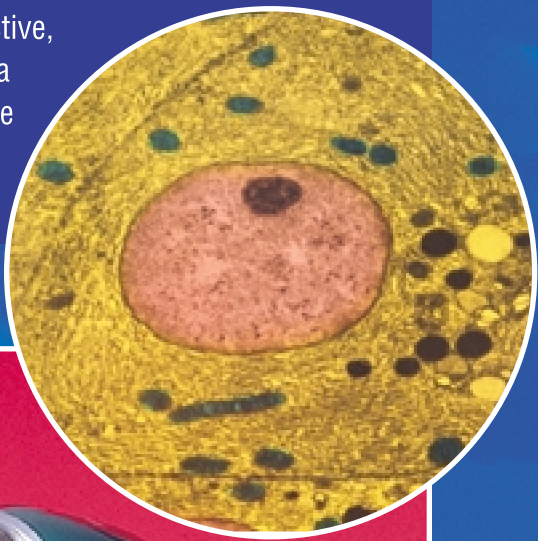
UNIT 2

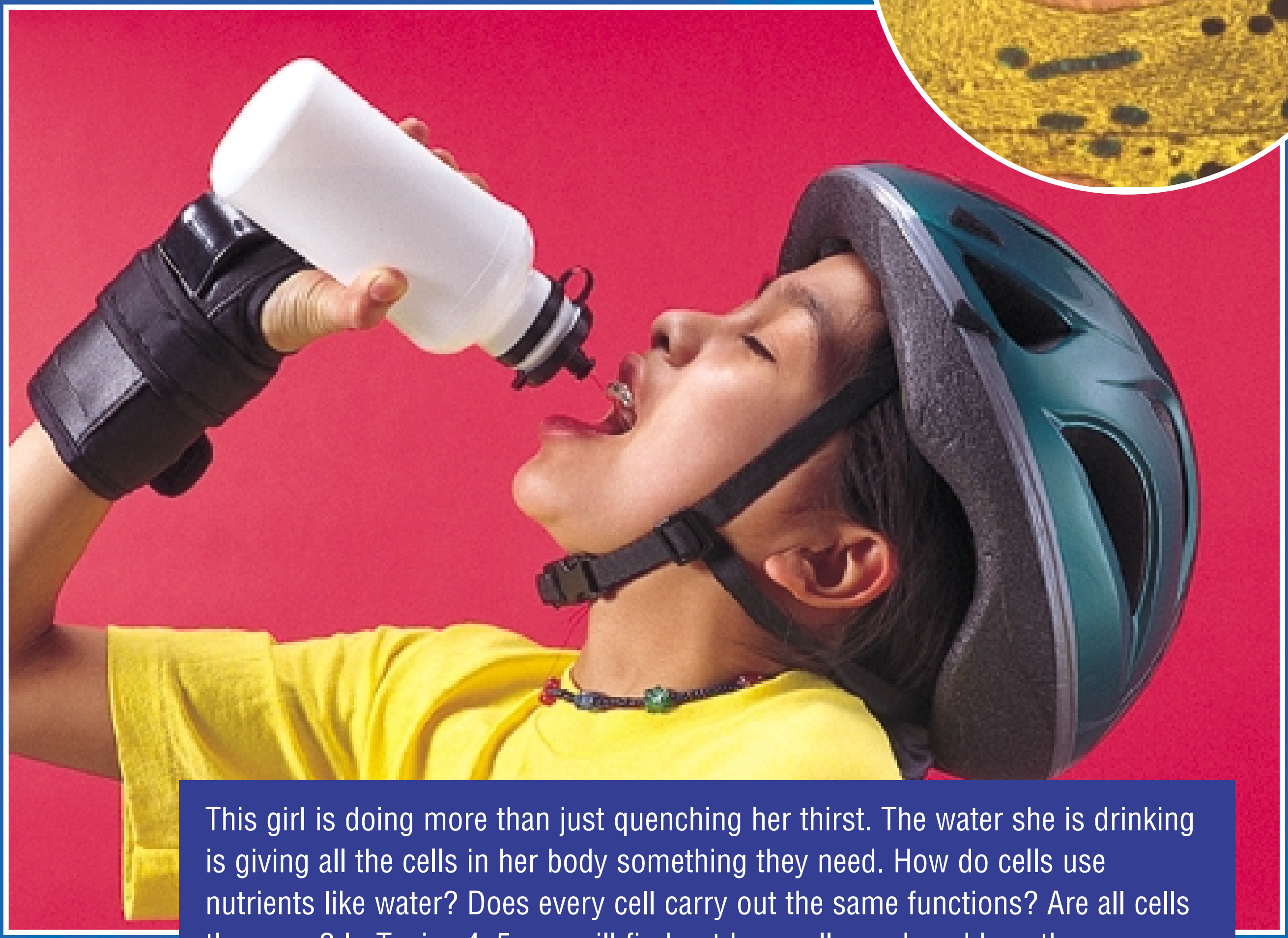
Preview

Focussing Questions

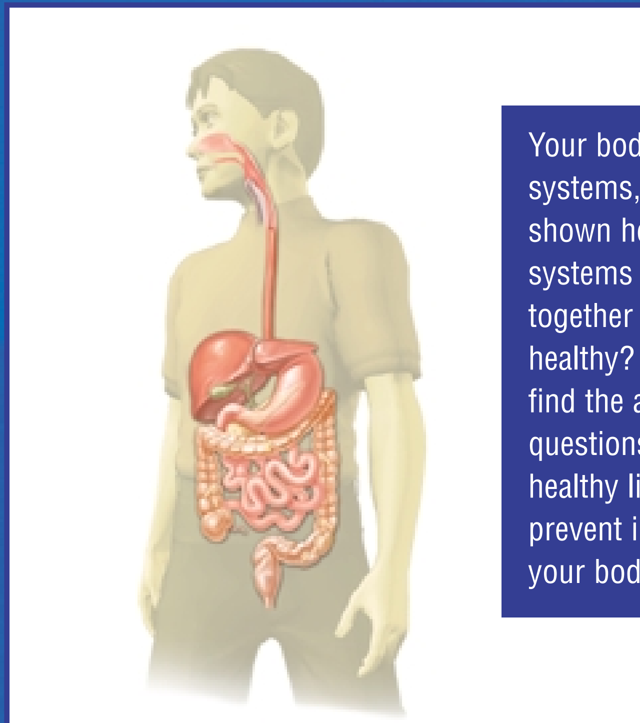
- What do living organisms have in common?
- How are cells organized to carry out different functions?
- How do systems work together to keep organisms healthy?

Why is a single cell like this one important to all living things, including you? What is inside a cell, and how were scientists able to finally "see" inside one? In Topics 1–3 you will discover what it means to be alive from a scientific perspective, and you will use a microscope to see the "invisible" world of cells.





This girl is doing more than just quenching her thirst. The water she is drinking is giving all the cells in her body something they need. How do cells use nutrients like water? Does every cell carry out the same functions? Are all cells the same? In Topics 4–5 you will find out how cells work and how they are organized to help organisms carry out their life functions.

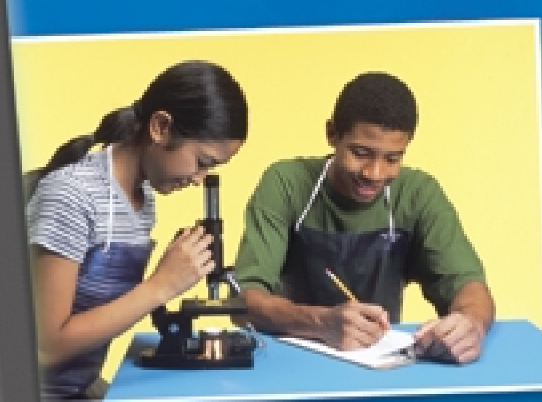


Your body is organized into systems, like the digestive system shown here. What do different systems do? How do they work together to keep you alive and healthy? In Topics 6–7 you will find the answers to these questions, and explore how healthy lifestyle choices can help prevent illness and disease in your body.

Looking Ahead

Read pages 166-167, Design Your Own Investigation. Here is a chance to display your skills in designing controlled experiments. You can start planning your investigation well in advance …

- Start sharing ideas with your teammates. Save all your ideas in an Experiment Planning file.
- Begin collecting the material you will need for your experiment.
- Think about how you might present your experimental results in a multimedia presentation.

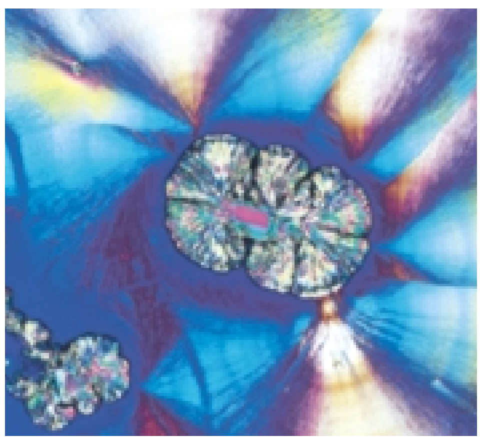


TOPIC 1

Living Organisms

Pause& Reflect

In your Science Log, make a list of characteristics you think are shared by all living organisms. Then share your list with a group of classmates. Make any changes to your own list based on the discussion.



Imagine that you are a scientist in the very early days of civilization. You observe all kinds of objects around you, and you begin to wonder about their similarities and differences. You wonder about the difference between yourself and these objects. You know that you are alive. What does this mean? How many of the objects pictured here are alive, and how do you know?

Movement is one of the signs that something is alive. Is it always a sign of life, though? A rock rolling down a hill moves, and it is certainly not alive. Perhaps you said that growth is a sign of life (and you would be correct), but crystals grow. Are they alive?

Living organisms can be found in all shapes and sizes. As different as they appear to be, they all have much in common. Some of the characteristics of living organisms that scientists agree on are:

- living organisms need energy
- living organisms respond and adapt to their environment
- living organisms reproduce
- living organisms grow
- living organisms produce wastes

Functions and Structures

All living organisms have to carry out certain functions to stay alive. To carry out these functions, organisms have different structures.

1. **Energy:** Animals get their energy from their food. What structures do different animals have to gather and use food? Most plants use the energy of the Sun to make their own food. What structures do plants have to make food?
2. **Environment:** Plants need light to make food, so they will bend toward a light source. What structures in plants enable them to move in this way? Raccoons feed at night, and deer feed during the day. They both use their eyes to see under very different conditions. In what ways are their eyes similar and different?
3. **Reproduction:** Living organisms reproduce so that life can continue. A wolf has pups. A watermelon has seeds. Do a wolf and a watermelon reproduce in the same way? What structures enable wolves to reproduce? What plant structures produce seeds?
4. **Growth:** A dandelion grows from a seed. What structures enable a plant to grow? You grew from a baby to your present size. What structures inside your body enabled you to grow? Why and how do all living organisms grow to the sizes they do?
5. **Wastes:** Animals get rid of waste gases like carbon dioxide. They also get rid of other wastes through urine and feces. What structures do they have to perform these functions? Plants also give off wastes as gases. What structures help plants do this?

Did You Know?

There are a few plants that get some of their energy from animals. Sundew plants photosynthesize just as other plants do, but they also capture tiny insects with the sticky droplets on their leaves. Nutrients from the rotting insects help the plant to grow.

Find Out ACTIVITY

Functions and Structures

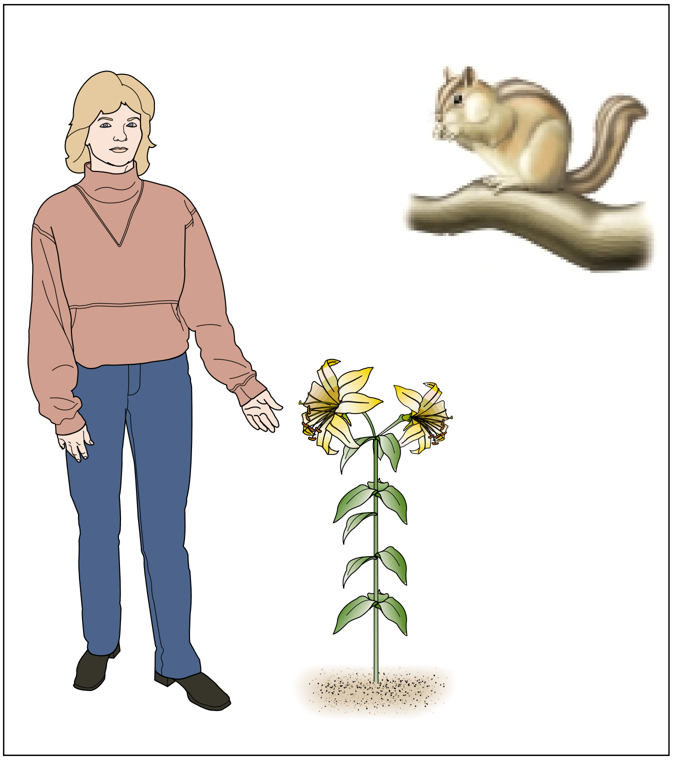
All living things must carry out the same functions. How do various organisms carry out their functions, and what structures do they use?

Procedure

1. Communication and Teamwork In your group, choose a function that all organisms carry out, such as getting food for energy. Each group member then chooses a different organism (an animal or plant) to find out how it carries out the function and the structures it has to do the task.
2. Performing and Recording Organize all the findings to show the comparison between the different organisms. You may use labelled diagrams, or another organizer of your choice. (To review graphic organizers, turn to Skill Focus 2.)

What Did You Find Out?

What general statement can you make about the relationship between structures and their functions?



Levels of Organization in Organisms

In the previous activity, you probably saw that organisms have very specialized structures to carry out their various functions. Does this mean that organisms like those shown here have nothing in common except these functions?

When scientists study anything, they try to find the similarities as a way of organizing their knowledge. Over many years of study, they have come to understand that most organisms have systems that perform certain functions to keep the organism alive.

Systems are made up of organs. Look at Figure 2.1A. The heart is a major organ of the human circulatory system. Which other organism shown here has a circulatory system and a heart?

Major organs such as the heart are made from tissues. These are groups of cells that perform similar functions. The basic unit of every system is the **cell**. For scientists, the cell is the feature that separates all forms of life from non-living things: All living organisms are made up of cells. The cell is the smallest thing that scientists consider to be alive. So the cell is another characteristic, and the most important biologically, that all plants and animals share.

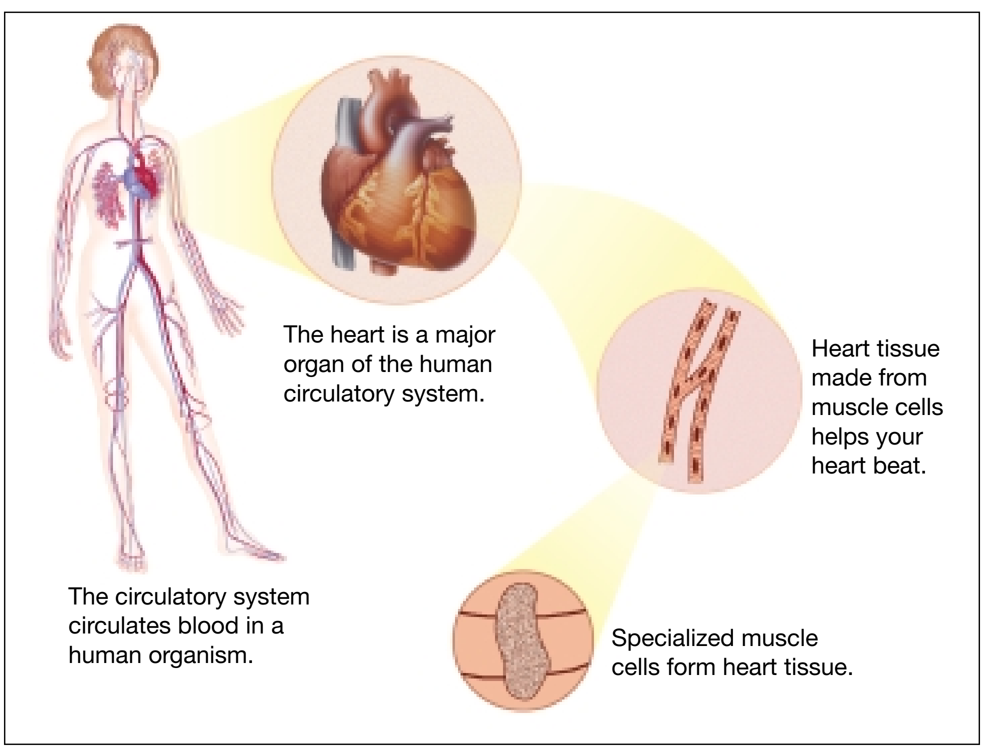


Figure 2.1A The human circulatory system

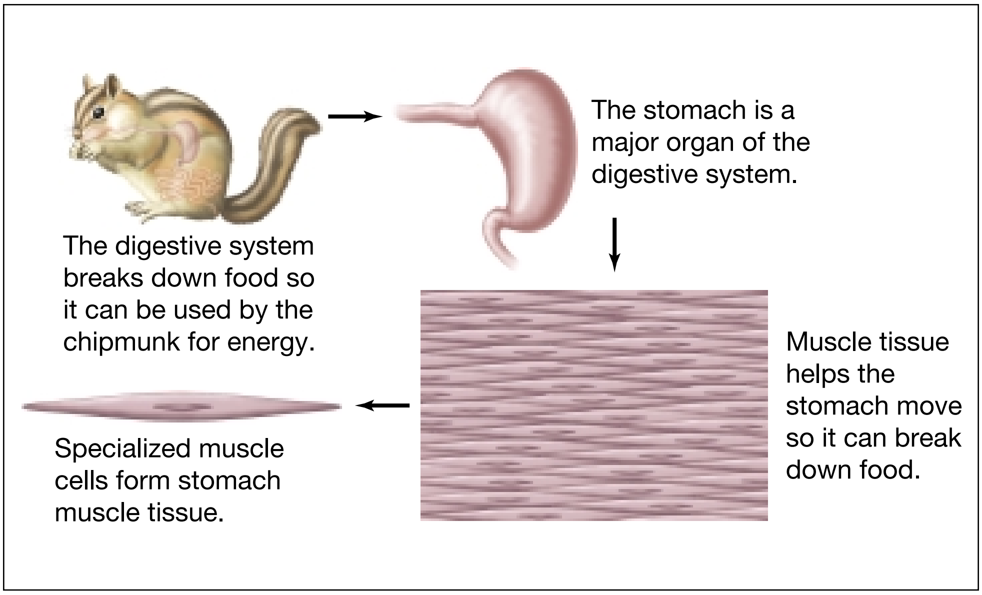


Figure 2.1B A chipmunk's digestive system

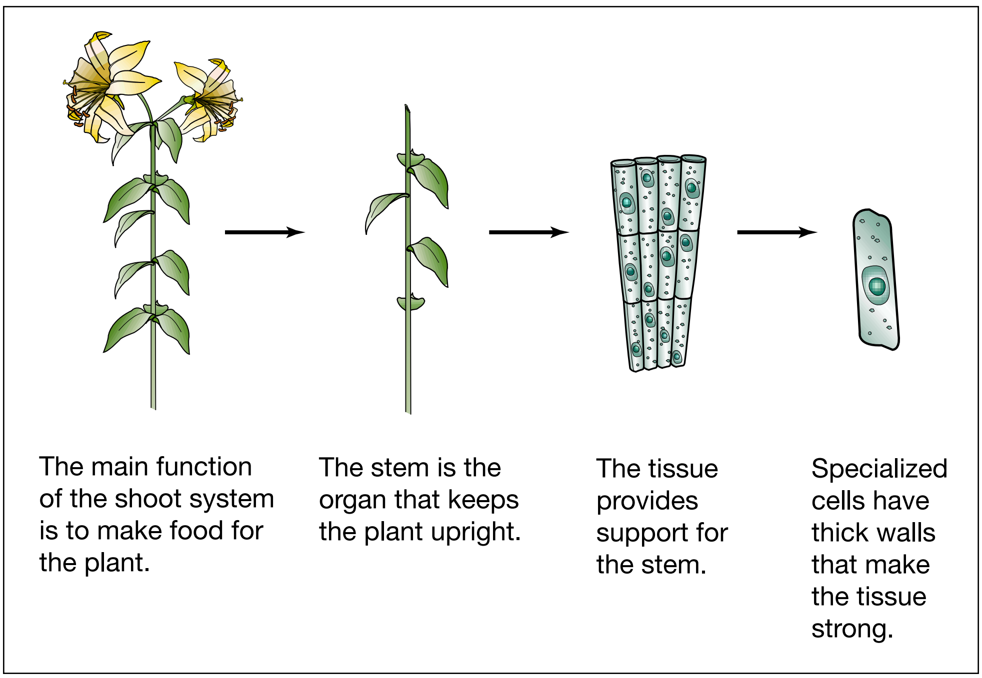


Figure 2.1C A plant's shoot system

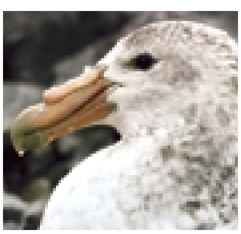
INTERNET CONNECT

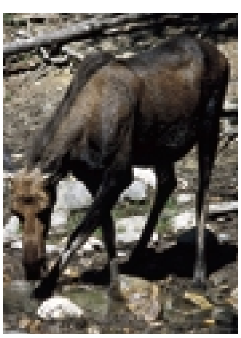
www.school.mcgrawhill.ca/resources/

How do scientists find out about plants' and animals' characteristics, structures, and life patterns and styles? For information on studies of organisms in Alberta, visit the above web site. Go to **Science Resources**, then to **SCIENCEFOCUS 8** to find out where to go next. Choose a study and prepare a report or other means of communication to explain the purpose of the study, its findings so far, and its final goals.

Off the Wall

Some animals get too much salt and some don't get enough. This seabird ingests salt every time it eats a fish. Its cells cannot function properly with all of that salt though, so its body gets rid of it by concentrating the salt and releasing it through the small tube on its beak. The cells of other animals, such as this moose, need more salt and they will often find it at salt licks, natural places where salt accumulates.





Cells Work Together

The pika is a small relative of the rabbit that lives only in the alpine areas of western North America, including Alberta and B.C. The pika is made of millions of cells that work together to help it perform its various activities. The cells in the pika's body — as in all living organisms — are organized in particular ways. The habits and environment of the animal will often direct the ways that cells are organized.

For example, pikas eat only plants. Plants are quite hard to digest, so pikas have a special baglike chamber where chewed and semidigested food collects. Here, tiny bacteria break down the food and help digest it. The way that a pika uses food differs a lot from the way you use food. The cells in a pika's digestive system are organized into different tissues and organs that help it digest plants. The cells in your body are organized into tissues and organs that help you digest a large variety of foods.

As you go through this unit you will learn more about how cells are organized and how they work together to keep organisms alive.

TOPIC 1 Review

1. Why might a biologist think that the cell is the most important characteristic of living organisms?
2. Name a characteristic of living things shown in each of these examples.
   (a) a cat purrs when petted
   (b) a robin eats a worm
   (c) a plant gives off oxygen
   (d) a runner sweats after a race
3. How are a dandelion and a deer alike? How are they different?
4. **Thinking Critically** A biologist from another galaxy might think that automobiles are a dominant form of life on planet Earth. Automobiles move, consume gasoline and oil, and produce wastes. They are sheltered in garages and respond to stimuli. Automobiles age and break down, but new automobiles appear every year. They evolve, changing in appearance from year to year. What arguments would you use to persuade the alien visitor that cars are not alive?

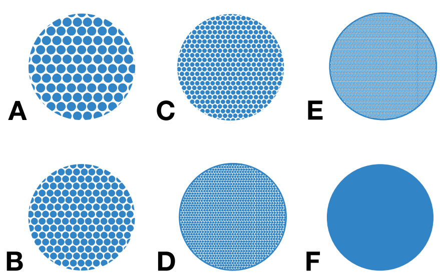
TOPIC 2 Microscopes and Cells

How do you enlarge something too small to be seen with the unaided eye? You do it in the same way that the student's face has been enlarged in the photograph. **Magnifying** an object makes it appear larger.

In this photograph, the student's face has been enlarged, or magnified, by the water-filled flask.

A World Too Small to See

There are living things around you that you cannot see. The human eye can see only objects that are larger than 0.1 mm. Look at the circles of dots shown below. In the first circle, you can probably see individual dots. In which circle does the colour appear solid? Is the colour really "solid" or is it, too, made up of dots? Separate dots must be more than 0.1 mm apart in order for most of us to see them.



Find Out ACTIVITY

What Does It Take to Enlarge an Object?

For how long have people tried to magnify objects? Two thousand years ago, early Romans used water-filled vessels to magnify objects that they were engraving. Test a similar magnifying technique in this activity.

Materials

bottles, jars, flasks of different shapes, water, textbook

Procedure ✸ Performing and Recording

1. Fill your containers with water and hold them in front of a page in your textbook, one at a time.
2. Move each container to different positions — closer to the page, further away, up, down, to the sides — to see if this changes how the print looks on the page.

What Did You Find Out? ✸ Analyzing and Interpreting

1. Which container magnified the print the most? Draw a lens that is in the shape of this container.
2. What happened as you moved the containers around?
3. Were the images of the print always right-side up?

Early Microscopes

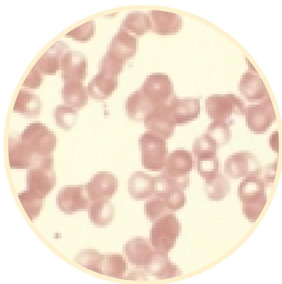


Figure 2.2 Leeuwenhoek was the first to see red blood cells such as these (160×).

