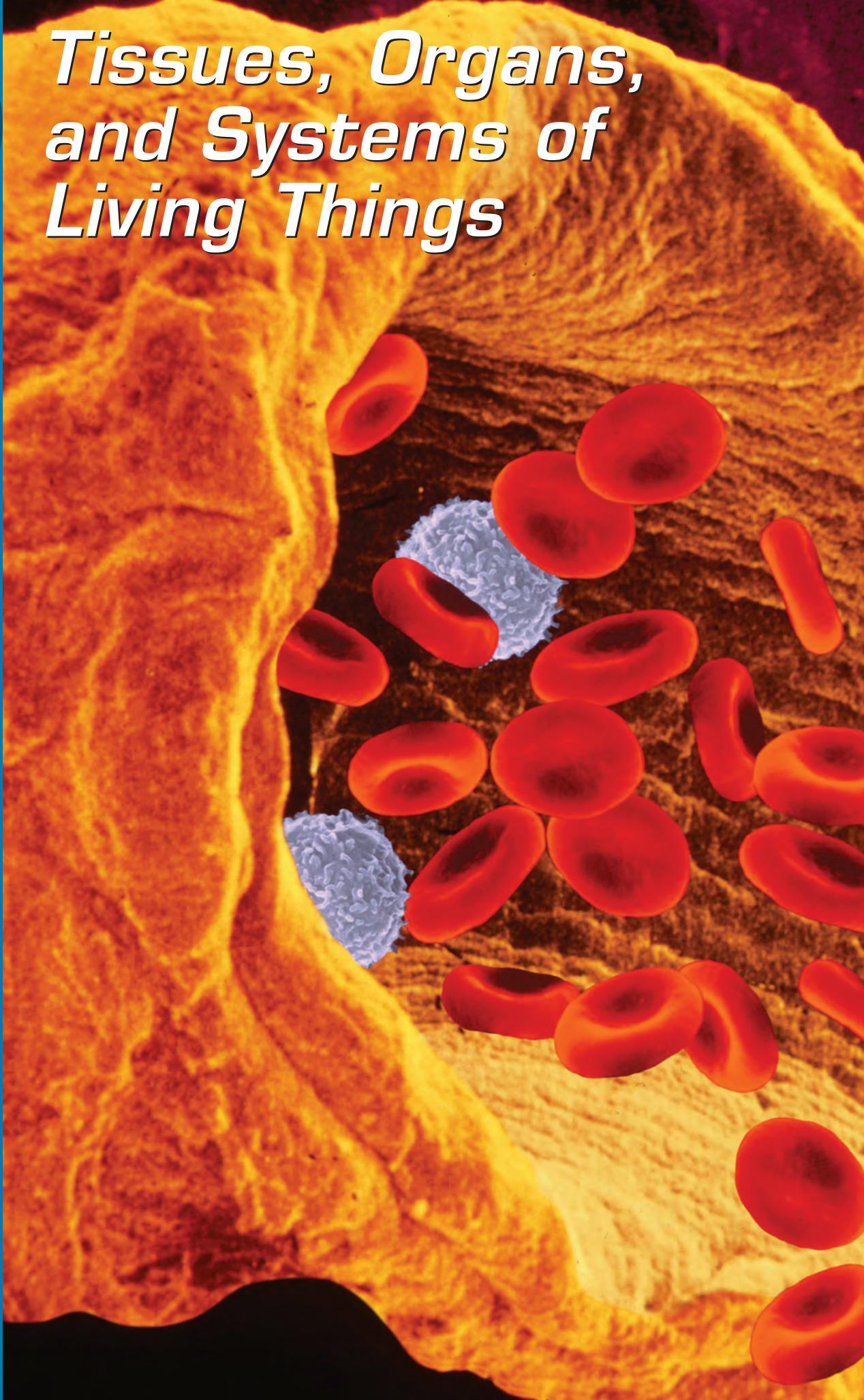
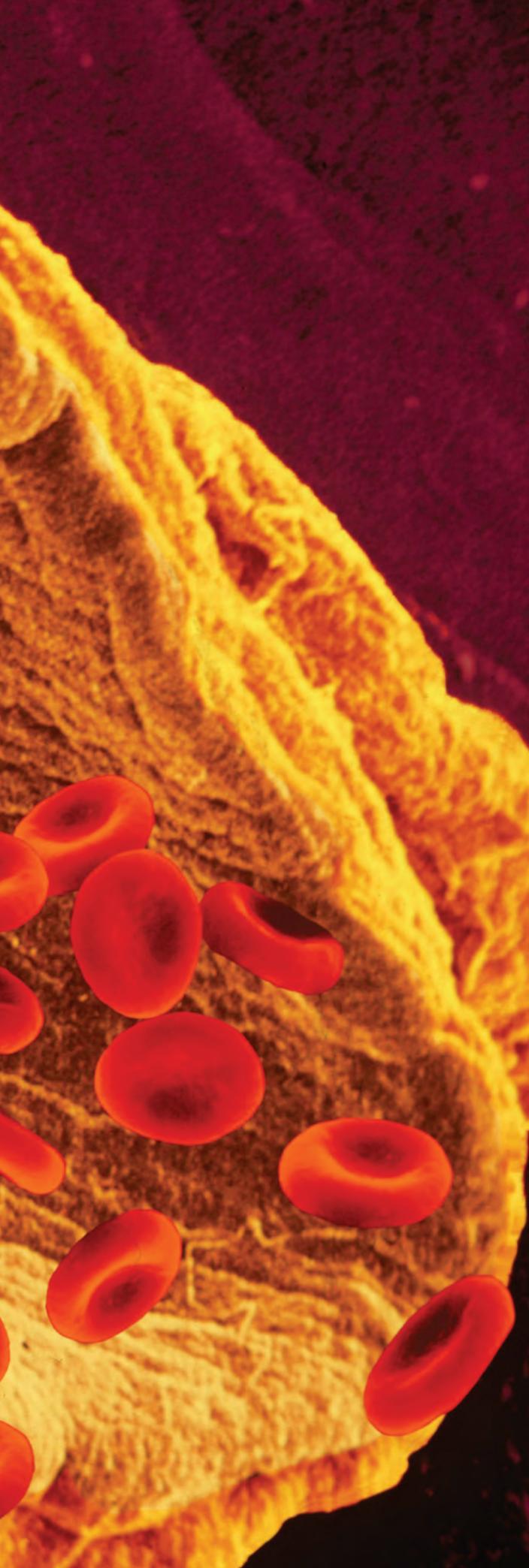


