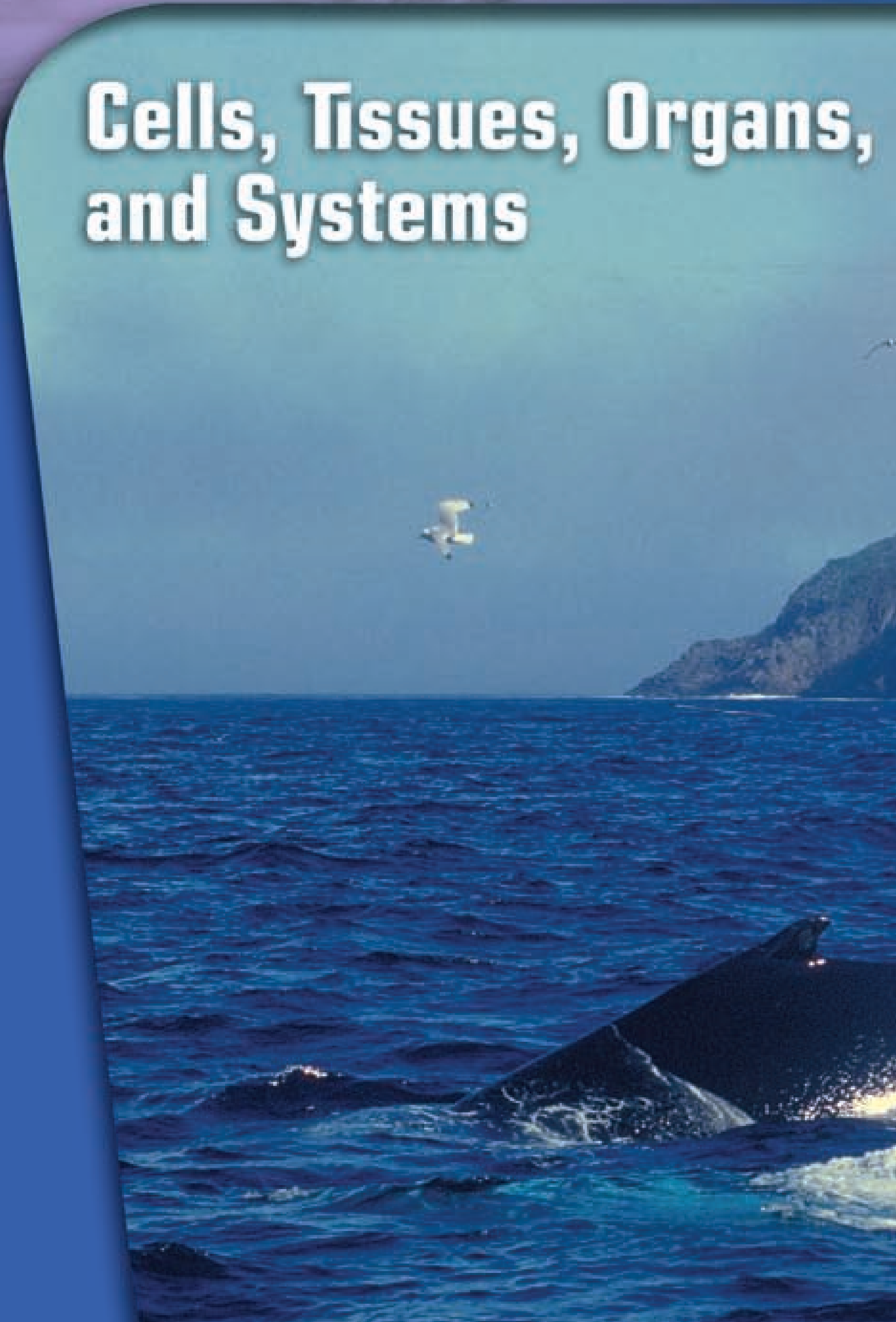
UNIT

4 Cells, Tissues, Organs, and Systems



Key Ideas

10 **The cell is the basic unit of life.**

- 10.1 Characteristics of Life
- 10.2 Focussing on Cells

11 **Human body cells are organized as tissues, organs, and systems.**

- 11.1 Cell Organization
- 11.2 Introducing Human Body Systems

12 **The health of the human body depends on the health of its interdependent systems.**

- 12.1 How Body Systems Are Connected
- 12.2 Body Systems and Health

Getting Started

This animal, called a tardigrade, is small enough that you need a magnifying device such as a microscope to see it.

Imagine that one winter the temperature starts to fall and it just keeps falling—five degrees, zero, minus ten, minus fifty, minus one hundred, and colder still! Unless you had a protected, climate-controlled environment to move to, you would not survive. If you were a tardigrade, however, you would simply curl up, dry out, and cease functioning until the return of more favourable living conditions.

Tardigrades are tiny living things that usually grow no larger than a speck of dust of about 0.5 mm. Some people affectionately call them "water bears" because of their short legs and slow movement. (The word tardigrade comes from Latin words that mean "slow walker.") Other people prefer to call them "moss piglets," because they are often found living on the moist surface of mosses. So far, 26 different species (kinds) of tardigrades have been identified in Newfoundland and Labrador. Worldwide, about 900 species are known.

One of the reasons that scientists are interested in tardigrades is their ability to go into a kind of suspended animation when living conditions are bad. In this condition, called cryptobiosis, all life activity comes to a stop. Tardigrades have been known to survive temperatures as high as 150°C and as low as –273°C. They can also survive powerfully lethal doses of X rays, poisonous chemicals, the airless vacuum of outer space, and pressures greater than six times that of the deepest ocean bottom. Studying cryptobiosis helps scientists to gain a better understanding of life, death, and what distinguishes one from the other. Such an understanding might some day help us travel to and live on distant planets or cure deadly diseases.

Word Connect

Cryptobiosis comes from two Greek words that mean "hidden life condition," referring to the unknown way in which tardigrades can stay alive in otherwise deadly living conditions.

Living or Non-living?

Find Out ACTIVITY

What makes one thing, such as a tardigrade, living and another thing, such as a stone, not living (non-living)? In this activity, you will discuss ideas with your partners to help you find out whether two similar-looking things are living or non-living.

Materials

- 2 samples in separate containers
- magnifying glass
- ruler
- 2 bowls
- warm sugar water

What to Do

1. Your teacher will give you two containers of similar-looking samples. Your task is to determine which characteristics these samples have in common and which characteristics they do not have in common. Then you will decide if one or both of these samples is a living thing.
2. Examine both samples using the magnifying glass. Use any other equipment available to help you add to your observations. Record your observations in a chart.

Science Skills

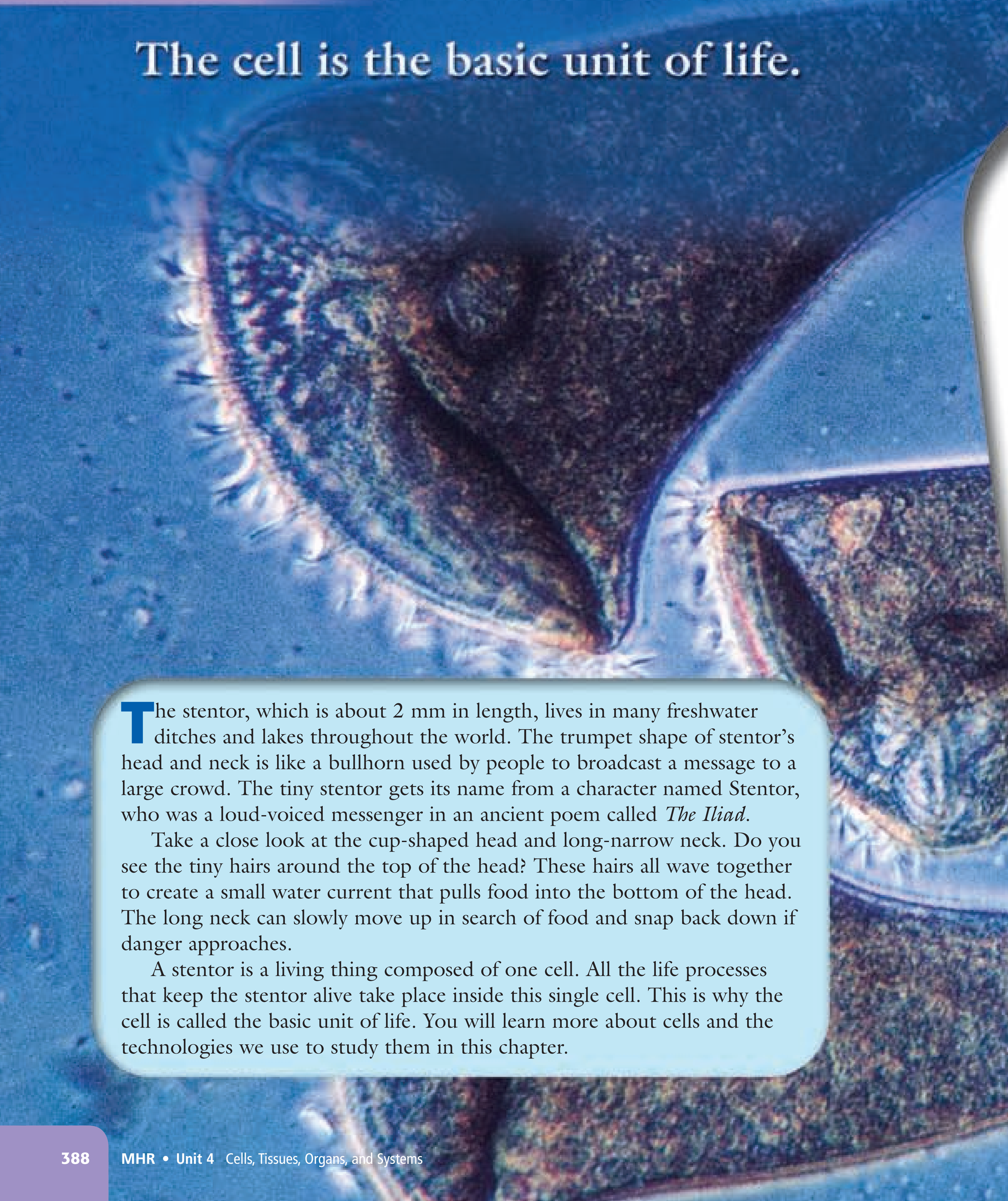
Go to Science Skill 6 for information about conducting a fair test.

3. Place a small amount of each sample in separate bowls. Add equal amounts of warm sugar water to both bowls. Observe and record any changes.
4. Perform one more test you think will provide evidence that one of these samples is living. Record your observations.
5. Clean up and put away the equipment you have used.

What Did You Find Out?

1. Discuss your results with your class.
2. Decide which observations suggest that one or both of the samples is living. Record these observations in a list.
3. Based on your evidence and your experiences in this activity, write a sentence that clearly explains what distinguishes a living thing from a non-living thing.

The cell is the basic unit of life.



The stentor, which is about 2 mm in length, lives in many freshwater ditches and lakes throughout the world. The trumpet shape of stentor's head and neck is like a bullhorn used by people to broadcast a message to a large crowd. The tiny stentor gets its name from a character named Stentor, who was a loud-voiced messenger in an ancient poem called *The Iliad*.

Take a close look at the cup-shaped head and long-narrow neck. Do you see the tiny hairs around the top of the head? These hairs all wave together to create a small water current that pulls food into the bottom of the head. The long neck can slowly move up in search of food and snap back down if danger approaches.

A stentor is a living thing composed of one cell. All the life processes that keep the stentor alive take place inside this single cell. This is why the cell is called the basic unit of life. You will learn more about cells and the technologies we use to study them in this chapter.

What You Will Learn

In this chapter, you will
- **identify** the characteristics of living things
- **identify** and state the major functions of the parts of a compound light microscope
- **identify** common structures of plant and animal cells, and explain their functions

Why It Is Important

Understanding how cells function can help you understand how your body and other living systems function.

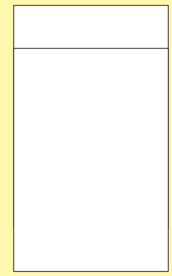
Skills You Will Use

In this chapter, you will
- **learn** the safe use of a microscope
- **use** a light microscope to produce a clear image of cells
- **model** the structures and functions of a cell

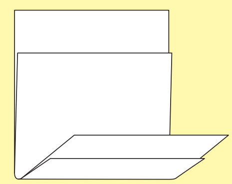
FOLDABLES™
Reading & Study Skills

Make the following Foldable to take notes on what you will learn in Chapter 10.

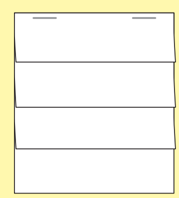
STEP 1 **Collect** 2 sheets of letter size paper and layer them 2.5 cm apart vertically. (Hint: from the tip of your index finger to your first knuckle is about 2.5 cm.) Keep the edges level.



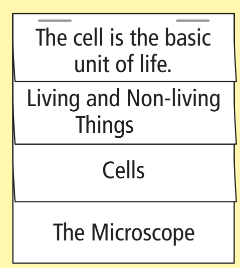
STEP 2 **Fold** up the bottom edges of the paper to form 4 tabs.



STEP 3 **Fold** the papers and crease well to hold the tabs in place. **Staple** along the fold.



STEP 4 **Label** the tabs as shown. (Note: the first tab will be larger than shown here.)



Summarize As you read the chapter, summarize what you learn under the appropriate tabs.

10.1 Characteristics of Life

The cell is the basic functional unit of life. All living things have characteristics that demonstrate they are alive. These include the ability to grow, to move, to reproduce, and to respond to stimuli. Some living things are very small and can be observed only with a microscope. To study tiny living things on prepared or wet mount slides, you must handle a compound light microscope carefully and learn how to operate it correctly.

Key Terms

arm
base
cell
coarse adjustment knob
compound light microscope
eyepiece
fine adjustment knob
iris diaphragm
light source
magnification power
objective lenses
resolving power
revolving nosepiece
stage
total magnification
tube

Imagine that you are a scientist in the early days of civilization. You observe your surroundings, such as those in Figure 10.1, and you start to wonder about how all the objects in the world around you are similar and how they are different. For instance, you wonder how these objects are different from you. You know that you are alive, but what does this mean? What is it that makes you a living thing, while a stone, a puddle, or a candle is *not* a living thing?

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. So does rain falling from the sky. Growth is another sign that something is alive. However, a mound of rice gets bigger as you pour it, and you have certainly seen icicles get bigger and longer in the winter. These types of "growth" are different from growth in living things, however. What makes rice, ice, and stones different from you and other living things such as cats, grass, and stentor?

Figure 10.1 Which objects in this scene are living? Which ones are non-living? What ideas are you using to help you decide?

The Smallest Unit of Life: The Cell

For scientists, one feature separates all forms of life from everything else. All living things are made up of one or more cells. The **cell** is the smallest, most basic functional system of any living thing. A functional system is any system that exhibits all of the characteristics of life outlined in Table 10.1. Something must have all of these characteristics to be considered a living thing.

Table 10.1 Four Characteristics of Living Things

	**All living things grow.** As you continue to grow as a teenager, you get taller and the mass of your bones and muscles increases. Your growth is the result of the cells in your body increasing in number. Even when you stop growing, your body will grow new cells as old ones die.
	**All living things move.** Movement involves changes to the shape, position, or location of the body or body parts. For instance, animals might have legs, wings, or fins to move from one location to another. Plants might have stems that change position with the Sun. Many single-celled living things (unicellular organisms) change their shape or have hair-like body parts that help them move or sweep in food.
	**All living things respond to stimuli in their environment.** A cat may hiss when it feels threatened by something in its external environment. Hissing is the cat's response to a stimulus. A stimulus (plural: stimuli) is anything that causes a living thing to respond. Living things also respond to stimuli in their internal environment. Think of the last time you were hungry or thirsty. Hunger and thirst are stimuli that cause you to respond by eating or drinking.
	**All living things reproduce.** Through reproduction, living things produce more of their own kind (offspring). Some living things (such as bacteria and some kinds plants) produce offspring that are identical to themselves, while other living things (such as most animals) produce offspring that are similar to themselves.

Examining Very Small Living Things

It might surprise you to know that there are many more living things that you cannot see with the unaided eye than ones that you can. The human eye can see objects that are larger than 0.1 mm. To see anything smaller, you have to use a microscope.

There are different types of microscopes, some of which you may have used to look at a leaf or an ant. A **compound light microscope** is the type of microscope that you will use in this unit to investigate living things. Observing living things through a microscope is one of science's most exciting and rewarding experiences. You will be introduced to this important study tool in this section.

The Compound Light Microscope

Figure 10.2 shows the correct way to hold and carry a compound light microscope. This is the type of microscope usually used in science classes and medical laboratories. Figure 10.3 shows the parts of the compound light microscope, and Table 10.2 outlines their functions.

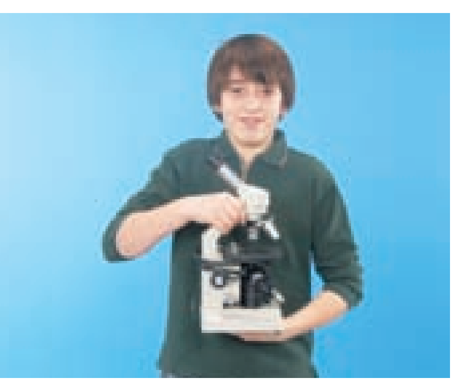


Figure 10.2 Always carry a microscope with one hand on the arm and one hand on the base.

Figure 10.3 A compound light microscope

Part	Function
Eyepiece	Is used for viewing and contains a lens that magnifies
Tube	Holds the eyepiece and objective lenses at proper distance from each other
Arm	Supports the eyepiece
Coarse adjustment knob	Brings an object into focus at low or medium power
Fine adjustment knob	Brings an object into focus at high power
Objective lenses	Magnify the image. Most microscopes have three or four lenses.
Revolving nosepiece	Holds the three objective lenses
Stage	Supports the slide. Some microscopes have stage clips to hold the slide in place.
Iris diaphragm	controls the amount of light reaching the specimen
Light source	Supplies the light needed to view the slide
Base	Supports the entire microscope

Table 10.2 The Parts of a Compound Light Microscope

Connection

Section 6.3 has more information about how a compound light microscope works.

How a compound light microscope works

Two sets of lenses work together to magnify and focus an image. When you look through this microscope, you see an image that is magnified (made larger), inverted (upside down), and reversed (backwards). See Figure 10.4.

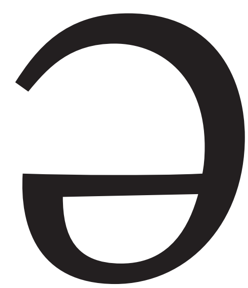


Figure 10.4 The letter "e" seen through the lens of a microscope will appear like this.

Magnification

The **magnification power** of a lens is the number of times larger an image looks under the lens. Each objective lens has a number that states its magnification power (see Figure 10.5). Most school microscopes have these magnification powers:

- low-power objective lens (4×)
- medium-power objective lens (10×)
- high-power objective lens (40×)

Suggested Activities

Conduct an Investigation 10.1A on page 394

Find Out Activity 10.1B on page 397

Usually the eyepiece lens has a magnification power of 10X. To find the **total magnification** of the microscope for each objective lens, you multiply the power of the objective lens by the power of the eyepiece. For example:

$$\text{low-power objective lens} \times \text{eyepiece lens} = \text{total magnification}$$

or

$$4 \times 10 = 40$$

The total magnification of a medium-power lens is 100× and a high-power lens is 400×.

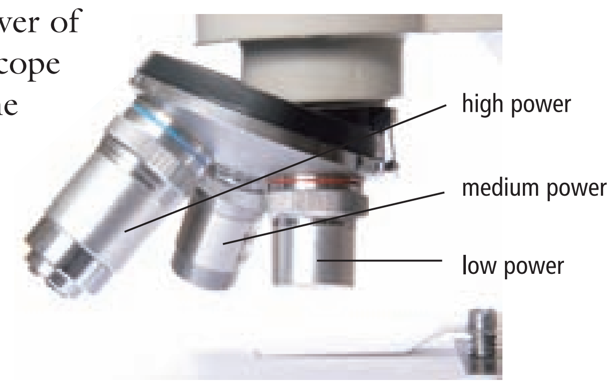


Figure 10.5 Magnification power of the three objective lenses

10-1A Setting Up and Using a Microscope Core Lab

SkillCheck
- Observing
- Measuring
- Communicating
- Working co-operatively

Safety
- Microscopes, slides, and cover slips can break, especially when using the high-power objective lens. Handle with care.
- Be careful when using sharp objects such as tweezers.
- Wash your hands thoroughly after doing this investigation.

Materials
- microscope
- prepared microscope slides
- see-through plastic ruler
- lens paper
- microscope slides
- cover slips
- medicine droppers
- tweezers
- water
- live specimens

Using a microscope can open up an exciting new world of discovery. In this activity, you will practise using a compound light microscope carefully and accurately. You will also examine some living and non-living things and learn how to prepare your own slides.

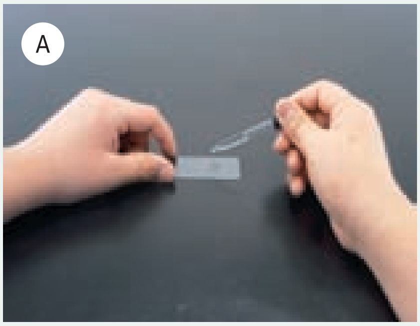
Procedure

Part 1 Focus the Image
1. Pick up your microscope and bring it back to your work table. Check that it is set to the low-power objective lens.
2. Select a prepared slide from the ones provided by your teacher. Place the slide on the stage of the microscope. If your microscope has stage clips, use them to hold your slide in place.
3. Turn the coarse adjustment knob carefully to bring your image into focus. Draw and label what you observe.
4. Move your slide to the right. Which way does the image move?
5. Move your slide up. Which way does the image move?
6. Change the lens to medium power and focus the image. You may need to turn the fine adjustment knob to make minor adjustments so that you can bring the image into focus. Draw and label what you observe.

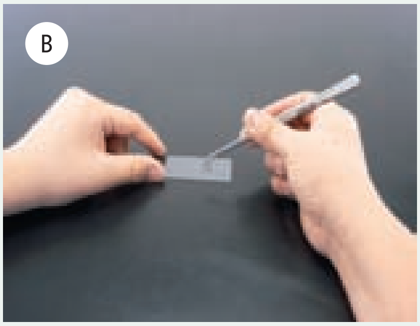
Part 2 Determine the Field of View
1. Place a see-through ruler on the stage and focus on the ruler at low power.
2. Record the length of the ruler you can see at low power. This is called the field of view.
3. You can use the field of view to estimate the size of an object you are viewing at low power. For example, the field of view at low power is usually 4.2 mm. If an object takes up half the field of view at low power, this would mean that its approximate size would be 2.1 mm. Another way to estimate the size of an object your are viewing is to estimate how many of that object could fit end-to-end across the field of view. To do this, divide the field of view by the number of objects. The answer is the approximate size of one object. (Note: Millimetre markings on the ruler are too far apart to permit direct measurement of the field of view for lenses with a magnification higher than 10×.)
4. Select another prepared slide and determine the approximate size of an object at low power. Record your answers.