Early scientists used their knowledge of magnification to see the invisible world of micro-organisms. One of these was a Dutch linen merchant named Anton van Leeuwenhoek (1632–1723). His hobby was making magnifying lenses. With his great skill at grinding very small lenses, Leeuwenhoek made instruments called **microscopes**, which magnified objects up to 300 times (300×). Using his simple microscopes, Leeuwenhoek studied substances such as blood (see Figure 2.2), pond water, and matter scraped from his teeth. He became the first person to observe organisms made of only one cell. He called these single-celled organisms "animalcules."

About the same time that Leeuwenhoek was making his observations in Holland, the English scientist Robert Hooke (1635–1703) was experimenting with microscopes he had built, like the one in Figure 2.3. Hooke looked through his microscope at a thin piece of cork that he had cut from the bark of an oak tree. He saw a network of tiny box-like compartments that reminded him of a honeycomb. He described these little boxes as *cellulae*, meaning "little rooms" in Latin. Hooke's descriptions have given us our present-day word "cell."

Cells in All Living Things

Over the next century, many other scientists used microscopes to study micro-organisms and to look at different parts of plants and animals. They saw cells in every living thing they examined. In 1839 German botanist Matthias Schleiden and zoologist Theodore Schwann combined their observations. They made the hypothesis that all organisms are composed of cells. A cell is the basic unit of life, they suggested, because all the functions carried out by living things are carried out by their individual cells, as well.

German scientist Rudolf Virchow contributed his ideas to those of Schleiden and Schwann. Their ideas formed the basis for a set of hypotheses called the cell theory. Two important points of this theory that you will learn about in this unit are:

- All living things are composed of one or more cells.
- Cells are the basic units of structure and function in all organisms.

You will explore more about the cell theory in later studies.

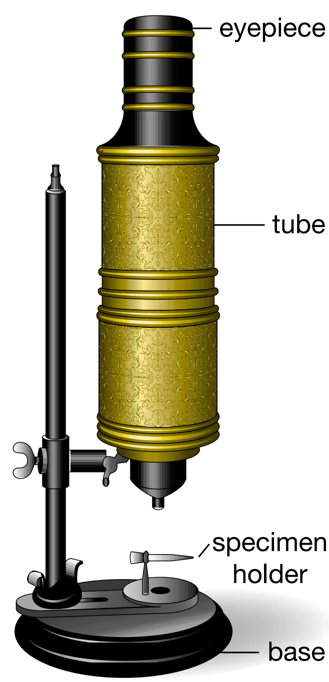


Figure 2.3 Hooke's microscope

Figure 2.4A A compound light microscope

Figure 2.4B A scanning electron microscope (SEM)

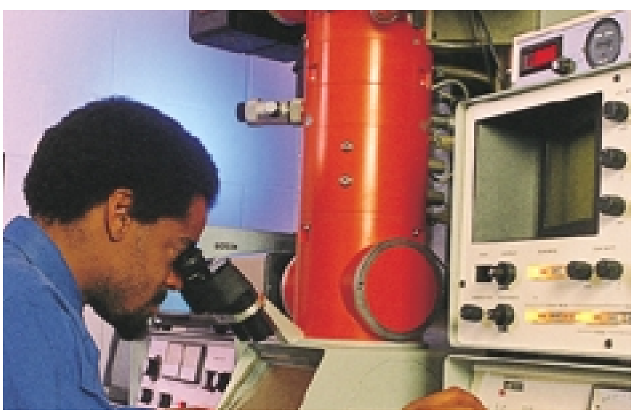


Figure 2.4C A transmission electron microscope (TEM)

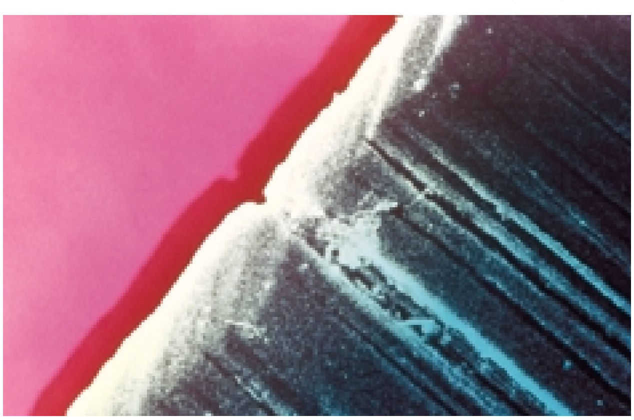


Figure 2.4D The edge of a razor blade as seen under an electron microscope.

Microscopes Today

Improvements in technology and design gradually led to the development of modern compound light microscopes, such as the ones in your school. Compound light microscopes have two lenses, which give a greater power of magnification.

The best light microscopes can magnify objects as much as 2000×. This is still not enough, though, to see some of the smaller structures inside cells. For this, scientists use electron microscopes, which use beams of electrons instead of light. The electrons are bounced off the sample, then enlarged to form an image on a television screen or photographic plate. The first electron microscope was built in Germany in 1932. It could magnify up to 4000×.

A Valuable Tool

In 1938, the first practical electron microscope was developed by two Canadians at the University of Toronto: James Hillier of Brampton, Ontario, and Albert Prebus of Edmonton, Alberta. To test their valuable new laboratory tool, they first looked at the edge of a razor blade. Under a light microscope, the magnified blade edge appeared relatively smooth. Under their electron microscope, however, the same edge looked like a mountain range of rugged peaks and valleys. This electron microscope could magnify up to 7000×. Today's electron microscopes can magnify up to 2 000 000×.

Both light and electron microscopes are used extensively today by scientists, engineers, and medical researchers. Look on page 114 to see some images these microscopes can produce.

Your investigations in this unit begin with an introduction to effective microscope use. With these skills, you too will be able to explore the microscopic world around you.

INQUIRY

INVESTIGATION 2-A

SKILLCHECK
- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Using a Microscope

In this investigation, you will learn about the different parts of a compound microscope and how to use them. Then you will look at some prepared microscope slides provided by your teacher. Practise drawing what you observe through the microscope. In this investigation, you will also find a way to estimate the size of microscopic objects. With these skills, you will later be able to study cells from plants and animals, and observe live microscopic organisms such as those first seen by Leeuwenhoek.

Part 1

The Compound Light Microscope

Question

What are the parts of a microscope?

Procedure

1. Study the photograph of the compound light microscope. Learn the names and functions of the different parts of the microscope.

2. Before going on to Part 2, close your book, and draw and label as many parts of the microscope as you can.

A Eyepiece (or ocular lens)
The part you look through. It has a lens that magnifies the object, usually by 10 times (10×). The magnifying power is engraved on the side of the eyepiece.

B Tube
Holds the eyepiece and the objective lenses at the proper working distance from each other.

C Coarse-adjustment knob
Moves the tube or stage up or down to bring the object into focus. Use it only with the low-power objective lens.

D Fine-adjustment knob
Use with medium- and high-power magnification to bring the object into sharper focus.

E Arm
Connects the base and tube. Use this for carrying the microscope.

F Revolving nosepiece
Rotating disk holds two or more objective lenses. Turn it to change lenses. Each lens clicks into place.

G Objective lenses
Magnify the object. Each lens has a different power of magnification, such as 4×, 10×, and 40×, or 10×, 40×, and 100×. The magnifying power is engraved on the side of each objective lens. Be sure you can identify each lens. For example, the low-power objective lens is usually 10×.

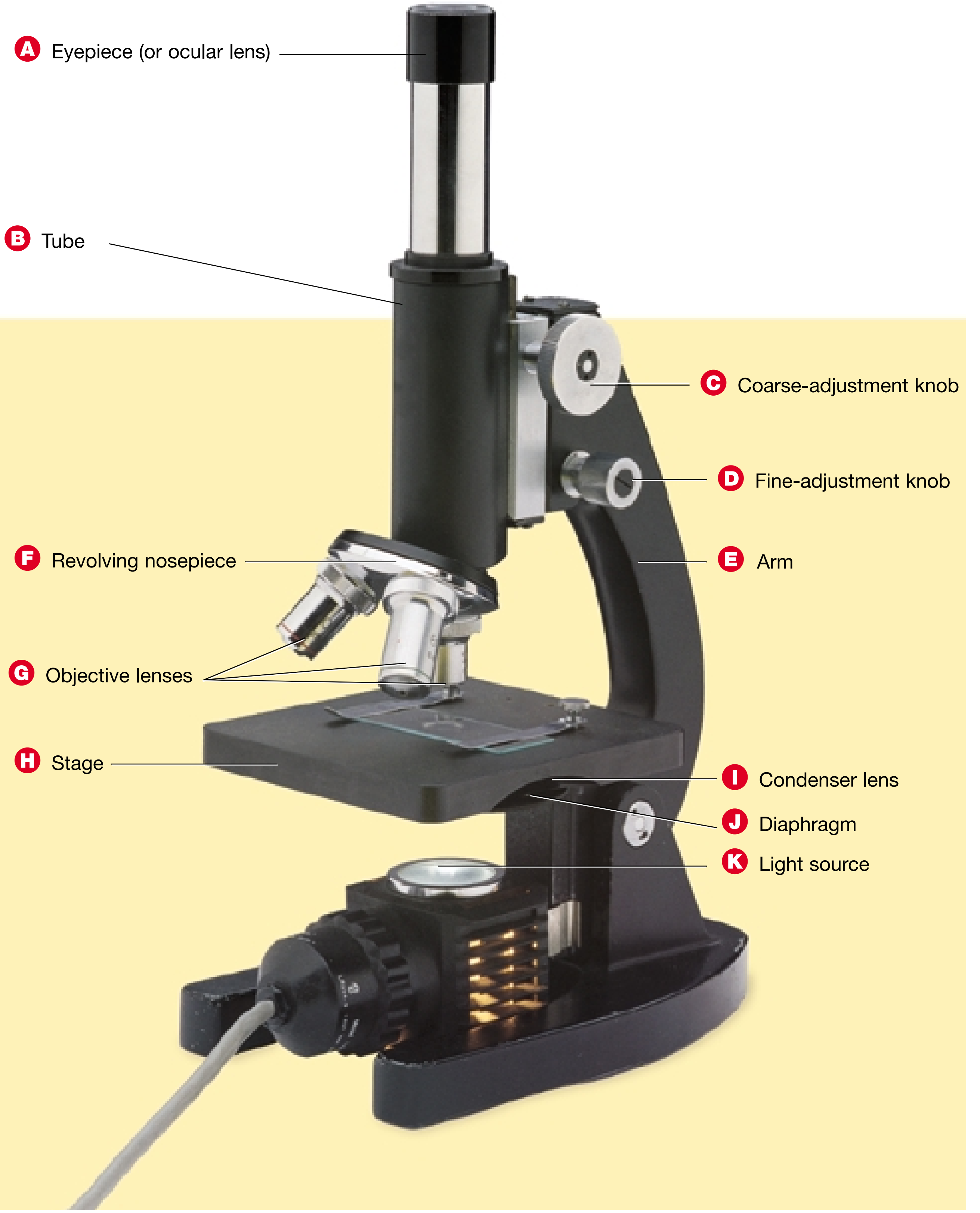
H Stage
Supports the microscope slide. Clips hold the slide in position. A hole in the centre of the stage allows the light from the light source to pass through the slide.

I Condenser lens
Directs light to the object being viewed.

J Diaphragm
Use this to control the amount of light reaching the object being viewed.

K Light source
Shining a light through the object being viewed makes it easier to see the details. (Your microscope might have a mirror instead of a light. If it does, you will adjust it to direct light through the lenses.)

Parts of a Compound Light Microscope



CONTINUED

Part 2

Using Your Microscope

Question

What is the proper way to use and care for a microscope?

Apparatus

microscope
prepared microscope slides

Materials

lens paper

Safety Precautions

- Be sure your hands are dry when you plug in or disconnect the cord of the microscope.
- Handle microscope slides carefully so that they do not break or cause cuts or scratches.

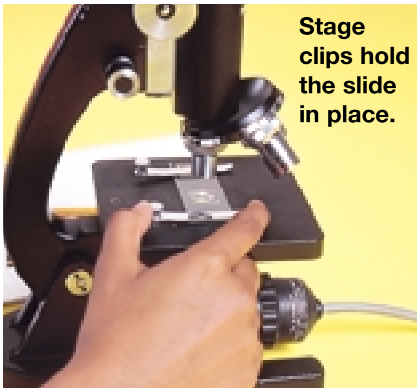
Procedure

1. Now that you know the parts of the microscope, you are ready to begin using it. Carry your microscope to your work area. When carrying a microscope, hold it firmly by the arm and the base, using both hands.
   - **(a)** Position the microscope at your work area with the arm toward you. If the microscope has an electric cord for the light source, make sure the cord is properly connected and plugged in.
   - **(b)** Use lens paper to clean the lenses and the light source (or mirror). Do not touch the lenses with your fingers.
   - **(c)** Do not turn any knobs until you have read through the rest of the Procedure.

2. The microscope should always be left with the low-power objective lens in position. If it is not, rotate the revolving nosepiece until the low-power objective lens clicks into place.
   - **(a)** Looking from the side, use the coarse-adjustment knob to lower the objective lens until it is about 1 cm above the stage.
   - **(b)** Look through the eyepiece (ocular lens) and adjust the diaphragm until the view is as bright as you can get it.

Skill FOCUS

To learn how to make accurate scientific drawings, turn to Skill Focus 11.



3. Place a prepared slide on the stage. Make sure the sample (object to be viewed) is centred over the opening.
   - **(a)** Look through the eyepiece and slowly turn the coarse-adjustment knob until the sample is in focus.
   - **(b)** Use the fine-adjustment knob to sharpen the focus.
   - **(c)** Adjust the diaphragm to a setting that shows the most detail.
   - **(d)** While looking through the eyepiece, move the slide a little to the left. **Observe** in which direction the image moves. Move the slide a little away from you and then toward you. **Observe** what happens to the image.

4. Find a part of the sample that interests you and, in your notebook, **sketch** what you see. Start by drawing a circle to represent the area you see through your eyepiece. This area is called the field of view. Make sure the details in your drawing fill the same space in the circle as they do when viewed through the microscope.
   - **(a)** Label your drawing to identify the sample.
   - **(b)** Calculate the magnification you are using. To do this, multiply together the magnifying power of the objective lens and the magnifying power of the eyepiece lens. **Record** this result on your drawing. **Example:** A 10× eyepiece and a 4× objective give a total magnification of 40×.

5. To see more details, rotate the revolving nosepiece to the next objective lens. **Do not change the focus first.** After the medium-power objective lens has clicked into place, adjust the focus using only the fine-adjustment knob.

   CAUTION Do not use the coarse-adjustment knob with the medium- or high-power objective lens.
   - **(a)** When you have finished viewing and drawing the sample, remove the slide and return it to the proper container.
   - **(b)** If you do not continue to Part 3, carefully unplug the microscope and return it to the storage area.

CONTINUED

Part 3

Measuring the Field of View

Question

How can the actual size of a microscopic object be determined?

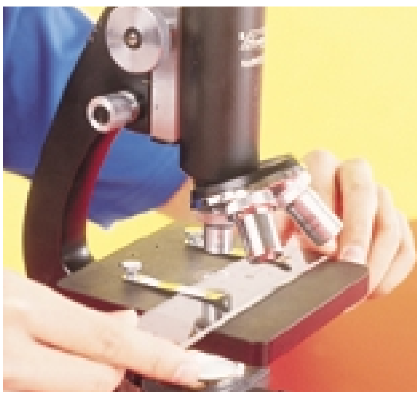
Apparatus

microscope
prepared microscope slides
transparent plastic ruler

Materials

lens paper

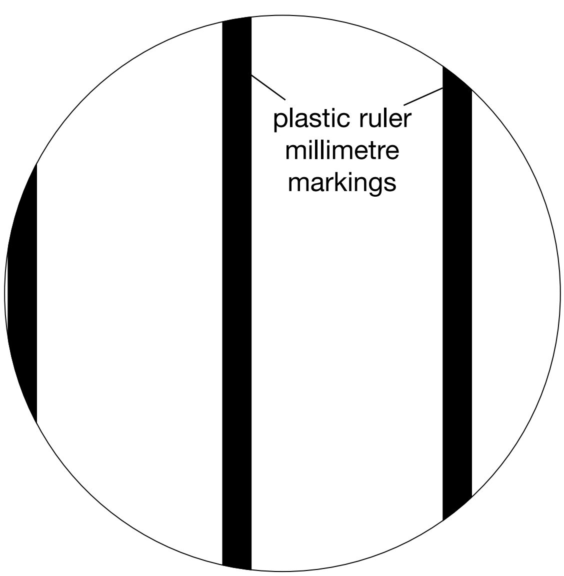
Procedure



1. Set your microscope to the low-power objective and place a clear plastic ruler on the stage.

2. Focus on the ruler and move it so that one of the centimetre markings is at the left edge of the field of view.

3. **Measure** and **record** the diameter of the field of view in millimetres (mm). Millimetre markings on the ruler are too far apart to permit direct measurement of the field of view for lenses with magnification higher than 10×. You can, however, calculate the field of view for a higher magnification. To find out how to do this, go to "How to Calculate the Field of View" on the following page.
   - **(a)** Unplug the microscope by pulling out the plug. Never tug on the electrical cord to unplug it.



The diameter of the field of view illustrated here is 2.5 mm.

How to Calculate the Field of View

If you know the diameter of the field of view for the low-power lens, you can calculate the field of view for the other lenses. Use the following formula to do this.

$$\text{Medium-power field of view} = \text{Low-power field of view} \times \frac{\text{Magnification of low-power objective lens}}{\text{Magnification of medium-power objective lens}}$$

If, for example, your low-power objective lens is a 4× lens with a field of view of 4 mm, and your medium-power objective lens is a 10× lens, then your calculations would be:

$$\text{Medium-power field of view} = 4 \text{ mm} \times \frac{4}{10}$$

$$= 4 \text{ mm} \times 0.4$$

$$= 1.6 \text{ mm}$$

Do a similar calculation to determine your high-power field of view. Record this value.

Math CONNECT

Scientists measure the size of cells in units called *micrometres* (μm); 1000 μm = 1 mm. If you know that your field of view (its diameter) under an objective lens is 2.5 mm, how many micrometres is its diameter? If two cells of equal size occupy the entire field of view, what is the diameter of each cell in micrometres?

Analyze

1. How many lenses does the light pass through between the light source and your eye? Name them.

2. The coarse-adjustment knob is used only with which objective lens? Explain why.

3. How can you tell which objective lens is in the viewing position?

4. When you move a slide on the microscope stage away from you, in what direction does the object seen through the eyepiece move?

5. Make a table with two columns like the one shown here. Give your table a title. In the first column, list the parts of a microscope. In the second column, record the function of each part.

Microscope part	Function of microscope part

Conclude and Apply

6. Why should you never allow an objective lens to touch the slide?

7. Calculate the magnifying power of your school microscope when you use:
   (a) the medium-power objective lens
   (b) the high-power objective lens

8. Use your measurement in question 7, part (a) to calculate the diameter of the field of view under high power (in mm).

9. Why is the field of view under high-power magnification less than that under low-power magnification?

Skill FOCUS

If you need to review units of measurement in the metric system, turn to Skill Focus 4.

INQUIRY

INVESTIGATION 2-B

SKILLCHECK
- Initiating and Planning
- ✸ Performing and Recording
- ✸ Analyzing and Interpreting
- Communication and Teamwork

Preparing a Wet Mount

Now that you have learned how to use a microscope properly, you are ready to prepare some slides of your own, using a variety of materials.

Question

How is a sample prepared on a microscope slide?

Safety Precautions

- Be careful when using sharp objects such as tweezers and scissors.
- Handle microscope slides and cover slips carefully so that they do not break and cause cuts or scratches.

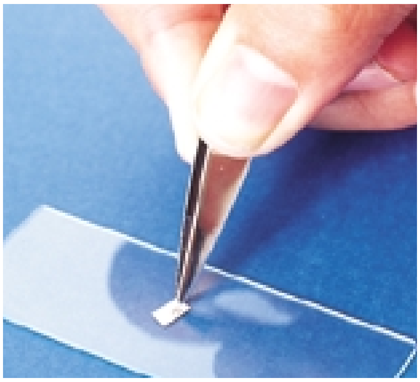
Apparatus

microscope
microscope slides
cover slips
medicine dropper
tweezers
scissors

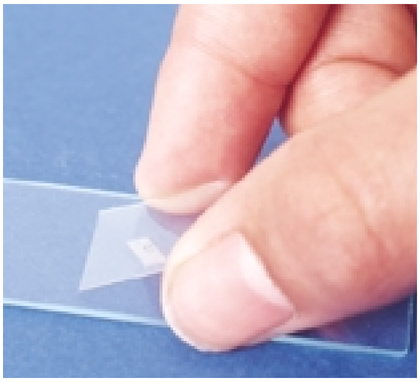
Materials

small piece of newspaper
tap water
other samples
lens paper

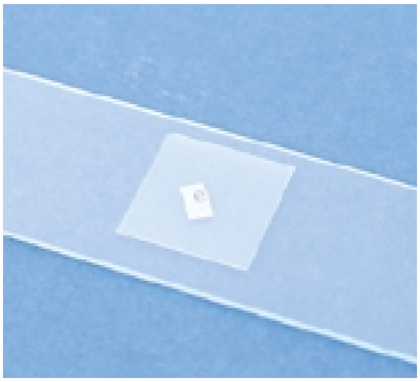
Procedure



1. Cut out a small piece of newspaper containing a single letter. Use an *e*, *f*, *g*, *s*, or *h*. Pick up the letter with the tweezers and place it in the centre of a clean slide. **Note:** Always use clean slides and cover slips. Wash the slides with water and dry them carefully with lens paper when you have finished.

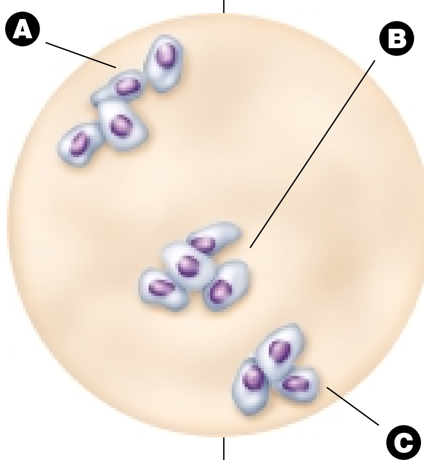


2. Use the dropper to place a very small drop of tap water on the newspaper sample. Then, hold a cover slip gently by its edges and place it at an angle of 45° on the surface of the slide. **Note:** Always hold microscope slides and cover slips by the edges to avoid fingerprints.



3. Slowly and carefully lower the cover slip over the sample. Make sure there are no air bubbles trapped underneath the cover slip. This type of sample preparation is called a **wet mount.**

Troubleshooting



- Do you see round or oval shapes on the slide? These are likely to be air bubbles. Move the cover slip gently with your finger to get rid of them, or study another area of the slide.
- Do moving lines and specks float across the slide? They are probably structures in the fluid of your eyeball that you see when you move your eyes. Don't worry; this is natural.
- Do you see a jagged line? This could be a broken cover slip.
- Do you close one eye while you look through the microscope with the other eye? You might try keeping both eyes open. This will help prevent eye fatigue. It also lets you sketch an object while you are looking at it.
- Always place the part of the slide you are interested in at the centre of the field of view before changing to a higher-power objective lens. The drawing on the right shows a view under low power. When you turn to medium and high power, you may not see A and parts of C. Why not?

4. Set your microscope to the low-power objective lens. Place the slide with the letter on the microscope stage.
   - **(a)** Look through the eyepiece and move the slide until you can see the letter. Adjust the coarse-adjustment knob until the letter is in focus.
   - **(b)** Move the slide until you can see the torn edge of the piece of newspaper. Slowly turn the fine-adjustment knob about one-eighth turn either way. **Observe** if the whole view is in sharp focus at one time.

Analyze

1. When scanning a microscope slide to find an object, would you use low, medium, or high power? Why?
2. Before rotating the nosepiece to a higher magnification, it is best to have the object you are examining at the centre of the field of view. Why?
3. To view the letter *e* through your microscope the right way up, how would you position the slide on the stage?
4. A student has made a wet mount of a piece of newspaper but sees several clear, round shapes in the field of view. What might these be? How could the student avoid having them appear on the slide?

Extend Your Skills

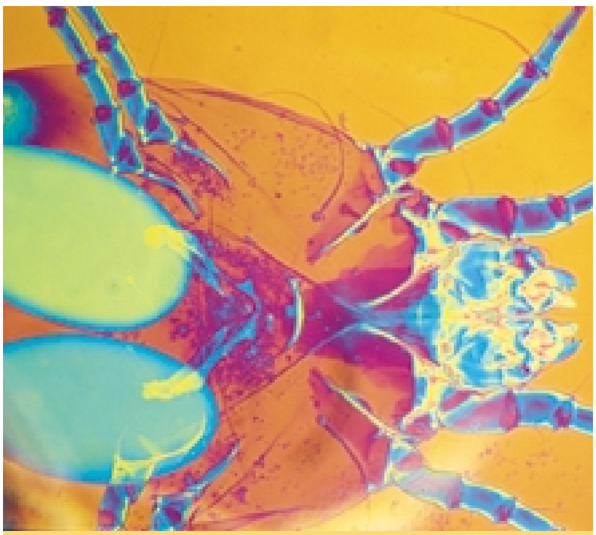
5. Prepare and examine microscope slides of different samples of materials, such as strands of hair, cotton, Velcro™, and grains of salt or sand. Obtain your teacher's approval of the material you select.

Cool Tools

Modern electron microscopes can magnify objects 2 000 000×. The image can be viewed on a television screen. However, it is usually photographed. The resulting image is known as an *electron micrograph*.

There are two main types of electron microscopes. In a transmission electron microscope (TEM), electrons are passed through very thin sections of a sample. Besides being sliced very thin, the object has to be placed in a vacuum. There is no air in a vacuum. Thus, only dead cells and tissues can be observed with a TEM. A scanning electron microscope (SEM) is used to observe the surfaces of whole objects. With a SEM, you can view and photograph living cells. In this type of electron microscope, electrons are reflected back from the surface of the sample, producing three-dimensional images.

