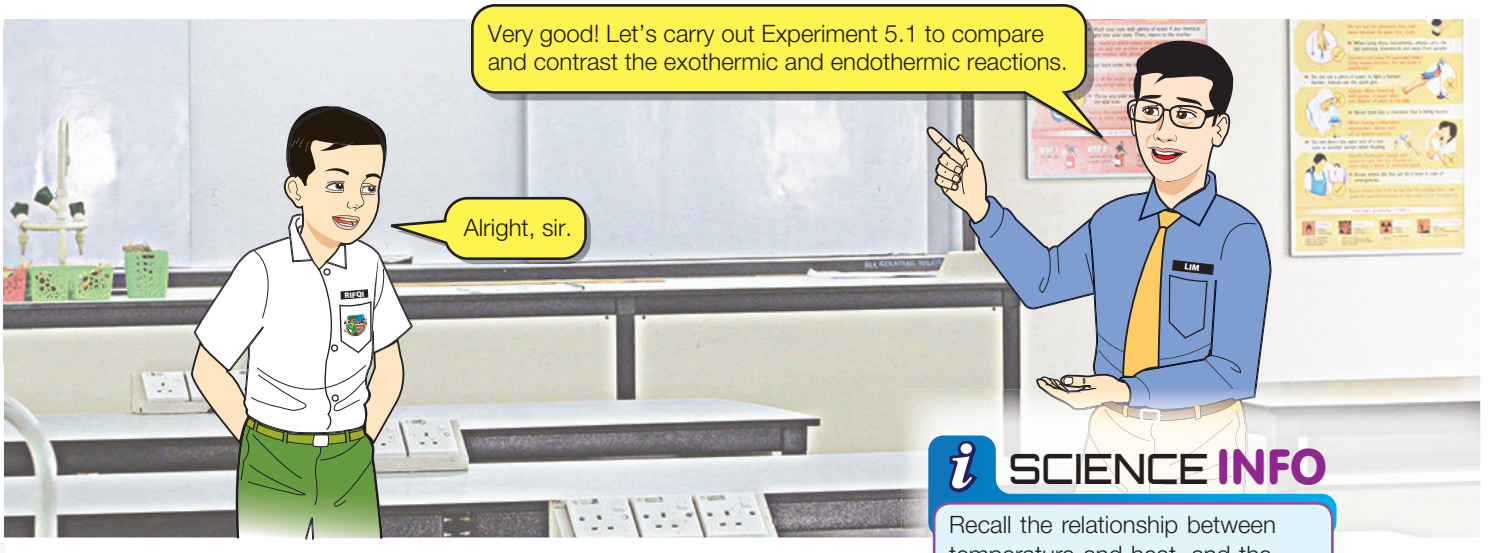
Chemical reactions can be divided into two types based on the heat change that occurs during the reactions. These are the **exothermic reactions** and **endothermic reactions.**

SCIENCE INFO

The prefix 'exo' originates from the Greek word which means 'outside' while the suffix 'thermic' originates from the Greek word which means 'heat'. The prefix 'endo' originates from the Greek word which means 'inside'.







SCIENCE INFO

Recall the relationship between temperature and heat, and the concept of thermal equilibrium which you have learnt in Form 2.

Experiment 5.1

Aim
Compare and contrast the exothermic and endothermic reactions

Problem statement
What are the similarities and differences between the exothermic and endothermic reactions?

Hypothesis
An exothermic reaction is a chemical reaction that releases heat into the surroundings while an endothermic reaction is a chemical reaction that absorbs heat from the surroundings.

5.1.2 5.1.3

Variables

(a) manipulated variable : Type of chemical substance
(b) responding variable : Final temperature reading
(c) constant variable : Volume of water

Materials

Sodium hydrogen carbonate powder, sodium hydroxide, ammonium chloride, 0.1M sodium hydroxide solution and 0.1M hydrochloric acid

Apparatus

Polystyrene cup, thermometer, spatula and measuring cylinder

Procedure

1. Measure and pour 50 ml of water into a polystyrene cup.
2. Leave the water in the polystyrene cup for 2 minutes.
3. Record the initial temperature reading of the water in the given table.
4. Add two spatulas of sodium hydroxide into the polystyrene cup and stir the mixture until all the sodium hydroxide dissolves in the water as shown in Figure 5.1.