Part 3 Make a Wet Mount Slide

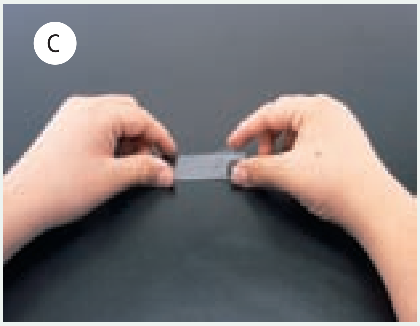
1. You can make your own slide rather than use a prepared one. This type of slide is called a wet mount slide. To prepare a wet mount slide, follow the instructions in the photos and captions below. (Make sure your slide is clean before you begin. If it is not, use lens paper to wipe it off.)
2. Prepare a wet mount slide of a strand of hair. Place the slide on the stage of the microscope. Observe and draw the hair at low power and then at medium power. Label your drawings.
3. Your teacher will provide you with a live specimen to observe. Prepare a wet mount slide. After placing the slide on the stage, determine which power would be best for observing it. Make your observations, then draw the specimen and label your drawing.
4. When you have completed Procedure steps 1–3, make sure your microscope is set at low power.
5. Clean up and put away the equipment you have used.



Place a drop of water on the slide.



Use tweezers to place your specimen in the drop of water.



Hold the cover slip at a 45° angle and gently lower it onto the slide. There should be no air bubbles under the cover slip. If there is any excess water on the slide, dab a piece of tissue paper on the slide.

Analyze

1. Compare the drawings you made in this activity. Describe how your images changed when you increased the power of magnification. For example, did you see more or less of an image, or was it easier or harder to focus on the whole image?
2. To view the letter "e" through your microscope the right way up, how would you position the slide on the stage?
3. You are looking at an image at low power. You see a round object in the top left corner of the image that you would like to see more clearly. You switch to medium power. List the steps you would have to take to get the round object in the middle of your view.

Conclude and Apply

1. A classmate has missed this lab activity and has asked you to explain how to use a microscope properly. Write a step-by-step set of directions. Include labelled diagrams where needed.

Resolving power

Examine the four circles in Figure 10.6. All the dots in circle A are 1 mm in diameter. They are also 1 mm apart. Now look at circles B, C, and D. Can you see the dots clearly in each picture?

Most people cannot see the dots in picture D. This is normal. Average human eyesight means people can see only dots that are separated by a distance of 0.1 mm or more. The microscope extends human vision by allowing you to view objects that are smaller and closer together. The ability to distinguish between two dots or objects that are very close together is called **resolving power**. The resolving power of a compound light microscope is about 0.2 microns (μm), which means that the microscope cannot separate two images that are less than 0.2 μm apart. A micron is one-millionth of one metre. If you were to observe a living thing that was one micron in size, you could fit one million of them side by side on a metre stick.

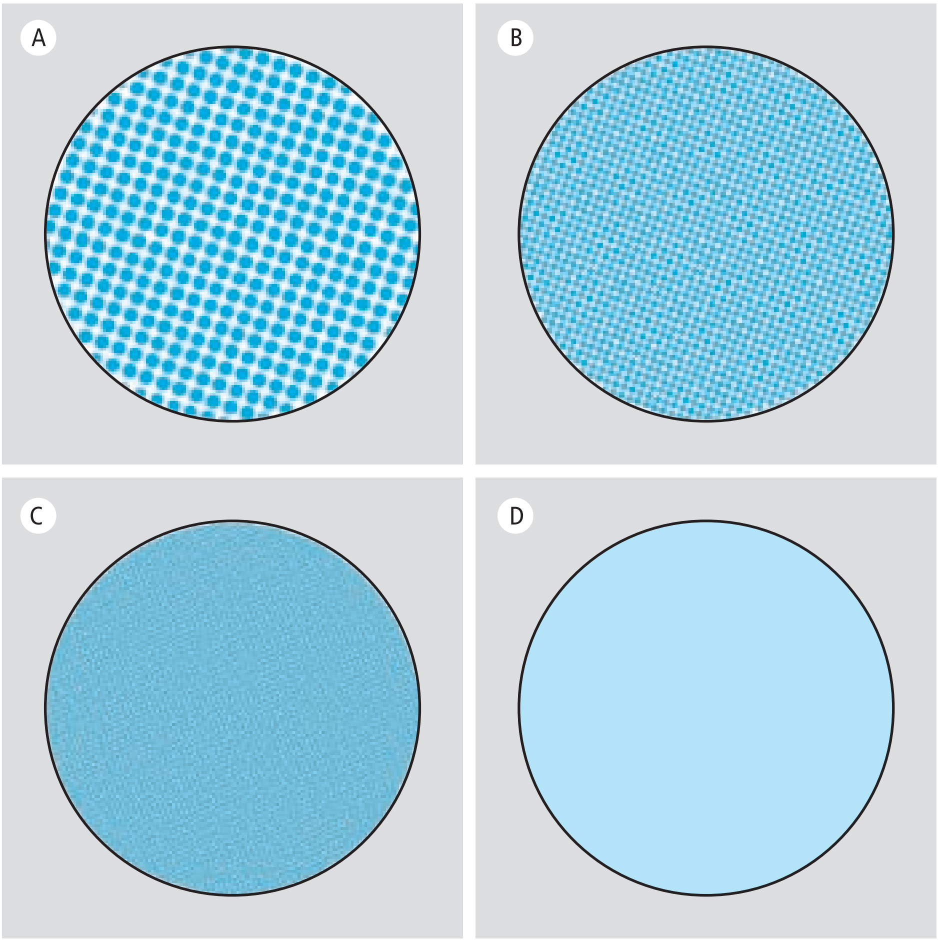


Figure 10.6 In which picture are you unable to make out individual dots?

Reading Check

1. What is a cell?
2. Name all the parts of a compound light microscope that are directly responsible for making a magnified image of an object. (Hint: There are three.)
3. Draw how the letter "G" would appear when viewed through a compound light microscope.
4. What is the total magnification for the medium-power objective lens?

10-1B Observing Organisms in Pond Water

Find Out ACTIVITY

In this activity, you will use a compound light microscope to observe a variety of organisms that live in pond water. As you are looking at these organisms, try to determine how each one demonstrates the characteristics of living things. For example, observe the different ways they move or respond to stimuli.

Materials

- microscope
- microscope slide
- cover slips
- medicine dropper
- tweezers
- pond water

Safety

Handle microscope slides and cover slips very carefully to avoid breaking them or cutting yourself. Treat the pond organisms respectfully. They are alive.

What to Do

1. Obtain a sample of pond water from your teacher. Make a wet mount slide with this sample. (See Conduct an Investigation 10.1A)
2. Examine the slide under low and medium power, looking for different organisms in the pond water.
3. Draw what you see for at least two different organisms. Include as much detail as possible.
4. For each organism, record which characteristics of living things you observe.
5. Clean up and put away the equipment you have used.

What Did You Find Out?

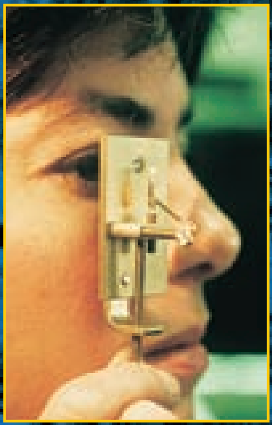
1. Summarize the evidence you collected that demonstrates the organisms you observed were living. Use a chart or write a paragraph to help you organize your summary.

NATIONAL GEOGRAPHIC

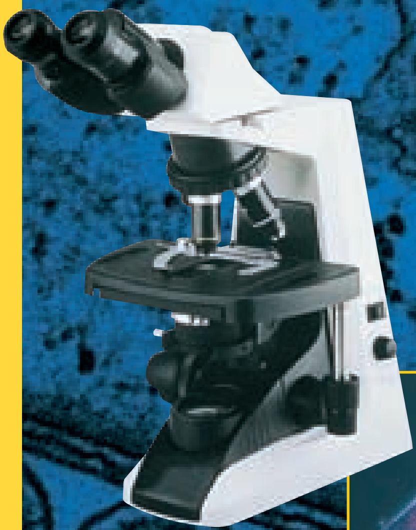
VISUALIZING MICROSCOPES

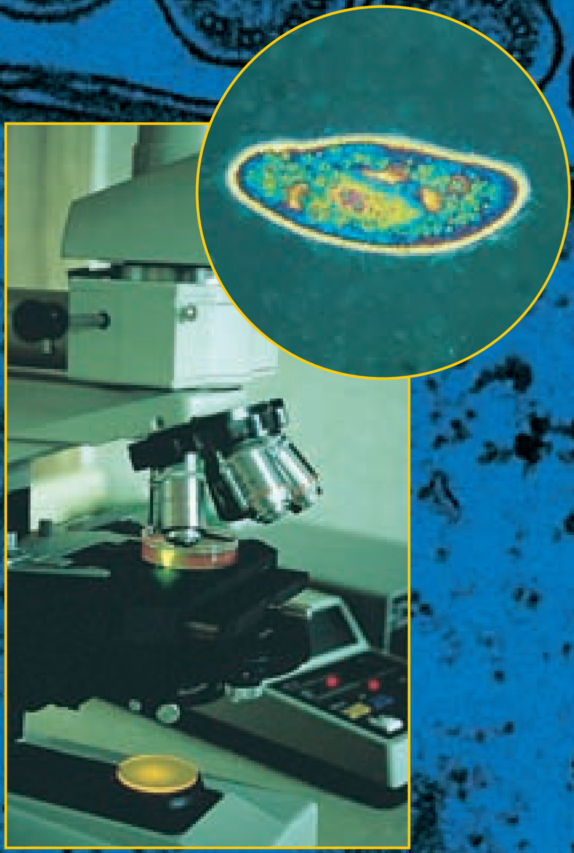
Microscopes give us a glimpse into a previously invisible world. Improvements have vastly increased their range of visibility, allowing researchers to study life at the molecular level. A selection of these powerful tools—and their magnification power—is shown here.

Up to 300× **LEEUWENHOEK MICROSCOPE** Held by a modern researcher, this early microscope allowed its user to view stentor and other single-celled organisms for the first time.



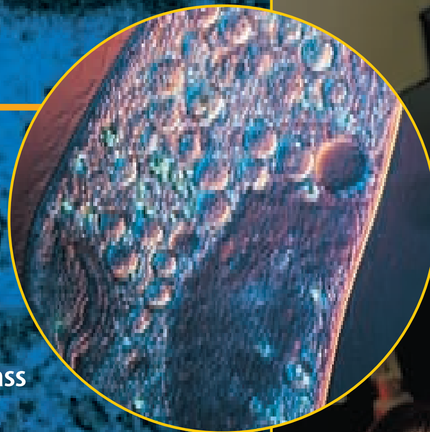
Up to 2000× **BRIGHTFIELD / DARKFIELD MICROSCOPE** The light microscope is often called the brightfield microscope because the image is viewed against a bright background. A brightfield microscope is the tool most often used in laboratories to study cells. Placing a thin metal disc beneath the stage, between the light source and the objective lenses, converts a brightfield microscope to a darkfield microscope. The image seen using a darkfield microscope is bright against a dark background. This makes details more visible than with a brightfield microscope. Below are images of a paramecium as seen using both processes.





Up to 1500× **FLUORESCENCE MICROSCOPE** This type of microscope requires that the specimen be treated with special fluorescent stains. When viewed through this microscope, certain cell structures or types of substances glow, as seen in the image of a paramecium above.

Up to 1 000 000× **TRANSMISSION ELECTRON MICROSCOPE** A TEM aims a beam of electrons through a specimen. Denser portions of the specimen allow fewer electrons to pass through and appear darker in the image. Organisms, such as the paramecium at right, can only be seen when the image is photographed or shown on a monitor. A TEM can magnify hundreds of thousands of times.



Up to 1500× **PHASE-CONTRAST MICROSCOPE** A phase-contrast microscope emphasizes slight differences in a specimen's capacity to bend light waves, thereby enhancing light and dark regions without the use of stains. This type of microscope is especially good for viewing living cells, like the paramecium above left. The images from a phase-contrast microscope can only be seen when the specimen is photographed or shown on a monitor.

Up to 200 000× **SCANNING ELECTRON MICROSCOPE** An SEM sweeps a beam of electrons over a specimen's surface, causing other electrons to be emitted from the specimen. SEMs produce realistic, three-dimensional images, which can only be viewed as photographs or on a monitor, as in the image of the paramecium at right. Here a researcher compares an SEM picture to a computer monitor showing an enhanced image.

Science Math connect

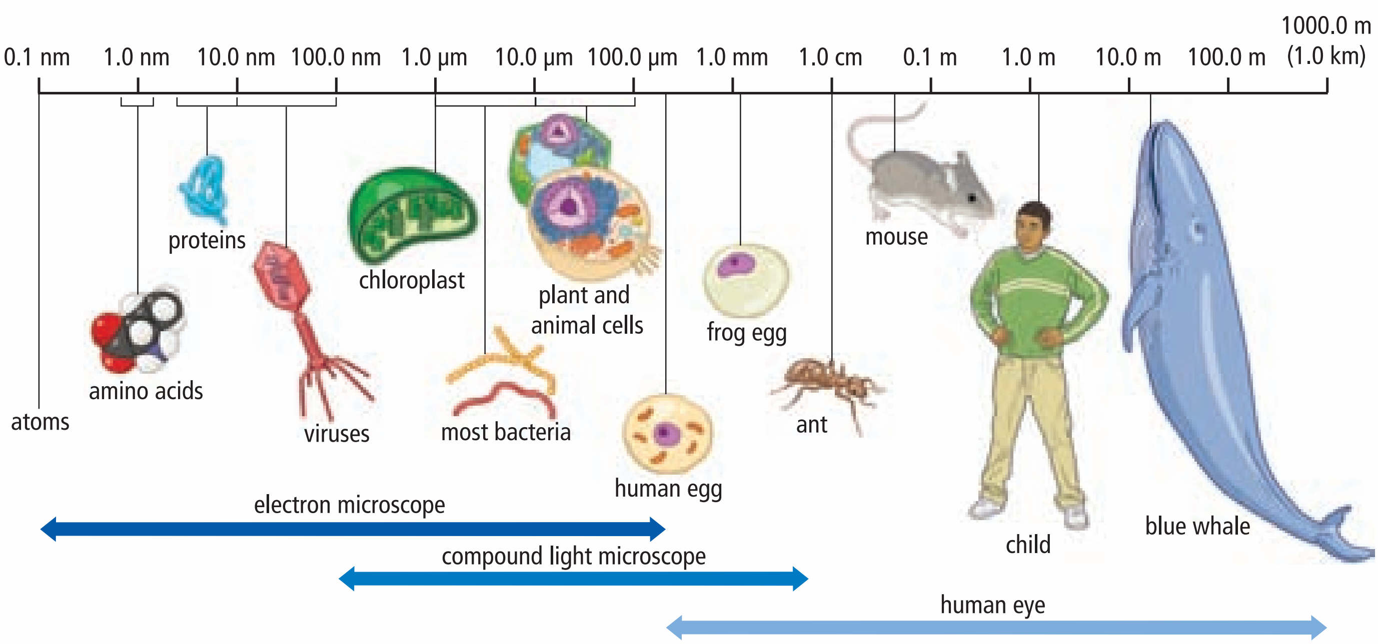
Size and Scale

The table below summarizes some of the units of measurement you will use in this textbook and future science courses. The table includes the prefix, the symbol, and the mathematical measurement. Three of these units are commonly used to describe living and non-living things that are observed through a microscope. Notice that each of these mathematical measurements increases by a factor (power) of 1000 (10^3). Use the scale in the diagram below to help you understand what this means.

Prefix	Symbol	Mathematical Measurement
nano	n	10^{-9} (billionth)
micro	μ	10^{-6} (millionth)
milli	m	10^{-3} (thousandth)
kilo	k	10^{3} (thousand)
mega	M	10^{6} (million)

Question

1. If the thickness of one sheet of paper in this textbook is 0.2 mm, how high would a pile of paper be for:
   (a) 1000 sheets (thousand)
   (b) 100 000 sheets (hundred thousand)
   (c) 1 000 000 sheets (million)
   (d) 1 000 000 000 sheets (billion)



The scale in this diagram increases by a factor, or power, of 10. Using this type of scale makes it mathematically easier to work with very small and very large numbers.

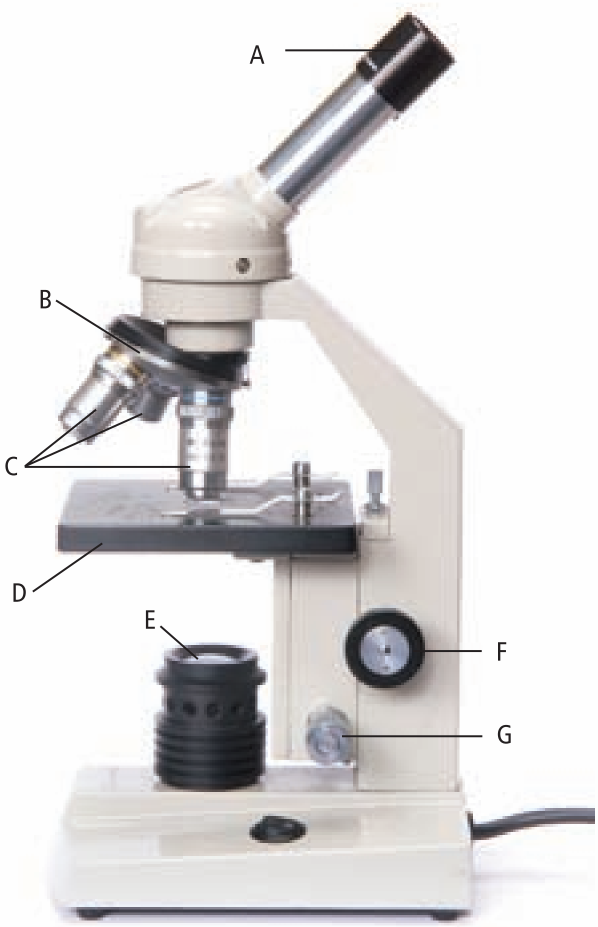
Check Your Understanding

Checking Concepts

1. List four characteristics of living things. Provide an example for each characteristic.

2. Describe the proper way to carry a microscope.

3. (a) Name each part identified with a letter in the photograph below.
(b) State the function of each part that you identified in (a).



4. Why do you start with the low-power objective lens when focusing an image?

5. Explain the steps you follow to make a wet mount slide.

6. If an objective lens has a magnification power of 40×, why is the image magnified 400×?

Understanding Key Ideas

7. You are exploring a remote region in Labrador. You unexpectedly discover what may be a new microscopic life form in a sample of pond water. How could you determine if this sample is living or non-living?

8. You observe several puffins eating herring along a coastline. How do the puffins demonstrate the characteristics of living things discussed in this chapter? If they do not, can you still say they are alive? Explain your answer.

9. You find a cracked microscope slide on the stage of a microscope. The objective lens is on high power. Describe a possible reason why the slide is broken.

Pause and Reflect

A biologist from another galaxy might think that cars are a form of life on Earth. State evidence that an alien biologist might use to explain why cars are a form of life. Give reasons to persuade the biologist that cars are not, in fact, alive.

10.2 Focussing on Cells

Using an analogy can help you understand science concepts, such as how the parts of a cell function. All cells have similar structures and organelles. Each structure and organelle carries out a specific task to help support the life functions of a cell. Cellular respiration is the process that produces energy for the cell. Cell theory states that the cell is the basic unit of life; all living things are composed of one or more cells; all cells come from other living cells.

Key Terms

cell membrane
cell theory
cell wall
chloroplast
cytoplasm
mitochondria
mitosis
nucleus
organelle
vacuole

Imagine a planet in a nearby galaxy. There is a star like our Sun that provides heat and light. Although smaller than Earth, the planet supports many different life forms. One life form is the Icthos (pronounced ICK-THOSS). They are an advanced life form and have developed a variety of technologies, such as the Protection Dome, inside which they live (see Figure 10.7). Unlike life forms on Earth, the Icthos live in a liquid, not an air atmosphere.

Over time, the Icthos have spread across the planet and settled in groups known as colonies. One of these colonies is called Newo (pronounced KNEW-OH). Newo is thriving, and the population has increased rapidly. The residents of Newo go about their daily activities, such as ingesting food packets and nutrient fluids (eating and drinking) and dreamdozing (sleeping).

Newo, however, has some serious problems, including pollution and a need for a new energy source. Management groups are responsible for performing different functions within the colony. You are a specialist on colony operations. The management groups have sent you their reports about their biggest problems. Your first task is to read these reports carefully.

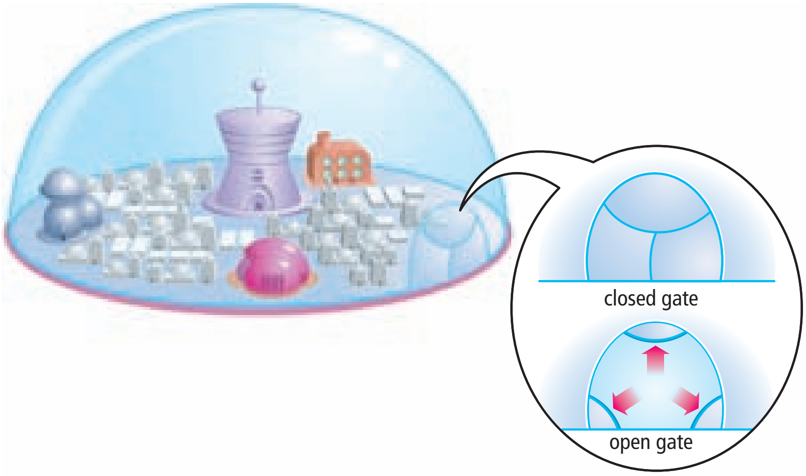


Figure 10.7 The Newo colony is an analogy of the structure and function of the cell.

Report 1 from Control Central (CC)

Control Central monitors all movement within Newo and ensures the day-to-day operations of the colony are successfully completed. To communicate with our workers, we send out messages telling them what to do. CC's problem is that sometimes these messages get lost or are sent to the wrong worker. This means a waste collector might end up delivering food. These mix-ups cause confusion and make it difficult for people to do their jobs. We sometimes lose track of what work has been done and what work needs to be done.

Report 2 from Protection Dome (PD)

We at PD have no major problems. The Protection Dome remains secure and to date no unauthorized entries have occurred. The only entry and exit gate is under constant guard. We only allow movement of materials through the gate with prior permission. This system gives us complete control of all movement, and it is working extremely well. If we were to increase the amount of material passing through the gate, there would be delays.

Report 3 from Food and Nutrient Fluid Transportation (FNFT)

The main problem facing FNFT is transportation. It is our task to transport four food packets and one packet of nutrient fluid from outside the Protection Dome to every resident in Newo. Nutrient fluid is like a sports drink that contains important food for the residents of Newo. Both types of packets are necessary for their survival. We need a better way to transport this amount of food and nutrient fluid. Also, we are unsure whether there is enough energy to operate a new transportation system if we make any improvements.

Report 4 from Energy Production (EP)

Energy Production is in serious trouble. EP needs a new source of energy to properly provide the colony with energy to perform essential functions, such as food and nutrient-fluid distribution. This energy source must produce no pollution, as we already have a pollution problem. Our scientists have been working on an energy system that would convert the wastes we produce into some sort of useful product. So far their attempts have been unsuccessful.