Electron microscopes have helped scientists understand many microscopic structures such as the parts of a cell. The image on the left below was produced by a transmission electron microscope, while that on the right was produced by a scanning electron microscope.



A This micrograph of a thin slice of a dust mite was taken by a transmission electron microscope.

B Scanning electron microscopes show great detail on the surface of an organism. This is a tiny dust mite magnified 350×.

TOPIC 2 Review

1. In a compound light microscope, what is the function of
   (a) the eyepiece
   (b) the coarse-adjustment knob
   (c) the stage
   (d) the diaphragm
2. (a) What is a wet mount?
   (b) How do you prepare a wet mount?
3. (a) Who first observed single-celled organisms?
   (b) What did this scientist call them?
4. Who was the first scientist to use the term “cell”?
5. **Thinking Critically** Why was the development of the microscope important to the study of cells?

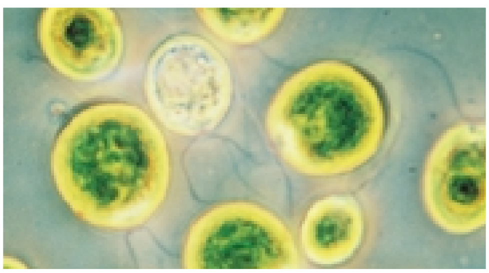
TOPIC 3 The Cell and Its Structures

Strange as it might seem, a cell in your finger has characteristics in common with a microscopic organism and with the cells in an oak leaf. One way to understand the structure and function of cells in **multicellular** (many-celled) organisms, such as human beings, is to investigate the characteristics of **unicellular** (single-celled) organisms, like the ones shown in Figure 2.5.

The photographs in Figure 2.5 show a variety of microscopic pond organisms. Although each organism consists of only one cell, they are not simple. Each has a way of moving, obtaining food, and carrying out all other functions essential for life.

Pause & Reflect

In what ways do you think a human home may be like a cell? Write your ideas in your Science Log.

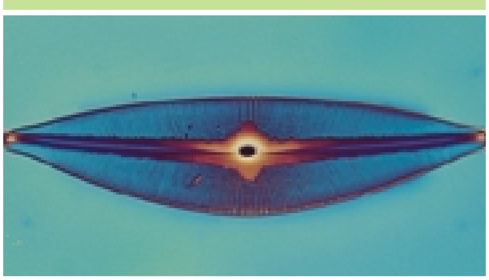


Chlamydomonas (180x) Makes its own food through photosynthesis, and moves by means of two long, whiplike structures called *flagella*.

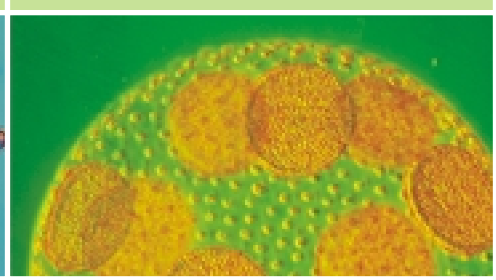
Euglena (100x) A common pond organism that also photosynthesizes, and moves by means of a single flagellum.

Paramecium (160x) Paramecia obtain their own food from the external environment. They are covered with short, hairlike structures called *cilia* that are used both for movement and to sweep food into a tiny groove that is similar to a mouth.

Stentor (125x) Stentor and some other unicellular organisms produce stalks to attach themselves to the bottom of ponds and streams. Stentor, like paramecium, has cilia, but these structures are used to bring in food rather than for movement.



Diatoms (100x) Varied in shape and beautiful. Diatoms produce shells around themselves, make their own food through photosynthesis, and are free-floating.



Volvox (30x) Living balls made of many volvox live together as a colony. Each has its own flagellum and makes its own food by photosynthesizing.

Figure 2.5

SKILLCHECK
- Initiating and Planning
- ✸ Performing and Recording
- ✸ Analyzing and Interpreting
- Communication and Teamwork

Pond Water Safari

In this investigation, you will observe and draw various micro-organisms found in pond water. Some of these tiny organisms are like animals, some are like plants. They move and feed in different ways. You will record which characteristics of living organisms you observe in unicellular organisms. You will probably also see small organisms made of more than one cell in the pond water you observe.

Question

How do unicellular organisms meet their basic life needs?

Safety Precautions

- Be careful when using sharp objects such as tweezers.
- Dispose of materials according to your teacher's instructions.

Apparatus

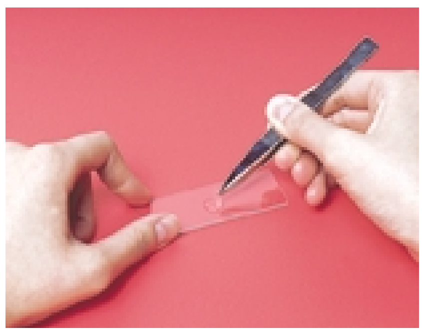
microscope
microscope slides
cover slips
medicine dropper
tweezers

Materials

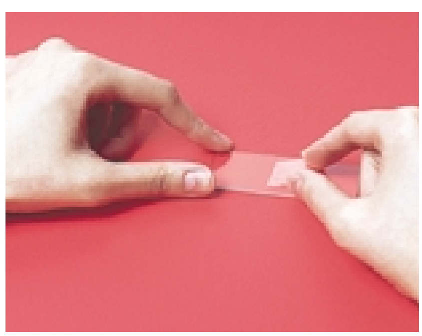
pond water
cotton fabric

Procedure

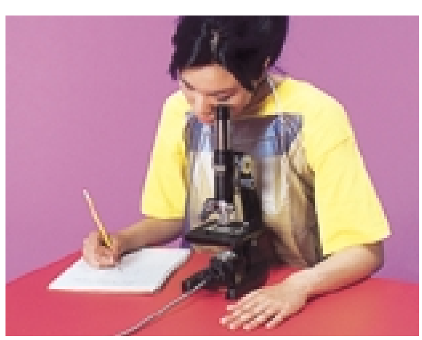
1. Obtain a sample of pond water from your teacher. Using a medicine dropper, place a drop of the pond water in the centre of a clean microscope slide.



2. Pull two or three cotton fibres from the cotton fabric and place them on the water drop.



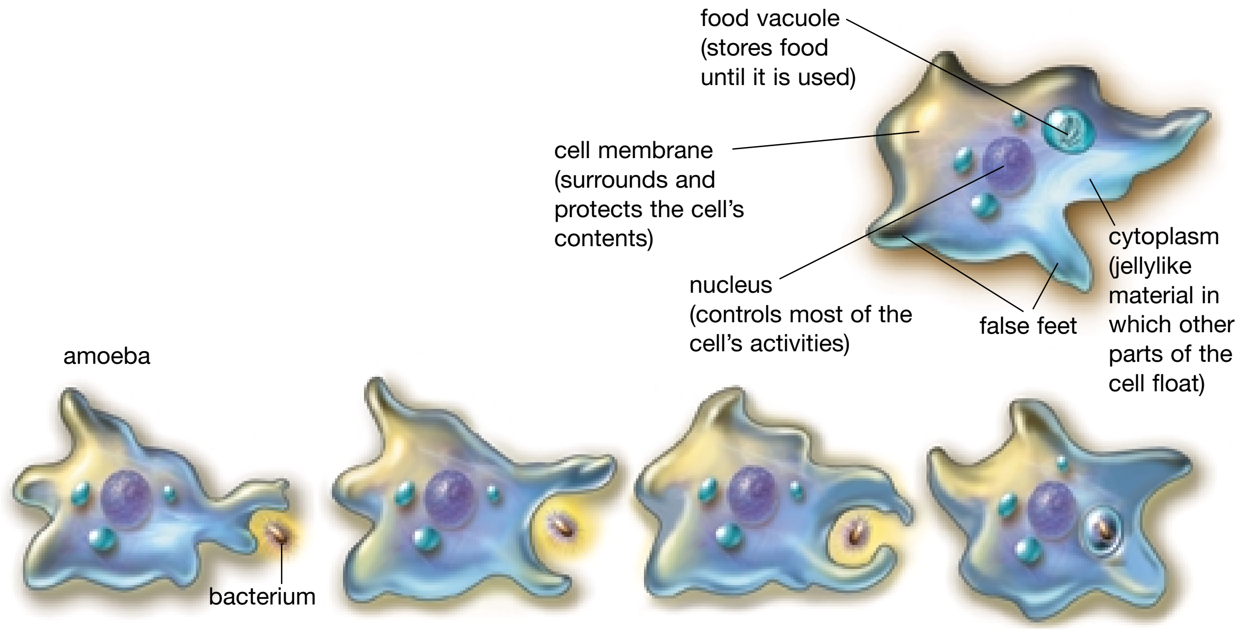
3. Place a cover slip on the sample.



4. Examine the slide under low power, looking for different unicellular organisms.
   (a) **Draw** several different organisms, putting in as much detail as you can observe. Try to identify the organisms from the photographs in Figure 2.5 on page 115.
   (b) **Record** which characteristics of living organisms you observe in unicellular pond organisms.
   (c) Wash your hands after this investigation.

Looking Ahead

Make a list of things that caused a response in the micro-organisms you saw. Add to the list as you work more with cells. You could use your list in the Unit Investigation, Responding to Changes.



In your pond water sample, look for the amoeba, another common unicellular organism shown in the introduction to this unit. You might be fortunate enough to observe an amoeba in action. The amoeba moves by changing its shape. It pushes its cytoplasm against one part of its cell membrane, causing a bulge. This bulge is called a *false foot* (pseudopod). Then the amoeba shifts the rest of its cytoplasm in the same direction. The amoeba's ability to "flow" from place to place using its false feet also allows it to obtain food. The amoeba simply moves around a smaller organism such as a bacterium, trapping it inside a food vacuole.

Analyze

1. Suggest why you were asked to add cotton fibres to the water drop.

2. Describe what evidence you saw that shows unicellular organisms are able to feed. Recall that organisms may feed by ingestion — taking in substances, or by photosynthesis — producing food themselves (using energy from sunlight).

Conclude and Apply

3. What methods of movement did you observe?

4. Describe any evidence of growth or reproduction you saw.

5. Do unicellular organisms respond to stimuli (changes in their environment)? Explain.

Extend Your Knowledge

6. If you also observed multicellular organisms, describe how they differ in general from unicellular organisms. How are they similar to unicellular organisms?

Extend Your Skills

7. Keep a sample of pond water in a safe place exposed to sunlight for about a week before returning it to the pond. Use a microscope to observe the microscopic life in the water every day or two. Record any changes you see. Suggest an explanation for these changes.

INQUIRY

INVESTIGATION 2-D

SKILLCHECK
Initiating and Planning
Performing and Recording
Analyzing and Interpreting
Communication and Teamwork

Observing Plant and Animal Cells

You are now ready to begin observing the cells of multicellular organisms. When you first look at the cells of a plant or an animal through a microscope, they may look like rows of squashed boxes stacked together. There may appear to be little or nothing inside them. To observe the parts of a cell more clearly, scientists usually add coloured stains of various kinds to help.

In this investigation, you will continue to develop your skills using a microscope to investigate cells. You will prepare a wet mount of onion skin cells and look at a prepared slide of human skin cells.

Question

What do plant and animal cells look like through a microscope?

Part 1

Observing Plant Cells

Safety Precautions

- Onion juice may sting your eyes. Wash your hands after handling the onion.
- Iodine solution may stain your hands or clothes. Avoid spilling it.
- Be careful when using sharp objects such as tweezers.
- Handle microscope slides and cover slips with care so they do not break.

CAUTION If you get iodine on your skin or in your eye, inform your teacher and rinse the affected area with water. The eye should be rinsed for at least 15 min — iodine is an irritant and is toxic.

Apparatus

microscope
microscope slides
cover slips
medicine dropper
tweezers

Materials

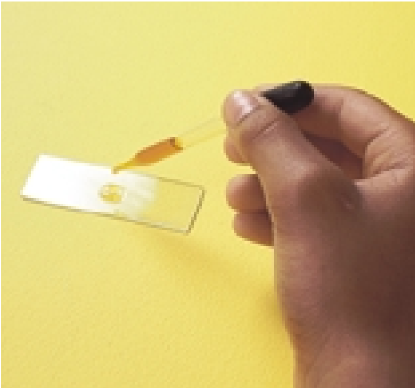
small piece of onion
tap water
dilute iodine solution
lens paper

Procedure

1. Use tweezers to peel a single, thin layer from the inner side of a section of onion. If you cannot see light through your onion skin sample, try again.

2. Carefully place your onion skin sample in the centre of a clean slide. Make sure the onion skin does not fold over.

An onion skin sample viewed through a compound light microscope (100×). The skin of an onion is made up of a collection of cells.



3. Add a small drop of water. Place a cover slip over the sample.
   - **(a)** Examine the onion skin sample using the low-power objective lens on your microscope.
   - **(b)** Move the slide until you locate a group of cells that you wish to study. Centre these cells in your field of view and **draw** what you see.

4. Prepare another wet mount of the onion skin cells. This time, use a small drop of dilute iodine solution instead of water.
   - **(a)** Examine the stained cells, first using the low-power objective lens and then the medium-power objective lens.
   - **(b)** Carefully rotate the nosepiece to the high-power objective lens. Focus on the cells using the fine-adjustment knob. **Draw** what you see and label your diagram. (Hint: **Observe** if any parts are similar to the parts of an amoeba shown on page 117.)
   - **(c)** Dispose of the onion material, clean your slides, and wash your hands. Set the microscope to the low-power objective lens.

CONTINUED ▶

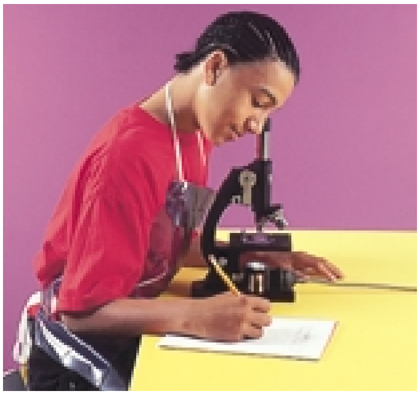
Part 2

Observing Animal Cells

Apparatus
microscope
prepared slide of human skin cells

Materials
lens paper

Procedure



1 Examine a prepared slide of human skin cells under different magnifications. **Draw** what you see and label your diagrams.

2 Clean your slide with lens paper, set the microscope to the low-power objective lens, and put the microscope away. Then wash your hands.

Human skin cells (250×).

Analyze

1. How was your study of cells affected by
   (a) using high-power magnification
   (b) adjusting the light
   (c) staining the cells
2. List any differences and similarities you observed between onion skin cells and human skin cells. Make a comparison chart to summarize the differences and similarities.

Conclude and Apply

3. One function of skin is to protect and support the parts underneath it. How might the structure and arrangement of cells in the onion skin help do this?
4. **Thinking Critically** Why do you think plant and animal cells have different structures?

Cell Parts Viewed With a Light Microscope

With your compound light microscope, you have been able to see the basic cell parts in unicellular organisms and in typical animal and plant cells. The cells of multicellular organisms fit together in much the same way as a building made of bricks (see Figure 2.6).

The cheek cells scraped from the inside of a person's mouth shown in Figure 2.7 again show you the major parts of an animal cell you should be able to see under a compound light microscope. Likewise, the cells scraped from the surface of a leaf (see Figure 2.8) show the major parts of a plant cell you should be able to see with your own microscope. Next, you will learn more about these cell parts and what they do to keep each and every cell alive and functioning.

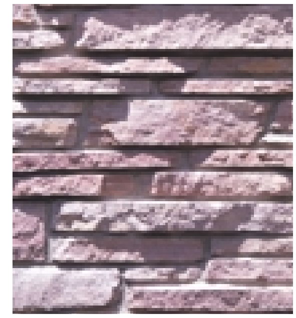


Figure 2.6 Cells fit together much like bricks in a wall.

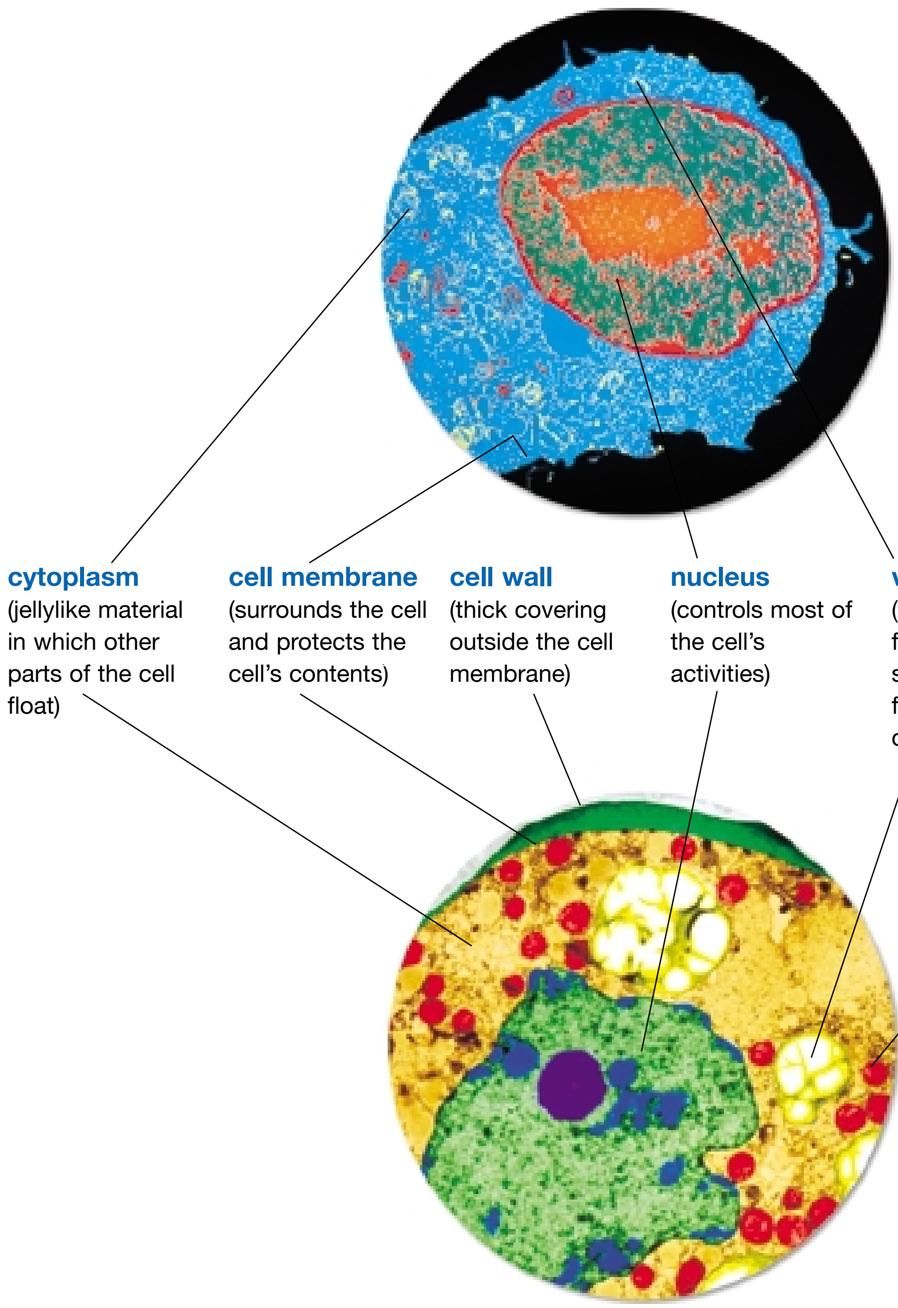


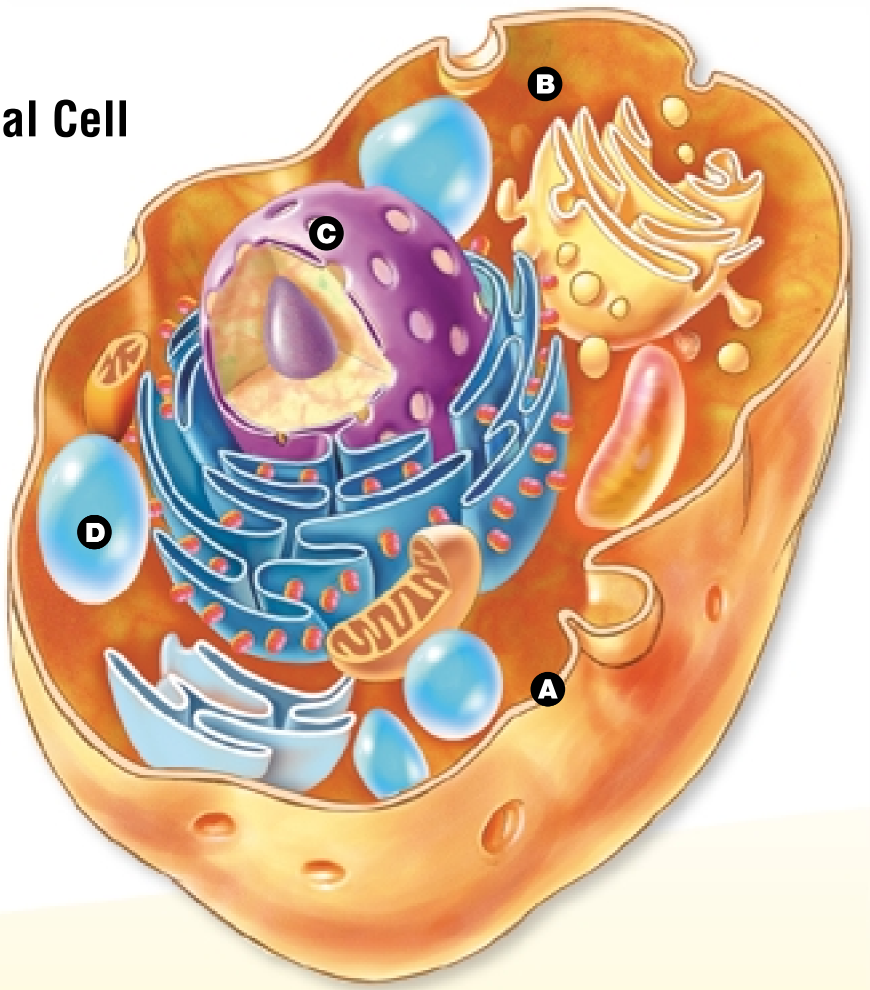
Figure 2.7 Colour-enhanced image of a typical animal cell magnified 250×.

Figure 2.8 Colour-enhanced image of a typical plant cell magnified 250×. Colour enhancement makes the chloroplasts appear red rather than green.

Cell Parts

Every cell must carry out certain activities that keep it alive. These activities include obtaining materials and supplies of energy, making products, and getting rid of wastes. To carry out these functions, cells have some basic structures in common. Structures inside the cell are known as **organelles**. Each organelle has a role to play in the activities necessary for life. Many of the details of cell organelles have only been discovered since the invention of the electron microscope. Look closely at the diagrams on these two pages to see which organelles are found in both plant and animal cells. Which parts are found only in plant cells? How do these diagrams compare with the images on page 121?

Animal Cell



DidYouKnow?

Because cells do work, they need energy. Their energy is produced by oval-shaped organelles called mitochondria (singular: mitochondrion). Inside the mitochondria, tiny food particles are broken down to release their chemical energy for the cell's activities. Some cells, such as muscle cells, have more mitochondria than others because they need more energy to function.

A Cell membrane

Like the skin covering your body, the **cell membrane** surrounds and protects the contents of the cell. The cell membrane is not simply a container, however. Its structure helps control the movement of substances in and out of the cell.

B Cytoplasm

A large part of the inside of the cell is taken up by the jellylike **cytoplasm**. Like the blood flowing throughout your body, cytoplasm constantly moves inside the cell. The cytoplasm distributes materials such as oxygen and food to different parts of the cell. The cytoplasm also helps support all the other parts inside the cell.

