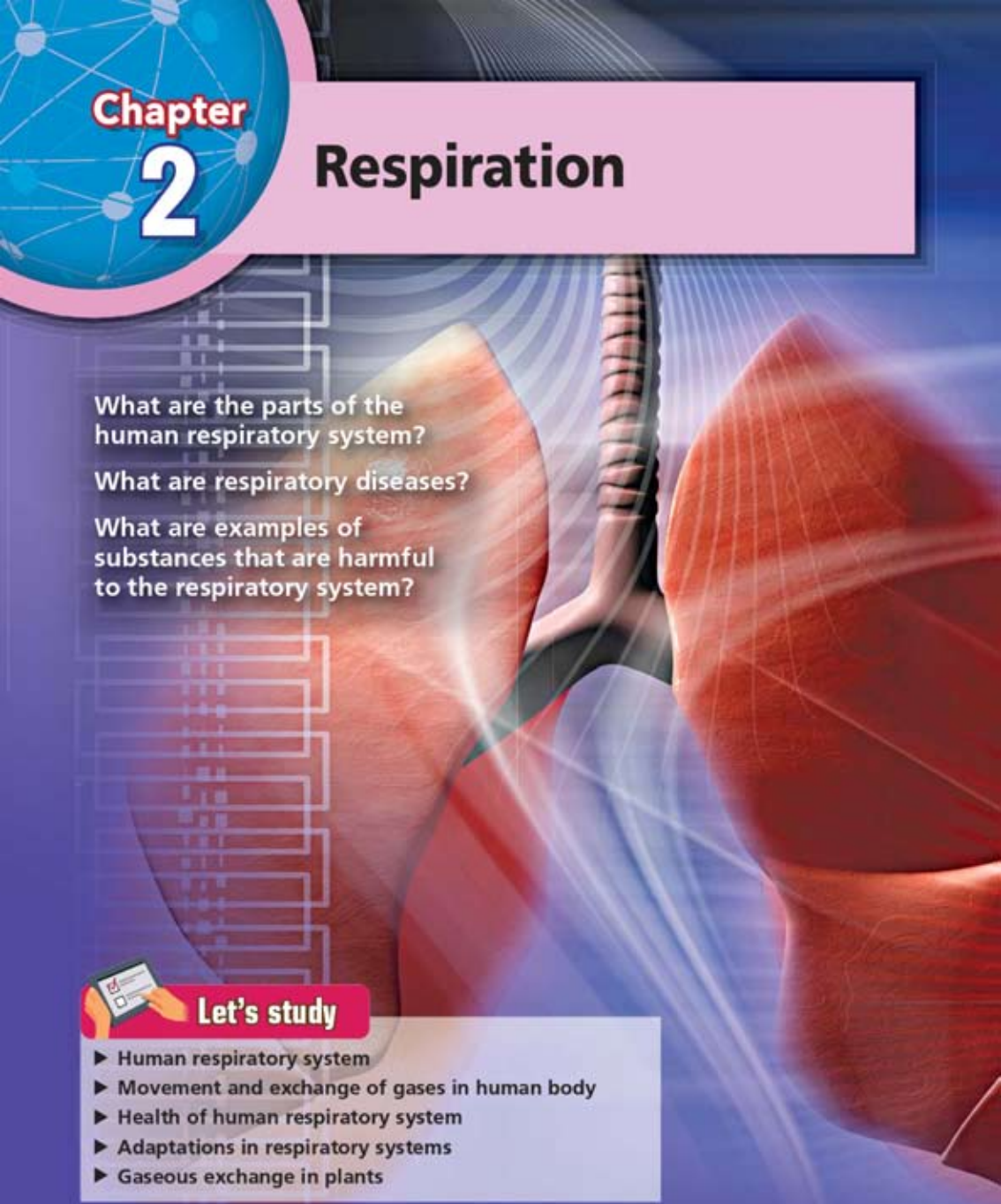
Chapter 2

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?

