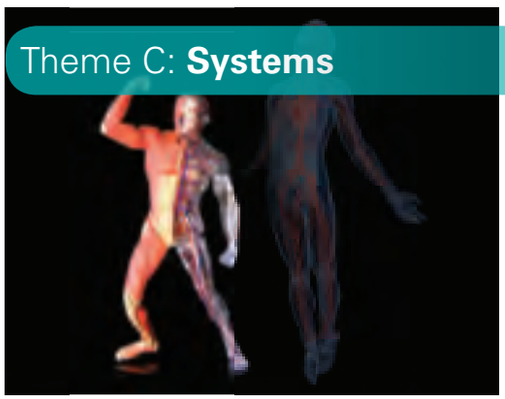
Contents



Theme C

Systems

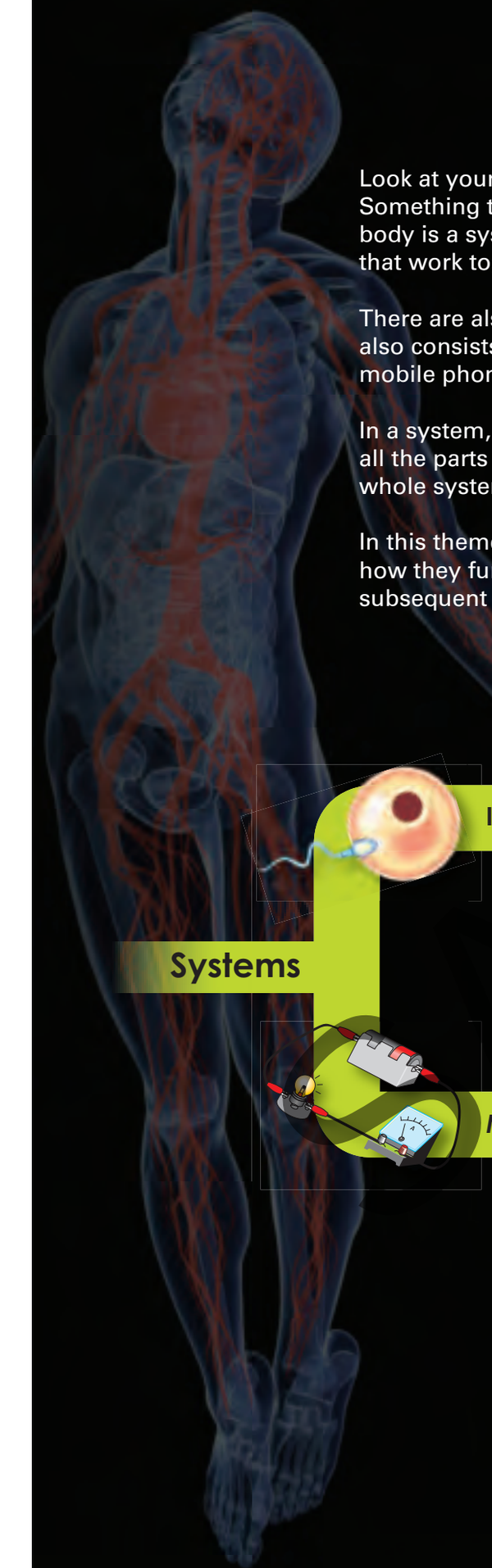
- How do parts of a system or different systems work together to perform a function?
- How can parts of a system affect the function of other parts?

Look at yourself in a mirror. You will see that your body has many parts. Something that is made up of different parts is called a system. The human body is a system. A plant is a system. Each is made up of many different parts that work together to perform a function.

There are also man-made systems. A computer is a man-made system; it also consists of different parts. Electrical equipment, from a simple torch to a mobile phone, are examples of man-made systems.

In a system, each part has a different function. For a system to work properly, all the parts must work together. If one part is missing or does not work, the whole system cannot function properly.

In this theme, you will learn about some living and man-made systems and how they function. The questions on the previous page will be answered in the subsequent chapters.



Systems

In nature

- Chapter 10 Transport System in Living Things
- Chapter 11 Human Digestive System
- Chapter 12 Human Sexual Reproductive System

Man-made

- Chapter 13 Electrical Systems

Chapter

10 Transport System in Living Things

How do parts of transport systems work together to transport essential substances?

How does the transport system in living things affect other systems in the body?

When we hear the word 'transport', we may think of vehicles such as cars, trucks and buses. These vehicles take people from place to place, carry goods to supermarkets and take away our rubbish. To move things from one place to another, roads are needed. The roads and the vehicles make up a transport system.

Many living things also have transport systems. In this chapter, you will learn about the transport systems in humans and flowering plants.

LEARNING OUTCOMES

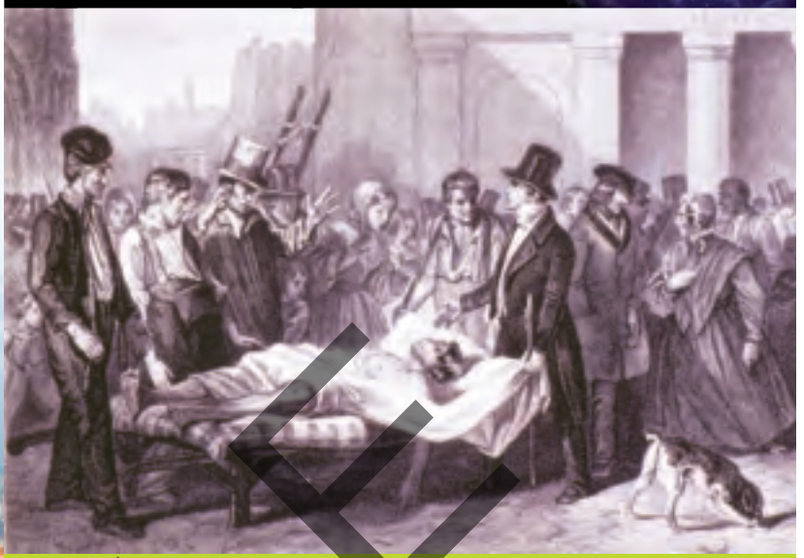
You will learn to:

- explain the need for a transport system in multicellular organisms (OPTIONAL FOR N(A))
- identify the parts of the human circulatory system and their respective functions (include heart, blood vessels and blood)
- state how diffusion facilitates the transport of substances in animals
- show an awareness of how the various parts of the plant transport system work together to transport useful substances within the plant
- state how diffusion facilitates the transport of substances in plants
- state how osmosis facilitates the absorption of water at the roots
- infer from investigations that particles move from a region of higher concentration to a region of lower concentration
- show curiosity in exploring how different systems (digestive, respiratory and excretory) work with the transport system in transporting useful and waste substances

Before you begin, look through this chapter and write down questions about what you want to find out. Here are some examples:

1. *What is a system?*
2. *What are the parts of the human and plant transport systems? How do they work?*
3. *What are diffusion and osmosis, and how are they used in living things?*

Science Mystery...



How did salt solution save the cholera victims?

In 1831, a cholera epidemic [a widespread outbreak of a disease] swept across Europe. Many people died due to dehydration — the loss of water and other substances such as salt.