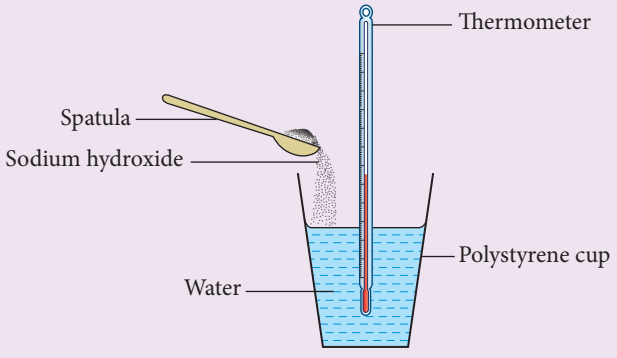


Figure 5.1

5. Record the maximum or minimum temperature in the table.
6. Repeat steps 1 to 5 by replacing sodium hydroxide with ammonium chloride.
7. Measure and pour 25 ml of hydrochloric acid into a polystyrene cup.
8. Leave the acid in the polystyrene cup for 2 minutes.
9. Record the initial temperature of the acid in the given table.
10. Measure and pour 25 ml of sodium hydroxide solution into the polystyrene cup and stir the mixture as shown in Figure 5.2.

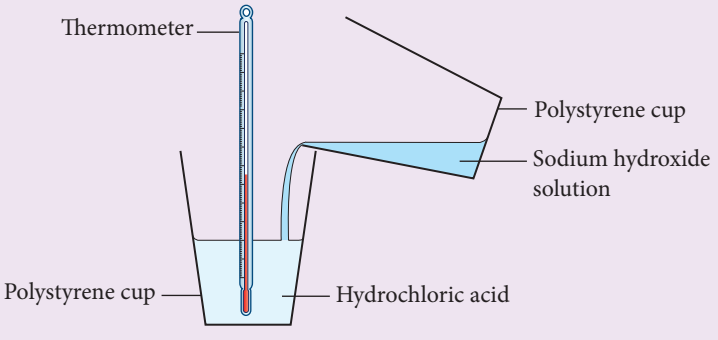


Figure 5.2

11. Record the maximum or minimum temperature in the table.
12. Repeat steps 7 to 11 by replacing sodium hydroxide solution with 2 spatulas of sodium hydrogen carbonate powder.

Observations

Reactants	Sodium hydroxide and water	Ammonium chloride salt and water	Hydrochloric acid and sodium hydroxide solution	Hydrochloric acid and sodium hydrogen carbonate
Temperature before reaction (°C)				
Maximum or minimum temperature during reaction (°C)				
Type of reaction				

Conclusion

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

Questions

1. What is the operational definition for:
   (a) the release of heat in this experiment?
   (b) the absorption of heat in this experiment?
2. (a) What happens when the temperature shown on the thermometer is at maximum or minimum?
   (b) Explain your answer to question 2(a).
3. State the criteria used in this experiment to classify the reaction as:
   (a) exothermic
   (b) endothermic
4. List the exothermic reactions in this experiment.
5. List the endothermic reactions in this experiment.
6. (a) How can the accuracy of the maximum or minimum temperature be increased?
   (b) Explain your answer to question 6(a).

Examples of Exothermic and Endothermic Reactions in Daily Life

Examples of exothermic and endothermic reactions in daily life are shown in Photograph 5.2.

Fireworks display

Photosynthesis

Cake baking

Respiration

Photograph 5.2 *Examples of exothermic and endothermic reactions*

Based on Photograph 5.2:
- which are exothermic reactions?
- which are endothermic reactions?

Designing Materials Using the Concept of Exothermic and Endothermic Reactions to Solve Problems in Daily Life

Carry out Activity 5.1 to design materials using the concept of exothermic and endothermic reactions to solve problems in daily life.