Tissues, Organs, and Systems of Living Things



Scanning electron micrograph of red and white blood cells flowing through a vein in a human leg (magnification 4000 \times)



Contents

1 Cells are the basic unit of life and often combine with other cells to form tissues.

- 1.1 Plant and Animal Cells
- 1.2 The Cell Cycle and Mitosis **DI**
- 1.3 Specialized Plant and Animal Cells

2 An organ consists of groups of tissues and works with other organs to form organ systems.

- 2.1 Organs in Animals and Plants **DI**
- 2.2 Organ Systems in Animals and Plants
- 2.3 Interdependent Organ Systems

3 Advances in biological technologies have an impact on individuals and society.

- 3.1 Medical Imaging Technologies **DI**
- 3.2 Public Health Strategies to Prevent Disease
- 3.3 Social and Ethical Issues in Systems Biology

Unit Task

Advancements in systems biology have affected society both in good ways and in bad ways. Your task is to present an opinion on how these advances have affected society. You may also discuss the controversies surrounding the advancements as well as the next step in development that may occur. Your presentation should be in the form of a collage, comic, video, PowerPoint presentation, monologue, written report, or brochure.

Essential Question

How have advancements in systems biology affected individuals and society?

Exploring



To protect themselves from the Spanish flu pandemic, people were encouraged to wear cloth masks.

Reviving a Killer

In 1918, one of the deadliest diseases was unleashed on the world. In early March of that year, medical authorities in the United States reported the first case of a deadly influenza. The symptoms — the skin turned blue, the feet turned black, and the lungs filled with blood — were unlike any symptoms previously seen. Victims, who were mostly young men and women, became ill and died within hours. At a time when hundreds of young adults were being killed while fighting in a world war, thousands more were being killed at home by the influenza virus. Within months of the first case, there were reports of widespread outbreaks in many parts of the world. Because the influenza infected people around the world, it was known as a pandemic. This influenza became known as the Spanish flu because it was first widely reported in Spanish newspapers. During the first six months of this pandemic, millions of people died. The Spanish flu was responsible for the deaths of between 25 million and 50 million people died from the Spanish flu.

Between 25 million and 50 million people died from the Spanish flu.