Report 5 from Waste Control (WC)

Waste Control is having problems storing and removing waste from Newo. For every food packet, two smaller containers, or pods, of waste are produced. For every nutrient fluid packet delivered, one smaller pod of additional waste is created. WC can get rid of only 7000 waste pods a day. There is a second problem that will have a long-term effect on the colony. Our research team has detected an increase in the level of a new form of pollution in Newo. The pollution produces small black particles that are causing the liquid atmosphere inside Newo to turn grey. We need to find a way to remove this pollution from our liquid atmosphere.

10-2A Finding Solutions for Problems in the Newo Colony

Find Out ACTIVITY

In this activity, your task is to work with your classmates to figure out a possible solution for each of the problems facing the management groups of Newo. Recall that the management groups are:

- Control Central
- Protection Dome
- Food and Nutrient Fluid Transportation
- Energy Production
- Waste Control

What to Do

1. Record each problem the management groups identified.
2. Brainstorm solutions for each problem.
3. Select the best solution for each problem. Each solution must also work with the other solutions you select.
4. Make a drawing of Newo that shows how you solved each problem. Use labels and descriptions to help explain your solutions.

What Did You Find Out?

1. Post your drawing on the wall.
2. Walk around and look at the drawings of other classmates. Make notes on what you observe in these drawings. Find an example of a drawing that:
   (a) Shows a solution different from yours. Record what is different.
   (b) Shows a solution the same as yours. Record what is the same.
3. Return to your drawing. Based on your observations, what would you change about one of your solutions so that it works better? Make this change on your drawing.
4. Share your own drawing with the class and discuss which solutions would probably work best for solving Newo's problems.

Explore More

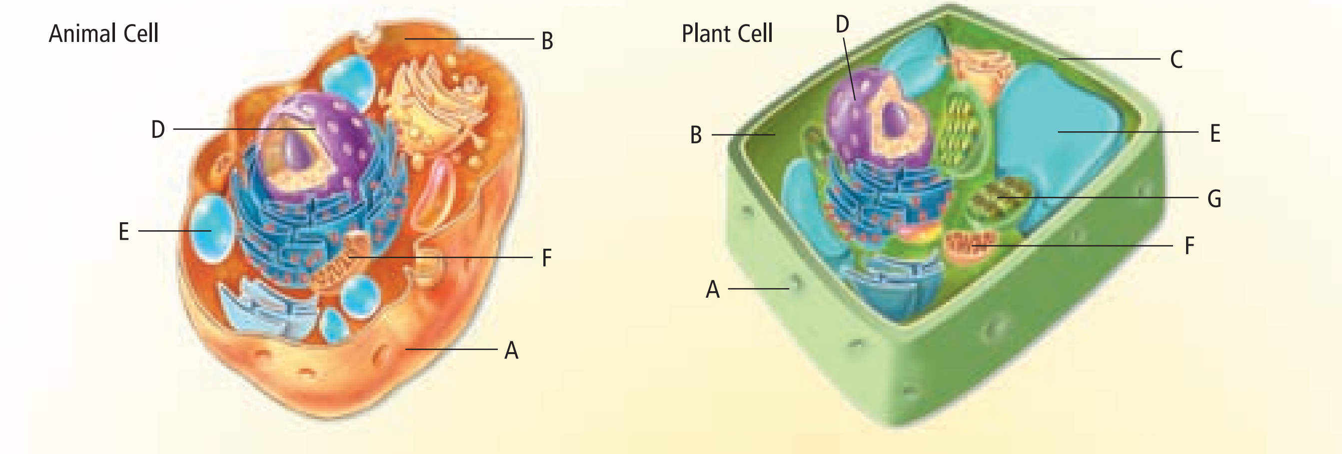
Create a table with two columns and seven rows. In the first column, list the cell organelles. In the second column, list the corresponding management group from the Newo colony. Invent a management group for any organelle that does not have one.

Using an Analogy to Understand a Cell

The colony of Newo is an analogy for a cell. An analogy is a way to understand new ideas by comparing the new ideas to something that is more familiar. For example, you have learned that each management group in Newo carries out a specific task. You have also seen how these groups work together to ensure the survival of the colony. Similarly, cells have different structures that carry out specific functions. In working together, all the structures of the cell help to keep it alive. The structures of a cell that perform a specific function are called **organelles**. Organelles occupy up to 30 percent of a cell. The rest of the cell consists of water.

Each organelle has a role to play in the activities that are necessary for the life of the cell. Table 10.3 on the next page lists some of the major organelles that are found in animal cells and in plant cells. Look closely at the diagrams and the information listed in the table. Take note of which organelles are found in both animal and plant cells and which organelles are found only in plant cells.

Table 10.3 Common Organelles of Animal and Plant Cells



Cell Organelle	Structure and Function
[A] **cell membrane**	• found in animal cells and plant cells • surrounds and protects the contents of the cell • helps to control the movement of foods, wastes, and other substances into the cell and out of the cell
[B] **cytoplasm**	• found in animal cells and plant cells • jelly-like, watery fluid in which internal organelles float • helps to distribute materials such as food and oxygen to different parts of the cell
[C] **cell wall**	• found in plant cells but not animal cells • tough, rigid structure that surrounds the cell membrane and gives plant cells a regular, box-like shape • made mostly of a material called cellulose (which you might know better as dietary fibre)
[D] **nucleus**	• found in animal cells and plant cells • large, round structure often clearly visible in most cells • contains the chromosomes—the structures that are made of genetic material that control a cell's growth, reproduction, and other life-sustaining activities
[E] **vacuole**	• balloon-like spaces within the cytoplasm • provide space to store extra food, wastes, and other substances that the cell cannot use right away • found in animal cells and plant cells (they are smaller and more numerous in animal cells)
[F] **mitochondria**	• oval, bean-shaped structures (singular: mitochondrion) • produce energy for the cell by breaking down food particles to release their stored energy • found in animal cells and plant cells
[G] **chloroplast**	• green structures that contain a green pigment (coloured substance) called chlorophyll • capture energy from the Sun, which is used to produce food (sugars) in the leaves and green stems of plants (this process is called photosynthesis) • found in plant cells but not animal cells

Word Connect

The word *permeable* comes from a Latin word that means "to pass through." You might know another word that is related: permeate. For instance, the smell of frying onions permeates (moves or spreads through) the kitchen.

The Importance of the Cell Membrane

Think about the Newo colony. One management group that had a problem was the Protection Dome—the barrier around the colony. It had only one entrance and exit. The Food and Nutrient Fluid Transportation group had to find other ways to get materials into the colony. The Waste Control group had to find new ways to get wastes out. A cell would have problems like these if the cell membrane had just one entrance and exit.

The cell membrane has many openings, but they are *selective*. They let some substances enter and leave the cell, but they also prevent other substances from entering and leaving.Because only some substances can cross it, the cell membrane is said to be *selectively permeable*. This is like a coffee filter—hot water can move through the filter, but the coffee grounds cannot.

The Cell Theory

During the 1800s, many scientists around the world were using compound light microscopes to study cells. The cell nucleus was first described in 1802, and it was studied in more detail about 30 years later. By 1846, the importance of the cytoplasm to the life of the cell was appreciated. A year later, the cell membrane was described. As time went on, more organelles were discovered, and their functions were investigated and described.

By the mid 1850s, scientists had recorded thousands of observations about the cells of plants, animals, and other living things. Based on their studies, scientists agreed on three important facts about cells and their connection with living things. Together, these facts are called the **cell theory**. The cell theory is one of the key ideas of biology. It helps scientists to describe and explain their observations of living things.

The Cell Theory

- The cell is the basic unit of life.
- All living things are made up of one or more cells.
- All cells come from other living cells.

Reading Check

1. What are organelles?
2. Why is the cell membrane said to be selectively permeable?
3. Why is the cell theory valuable to scientists?

10-2B Building a 3-D Cell

Conduct an INVESTIGATION

Inquiry Focus

SkillCheck

- Modelling
- Explaining systems
- Communicating
- Working co-operatively

Criteria

- Your model must contain all the correct parts in approximately the correct proportions.
- The cell is three-dimensional.
- All organelles that you have learned about are present and clearly identifiable.
- Your finished model should be larger than a shoebox or a basketball.

A cell may look flat (two-dimensional) under a microscope, but it actually has three dimensions: length, width, and thickness. This activity gives you a chance to build your own three-dimensional cell using materials of your choice. Using models to explain an idea or concept is a key skill in science. By developing a model, you are demonstrating your understanding of the cell.

Problem

How can you build a model of a plant or animal cell using a variety of materials?

Plan and Construct

1. Decide whether you are going to construct a plant cell or an animal cell.
2. Make a rough drawing of your cell. Include the following cell parts:

   cell membrane

   nucleus

   cell wall (plants only)

   chloroplasts (plants only)

   vacuole

   cytoplasm

   mitochondria
3. For each cell part, determine what kind of material you will use. Ideas for materials include yarn, beads, toothpicks, pipe cleaners, string, straws, plastic foam, food, and modelling clay.
4. Build your cell. Use clear-drying glue if possible.
5. Deliver your model in a box. Provide a labelled diagram with a key that matches each building material to the cell part.

Evaluate

1. Before you submit your model, make sure you have met all the criteria.
2. Your teacher may ask you to fill out a summary sheet that asks you to explain your work.

10-2C Observing Plant and Animal Cells

SkillCheck
- Observing
- Communicating
- Evaluating information

Safety
- Microscopes, slides, and cover slips can break. Handle with care.
- Be careful when using sharp objects such as tweezers.
- Wash your hands thoroughly after doing this activity.

Materials
Part 1
- microscope
- microscope slides
- cover slips
- lens paper
- tweezers
- medicine droppers
- water
- onion
- iodine solution
- paper towel

Part 2
- microscope
- prepared slide of human skin cells
- lens paper

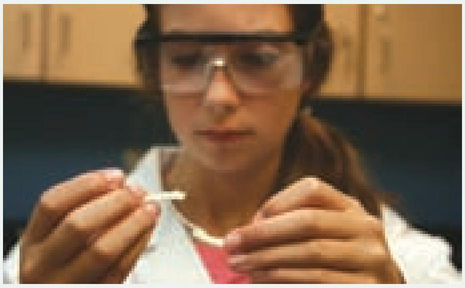
In this investigation, you will continue to develop your microscope skills by preparing and observing a wet mount of onion skin cells and observing a prepared slide of human skin cells. You will also learn about a process called staining. Scientists stain cells to help them see organelles that are not visible in a standard wet mount slide.

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

Procedure

Part 1: Observing Plant Cells

1. Obtain your microscope and the materials you will need to make a wet mount slide.
2. Clean your slides with lens paper before you begin. Prepare a wet mount slide by putting a drop of water on the slide. Review Part 3 of Conduct an Investigation 10-1A if you want to review how to prepare a wet mount slide.
3. Take a piece of onion from the outer layer and carefully break it in half. As you separate the two sections, use tweezers to pull the top layer of the onion sideways as shown below. This should give you a sample of translucent onion skin.



Pull the top layer of the onion skin sideways to make a thin section.

4. Place the onion skin in the drop of water on the slide. Finish making your wet mount slide.
5. Place your slide on the stage of the microscope and focus at low power. Select one cell and draw it. Include all the organelles you recognize, and label them.
6. Place a drop of iodine solution on one side of your slide. On the other side, place a small piece of paper towel as shown below. The paper towel will soak up the water under the cover slip and draw the iodine solution under the slide and into the cells. This process is called staining the cells.

7. Estimate the size of one cell under low power. First, recall the diameter of the field of view from Investigation 10-1A. Next, estimate how many cells could fit end to end across the field of view. Then divide the field of view by the number of cells you estimated. For example, if the field of view is 1.5 mm, and if you estimated 10 cells, then 1.5 ÷ 10 = 0.15. Each cell would be about 0.15 mm in diameter.
8. Observe the onion cell under medium and high power. Add any more organelles you observe to your drawing and label them.
9. Your teacher either will have you continue on to Part 2 or will ask you to clean up and put away your equipment.

Place a drop of iodine on one side of your slide, and hold a small piece of paper towel on the other.

Part 2: Observing Animal Cells

1. Obtain a prepared slide of human skin cells.
2. Set up the slide on your microscope, and examine the skin cells under low power. Select one cell and draw it. Include all the organelles you recognize, and label them.
3. Estimate the size of one skin cell.
4. Observe the skin cell under medium power. Make a new diagram, showing and labelling the organelles.

Analyze

1. Which organelles became more visible after you stained the cell with iodine?
2. Vacuoles tend to be larger in plant cells than in animal cells. Why do you think they are larger?
3. Compare your drawings and cell sizes with those of your classmates. Explain any differences in details shown or sizes estimated.

Conclude and Apply

1. Make a comparison chart to summarize the differences and similarities between onion skin cells and human skin cells.
2. 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 and human skin help do this?

Dividing Cells

All cells divide at some point during their life cycle. When cells divide, one cell becomes two cells. Then each of these two cells divides into two more cells, and so on. Unicellular organisms such as bacteria divide like this to produce more of their kind. You can see this in Figure 10.8.

Most of the cells in multicellular organisms such as you divide in order to replace other cells that are dead, dying, or in need of repair. For example, the skin cells of your body divide all the time to replace dead skin cells or skin cells that rub off your body if you scrape yourself. Figure 10.9 shows a dividing skin cell. Your red blood cells live for about 120 days, and then they divide to replace those that die. The only cells in the human body that do not divide in this manner are sperm cells (if you are male) and egg cells (if you are female). You will learn how sperm and egg cells form and divide in your science class next year.

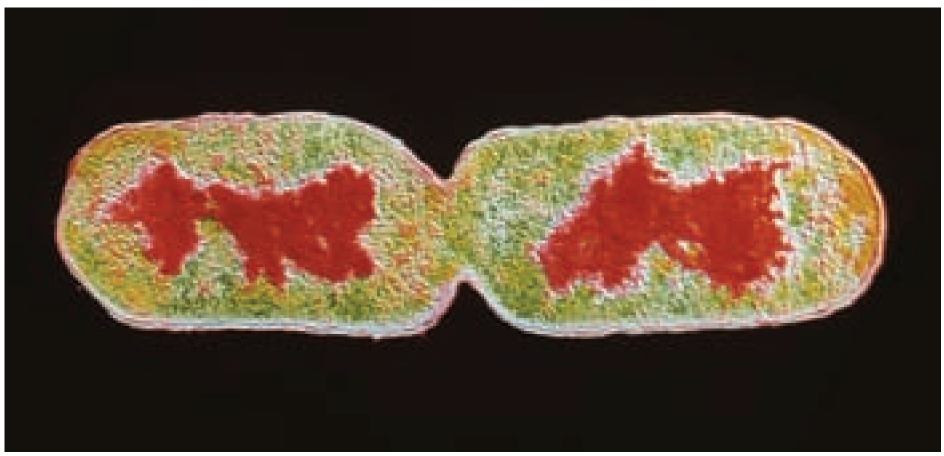


Figure 10.8 This bacterium is a single cell that has almost finished dividing from one cell into two cells.

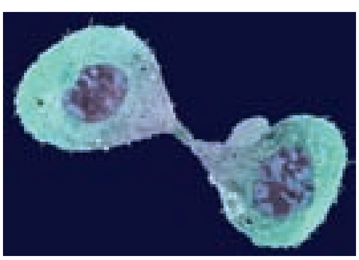


Figure 10.9 This skin cell is one of millions of skin cells that divide constantly to replenish human skin.

Mitosis

How does one cell divide to become two cells? If you look at cells under a microscope, you might be able to observe them in the process of dividing. The best places to look for dividing cells are in parts of a living thing that are growing quickly, such as the root tips of young plants. You can see this in Figure 10.10.

Notice that some cells in Figure 10.10 do not have a solid, round nucleus. Instead, they have clusters of dark, tangled, thread-like structures. These structures are chromosomes. Chromosomes are contained within the nucleus, but they become visible only when a cell is about to divide. Chromosomes contain a cell's genetic material. These are instructions for producing new cells that have the same characteristics as the original cell.

When a cell divides, the genetic material duplicates and then divides into two identical sets of chromosomes. This process is called **mitosis**. It is similar in all living things—whether they are unicellular, such as stentor, or multicellular, such as you. The two new cells that form by this division are referred to as daughter cells. Each daughter cell gets one set of the duplicated genetic material. You will learn more about mitosis and other ways that cells can reproduce in your science class next year.

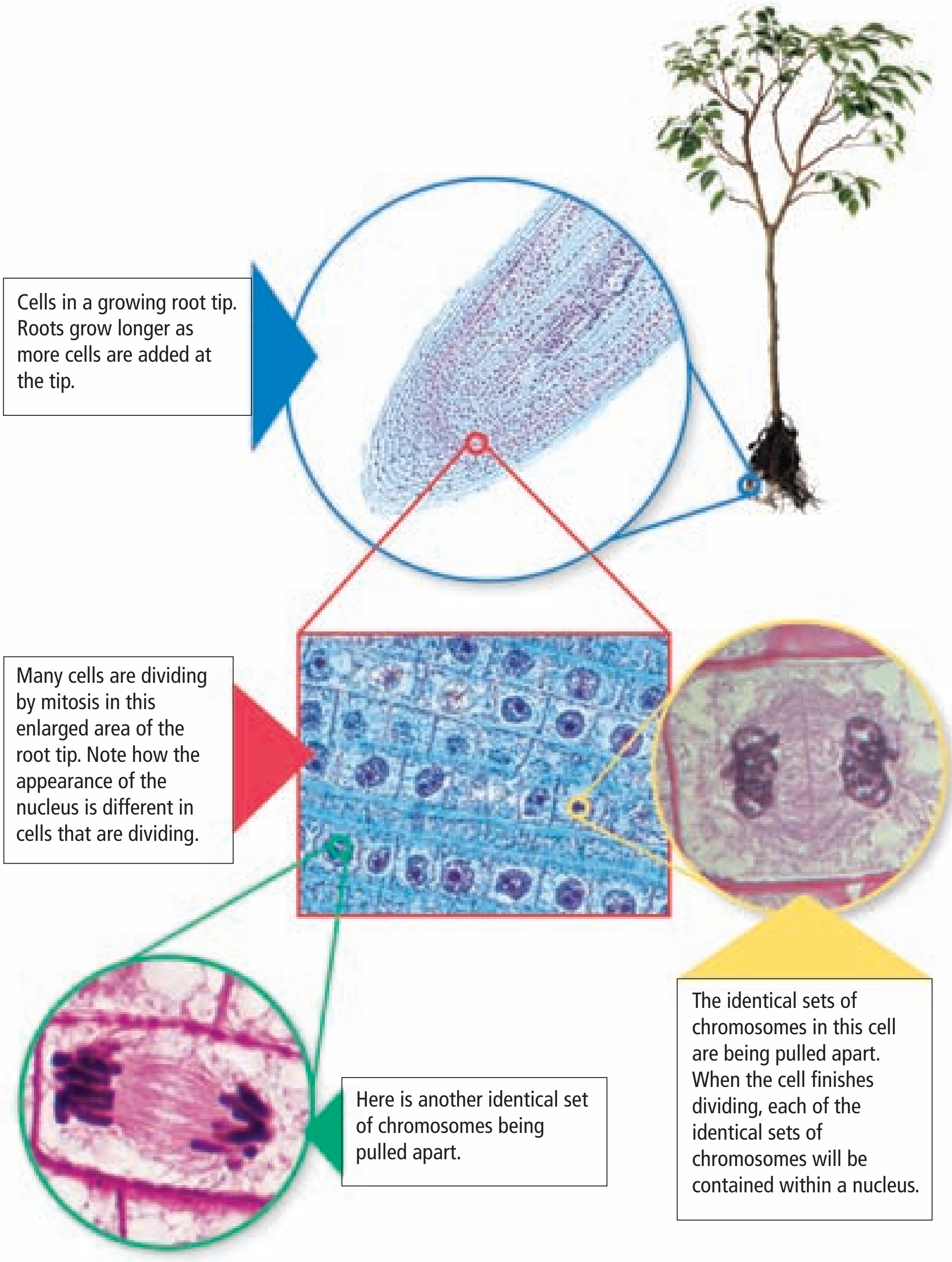


Figure 10.10 The root tips of a growing plant are made up of rapidly dividing cells.

10-2D Observing Root Tip Cells

Find Out ACTIVITY

In this activity, you will look for evidence of cells dividing in a prepared slide of a root tip from an onion.

Materials

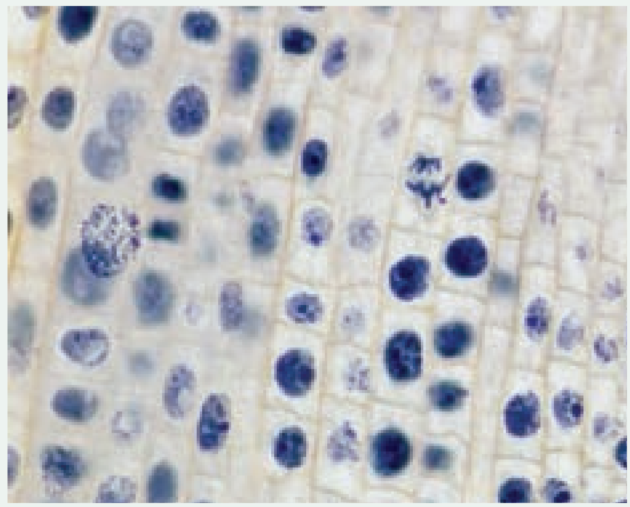
- compound microscope
- prepared slide of onion root tip

What to Do

1. Put the prepared slide of the onion root tip on the stage of the microscope.
2. View the cells using low power.
3. Look for the part of the root tip where cells appear to be dividing most actively. Reposition the slide so that these cells occupy most or all of your field of view.
4. Change to medium power and refocus.
5. Sketch the cells that are visible in your field of view.

What Did You Find Out?

1. On the sketch you made, identify the cell or cells in which you can see:
   (a) a cell dividing to become two cells
   (b) a cell in which chromosomes are visible (refer to page 410 to review what chromosomes are and when they are visible)
   (c) a cell in which chromosomes are not visible
2. Compare your sketch with sketches made by other members of your class. As a class, discuss and identify similarities and differences in your sketches.
3. (a) Why would you look at a root tip to find evidence of cells dividing?
   (b) Suggest one other part of a plant that you think would show evidence of cells dividing if you viewed it with a microscope. Explain your reasoning.



Energy for Cells

Cells need energy to reproduce as well as to carry out all their other life functions. The energy that cells use is stored in their food. The food substance that cells use for energy is a type of sugar called glucose. You eat glucose all the time. Figure 10.11 shows some examples of foods that contain glucose.

Figure 10.11 Glucose is a part of all fruits, vegetables, and grains. It is also the main sugar in honey and corn syrup.

Plant and animal cells depend on the energy stored in glucose for their life functions. To release the energy stored in glucose, their cells carry out a process called cellular respiration. During cellular respiration, the energy in glucose is converted to other forms of energy. The process takes place in the mitochondria of the cells. Half or more of the energy from glucose is released as heat. The rest is used to carry out life functions.

Plant and animal cells need oxygen to carry out cellular respiration. The oxygen combines with glucose in a chemical change. This chemical change releases energy, and it produces two waste gases: carbon dioxide and water vapour. These wastes are removed from the cell.

You may have heard the word "respiration" before when people talk about breathing. In fact, the word respiration comes from a Latin word that means "breathe." In Chapter 11, you will find out how breathing and cellular respiration are linked.