Activity 5.1

21st Century Skills
- ICS, CPS, STEM
- Project-based learning activity

To study engineering designs to solve problems in daily life

Instructions

1. Work in groups.
2. Gather information on the engineering design process to:
   (a) produce materials to relieve muscle cramp

   (b) produce an emergency lamp when there is a power failure

   (c) design a container that can maintain high or low temperature

3. Write the information and research results obtained by your group in the form of a folio.

Formative Practice 5.1

1. Define the following types of chemical reactions:
   (a) Endothermic reaction
   (b) Exothermic reaction
2. What is thermochemistry?
3. Why does our body temperature increase when performing vigorous physical activities?
4. (a) Name **one** example of a global phenomenon caused by exothermic reaction.
   (b) Give **one** solution to the phenomenon mentioned in question **4**(a).
5. (a) Name the reaction produced by materials to relieve muscle cramp.
   (b) Explain your answer.

Summary

Thermochemistry

is

The study of heat changes that occur when chemical reactions take place

where

Heat is released into the surroundings	Heat is absorbed from the surroundings
in	*in*
Exothermic reactions	Endothermic reactions
in processes such as	*in processes such as*
Burning of paper, bomb explosion, respiration, neutralisation of acid with alkali	Photosynthesis, cake baking, extraction of iron from iron ore, dissolving ammonium salt in water
which cause	*which cause*
A rise in temperature	A drop in temperature
in the	*in the*
Product of reaction	Product of reaction

Self-reflection

After studying this chapter, you are able to:

5.1 Endothermic and Exothermic Reactions

- ☐ Define endothermic and exothermic reactions.
- ☐ Relate heat absorbed or released in a chemical reaction to endothermic and exothermic reactions.
- ☐ Carry out an experiment to compare and contrast endothermic and exothermic reactions.
- ☐ Explain with examples exothermic and endothermic reactions.
- ☐ Design materials using the concept of exothermic and endothermic processes to solve problems in life.

Summative Practice 5

Answer the following questions:

1. There are two types of reactions: exothermic reaction and endothermic reaction. Match the examples of processes with the correct type of reaction.

(a) Burning of petrol	Exothermic reaction
(b) Photosynthesis	Endothermic reaction
(c) Respiration	
(d) Making bread	
(e) Neutralisation	
(f) Rusting of iron	

2. Underline the **correct** answers.

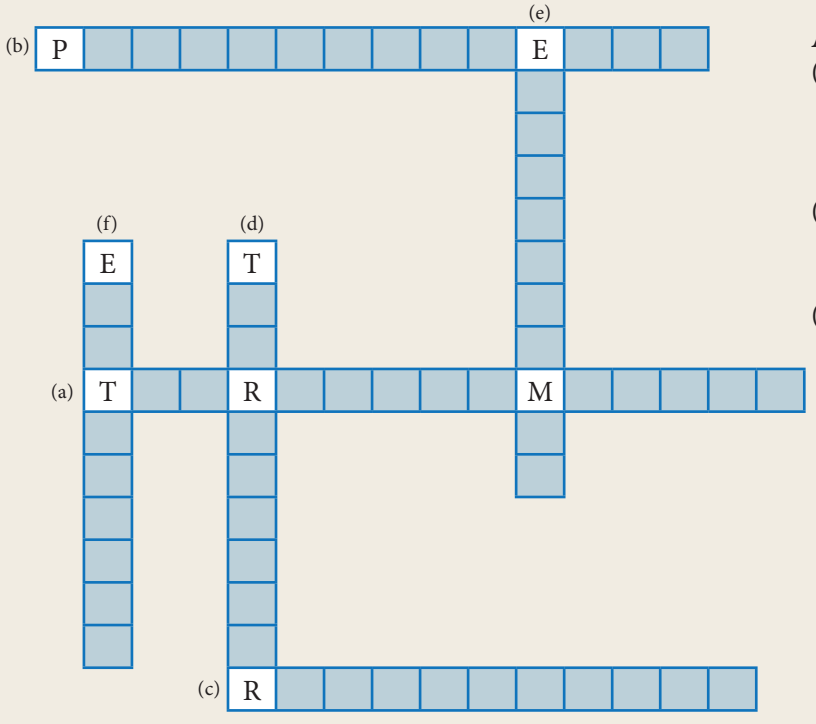
(a) The burning of a candle is an exothermic reaction because heat is (released/absorbed).