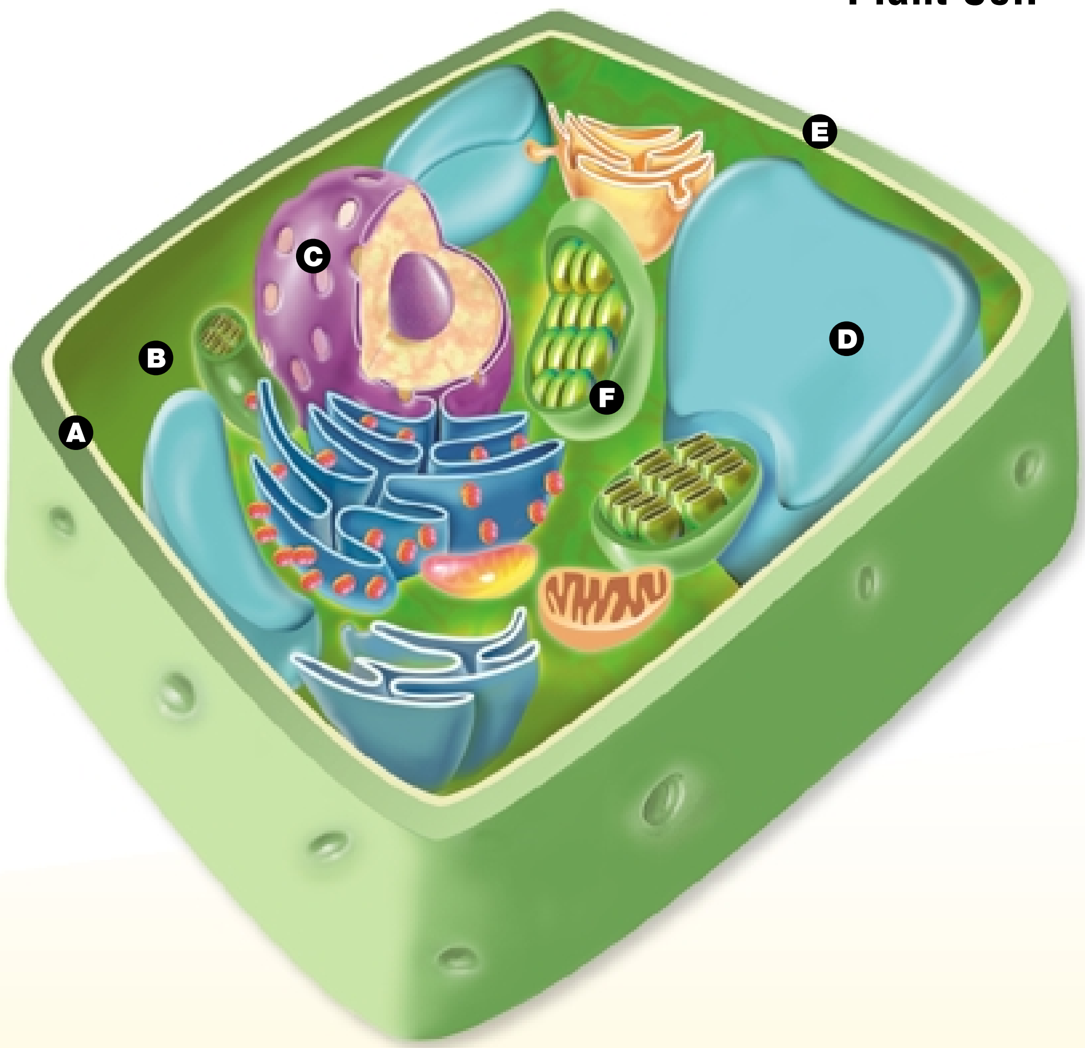
C Nucleus

A large, dark, round nucleus is often the most easily seen structure in a cell. The **nucleus** controls the cell's activities. It contains the chromosomes — structures made of genetic material that direct a cell's growth and reproduction. The cell nucleus is enclosed by a nuclear membrane, which controls what enters and leaves the nucleus.

DidYouKnow?

The structures that Robert Hooke saw in a piece of bark were not living cells at all, but only the cell walls of dead, empty plant cells.

Plant Cell



DidYouKnow?

A tree consists mainly of dead cells. The strength and rigidity of wood come from the cell walls. These cell walls remain stacked together solidly like bricks, long after the cells have ceased to carry out their living functions. The only living parts of a tree are the leaves, the growing tips of branches and roots, a thin layer of cells just under the bark, and the pith in the centre of the roots and the branches.

D Vacuoles

Balloonlike spaces within the cytoplasm are storage places for surplus food, wastes, and other substances that the cell cannot use right away. These structures, called **vacuoles**, are surrounded by a membrane.

E Cell wall

The **cell wall** occurs only in the cells of plants and fungi, and in some unicellular organisms. Cell walls are much thicker and more rigid than cell membranes, and are made mostly of a tough material called **cellulose**. They provide support for the cell.

F Chloroplasts

Chloroplasts are the structures in which the process of photosynthesis takes place. Photosynthesis uses energy from the Sun to make carbohydrates. Folded membranes inside each chloroplast contain the green pigment chlorophyll, which absorbs sunlight.

Chloroplasts are found only inside cells in green plants and in some unicellular organisms. They are not found in animal cells.

SKILLCHECK
- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Build Your Own 3-D Cell

Making a three-dimensional model of a cell will help you remember all the different parts of a cell and how they fit together.

Challenge

Design and build a three-dimensional model of a cell that features the organelles a cell needs in order to function.

Safety Precautions

- Never eat or drink anything in the science laboratory.
- Wash your hands after completing this activity.

Materials

Everyday items of your choice, for example, gelatin, modelling clay, shoe box, Styrofoam™, pipe-cleaners, plastic film, hard candies, dried pasta, craft items, etc.

Design Specifications

A. Your model cell may be either a plant cell or an animal cell.

B. The organelles needed for the cell to function must be present.

C. Your model cell must contain all the right parts in the right proportions, and the parts must be clearly visible. It should be no larger than a shoe box or a basketball.

Plan and Construct

1. With your group, decide whether to build a plant cell or an animal cell.
2. List the organelles that your cell needs in order to function.
3. Decide which materials would best represent your cell and each organelle in your cell. Write each item beside the matching organelle in the list of organelles you made in step 2.

4. Make a neat labelled sketch of your design. Make sure you include and label all the organelles.
5. Start building your cell!

Evaluate

Work together to examine and compare the model cells constructed by the various groups. In what way or ways could you modify your design to improve it?

INTERNET CONNECT

www.school.mcgrawhill.ca/resources/

Do you want to take an imaginary journey through a cell? Go to the above web site, then to **Science Resources**, and on to **SCIENCEFOCUS 8** to find out where to go next. You can zoom in, turn around, and check out different organelles inside a virtual cell.

Cell Size and Function

Why are cells so small? Why aren't larger organisms, such as the trees in Figure 2.9, made from one large cell instead of millions of microscopic cells? The explanation of why cells do not grow very large can be found in how cells function.

To carry out their work, cells need a constant supply of materials such as oxygen, water, and food particles. They also need to get rid of waste products. A larger cell would need more materials and would produce more waste products. However, the only way for materials to get in and out of the cell is through the cell membrane.

To have an idea of the problem this causes, imagine the cell as a round swimming pool with a diameter of 50 m. To keep this imaginary cell alive, you must swim to the centre of the pool carrying a beach ball (representing food particles), then swim back to the side carrying a lifebuoy (representing waste products). Suppose you must do this twelve times in a certain period of time. What differences would it make if the diameter of the pool were 100 m instead of 50 m?

Figure 2.9 Why are all large organisms, including you, multicellular?

Pause & Reflect

Each organelle has a characteristic structure, and carries out the same function in every cell where it is found. How might the organelles of a cell be compared with the organs of your body, such as the stomach, lungs, and brain? In your Science Log, list some organelles. Beside each one, write what body organ they appear to be most like and why. Try this now, then after you have completed Topic 6, check to see if you would like to change any of your comparisons.

Did You Know?

A single cell may contain many thousands of organelles. If the cell were the size of a large building, such as a school, the organelles would range in size from beachballs to classrooms.

Small, Smaller, Smallest

Cells come in a variety of sizes and shapes. Most cells, however, fall into a narrow range of size — the size in which they function most efficiently. To grow bigger, organisms add more cells to their bodies rather than growing bigger cells. This occurs when cells divide.

Recall that cells are measured in micrometres (μm). Most cells in plants and animals have a diameter between 10–50 μm (see the examples in Figure 2.10). Bacterial cells are much smaller. They are only 1–5 μm across.

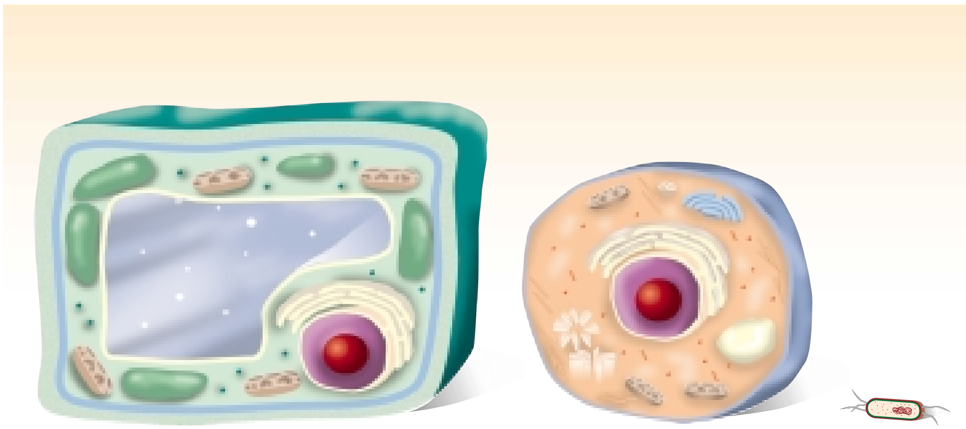


Figure 2.10 Relative sizes of a plant cell, animal cell, and bacterial cell

Career CONNECT

The Art of Science

Many people with a passion for both art and science combine them to become scientific illustrators. Besides an eye for fine detail, most scientific illustrators have a degree or a diploma from an art college, as well as a university degree in a specific area of science.

Take a look at a few of the scientific illustrations in this unit. Which school subjects do you think would be important if you were planning to work in this field? What are some outside-school interests that might be useful? You can start thinking now about the types of drawings to include in your portfolio, if you think you might like to become a scientific illustrator.

TOPIC 3 Review

1. Give two examples each of (a) a unicellular organism, and (b) a multicellular organism.
2. List three key differences between a unicellular organism and a multicellular organism.
3. Describe two characteristics of life you have observed in a unicellular organism.
4. From your observations, list two structures that all cells seem to have in common.
5. Why might scientists add stains to cells they view under microscopes?
6. Name two structures in a plant cell that are not found in an animal cell.
7. Do organisms grow larger by (a) increasing the size of their cells, or (b) adding more cells? Explain your answer.
8. **Thinking Critically** Why would you not expect to see chloroplasts in cells from an onion root?

If you need to check an item, Topic numbers are provided in brackets below.

Key Terms

cell
magnify
microscopes
wet mount
multicellular
unicellular
organelles
cell membrane
cytoplasm
nucleus
vacuoles
cell wall
cellulose
chloroplasts

Reviewing Key Terms

1. In your notebook, match the description in column A with the correct term in column B.

A	B
• carries out photosynthesis in plant cells	• nucleus (3)
• gives plant cells strength and support	• cell membrane (3)
• a moving fluid that distributes materials	• chloroplast (3)
• controls the cell's activities	• cytoplasm (3)
• a thin, protective "skin"	• vacuole (3)
• stores materials	• cell wall (3)

2. Is an earthworm unicellular or multicellular? Explain your answer. (3)

3. Describe two differences between the cell membrane and the cell wall. (3)

Understanding Key Ideas

4. List three characteristics of living organisms. (1)

5. How were cells first discovered? (2)

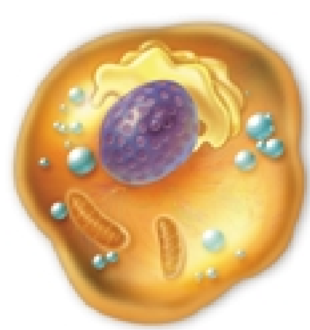
6. Copy the different parts of a microscope listed below in your notebook and describe the function of each part. (2)
   (a) ocular lens
   (b) tube
   (c) coarse-adjustment knob
   (d) fine-adjustment knob
   (e) arm
   (f) revolving nosepiece
   (g) objective lenses
   (h) stage
   (i) condenser lens
   (j) diaphram
   (k) light source

7. Where would you find the substance chlorophyll in a cell? What is its function? (3)

8. Which of the following would you expect to find in an animal cell? Give a reason for each answer. (3)
   (a) nucleus
   (b) chloroplast
   (c) vacuole

9. Explain why cells are limited in size. (3)

10. Copy the diagram of a cell shown below and label the cell parts that you know. (3)



TOPIC 4 Fluid Movement in Cells

Pause& Reflect

How do you think cells manage such functions as "breathing" and "eating"? List or sketch your ideas in your Science Log. Look back on your ideas after you have finished this Topic.

The Cell Membrane

How long could you live without drinking? Without breathing? Without eating? These everyday activities are essential for life, but why do we need to drink, breathe, and eat? There are many ways to answer this question. One way is to look at these essential life functions at the level of cells.

Individual cells carry out the same activities as whole organisms. When you drink water, the water is eventually used by your cells, helping them to carry out their functions. Similarly, your cells also make use of the air you breathe and the food you eat. In this Topic, you will learn about some of the ways in which cells function.

At the border separating two nations, customs officers check the items that travellers are carrying. It is against the law to transport certain items across international borders. In a similar way, materials passing into and out of a cell are "checked" at the cell membrane. Like the customs checkpoint, a cell membrane allows some substances to enter or leave the cell, and it stops other substances. Because it allows only certain materials to cross it, the cell membrane is said to be **selectively permeable**. (A membrane that lets all materials cross it is **permeable**. A membrane that lets nothing cross it is **impermeable**.)

How does a cell membrane carry out this function? The answer is in the structure of the membrane. Imagine you have two small bags. One is made of plastic, the other of cheesecloth. Now imagine you pour water into both bags, as shown in Figures 2.11A and B. The plastic holds the water, but the cheesecloth lets the water run through. The plastic is impermeable to water, while the cheesecloth is permeable to water. This difference is due to differences in the structure of the materials from which the bags are made.

Figure 2.11A Plastic is impermeable to water.

Figure 2.11B Cheesecloth is permeable to water.

Now imagine you are pouring a mixture of water and sand into both bags. Is each bag permeable, impermeable, or selectively permeable to the mixture? (If you are not sure, you could try carrying out a demonstration like the one in Figures 2.11A and B and observing what happens.)

Diffusion

The structure of the cell membrane controls what can move into and out of a cell. What causes substances to move in the first place? One clue is shown in Figure 2.12. What makes the blob of ink move outwards through the water in the container?

Figure 2.12 In time, the ink particles will become evenly dispersed with the water particles, and the whole solution will appear ink-coloured.

Our understanding of particle movement is expressed in the particle model. It describes the constant movement of particles in all liquids and gases. These particles move in all directions, bumping into each other. (To review the particle model, see page 72.) These collisions explain why particles that are concentrated in one area, such as the ink blob, spread apart into areas where there are fewer ink particles, and thus fewer collisions. This spreading-out process is called **diffusion**. Eventually, the ink particles will become evenly distributed throughout the container of water. At this time, individual ink particles continue to move, but there is no further change in the overall distribution of the ink in the water. Just like the ink, food colouring and the colour from certain crystals would also diffuse throughout the water, if left undisturbed for several minutes.

Off the Wall

Recall that an average cell has a diameter of 20–30 μm. Suppose this cell was placed in a solution with a concentration of oxygen higher than in the cell's cytoplasm. The time required for diffusion to equalize the concentrations would be about 3 s at room temperature. If the cell were much larger — with a diameter of 20 cm, say — the same process would take about 11 years!

Pause & Reflect

Here are some situations in which diffusion occurs: a sugar cube is left in a beaker of water for a while; fumes of perfume rise from the bottle when the top is removed. Give some other examples of diffusion. Can solids diffuse? Why or why not? Write your responses in your Science Log.

Pause & Reflect

You can observe diffusion by means of your sense of sight. Is there another way to observe this process? Try this. Have a friend or a family member stand at one end of a room with an orange while you stand at the other end facing the wall. Ask your friend to peel the orange. How do you know that particles have diffused from the orange throughout the air in the room? Does the process of diffusion in air work the same way it does in water?

DidYouKnow?

Can your doctor give you medicine without using pills, syrups, or needles? Yes, by using diffusion. Drugs can be put into a patch similar to a Band-Aid™ that is stuck onto the skin. There is a high concentration of drugs in the patch but a low concentration in the body. Therefore, the drug particles diffuse through the skin into the bloodstream.

Diffusion in Cells

Diffusion also plays a part in moving substances into and out of cells. For example, imagine an amoeba living in water. The concentration of dissolved carbon dioxide gas in the water is the same as the concentration of dissolved carbon dioxide gas in the amoeba's cytoplasm. Carbon dioxide particles therefore move into and out of the cell at the same rate, passing through small openings in the amoeba's selectively permeable membrane (see Figure 2.13A).

Now imagine the amoeba has been producing carbon dioxide as a waste product inside its single cell. The concentration of dissolved carbon dioxide particles in the amoeba's cytoplasm is now greater than the concentration of carbon dioxide in the surrounding water. As a result, more carbon dioxide particles move out of the cell by diffusion during a given time than move into the cell (see Figure 2.13B). The diffusion process continues until the concentration of the dissolved carbon dioxide gas on both sides of the cell membrane is once again equal.

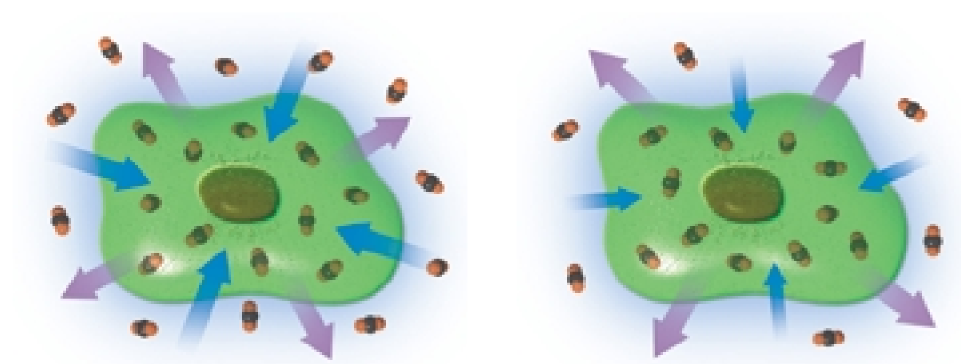


Figure 2.13A An equal concentration of carbon dioxide particles on both sides of the cell membrane. The particles move into and out of the cell at an equal rate.

Figure 2.13B A greater concentration of carbon dioxide particles inside the cell. The particles move out of the cell at a greater rate than they move into the cell.

Figure 2.14A Limp carrot sticks

Figure 2.14B Carrot sticks 24 h later

Osmosis

The most common substance found inside and around cells is water. About 70 percent of a cell's content is water, and most cells die quickly without a supply of this liquid. Water particles are small and can easily move into and out of cells by diffusion. The diffusion of water through a selectively permeable membrane is called **osmosis**.

You have probably already seen osmosis at work. Have you ever cut carrot sticks from a fresh carrot? You may have left some extra sticks in the refrigerator. By the next day, they have lost some of their moisture and they have gone limp. Suppose you place the sticks in a glass of water. Several hours later they are crisp again. What has happened? Water particles have moved from the water in the glass into the carrot cells by osmosis. (See Figures 2.14A and B.)

Now recall the idea introduced at the beginning of this Topic. It suggested that you drink water to help your cells carry out their functions. When you are very active, you lose moisture from your body in your breath and in sweat. Moisture is lost by the body through the skin's surface and the surface of the lungs. Water is then drawn from other cells and structures of the body to replace the water lost from these surfaces. This happens partly by osmosis and partly as a result of the body's circulatory system. At some point, you need a new supply of water to restore the cell water content in your body to its normal level.

Water is important to living things because it dissolves many of the substances involved in cell processes. For example, glucose (which cells use for energy) dissolves in water to form a glucose solution. When water moves out of a cell, the dissolved substances inside the cell become more concentrated. When water moves into a cell, the dissolved substances inside the cell become more diluted.

Water tends to move by osmosis from a diluted solution to a more concentrated solution (see Figure 2.15). In other words, water moves from a region where it is in high concentration to one where it is in lower concentration. That is why water moves into dehydrated carrot cells. What do you think would happen if you put a fresh carrot stick into a glass containing a concentrated salt solution? Why might this happen? See for yourself in the next investigation.

Pause& Reflect

What is the *solvent* in a salt solution? What is the *solute* in a salt solution? For that matter, what is a *solution*? If you remember these terms from your earlier studies, you are ready to do Inquiry Investigation 2-F. If you need review, look up the three terms in the Glossary at the back of this book. Write the definitions in your Science Log.

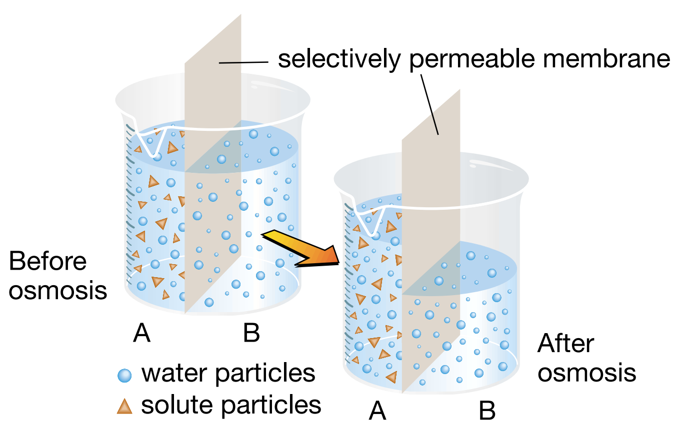


Figure 2.15 Water moves by osmosis from side B to side A inside the beaker. In this simplified diagram, which side represents a carrot stick and which side represents a glass of water?

Looking Ahead

What would happen to a micro-organism if salt were added to its watery environment? How could you test your prediction? Jot your ideas in your planning file for consideration when you do the Unit Investigation, Responding to Changes.

Off the Wall

Can cells break sidewalks? With the help of osmosis, they can! When cells take in water by osmosis, they tend to swell. The increasing pressure from the added volume of water may burst open animal cells. Plant cells, however, can withstand much greater pressure because they are surrounded by rigid cell walls. This pressure is called *osmotic pressure*. Have you ever seen weeds breaking through a paved sidewalk? They force their way through asphalt by osmotic pressure, generated by water in the cells of the shoot tip.

INQUIRY

INVESTIGATION 2-F

SKILLCHECK
- Initiating and Planning
- ✸ Performing and Recording
- ✸ Analyzing and Interpreting
- Communication and Teamwork

Measuring Osmosis

Just underneath the shell of an egg is a selectively permeable membrane. In this investigation, you will measure the movement of water by osmosis across this membrane. What conditions will cause water to move into the egg? What conditions will cause water to move out?

Note: You must start preparing your eggs for this investigation 24 h in advance. You will also need about 24 h to observe the results of osmosis.

Question

How can you measure the effects of osmosis?

Safety Precautions

- Handle all glassware carefully.
- Never eat or drink any substances in the science laboratory.

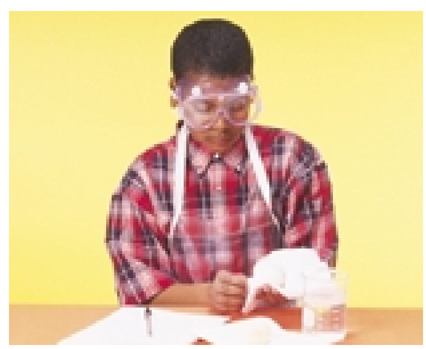
Apparatus

2 clean beakers (or glass jars) with lids
graduated cylinder
balance

Materials

2 uncooked eggs
white vinegar
pen or marker
labels
200 mL distilled water
200 mL salt solution
paper towel
water

Procedure



1. Prepare two raw eggs a day before your experiment by covering them with vinegar for 24 h.

   (a) From your knowledge of osmosis, **predict** what will happen to the water content of an egg placed in distilled water, and one placed in salt solution. **Record** your predictions.

   (b) **Prepare a table** like the one shown here. Give your table a title.

2. Label one jar "distilled water" and the other jar "salt solution."

3. Carefully remove the eggs from the vinegar, rinse them with water, and dry them with a paper towel. **Record** the appearance of the eggs.

Calculations	Egg in distilled water	Egg in salt solution
Original mass of egg		
Final mass of egg		
Change in mass (+ or –)		
Original volume of liquid		
Final volume of liquid		
Change in volume (+ or –)		

4 **Measure** and **record** the mass of each egg.

5 Place one egg in each jar. Pour 200 mL of distilled water into one jar and 200 mL of salt solution into the other. Cover the jars with lids and wait 24 h.

6 Carefully remove one egg and dry it. **Measure** and **record** its mass.

7 Using a graduated cylinder, **measure** and **record** the volume of liquid remaining in the jar.

(a) Repeat steps 6 and 7 for the other egg.

(b) Wash your hands after this investigation.

Skill FOCUS

To review how to measure the mass of an object and the volume of a liquid, turn to Skill Focus 5.

Analyze

1. From your observations, make an inference about the effect of vinegar on eggshells. Why was this an important first step in the investigation?
2. What variables are held constant in this investigation? What variable is changed?
3. **(a)** What happened to the volume of liquid in the jar if the mass of the egg increased?
   (b) What happened to the volume of liquid in the jar if the mass of the egg decreased?
   (c) Explain these relationships.

Conclude and Apply

4. From your data, make an inference about the effect of osmosis on an egg placed in (a) distilled water, and (b) salt solution. In your answer, refer to the movement of water particles from a region where water is in high concentration to one where it is in lower concentration.

Extend Your Knowledge

5. Predict what results you might get if you repeated the experiment with a solution having double the concentration of salt. Explain your prediction.
6. Draw a flowchart to illustrate the sequence of events in this investigation. Show the movement of particles in the appropriate places.

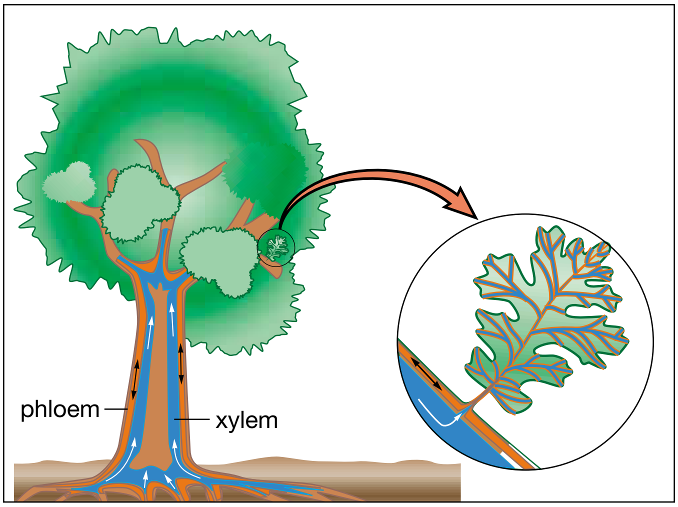


Figure 2.16 Xylem tissue conducts water from the roots to the rest of the plant. Phloem tissue carries sugars from the leaves to the rest of the plant.