At the time, doctors believed that the spread of influenza could be controlled by limiting contact with the source of disease. People were told to wear masks when they were out in public, to cover the nose and mouth when coughing, and not to shake hands. Some people were put in quarantine, a situation in which an ill person or a suspected ill person was kept away from other people.

Lessons Learned

Scientists learned valuable lessons from the 1918–1919 Spanish flu pandemic and were better prepared for the Asian influenza pandemic that occurred in 1957–1958 and the Hong Kong influenza pandemic in 1968. Governments and organizations, such as the World Health Organization, developed plans to handle future influenza pandemics.

One strategy involved studying and researching the Spanish flu virus itself. In 1997, a team of researchers led by Canadian Dr. Kirsty Duncan dug up bodies of 1918 influenza victims buried in a Norwegian cemetery and attempted to “revive” the virus. Although researchers believed that the virus would still be capable of reproducing, this was not true. However, in 2005, American researchers were able to restore the virus using pieces of the virus obtained from various sources. Researchers in Canada and the U.S. are currently working with the restored virus to understand what made it so deadly.

In 2008, scientists gained permission to study the corpse of a 39-year-old British diplomat who had died in 1918 from influenza. Because the body is in a lead-lined casket, researchers believe the body will be very well preserved and they will be able to obtain samples that will reveal information about the virus. By reviving and studying a killer virus, scientists hope to prevent future deaths from the virus.



A scientist works with the resurrected 1918 influenza virus in a special airflow cabinet. Air is sucked into the cabinet and filtered before it is recirculated in a sealed laboratory.

A1 STSE *Science, Technology, Society, and the Environment*

Questions about Quarantine

During the Spanish flu pandemic, health officials attempted to prevent the spread of the disease by placing sick people in quarantine. Quarantine restricted the actions of individuals who appeared to have the illness and kept them away from healthy people. An individual would be kept in quarantine until symptoms of the illness were gone. In some situations, signs would be posted on the front door of houses to indicate the presence of a quarantine. Today, public health officials may impose quarantine to stop the spread of disease.

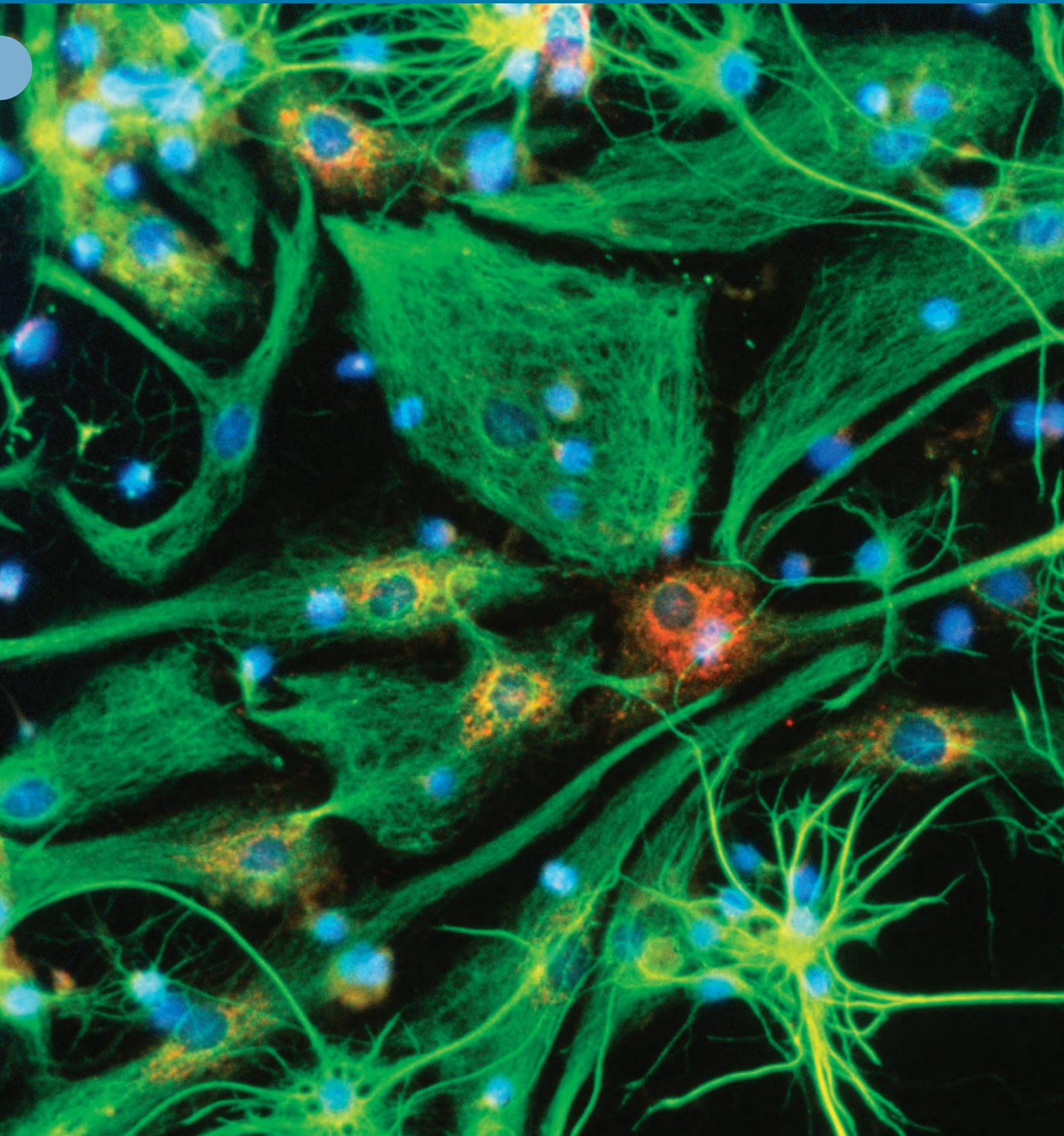
You will consider some of the political, economic, social, and ethical issues associated with using quarantine to prevent the spread of infectious diseases.