(b) Exothermic reaction in the body (increases/decreases) the body temperature.

(c) Exothermic reaction is applied in instant (cold/hot) packs.

(d) Baking a cake is not an exothermic reaction because heat is (released/absorbed).

3. Solve the crossword puzzle below.



Across

(a) Study of heat change when chemical reactions take place.

(b) Endothermic reaction that occurs in plants.

(c) Exothermic reaction that occurs in animals.

Down

(d) A device that measures change in temperature during exothermic and endothermic reactions.

(e) Chemical reaction that absorbs heat from the surroundings.

(f) Chemical reaction that releases heat into the surroundings.

4. Figure 1 shows an apparatus set up to heat calcium carbonate.

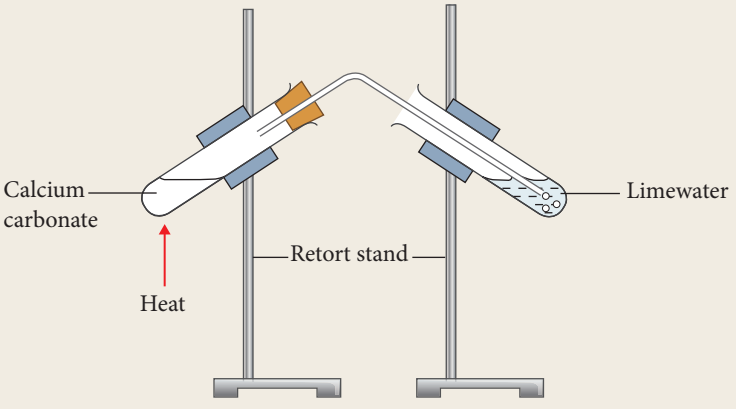


Figure 1

Is the heating of calcium carbonate an exothermic reaction or an endothermic reaction? Explain your answer.

5. Differentiate the reaction between hydrochloric acid and sodium carbonate, and the reaction between hydrochloric acid and sodium hydrogen carbonate.

6. How can the effects of global warming be reduced by the replanting of trees?

7. (a) Figure 2 shows a thermite reaction, that is the heating of iron(II) oxide, aluminium powder and magnesium tape.

Figure 2

Is a thermite reaction an exothermic reaction or endothermic reaction? Explain your answer.

(b) Figure 3 shows an application of a thermite reaction.

Figure 3

Describe the application of thermite reaction in Figure 3.

8. Figure 4 shows an instant hot pack and an instant cold pack used in hospitals to relieve muscle cramps and reduce the swelling of wounds.