Explore More

When you breathe, you inhale oxygen from the air and you exhale carbon dioxide back into the air. You might also know that you exhale some water vapour, too. (That's the mist you see when you exhale on a cold day.) What do you think the link between breathing and cellular respiration is?

10-2E Observing Evidence of Cellular Respiration

Find Out ACTIVITY

Yeasts are unicellular organisms that are part of the same kingdom as mushrooms and other fungi. In this activity, you will look for evidence that yeast cells are carrying out cellular respiration.

Materials

- warm water
- 2 beakers (500 mL)
- 2 scoopulas or measuring spoons
- 2 samples of white sugar (5 mL each)
- 2 samples of active dry yeast (15 mL each)
- 2 stirring rods
- 2 plastic pop bottles (600 mL or 1 L)
- 2 balloons
- tape

What to Do

1. Read through all the instructions, and prepare a table to record your observations.
2. Work with a partner. Each of you should carry out the following steps at the same time.

Partner 1	Partner 2
(a) Pour 250 mL of warm water into the beaker.	(a) Pour 250 mL of warm water into the beaker.
(b) Add 5 mL of sugar.	(b) Add 15 mL of yeast. Use the stirring rod to stir the mixture.
(c) Add 15 mL of yeast. Use the stirring rod to stir the mixture.	(c) Pour the mixture into the pop bottle.
(d) Pour the mixture into the pop bottle.	(d) Blow up a balloon, and then release the air. Fit the open end of the balloon over the neck of the bottle, and tape it securely.
(e) Blow up a balloon, and then release the air. Fit the open end of the balloon over the neck of the bottle, and tape it securely.	(e) Cup the sides of the bottle at the bottom with both hands. Take note of how cool or warm it feels.
(f) Cup the sides of the bottle at the bottom with both hands. Take note of how cool or warm it feels.	(f) Label the bottle with the contents.
(g) Label the bottle with the contents.	

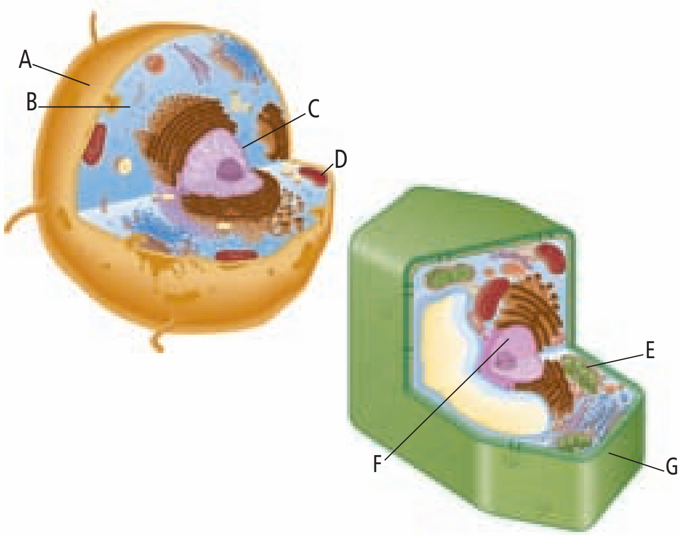
3. Observe the bottles every 15 minutes for the next few hours. Each time you observe, also feel the bottom of each bottle and swirl the contents of the bottles gently.

What Did You Find Out?

1. In which bottle did you observe evidence of a gas being given off? Describe this evidence.
2. In which bottle did you observe evidence of energy being released? Describe this evidence.
3. (a) How did the changes you observed in Partner 1's bottle compare with Partner 2's bottle?
   (b) What is the function of Partner 2's bottle?
4. What evidence did you observe that cellular respiration was taking place?

Checking Concepts

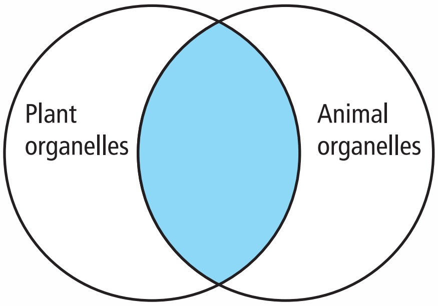
1. What is the role of the nucleus in a cell?
2. Describe the function of the cell membrane.
3. Which cell organelle produces the energy that the cell needs to carry out its life activities?
4. Which organelle is like a storage container?
5. Predict what would happen to a plant cell if the chloroplasts stopped functioning.
6. Correctly identify the labelled organelles in the illustrations below.



7. Which cell in question 6 is a plant cell? Support your answer.
8. Describe the composition of cytoplasm.
9. List the key points of the cell theory.
10. Why do scientists consider the cell theory to be a main idea of modern biology?

Understanding Key Ideas

11. Recall the Protection Dome of Newo. Explain why a cell membrane could not be like the Protection Dome, which had a solid wall and just one opening.
12. Draw a Venn diagram like the one below. Fill in each section with the correct organelles.



13. Why would you not find chloroplasts in an onion root cell?
14. Explain why animal cells do not have chloroplasts.
15. Why do animal cells have different shapes while plant cells have a more regular, box-like shape?
16. (a) Which point of the cell theory is related to cell division?
    (b) The cells of some living things divide to produce new living things. The cells of other living things divide to replace or repair older cells. Name two examples for each of these statements.

Pause and Reflect

Over 2000 years ago, many Greek philosophers (thinkers) believed that organisms and all other objects in the world were made of four basic things that they called elements: air, earth, fire, and water. Although the ancient Greeks did not know about cells, they would have believed that cells are made of air, earth, fire, and water, too. How is this idea about the make-up of cells and other organisms different from the ideas about cells stated in the cell theory?

Chapter Review

Prepare Your Own Summary

In this chapter, you investigated the cell as the basic unit of life. Create your own summary of the key ideas from this chapter. You may include graphic organizers or illustrations with your notes. (See Science Skill 10 for help with using graphic organizers.) Use the following headings to organize your notes:

1. Characteristics of Living Things
2. The Microscope
3. Cell Theory
4. Cell Organelles

Checking Concepts

1. How are living things different from non-living things?
2. What do unicellular organisms and multicellular organisms have in common?
3. List four characteristics of living things.
4. Why must living things reproduce?
5. The coarse adjustment knob on a microscope should be used with which objective lens(es)?
6. A slide on a microscope is moved toward you. In which direction does the object you are viewing through the eyepiece move?
7. Why should an objective lens never touch the slide?
8. What is a wet mount slide?
9. What organelles do plants have that animals do not?
10. Which part of the cell stores food and waste materials?
11. Which organelle controls the movement of substances in and out of the cell?
12. In which organelle would you find the genetic material in a cell?

Understanding Key Ideas

13. What is the difference between the cell wall and the cell membrane?
14. A friend tells you that all living things grow larger by increasing the size of their cells. Write one or two sentences explaining to your friend why this is not correct.
15. Why do the cells of a multicellular organism continue to reproduce even after it is fully grown?
16. How can you tell if a cell is undergoing mitosis?
17. Suppose that you are studying a slide of plant cells. You count 40 cells in a row across the diameter of the field of view. Describe a technique that you can use to estimate the average size of each cell.

18. You have been given the responsibility of teaching some new classmates how to hold, carry, and use a microscope safely and properly.

(a) Explain how the students should bring the microscope from a storage cart to their desks.

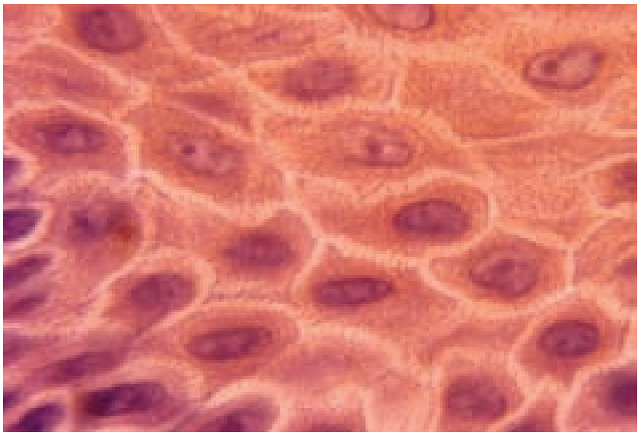
(b) List the steps the students should follow to set up a wet mount slide.

(c) List the steps the students should follow to observe the slide under low power and then under medium power.

19. Examine the photograph of cells shown below.

(a) State whether these are plant cells or an animal cells and explain how you decided.

(b) Identify two organelles that are visible in this photograph.

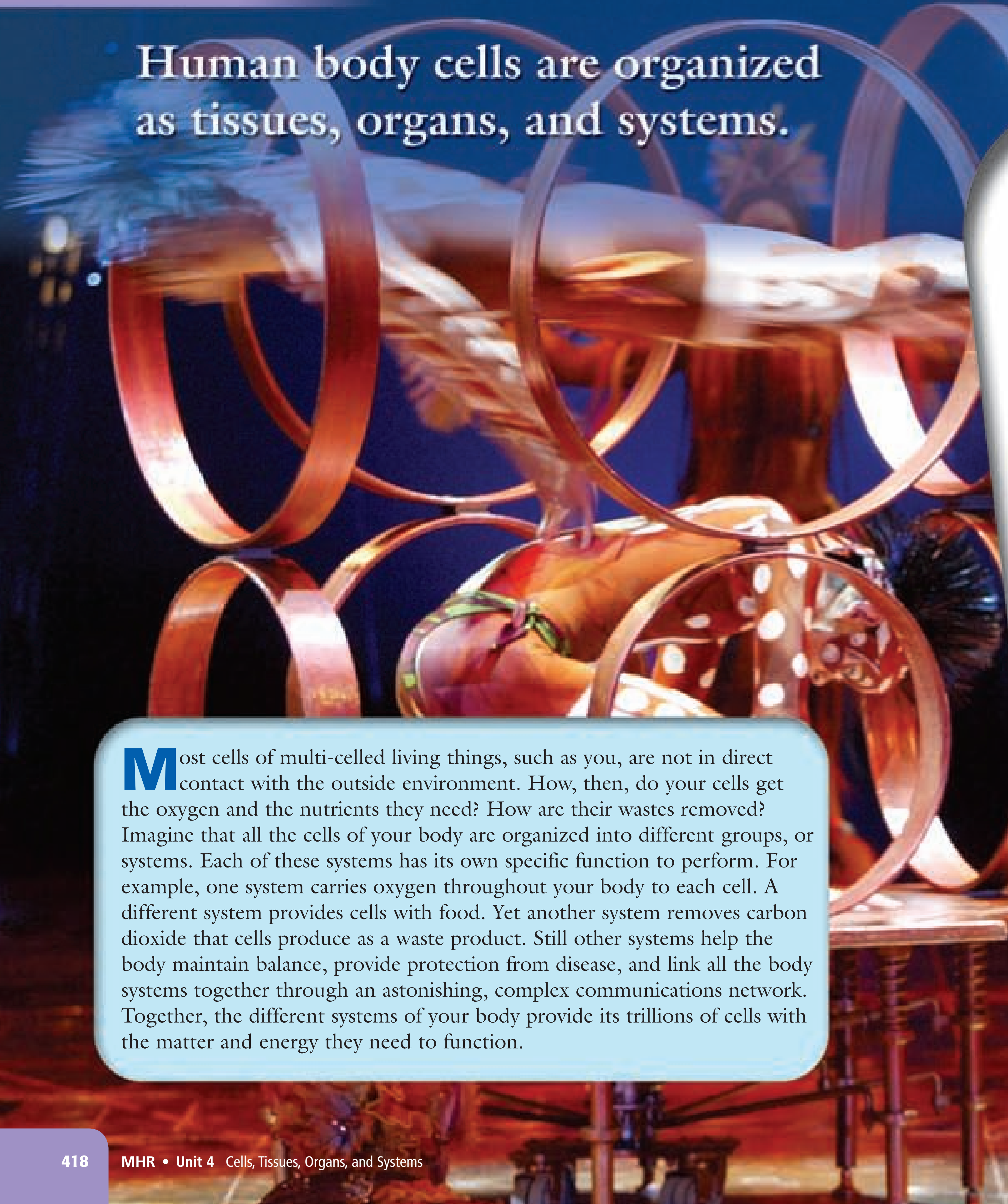


Pause and Reflect

You set up a slide on the stage of a compound light microscope. When you look into the eyepiece, you see only darkness. Give three reasons that could account for this problem.

Chapter 11

Human body cells are organized as tissues, organs, and systems.



Most cells of multi-celled living things, such as you, are not in direct contact with the outside environment. How, then, do your cells get the oxygen and the nutrients they need? How are their wastes removed? Imagine that all the cells of your body are organized into different groups, or systems. Each of these systems has its own specific function to perform. For example, one system carries oxygen throughout your body to each cell. A different system provides cells with food. Yet another system removes carbon dioxide that cells produce as a waste product. Still other systems help the body maintain balance, provide protection from disease, and link all the body systems together through an astonishing, complex communications network. Together, the different systems of your body provide its trillions of cells with the matter and energy they need to function.

What You Will Learn

In this chapter, you will
- **investigate** how cells of multicellular organisms are organized as tissues, organs, and systems
- **survey** systems of the human body and investigate certain systems in greater depth

Why It Is Important

A systems approach to studying life can help you appreciate how truly complex and marvellous humans and other multicellular organisms are.

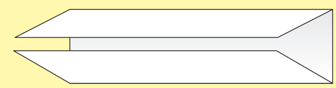
Skills You Will Use

In this chapter, you will
- **identify** the main types of animal tissues
- **research**, describe, and present information about selected human body systems

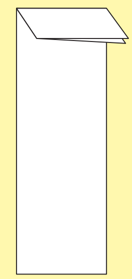
FOLDABLES™ Reading & Study Skills

TO COME

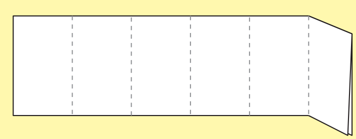
STEP 1 **Fold** one piece of letter size paper widthwise into thirds.



STEP 2 **Fold** down 2.5 cm from the top. (Hint: From the tip of your index finger to your first knuckle is about 2.5 cm.)



STEP 3 **Fold** the rest into fifths.



STEP 4 **Unfold**, lay the paper lengthwise, and draw lines along the folds. **Label** your table as shown.

Systems	Structure	Function
Muscular		
Nervous		
Digestive		
Excretory		
Circulatory		
Respiratory		

Make a Table As you read the chapter, develop a table describing the structures and functions of various human systems.

11.1 Cell Organization

A system is made up of parts that work together as a whole. Each system of the human body consists of organs that are made up of different kinds of tissue. Tissues are themselves made up of many similar cells working together to carry out a specific function.

Key Terms

organ
organ system
system
tissue

Have you ever walked into a bicycle shop like the one in Figure 11.1 and noticed all the bike parts, such as wheels, chains, cables, and brake pads? To understand what these parts do, it is helpful to think of the systems that make up a bicycle, such as the gear system and the brake system. It is the parts of these systems working together that enable a bicycle to function properly.

Figure 11.1 What are the systems that make up a bicycle, and what parts make up each of these systems?

The Characteristics of Systems

All **systems** have the following characteristics.

1. A system is made up of individual parts that work together as a whole.
2. A system is often connected to one or more other systems.
3. If one part of a system is missing or damaged, the system will not function well or may not function at all.

The idea of a system is probably not new to you. Think of the human-made computer system you use and the electrical system that powers it. Scientists use the system idea to study nature, too. For example, scientists study the interaction of living things within ecosystems. (See Figure 11.2 on the next page.)

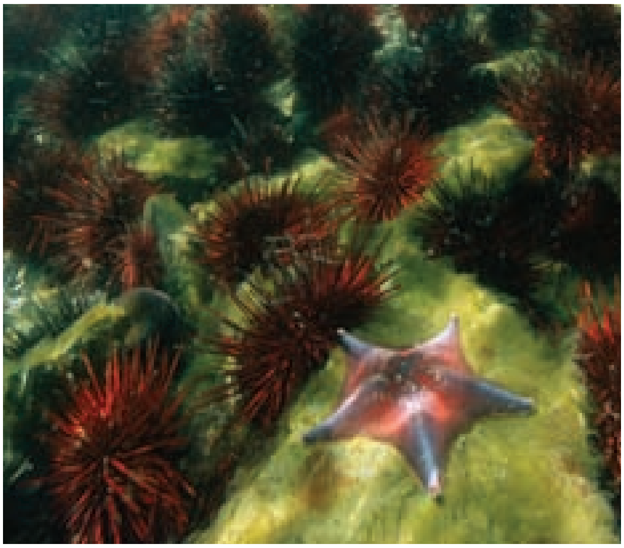


Figure 11.2 The living components of an *ecosystem* include *communities* of *populations* that consist of *individuals*. For example, this individual starfish is shown here among a population of sea urchins. Populations of sea urchins and starfish live together as part of a community that includes populations of algae, fish, otters, and other kinds of organisms.

Explore More

Imagine a bicycle that is missing one of its systems. Describe how this would affect the proper functioning of the bike.

11-1A Represent the Relationship

Think About It

To picture how the cells of your body are organized, think about the way that students are organized in a school district. First, individual students in the same grade are grouped together in classes. Different classes of students together make up a school. Finally, a number of schools are organized into a single school system called a district. You can show how the parts of a school district are related with a flowchart such as this.

student (individual) → classes (group) → school (many interacting groups) → school district (a system of interacting groups)

You could use a similar flowchart to represent the relationship among the components of an ecosystem such as the one in Figure 11.2.

organism (individual) → population (group) → community (many interacting groups) → ecosystem (a system of interacting groups)

What to Do

1. Read the following information about the organization of cells in the human body.

Cells that have the same structure and that perform the same function are grouped into tissues. Groups of different tissues interact to form organs. Organs work together as interacting organ systems. Interacting organ systems together make up a multicellular organism.

2. Create a flowchart to represent the relationship among the components of the human organism.
3. Add the following words or phrases to your flowchart.
   - individual
   - group
   - many interacting groups
   - a system of interacting groups

What Did You Find Out?

1. Interpret your flowchart. In other words, explain how the parts that make up the human organism are related.

Tissues Are Groups of Similar Cells

internet connect

Onion skin tissue is a type of tissue called epidermal tissue. Go to **www.discoveringscience8.ca** to investigate other kinds of tissues that plants have.

Tissues are groups of similar cells. All multicellular organisms—not just humans—have tissues. You saw an example of this in Chapter 10 when you observed onion skin. Onion skin is a tissue that is made of sheets of thin, tightly packed cells. These specialized skin cells form a layer of tissue that covers and protects the onion. Figure 11.3 shows the main types of tissues found in most animals, such as you. These tissues are classified according to the functions they perform.

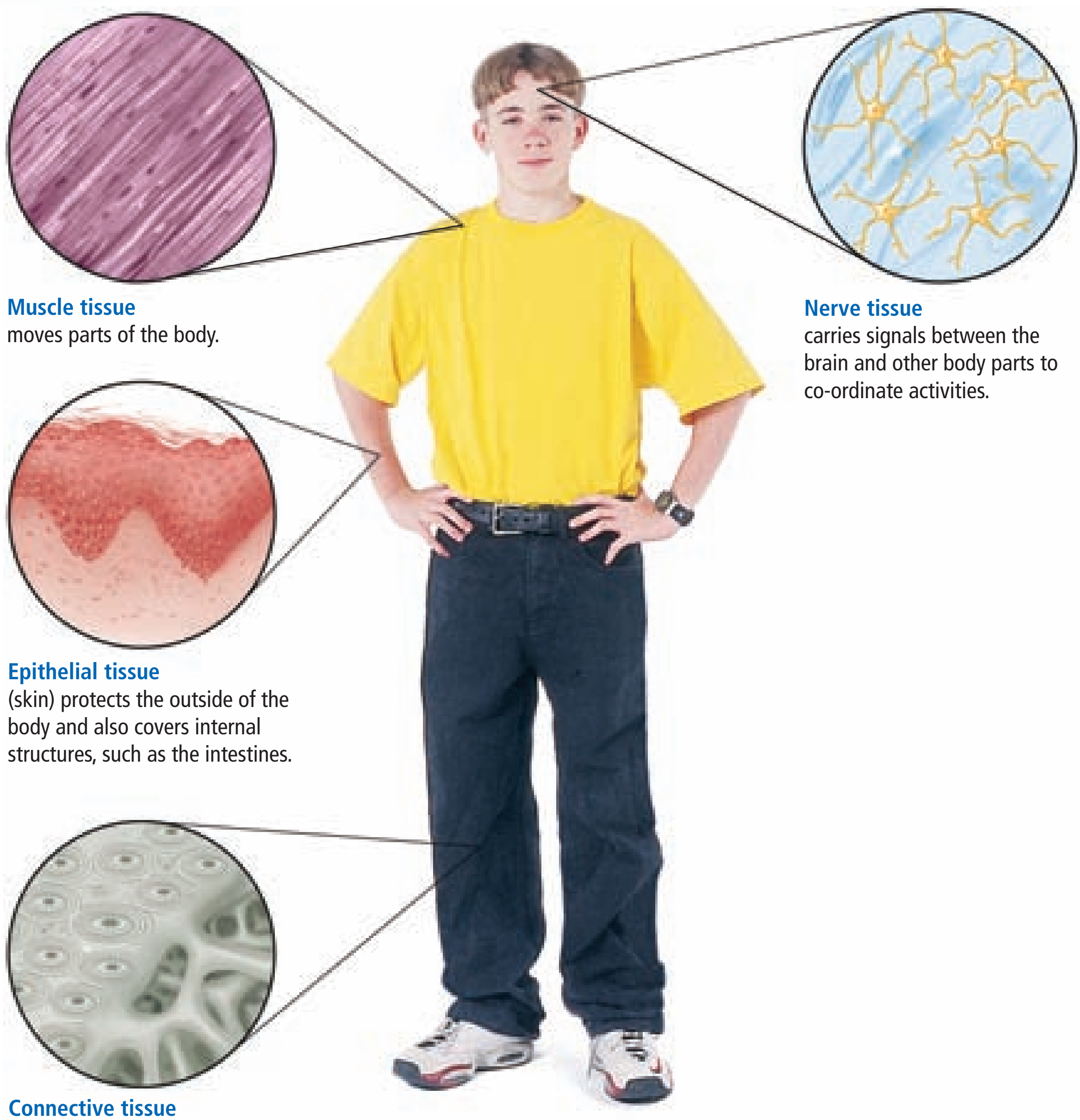
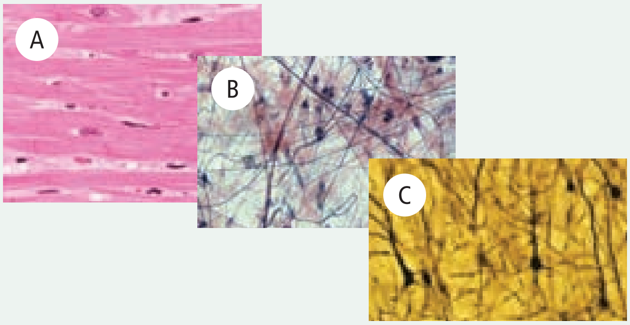


Figure 11.3 The main types of tissues that make up humans and other animals

11-1B Looking at Animal Tissues

Find Out ACTIVITY

These photos show human tissues observed under a compound light microscope. Your teacher also might use a flex camera to show prepared slides of other body tissues.



What to Do

1. Images A, B, and C show bone tissue, nerve tissue, and muscle tissue. Label each type of tissue.
2. Do the same with additional tissue images if they are provided.