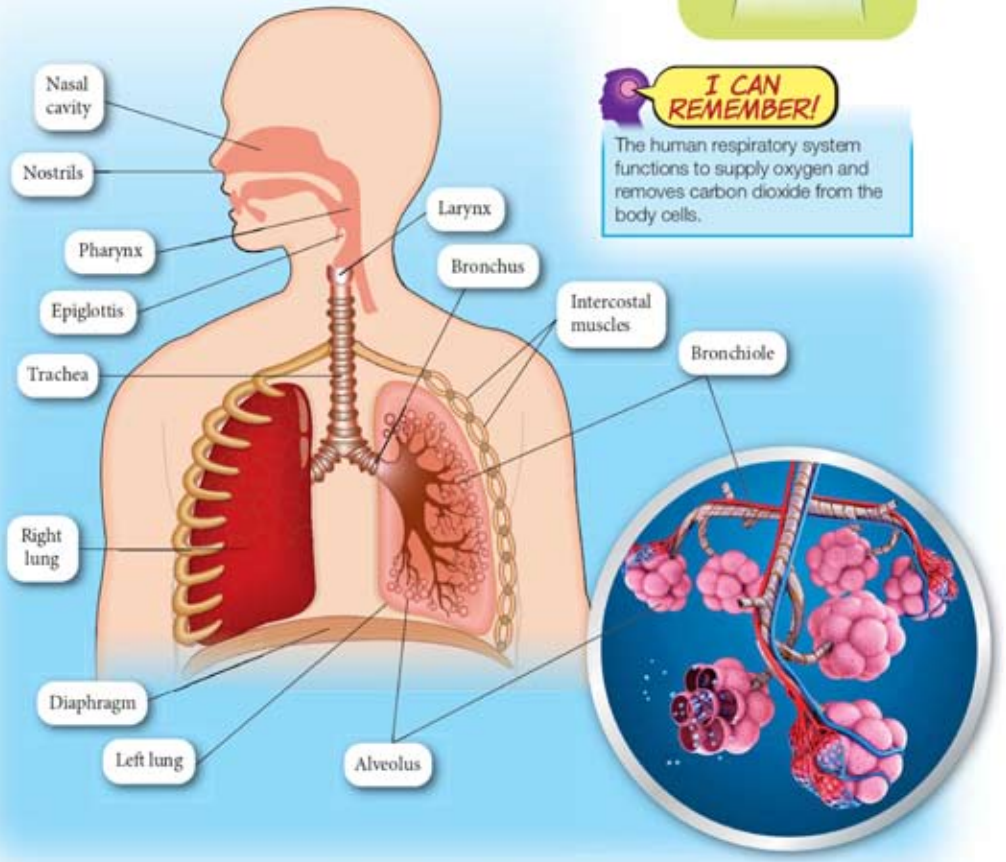
Keywords

- 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 shown in Figure 2.2.

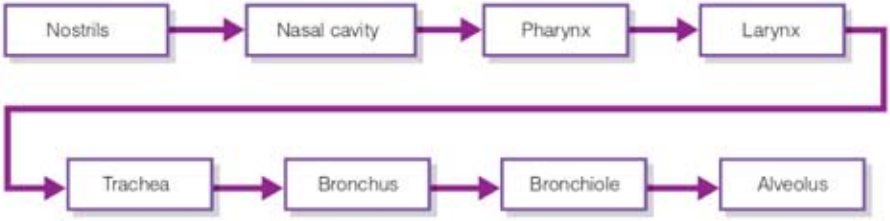


Figure 2.2 Direction of air in breathing mechanism

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 performance during exercise or sports events such as weightlifting.

VIDEO

Inhalation and exhalation

SCAN PAGE

Inhalation

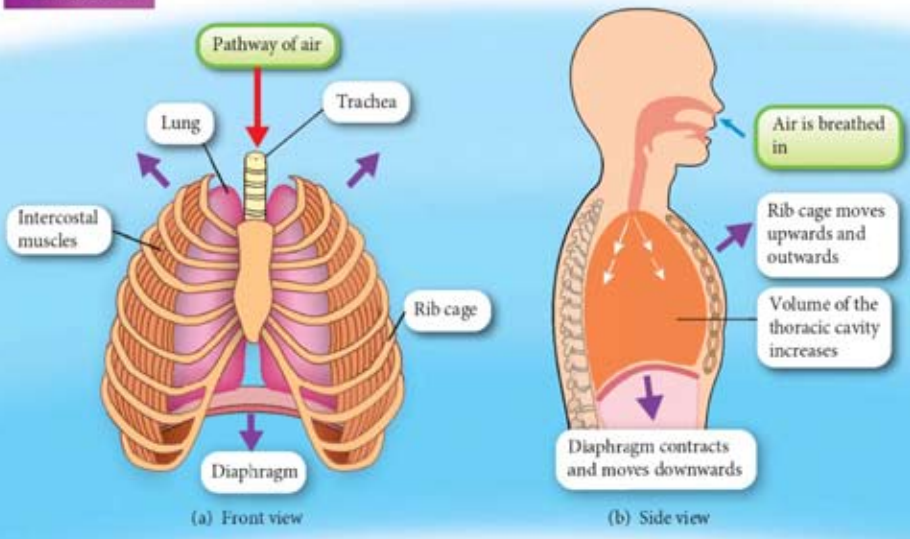


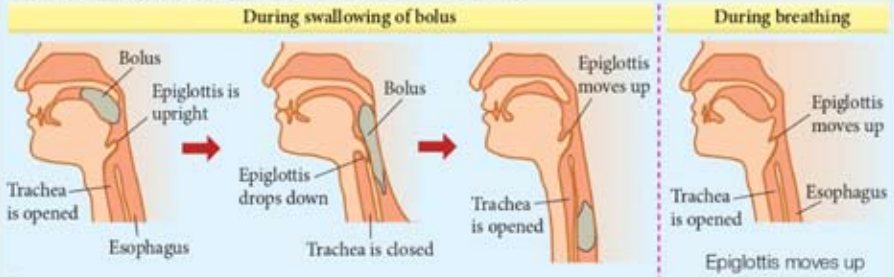
***Figure 2.3** Inhalation*

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



Epiglottis drops down and closes the trachea when a bolus is swallowed into the esophagus.

Epiglottis moves up causing the trachea to open.