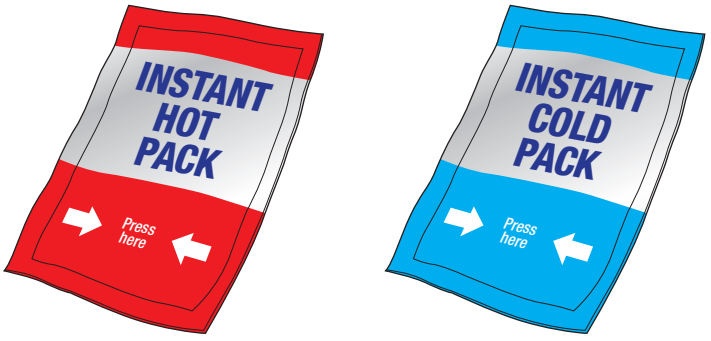
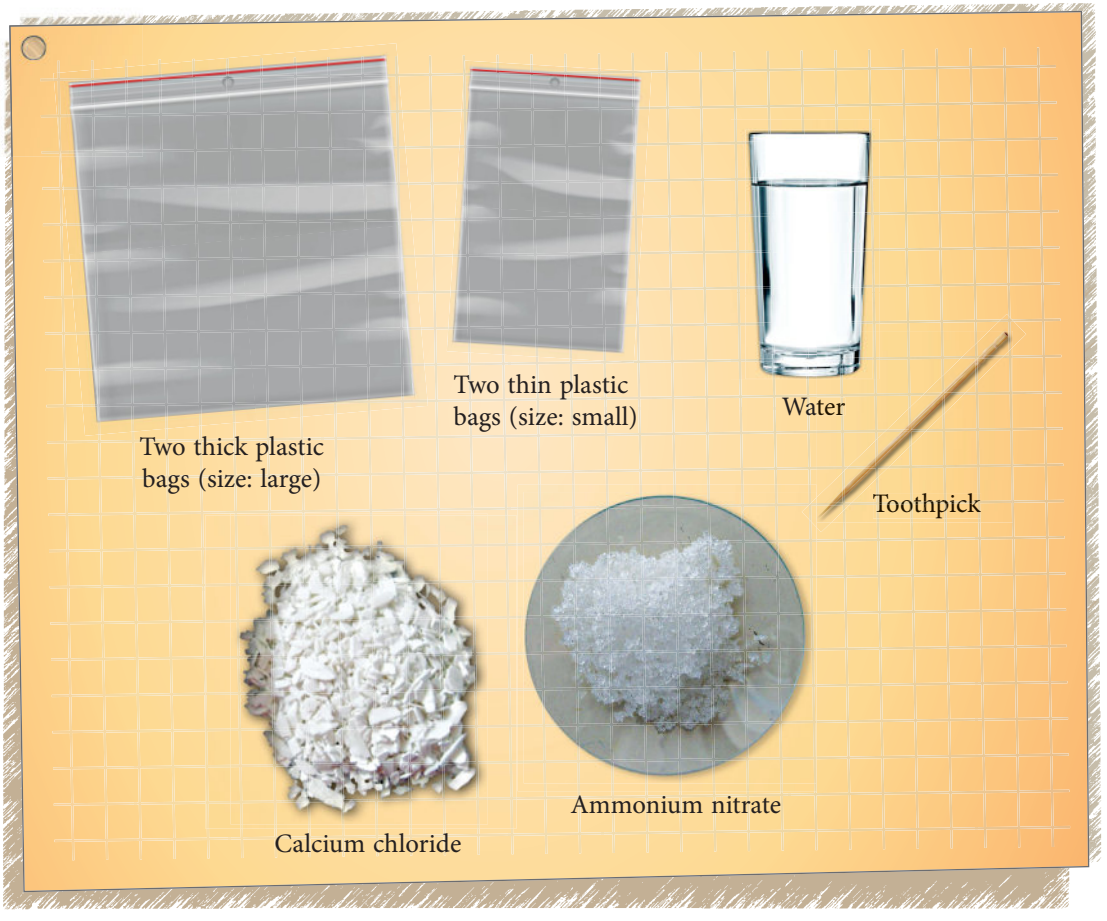


Figure 4

Using your creativity, modify and make an instant hot pack and an instant cold pack using the following materials. Explain.