When the epidemic arrived in Scotland, a doctor, Thomas Latta, came up with an idea to save the cholera victims. He injected a weak solution of salt into the veins of patients. Amazingly, it worked! However, Dr Latta had to be careful that the solution contained just the right amount of salt; too much or too little would kill the patient.

How did Dr Latta's idea of injecting salt solution help? Why was the amount of salt in the solution critical? As you read this chapter, look for clues to answer these questions and solve the mystery.

10.1 Why Do Organisms Need Transport Systems?

In Chapter 6, you learnt that living things are made up of cells.

Cells need a continuous supply of oxygen and nutrients. Cells also produce waste products that need to be removed. How are substances brought to or removed from cells?

In single-celled organisms, such as the amoeba, substances move into and out of the cell directly. Therefore, these organisms do not need a transport system.

In complex organisms, such as mammals and flowering plants, there are millions of cells. Most of these cells are far away from the environment and cannot get materials directly from the environment. Therefore, a transport system is needed to transport substances to and away from the cells.

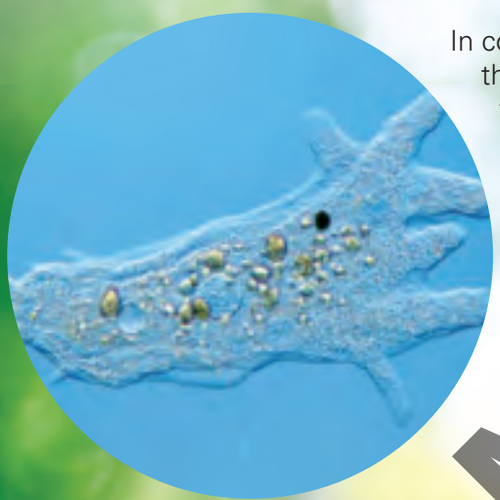


Figure 10.1 A single-celled organism

Think About it!

1. A system is made up of different parts. Name some parts of a road transport system.
2. What other transport systems are there in Singapore and what do they transport?

[elaborating]

Figure 10.2 A multicellular organism >>

10.2 How Does the Human Transport System Work?

What are the parts of the human transport system?

The main transport system in the human body is called the **circulatory system**. It consists of three parts — the **heart**, **blood** and **blood vessels**.

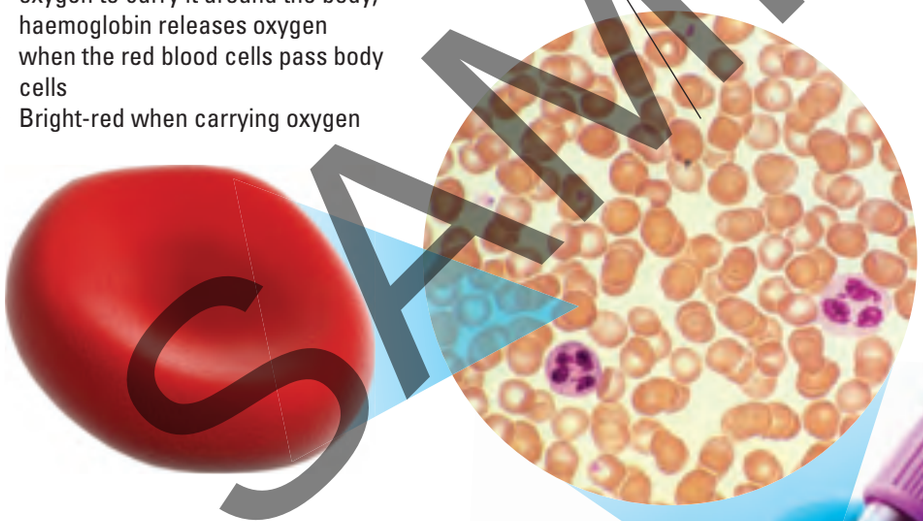
What is the role of blood?

The human body has about five litres of blood. One of the main functions of blood is to carry substances to and from cells in the body. These substances include nutrients, oxygen and carbon dioxide.

Blood contains **red blood cells**. These are suspended in a pale yellow liquid called **plasma**.

Red blood cells
- Have no nucleus
- Responsible for the red colour of blood
- Contain a substance called haemoglobin which combines with oxygen to carry it around the body; haemoglobin releases oxygen when the red blood cells pass body cells
- Bright-red when carrying oxygen

Plasma
- Made up of water and dissolved substances including nutrients (glucose, amino acids, fatty acids and mineral salts) and waste substances



Know it!

Blood cells

Unlike other cells, red blood cells have no nuclei and do not divide. The cells gradually die and are replaced with new ones at a rate of about 5 million per second.

Figure 10.3 Some components of blood

What is the role of the heart?

Put your hand on the place where you think your heart is. What can you feel?

The heart is an organ which pumps blood around the body. It is about the size of your fist. Figure 10.5 shows the structure of the heart. All mammals have hearts that are similar in structure.