Exhalation

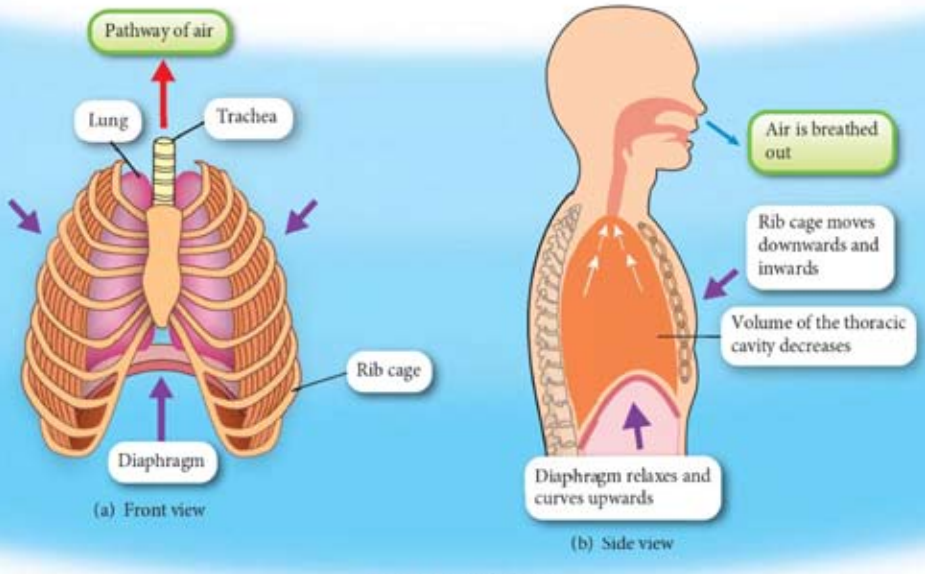


Figure 2.4 Exhalation

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).

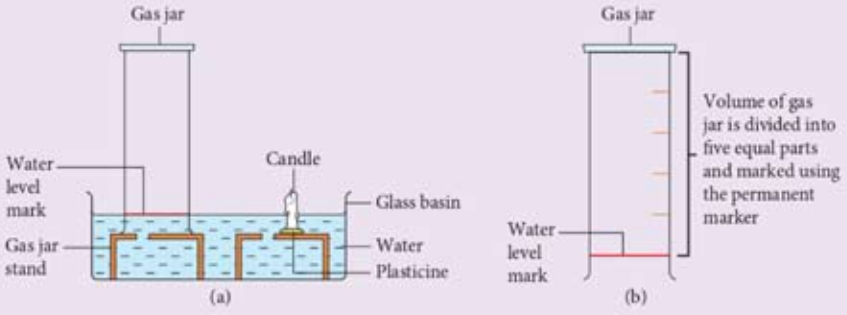


Figure 2.5

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.

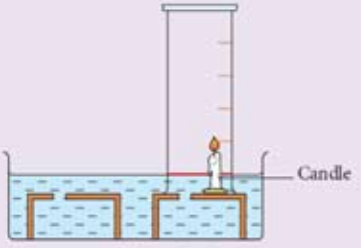


Figure 2.6

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.

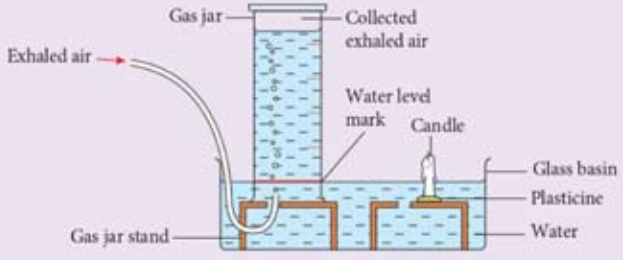


Figure 2.7

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.

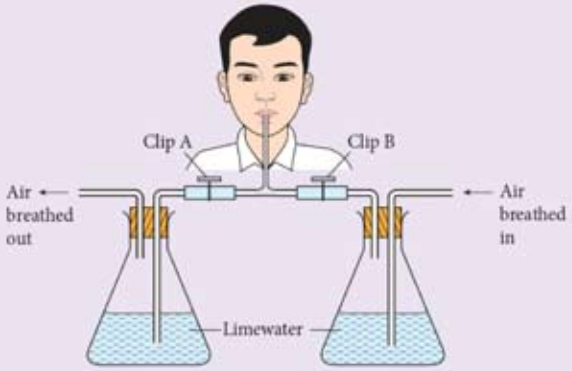


Figure 2.8

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.

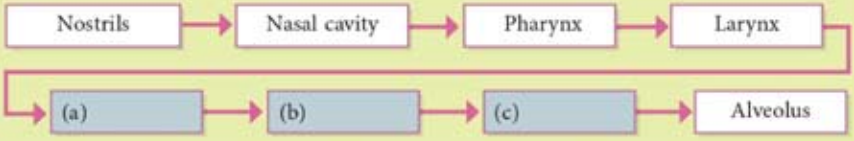
In theory,

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.

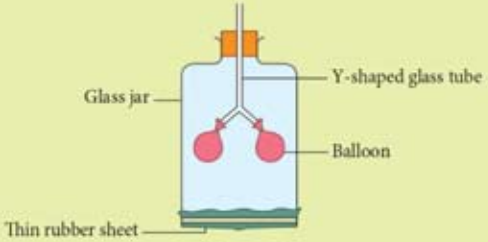


Figure 1

(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.