Fluid Movement in Plants

Most plants need a large supply of water. Plants require water to make sugars in the process of photosynthesis. Plants obtain water from the soil. How does water get from the soil into the plants? Roots need the sugars made in the leaves. How do cells in the roots of plants obtain these sugars?

Recall from Topic 1 that tissues are groups of cells that perform similar functions. The transport of nutrients is the role of the plant's tissues. Inside the plant, two types of tissues, called **vascular tissues**, connect the roots to the leaves. **Phloem tissue** transports sugars manufactured in the leaves to the rest of the plant. **Xylem tissue** conducts water and minerals absorbed by the root cells to every cell in the plant (see Figure 2.16).

Xylem and phloem tissue usually occur together, along the length of the plant stems and roots. Both types of tissue are surrounded and supported by other tissue that gives the plant strength. This other tissue has large vacuoles for storing food and water.

From Root to Leaf

If you examine the structure of a root system, you will see that its growing tips are covered with fine **root hairs**. These "hairs" are, in fact, extensions of single epidermal cells (see Figure 2.17). Epidermal cells form epidermal tissue, which protects the outside of a plant. When the concentration of water in the soil is greater than the concentration of water in the root cells, water enters these root hairs by osmosis.

From the root hairs, water passes from cell to cell by osmosis until it reaches the xylem tissue. The tube-shaped cells making up xylem tissue have thick walls with holes in their ends (see Figure 2.18). Stacked end to end, they form bundles of hollow vessels similar to drinking straws. Water can flow easily through these vessels. As more water enters the root hairs, it creates pressure that pushes water up the plant through the xylem tissue.

DidYouKnow?

The phloem of a tree lies close to the outer surface of the trunk, just below the bark. Because of this, sugar tappers can easily draw sugar solution from the trunks of maple trees. This is done by boring a small hole through the bark and pushing small tubes into the phloem tissue. The best time to tap maple trees is early in the spring, when large amounts of sap are flowing to provide energy for new growth.

Water is transported by xylem tissue into the stems and the leaves. Leaves are the plant's food-producing organs. Recall that photosynthesis manufactures sugars from water, carbon dioxide, and sunlight. Most photosynthesis takes place in a layer of cells in the leaf that are filled with chloroplasts. These cells are called palisade cells. Why are many leaves typically flat and thin? This shape provides a large surface area to absorb sunlight. This shape also makes it easy for gases to diffuse into the leaf cells (see Figure 2.19).

Notice the tiny openings on the underside of the leaf. These openings are called stomata (singular: stoma). They allow air to enter the leaf, supplying the oxygen the cells need for respiration and the carbon dioxide they need for photosynthesis. Spaces between leaf cells allow the air to flow around each cell. Surrounding each stoma are guard cells, which can expand to close off the stoma.

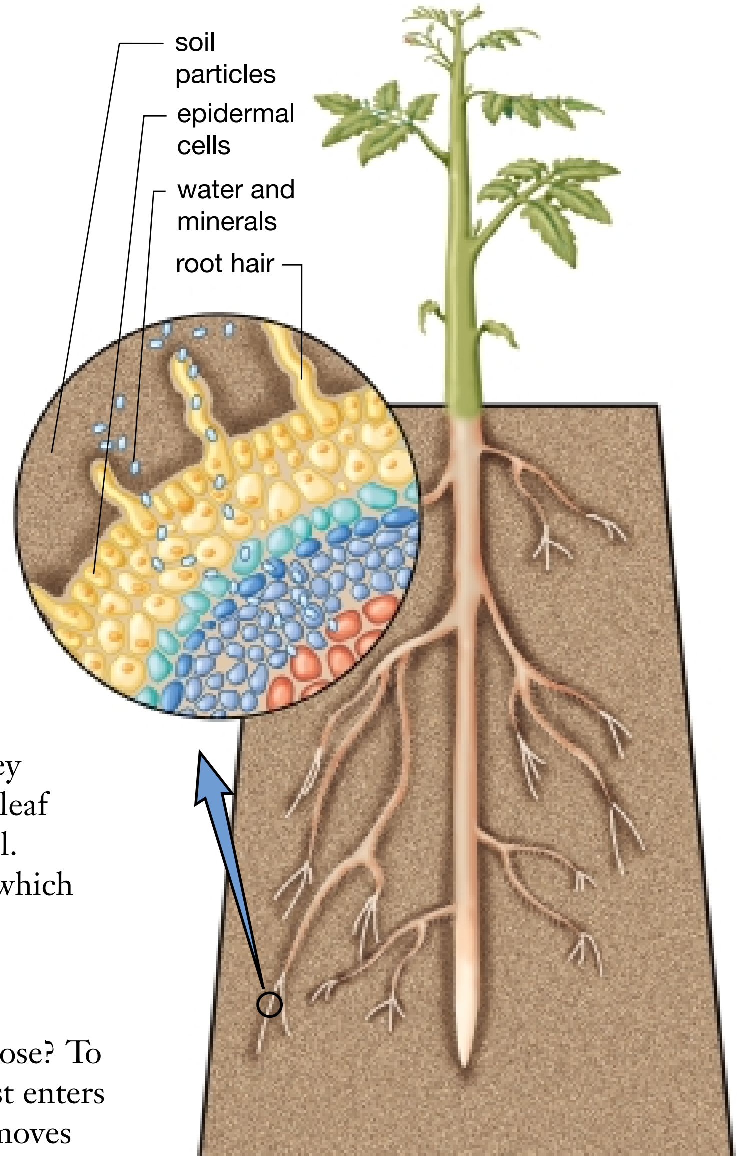


Figure 2.17 Water and dissolved minerals enter the plant by osmosis through the root hairs.

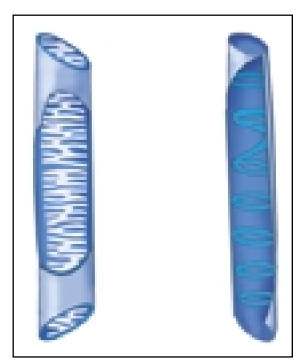


Figure 2.18 Xylem cells have thick walls for strength. Their open ends allow water to pass through freely.

Transpiration

Why do the stomata in a leaf open and close? To answer this question, recall that water first enters a plant through its root system. Then it moves into its shoot system. What happens next? The water does not continually circulate like the blood in our bodies. It does not go back into the root system. Instead, it exits the plant — through the open stomata in the leaves.

This loss of water from a plant through evaporation is called **transpiration**. The loss of water is not a problem as long as it is replaced by more water that enters the plant through the roots. In periods of drought and in deserts, however, water loss from a plant can be a serious problem.

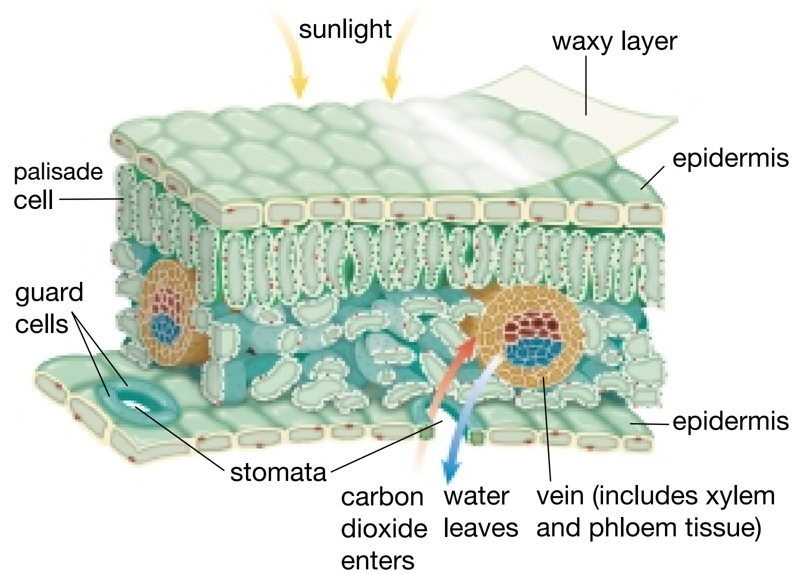


Figure 2.19 The structure of a typical leaf

Find Out ACTIVITY

Transpiration and Leaves

What is the relationship between leaves, transpiration, and the movement of water through a plant? You can find out by doing this activity.

Materials

2 leafy stalks of celery

beaker (or jar) of water

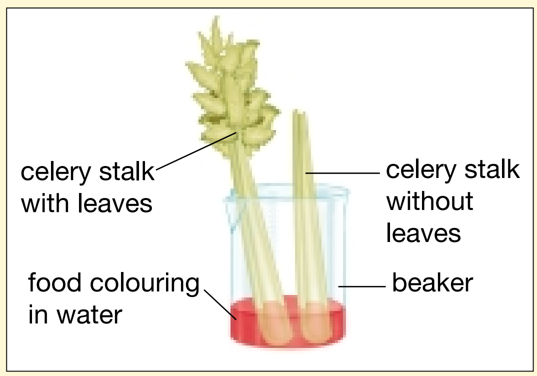
red food colouring

single-edged razor blade or sharp knife

cutting board or other cutting surface

Procedure

1. Take two leafy stalks of celery of about the same length.
2. Remove all the leaves from one stalk.
3. Place both stalks in a beaker or jar of water to which red food colouring has been added, as shown in the diagram.
4. Leave the jar in a sunny spot or under a bright light for at least 3 h.
5. Place the stalks on a cutting board. Beginning near the bottom end of the stalks, cut across the stems at short intervals to determine how far the coloured water has risen up each stalk.



CAUTION Never cut an object held in your hand. Place the object on a cutting surface and cut with the blade moving away from you. Cut the celery stalk with your teacher present.

What Did You Find Out? Analyzing and Interpreting

1. Based on your observations, what inference can you make about the effect of leaves on the rate of transpiration?

Pulling and Pushing

If all the tissues of a plant were to magically disappear, leaving only the water in them behind, you would see a ghostly outline of the plant in a weblike network of water. There is no break in this water system. Fine columns of water connect every cell, from the leaves to the roots. The network extends even beyond the root hairs — it connects root hairs to channels of water in the soil.

According to the particle model, individual water particles are held together by bonds of attraction, which make the plant's water network behave as a single unit. Water drawn into the root hairs by osmosis *pushes* slender water columns up the plant. At the same time, water lost from the leaves by transpiration *pulls* water up the xylem tissues all the way from the roots. Both these actions — pushing and pulling — are necessary to raise the water up to the top of very tall trees. In this way, trees can transport water without having a pumping organ similar to the human heart.

TOPIC 4 Review

1. What process causes water to enter or leave a cell?
2. How are osmosis and diffusion alike? How are they different?
3. If your teacher opens a bottle of ammonia at the front of the classroom, you will smell ammonia at the back of the room a short while later. Explain what has occurred.
4. Which tissues conduct water in plants?
5. Which tissues conduct sugars in plants?
6. What is the function of guard cells?
7. **Apply** Why do grocery stores spray their fresh vegetables with water?
8. **Design Your Own** Is it better to water plants in the evening or during the day? Make a hypothesis that answers this question, and then design an experiment to test it. Remember to include a control in your experiment.
9. **Design Your Own** Choose one of the following:
   - **(a)** Design an experiment to test the effectiveness of different substances in preventing flowers from wilting.
   - **(b)** Formulate your own question about some aspect of cell functioning, and design your own experiment to explore possible answers.

TOPIC 5

Cell Specialization and Organization

Imagine an orchestra made up of only a hundred trumpet players or a hundred violins. Such an orchestra would be very limited. To play every kind of music, an orchestra needs a variety of musical instruments, each with its own special sound. In an orchestra, the same instruments and those that are similar are grouped together so they can work together more easily to make their particular, unique sound. In the same way, a multicellular organism has different kinds of cells, which are organized in ways that help them to do their jobs.

Off the Wall

A nerve fibre in the neck of a giraffe can be up to 1 m in length. However, the main part of the cell from which it comes is about the same size as a human nerve cell.

Specialized Cells

Although multicellular organisms grow from single cells that repeatedly divide, their cells are not all the same. Like the instruments in an orchestra, different cells have different appearances and perform different jobs. They are said to be **specialized** for particular tasks. For example, your muscle cells are shaped to move parts of your body, and your skin cells are built to protect your body from the drying rays of the Sun. Humans have about a hundred different types of cells, each with its own particular structure and functions.

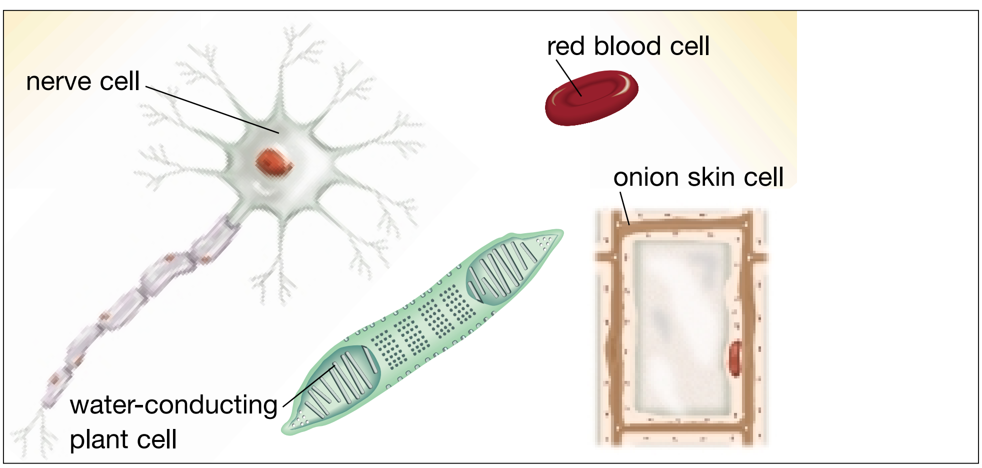
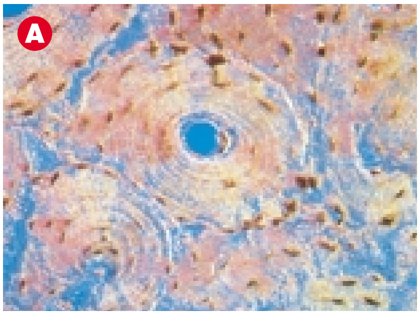
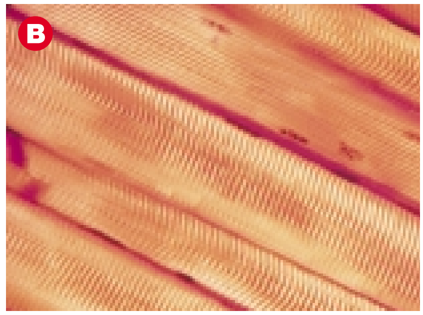


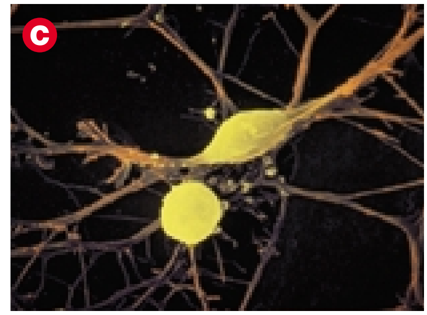
Figure 2.20 Different cells have different shapes and functions.

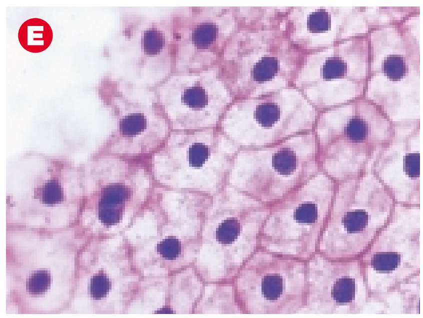
Look at the examples of plant and animal cells in Figure 2.20. How do their shapes relate to their functions? Nerve cells have long, branched fibres running from the main part of the cell, shaped to carry nerve signals from one part of the body to another. Red blood cells, which carry oxygen in the bloodstream, have a thin, disklike shape. This gives them a large surface area to pick up large amounts of oxygen. The water-conducting cells of a plant are tubelike, with thick walls and a network of holes that lets water pass easily through them. Onion skin cells are flat and brick-shaped, so they can fit closely together to form a continuous protective layer.

Now look at the photographs of different cells below and think about the structure of each and what function it might perform. Can you match the cells that come from the following part of your body — blood in your heart, nerve in your toe, muscle in your arm, bone in your leg, and skin on your head?





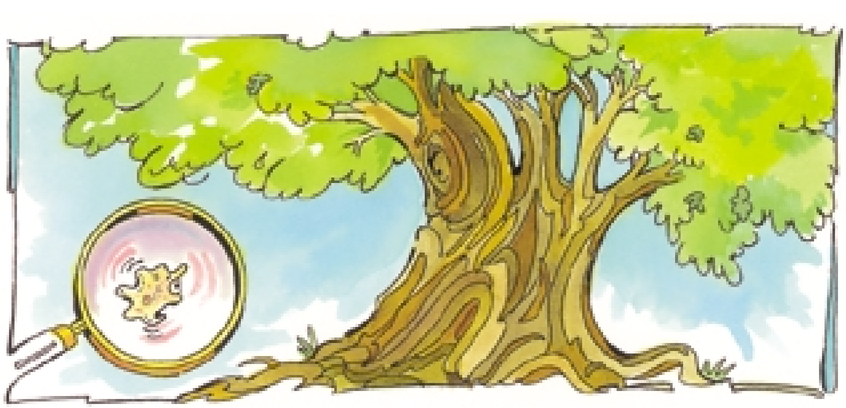




The Advantages of Being Multicellular

Imagine you are a microscopic, unicellular organism. Your whole body is one cell. This one cell must carry out all the functions needed to keep you alive. It must be able to move, obtain food, reproduce, and respond to the environment. There are many living organisms that consist of only one cell. What disadvantages do you think they have, compared with multicellular organisms?

You have already learned one disadvantage. Unicellular organisms cannot grow very large. Also, because they must take in all the materials they need through their cell membranes, most unicellular organisms can only live in watery, food-rich surroundings.



DidYouKnow?

Most household dust is made up of dead human skin cells. You and everyone around you are continually shedding parts of the thin outer layer of skin. Your entire outer layer of skin is completely replaced by the growth of new cells approximately every 28 days.

Cell Organization

Multicellular organisms have several advantages compared to unicellular living things. They can live in a wide variety of environments. They are able to grow very large — as large as a whale or a Douglas fir. Multicellular animals can obtain their energy from a wide variety of foods. Their bodies are more complex. By specializing in particular functions, each cell in a multicellular organism can work much more efficiently than the cell of a unicellular organism.

In multicellular organisms, specialized cells of a similar kind work closely together, and are usually found grouped closely together in the body. Groups of specialized cells, in turn, work in harmony with other groups.

Figure 2.21 The body of this whale contains trillions of cells that are grouped into tissues, organs, and systems.

Many animals and plants are made of trillions of cells. To learn how these cells are organized, compare the organization of cells with the way students are organized in a school district. First, students in the same grade are grouped together in classes. Then, different classes of students together make up a school. Finally, a number of schools are organized into a single school district.

Similarly, as you saw at the beginning of Topic 1 (page 100), cells with the same structure and function are grouped into **tissues**. Groups of different tissues form **organs**. Organs work together in **systems**. Systems work together to form an organism. This arrangement of cells, tissues, organs, and systems forms several different **levels of organization** in living things. Each level can be studied on its own, as you have done with cells. Or they can be studied in relation to the levels above or below it, as you have done with plant cells and tissues.

Tissues

Tissues are groups of similar cells. Onion skin is a tissue made of sheets of similar, thin, tightly packed cells. These specialized skin cells form a layer that covers and protects the onion. Figures 2.22 and 2.23 show the main types of tissues found in animals and plants. These tissues are classified according to the functions they perform.

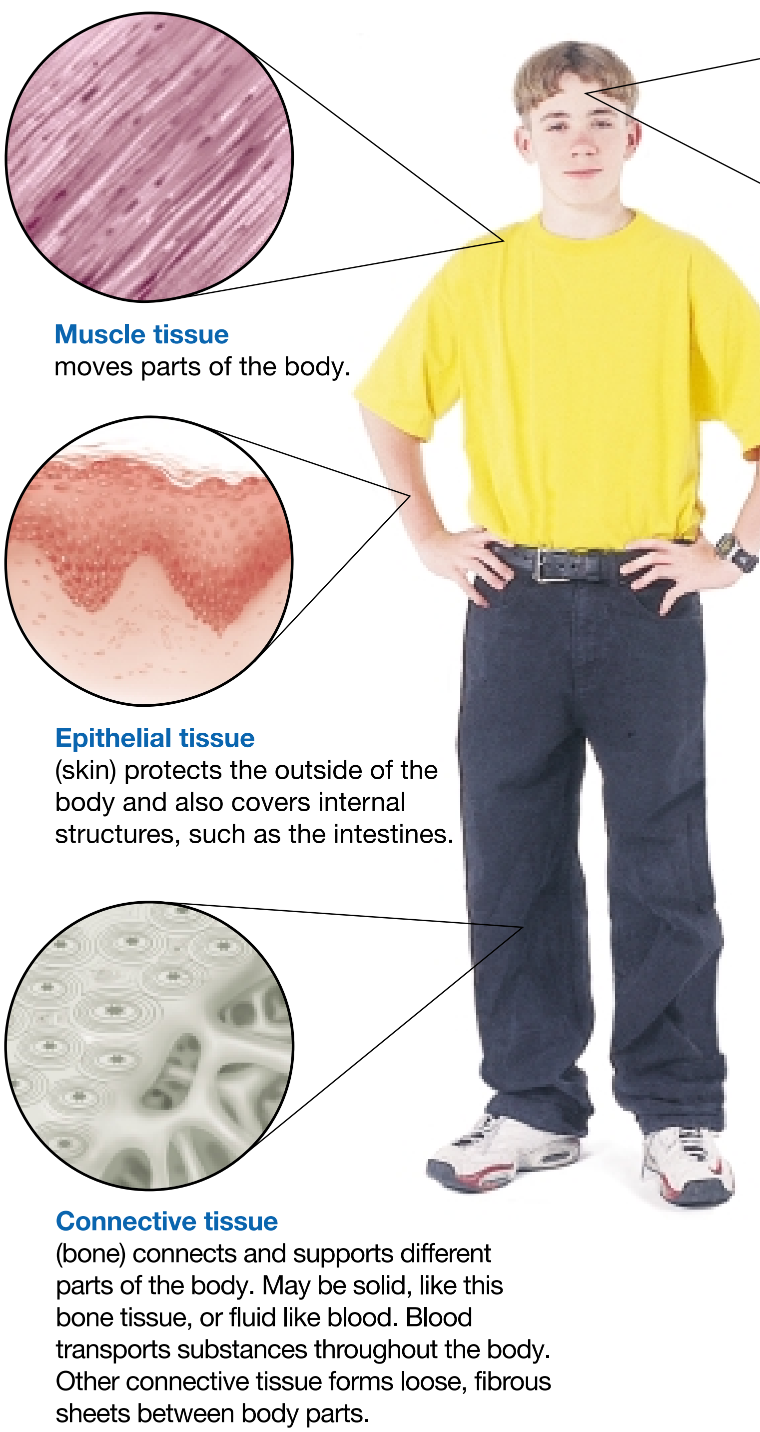


Figure 2.22 Main types of tissues found in animals

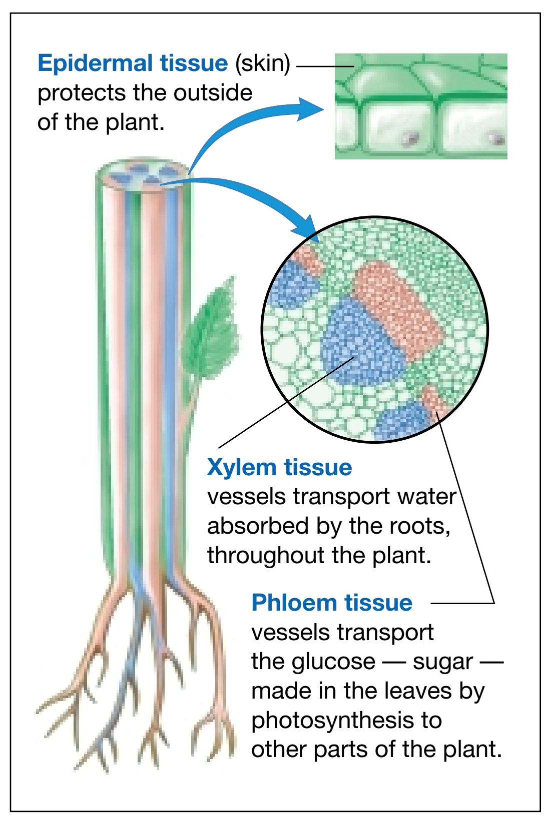


Figure 2.23 Main types of tissues found in plants

Find Out ACTIVITY

Looking at Animal Tissues

The photographs below show tissues observed under a compound light microscope similar to the one you have used.

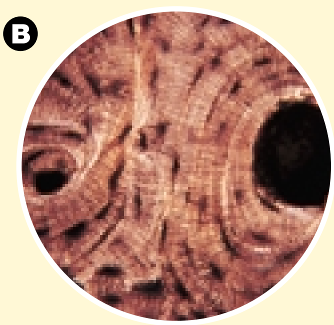
Procedure — Communication and Teamwork

1. With your group, look closely at the tissues shown in A, B, and C. The tissues are bone tissue, nerve tissue, and skeletal muscle (the kind of muscle you use, for example, to bend your arm).
2. Performing and Recording — Based on what you have read about these tissues, try to identify each type. Record your decision and reasons for your decision for each tissue.

What Did You Find Out? — Analyzing and Interpreting

1. Which tissue did you find easiest to identify and why?
2. List three different careers in which a person might need to examine tissues. Suggest at least one way a person could use information obtained by observing tissues.