What Did You Find Out?

1. Which tissue was easiest to identify? Why?
2. How does the structure (shape) of the tissue appear to relate to its function in the body?

Organs are Groups of Tissues

Organs are distinct structures that perform specific functions. Each organ in the body is made up of two or more types of tissues that work together. For example, Figure 11.4 shows the main tissues that make up your stomach. Other examples of organs are the lungs, heart, and kidneys.

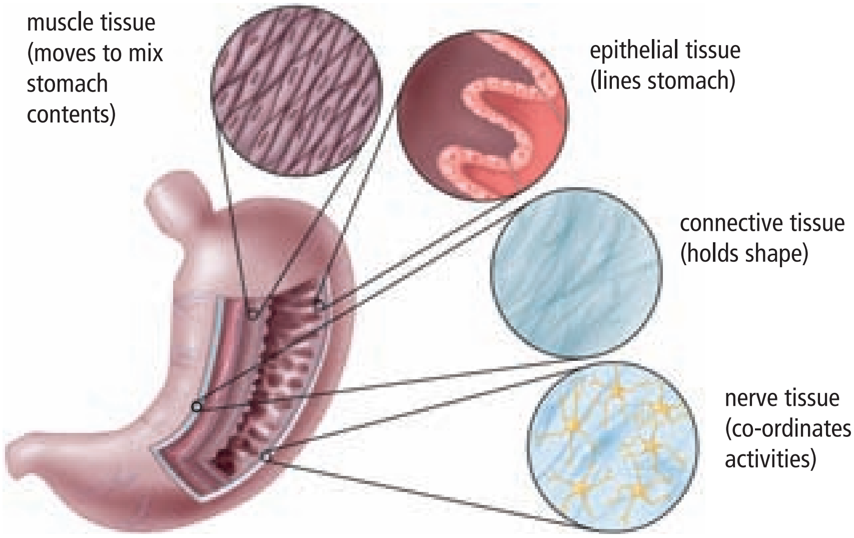


Figure 11.4 The stomach is an organ that is made up of different kinds of tissues.

Organ Systems are Groups of Organs

Organs are organized into **organ systems** to perform activities that help the body as a whole. For example, your stomach is part of a group of organs that form your digestive system. Other organs of this system include your mouth, small intestine, and anus. The function of the digestive system is to break down food and remove solid waste.

Reading Check

1. What is a system?
2. What happens if one part of a system is missing or damaged?
3. How are tissues related to cells?
4. How are organs related to tissues?

Science Watch

Pig Parts for People?

A 13-year-old lies seriously ill in hospital. He must get a new kidney immediately or he will die. No suitable human kidneys are available. His surgeon has a solution, but she must convince the ethics board of the hospital that it is a good decision.

Thousands of Canadians are waiting for kidney transplants because they have kidney disease. Kidney disease occurs in young people most often because of a bacterial or viral infection. In adults, kidney disease is usually caused by hereditary factors, diabetes, or high blood pressure.

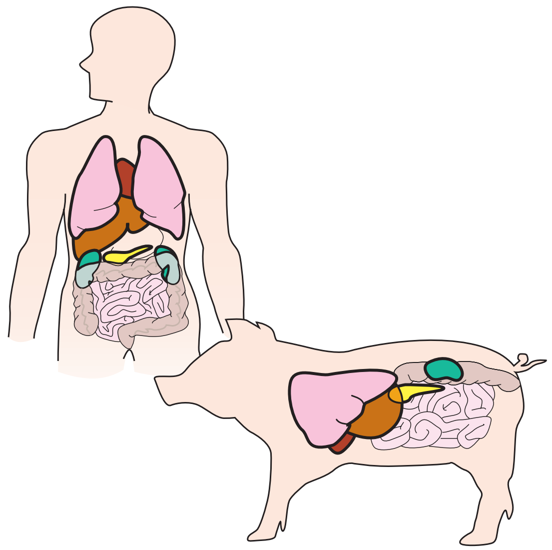
The number of successful organ transplants increases each year as techniques to match donors and organ recipients improve. However, the recipient's white blood cells might attack the foreign tissue of the donated organ and reject it. Patients must take powerful drugs to prevent organ rejection.

The problem for people with kidney disease is that donated organs are in short supply. Pigs may be the solution. Pigs could offer an endless supply of organs for humans in the future. Pig organs are similar in size to human organs, and pigs reproduce quickly. Most importantly, scientists can change pig cells genetically so that a human body will not recognize pig organs as foreign tissue.

Transplanting an organ from one species into another is called xenotransplantation. *Xeno* is pronounced ZEENO and means "foreign" in Greek. The major concern with xenotransplantation is the risk of transferring an animal disease to the patient, who could transfer it to others. The disease would be new to humans so we would not have the natural ability to fight off this disease.

We will not know for certain if xenotransplantation is dangerous until experiments are done on humans. Laws controlling xenotransplantation may require patients to agree to certain life restrictions to prevent the possible transmission of diseases. These could include never having children, never travelling outside the country, and being monitored by authorities for as long as they live.

At present, about 20 percent of all people on waiting lists die before a suitable organ is found. Despite concerns, xenotransplantation offers hope to the thousands of patients on transplant waiting lists in Canada.



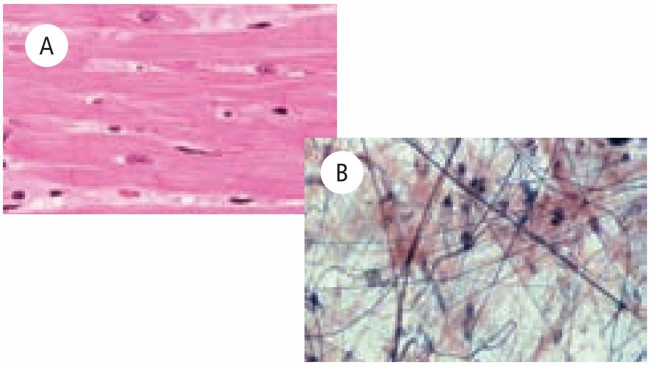
Questions

1. Why are scientists considering pigs for human organ transplants?
2. What major concerns do scientists have about xenotransplantation?
3. The 13-year-old patient will die within the next few days without a new kidney. Do you think his doctor should recommend xenotransplantation of pig kidneys? Why or why not?

Check Your Understanding

Checking Concepts

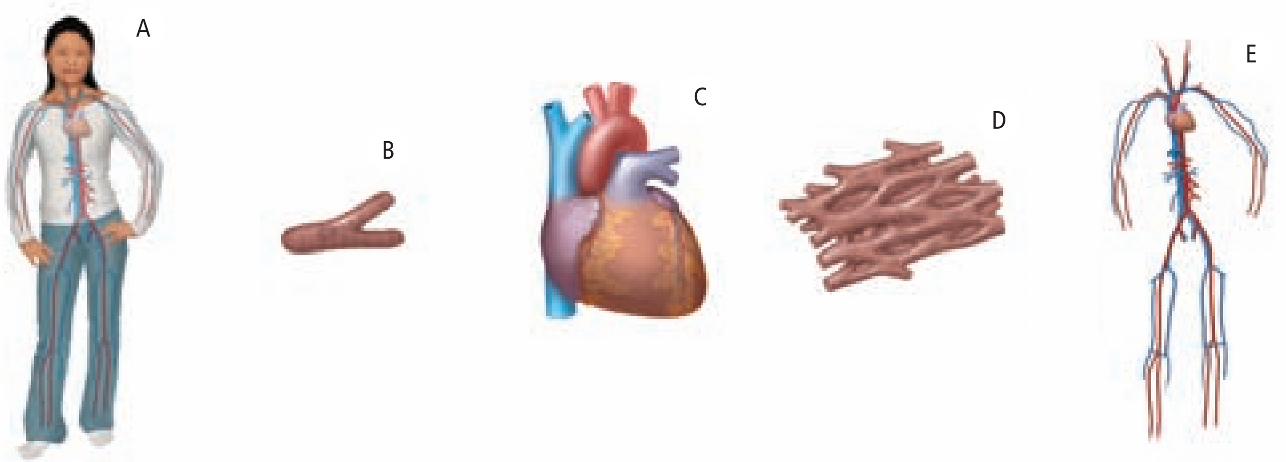
1. What are the three characteristics of a system?
2. How is a bicycle an example of a human-made system?
3. Match the following two images of tissue to the correct function.



   (a) holds together and supports other tissues
   (b) transfers signals in the body
   (c) assists in body movement
4. What is the difference between an organ and a tissue?

Understanding Key Ideas

5. Think of a human-made system not discussed in this textbook. Describe this system and explain how the three characteristics of a system are represented in your example.
6. Think of a natural system not discussed in this textbook. Describe this system and explain how the three characteristics of a system are represented in your example.
7. Imagine that you have been asked to make a model of each type of body tissue as part of a lesson for pre-school children. Select an appropriate material that you think is a suitable model for each type of tissue, and explain your choices.
8. Place the letters for the five pictures below into the sequence that correctly shows the organization of a human from cell to organism. Then explain how these levels of organization are related.



Pause and Reflect

Many people think of their skin as just a body covering. How do you think skin (epithelial) cells are important to the body?

11.2 Introducing Human Body Systems

The human body is made up of eleven systems that, working independently and together, support and maintain the function of the whole body.

Key Terms

circulatory system
digestive system
endocrine system
excretory system
immune system
integumentary system
muscular system
nervous system
reproductive system
respiratory system
skeletal system

Imagine a system that can:

- pump fluids for years and years without stopping or slowing down
- gather and release energy from the fuel it needs to run
- reuse and recycle some of its wastes and eliminate the rest
- manufacture some of the materials it needs to function
- send and receive messages almost instantly
- protect itself from invaders
- repair parts of itself that have worn out or stopped working
- make other functioning machines that are similar to itself
- move itself from one place to another

One day, scientists expect that human-made systems such as the one shown in Figure 11.5 will possess some—perhaps many—of these abilities. However, what if you want such a system now? If so, simply look in the mirror. The human body is quite likely the most sophisticated living system on Earth.

In the next activity, you will work with a team to find out about one organ system of the human body. Table 11.1, which gives a brief overview of all the major organ systems of the human body, follows on pages 428 to 430. Then, in Chapter 12, you will explore the ways in which body systems work independently and together to support and maintain the health of the whole body. You will also consider factors that can result in unhealthy body systems.

Figure 11.5 The current model of the Asimo humanoid robot is able to recharge its own batteries, step out of the way of an oncoming person, and work with other Asimo robots to perform simple tasks. Compared with human systems, however, even the most advanced robot is currently about as complex as an insect.

11-2A Teamwork

Find Out ACTIVITY

Working together on a project that has many parts or ideas often is faster and more efficient than working on it by yourself. In this activity, your class will be divided into teams to find out and present information about human body systems.

What to Do

1. Each team will be assigned one of the following organ systems:
    - circulatory system
    - digestive system
    - excretory system
    - muscular system
    - nervous system
    - respiratory system
2. Decide how the class will evaluate each group's presentation. At a minimum, each team's presentation must answer the following questions:
    - What is the function of the organ system?
    - Which organs are part of the system?
    - How do the organs of the system work together to enable the system to perform its function?
3. Decide how the members of your team will obtain the information it needs.
4. Use your library, the Internet, and any other resources you think are useful to find the information your team needs. Research your team's organ system.
5. Decide how the members of your team will coordinate and present the results of its research. For instance, your team could choose to:
    - deliver a lecture with charts and graphs
    - write a play and act the roles of tissues, cells, and organs
    - construct a three-dimensional model
    - create a multimedia display

Table 11.1 The Eleven Human Body Systems

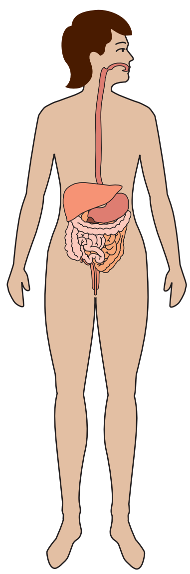
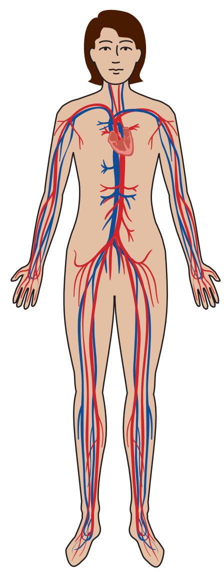
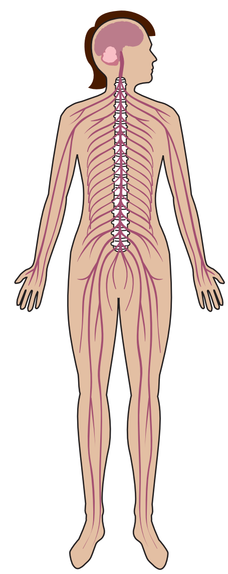
	Digestive System	Circulatory System	Nervous System
Main Functions	• Takes in food and breaks it down into its component nutrients • Absorbs nutrients • Eliminates solid wastes	• Transports blood, nutrients, oxygen, and liquid and gaseous wastes	• Controls and coordinates body activities • Senses and responds to internal and external changes
Main Organs and Tissues	 • mouth • esophagus • stomach • gall bladder • liver • pancreas • small intestine • large intestine • anus	 • heart • arteries • veins • capillaries • blood (tissue)	 • brain • spinal cord • nerves (tissue)

Table 11.1 The Eleven Human Body Systems—continued

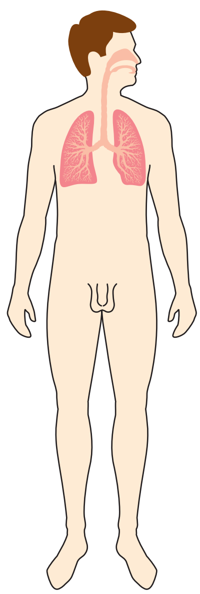
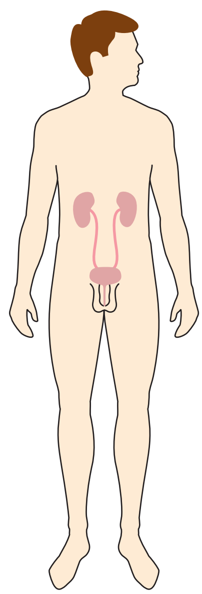
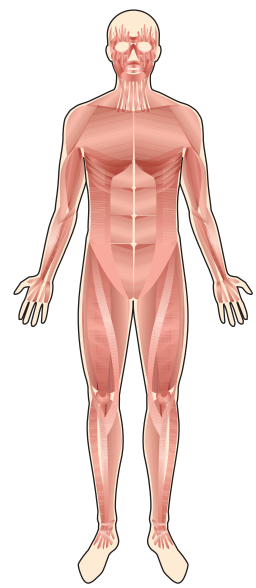
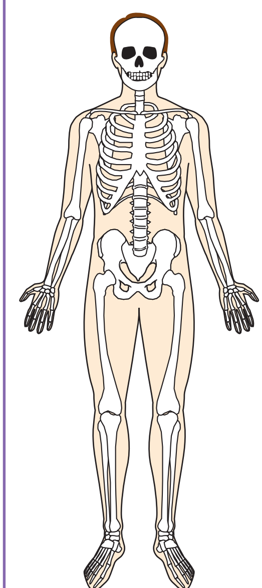
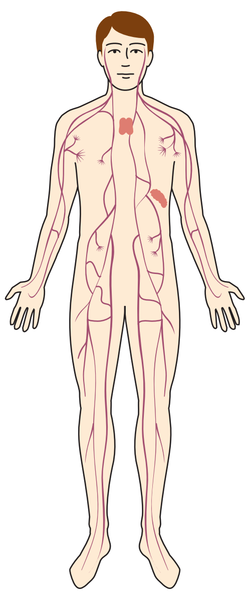
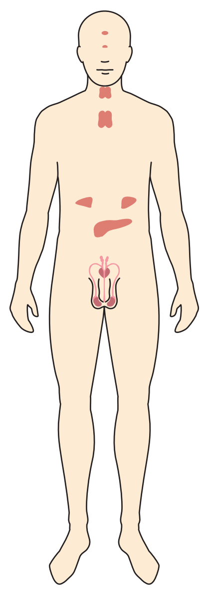
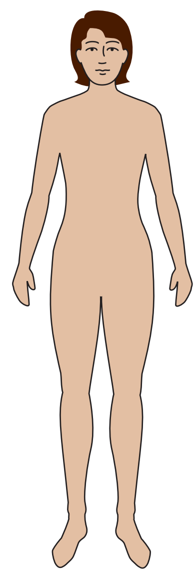
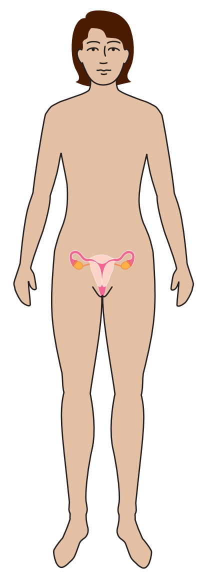
	Respiratory System	Excretory System	Muscular System	Skeletal System
Main Functions	• Controls breathing • Exchanges gases (oxygen and carbon dioxide) in lungs and tissues	• Removes liquid and gaseous wastes from the body • Maintains the volume and composition of body fluids	• Enables certain organs (such as the heart and stomach) to contract and relax • Works with the skeletal system to move parts of the body	• Supports the body • Protects some internal organs • Works with muscles to move parts of the body
Main Organs and Tissues	 • nose • trachea • lungs	 • kidneys • ureters • bladder • urethra • skin	 • muscle (tissue)	 • bone (tissue)

Table 11.1 The Eleven Human Body Systems—continued

	Immune System	Endocrine System	Integumentary System	Reproductive System
Main Functions	• Defends the body against diseases and infections	• Manufactures and releases hormones	• Serves as a waterproof protective barrier between the external environment and the body's internal environment	• Producing specialized cells (sperm and eggs) that, in combination, result in the growth and development of offspring
Main Organs and Tissues	 • lymph nodes • lymph vessels • lymph (tissue)	 • glands • ducts	 • skin	 • female: ovaries, oviducts (Fallopian tubes), uterus, vagina • male: testes, penis, various glands and vessels

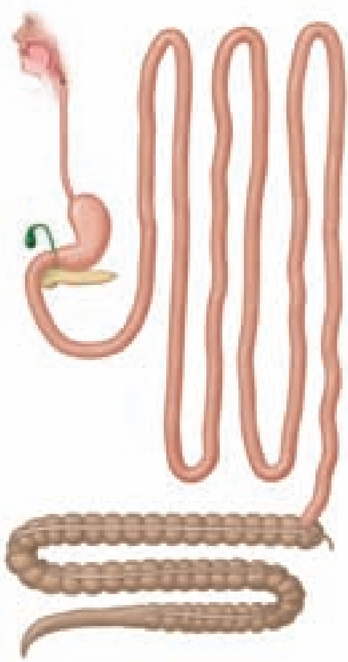
Check Your Understanding

Checking Concepts

1. Name six systems of the human body.
2. Identify the system of the body to which each of the following organs belongs.
   (a) arteries
   (b) liver
   (c) kidneys
   (d) nose
   (e) mouth
3. Name the organ system that provides your body with matter and energy for all the life activities of the cells of your body.
4. Identify the body system represented in the following illustrations.

Understanding Key Ideas

5. Two organ systems provide the body with a means for transferring fluid (liquid and gaseous) wastes from its internal environment to the external environment. Name these two organ systems.
6. The illustration shows organs of one of the body systems, presented in an unusual manner.
   (a) Name the body system.
   (b) The organs of this body system are linked together so that materials can enter the internal environment of the body from the external environment and exit the internal environment of the body back into the external environment. Is this the only body system that connects the external and internal environments? Examine the illustrations on pages 428 to 430 to help you support your answer.
   (c) Examine the illustration of this body system on page 428. Explain how a system that is about 8 m long can fit inside your body.



Pause and Reflect

The proper functioning of the whole body requires the proper functioning of each of its body systems. Based on your current understanding of the body's organ systems, organize these systems into three or four groups. Explain your reasoning.

Chapter Review

Prepare Your Own Summary

In this chapter, you studied how the cells of multicellular organisms are organized, and you surveyed the different organ systems of the human body. Create your own summary of the key ideas from this chapter. You may include graphic organizers or illustrations with your notes. (See Science Skill 10 for help with using graphic organizers.) Use the following headings to organize your notes:

1. Systems
2. Organization of Cells of the Human Body
3. Survey of Human Body Systems

Checking Concepts

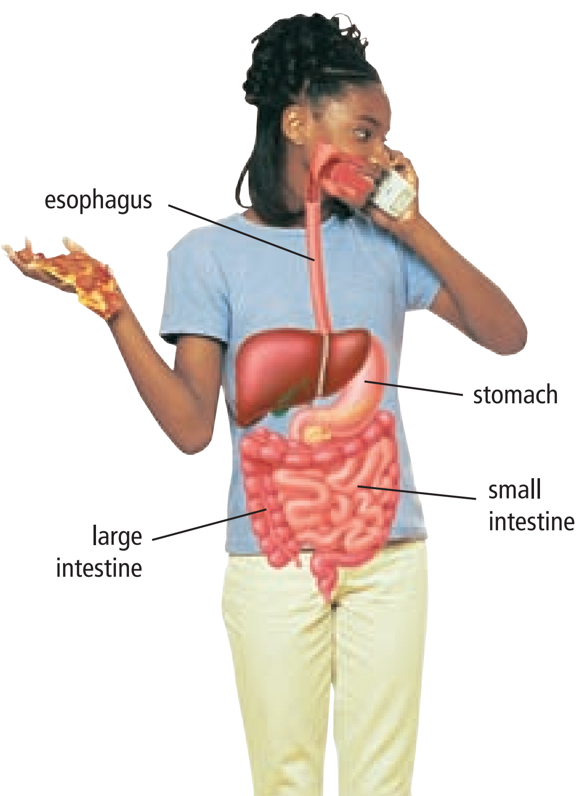
1. In Chapter 10, you learned how to operate a microscope. Use the characteristics of systems to explain why a microscope is an example of a system.

2. Draw a flowchart that shows the following terms in their correct order from least inclusive (simplest) to most inclusive (most complex): tissues, organ systems, organism, organ, cells.
3. Define and state one example from the human body for each term in question 3.
4. Identify the main function for each of the following body systems:
   (a) circulatory
   (b) digestive
   (c) excretory
   (d) muscular
   (e) nervous
   (f) respiratory

Understanding Key Ideas

5. A plant such as a tree is a multicellular organism. Do you think a tree has tissues, organs, and organ systems like humans and other animals do? Give reasons and include examples to explain your answer.
6. Think about the functions of the different systems of the human body. Also think about the main functions of the different organelles of a cell. Explain how the needs of the cells of the human body are related to the functions of the body systems.

7. When you swallow a chewed-up mouthful of food, it moves to the stomach through a vertical tube called the esophagus. From the stomach, food passes through the twists and turns of the folded-up small intestine, and then it passes through the vertical and horizontal lengths of the large intestine. In order for food to move through these different types and orientations of tubes, the tissues that make up these organs must contract (squeeze) and then relax. (Think of moving a marble along a length of rubber tubing by squeezing the part of the tubing just behind the marble repeatedly.)