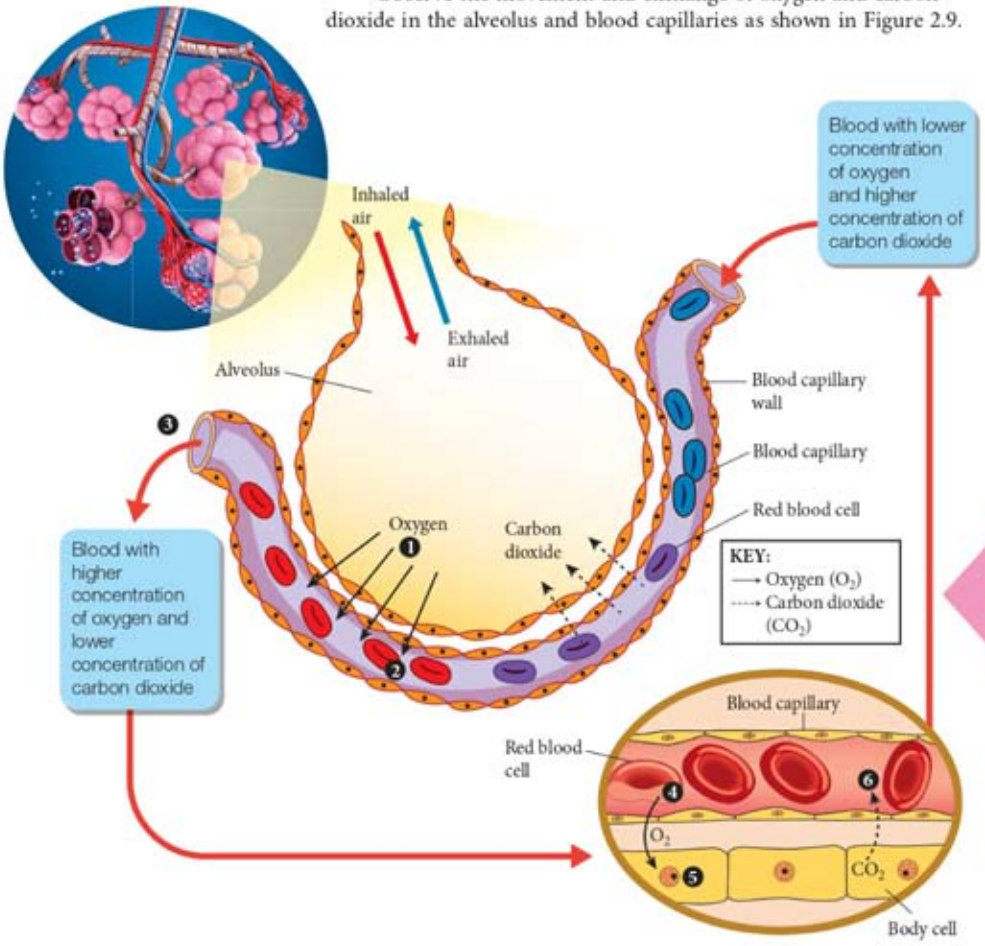


Figure 2.9 Movement and exchange of oxygen and carbon dioxide in the human body

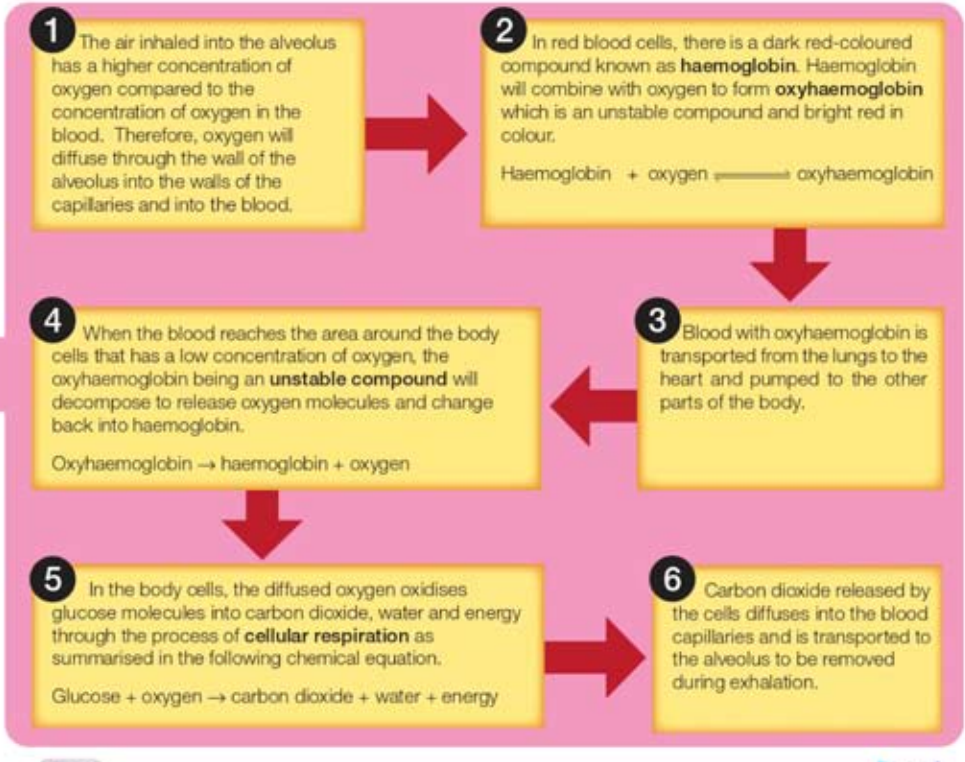
Activity 2.3

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



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.

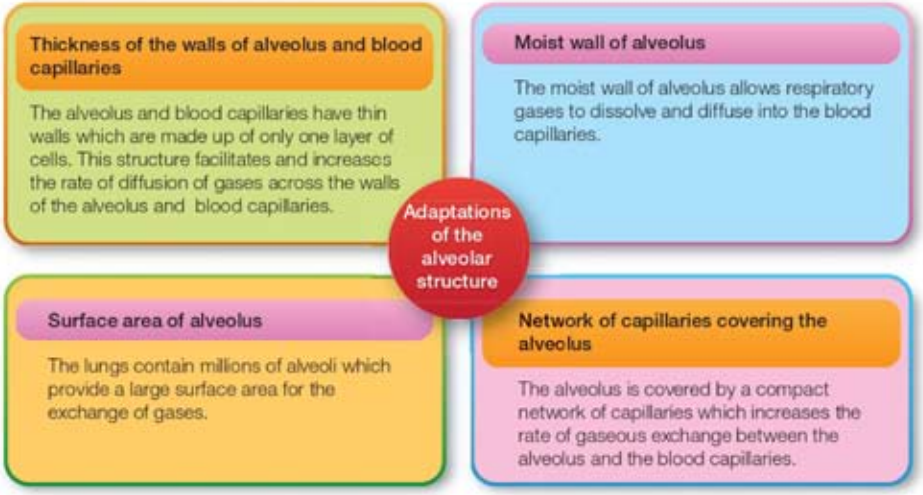


Figure 2.10 *Adaptations of the alveolar structure to increase efficiency in the exchange of gases*