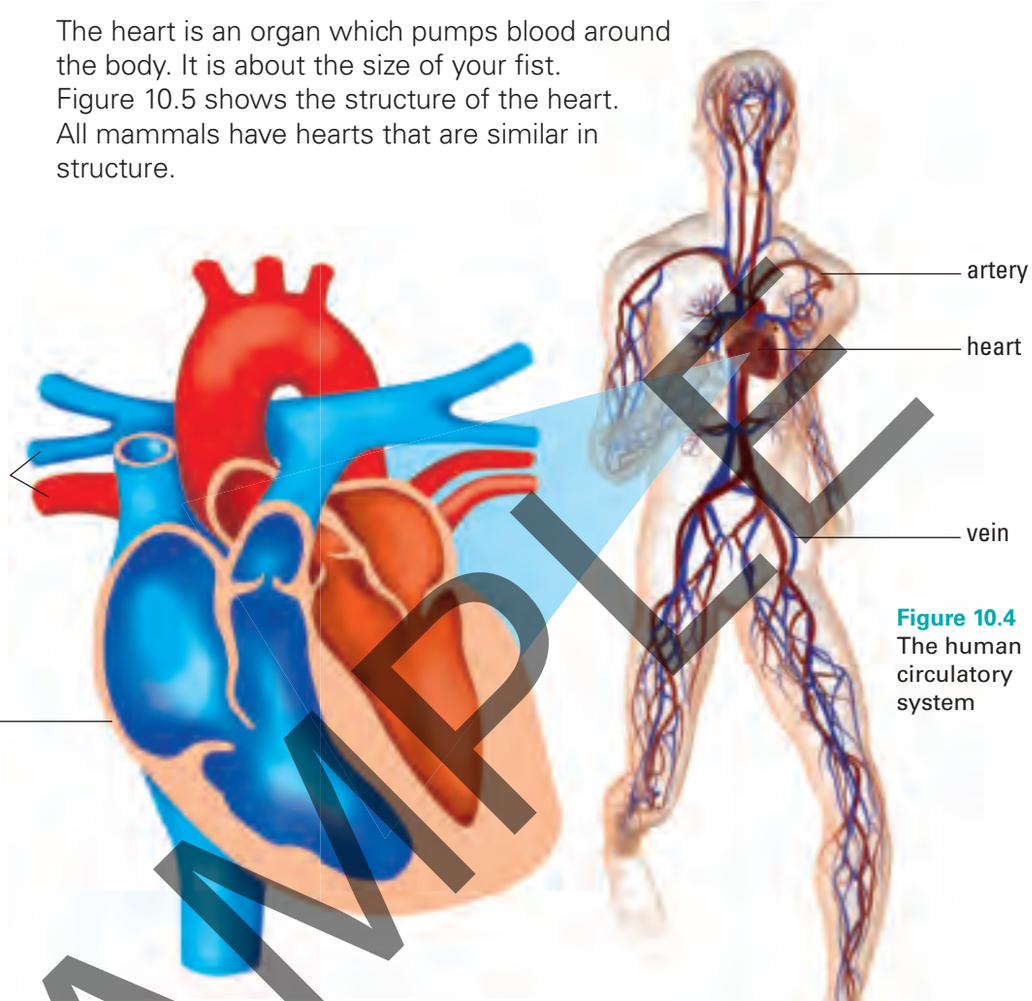


Figure 10.4 The human circulatory system

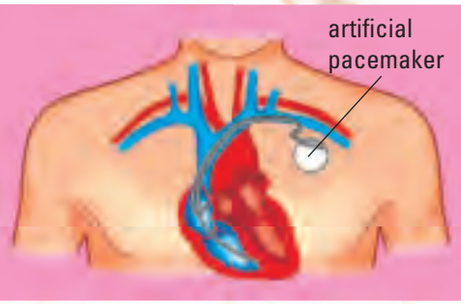
Figure 10.5 Cross-section of the human heart

Know it!

Helping the heart to function

Sometimes the heart fails to beat properly.

To help the heart, a device called an **artificial pacemaker** is placed in a person's chest and connected to the heart. A battery in the pacemaker produces a small electric current to keep the heart beating regularly.



Investigate it!

The beating heart

Carry out an Internet search for more information on the heart and to see the movement of the heart.

Search terms: ***heart, movement, animation***

What is the role of the blood vessels?

The heart pumps blood around the body. From the heart, blood circulates through the rest of the circulatory system in tubes known as the **blood vessels**.

Two types of blood vessels are arteries and veins. Arteries carry blood away from the heart while veins carry blood to the heart. Figure 10.6 is a simplified diagram of how blood circulates around our body.

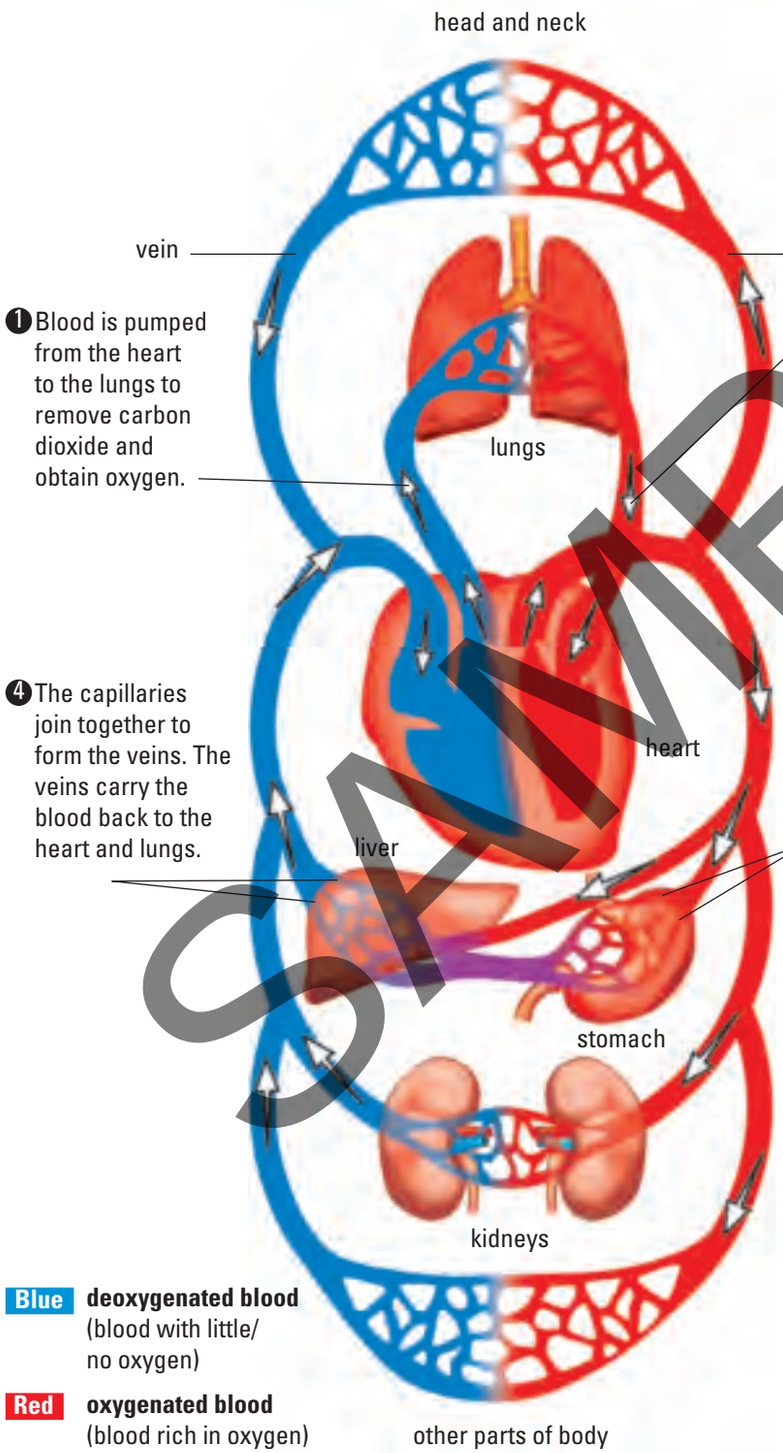


Figure 10.6 How blood circulates around our body

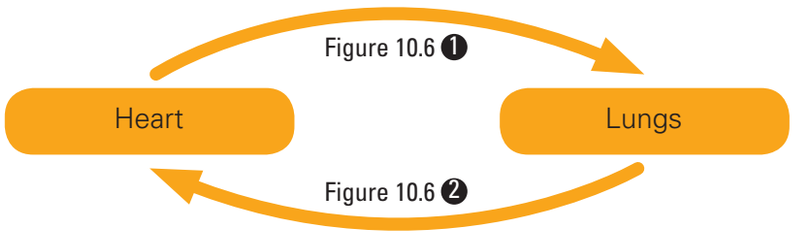
Link it
PW: Activity 10.1

Think About it!
The human transport system is also called the circulatory system. Explain. **[analysing]**

Know it!
If all the capillaries in a human body were taken out and joined together, they would go around the world twice!