A


B


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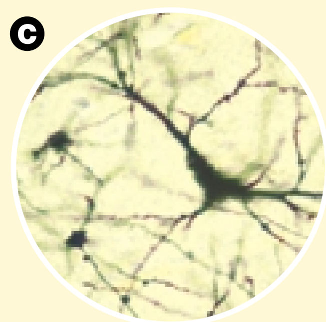


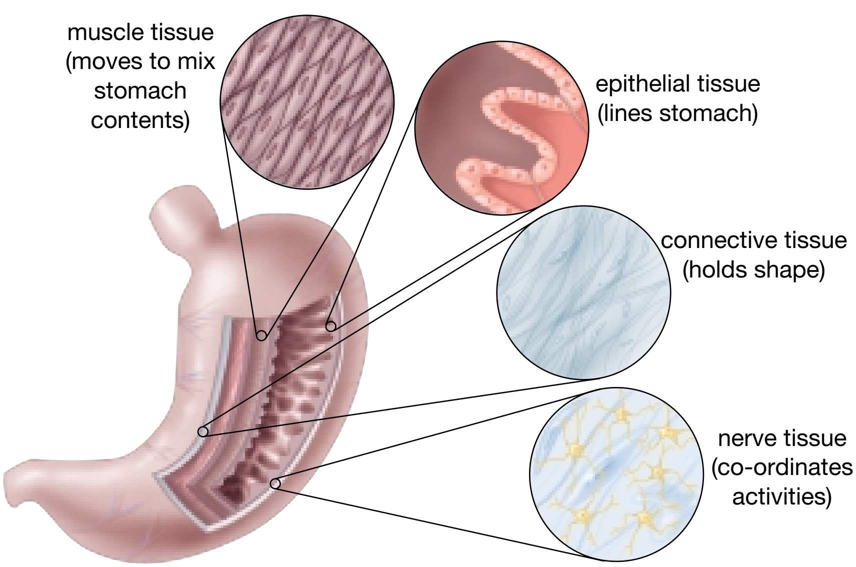


Figure 2.24 The stomach is an organ made of different tissues.

Organs

Suppose you feel hungry, see a juicy apple, and eat it. This simple action would not be possible without the next level of organization in the body — the organs. Organs are distinct structures in the body that perform particular functions. You used your eyes (to sense the apple), your brain (to plan and co-ordinate your actions), and your mouth and stomach (to start digesting the apple). Each organ is made of several tissues working together. For example, your stomach is made of four main types of tissues, as shown in Figure 2.24. Other examples of organs in your body are the lungs, the heart, and the kidneys. Plants have organs, as well. Plant organs include roots, stems, and leaves.

INVESTIGATION 2-G

SKILL CHECK
- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Teamwork!

Think About It

Why do you need a liver? A heart? A pair of lungs? What do these and other organs do? What are their main parts? Are they part of a system? Your class will divide into small groups to investigate these questions and each group will present its findings to the class. How you complete this task is up to your imagination and your research skills!

What to Do

1. As a class, brainstorm a list of organs found in the human body. Divide into groups and assign one organ to each group.
2. Decide how the class will evaluate each group's presentation. As a minimum, each group's presentation must answer these three questions:
   - What is the organ's function?
   - What is the organ's structure?
   - To which system does the organ belong?
3. Use your library, the Internet, and any other resources to research the structure and function of your group's organ. Here are some more ideas to start you thinking:
   - What happens if the organ does not work properly?
   - Can the organ be transplanted? Can it be replaced by an artificial organ?
   - Which other animals have this organ? Are there some interesting differences or similarities compared with the human organ?
4. Decide how your group will co-ordinate and present the results of its research to the class. Your group may choose to do one of the following:
   - present a scientific lecture with charts and graphs
   - write a play and act the roles of tissues, cells, and organs
   - devise a quiz modelled on games such as "20 Questions" or "Jeopardy"
   - invent a board game
   - construct a three-dimensional model.

Analyze

Use the criteria decided in advance (see step 2) to evaluate each group's presentation.

INTERNET CONNECT

www.school.mcgrawhill.ca/resources/

For information about organs in the human body and diseases affecting them, visit the above web site. Go to **Science Resources**, then to **SCIENCEFOCUS 8** to find out where to go next. Search for facts or diagrams that you might use in this investigation.

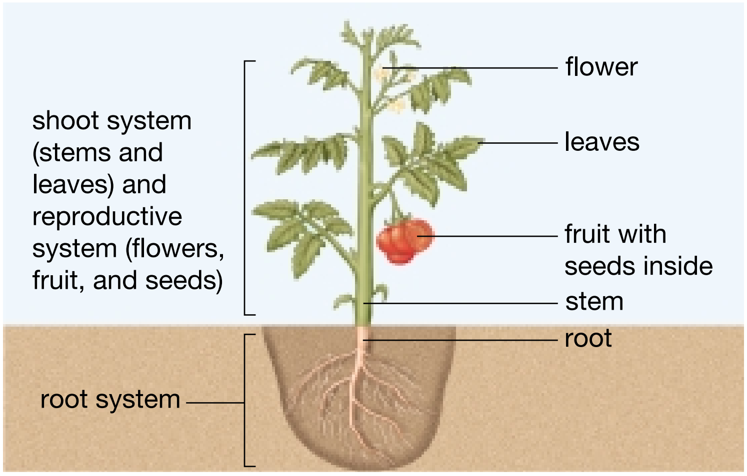


Figure 2.25 The purpose of each system is to provide the organism with what it needs to stay alive.

Systems

As you have seen, organs work together just as cells and tissues do. Organs form systems to perform activities that help plants and animals function as a whole. Because of differences in how plants and animals survive, plants have fewer systems than animals have. Plants have only two main systems: a root system below ground and a shoot system (the stems and leaves) above ground, as shown in Figure 2.25. The functions of the root system are to obtain water and minerals from the soil and to anchor the plant in the ground. The function of the shoot system is to make food for the plant. At certain times, flowering plants produce a third system for reproduction. The reproductive system can include flowers, fruits, and seeds.

TOPIC 5 Review

1. Why do cells in your body need to be specialized?
2. Why do nerve cells have long fibres, whereas red blood cells are thin and disklike?
3. Why do unicellular organisms live mainly in a watery environment?
4. Choose the correct answer and write each complete sentence in your notebook.
   - **(a)** A tissue is made from groups of (i) organs, (ii) cells, (iii) organelles.
   - **(b)** Muscle is an example of (i) a system, (ii) an organ, (iii) a tissue.
   - **(c)** The heart is an example of (i) an organ, (ii) a system, (iii) epithelial tissue.
   - **(d)** One example of connective tissue is (i) nerve tissue, (ii) bone tissue, (iii) epithelial tissue.
   - **(e)** An example of a system in plants is (i) seeds, (ii) the shoot system, (iii) xylem.
   - **(f)** The type of tissue that protects the outside of a plant is called (i) epithelial tissue, (ii) epidermal tissue, (iii) connective tissue.
5. **Apply** Most people think of the skin as just a body covering. How do you think skin cells are important to other body cells?

Wrap-up TOPICS 4-5

If you need to check an item, Topic numbers are provided in brackets below.

Key Terms

selectively permeable
permeable
impermeable
diffusion
osmosis
vascular tissues
phloem tissue
xylem tissue
root hairs
transpiration
specialized
tissues
organs
systems
levels of organization

Reviewing Key Terms

1. In your notebook, complete each sentence from column A with the correct ending from column B.

A	B
• A cell membrane is	• osmosis (4)
• Water enters or leaves cells by	• diffusion (4)
• Oxygen enters or leaves cells by	• transpiration (4)
• Water evaporates from a plant by	• selectively permeable (4)
	• permeable (4)

2. Draw a flowchart illustrating the following terms in the correct order:
organs, cells, tissues, organism, systems. (5)

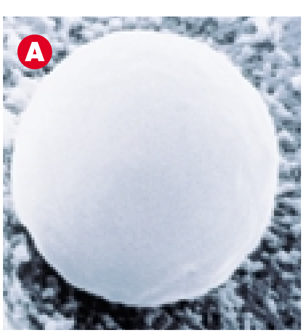
Understanding Key Concepts

3. Compare cell membranes with the screen doors used on houses in summer. Explain why neither can be completely impermeable or permeable. (4)

4. How are osmosis and diffusion different? (4)

5. If a cell is placed in a concentrated solution of glucose, would you expect water to move into or out of the cell? Explain. (4)

6. Explain why cells need (a) water, and (b) food. (4)



7. Why might a plant with a huge stem system and a tiny root system have difficulty surviving? (4)

8. Why are cells specialized in multicellular organisms? (5)

9. Name the main types of specialized cells in animals. (5)

10. Explain how the structure of a specialized cell is related to its function in the body of a multicellular organism. (5)

11. List some advantages that multicellular organisms have over some unicellular organisms. (5)

12. Name the five levels of organization in a multicellular organism and give an example of each. (5)

13. Give two examples of systems in plants and explain their functions. (5)

14. Study the two photographs of red blood cells. One cell was part of a group of cells placed in distilled water, while the other was placed in a strong salt solution. Make an inference about which one was in which solution, giving your reasons for your inference. (4)

TOPIC 6 Body Systems in Humans

DidYouKnow?

There are 11 different systems in the human body. Each system has a major function. The systems are co-ordinated into the total living organism, and all the systems depend on one another.

As you learned, every cell in the body needs a steady supply of food and oxygen to give it energy. Three different organ systems must work together to make this possible. Do you know what they are?

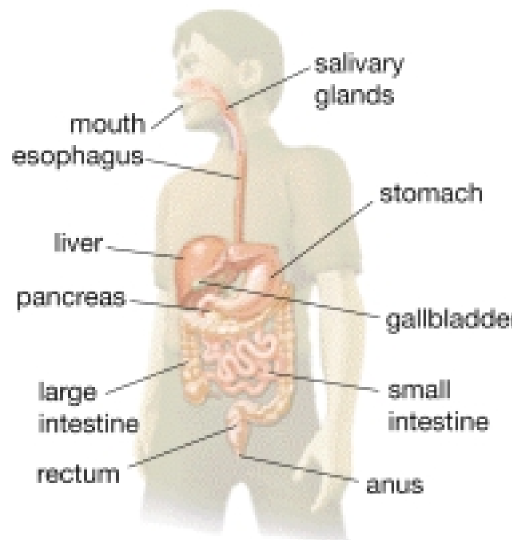


Figure 2.26 This organ system breaks down food by digestion.

The Digestive System

Food first enters the body through the mouth, then passes to the stomach and the intestine. It is broken down along the way into small, soluble particles that can be used by cells. Unused food is expelled from the body as waste. The organs involved in these processes form the **digestive system**, as shown in Figure 2.26.

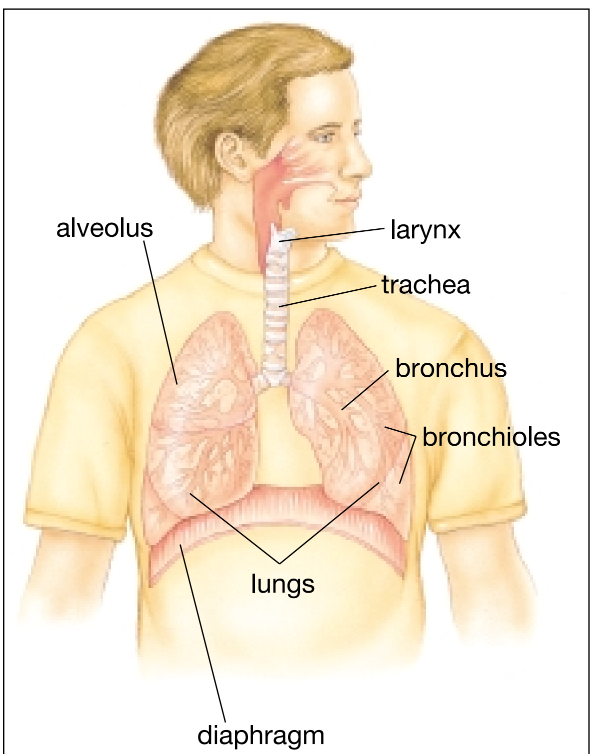


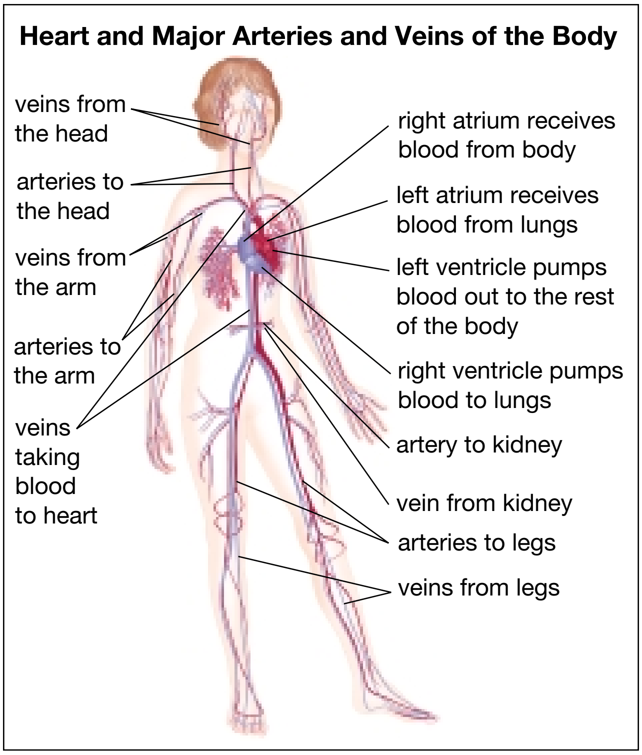
Figure 2.27 This system moves air in and out of the body. This in-and-out movement of air supplies oxygen for cells and removes waste carbon dioxide.

The Respiratory System

Breathing in (inhalation) fills our lungs with oxygen-containing air. Breathing out (exhalation) rids our bodies of waste carbon dioxide. The organs involved in this gas exchange form the **respiratory system**, as shown in Figure 2.27.

The Circulatory System

The digestive system puts food into the intestine and the respiratory system puts oxygen into the lungs. How do particles of food and oxygen eventually get from these systems to cells in the toes, the brain, and other parts of the body? A third system transports particles of food and oxygen. The **circulatory system** consists of the heart, blood, and blood vessels (see Figure 2.28). This system circulates blood around the body, delivering food particles, dissolved gases, and other materials to every cell and carrying away cell wastes.



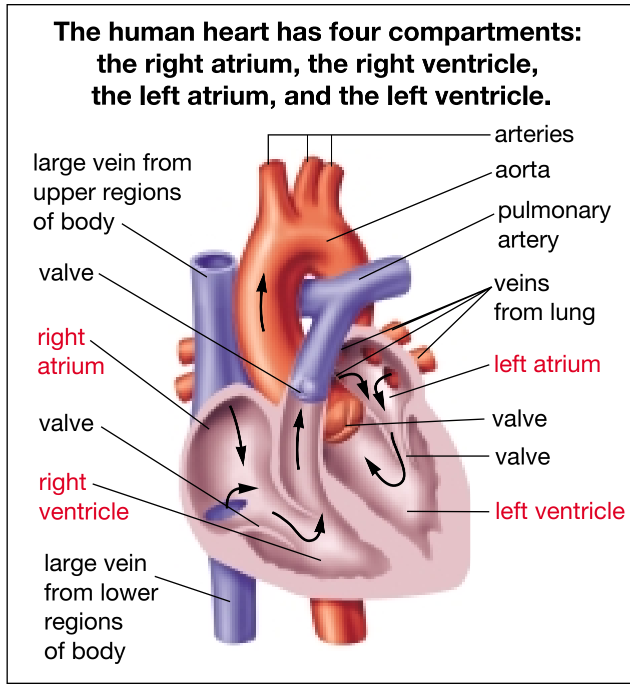


Figure 2.28 The circulatory system's function is to carry materials to and from all the cells in the body.

Find Out **ACTIVITY**

Changing Your Pulse Rate

Your pulse is produced by blood surging through your arteries each time your heart "beats." It is one guide as to how well your circulatory system is working. What factors affect the rate at which your heart pumps blood? Measure your pulse rate to find out.

Procedure ✷ Performing and Recording

1. Locate one of your radial arteries, on the inside of your wrist in line with your thumb (see the photograph).

2. Using a watch or timer, count the number of pulses you feel in 15 s while you are sitting comfortably at rest. Multiply the number by 4 to obtain your heart rate per minute. Record your results.
3. Stand up and do five deep knee bends as shown in the photograph. Immediately measure and record your pulse rate.

CAUTION Do not do this activity if you have any health problems that may put you at risk.

4. Rest for 1 min and again measure and record your pulse rate.

What Did You Find Out? ✷ Analyzing and Interpreting

From your results, what is the relationship between exercise and pulse rate? Suggest an explanation for this relationship.

DidYouKnow?

A capillary may be so narrow that only one red blood cell can pass through it at a time.

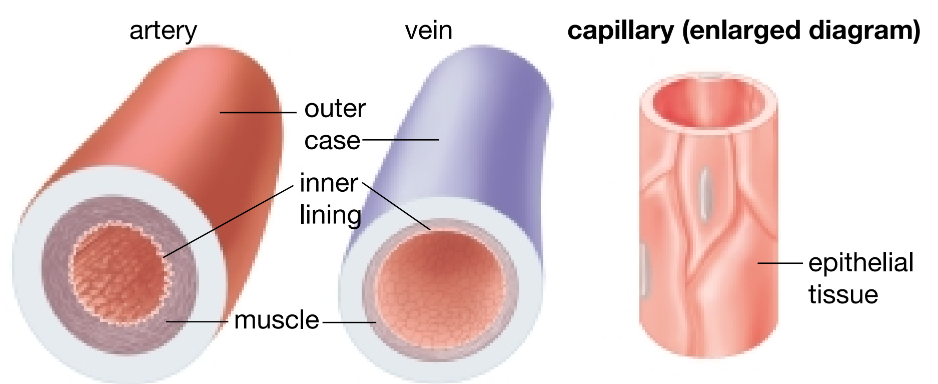
How the Respiratory and Circulatory Systems Connect

To connect the cells throughout your body with the air, the respiratory system and the circulatory system work together.

The respiratory system exchanges oxygen and carbon dioxide, while the circulatory system transports those gases throughout the body. The gases pass from one system to the other where the two systems come into closest contact — among the tissues of the lungs.

Look at Figure 2.27 on page 146. After air enters the nose, it passes to the lungs through a series of smaller and smaller tubes. The trachea (windpipe) is about 20 mm in diameter. It divides into a right and a left bronchus, each about 12 mm across. Each bronchus tube branches into thousands of small, narrow bronchioles, with diameters of 0.5 mm. Finally, the bronchioles divide and end in millions of tiny air sacs called **alveoli** (singular alveolus), only 0.2 mm in diameter.

The circulatory system also involves a series of tubes — the blood vessels. Blood vessels branch and divide into smaller and smaller channels. The three main types of blood vessels are shown in Figure 2.29. The smallest blood vessels are the **capillaries**.



Arteries have thick, muscular walls for carrying blood under pressure.

Veins have thinner walls than arteries. Valves inside veins prevent blood from flowing backward.

Capillaries are hair-thin vessels. Their walls are made of epithelial tissue only one cell layer thick.

Figure 2.29 Cross sections of human blood vessels

Diffusion causes oxygen to pass from the alveoli into the capillaries. The oxygen first dissolves in a thin film of moisture covering the walls of the alveoli. Then it diffuses from the alveoli through the thin capillary walls into the bloodstream.

Now look closely at Figures 2.30A and B on page 149. Each alveolus is surrounded by a web of capillaries. It is here that gases are exchanged. Oxygen and carbon dioxide pass back and forth between the air in the alveoli (part of the respiratory system) and the blood in the capillaries (part of the circulatory system).

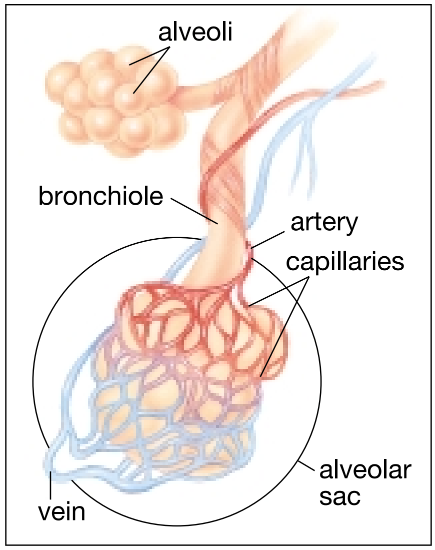


Figure 2.30A Gases move back and forth between the alveoli and the surrounding blood vessels.

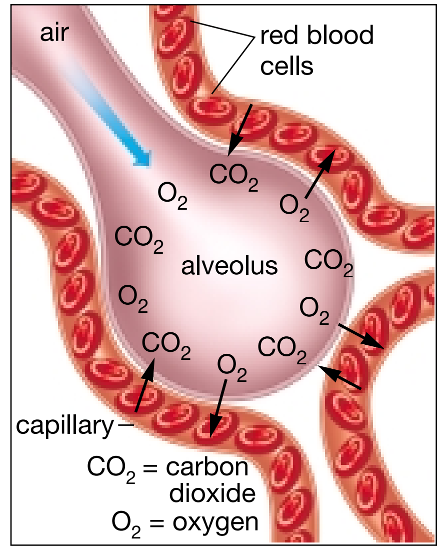


Figure 2.30B An enlarged alveolus. There are about 300 million alveoli in the human lungs.

How the Circulatory and Digestive Systems Connect

You have discovered how your bloodstream obtains oxygen from your lungs. Your bloodstream also carries food particles. The transfer of food from the digestive system to the circulatory system takes place at the inner lining of the small intestine, as shown in Figure 2.31. Covering the surface of this lining are millions of tiny, fingerlike projections called villi (singular: villus). Each villus contains a network of capillaries. Dissolved food particles pass from the intestine into the capillaries by a process called absorption. The food particles are now small enough to enter your body's cells to supply them with the food they need. The arteries of your circulatory system provide the transportation network.

Like alveoli, villi have thin walls through which particles can pass into the circulatory system. Both alveoli and villi consist of tiny projections, and both occur in huge numbers. This arrangement greatly increases the surface area that is in contact with capillaries without taking up a large amount of space in the body.

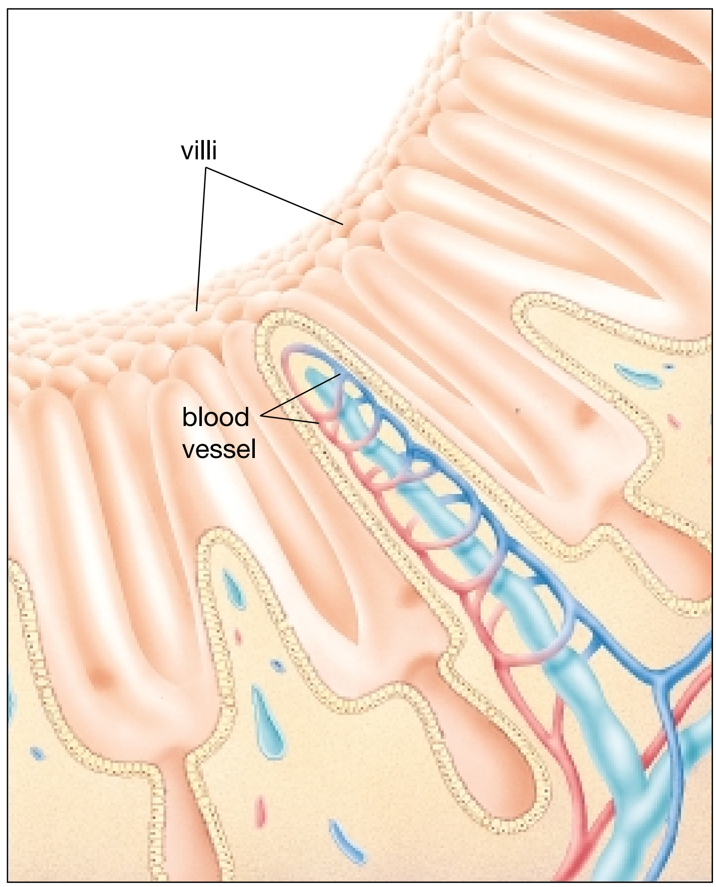


Figure 2.31 The villi in the small intestine. These structures increase the surface area of the small intestine for more efficient absorption of nutrients.

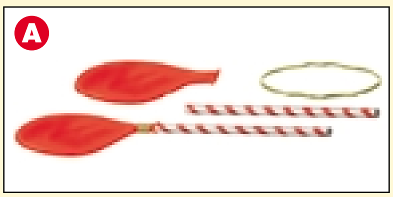
Find Out ACTIVITY

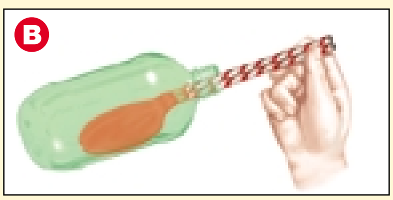
Make a Model of the Lungs

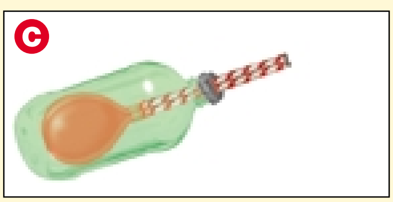
If you look at lung tissue under a microscope, you will see that it has no muscle cells. So what makes your lungs expand and contract? Make a model of your lungs and chest cavity to find out.

Materials

large plastic pop bottle
2 small balloons
modelling clay
2 plastic straws
2 elastic bands







Procedure

1. Inflate the balloons to stretch them, then let out the air. Insert a straw into the neck of each balloon and fasten the balloon and straw tightly together, using elastic bands (see Diagram A).
2. Insert the straws into the bottle so the balloons are hanging inside the bottle, and the other ends of the straws are sticking above the neck, as in Diagram B.
3. Completely seal the neck of the bottle around the straws with modelling clay, as shown in Diagram C.
4. Squeeze and release the sides of the bottle and watch what happens to the balloons.