i 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

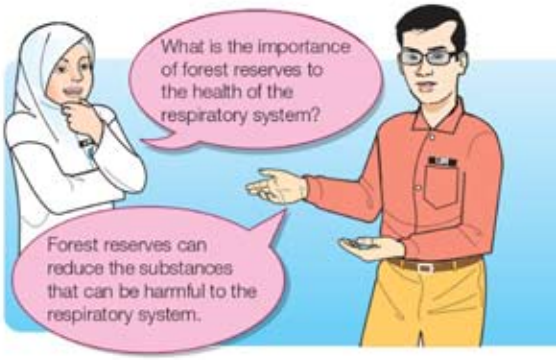
1. What factor determines the rate of exchange of oxygen between the alveolus and blood capillaries?
2. Describe the conditions in the following processes:
   (a) Haemoglobin changes into oxyhaemoglobin
   (b) Oxyhaemoglobin decomposes into haemoglobin
3. Write a chemical equation to describe cellular 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 follows:

- 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 'total aerosol residue'.

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.

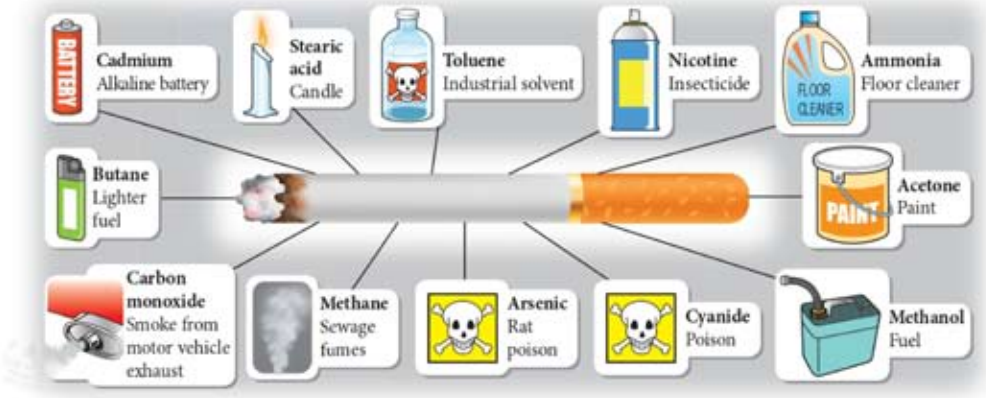


Figure 2.11 Harmful substances found in cigarette smoke

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://bt.sasbadi.com/sc3059

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.

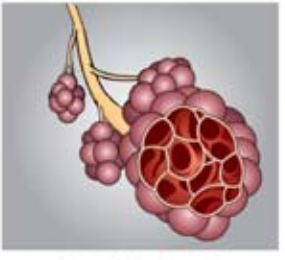
Bronchitis

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://bt.sasbadi.com/sc3060-1
- Emphysema, symptoms and ways to treat it
  http://bt.sasbadi.com/sc3060-2

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://bt.sasbadi.com/sc3061-1

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://bt.sasbadi.com/sc3061-2

http://bt.sasbadi.com/sc3061-3

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

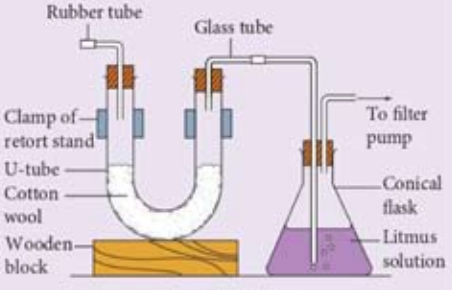


Figure 2.13(a)

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).

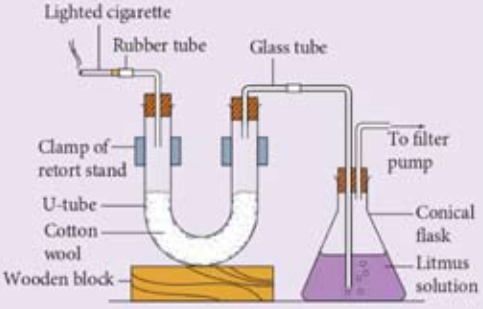


Figure 2.13(b)

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.

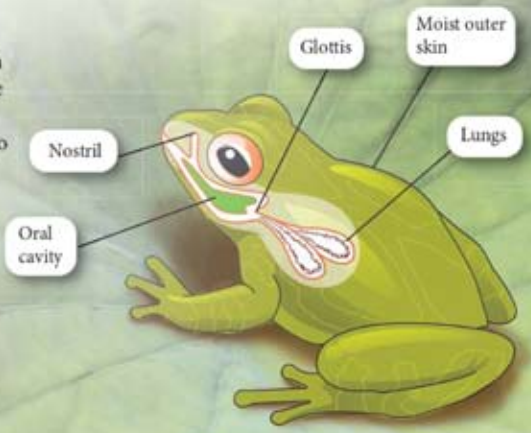


Figure 2.14 *Respiratory system of a frog*

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.