(a) The esophagus, small intestine, and large intestine are different organs. Is it possible that they are made of the same kind of tissue? Explain why or why not.
(b) Name one type of tissue that would probably make up these organs. Explain your choice.
(c) One of the functions of the stomach is to mix and churn swallowed food with acid and saliva. Infer at least one type of tissue that you would expect to make up the stomach.

8. The chemical reactions that release energy from the food you eat take place in the mitochondria of cells. Muscle cells have many more mitochondria than the cells of most other organs. Explain why this does or does not surprise you.

Pause and Reflect

In the next chapter, you will explore ways in which body systems are related. Based on your current understanding of human body systems, suggest at least one way that you think each of the following systems are related.

- digestive and circulatory
- circulatory and respiratory
- respiratory and digestive

Chapter 12

The health of the body depends on the health of its interdependent systems.

Don't tell Sarah Reinertsen it can't be done, unless you want to be proven wrong. In the world of running, she has just about done it all—100 m, 200 m, 400 m, 5 km, 10 km, marathon, and triathlon. Compared with an athlete with two legs, Sarah must use 40 percent more oxygen and twice as much energy to accomplish the same basic tasks. All her body systems are finely tuned, through training, to work together in the most effective manner. In this regard, however, she is no different from you or anyone else. Body systems provide the cells of the body with the matter and energy the cells need to survive and carry out their life functions.

What You Will Learn

In this chapter, you will
- **explain** how the needs and functions of cells and organs are related to the needs and functions of the whole body
- **describe** factors that can have a positive effect on various body systems
- **describe** factors that can have a negative effect on various body systems

Why It Is Important

Understanding how all body systems are dependent on one another can help you appreciate how easy it can be to support and maintain your health.

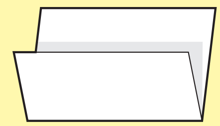
Skills You Will Use

In this chapter, you will
- **investigate** and **communicate** the roles of diet, exercise, and stress on various body systems
- **evaluate** energy drinks for their health benefits
- **examine** and **evaluate** conflicting evidence related to medical support of the body

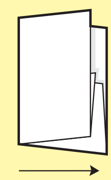
FOLDABLES™
Reading & Study Skills

Make the following Foldable to take notes on what you will learn in Chapter 12.

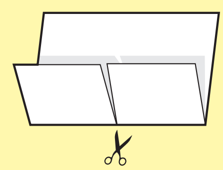
STEP 1 **Fold** a letter size sheet of paper as shown, so that about one third of its length is folded upwards. This should leave a tab 8-10 cm long exposed at the top of the sheet.



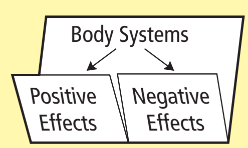
STEP 2 **Fold** the sheet in half width-wise.



STEP 3 **Unfold** the sheet and **cut** the bottom tab along the fold line as shown.



STEP 4 **Label** the Foldable as shown. **Draw** arrows from "Body Systems" to "Positive Effects" and "Negative Effects" to list the effects of various factors on the health of body systems.



Organize As you read this chapter, complete the Foldable by recording information, providing examples, and defining terms under the appropriate tabs.

12.1 How Body Systems Are Connected

All the cells of the body have the same basic need for energy, nutrients, and oxygen to carry out their functions. All cells also have the same basic needs for removing wastes. Body systems work together to provide cells with what they need. In so doing, body systems support themselves, one another, and the whole human body.

Key Terms

nutrients

In Chapter 10 you learned that all cells need energy. This statement applies to unicellular living things as well as multicellular living things. Cells need energy to carry out all their life functions, and the source of energy that cells use is their food. When you eat, your digestive system breaks down food into substances that are commonly called **nutrients**. These nutrient substances include carbohydrates, fats, and proteins. Cells can use any of these nutrient substances for energy, but the main nutrients used for energy in the body are carbohydrates. The main carbohydrate that your body uses for energy is the sugar, glucose.

You also learned in Chapter 10 that cells use a chemical process to release the energy that is stored in glucose. This chemical process is called cellular respiration. Figure 12.1 summarizes this process.

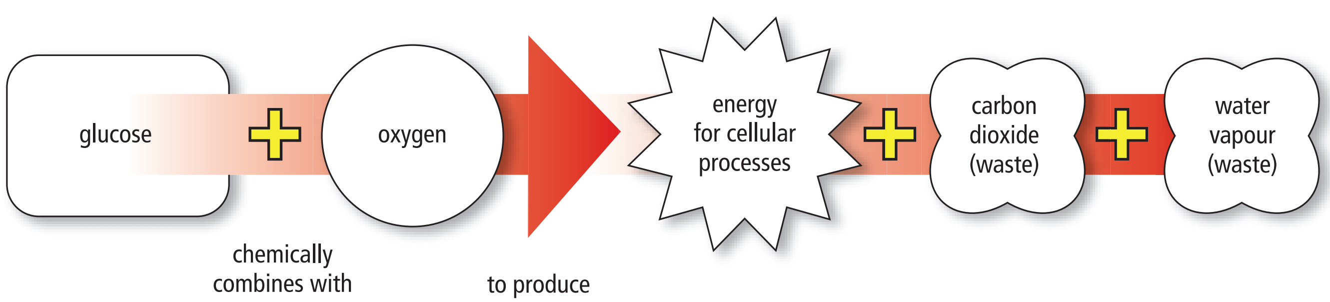


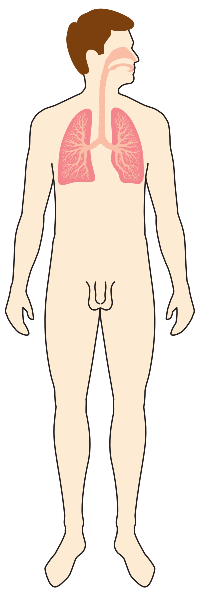
Figure 12.1 Cellular respiration releases energy that the cell needs for its life functions. Notice that cellular respiration requires two raw substances: oxygen and glucose. Cellular respiration uses these substances to release energy. At the same time, it produces two waste substances: carbon dioxide and water.

Several organ systems are directly involved with cellular respiration. These systems, shown in Figure 12.2, include:

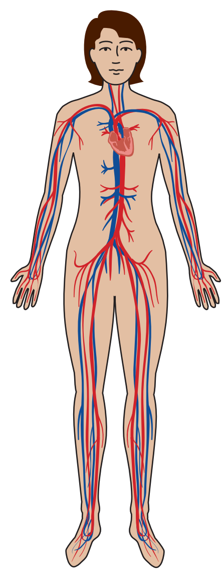
- the respiratory system
- the digestive system
- the circulatory system
- the excretory system

No single system can work by itself to perform this task. Instead, there are connections between these and other organ systems.

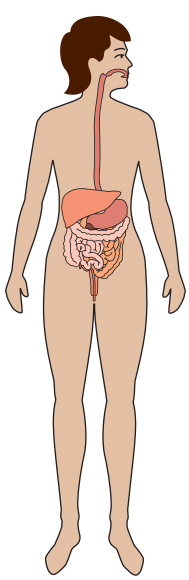
Figure 12.2 These four systems of the human body play important roles in the process of cellular respiration.



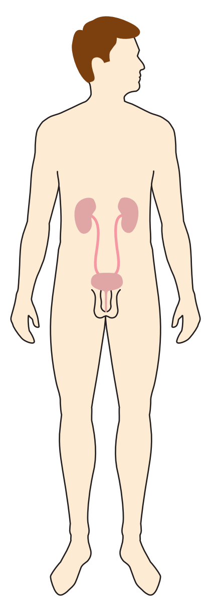
respiratory system
nose (takes in oxygen-rich air)
windpipe (directs oxygen-rich air to lungs)
lungs (exchange oxygen and carbon dioxide, and remove carbon dioxide through the nose)



circulatory system
heart (pumps blood)
veins (transports blood from body cells)
arteries (transports blood to body cells)



digestive system
mouth (grinds up food)
esophagus (moves food to stomach)
stomach (breaks down and churns food)
small intestine (breaks food down into nutrients so they can be absorbed)
large intestine (processes solid waste material)
anus (removes solid waste material)



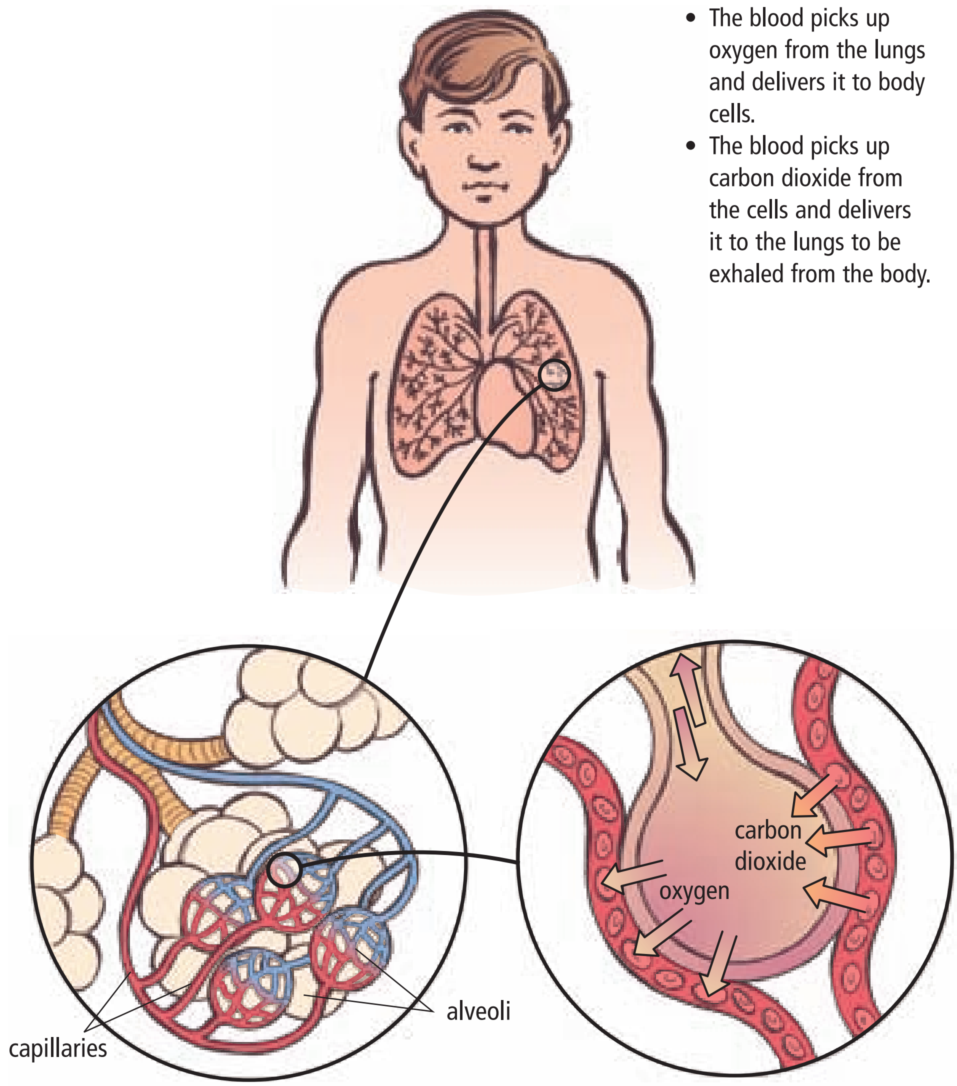
excretory system
kidneys (filter blood to produce urine)
ureters (transport urine)
bladder (stores urine)
urethra (excretes urine)

Connections between the Circulatory and Respiratory System

Suggested Activitiy

Conduct an Investigation 12-1B (Core Lab) on page 442

Your heart is always beating, and your lungs are always expanding and contracting. Figure 12.3 shows what happens inside your cells as your circulatory and respiratory systems work together.



- The blood picks up oxygen from the lungs and delivers it to body cells.
- The blood picks up carbon dioxide from the cells and delivers it to the lungs to be exhaled from the body.

- Inside each lung, there are many tiny sacs called alveoli. The alveoli are surrounded by a mesh-like network of small blood vessels called capillaries.

- The alveoli and capillaries have very thin cell membranes.
- The oxygen passes through (diffuses through) the membrane of the alveolus and the membrane of the capillary into the blood.
- Carbon dioxide diffuses in the opposite direction. The gas moves from the blood into the alveolus.

Figure 12.3 How the respiratory system and the circulatory system work together during cellular respiration

Connections between the Circulatory and Digestive Systems

When you eat, your digestive system breaks down food into glucose and other nutrients. Your body uses these nutrients for energy and to repair or make new cells. Figure 12.4 shows what happens inside your cells as your digestive and circulatory systems work together.

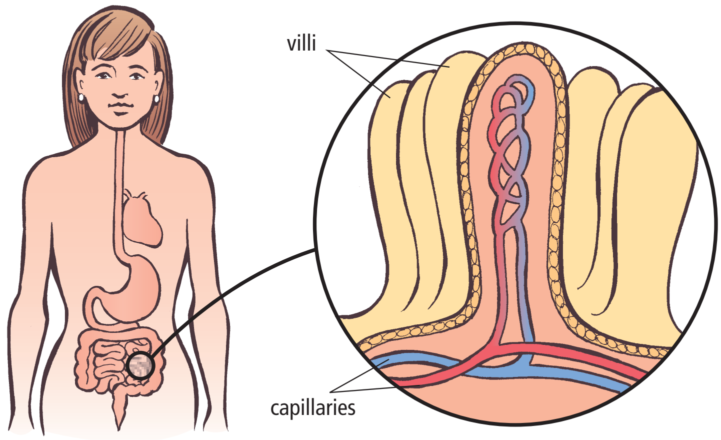


Figure 12.4 How the digestive system and the circulatory system work together during cellular respiration

- On the inside wall of the small intestine, there are many structures called villi. They look like very tiny fingers.
- Inside the villi there are many capillaries. The villi and capillaries have very thin cell membranes.
- The nutrients pass through the villi into the capillaries.
- Carbon dioxide wastes from the body cells pass into the capillaries. Some of these wastes are carried to the lungs so they can leave the body.

- Nutrients enter the blood from the small intestine. The blood carries nutrients to the body cells.

Explore More

In Chapter 11, Find Out Activity 11-2A, you studied one organ system. Return to your team and work together with another team that studied a different system to discover ways that your two systems work together. Decide how to present your findings to the class.

Connections between the Circulatory and Excretory Systems

What is urine? Would it surprise you to find out that urine is what remains after your blood has been filtered by the kidneys? Recall that the kidneys, shown in Figure 12.5, are part of the excretory system. It is their job to extract substances from the blood that your body can use again and to remove waste substances such as excess sodium, dissolved carbon dioxide, and nitrogen-containing compounds called urea and uric acid. If these substances are allowed to build up, they can overwhelm and poison other body systems.

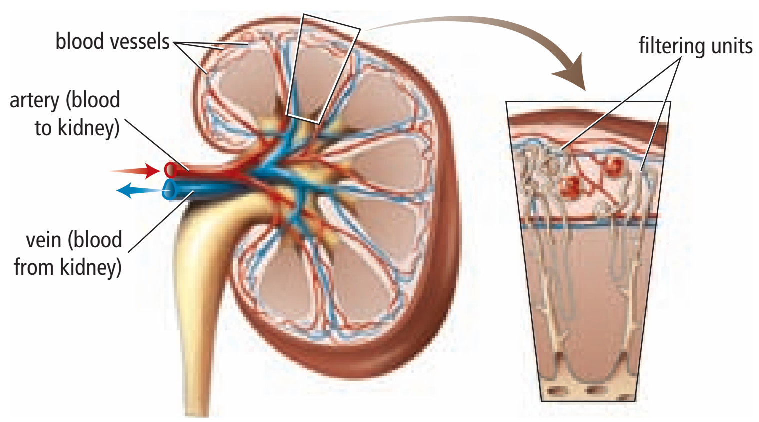


Figure 12.5 Notice that there are blood vessels in the kidneys. The red-coloured vessels carry blood into the kidneys. The blue-coloured vessels carry blood from the kidneys. Each kidney has more than one million filtering units. These filters remove some substances from the blood that your body can reuse, such as glucose and calcium particles. Undesired wastes are removed from the body when you urinate.

Did You Know?

People have studied the muscular system for thousands of years. It is one of the best-studied systems of the body. In 1996, two American dentists surprised themselves and the rest of the scientific community when, during a dissection to study the muscles involved in chewing, they discovered a muscle that nobody had ever described before.

Connections between the Nervous and Muscular Systems

The cells of your body need a stable temperature to function best. This temperature is 37°C. Connections between your nervous system and muscular system help to keep your body temperature stable. The nervous system monitors conditions outside of the body through special temperature-sensing cells in the skin. Information from these cells is sent to the brain. In response, the brain sends nerve signals to different parts of your body, including your muscles.

For instance, if your body temperature is too low, the nervous system might stimulate muscles to contract and relax repeatedly. You know this feeling as shivering. When you shiver, the cells in your muscles are rapidly carrying out cellular respiration. The energy that results from this helps warm your body quickly.

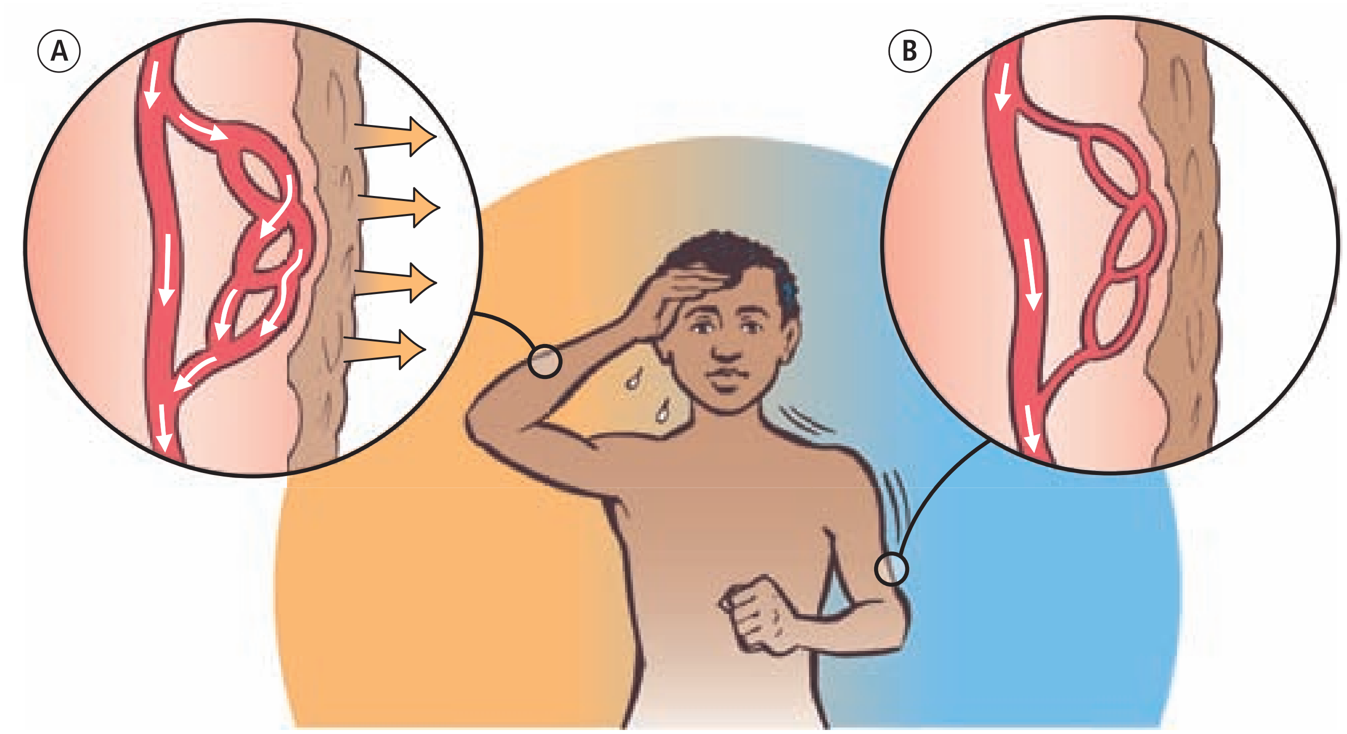


Figure 12.6 The nervous system controls blood flow to the skin to help remove or conserve body heat.
(a) When the body's inside environment is too warm, blood vessels near the surface of the skin expand. This increases blood flow near the body surface so that heat can be lost to the outside. One way this happens is by sweating. Sweating helps cool your body as the moisture evaporates from your skin surface.
(b) When the outside environment is too cold, blood vessels near the surface of the skin contract. This reduces blood flow near the body surface so that less heat is lost through the skin to the outside. The body might also shiver to produce more heat in muscle cells. The heat is spread through the body by the blood.

Other body systems also work together to keep a stable body temperature. Figure 12.6 shows roles played by the skin (integumentary system) and blood vessels (circulatory system). In fact, these and other body systems are always making adjustments to keep a stable internal environment for your cells.

12-1A Muscle Activity and Heat

Find Out ACTIVITY

In this activity, you will use a computer interface and temperature probe, if available, to discover a link between muscle activity and heat production.

Materials

- dumbbell
- computer
- data collection interface
- temperature probe
- digital thermometer
- liquid (alcohol) thermometer

What to Do

1. Select a dumbbell that is light enough for you to do 10 biceps curls with one arm. If computer and temperature probe equipment is available, continue with step 2. If not, move to step 4.
2. Connect and activate the computer interface and temperature probe. Obtain a base temperature reading for your muscle by holding the probe firmly against your rested biceps (no dumbbell) for 60 s.
3. With the probe still firmly pressed against your biceps, do 10 curls with the dumbbell. Record the temperature.
4. Repeat step 3 using the digital thermometer. Obtain and record a base temperature reading for your muscle first.
5. Repeat steps 3 and 4 using the liquid thermometer. Obtain and record a base temperature reading for your muscle first.

What Did You Find Out?

1. What evidence did you collect that shows a link between muscle activity and heat production?
2. What can you conclude about the effectiveness of different temperature-measuring technologies from your observations?

Reading Check

1. What is cellular respiration?
2. What key substances does the circulatory system move through the body?
3. What key substances does the digestive system move through the body?
4. What key substances does the respiratory system move through the body?

12-1B The Effect of Activity on Heart Rate and Breathing Rate

SkillCheck
- Observing
- Recording
- Communicating
- Explaining systems

Safety
- Always take a pulse at the wrist, never at the neck.
- Make sure you do not over-exert yourself.
- Let your teacher know if you have any health conditions that prevent you from participating in physical exercise.

Materials
- electronic heart monitor (if available)
- various pieces of sports equipment supplied by your teacher or brought from home
- graph paper
- data tables supplied by your teacher

The circulatory system and the respiratory system are strongly connected, since they work together to supply your body with the oxygen all your cells need. In this investigation, you will look for evidence of the connection between these two systems. In Part 1, you will learn how to take a pulse safely. Taking a person's pulse lets you determine heart rate—the number of times the heart beats in one minute. You will compare pulse (heart) rate to breathing rate—the number of times a person inhales and exhales in one minute. Then, in Part 2, you will design your own investigation to determine the effect of activity on heart rate and breathing rate.

Question
What affect does activity have on heart rate and breathing rate?