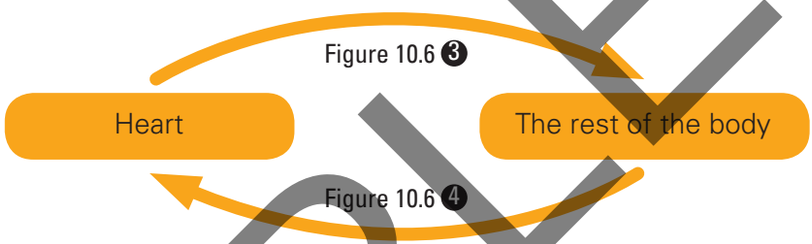
In Figure 10.6, we also see that blood circulates in two paths.

- From the heart to the lungs and back to the heart



In the lungs, blood collects oxygen and releases carbon dioxide. The blood is now rich in oxygen and is called **oxygenated blood**.

- From the heart to the rest of the body and back to the heart



Blood carries oxygen to the rest of the body. After the blood has given up its oxygen to all the cells, it will have little oxygen. This blood is called **deoxygenated blood**.

Mystery Clue

Describe what happens to the salt solution once it enters the blood of Dr Latta's cholera patients.

All working together

The three parts of the circulatory system must work together for the whole system to work properly. If one part does not work well, the whole system will be affected. For example, if the heart stops pumping, no blood will flow and the person will die!

The circulatory system also works with other body systems in the following ways.

- Food passes from the **digestive system** into the blood. Oxygen is taken in by the lungs (the main organs in the **respiratory system**) and enters the blood. The **circulatory system** carries the food and oxygen to all cells of the body.
- The circulatory system also takes waste substances from the cells to the lungs and kidneys, which are part of the **excretory system**, where they are removed from the body. We will learn more about these waste substances in Chapter 11.

Link it
Section 11.4: Human digestive system
TW: Exercise 10.1

Think About it!

Give an example of what would happen to the body if one part of the circulatory system is not working. **[predicting]**

GOT it?

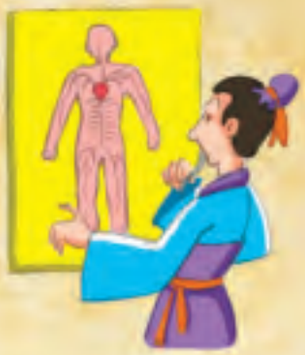
1. Name the parts of the circulatory system and state a function of each.
2. Describe the movement of the blood around the body.
3. Give two examples of how other systems in the human body work with the circulatory system.

The Discovery of the Circulation of Blood

1

From early times, people observed hearts and blood vessels. They saw that blood flowed when animals were killed.

2



In Chinese books written more than 4 000 years ago, there are descriptions of the blood moving through the heart and blood vessels.

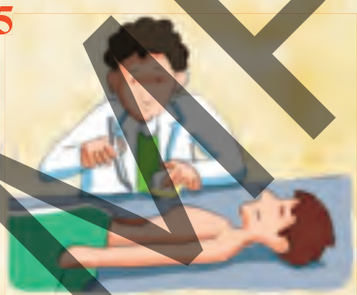
3

The Greeks thought that the heart controlled feelings like love and hate and that we could think with the heart. One Greek doctor cut up animals (mainly apes) and made many discoveries about the heart and blood vessels.

4

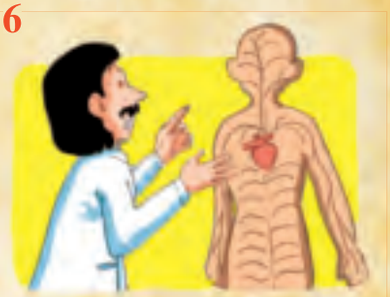
About 1600 AD, doctors in Italy found that blood in the veins flowed towards the heart.

5



William Harvey was an English doctor. He studied in Italy and later became a doctor to the King of England. Harvey used to do experiments by cutting up the bodies of animals and executed criminals.

6



In 1628, Harvey found how the blood circulates around the body. He also discovered that the heart works like a pump which forces blood through arteries, and that veins return this blood to the heart.

Investigate it!

William Harvey and the circulatory system

1. William Harvey discovered how blood circulates around the body. However, he needed to experiment on human bodies in the process. Do you think experimentation on human bodies, even dead bodies, should be allowed? List some points 'for' and 'against'.
2. On the Internet, carry out a search to find out more about William Harvey.

   Search terms: ***William Harvey***

Think! About it

1. Scientific knowledge on the circulation of blood can be used to bring benefits. Suggest an example of this.
2. Scientific knowledge comes partly from observation and experimentation. Give examples of each from the story.

[generating possibilities]

10.3 How Does the Plant Transport System Work?

Think About it

1. How is the plant transport system similar to the human transport system? How is it different?
2. The parts of the plant transport system work together. What will happen to the cells and the plant if one of these parts does not work properly? Give an example.

[comparing, analysing]

Like animals, flowering plants also need a transport system. This transport system is used to carry water, minerals and nutrients to all cells in the plant. The transport system is made up of vessels in the roots, stems and leaves.

There are two types of vessels in a flowering plant. They are the **xylem** and the **phloem**. In many flowering plants, the xylem and phloem run side by side forming bundles called vascular bundles. Figure 10.7 describes the movement of substances through the xylem and phloem of a plant.