THEME

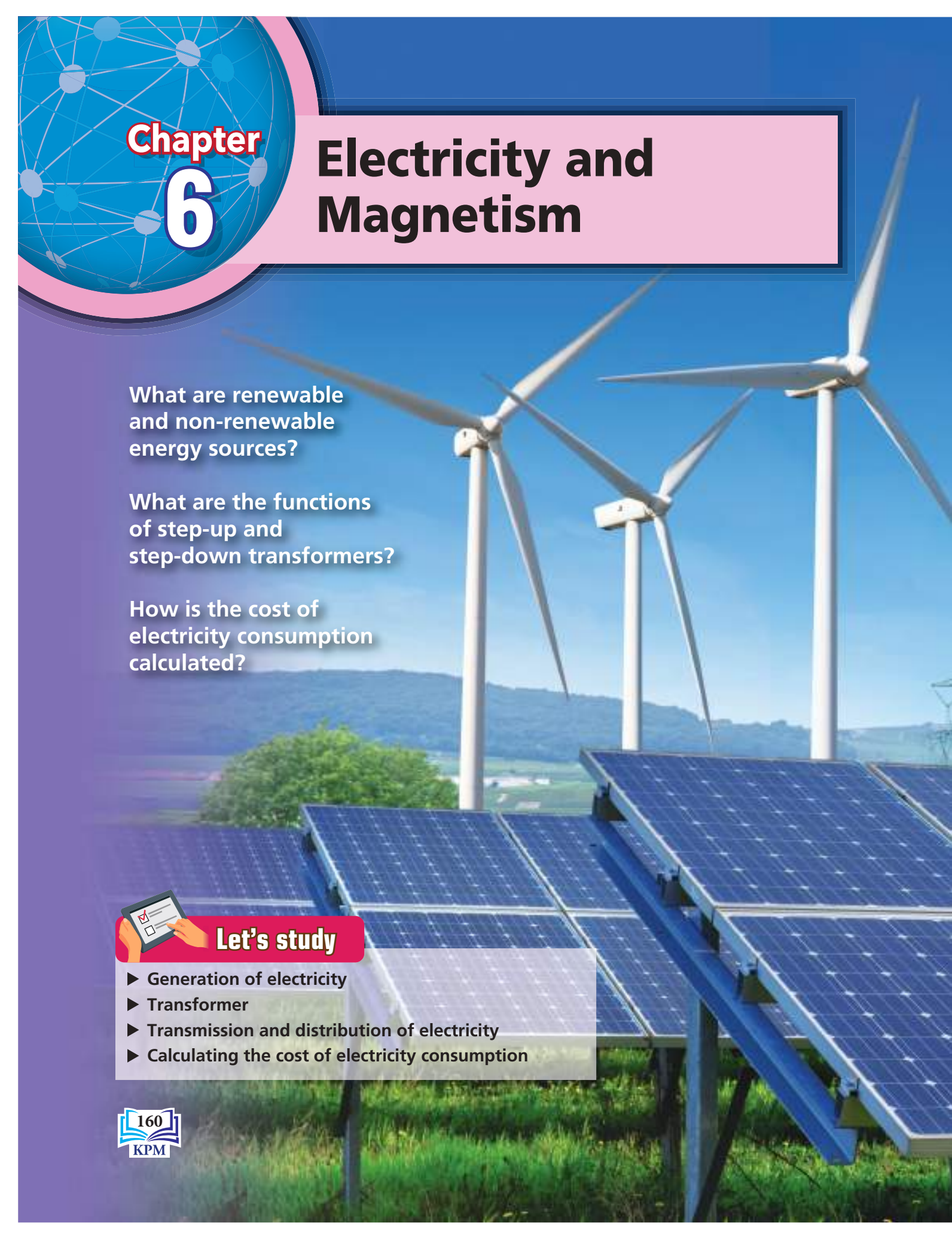
3 Energy and Sustainability of Life

Solar cells are used to generate electricity. What is the importance of the generation of electricity using solar energy in Malaysia?

According to the law in Malaysia, the installation of smoke detectors in buildings such as hospitals, hotels, supermarkets and office buildings is compulsory. Smoke detectors normally contain a small amount of radioactive substance. Name this radioactive substance. What is the importance of handling radioactive substances effectively in daily life?

Chapter 6

Electricity and Magnetism



What are renewable and non-renewable energy sources?

What are the functions of step-up and step-down transformers?

How is the cost of electricity consumption calculated?

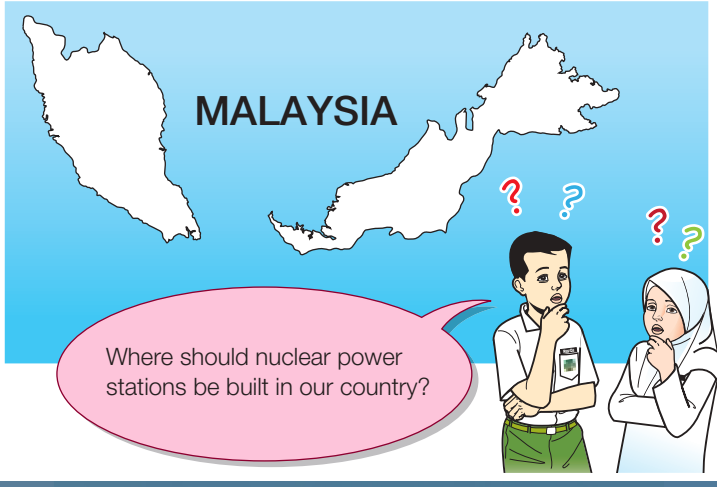
Let's study

- Generation of electricity
- Transformer
- Transmission and distribution of electricity
- Calculating the cost of electricity consumption

Science Gallery

According to a report from the Malaysian Nuclear Agency, Malaysia needs to have a nuclear power station in 2030. This power station should generate electricity that is sufficient to meet the electricity needs of our country. Do you agree or disagree with having of this power station in Malaysia? Why?