Procedure
Part 1 Measuring Resting Heart Rate and Breathing Rate
1. Your teacher will provide you with a data table to record your measurements and calculations.
2. The resting heart rate is the number of times a person's heart beats per minute while that person is completely at rest. You will find your partner's resting heart rate by taking your partner's pulse. To take a pulse, locate the artery in your partner's wrist. (An artery is a blood vessel that carries oxygen-rich blood throughout the body.) Press your index finger and one or two other fingers against the artery. (Don't use your thumb. It has its own pulse.) Count the number of pulses in 15 s. Then multiply that number by 4. This will give you the number of times the heart beats in 1 min, which is the heart rate (number of beats per minute). Record your partner's resting heart rate in the data table.

3. Repeat step 2 two more times. Add the three values for heart rate together, and divide by three. This will give you your partner's average resting heart rate.
4. The resting breathing rate is the number of times a person breathes per minute while that person is completely at rest. To determine your partner's resting breathing rate, count the number of times your partner breathes (one inhale and one exhale) in 15 s. Then multiply that number by 4. This will give you the number of times your partner breathed in 1 min, which is the breathing rate (breaths per minute). Record your partner's resting breathing rate in the data table.

5. Repeat step 4 two more times. Add the three values for breathing rate together, and divide by three. This will give you your partner's average resting breathing rate.
6. Switch roles with your partner and repeat steps 2 to 5.

Part 2 Recovery Time

1. With a partner, state a hypothesis about the time it takes for heart rate and breathing rate to return to their resting rate after light exercise, medium exercise, and intense exercise.
2. Design a procedure to test your hypothesis. As part of your procedure, make decisions about the following:
   - activities to represent light, moderate, and intense exercise (for example: walking, jogging, and running)
   - how long to carry out each activity
   - the time interval between measuring heart rate and breathing rate (for example, taking measurements every 30 s or every 60 s)
3. Write down the procedure you plan to follow. Include the data table you intend to use to record your measurements. Show the procedure to your teacher for approval.
4. Carry out your procedure.
5. Use your completed table to plot recovery rate data on a graph. Title and label the axes of your graph.

Analyze

1. Interpret your graph. Are the patterns that you observe what you would have expected? Explain why or why not.
2. Identify all the variables that you controlled in your investigation.
3. In step 5, you determined an average breathing rate. In step 3, you determined an average heart rate.

   (a) How did the average breathing rate and average heart rate compare with the individual values for breathing rate and heart rate that you counted?

   (b) Explain why using an average breathing rate and an average heart rate improves the accuracy of your overall results.

Conclude and Apply

1. Did your results support your hypothesis? If not, explain why that might be the case.
2. Is it possible that there were variables that were not controlled in your investigation? Identify at least one other variable that you might not have controlled, and explain how you think this might have affected your results.

Science Watch

Too Much Sugar—Not So Sweet

Can your body get too much of a good thing? The trillions of cells in your body need energy to work, and that energy comes from the sugar, glucose. So how can too much glucose be bad for the body?

Glucose can only enter cells through specialized channels in the cell membrane. These channels are like doors to let glucose pass from the blood through the cell membrane and into cells. A chemical called insulin unlocks the doors to allow glucose to enter the cells. Special cells in the pancreas make insulin. If the pancreas cannot make insulin properly, glucose cannot enter cells and remains, instead, in the blood. This condition is known as type 1 diabetes. If there are not enough channels, glucose also remains outside the cells and in the blood. This condition is called type 2 diabetes.

If glucose stays in the blood, a person feels tired, because the cells are not getting the energy they need to function. The kidneys have to work harder to filter the extra glucose out of the blood. This can result in higher blood pressure and, eventually, kidney failure. Nerve cells do not get enough energy from glucose to pass information to the heart, so the heart does not pump efficiently. This could lead to a heart attack. Blood flow drops, because nerve cells in the blood vessels are affected. This could lead to blindness, prevent sores from healing, and cause confusion or even a coma.

Type 2 diabetes is the most common form of the condition, and millions of Canadians have it. The number continues to climb, with large increases reported in the number of young Canadians having the condition. Type 2 diabetes can affect anyone, but it is much more common in Aboriginal Canadians as well as Hispanic, Asian, South Asian, and African Canadians.

At present, there is no cure for diabetes. However, medications, healthy eating, and regular exercise can control it. Maintaining a healthy weight is an important factor in controlling diabetes. In the future, scientists hope to find cures if they can transplant healthy pancreas cells into people with type 1 diabetes and help cells produce more channels for people with type 2 diabetes.

Questions

1. What two things are needed for glucose to enter cells?
2. How does type 1 diabetes differ from type 2 diabetes?
3. If you were a family doctor, what recommendations would you give people who are at risk for developing diabetes?

Check Your Understanding

Checking Concepts

1. Why do cells of the body need oxygen?
2. Describe one way that the circulatory system and the respiratory system are connected.
3. Describe one way that the circulatory system and the digestive system are connected.
4. Describe one way that the nervous system and the muscular system are connected.

Pause and Reflect

Describe how carbon dioxide from a cell in your hand leaves your body.

Understanding Key Ideas

5. (a) How does your circulatory system help you stay cool?
   (b) What other body system(s) work together with the circulatory system to help you stay cool?
6. Explain why it makes sense for there to be blood vessels that enter and leave the kidneys.
7. The table below shows what happens to six substances that are found in the blood when the blood is filtered by the kidneys. (Urea and uric acid are substances that result when proteins are broken down during digestion.)
   (a) Copy the table into your notebook and complete the calculations.
   (b) Which of these substances would you not expect to find in urine? Explain how you know.
   (c) If the substance that you identified in part (b) were to show up in urine, this would be a sign that the kidneys are malfunctioning. Healthy kidneys, on the other hand, filter out this substance so that it may be returned to the circulatory system and reused by the body. Describe one benefit of returning this substance for reuse in the body, rather than excreting it from the body.

Substance in Blood	Amount in Blood before Reaching Kidneys	Amount Returned to Bloodstream	Amount in Urine
water	100 L	99 L	100 L – 99 L = 1 L
chloride	370 g	364 g	
glucose	70 g	70 g	
urea	30 g	10 g	
uric acid	4 g	3.5 g	
calcium	10 g	9.85 g	

12.2 Body Systems and Health

All body systems work together with other body systems. If one system does not function properly, the whole network of systems is disrupted, and the whole body is affected. In the same way, maintaining the health of each body system keeps the network of systems, and the whole body, healthy. Factors such as diet, exercise, and stress affect the health of the body systems.

Key Terms

genetic factors
homeostasis
lifestyle factors

A good example of the way body systems work together involves the circulatory system. The heart circulates blood throughout the body. Blood supplies oxygen and nutrients that each cell needs to function. Blood also carries wastes produced by cells to other organ systems that break them down or remove them from the body.

The heart is a pump. As it contracts, it pushes blood through your blood vessels. The blood is forced out of your heart under pressure. You can feel this rush of blood when you check your pulse with your fingers. Your pulse tells you how fast your heart is beating. It also is an indication of how hard your heart is working.

Word Connect

The name for the device used to measure blood pressure is sphygmomanometer. This word comes from a Greek word that means "pulse" *(sphymos)* and a French word that means "pressure gauge" *(manomètre)*.

Blood Pressure

Doctors measure blood pressure as a simple first step to assess the health of the circulatory system. A device like the one in Figure 12.7 is used to measure blood pressure. The device has an inflatable cuff that is wrapped around the arm. Air is pumped into the cuff. This squeezes it against the artery in the arm and restricts the blood flow. Air is then slowly let out of the cuff to the point where the blood pressure matches the cuff pressure. When the pressures match, blood can flow once again through the artery. A doctor then listens for the sound of the blood with a stethoscope, as shown in Figure 12.8.

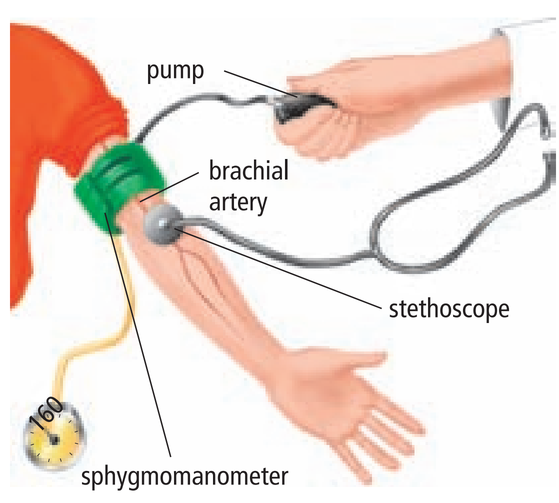


Figure 12.7 Blood pressure is measured using a device called a sphygmomanometer.

Blood pressure can indicate several things about the health of the circulatory system.

- *Heart rate:* A fast-beating heart pushes blood quickly through the arteries, building up blood pressure.
- *Artery size:* Large, open arteries conduct larger volumes of blood, which produces low blood pressure. Small, narrow, or partly clogged arteries conduct smaller volumes of blood, which produces high blood pressure.
- *Artery elasticity:* Flexible arteries can expand easily, letting more blood flow through. Loss of elasticity results in "hardening of the arteries." This condition produces higher blood pressure.
- *Blood viscosity:* Thick fluids flow less easily than thin fluids. Thus, the heart must work harder if blood viscosity is greater than normal, which can happen if the number of blood cells increases due to illness or injury.
- *Blood volume:* If a person has lost a lot of blood through injury, the blood pressure will be low.

Figure 12.8 A doctor uses both a stethoscope and a sphygmomanometer to assess a person's blood pressure.

Factors That Affect Blood Pressure

Factors that can increase blood pressure include smoking, a high-fat diet, and lack of regular exercise. Cigarette smoking is a double threat to the circulatory system. Nicotine in cigarette smoke causes blood vessels to constrict. This increases heart rate and raises blood pressure. Also, carbon dioxide in smoke competes with oxygen in the lungs. This reduces the ability of the blood to carry oxygen to the cells.

Unhealthy diet choices can also lead to disorders of the system. For example, a diet high in salt can raise the blood pressure, putting greater strain on the heart. The heart gradually increases in size, and it pumps less efficiently. High-fat diets can cause fatty deposits to build up inside arteries. (Refer to Figure 12.9.) As the arteries narrow and become blocked, tiny tears in their walls cause blood clots. The clots 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.

Suggested Activitiy

Find Out Activity 12-2A on page 452

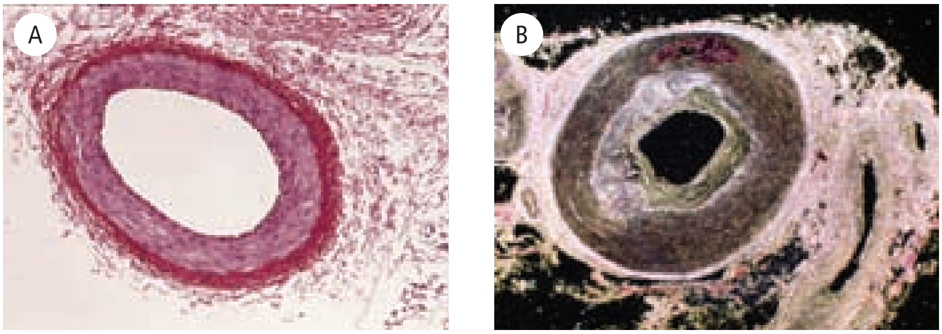


Figure 12.9 The cross-section view of a healthy artery (A) shows a clear, wide-open pathway through which blood can flow easily. The cross-section view of an unhealthy artery (B) shows a pathway narrowed by the buildup of fatty deposits. Blood does not flow quickly or easily through this artery.

Body Systems in Balance

The environment around you is always changing. The environment inside your body is always changing as well. For example, during stressful situations, your nervous system causes your heart rate and breathing rate to speed up. This reaction to stress helps you perform well in an emergency, as well as during competitions and tests. When the stressful situation is over, your body systems adjust to return your heart rate and breathing rate to normal.

Your body must maintain the proper internal conditions for all its cells. The ability of your body to maintain an internal balance is called **homeostasis**. All the body systems work together to achieve homeostasis, as illustrated in Figure 12.10.

Waste Product Levels: Each time you exhale, your respiratory system removes waste carbon dioxide. Your body gets rid of toxic substances by filtering the blood through the kidneys.

Blood Sugar Level: After you eat a meal, the concentration of glucose in the blood rises. In response, the pancreas releases a chemical called insulin. Insulin moves glucose from the blood to body tissues. This returns glucose concentrations to normal levels.

Concentration of Substances in Blood: The concentration of substances in your blood is always changing. The organs of different body systems have a role to play in distributing various substances that circulate in the blood throughout the day. These include oxygen, carbon dioxide, glucose, minerals, vitamins, and wastes.

Heart Rate: During times of stress or high activity, your heart rate increases to circulate more blood to deliver the necessary nutrients and oxygen to the cells.

Water Balance: Human bodies are about two-thirds water, and most of a cell's cytoplasm is water. Certain chemicals in the body influence mineral and water balance in the body. If the concentration of minerals is too high, more are excreted from the body. If the concentration is too low, less urine is excreted.

Figure 12.10 Homeostasis maintains the proper conditions for life.

What Affects Homeostasis?

Many things can interfere with the balance of body systems. Some of these are **genetic factors**. These are things that you inherit from one or both birth parents. Other factors that can affect the balance of body systems are within your control. These **lifestyle factors** include diet (the types and amounts of food you eat), exercise, and how you respond to stress. Table 12.1 outlines some of the effects that these and other lifestyle factors can have on body systems. Note: Some of the factors in the table are genetic. This means that, for some people, the factors are determined before birth. For instance, genetics may increase a person's chance of becoming overweight or obese or of abusing alcohol.

Table 12.1 Effects of Lifestyle Choices on the Health of Body Systems

Lifestyle Factors	Effects
Diet high in fats and cholesterol (a fat-like substance)	• fats are harder to digest than other nutrients; high-fat diets tax the digestive system • fatty deposits from cholesterol and fats clog blood vessels • fatty deposits in the arteries make the heart work harder • cholesterol can crystallize in the gall bladder to form gallstones
Overweight (people whose body weight is more than the maximum desirable weight for their height and bone structure) and obesity (people whose body weight is 20 percent above the maximum desirable weight)	• added weight strains heart functions, adding a risk of heart disease • added weight is a particularly high risk factor when it is associated with high cholesterol levels, high blood pressure, or diabetes
Smoking	• causes an increase in blood pressure, which makes the heart work harder • decreases the amount of oxygen available to body cells • doubles the risk of heart attacks and sudden death • can cause indigestion • linked to respiratory problems and lung cancer
Drugs and alcohol	Stimulants: • temporarily increases rate of life functions • speed up heart rate • may cause diarrhea, stomach pain, changes in sleep patterns, anxiety, loss of appetite, vomiting • can lead to dehydration, which could lead to constipation Depressants: • decrease the rate of life functions • slow down heart rate • may cause nausea, increased acid production, vomiting, and diarrhea or constipation , depending on other factors such as whether the person is dehydrated or not, or if the person is taking other drugs or has pre-existing medical conditions
Lack of exercise	• digested food stays in large intestine too long; coating of feces on walls of large intestine results in poor absorption of water and nutrients • constricts blood vessels • increased risk of heart disease • risk of becoming overweight • increased risk of joint disorders such as arthritis • poor digestion leading to constipation

Technology in Support of Homeostasis

Health-care providers use technology to diagnose and treat illnesses and diseases. Technology can also be used to support or, in some cases, replace the function of an organ or a body system. Figure 12.11 shows several examples.

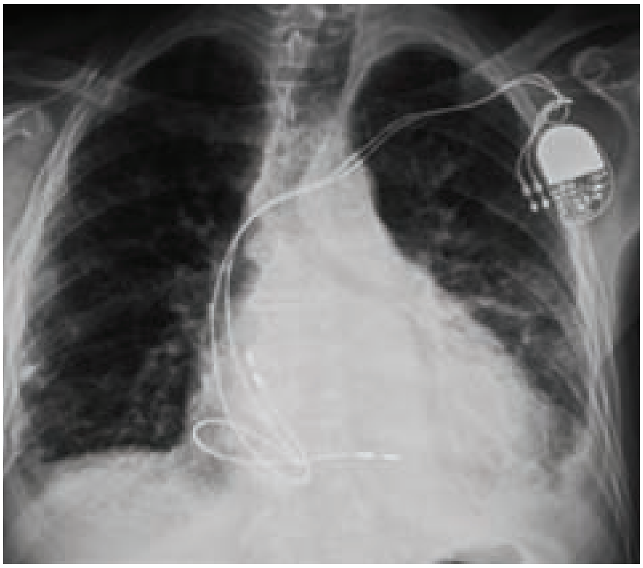


Figure 12.11A A healthy heart has cells that create impulses to cause the heart to beat. If these cells become damaged, an artificial pacemaker can be used. An artificial pacemaker is an electrical device that is implanted under the collarbone. It releases electrical charges to stimulate the heart to beat with a steady rhythm.

Figure 12.11B People who have diabetes (see Science Watch on page 444) have to monitor their glucose levels all the time and may receive injections of insulin. An insulin pump is a device that some people with diabetes wear all the time. The pump is programmed to deliver a specific dose of insulin at specific times during the day. The person must still continue to monitor glucose levels.

Figure 12.11 C The Jarvik-7 is an artificial heart. Artificial hearts are sometimes used because there are not enough donors of human hearts, and it is difficult for humans to stay alive for any length of time using hearts from other species.

Figure 12.11D Kidney dialysis is used when the kidneys no longer function. In one type of dialysis, a system of tubing allows blood to flow into a machine that removes waste products from the blood. Filtered blood is then cycled back into the body. In another type, shown here, the filtering is done by the lining of the intestines.

You and Your Body Systems

What would you think if someone advised you to sit on a couch for at least 8 hours a day in a smoke-filled room, eat plenty of candy, drink lots of pop, and get three or four hours of sleep a night? You would probably think that you would not feel very well after a week or two. You know that your body needs proper care to function properly. However, some people pay less attention to the health of their bodies than they do to maintaining a bicycle or a car.

To support healthy organs and body systems, everyone has the same essential needs: clean air and water, a nutritious, well-balanced diet, exercise, and restful sleep. Clean air means oxygen for your cells. Pollution decreases the ability of oxygen to get into your body. A nutritious, well-balanced diet provides your cells with the materials they need for growth and activities. Lack of essential materials weakens the body. Too much of some substances, such as fats, processed sugars, and salt, places a strain on certain organs and systems.

Exercise helps the body process food and oxygen more efficiently. A healthy heart, lungs, and kidneys help carry materials to the cells and get rid of wastes. Strong muscles help protect the body from injury, and—coupled with a healthy heart and lungs—they use energy more efficiently.

The choices that you make in support of a healthy lifestyle can help to support your body systems for all of their life—and yours.

Reading Check

1. What are genetic factors?
2. What are lifestyle factors?
3. Name two types of technology that support or replace the function of an organ or a body system.

internet connect

The two types of kidney dialysis are called hemodialysis and peritoneal dialysis. Go to **www.discoveringscience8.ca**, and find out how these types of dialysis are similar and different.

Suggested Activity

Find Out Activity 12-2B on page 453
Conduct an Investigation 12-2C on page 454

12-2A Health Watch

Find Out ACTIVITY

All health-care providers agree that the following factors have a signficant efffect on the health of body systems:

- diet
- exercise
- stress

In Activity 11-2A, you examined one body system in detail. At that time, your focus was on the organs that are a part of it and how they work together in a healthy body. In this activity, you will explore ways that diet, exercise, or stress can affect this body system.

What to Do

1. Review what you learned about your group's body system from Activity 11-2A.
2. Discuss the meaning of the terms diet, exercise, and stress, and make sure everyone agrees on the meanings that you will use for them.
3. Choose to investigate the effect of either diet, exercise, or stress on the health of this body system. If there are other groups in the class that studied this system, try to investigate a factor that is different from theirs.
4. In step 3, you investigated the effect of one factor--diet, or exercise, or stress--on the health of one body system. Choose two other body systems whose functions are closely related to the function of the body system from step 3, and investigate the effect of diet, exercise, or stress (whichever factor you chose in step 3) on the health of these two systems.
5. Decide how the members of your group will get the information needed. For instance, you could do one or several of the following:
   - do library/Internet research
   - interview a medical specialist
   - interview a person who has worked hard to keep your system healthy or to recover from poor health
   - interview or invite a representative from an organization that specializes in your system or some aspect of its health
6. Decide how your group will coordinate and present its findings.

12-2B Evaluating Energy Drinks

Find Out ACTIVITY

Energy drinks are sold in grocery stores, gas stations, and bars. Manufacturers claim that energy drinks improve physical endurance and mental alertness. Energy drinks are not the same as sports drinks. Sports drink such as Gatorade™ are designed to replace glucose and several other nutrients that are lost from the body during exercise. Research energy drinks to learn more about why people use them and how safe they are.

Materials

- labels from one or more energy drink products
- labels from one or more sports drink products
- library and/or computer with Internet access

What to Do

1. Work in teams of three or four.
2. Each team will be given an energy drink to investigate. Do research to answer the following questions about your energy drink:
   - What is the name of your energy drink?
   - What are the ingredients in your energy drink?
   - What advertising claims are made about it?
   - What, if any, safety warnings are given on the label or on the drink's web site?
3. Use an approved Internet search engine. Key in the terms "safety issues energy drinks." Go to at least two of the sites that the search engine shows. List four health and safety issues associated with energy drinks.
4. Each team will be given a sports drink to investigate. Repeat steps 2 and 3 for your sports drink.

What Did You Find Out?

1. Compare what you learned about your energy drink and sports drink with what another group learned. Use a table or a Venn diagram to compare your findings.
2. A PMI chart is a type of tool to help you make a decision about a problem or an issue. In the chart, you list the advantages (plus), disadvantages (minus), and interesting points about a problem or issue. Complete one PMI chart for energy drinks and another PMI chart for sports drinks.

Plus (P)	Minus (M)	Interesting (I)

3. Based on your PMI charts, would you recommend using energy drinks to prepare for an exam? Explain why or why not.
4. Based on your PMI charts, would you recommend using energy drinks to prepare for a sports activity? Explain why or why not.

12-2C Debate: Conventional versus Alternative Medicine

SkillCheck
- Evaluating information
- Working co-operatively

Background Information

Conventional medicine is medicine that is based on science as it is understood and practised mostly by Western cultures such as Canada, the United States, and many parts of Europe. Conventional medicine has helped to develop vaccines, antibiotics, and surgical techniques that have improved the lives of many people.

Alternative medicine is medicine that is based on science as it is understood and practised mostly by Eastern cultures, such as those of China, Japan, and India, and by Aboriginal cultures throughout the world. For example, acupuncture was developed in ancient China. It involves inserting needles into certain places in the skin to relieve pain and to help organs to function properly. Other examples of alternative medicine include herbalism, homeopathy, naturopathy, chiropractic, and Aryuvedic medicine.

Some practitioners of conventional medicine are licensed to use selected alternative methods—notably acupuncture. One health-care facility in Quebec and two in Alberta provide both conventional and alternative methods of treatment. This approach is sometimes called integrative medicine. In general, however, practitioners of conventional medicine do not support the use of alternative medicine, because its techniques have not been tested to the same standards used to establish the value of conventional therapies and practices.

This large device is a gamma camera, which is used in nuclear medicine to treat cancer.

Acupuncture needles are placed at points along lines of chi (body energy) called meridians.

Identify and Analyze Alternatives

Your teacher will provide you with a set of debating procedures to follow. Debate the following resolution: Be it resolved that methods used in alternative medicine are unproven as effective ways of treating illness.