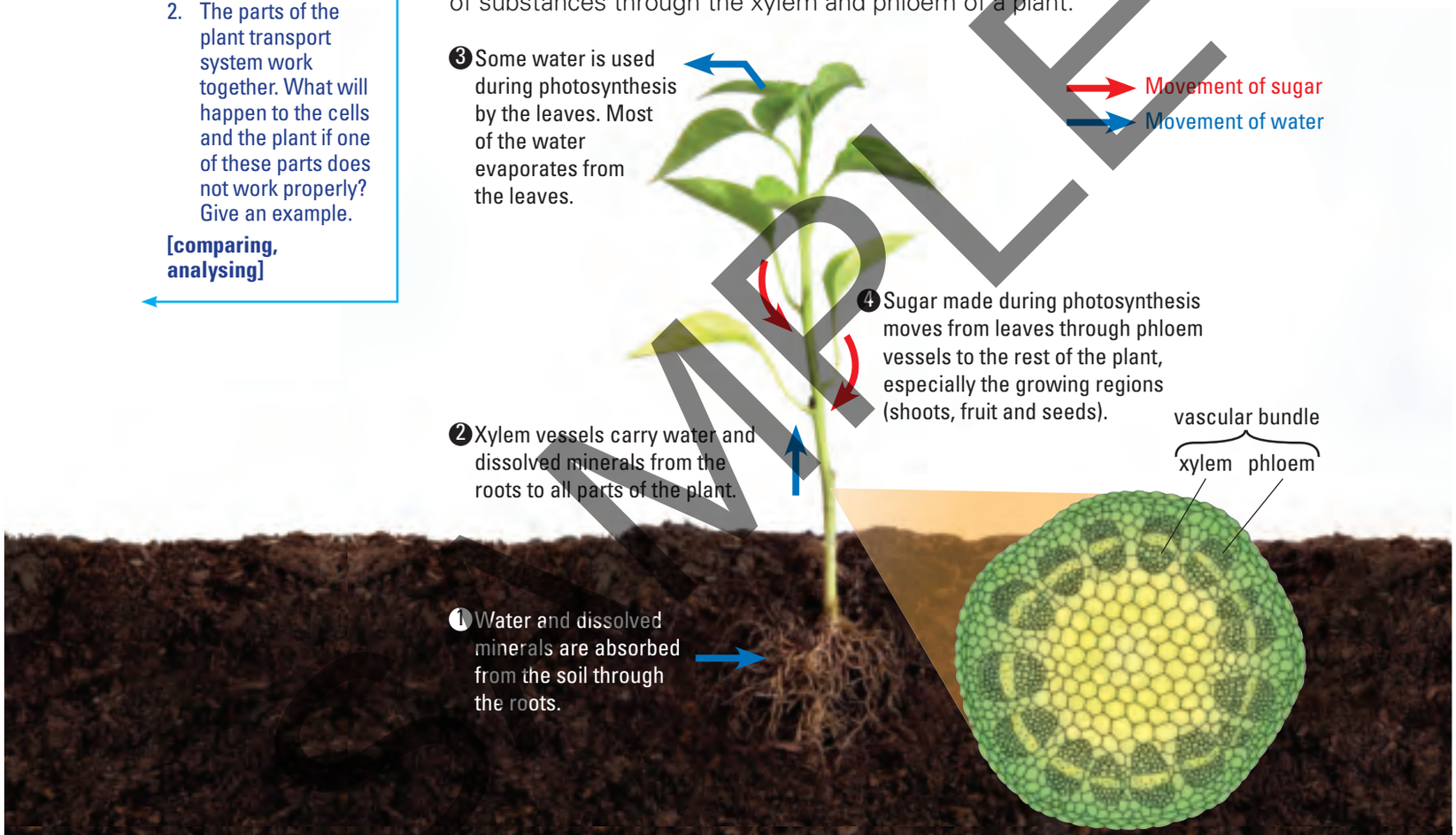


Figure 10.7 The transport system in a flowering plant ensures that all parts of the plant receive water, mineral salts and sugar.

The xylem and phloem work together to ensure that all cells in the plant get the necessary sugar, water and minerals. If one part does not work properly, the cells will not get the nutrients they need and the plant will die.

Link it

Section 6.3: Plant tissues
TW: Exercise 10.2
PW: Activity 10.2

GOT it?

(a) Name three kinds of substances that plant cells need.
(b) Which parts of the plant transport system carry these substances to the cells?

10.4 How Do Substances Move Into and Out of Cells?

Every cell in a living thing needs water and food to live. Most cells also need oxygen. At the same time, cells need to remove waste substances, such as carbon dioxide.

In this section, we will study two ways in which substances move into and out of cells — **diffusion** and **osmosis**.

What is diffusion?

Diffusion is the overall movement of molecules from a region of **higher concentration** to a region of **lower concentration**.

Look at Figure 10.8 to see how diffusion works when a drop of ink is added to water.

❶ The drop of ink contains many ink molecules (high concentration of ink molecules). The water does not have any ink molecules (low concentration of ink molecules).

❷ As the water and ink molecules move and mix, the water becomes blue in colour. The ink molecules have diffused, or moved from a region of higher ink concentration to lower ink concentration.

Link it
Section 7.1: Movement of molecules in gases and liquids

Figure 10.8 A drop of ink spreads through water due to diffusion.

Know it!

Word analysis

partially permeable:

partially = only a part, not all

permeable = able to move through

Mystery Clue

Unlike starch molecules, water and salt molecules are both small. What movement would take place in Figure 10.9 if salt and water were used instead of starch?

Link it

PW: Activity 10.3

Diffusion through a membrane

Diffusion can also take place through a membrane. Membranes have small holes (pores) that allow small molecules to pass through but not large molecules. As they do not allow all molecules to pass through, they are called **partially** (or **selectively**) **permeable membranes**.

One tube that has a partially permeable membrane is Visking tubing. Figure 10.9 shows Visking tubing containing an ink and starch mixture.

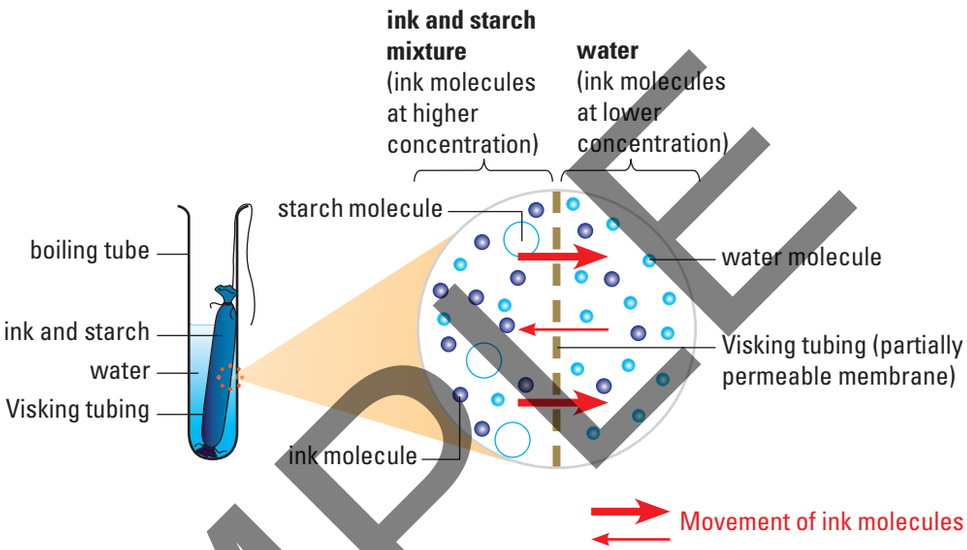


Figure 10.9 Diffusion through Visking tubing — only molecules smaller than the pores of the membrane can pass through

In this set-up, the starch molecules are too large to pass through the membrane.

The smaller ink molecules diffuse through the membrane, from inside the tubing into the water in the boiling tube. But as the particles are in constant motion, some of them will also diffuse back again. Thus, there is a two-way movement of ink particles across the membrane.

Overall, there is a net movement of ink particles from inside the Visking tubing to the water in the boiling tube. Eventually, both sides have the same concentration of ink particles.

What is osmosis?

Osmosis is a special kind of diffusion. It refers to the diffusion of water molecules only (and not other molecules) through a partially permeable membrane.

Osmosis is the overall movement of **water molecules** from a region of **higher water concentration** to a region of **lower water concentration** through a **partially permeable membrane**.

We can demonstrate osmosis using Visking tubing. Figure 10.10 shows Visking tubing containing a concentrated sugar solution.