What Did You Find Out? Analyzing and Interpreting

1. What happened to the balloons when the bottle was squeezed? What happened when the bottle was released?
2. Write an explanation for your observations. Try to use the term "air pressure."
3. In what way is the squeezing and releasing of the bottle similar to inhaling and exhaling?

Off the Wall

Many seals, with lungs no bigger than a human adult's, can easily stay underwater without breathing for 20 min or more. Even more curious, they breathe out before they dive. The explanation for this puzzle lies in how the seal's blood and circulatory system function. All the oxygen a seal needs while underwater is stored in its blood and muscle tissue, rather than in its lungs. To be able to store this large amount of oxygen, a seal has about one-and-a-half times to twice as much blood in its body as other mammals of similar size.

As soon as a seal dives underwater, a series of changes takes place in its body. Its heartbeat slows at once, from about 100 beats per minute to about 10 beats per minute. Blood flow to some parts of its body, such as the kidneys and the muscles, slows or stops. The seal is also able to tolerate a high level of carbon dioxide in its blood, as this gas builds up during the dive.

When the seal returns to the surface, it can breathe in and out very rapidly, almost completely emptying its lungs of waste gas. With each breath, a seal can exchange 90 percent of the air in its lungs. By comparison, with each breath, humans exchange only about 20 percent of the air in their lungs.

The Excretory System

Getting food and oxygen to your cells is only one half the equation for good health. Your body must also get rid of wastes. Filtering waste materials from the blood is the main function of another system — the **excretory system**. The key organs in this system are your two kidneys. You can research this system for yourself in the Find Out Activity below.

Sensory Awareness Systems

Feeling cold? Why not put on a sweater? Feeling hungry? It's time to eat. In these and other ways, you respond to changing conditions and make adjustments. Your body systems also make constant adjustments to maintain a stable internal environment for your cells.

For example, nearly 90 percent of your body heat is lost through the skin. Most of the rest of your body heat is lost through your lungs. When you get cold, you may shiver. Your quivering muscles generate heat. You may also get "gooseflesh" — small bumps on your skin. The bumps are produced by the contraction of small muscles in the skin that make your hairs stand on end. In animals with a thick coat of hair, and in our hairier prehistoric ancestors, fluffing up the body hair helps reduce heat loss by improving insulation.

When you are hot, your body tries to cool you down. Do you get flushed and red after hard exercise? This happens because tiny blood vessels in your skin expand. This increases blood flow near the body surface where heat can be lost to the outside. Sweating helps cool your body as the moisture evaporates from your skin surface.

Find Out ACTIVITY

Employment — Excretion!

Imagine you are a body in search of kidneys. You must write a job description to get the right organs for the job. What exactly must kidneys do? What qualifications (structure) do they need? Will they be expected to work in co-operation with other organs? Present your job description in class.

Procedure

1. Do some research on kidneys and the excretory system to answer the questions above.
2. Performing and Recording Present your findings in the form of a job advertisement with the heading: "Wanted: Highly Qualified Kidneys." The ad should give details of kidney structure and functions, and it should include a labelled sketch.

What Did You Find Out?

1. What waste materials do kidneys remove from the body, where do these wastes come from, and why must they be removed?
2. Which other system is most closely connected with the excretory system?

To keep your body temperature stable, your nerves, muscles, and blood all function together. Your nervous system monitors conditions outside the body through temperature receptors in your skin. Information from the temperature receptors goes to the heat-regulating centre of your brain (the hypothalamus). Responding to this information, the brain sends nerve signals to your muscles, skin, and blood vessels. Working together, your muscles, skin, and blood vessels adjust your blood flow and muscle activity. In response, your body increases its heat production or reduces its heat loss.

Your body's responses to stimuli are co-ordinated by the **nervous system** (the brain, spinal cord, and nerves) and the endocrine system (glands that produce chemical messengers called hormones). In the body, a number of factors can affect the smooth working of the body systems (listed in Table 2.1 on page 153).

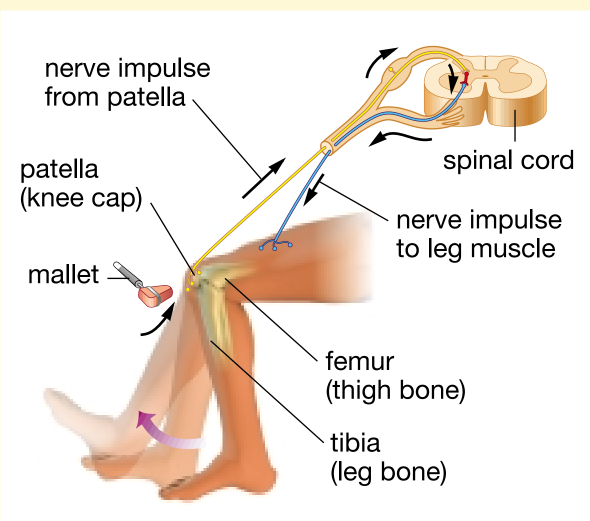
Find Out ACTIVITY

A Simple Reflex

The knee-jerk reaction is a simple example of a feedback system controlled by the nervous system in the body. A sharp tap (stimulus) at the knee causes a signal to be sent to the spinal cord. A return signal (the feedback) causes the leg to react to the stimulus (see the diagram below). You can observe this feedback system for yourself.

Materials

rubber reflex hammer



Procedure

1. Your teacher will ask for two volunteers to come to the front of the classroom. One student sits on the edge of a bench or table so his or her legs hang freely and do not touch the floor.

2. The second student locates the first student's kneecap and feels the position of the tendon at its lower edge. With the rubber hammer, or the edge of a hand, the second student (guided by the teacher) quickly and firmly taps the tendon. Note the automatic response of the lower leg.

3. The students will change roles and repeat steps 1 and 2.

What Did You Find Out? Analyzing and Interpreting

1. Which muscles contract to lift the leg?

2. Draw a flowchart showing the sequence of events from tapping the tendon to the response of the leg.

Diet, exercise, drugs, injury, and disease can affect body systems and disrupt how they function.

Table 2.1 Major Body Systems

System	Functions
Digestive	Breaks down food, absorbs food particles, and eliminates wastes.
Respiratory	Exchanges oxygen and carbon dioxide.
Circulatory	Circulates blood. Transports food particles, dissolved gases, and other materials.
Nervous	Controls and co-ordinates body activities. Senses internal and external changes.
Excretory	Regulates blood composition and excretes waste fluids.

Across Canada

In 1921, Canadian researchers Frederick Banting and Charles Best, working at the University of Toronto, discovered the hormone insulin. This hormone, produced by cells in the pancreas, sends a message to other cells in the body when there is a lot of glucose in the blood. The cells respond by processing the glucose, which lowers the blood's glucose level. Hormone production is constantly adjusted by the pancreas as glucose levels rise and fall. (The amount of glucose in a person's blood depends on their eating habits and amount of physical activity.)

Some people's bodies are unable to control the glucose levels in their blood. This leads to the disorder called diabetes. Before the discovery of insulin, diabetes was fatal. Today, people with diabetes are able to live full lives by controlling their diets and by injecting insulin, if their bodies cannot make it for themselves.

DidYouKnow?

Drug addiction or dependence is an example of how our bodies work to provide a stable internal environment. When the body is first exposed to a drug (whether caffeine, nicotine, opium, or another chemical), the cells respond so as to maintain their normal function in the presence of the new chemical. After a time, the cells become so tolerant that the drug loses its effect. The person may then need to take larger quantities of the drug to produce the desired effect. If the substance is withdrawn, the cell response is disturbed for a time — sometimes severely — until a new readjustment is made.

TOPIC 6 Review

1. Why does the body need oxygen?
2. Describe how carbon dioxide from a cell in your hand leaves your body.
3. The lungs can expand and contract because they have muscular walls. Is this statement true or false? Explain.
4. What structures help increase the absorption of food in the small intestine? How do they do this?
5. How might your muscular system help you stay warm?
6. How might your circulatory system help you stay cool?

Ask an Expert

Turn to page 164 to find out what another researcher is doing today to find a cure for diabetes.

TOPIC 7 Body Systems and Your Health

During the fast-paced excitement of a hockey game, both players and spectators experience rapid breathing and heart rates. This happens because our muscles demand more oxygen and nutrients as our activity level rises. Our heart responds by pounding more than twice as fast as when we are asleep. Throughout our lives, during active as well as quiet moments, the heart works continuously to deliver nutrients and remove wastes from every cell of our bodies.

If you press your fingers to your chest a few centimetres left of the centre, you may be able to feel the thumping of your heart. That rhythmic pulse is evidence of a pump at work, pushing your blood in a continuous flow through all the vessels of your body (see Figure 2.32).

Blood — The Body's Transportation System

In unicellular organisms, materials are directly exchanged between the cell and its external environment, as shown in Figure 2.33. In multicellular organisms, most cells are not in direct contact with the external environment. Substances must be brought to cells and taken away from them by the circulatory system. The blood vessels of the circulatory system form a complex network linking the outside environment with the internal environment of the body.

In humans, substances are transported around the body in the blood. About 8 percent of an adult's body weight is blood. What exactly is blood made of? The main components of this fluid and their functions are listed in Table 2.2. Plasma and red blood cells make up 99 percent of the volume of blood. Plasma is the liquid portion of the blood. It transports most of the carbon dioxide produced by the body. The red blood cells are specialized to carry oxygen. They contain an iron-rich chemical called hemoglobin, which attracts oxygen. This allows the blood to carry much more oxygen than it otherwise could.

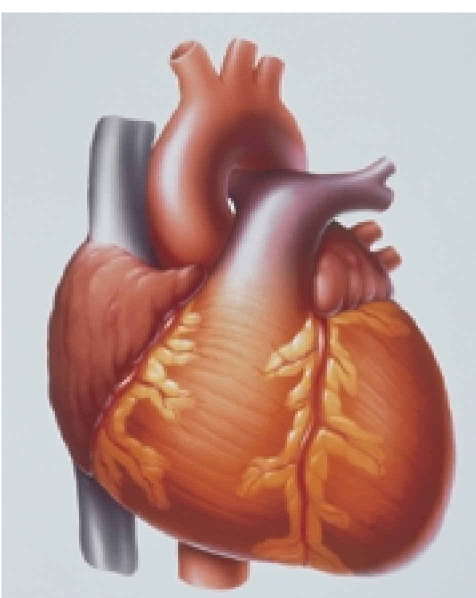


Figure 2.32 The heart is a pumping organ. You can feel it contracting and relaxing as it pushes blood through your arteries.

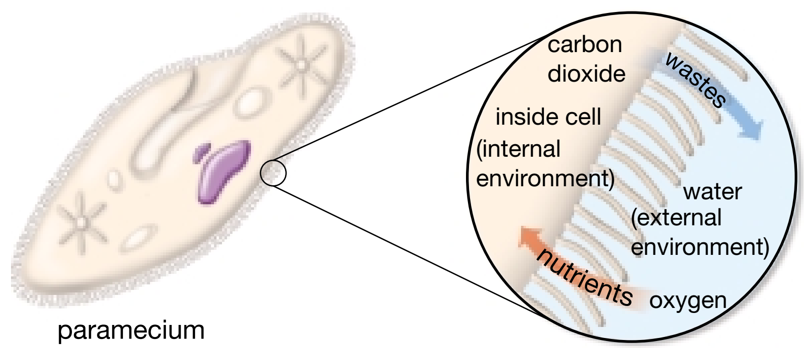


Figure 2.33 Paramecium exchanging materials with its external environment.

Table 2.2 Blood Components and Their Functions

Component	Percentage of blood (by volume)	Main function
plasma	55%	carries nutrients, waste products, hormones, and blood cells
red blood cells	44%	carry oxygen
white blood cells	less than 1%	defend body against infection and disease cause blood to clot (thicken) at site of
platelets	less than 1%	wounds to prevent blood loss

Just as highways bring materials from outside your neighbourhood, the circulatory system continuously brings oxygen and nutrients from the outside environment into your body. In order to do this, it works closely with two other systems, the respiratory and the digestive systems.

If one of these systems is not functioning properly, the whole network is disrupted and the entire body is affected. Leading causes of hospitalization in Canada are disorders of the circulatory system (15 percent), digestive system (11 percent), and the respiratory system (10 percent).

A Healthy Circulatory System

The pumping action of the heart circulates the blood throughout the body, supplying oxygen and food that cells need for their activities. The circulating blood also carries wastes produced by the cells to other organ systems that break them down or excrete them from the body.

Disorders of the circulatory system are the leading cause of death in North America. One of the most common is high blood pressure (hypertension). High blood pressure can affect the circulation of the blood and can lead to heart attacks (damage to heart muscle) and strokes (brain damage). High blood pressure is sometimes known as the "silent killer" because people with hypertension may not feel ill.

DidYouKnow?

Iron (found in red blood cells) is obtained from certain foods, such as liver, egg yolks, beans, nuts, dried fruits, and leafy green vegetables. A shortage of iron in the body may result in anemia. This is a condition in which the blood's ability to carry oxygen is greatly reduced. Symptoms of anemia include dizziness, fainting, and shortness of breath. The problem can be remedied by an improved diet that is rich in iron.

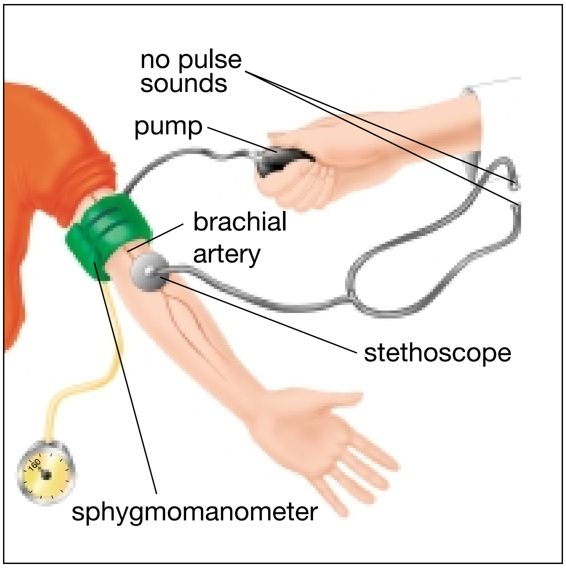


Figure 2.34 Measuring blood pressure

Figure 2.35 A doctor uses both a sphygmomanometer and a stethoscope to measure blood pressure.

Blood Pressure

Doctors measure blood pressure as a simple first step to assess the health of the circulatory system. The device used to measure blood pressure is called a sphygmomanometer (see Figure 2.34). It consists of an inflatable cuff that is wrapped around the arm. Air is pumped into the cuff, squeezing it against the artery in the arm and restricting the blood flow. Air is then slowly let out of the cuff to the point where the blood pressure matches the cuff pressure, letting blood force its way back through the artery. A doctor can listen for the sound of the blood using a stethoscope (see Figure 2.35).

Blood pressure indicates several things about the health of the circulatory system:

- *The volume of blood:* If a person has lost a lot of blood through injury, the blood pressure will be low.
- *Heart rate:* A fast-beating heart pushes blood rapidly through the arteries, building up blood pressure.
- *Artery size:* Large, open arteries conduct larger volumes of blood, producing low blood pressure. Small, narrow, or partly clogged arteries produce high blood pressure.
- *Artery elasticity:* Flexible arteries can easily expand, letting more blood through. Loss of elasticity results in "hardening" of the arteries, producing higher blood pressure.
- *Blood viscosity:* Viscosity refers to the thickness of the blood. Thick fluids flow less easily than thin, watery fluids. Blood viscosity is a measure of the balance between red blood cells and plasma.

DidYouKnow?

Cells need to divide so your body can grow and repair itself. What happens if cells begin to divide and spread in an uncontrolled way? This is what happens in the bodies of people with cancer. As abnormal cancer cells continue to multiply, they spread to other parts of the body and damage them.

There are some treatments that can slow or stop the spread of cancer by destroying the cancerous cells and leaving normal cells intact. This can be done by chemicals (chemotherapy) or radiation (high-energy particles). These treatments are most successful if the cancer is diagnosed in the early stages, before the abnormal cells have spread widely through the body.

New techniques may give better methods of curing cancer in the future. One method is gene therapy — the changing of genes that cause cells to divide and produce cancer. Alternative therapies focus on ways to boost the body's own natural immune system. For example, people may be able to use vaccines or drugs that stimulate their bodies to destroy cancer cells, making them immune to cancer.

Disorders of the Circulatory System

Certain conditions place people at greater risk of disorders of the circulatory system. Some of these are smoking, a high level of cholesterol in the blood, high blood pressure, and lack of regular exercise.

For example, cigarette smoke is a double threat to the circulatory system. Nicotine in cigarette smoke causes blood vessels to constrict, increasing the heart rate and raising blood pressure. Also, carbon monoxide in the smoke competes with oxygen in the lungs. This reduces the blood's ability to carry oxygen to the cells.

A poor diet can also lead to disorders of the circulatory system. For example, a high-salt diet can raise the blood pressure, putting greater strain on the heart. The heart gradually increases in size and becomes less efficient. High-fat diets can cause fats such as cholesterol to build up inside arteries. As arteries narrow and become blocked, tiny tears in their walls cause blood clots that can travel to the brain causing a stroke. As well, blood flow through the arteries can become very limited or stop, causing a heart attack (see Figures 2.36A and 36B).

Risks of disorders to the circulatory system can be reduced or avoided by choosing healthy lifestyle habits: not smoking, eating a proper diet, and getting regular exercise.

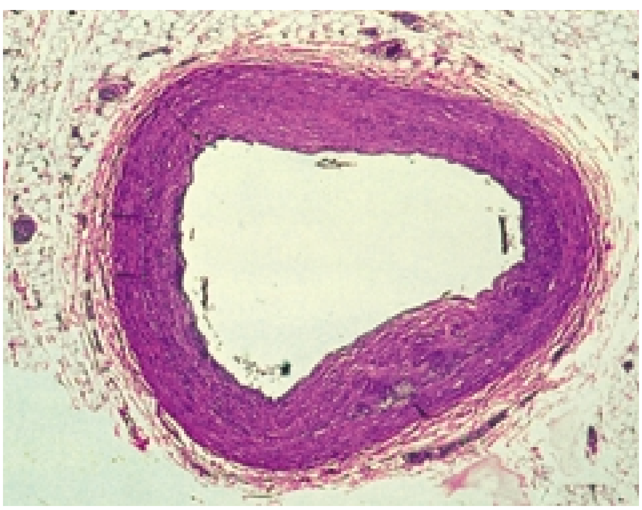


Figure 2.36A This cross section of a healthy artery shows a clear, wide-open pathway through which blood flows easily.

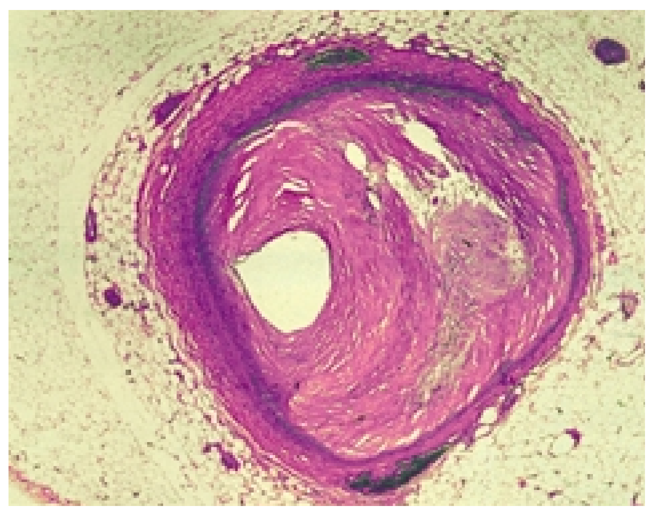


Figure 2.36B Here the blood-flow path has been narrowed by a buildup of fatty deposits and blood flow is slowed.

DidYouKnow?

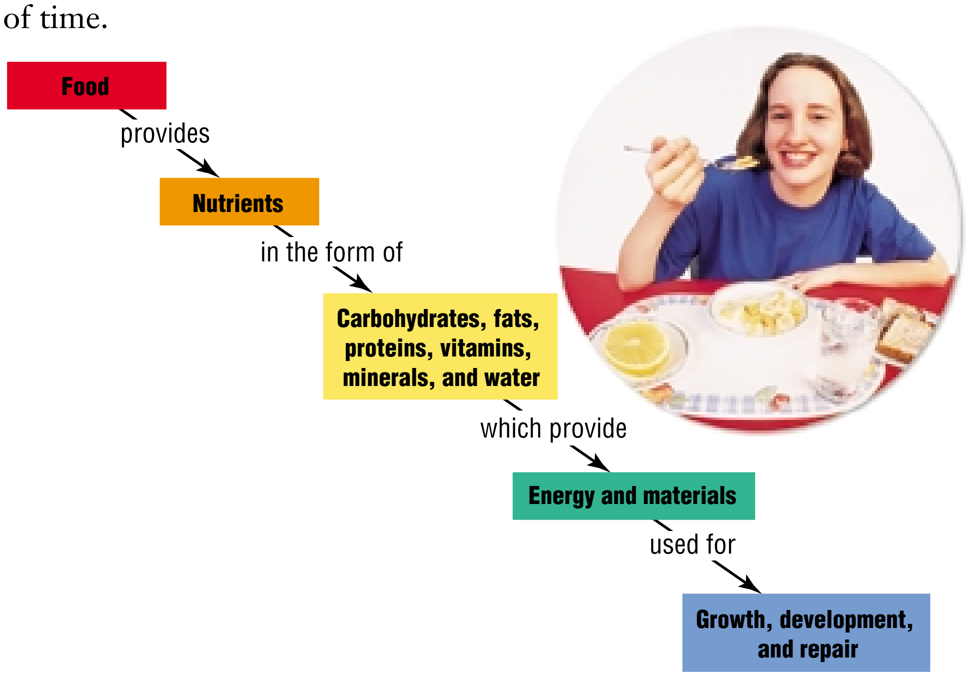
Research conducted by scientists has shown a link between heart disease and high levels of cholesterol in the blood. Cholesterol is a chemical that can cause the buildup of fatty deposits on artery walls. Some people assume that any cholesterol in the body is unhealthy. In fact, the liver produces this chemical, which is involved in maintaining nerve cells and helping the body use certain hormones. Normal levels of cholesterol are necessary for good health; high levels can contribute to poor health.

A Healthy Digestive System

That old saying, "What you put into something is what you get out of it" also applies to your body. The foods we eat contain different combinations of substances. Some of these substances provide energy and materials for cell development, growth, and repair, and are often called nutrients. Other substances in foods can cause poor health and promote disease when consumed in large quantities over long periods of time.

DidYouKnow?

North Americans tend to have a low-fibre diet, consuming almost 1 kg of simple sugars (refined sugar) every week. If you find this hard to believe, start looking at the labels on cereal boxes, soft drinks, and prepared foods. Corn syrup and dextrose are examples of refined sugars. Refined sugar not only lacks fibre, it also contains no vitamins or minerals.



Nutrients in Food

Starch and sugars are carbohydrates and provide the body with its main source of energy. Starch is a complex carbohydrate found in fleshy fruits, cereal grains, beans, and peas. It should be the main carbohydrate in a diet because it is easily digested into simple sugars to provide quick energy, and it is also high in fibre.

INTERNET CONNECT

www.school.mcgrawhill.ca/resources/

Do you know the kinds and quantities of food you should eat? For information on Canada's Food Guide, visit the above web site. Go to **Science Resources**, then to **SCIENCEFOCUS 8** to find out where to go next. Then keep a list of what you eat for two or three days, and use the information you found to analyze your diet. What should you change for a healthy diet?

Despite a bad reputation, fats are essential in our diet. Fats provide us with energy and cushion our vital organs from shock. Unlike carbohydrates, however, fats can be stored in the body. When you eat more fats than your body requires, it stores them in special tissues. Once fat cells are formed, they remain in the body waiting to be filled. A proper diet and exercise will ensure that you have enough fat for the proper functioning of your body, but not more than you need.

Proteins found in foods such as meat, fish, and eggs, are essential for growth and repair of body tissues. In order to obtain all the protein that is required, vegetarians must be careful to eat a combination of plants.

In addition to carbohydrates, fats, and proteins, a complete, healthy diet provides all the minerals and vitamins that a person needs.

DidYouKnow?

The large intestine contains a small fingerlike projection called the appendix. The appendix does not aid in digestion, but it does contain cells that fight off viruses and bacteria. Sometimes a piece of hard feces resulting from a low-fibre diet can become trapped in the appendix, blocking its blood supply. When this happens, the appendix becomes enlarged and may rupture if it is not surgically removed.

Disorders of the Digestive System

The digestive system consists of many organs that work continuously and efficiently to provide your body with all the nutrients you require. Like any body system, it is susceptible to disorders that can arise through poor lifestyle habits or disease. For example, why is a high-fibre diet so important? When there is little fibre, it takes the colon a longer time to process waste material (feces). This increases the chances of irritating the colon wall. Over a long period of time, a low-fibre diet may lead to colon cancer. Sometimes the fast pace of life leads people to skip meals, eat too much too quickly at one meal, and eat foods high in sugar, cholesterol, and salt. All of these habits contribute to colon cancer, but a low-fibre diet is the most important contributing factor.

Long-term emotional stress, smoking, or excessive use of alcohol or aspirin can lead to a peptic ulcer. A peptic ulcer occurs when the unprotected wall of the stomach or small intestine is damaged by excess stomach acid. Peptic ulcers can usually be cured by heavy doses of antibiotics.