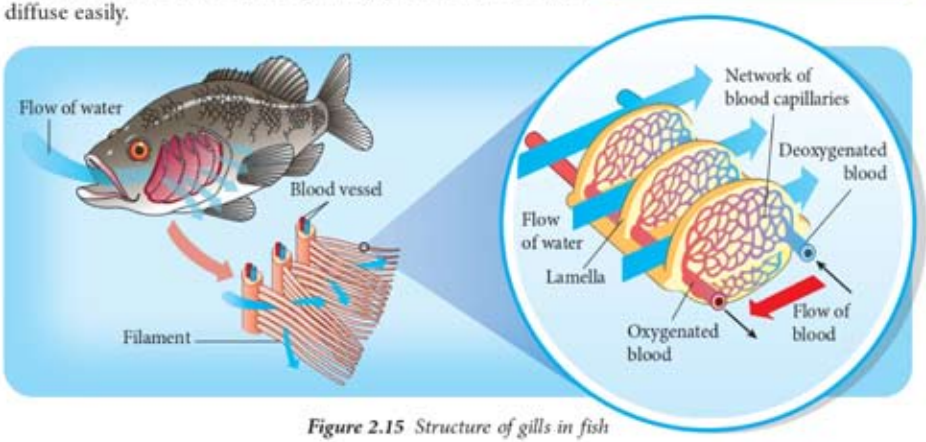


Figure 2.15 *Structure of gills in fish*

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.

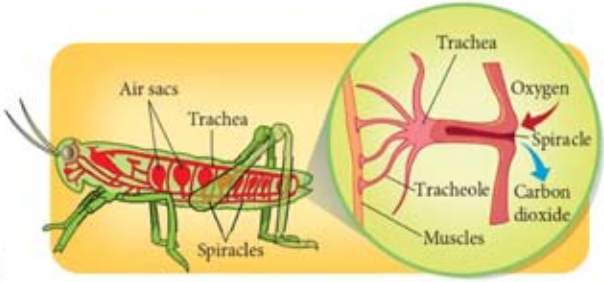


Figure 2.16 *Trachea system of grasshopper*

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

To carry out 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://bt.sasbadi.com/sc3066-3

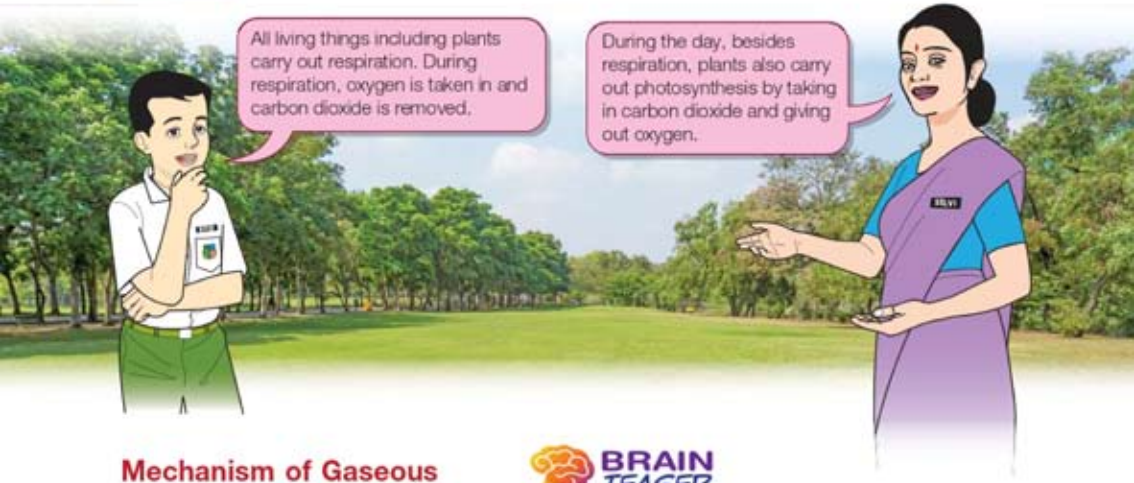
Info 1
The adaptation and ability of the human respiratory system during exercise
http://bt.sasbadi.com/sc3066-1

Info 2
Sickle cell anaemia
http:bt.sasbadi.com/sc3066-2

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.