- As a class, discuss the term “quarantine” and give examples of the use of quarantine in society.

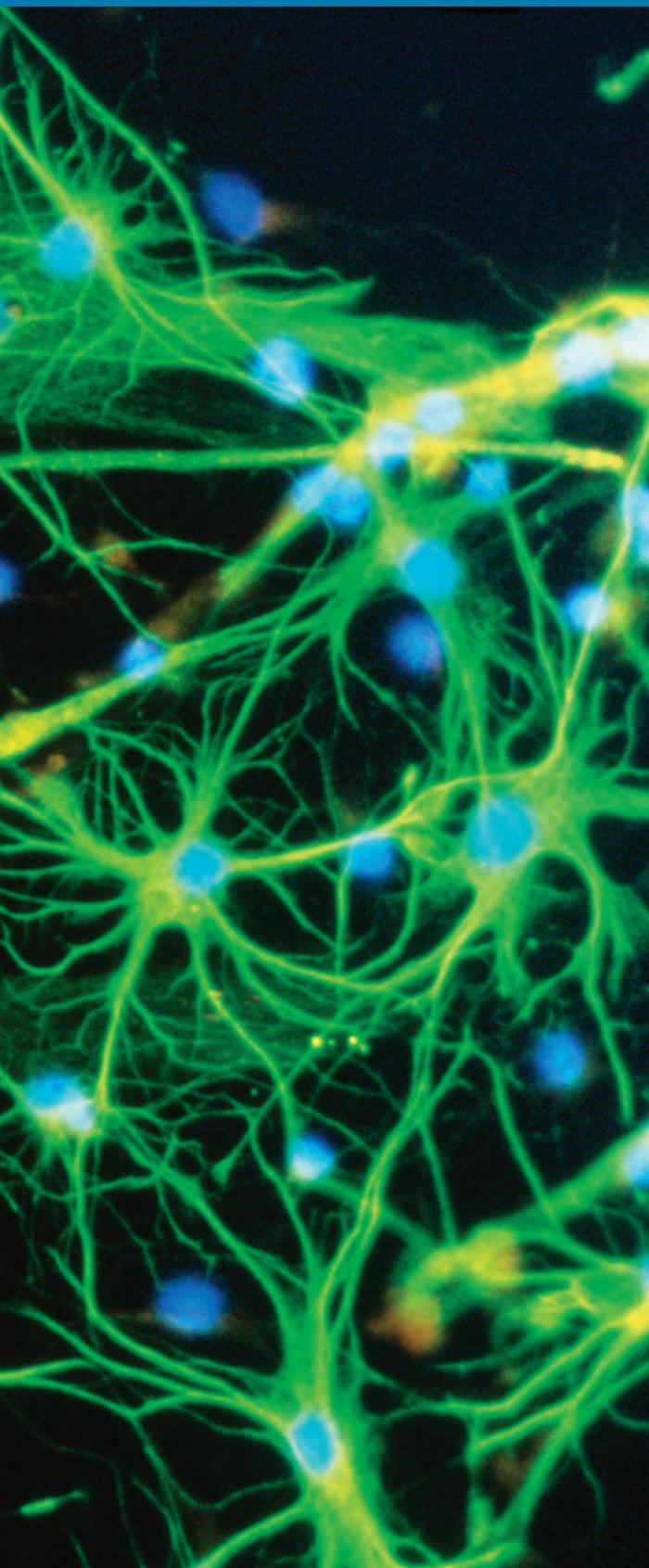
- Work with a partner and think about the implications of living in your house under an imposed quarantine for two weeks.
- Repeat step 2, but assume that you are in need of medical care and that the local hospital is under quarantine.
- Should governments have the right to impose a quarantine on individuals? Explain your answer.
- What economic problems could be associated with the imposition of quarantine?
- Explain some of the social problems that could be associated with the imposition of quarantine.
- Explain some of the ethical issues associated with the imposition of quarantine.
- Do you think that placing sick people in quarantine prevents the spread of disease? Explain your answer.