Career CONNECT

As a sports nutritionist, Helga Rempel advises athletes about the effects of the foods they eat on athletic performance. She knows how the different parts of the body respond to nutrients such as fats, vitamins, or sugars. She also knows that different sports require different diets. For example, because of how our muscles use energy, a marathon runner needs to eat more protein than a weight lifter.

A dietitian is another professional who knows how food affects the body. Talk to a teacher or guidance counsellor about the difference between a dietitian and a nutritionist. Check your phone book, local medical centre, or hospital to find a nutritionist or dietitian in your area. Perhaps you could arrange to speak to them about the work they do. Take notes on your conversation and present your findings in class.

A Healthy Respiratory System

If you live in an area where there is air pollution, spend time in buildings with poor air quality, or sit beside a smoker, you are putting a strain on your respiratory system. Smoking, air pollution, and industrial by-products such as coal dust have been related to many disorders of the respiratory system.

Disorders of the Respiratory System

Your respiratory system is lined with cells with cilia, small hairlike projections (see Figure 2.37). These cilia beat continuously to remove airborne particles.

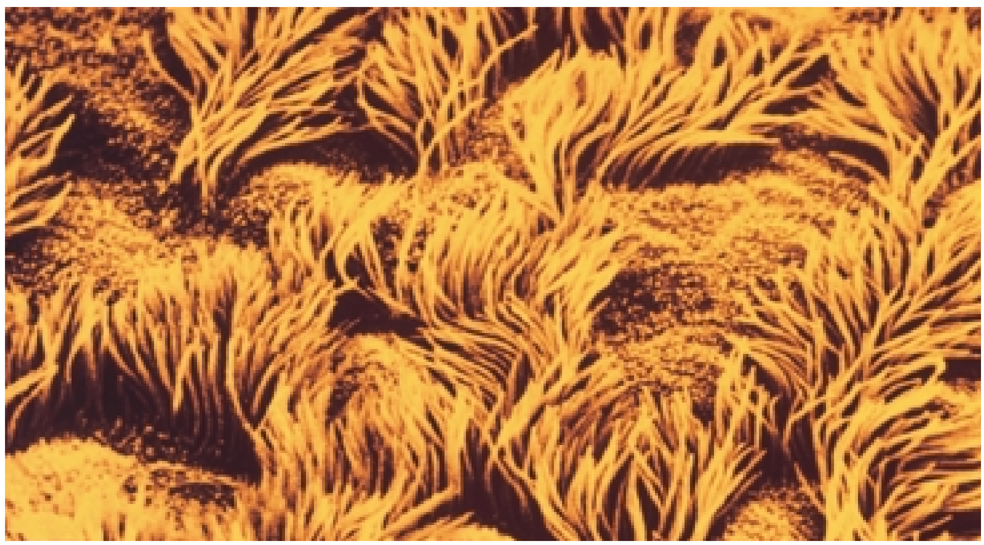


Figure 2.37 Hairlike cilia in respiratory passages trap and remove matter like dirt and bacteria that enters the passages.

Poisons in cigarette smoke and pollutants irritate this lining, causing mucus-producing cells to produce more mucus. At first, you can remove the mucus by coughing. Over time, however, the irritated lining will become inflamed, leading to a condition called bronchitis. Bronchitis can be treated, but if the irritation continues, the ciliated cells will be destroyed and the mucus-producing cells will multiply. If this continues for a long time, the respiratory airways will narrow and become blocked. Eventually, the bronchitis can lead to a condition called emphysema. Some people inherit this disease, but its major cause is smoking.

Smoking is the leading cause of lung cancer. Lung cancer occurs when certain compounds in the tar and the smoke contact the lung tissue and cause the cells to grow out of control. Large clusters of these "uncontrolled" cells begin to out-compete the healthy cells for nutrients. The healthy cells are killed, and the cancerous cells continue to divide, leading to cancer.

In the following Think & Link Investigation, you will analyze some statistics to find out how "deadly" smoking can be.

THINK & LINK

INVESTIGATION 2-H

Working with Statistics

Think About It

Cigarette smoking is the most preventable cause of premature death in North America. According to recent statistics compiled by the Canadian Cancer Society, tobacco use causes over 40 000 deaths per year in Canada; cigarette smoking causes about 30 percent of cancers in Canada and over 80 percent of lung cancer cases; and lung cancer is the leading cause of cancer death for both men and women.

What to Do ✷ Analyzing and Interpreting

1 Study the table below.

Estimated Smoking-Attributed Deaths Canada, 1965–1995

	Men	Women	Total
1965	12 000	1000	13 000
1975	21 000	3000	24 000
1985	26 000	9000	35 000
1995	31 000	17 000	48 000

Source: The National Clearinghouse on Tobacco and Health, Ottawa

Skill FOCUS

For tips on constructing bar graphs, turn to Skill Focus 10.

2 Construct a bar graph of the data. Let the *x*-axis represent the year and the *y*-axis represent the number of deaths. Use three different colours and a legend to distinguish the three groups of statistics from one another. Give your graph a title.

Analyze ✷ Analyzing and Interpreting

1. What is the ratio of male deaths versus female deaths for each of the years listed? What do these ratios tell you?

2. What is the overall trend of smoking-attributed deaths over these 30 years? Why do you think this is the case?

Extend Your Skills

✷ Communication and Teamwork

3. Choose one or more of the statistics from this investigation and work with some classmates to make an anti-smoking poster based on the statistic(s).

You and Your Body

What would you think if someone advised you to sit on a couch for at least eight hours a day in a smoky room, eat plenty of candy bars, drink lots of pop, and get no more than three or four hours of sleep each night? You would probably assume that you would not feel too well after a few weeks. Your body needs proper care to function properly. However, people sometimes pay less attention to the health of their bodies than they do to maintaining a bicycle or car.

To maintain healthy organs and systems, everyone has the same essential needs: clean air and water, nutritious foods, exercise, and sleep.

Clean air means oxygen for your cells. Pollution decreases the ability of oxygen to get into your body. A balanced diet provides your cells with the food materials they need for growth and activities. Lack of essential materials weakens the body, while too much of some substances such as fats, sugar, and salt can place a strain on certain organs and systems.

Exercise helps the body process food and oxygen more efficiently. A healthy heart and lungs help carry materials to the cells and get rid of wastes. Strong muscles help protect the body from injury. Your body is designed to work, and you feel better when you are active.

Healthy lifestyle habits make you feel better, and they help your body resist diseases. Your immune system works more effectively when you are well fed and rested. Your immune system attacks and destroys invading germs and helps break down harmful materials in your body. If you do get a cold, a disease, or an injury, you are likely to recover faster if you are basically healthy.

TOPIC 7 Review

1. Why do humans need a complex circulatory system while an amoeba does not?
2. What can happen if arteries in humans become clogged or narrow?
3. What are the three main types of food? What does each type provide for your body?
4. How do smoke or pollutants in the air affect your respiratory system?
5. **Apply** When people living in rural India emigrate to a city in Canada, they increase their risk of contracting colon cancer. Explain why.

Wrap-up TOPICS 6-7

If you need to check an item, Topic numbers are provided in brackets below.

Key Terms

digestive system
respiratory system
circulatory system
alveoli (singular alveolus)
capillaries
excretory system
nervous system

Reviewing Key Terms

1. Describe one difference between a vein and a capillary (6)
2. In your notebook, write the correct term to complete the following sentences:
   (a) The ______ system transports dissolved food particles and oxygen. (6)
   (b) Your body's responses to stimuli are coordinated by the ______ . (6)
3. What do the digestive system and the respiratory system have in common? (6)
4. (a) Which system in the human body regulates blood composition and gets rid of waste fluids? (6)
   (b) Which system exchanges oxygen and carbon dioxide? (6)

Understanding Key Concepts

5. Why is such a large percentage of your blood volume made up of red blood cells? (6)
6. Carbon dioxide is transported through the body in solution in plasma, but oxygen is not. Explain why there is a difference in the way these two gases are transported by the circulatory system. (6)
7. Suppose you receive a sudden surprise, such as your teacher announcing a surprise test. Your heart may beat faster and your breathing may become irregular. After a short time, your breathing and heart rate return to normal.
   (a) Which two systems are interacting in this initial reaction? (6)
   (b) Which system controls and co-ordinates their interaction? (6)
8. Explain how a fatty diet can affect your circulatory system. (7)
9. What are cilia? How does smoking affect their functioning? (7)

UNIT 2

Ask an Expert

Diabetes is a disease that affects more than 1.5 million Canadians. That number is expected to double by the year 2010. Research into how our cells function is being done in hopes of finding a cure — or at least better treatment — for this disease. That is where people like Dr. Amira Klip come in. She is a biochemist and research scientist whose work is known around the world.

Q How did you become interested in science?

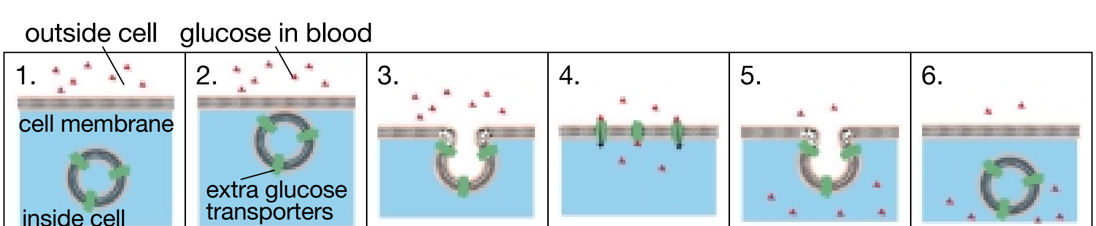
A When I was in high school, I had a terrific teacher of organic chemistry, the chemistry of living things. I learned from this teacher that although we can't always see what is happening inside our cells, we can still understand what is happening because of the reactions that we *can* see. It's a bit like looking at the wind — you can't see it but you know it's blowing because you can see the trees moving.

Q When did you begin doing scientific research for a living?

A I completed my bachelor's and master's degrees in biochemistry at the Centre for Advanced Studies in Mexico City, where I lived. Then I worked in laboratories running experiments for other scientists. Most of the research I did involved studying the membranes of human cells. I was trying to understand how materials pass in and out through cell membranes.

Q Does your early research have much to do with the research you do now?

A Yes. I study one particular kind of protein in the cell. This is the protein that takes glucose from the bloodstream and brings it into the cells of our bodies, especially our fat and muscle cells. This protein is called a "glucose transporter". It transports, or carries, the glucose from outside the cell membrane to the inside of the cell.



Fat and muscle cells have extra glucose transporters inside them. When the hormone insulin signals that there is a lot of glucose in the blood, these extra transporters come to the membrane and let glucose pass through the membrane and into the cell. These diagrams show what scientists think happens as those extra transporters come to the membrane and then return inside the cell once their job is done.

Q How does your research relate to diabetes?

A When a person has diabetes, the glucose in the blood does not get processed by the cells. In our lab, we study how the glucose transporter does its job. We try to figure out what goes wrong in the bodies of people who have diabetes. We know that people with type 1 diabetes can't produce their own insulin. They need daily insulin injections just to stay alive. Many more people have type 2 diabetes. For some reason, insulin doesn't activate their cells to process the glucose. If we can find out more about how the insulin and the parts of the cells work together, maybe we can find better medical treatment for diabetes.

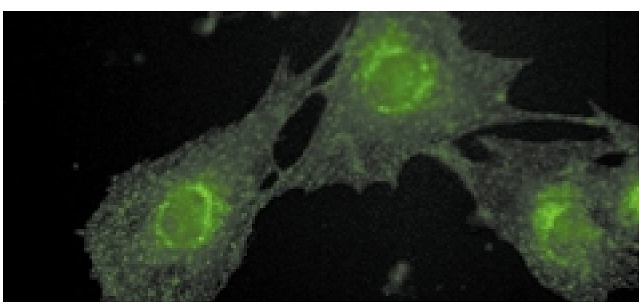
Q How do you study these cells? Can you observe them with a microscope?

A It's not quite that simple. The cell parts we study are too small to be visible, even with a microscope. One way researchers study what's happening is by tagging the glucose transporters with something that we are able to see. That means we attach something to them, such as a tiny bit of chemical that gives off fluorescent light. Then we can examine samples of cells at different points in the experiment. The location of the fluorescence tells us how the glucose transporter has responded to various stimuli. If the bit of fluorescent light shows up in the centre of the cell, then we know that that's where the glucose transporter is. If the fluorescent tag is at the cell membrane, we know the transporter is at the membrane to do its job.

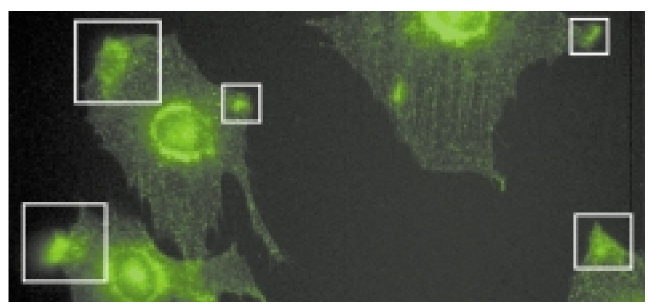
Q Do you spend most of your day at the microscope?

A Not really. I hire research technicians and train graduate students to run many of the experiments. I look at the experimental results and try to understand what they mean.

The rest of my time is spent teaching university classes and lecturing at conferences all over the world. Conferences keep me in touch with my fellow researchers so we can share what we have learned, either new data concerning glucose transporters or new techniques for studying them.



In this micrograph showing muscle cells, the glucose transporter proteins have been tagged with a fluorescent chemical so that they appear as bright green spots clustered around the nucleus of the cell.



These same muscle cells have been stimulated with insulin for 30 min. The highlighted green spots are glucose transporters that have responded to the insulin and have come to the cell membrane.

EXPLORING Further

Watch Some Cells at Work

Researchers have developed a technique for videotaping special fat cells cultured (grown) in the laboratory, as they take glucose from the bloodstream. Visit the McGraw-Hill Ryerson web site at **www.school.mcgrawhill.ca/resources/** to see some green fluorescent-tagged glucose transporters moving about in a cell as they are stimulated.

Search for other Internet sites related to diabetes to find information on the disease itself and to learn what it is like to live with diabetes. Write a brief summary of the information you find at each of the sites.

DESIGN YOUR OWN

INVESTIGATION

SKILLCHECK

- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Responding to Changes

Think About It

Cells, either as a part of plants and animals, or existing alone as a micro-organism, are always part of a larger system. They are influenced by changes within the cell, and also by changes outside the cell. This means that environmental changes may affect their functioning.

What would happen to the plants in your garden if they were exposed to salt water instead of plain water? What happens to micro-organisms when snow and ice from salted roads melt and run into rivers and ponds, or when oil that drips from vehicles is washed down storm sewers?

In this investigation, you will work with a team to explore the responses of cells to specific environmental changes.

Apparatus (per student or group)

microscope

medicine dropper

tweezers

depression slide or plain slide

cover slip

Materials (per student or group)

Depending on your team's experimental design, you may require

- specimens of plant cells (for example, onion skin)
- pond water
- various crystals and solutions

Safety Precautions

- If you use pond water, use medicine droppers to handle it.
- Do not use animal tissue unless it is a prepared slide.
- Wash your hands with soap and water when you have completed your investigation.

Initiate and Plan

1. With your team, brainstorm a number of variables you may wish to investigate. Choose a manipulated variable that is testable with the time and materials you have available.
2. Decide on an experimental question to investigate.
3. Formulate a hypothesis or prediction that will answer your question. Base this on past observations, inferences, and research.
4. Design an experiment to test your hypothesis or prediction. Your design must identify the manipulated, responding, and control variables. The steps of your procedure must clearly explain how the experiment will be carried out. Use diagrams to help explain the procedure if they will help. (You might find it helpful to refer to the Experimental Design Checklist on the next page.)

5. Share your design with your teacher and other classmates for feedback. Make any changes necessary to your design before you proceed.

Perform and Record (Test Your Hypothesis)

6. Set up and perform your experiment. Modify your design if necessary. Carry out two or three trials to verify your findings.

7. Gather and record data and observations. Decide how to record and present your data in a clear format (table, graph, diagram, etc.).

8. Write up a laboratory report. Be sure to include all the parts of the report, along with diagrams or drawings.

Analyze and Interpret (Draw Conclusions)

9. Draw conclusions based on the results of your experiment. Discuss your conclusions with your team.

10. Was your hypothesis/prediction supported? If so, what evidence supported it?

Experimental Design Checklist

1. Have you stated the purpose of your experiment (the question you want answered)?
2. Have you written your hypothesis or prediction about what you expect the answer will be?
3. Have you obtained all the information you need from a variety of sources to design your experiment?
4. Have you made a complete list of all the materials you will need?
5. Have you identified the manipulated, responding, and controlled variables?
6. Have you written a step-by-step procedure?
7. Have you re-evaluated your experiment to look for errors in its design?
8. Have you repeated your experiment several times? Were the results the same each time?

Skill FOCUS

For tips on designing an experiment, turn to Skill Focus 6.

UNIT

2 Review

Unit at a Glance

- All living things are made from cells.
- Living things need energy, respond to their environment, reproduce and grow, and produce wastes.
- The invention of the microscope allowed scientists to see and study the structures and functions of cells.
- All cells, whether in unicellular or multicellular organisms, carry out similar functions.
- Organelles are the structures within cells that enable them to carry out activities necessary for life.
- Plant and animal cells have a cell membrane, cytoplasm, a nucleus, and vacuoles in common. Only plant cells have cells walls and chloroplasts.
- A cell membrane is selectively permeable because it allows only certain substances in and out of cells.
- Diffusion and osmosis are the processes by which substances move through cell membranes.
- Cells are specialized to perform particular tasks, and their structures are related to their functions.
- Cells with the same structure and function are grouped into tissues; groups of tissues form organs; organs work together in systems.
- Plants have three systems: a root system, a shoot system, and sometimes a reproductive system.
- The two tissues that transport nutrients in a plant are phloem and xylem tissues.
- In humans, the digestive system provides food for the cells, the respiratory system supplies oxygen and gets rid of waste gases, and the circulatory system distributes food and oxygen and carries away wastes through blood.
- The excretory system filters waste material from blood.
- The nervous and endocrine systems work together to co-ordinate the body's responses to stimuli and provide a stable environment for cells.
- Our bodies need clean air and water, nutritious foods, regular exercise, and sufficient sleep to maintain healthy organs and systems.

Understanding Key Concepts

1. Make a drawing of the microscope shown and label its parts.

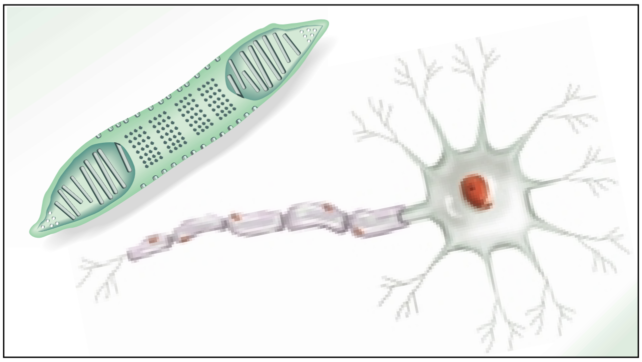
2. Describe how to prepare a wet mount. You may show the procedure in a diagram.
3. Explain why cells are considered to be living systems.
4. Make a labelled diagram of a cell showing the structures both plant and animal cells have in common.
5. Which part of a cell allows it to exchange substances with its surroundings?
6. Write a definition of (a) diffusion, and (b) osmosis.

7. How does the particle model help us to understand how substances move in and out of cells?

8. Explain how (a) animals and (b) plants obtain carbohydrates.

9. Explain how the structure of a specialized cell is related to its function in the body of a multicellular organism.

10. Identify the specialized cells shown. Describe how each cell is suited to its role.



11. Explain the function of each of the three systems of a plant.

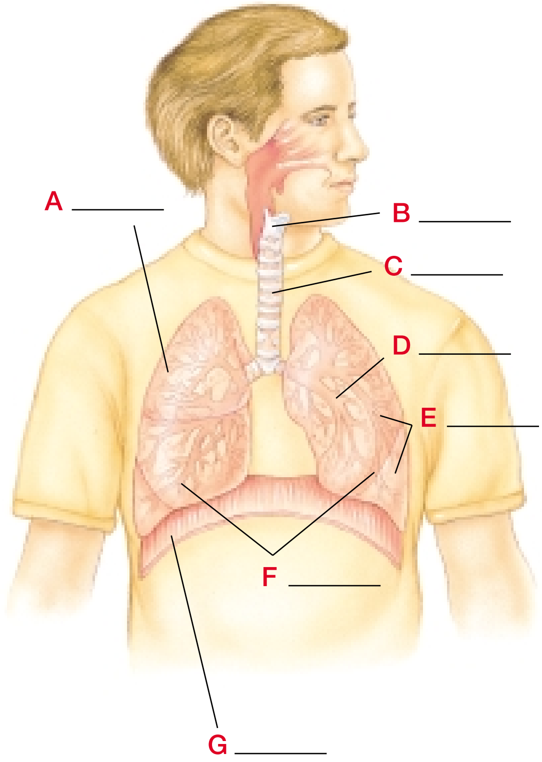
12. Describe the process by which water (a) enters a plant and (b) leaves a plant.

13. What effect might pruning (trimming) a tree's branches have on the transport of water up the tree trunk?

14. Why is a plant growing in the shade less likely to wilt than one growing in sunlight?

15. List five body systems found in humans.

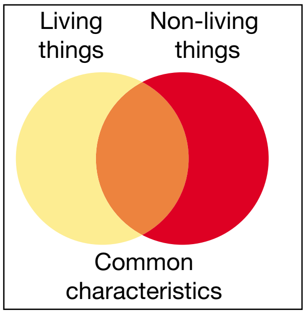
16. Copy the letters from the diagram below into your notebook. Beside each letter write the correct term.



17. Name the organs in which substances pass between the circulatory system and (a) the respiratory system, (b) the digestive system, (c) the excretory system.

Developing Skills

18. Draw a Venn diagram like the one shown. Where the circles overlap, list characteristics that living things and non-living things have in common. In the left circle, list characteristics shown by living things only. In the right circle, list characteristics shown by non-living things only.



19. Suppose you are studying a slide of plant cells. You count 40 cells in a row across the diameter of the field of view. Make a flowchart describing or showing a technique you can use to estimate the average size of each cell.

20. The table shows the results of an experiment to find the effect of osmosis on potato cells. Two cubes of potato were weighed and placed in distilled water, and two cubes were weighed and placed in salt solution. The mass of each potato cube was determined at 15 min intervals.
    (a) Calculate the average mass of the cubes in the water and the average mass of the cubes in salt solution at each time interval.
    (b) Plot the data on a graph, showing average mass along the *y*-axis (the vertical axis), and time along the *x*-axis (the horizontal axis).
    (c) Briefly interpret the results. What has happened to the mass of potato in water? What has happened to the mass of potato in salt solution? Why?

Time (min)	Salt water			Distilled water		
	Cube 1 mass (g)	Cube 2 mass (g)	Average (g)	Cube 1 mass (g)	Cube 2 mass (g)	Average (g)
0	59	60		51	52	
15	58	58		51	52	
30	50	55		52	53	
45	50	54		53	54	
60	50	53		55	53	

21. These two sets of data represent the heart rates of 30 individuals — 15 athletes and 15 non-athletes — after 10 min of intense physical activity. The sample frequency table shows the number of athletes in five different heart rate ranges. Follow this model to make a frequency table for the non-athletes. Compare the data in the two tables. What can you conclude about the effect of physical training on heart rate? How could you display the data to make it easier to analyze?

Heart rates of 15 trained athletes after physical activity: 128, 131, 120, 127, 132, 125, 129, 122, 127, 133, 135, 130, 123, 128, 124

Heart rates of 15 non-athletes after physical activity: 143, 139, 144, 132, 138, 135, 141, 137, 128, 139, 140, 136, 133, 143, 135

Sample Frequency Table
Heart Rate of Athletes after 10 min of Activity

Range of heart rates	Tabulate data	Total number of athletes in range (frequency)
119–122	//	2
123–126	///	3
127–130	//////	6
131–134	///	3
135–138	/	1

22. Make a concept map to show how the following are related in humans. Link the concepts together using a few key words or descriptions. Add any other terms you need.

food	external environment
oxygen	lungs
small intestine	cells
circulatory system	carbon dioxide

Problem Solving/Applying

23. Imagine you are exploring another planet and you find a small, green, leaf-shaped object on the ground. How would you tell if it was a living, alien organism or part of the non-living world?

24. Explain why animals and plants are made of billions or trillions of microscopic cells rather than a few large cells. You may use a diagram in your answer.

25. Suggest what adaptations might be found in (a) the leaves and (b) the roots of a plant living on the tundra, where conditions are cold and dry. Give reasons for your ideas.

26. **Design Your Own** Why might a plant wilt in hot weather? Why might a different plant not wilt in hot weather? Design your own experiment to compare the responses of two different kinds of plants to an increase in temperature. Write or sketch the steps of your procedure.

27. The normal breathing rate of an infant is faster than that of a teenager. Why do you think this is so?

Critical Thinking

28. Suppose a new disease destroys chloroplasts in plant cells. Explain what would happen to (a) the plant cells, (b) the plant, (c) other forms of life.

29. A friend tells you that people and trees are completely different forms of life. Explain why you would agree or disagree with your friend's comment.

30. Why will a goldfish die if it is placed in salt water?

31. What problem might athletes face if they drink only distilled water after a race? Explain your reasoning and suggest how the problem could be avoided.

32. Three items that you cannot live without are water, food, and air. Why does a lack of air lead to death much faster than a lack of the other two items?

33. When you exercise on a hot day, you sweat and become thirsty. Explain how sweating and thirst are examples of your body's response to changing conditions.

Pause & Reflect

In your Science Log, write about the things you are doing or should be doing to keep your body healthy and functioning properly. Explain why these things are important using what you have learned about cells, tissues, organs, and systems.