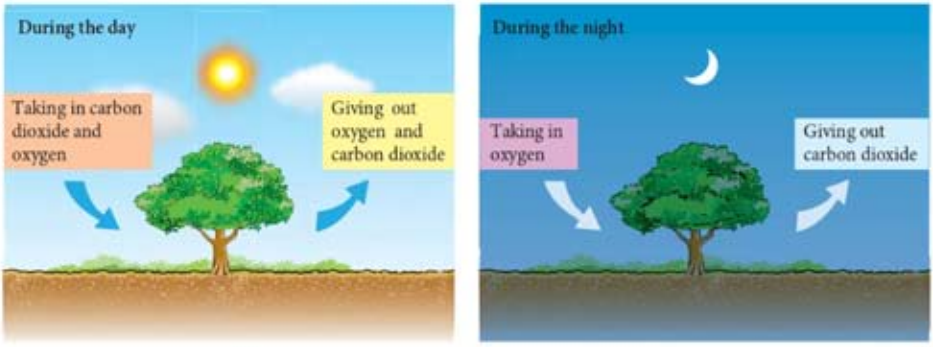


Figure 2.17 Gaseous exchange in plants

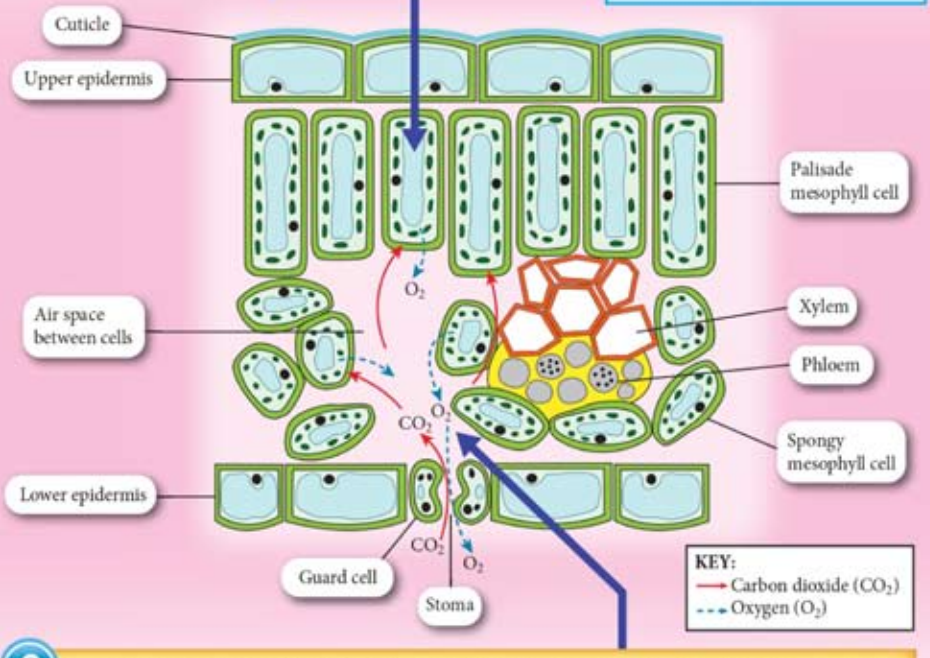
Diffusion of Carbon Dioxide

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.

I CAN REMEMBER!

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

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.

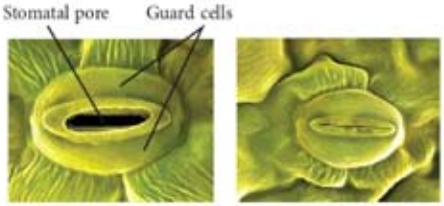


2 This causes the concentration of carbon dioxide in the air space between the cells to become lower compared to the concentration of carbon dioxide in the air outside the stoma. This difference in concentrations causes the diffusion of carbon dioxide from the atmosphere into the air space between the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

i 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.

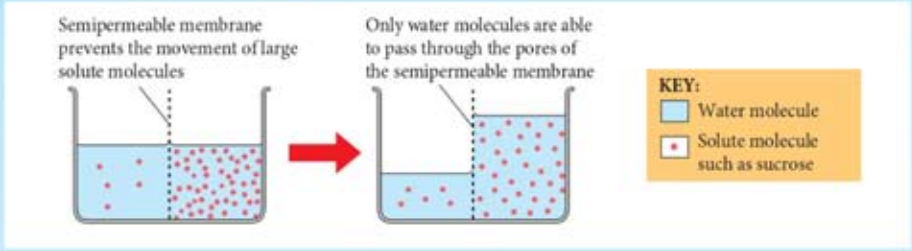


Figure 2.19 *Osmosis*

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**.

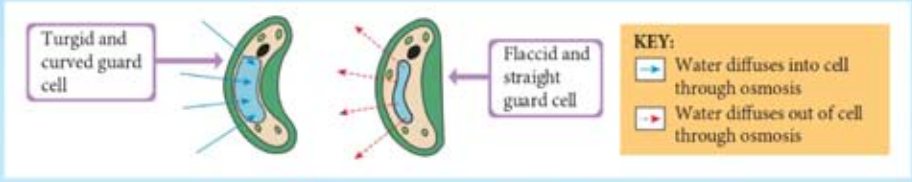


Figure 2.20 *Change in shape of guard cells caused by osmosis*

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. This closes the stoma as shown in Figure 2.22.

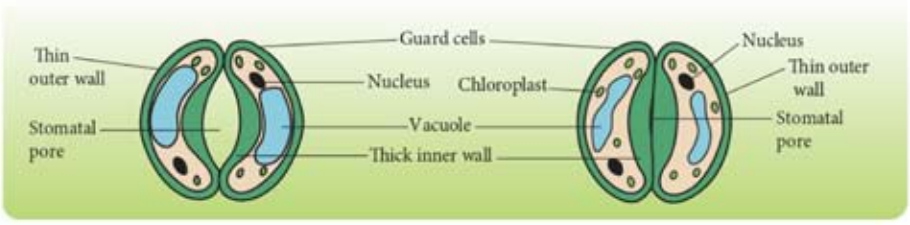


Figure 2.21 Open stoma

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 this opens 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 surroundings 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 surroundings. 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://bt.sasbadi.com/sc3071-3

ASEAN – Haze preventive measures
http://bt.sasbadi.com/sc3071-2

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.