1

Cells are the basic unit of life and often combine with other cells to form tissues.



Astrocites (light green) are star-shaped cells in the brain and spinal cord.



Skills You Will Use

In this chapter, you will:

- examine cells under a microscope to identify the various stages of mitosis in plants and animals
- examine different plant and animal cells under a microscope, and draw labelled biological diagrams to show how the cells' organelles differ
- investigate, using a microscope, specialized cells in the human body or in plants, focussing on different types of cells, and draw labelled biological diagrams to show the cells' structural differences
- investigate the rate of cell division in cancerous and non-cancerous cells using pictures or images, and predict the impact of this rate of cell division on an organism

Concepts You Will Learn

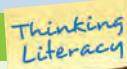
In this chapter, you will:

- describe the cell cycle in plants and animals, and explain the importance of mitosis for the growth of cells and repair of tissues
- explain the importance of cell division and cell specialization in generating new tissues
- explain the links between specialized cells and tissues in plants and animals

Why It Is Important

An important step in understanding how your body works is understanding the cell. Your body is made of trillions of cells.

Before Reading



Set a Goal to Understand New Vocabulary

To understand the content of this chapter, you will need to understand many new terms. How many words in the following list of key terms do you recognize? Preview section 1.1, and note the terms in bold print. Make a two-column chart, recording new terms in the first column. Add definitions or explanations in the second column as you read.

Key Terms

- anaphase • cell • concentration • differentiation • diffusion
- meristematic cells • meristematic tissue • mesophyll
- mitosis • organelle • phloem • prophase • red blood cells
- regeneration • stomate • tissue • xylem

1.1

Plant and Animal Cells

Here is a summary of what you will learn in this section:

- Cells have special structures that enable them to perform important life functions.
- Scientists use technology, such as the microscope, to understand the cell.