(Source:http://www.utusan.com.my/sains-teknologi/inovasi/loji-nuklear-negara-beroperasi-2030-1.146680)



Keywords

- Power station
- Induced current
- Direct current
- Alternating current
- Primary coil
- Secondary coil
- Input voltage
- Output voltage
- National Grid Network
- Earth wire
- Short circuit
- Electric shock
- Kilowatt-hour (kWh)
- Energy efficiency

6.1 Generation of Electricity

Various Energy Sources to Generate Electricity

Did you know that our country, Malaysia is a country which is very successful in using various energy sources to generate electricity? What are the energy sources used in Malaysia to generate electricity?

Electricity is generated through various energy sources. These different energy sources can be classified into two main groups, namely **renewable energy sources** and **non-renewable energy sources** as shown in Figure 6.1. Figure 6.2 shows renewable and non-renewable energy sources used in power stations in Malaysia.

My Malaysia

Malaysia is currently the leading country in biomass industry in the Southeast Asian region. Sarawak and Sabah are two states in Malaysia that have a variety and a large amount of biomass. The variety of biomass includes the biomass of oil palm, forests, rubber trees, garbage, rice husks and maize. Besides the generation of electricity, biomass is also used to produce innovative products such as building materials.

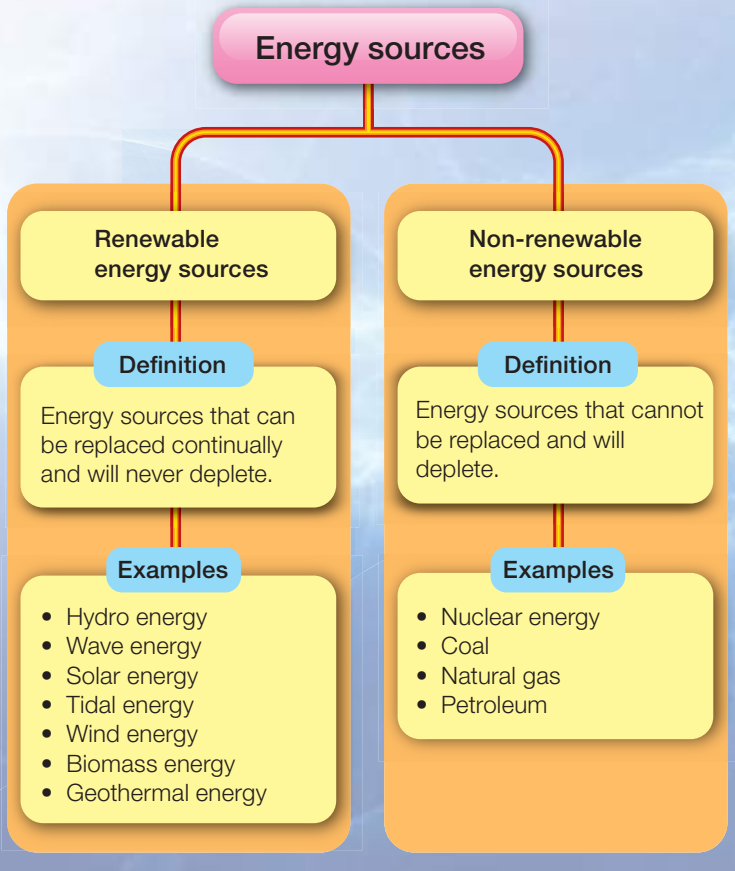


Figure 6.1 *Renewable and non-renewable energy sources*

Hybrid power station in Pulau Perhentian Kecil, Terengganu (Energy source: Wind, Solar, Diesel)