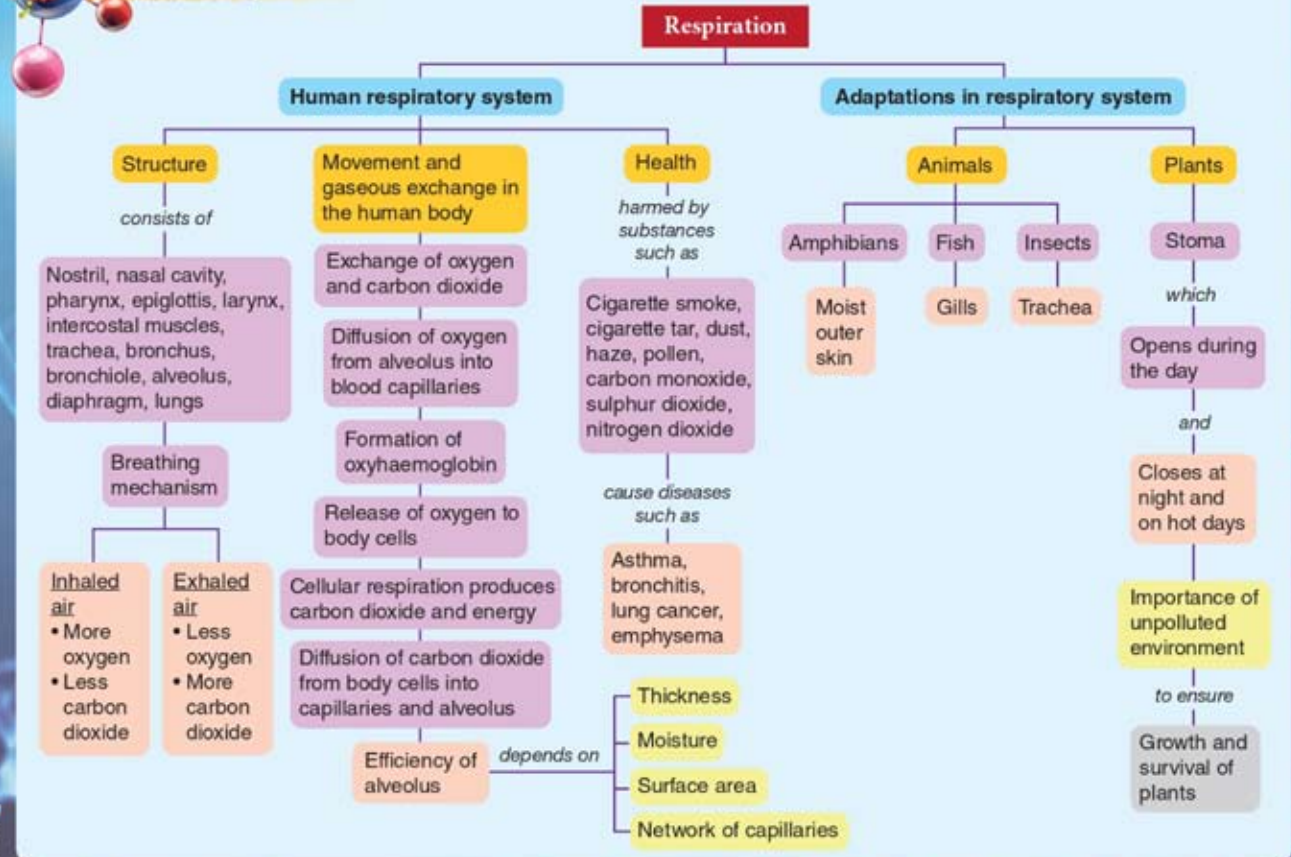
Figure 2

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 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.

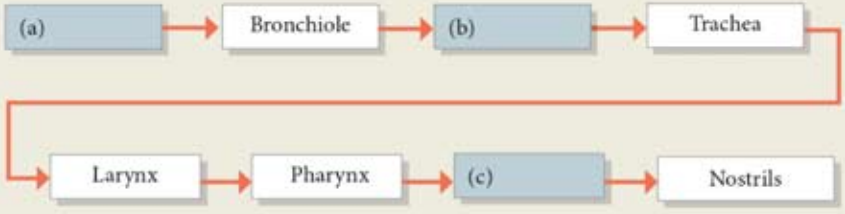
2.5 Gaseous Exchange in Plants

- ☐ 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.

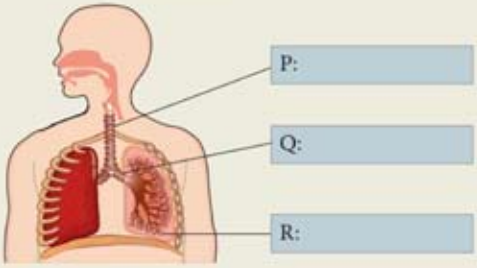


Figure 1

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).

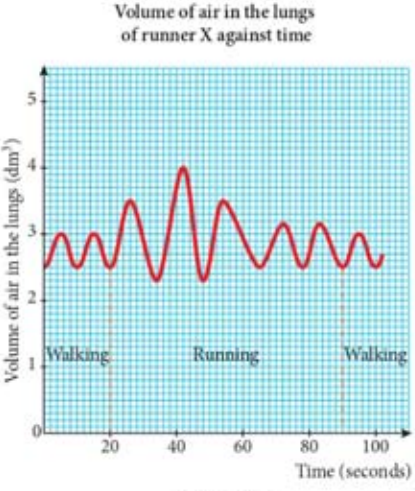


Figure 3(a)

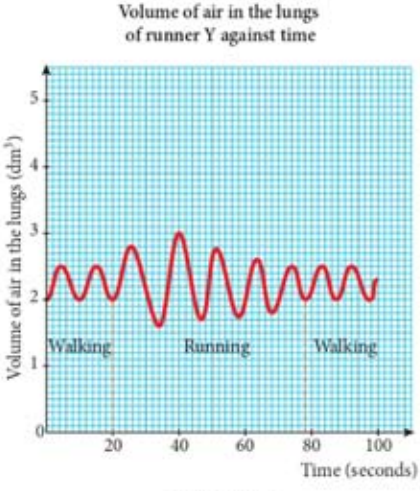


Figure 3(b)

(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 the lungs of each runner. Explain.

(d) Which one is the smoker, runner X or Y? Explain.

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