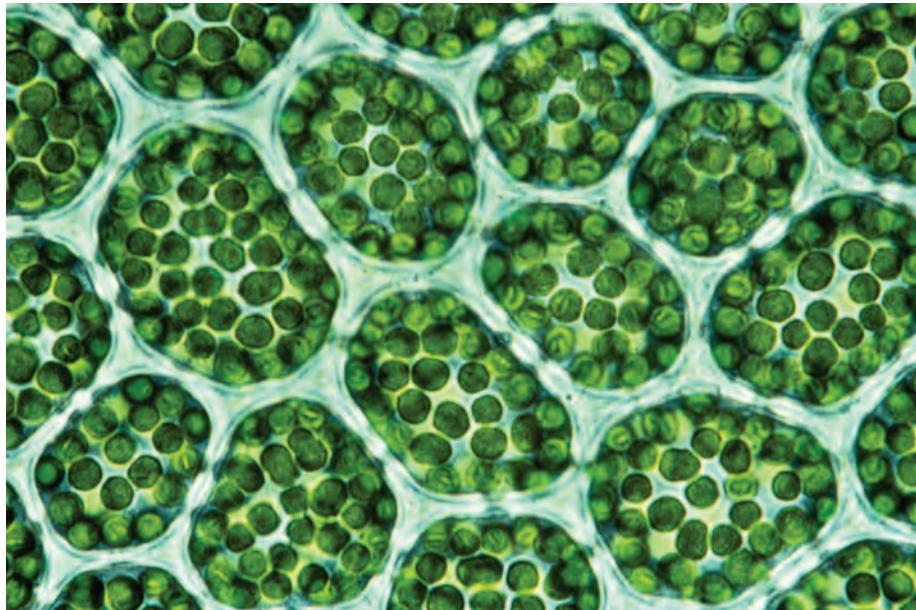


Figure 1.1 A piece of moss, as seen through a microscope, shows many cells filled with chloroplasts, an organelle involved in photosynthesis. The cells are shown at a magnification of 500 \times .

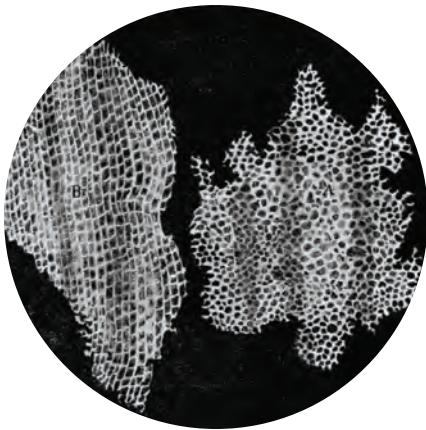


Figure 1.2 Robert Hooke's drawing of cork cells, as seen under a microscope. He used the term "cells" based on what he saw.

The Discovery of the Cell

When the microscope was invented in the mid-1600s, it became possible for scientists to look at the previously invisible world of the cell. Imagine the strange and beautiful structures that appeared before the eyes of these scientists. Today, we use sophisticated electron microscopes that allow us to not only see the cell in detail but also to get a glimpse of some amazing sights (Figure 1.1).

Robert Hooke was the first to describe cells in 1663 (Figure 1.2). He thought that the cells were the passages for fluids in a plant. Today, we understand that a cell is the basic building block of life. Every living organism is made of cells. A cell takes in nutrients from its environment and releases waste products into its environment. A cell can also divide to make copies of itself. A cell contains everything that it needs to live and grow.

Using Technology to Study the Cell

In the early days of cell biology, scientists used simple light microscopes to view sliced sections of living cells. These microscopes helped scientists see and study the external structure of a cell but revealed few details about the tiny specialized working parts within the cell.

Advances in technology, such as the development of the electron microscope (Figure 1.3), have allowed biologists to learn detailed information about different cell parts and their functions. Technology has also made the process of learning about the cell easier. For example, the electron microscope can produce images that are 1000 times more detailed than the light microscope (Figure 1.4).

The discovery of the cell is an example of how scientific knowledge depends on technology. As our technology continues to improve, our knowledge and understanding of the cell will continue to expand.



Figure 1.3 The world's most powerful electron microscope, the Titan 80-300 Cubed, was installed at McMaster University in Hamilton, Ontario, in October 2008.

Figure 1.4 Red blood cells viewed through a scanning electron microscope (magnification 3700 \times)

A2 Quick Lab

What We Remember about the Cell

Cells come in a variety of shapes and sizes. However, there are some structures that are common to cells. There are also some differences. This activity will give you an opportunity to review the information that you know about the cell.

Purpose

To create a graphic organizer that shows what you remember about the cell

Procedure

1. Work in a small group of 2–4 students.
2. Brainstorm for two minutes with your group about what you remember about the cell. You may wish to use words, pictures, or phrases. Think about the different parts of the cell, the functions of these parts, or different examples of cells.
3. Create a graphic organizer using the words, pictures, or phrases that you came up with in step 2.

Questions

4. Sometimes, we remember things better if we can visualize an example or illustration. What type of cell did you visualize when you were brainstorming about the cell?
5. There are many parts in a cell. Sometimes, it is easier to remember the functions of the different cell parts by using analogies to everyday things. For example, we may say that the cell has a part that acts like a brain. Use an analogy to describe one specific part of the cell that you placed in your graphic organizer.
6. Did your group find that it was easier to remember the parts of the cell, functions of the cell, or examples of cells? Explain.

WORDS MATTER

The word “cell” is derived from the Latin word *cellula*, meaning small compartment. The word “cyto,” as in cytoplasm, is from the Greek root meaning cell.