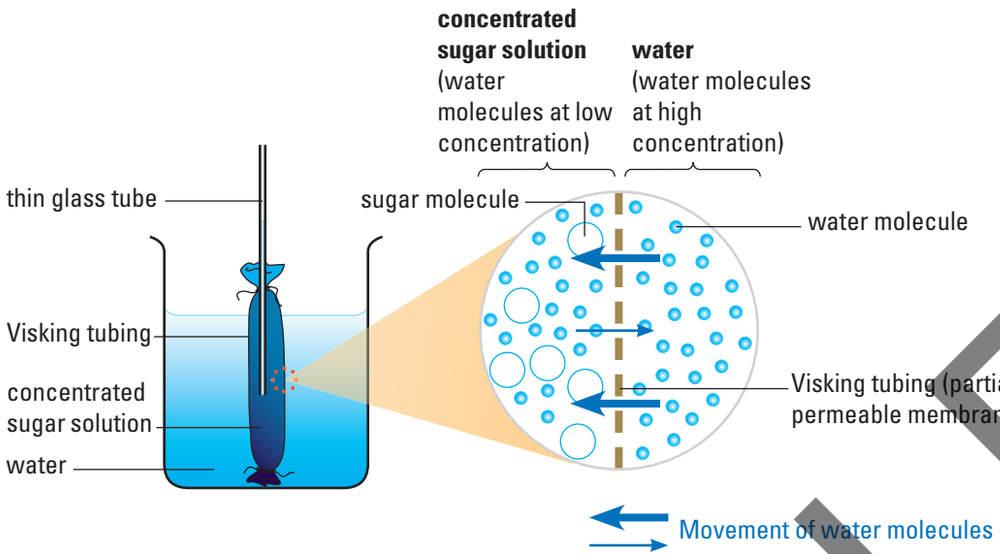


Figure 10.10 Osmosis through Visking tubing — only water molecules can pass through the membrane

In this set-up,

- the smaller water molecules, not the larger sugar molecules, can pass through the pores of the Visking tubing;
- the water concentration in the beaker is higher than that in the Visking tubing, hence more water molecules move from the beaker into the tubing; and
- the overall movement of water into the tubing causes the level of sugar solution to rise in the thin glass tube.

Know it!

Spraying fruit

Fruit are sometimes sprayed with water. By osmosis, the water moves into the cells on the surface of the fruit keeping them firm for a longer time.

Link it

PW: Activities 10.4 & 10.5

Investigate it!

Investigating membranes [CIT: explores possibilities and generates ideas]

You are given a few different materials — a piece of plastic, a piece of aluminium foil, a thin rubber sheet and a piece of cellophane. How would you show whether the materials are fully permeable, partially permeable or not permeable?

Diffusion and osmosis

Use the Internet to find and view animations of diffusion and osmosis.

Search terms: ***diffusion, osmosis, animation***

Mystery Clue

What might happen to the cells in the bodies of Dr Latta's patients if the solution contained [a] too much salt, or [b] no salt? Explain.

GOT it?

1. Define diffusion and osmosis. How are they (a) similar, and (b) different?
2. What is a partially permeable membrane?
3. << In Chapter 4, you learnt about reverse osmosis. How does osmosis differ from reverse osmosis? Present the differences in a table. >>

OPTIONAL FOR N(A)

10.5 Why Are Diffusion and Osmosis Important in Living Things?

All cells in living things have a cell membrane. Like Visking tubing, the cell membrane is partially permeable. It allows certain substances to move into and out of a cell.

In the human body

Link it
Section 11.4: Absorption in the small intestine

In the digestive system, small molecules of digested food diffuse through the walls of the small intestine into the bloodstream. In the lungs, oxygen from the air diffuses into the bloodstream.

The blood transports oxygen and food molecules to all the cells in the body. Oxygen moves out of the red blood cells and diffuses from the blood (where its concentration is higher) through the cell membranes into the cells (where its concentration is lower). Digested food molecules also diffuse into the body cells.

At the same time, waste products produced in the cells, such as carbon dioxide, diffuse in the opposite direction. Refer to Figure 10.11.

Think About it!
How is carbon dioxide able to pass from our body cells into the blood? **[inferring]**

Mystery Clue
Both the salt and the water injected into the cholera patients entered the body cells. Describe how this occurred. How did this help the patients recover?

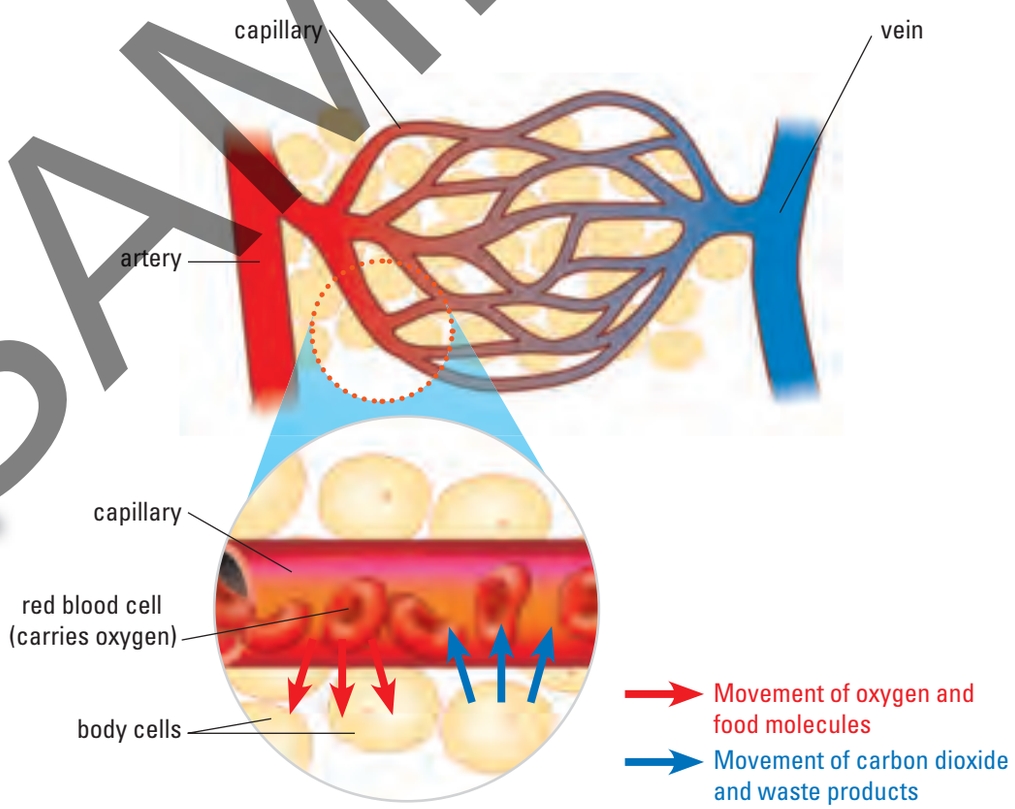


Figure 10.11 Diffusion occurs between the body cells and blood capillaries.

In flowering plants

Plants take in carbon dioxide from the air, and water and mineral salts from the soil.

Photosynthesis

During photosynthesis, carbon dioxide diffuses from the air into the cells of the leaves. The oxygen produced diffuses from the cells in the leaves into the air. These gases enter or leave the plant through the stomata (singular: stoma) on the surface of the leaves.

Absorption of water and minerals

Water and minerals enter a plant through root hairs. The root hairs are very small and thin, and grow mainly at the tips of the roots.

Absorption occurs in the following ways.