Read the "In Favour" and "Against" points listed here, and start to think about other points that could be made in favour of the resolution and against the resolution. Your class with be divided into groups of six. In each group, two students will speak in favour of the resolution, and two will speak against it. Each of the remaining students will be asked to join a side and work with the speakers to gather the background information needed to put forward a strong case for the point that side is defending. (To help make the research more manageable, each team can choose to find detailed information about one of the alternative therapies mentioned.)

Each group will take turns presenting its debate to the rest of the class. The class will vote to declare which side is the winner.

In Favour	Against
• There is little or no statistical evidence based on controlled clinical trials that demonstrate that alternative therapies produce cures.	• Good health is a result of many factors that affect organ systems as a whole, and alternative medicine looks at this complex balance, rather than just single factors.
• Many alternative therapies contradict what Western science teaches about how cells and organs in the body carry out their functions.	• Many alternative therapies are based on practices that have been used to treat illnesses successfully for hundreds and, in some cases, thousands of years.
• The apparent success of some alternative therapies may be the result of a faulty diagnosis. In other words, people seem to recover because they did not have the illness that was diagnosed in the first place.	• Alternative therapies might use some principles that have not yet been discovered by scientific research.

Evaluate

1. Did the side that won in each group provide better research or make a better presentation?
2. (a) What was your own opinion about the use of alternative medicine vs. conventional medicine before the debates?

   (b) Did your opinion change as a result of the debates? Explain why it did or did not.

Career Connect

Robyn Bagley

Robyn Bagley (far left) is a Certified Athletic Therapist with a Bachelor of Kinesiology degree. Kinesiology is the study of human-body movement.

Q. Athletes train to challenge the limits of the human body. What are the most common kinds of injuries you see?

A. Injuries vary with the sport, but generally injuries to the joints—ankles, knees, shoulders—are quite common because the joints are a point of weakness. Joints are where two bones come together, held by ligaments and acted upon by muscle tissue.

Q. Have advances in technology and equipment changed the stresses on the body? How?

A. Definitely. Advances in technology and equipment will always add new dimensions, both positive and negative, to a sport. In some ways, advances have improved a sport so we see fewer injuries than we once did. For example, visors in hockey reduce the incidence of eye injuries. Unforeseen aspects that advances bring include athletes' ability to hit each other harder, which increases the severity of injury and the occurrence of spinal and head injuries; newfound ability to push themselves further in training, which increases the risk of repetitive injuries; the ability to perform tasks they could not do without the new equipment; the creation of a longer season, which also increases the risk of repetitive injuries.

Q. How does the work of an athletic therapist differ from that of a physiotherapist?

A. Athletic therapists share a similar skill set, but we specialize in musculoskeletal conditions. We traditionally follow the cyclical nature of sport from the field of play, to the clinic, and back to the field of play. Physiotherapists also work with patients with neurological, cardio, and respiratory conditions—usually in a clinical setting.

Q. What advice do you have for serious athletes?

A. Balance in training and life is always important to help the body keep up with the demands we place on it. For high-level athletes, it is all the more important. Rest and recovery, along with proper training, proper nutrition and hydration, core strengthening, and sport-specific drills, all provide a strong base for all athletic pursuits. Core training—the strengthening of the muscles located mainly in the trunk of the body—is important for all people, regardless of their activity level. The abdominal muscles, for a start, provide the body with a good foundation to perform daily activities, let alone a high level of sport.

Questions

1. How have technology and equipment affected athletes?
2. What advice does Robyn give that applies to everyone, not just athletes?

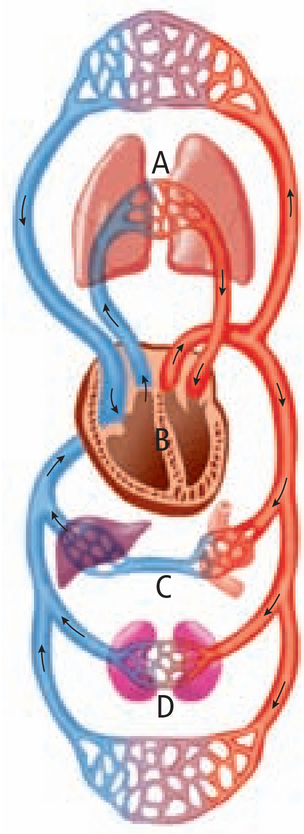
Check Your Understanding

Checking Concepts

1. Give two examples of choices people make that can support the health of their body systems and two examples of choices that can harm the health of their body systems.
2. Why must the heart work harder if blood viscosity is greater than normal?
3. (a) How can technology help health-care providers?
   (b) Name two technologies that can support or replace the function of an organ or a body system, and explain how they work.
4. Explain why cigarette smoking is a double threat to the circulatory system.
5. Define the term homeostasis.
6. How are lifestyle factors different from genetic factors in their effect on body systems?

Understanding Key Ideas

7. How can a high-fat diet affect the flow of blood through the body?
8. What effects can drugs and alcohol have on the nervous system?
9. The diagram summarizes the relationship between the circulatory system and other body systems. The blue colour represents blood vessels through which blood flows to the heart to get more oxygen to be pumped to the rest of the body. The red colour represents blood vessels that carry the high-oxygen blood to other body systems. Name a body system that is represented at each letter on the diagram, and explain the interdependence of each system and the circulatory system.



Pause and Reflect

Some people who experience a lot of stress in their lives get sick more often than people who experience less stress or people who handle stress better. Explain how this could be possible.

Prepare Your Own Summary

In this chapter, you explored how the systems of the body depend on one another to support the health of the whole body. Create your own summary using the key ideas from this chapter. You may include graphic organizers or illustrations with your notes. (See Science Skill 10 for help with using graphic organizers.) Use the following headings to organize your notes:

1. How Body Systems are Connected
2. Body Systems in Balance
3. How Technology can Help Body Systems
4. Healthy Choices Support Healthy Body Systems

Checking Concepts

1. Make a concept map to show how the following terms are related. Link the concepts together using a few key words or descriptions. Add any other terms you need.
   - nutrients
   - external environment
   - oxygen
   - lungs
   - cells
   - circulatory system
   - carbon dioxide
   - cellular respiration
2. The normal breathing rate of an infant is faster than that of a teenager. Why would this be the case?
3. Describe one example of a connection between each of the following pairs of body systems:
   (a) circulatory system and digestive system
   (b) respiratory system and excretory system
   (c) nervous system and circulatory system
   (d) muscular system and digestive system
   (e) digestive system and respiratory system
   (f) muscular system and circulatory system

Understanding Key Ideas

4. 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.
5. The body's systems work together to maintain homeostasis. Why is homeostasis important?

Vegetarian diets	Fad diets
Vegetarian diets: Some people choose to eat foods that do not include animal products. This choice might be based on spiritual beliefs as well as for personal or ethical reasons. Strict vegetarian diets (called vegan diets) contain no animal products at all. Other vegetarian diets may include dairy and eggs, and sometimes small amounts of fish. Vegetarian diets are high in whole grains and fibre, high in good fats, and low in bad fats. One drawback, however, is that such diets can be too low in some vitamins and minerals, so many vegetarians take supplements.	**Fad diets:** This term refers to a specialized diet that becomes very popular for a short period of time. Fad diets usually promise speedy weight loss. They often feature an emphasis on a specific food (for example, the grapefruit diet) or a specific nutrient (for example, the Atkins diet, which stressed high amounts of protein and low amounts of carbohydrates). Most people do not stay on a fad diet for lengthy periods of time.

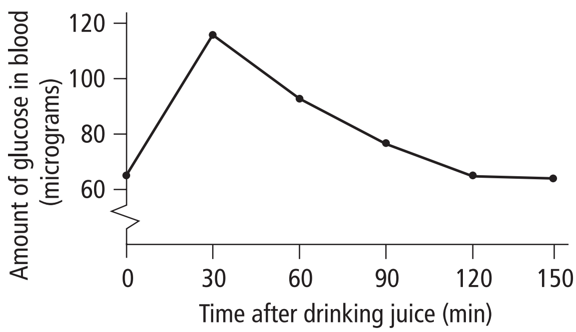
6. Statistics Canada collected data on the obesity rates of Canadians in 1978 and 2004. The obesity rates were calculated using something called a body mass index (BMI). The table below shows representative data from these two studies.

Age Group	Obesity Rate, 1978	Obesity Rate, 2004
12–17	3%	9%
25–34	9%	21%
75+	11%	24%

(a) Interpret what is happening to the obesity rate for each age group. (You might find it helpful to make a bar graph of the data first.)

(b) Infer three reasons for the changing obesity rates for each age group.

7. The graph below shows how the amount of glucose in a person's blood changed after she drank some fruit juice. Before she drank the fruit juice, the amount of glucose in her blood was about 65 micrograms. Does this graph provide an example of homeostasis? Explain your answer.



8. Read the information at the top of this page comparing vegetarian diets and fad diets. Which of these types of diets is more likely to provide long-term health and support of the body? Explain your answer.

Pause and Reflect

Name three things that you are doing, or could be doing, to support the healthy functioning of your body. Explain why these things are important, based on what you have learned about cells, tissues, organs, and systems.

Unit Summary

10 The cell is the basic unit of life.

- All living things have characteristics that demonstrate they are alive. These include the ability to grow, to move, to reproduce, and to respond to stimuli. (10.1)
- Some living things are very small and can be observed only with a microscope. (10.1)
- A compound light microscope is an important tool in the study of cells and microscopic living things. (10.1)
- All cells have similar structures and organelles. Each structure and organelle carries out a specific task to help support the life functions of a cell. (10.2)
- Cellular respiration is the process that produces energy for the cell. (10.2)
- Cell theory states that the cell is the basic unit of life; all living things are composed of one or more cells; all cells come from other living cells. (10.2)

11 Human body cells are organized as tissues, organs, and systems.

- A system is made up of parts that work together as a whole. (11.1)
- Each system of the human body consists of organs that are made up of different kinds of tissue. (11.1)
- Tissues are made up of many similar cells working together to carry out a specific function. (11.1)
- The human body is made up of eleven systems that, working independently and together, support and maintain the function of the whole body. (11.2)

12 The health of the body depends on the health of its interdependent systems.

- All the cells of the body have the same basic need for energy, nutrients, and oxygen to carry out their functions. All cells also have the same basic needs for removing wastes. (12.1)
- Body systems work together to provide cells with what they need. Thus, they support themselves, one another, and the whole human body. (12.1)
- All body systems work together with other body systems. (12.2)
- If one system does not function properly, the whole network of systems is disrupted, and the whole body is affected. In the same way, maintaining the health of each body system keeps the network of systems, and the whole body, healthy. (12.2)
- Factors such as diet, exercise, and stress affect the health of the body systems. (12.2)

Key Terms

- arm
- base
- cell
- cell membrane
- cell theory
- cell wall
- chloroplast
- coarse adjustment knob
- compound light microscope
- cytoplasm
- eyepiece
- fine adjustment knob
- iris diaphragm
- light source
- magnification power
- mitochondria
- mitosis
- nucleus
- objective lenses
- organelle
- resolving power
- revolving nosepiece
- stage
- total magnification
- tube
- vacuole

Key Terms

- circulatory system
- digestive system
- endocrine system
- excretory system
- immune system
- integumentary system
- muscular system
- nervous system
- organ
- organ system
- reproductive system
- respiratory system
- skeletal system
- system
- tissue

Key Terms

- genetic factors
- homeostasis
- lifestyle factors
- nutrients

Project

Building a 3-D Model of Human Body Systems

In this project, you will work in groups to create a life-sized, three-dimensional model of four organ systems using a variety of everyday materials.

Problem

How can you use everyday materials, such as those you find at home and at school, to build a three-dimensional model of the digestive, excretory, circulatory, and respiratory systems?

Criteria

You must complete three drawings.

- The different structures of each organ system are made from everyday materials.
- Each structure in each organ system is correctly labelled.
- The model demonstrates at least one example of the interaction between two organ systems.
- The way the model is presented to your class follows your teacher's instructions.

Procedure

Part 1 Brainstorming Ideas

1. With your group, brainstorm various materials you could use to create your model of the digestive, excretory, circulatory, and respiratory systems. Write down any materials and the body parts they represent in a particular organ system on a large sheet of chart paper. An example is shown below.

Digestive System vacuum hose—small or large intestine	Excretory System bean bag—kidney
Circulatory System rubber tubing—blood vessels	Respiratory System sponge—lung

2. Decide on a final list of materials you will use for each organ system. Assign different group members to collect the materials. (Use any material that is available and safe. If you are unsure, check with your teacher.)
3. Ask your teacher to review this list before you collect your materials.

Part 2 Building Your Model

4. Outline the body of one member of your group on a large piece of chart paper.
5. Using the materials your group collected, build your three-dimensional model. Your materials should fit within the body outline you have drawn and clearly show the four organ systems.
6. When you have completed your model, review the criteria at the beginning of this project and make sure you have correctly labelled each system. Be sure to include an example of where two systems interact.

Report Out

1. After building your model, follow the directions provided by your teacher for presenting your work to the class. In your presentation, be sure to explain your choice of materials to build each organ system and describe where two organ systems interact.

Advances in Biotechnology

As our understanding of cells, tissues, and organ systems has grown, so too have the ways in which we use this knowledge. Biotechnology is an example of an area of research that has expanded because of our ability to apply new knowledge to the development of new products for human use. In this integrated research investigation, you will use print and electronic resources to study the role of biotechnology in our society.

Background

The United Nations, an international organization that promotes world peace, security, and human improvement, defines biotechnology as "any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use."

Biotechnology has expanded to include many different areas of research. Many, but not all, of these areas investigate what happens when changes are made to the DNA of living things such as bacteria, plants, and some animals. The table below describes some of these areas.

Find Out More

Choose one area of biotechnology from the table and conduct research on a topic in this area. If you would rather select a different area to study check with your teacher. Start at **www.discoveringscience8.ca** and use magazines and newspapers to find out information on your topic. You may also wish to contact universities that are conducting research in your chosen area.

Report Out

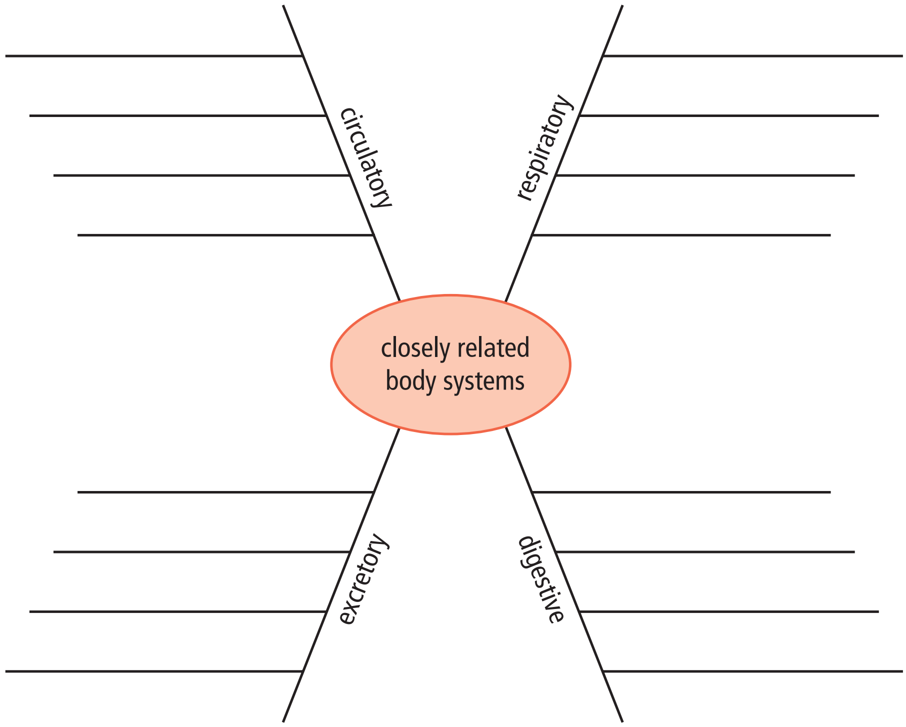
Create an information pamphlet, brochure, or electronic presentation that could be used to inform people about recent advances in the biotechnology topic you selected. Include an overview of your topic area, what new discoveries have occurred in this area, what potential applications could come from this research, and a description of any ethical issues resulting from this type of research.

Biotechnology Area	Example
Bioethics	Changing the DNA (genetic material) of living things has raised questions about the safety and ownership of newly created living things.
Biomedicine	Scientists are modifying bacteria in such a way that the bacteria make products useful to humans. For example, insulin that is used by people with diabetes can be made from modified bacteria.
Bioengineering	The production of foods such as cheese and yogurt requires bacteria. Bioengineering finds ways to modify the bacteria to produce new and tastier foods.
Bioremediation	Certain bacteria can be used to clean up toxic wastes and other types of pollution.
Molecular biology	Police use DNA fingerprinting to discover who may be responsible for committing a crime.

UNIT 4 Unit Review

Visualizing Key Ideas

1. Copy the following spider map into your notebook. Beside each topic, fill in as many words as you can that are related to their topic. Do not look at your textbook. When you have completed the map, go back and look for other words you could include. Add these words to the map using a different colour of pen.



Using Key Terms

2. (a) Use the key terms below to create your own fill-in-the-blank quiz. For example, for the key term "cell," an acceptable quiz statement might be:
The basic unit of life is called a _____.

- arm
- base
- cell
- cell membrane
- cell theory
- cell wall
- chloroplast
- coarse adjustment knob
- compound light microscope
- cytoplasm
- diaphragm
- eyepiece
- fine adjustment knob
- light source
- magnification power
- mitochondria
- nucleus
- objective lenses
- organ
- organ system
- organelle
- resolving power
- revolving nosepiece
- stage
- system
- tissue
- tube
- vacuole

Checking Concepts

10

3. You have found something that you think is living. What characteristics would your discovery have to demonstrate to be considered living?
4. (a) What are two differences between unicellular living things and multicellular living things?
   (b) What are two similarities between unicellular living things and multicellular living things?
5. State the function of each of the following parts of a compound microscope.
   (a) eyepiece
   (b) revolving nosepiece
   (c) coarse adjustment knob
   (d) light source
   (e) stage
   (f) diaphragm
   (g) objective lenses
6. Name the part of the microscope that does each of the following:
   (a) holds the slide in place
   (b) brings objects into clearer focus
   (c) controls the amount of light
   (d) supports the microscope
7. Describe how an object appears when it is viewed through a compound light microscope.
8. What is the difference between a micron and a millimetre?
9. Which organelle produces energy for cellular activities?
10. What function does the vacuole perform in a cell?
11. (a) Which organelles are found only in a plant cell?
    (b) What is the function of each of these organelles, and why is each one necessary for a plant's survival?
12. Which organelle directs the process of mitosis?
13. Summarize the cell theory.
14. Under low power, an eyelash has a total magnification of 40×.
    (a) Explain how this magnification is calculated.
    (b) What is the total magnification of an eyelash when it is viewed under medium power?
    (c) What is the total magnification of an eyelash when it is viewed under high power?
    (d) Make a sketch to compare the difference in size of an eyelash viewed under low and then medium power.

11

15. Explain the characteristics of a system, using the circulatory system as an example.
16. List the four types of human tissue, and give an example of each.
17. Which of the following terms defines a group of similar cells working together: cells, tissue, organ, or organ system?
18. Use a diagram to explain how the terms in the previous question are related.
19. The arteries of the circulatory system carry oxygen to the cells of the body. How do the arteries get the oxygen?
20. Three things 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?

12

21. Several body systems that you have studied in this unit are:
- circulatory system
- digestive system
- excretory system
- muscular system
- nervous system

(a) Briefly describe the main function of each of these systems.
(b) Choose two of these systems, and give an example to show how they are connected.
(c) Repeat part (b) with a different pair of systems.
(d) Repeat part (b) again with another different pair of systems.

22. Explain why cellular respiration is so important to the health of the human body.

23. The blood vessels in the kidneys are very sensitive to changes in blood pressure. What could happen if high blood pressure damages these blood vessels?

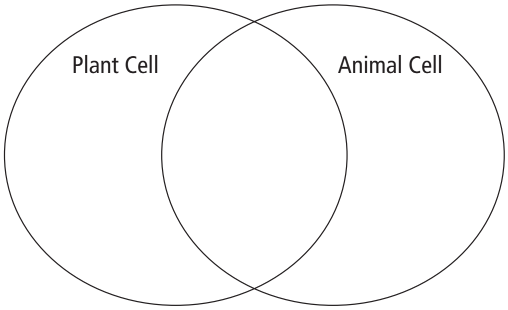
24. (a) Define the term homeostasis.
(b) Use your answers to question 21 to write a brief paragraph about the role of homeostasis in the body.

Understanding Key Ideas

25. Draw a cell that would take up half the field of view under a compound light microscope at low power. (You can use your imagination in your drawing.) Now draw what this organism would look like under medium power.

26. Would you expect to find chloroplasts in the root tip of a growing plant? Why or why not?

27. Use a Venn diagram like the one below to compare the structure and organelles of plant and animal cells.



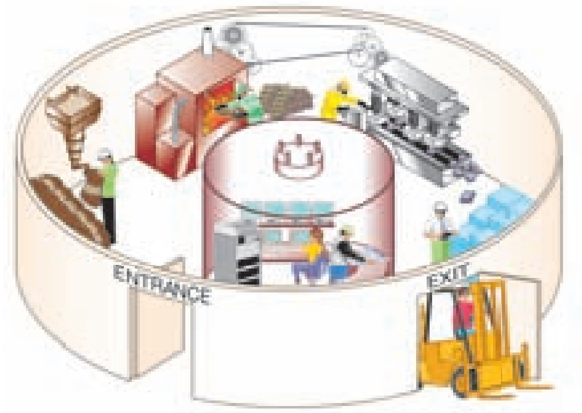
Thinking Critically

28. Your body releases carbon dioxide when you exhale. Where in the body does this carbon dioxide originally come from?

29. Describe the difference in blood pressure of blood flowing through a healthy artery and blood flowing through an artery with a buildup of fatty deposits.

30. Your teacher announces a surprise quiz. This sudden surprise may cause your heart to beat faster and your rate of breathing to increase. After a short time, your heart rate and breathing rate would return to normal.
(a) Which two body systems are interacting in this example?
(b) Which system controls and coordinates their interaction?
(c) What word is used to describe the return to normal functioning of these systems?

31. Sometimes the living cell is compared with a factory. Write a paragraph or design a table to compare the parts and functions of a cell with what happens in a factory? Use the illustration to guide your answer.



Developing Skills

32. How do you prepare a wet mount slide? Use labelled diagrams to describe the steps.
33. Explain the steps involved in safely moving a microscope from its storage area to your work area and setting it up to view a specimen.
34. The average human heart beats about 70 times per minute. How many heart beats would occur in one day, one month (30 days), one year, and a lifetime of 80 years?
35. In a study comparing heart rates of athletes and non-athletes, 30 individuals were given 10 min of intense physical exercise. Half the individuals were athletes and the other half were not. The following table summarizes the data collected for the athletes. Follow this model to make a similar 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

Range of Heart Rates	Total Number of Athletes in theRange
119–122	2
123–126	3
127–130	6
131–134	3
135–138	1

Pause and Reflect

Review the titles of the three chapters in this unit. Explain how the relationship of these three titles outlines what people should know about how cells and body systems function.