- Water enters the root hair cells by osmosis. This is because the concentration of water is higher in the soil than in the cell sap of the root hair cells.
- Dissolved minerals diffuse into the root hair cells when the concentration of minerals in the soil is higher than in the root hair cells.

The water and minerals then pass from one cell to the next through the root until they reach the xylem. The xylem then carries the water and minerals up the stem of the plant.

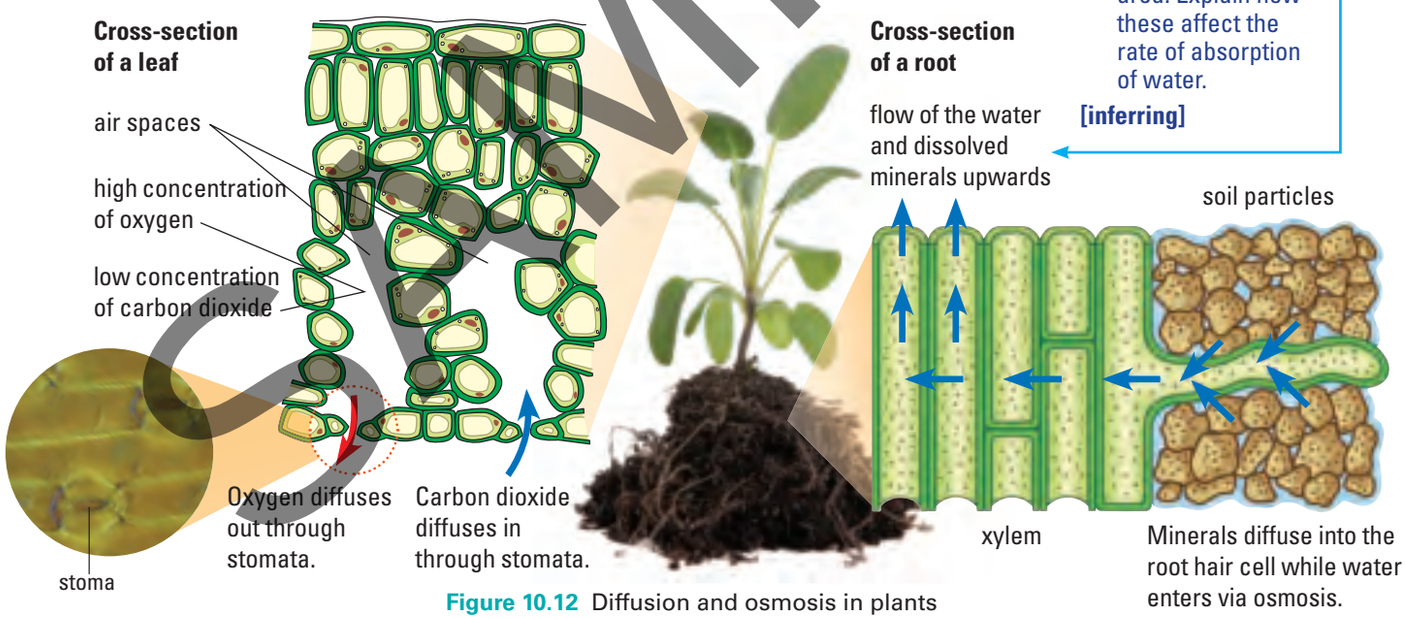


Figure 10.12 Diffusion and osmosis in plants

Know it!

Plant cell wall

The cell wall in a plant cell is fully permeable. This means it has pores that are larger than the pores in a cell membrane. The cell wall allows most substances to pass through it.

Think About it!

1. The carbon dioxide that enters a leaf is used up during photosynthesis. How does this enable more carbon dioxide to diffuse from the air into the leaf?
2. The roots of a plant have many root hairs and a large surface area. Explain how these affect the rate of absorption of water. **[inferring]**

Got it?

1. Give examples and describe how diffusion helps in the transport of substances
   (a) in the human body, and
   (b) in flowering plants.
2. Give examples and describe how osmosis helps in the transport of substances in flowering plants.
3. Describe how water moves through a plant.

Link it

TW: Exercise 10.3

Read it!

Dialysis and the Kidney Dialysis Machine

The kidneys in the human body are part of the excretory system. All the blood in the body passes through the kidneys where waste substances are removed and passed out of the body in the urine. If a person's kidneys do not work properly, waste is not removed from the circulatory system. The person may be poisoned by waste circulating in the blood and die.

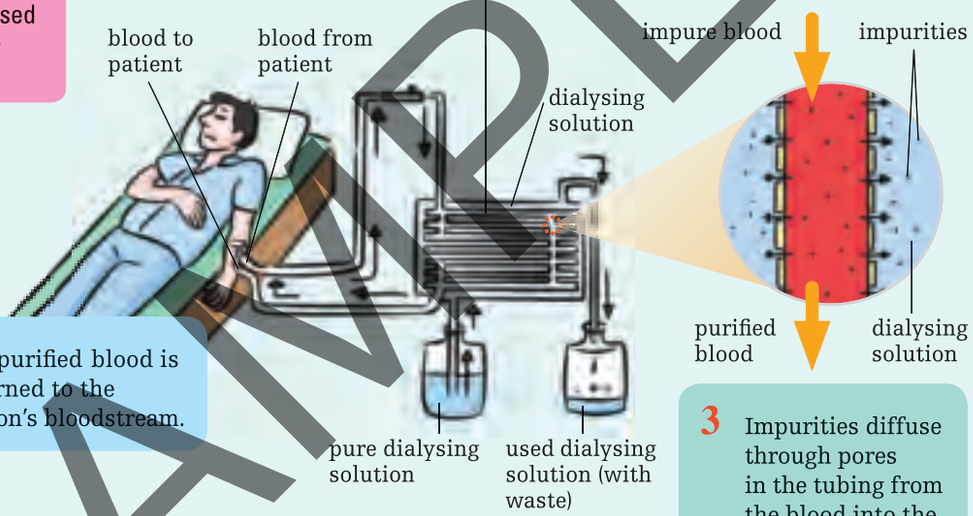
In such situations, a kidney dialysis machine may be used to 'clean' the blood three or four times a week (Figure 10.13).

Know it!

Singapore has the fifth highest incidence of kidney failure in the world. About 750 people are diagnosed with kidney failure each year.

1 Two tubes are placed into the blood vessels in the arm.

2 Blood from the body flows through a partially permeable tubing which is immersed in a bath of dialysing solution (salt solution).



3 Impurities diffuse through pores in the tubing from the blood into the dialysing solution.

4 The purified blood is returned to the person's bloodstream.

Figure 10.13 A simplified description of how a kidney dialysis machine works

Instead of a kidney dialysis machine, doctors can replace a bad kidney with a healthy kidney from another person (kidney transplant). However, there is a shortage of donated kidneys. Patients may have to wait as long as four to six years for a suitable kidney. That is why people are encouraged to be kidney donors to save lives.

Investigate it!

Kidney dialysis and kidney donation in Singapore
[CIT: sound reasoning and decision-making]

Use the Internet or other sources to collect information about kidney dialysis and donation in Singapore. Then discuss the following questions.

1. What are some difficulties faced by kidney dialysis patients?
2. What are some advantages of a kidney transplant?
3. Would you consider becoming a donor when you are older?

Search terms: ***Singapore, kidney dialysis***

Solving the Mystery...

How did salt solution save the cholera victims?

To survive, the human body needs both water and salt. People who have cholera suffer from severe diarrhoea which causes them to lose these substances. When a salt solution is injected into their arms, the circulatory system carries it to all the cells in the body where it replaces the water and salt that have been lost.

However, the amount of salt in the solution must be just right. If it contains too much salt, more water leaves the cells by osmosis. The cells then shrink and die. If a weak salt solution or plain water is used, the opposite happens – water moves into the cells which then swell up and burst. In both cases, the patients may die. This movement of water is similar to the movement of water into and out of the potato cells you investigated in your practical work.

Today, Dr Latta's invention is used to treat patients with other illnesses. Medicines may be added to the salt solution. These are transported around the body to where they are needed. The photo on this page shows a patient receiving this treatment.

Link it
PW: Activity 10.5

Infer

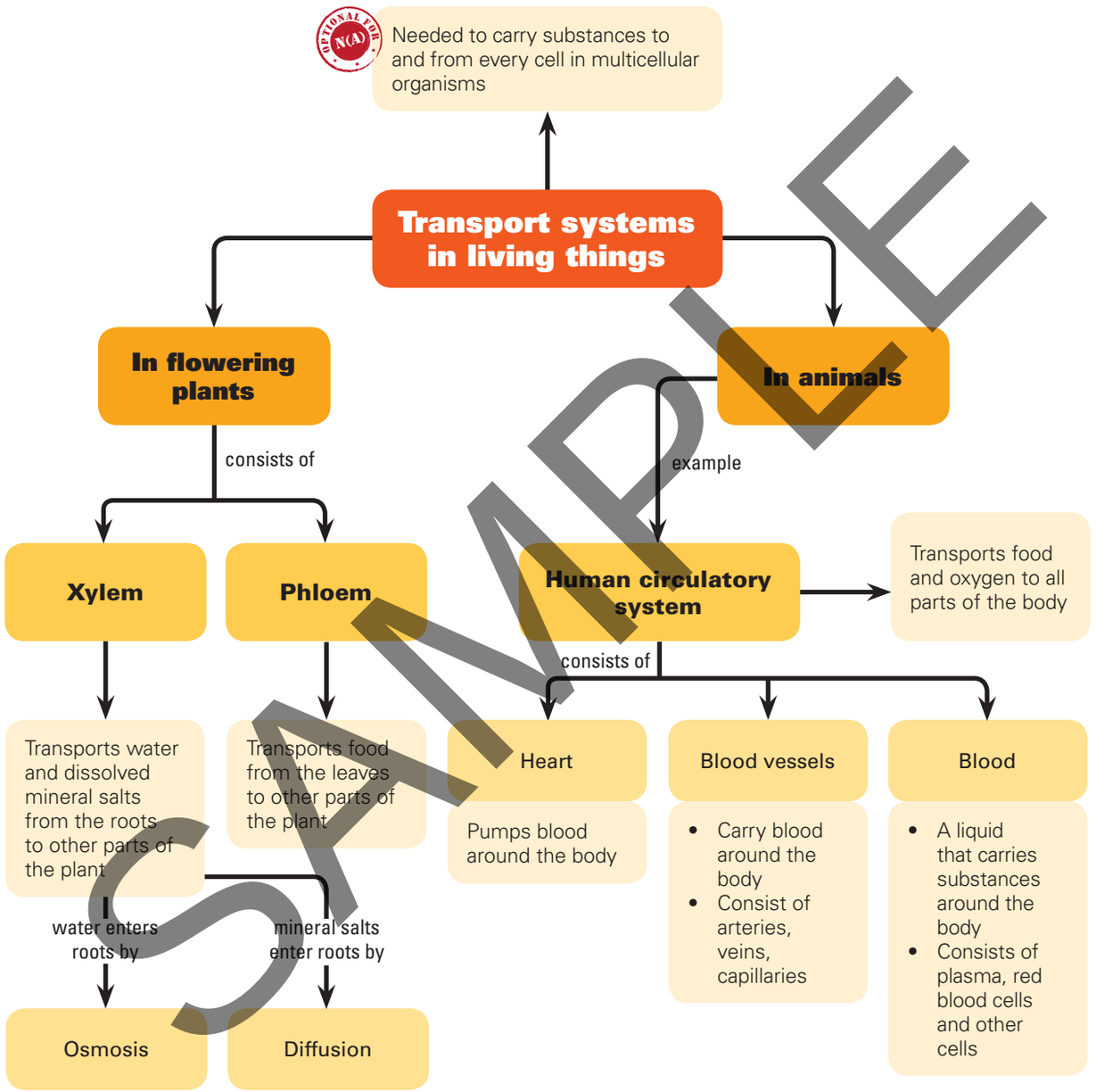
Today, cholera patients are often given a solution of salt [and glucose] in water to drink instead of being injected with the solution. What is an advantage of this?

Further thought

Drinking seawater is dangerous and can lead to death. Why is this so?

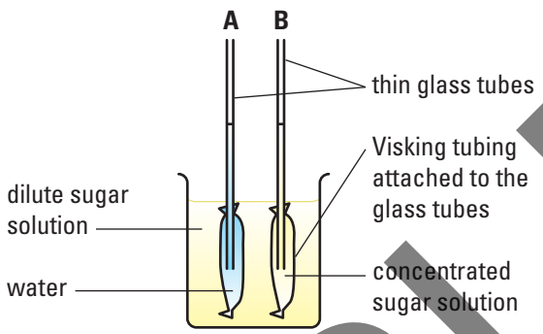
Chapter Review

Map it!



Apply it!

1. May sets up the apparatus shown in the diagram below. After about two hours, she observes the level of the liquid in the two tubes.



(a) The Visking tubing is a partially permeable membrane. Which particles, sugar or water, can move through the Visking tubing? Explain.
(b) (i) What will happen to the liquid level in Tube A?
(ii) Name the process that causes this change and explain how it happens.
(c) (i) What will happen to the liquid level in Tube B? Explain how it happens.
(ii) Is this caused by the same process as in Tube A? Explain.
[inferring, comparing]

2. During respiration in the human body, glucose and oxygen diffuse into cells from the blood while carbon dioxide and water diffuse from cells back into the blood.
(a) Through which part of cells does this diffusion take place?
(b) Briefly describe how glucose and oxygen enter the cells during respiration.
(c) Briefly describe how the carbon dioxide and water leave the cells.
[elaborating]

3. (a) (i) Which tissue in the stem of a flowering plant transports water and dissolved mineral salts from the roots to the leaves?
(ii) Name the process by which the water enters the roots.
(iii) Name the process by which the mineral salts normally enter the roots.
(b) Which tissue transports sugars from the leaves to other parts of the plant?
(c) State two things that happen to the water in the leaves.
(d) Name the process(es) by which substances move into the cells of the plant.
[elaborating]