Cell Parts and Their Functions

All living things are made of cells. Our bodies are made up of between 10 trillion (10^{13}) and 100 trillion (10^{14}) cells. A **cell** is the basic unit of life. Each cell contains smaller parts called **organelles**. These organelles have special functions that maintain all the life processes of the cell, including:

- intake of nutrients
- movement
- growth
- response to stimuli
- exchange of gases
- waste removal
- reproduction

There are two types of cells: plant cells and animal cells (Figures 1.5 and 1.6).

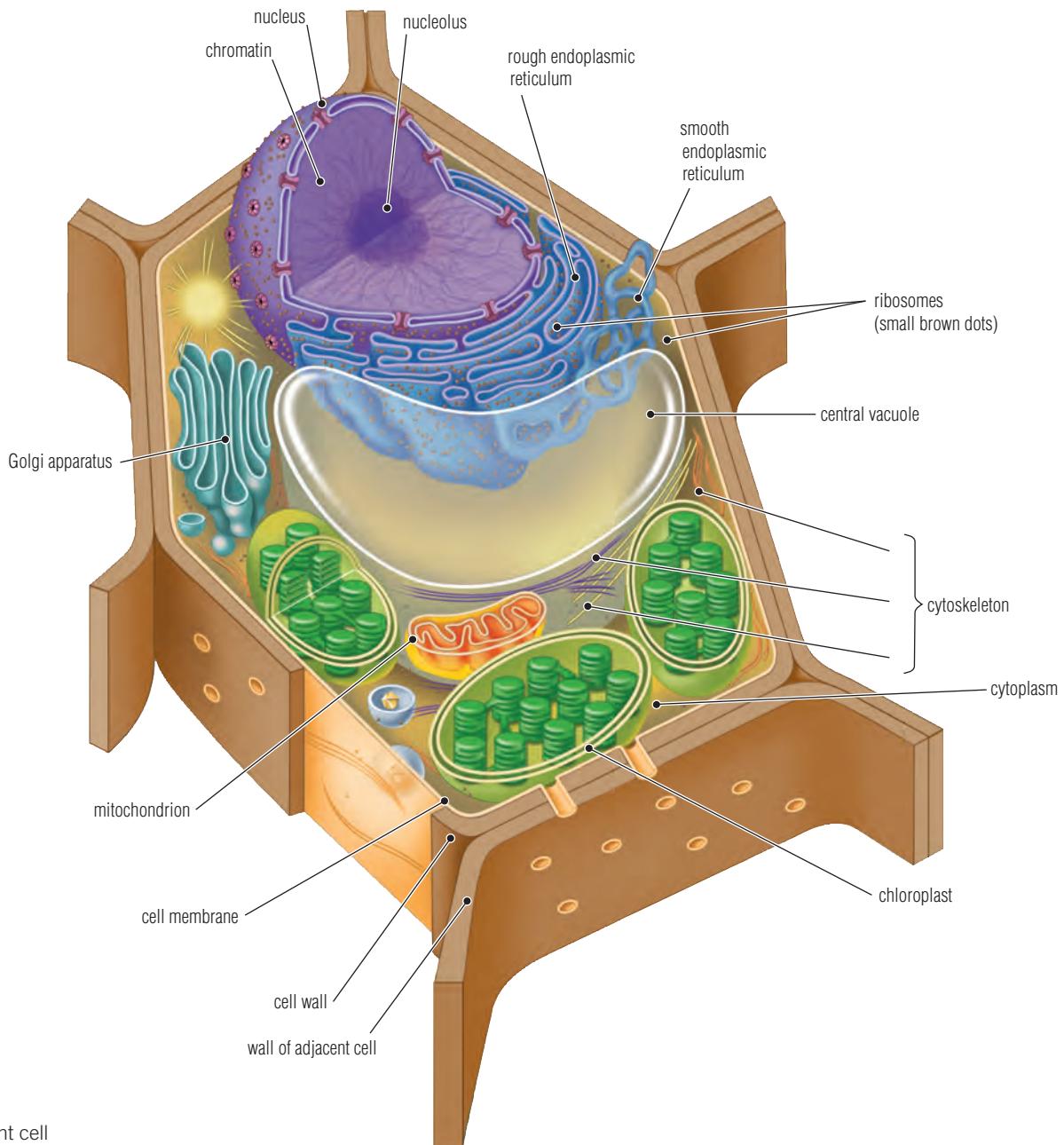


Figure 1.5 A plant cell

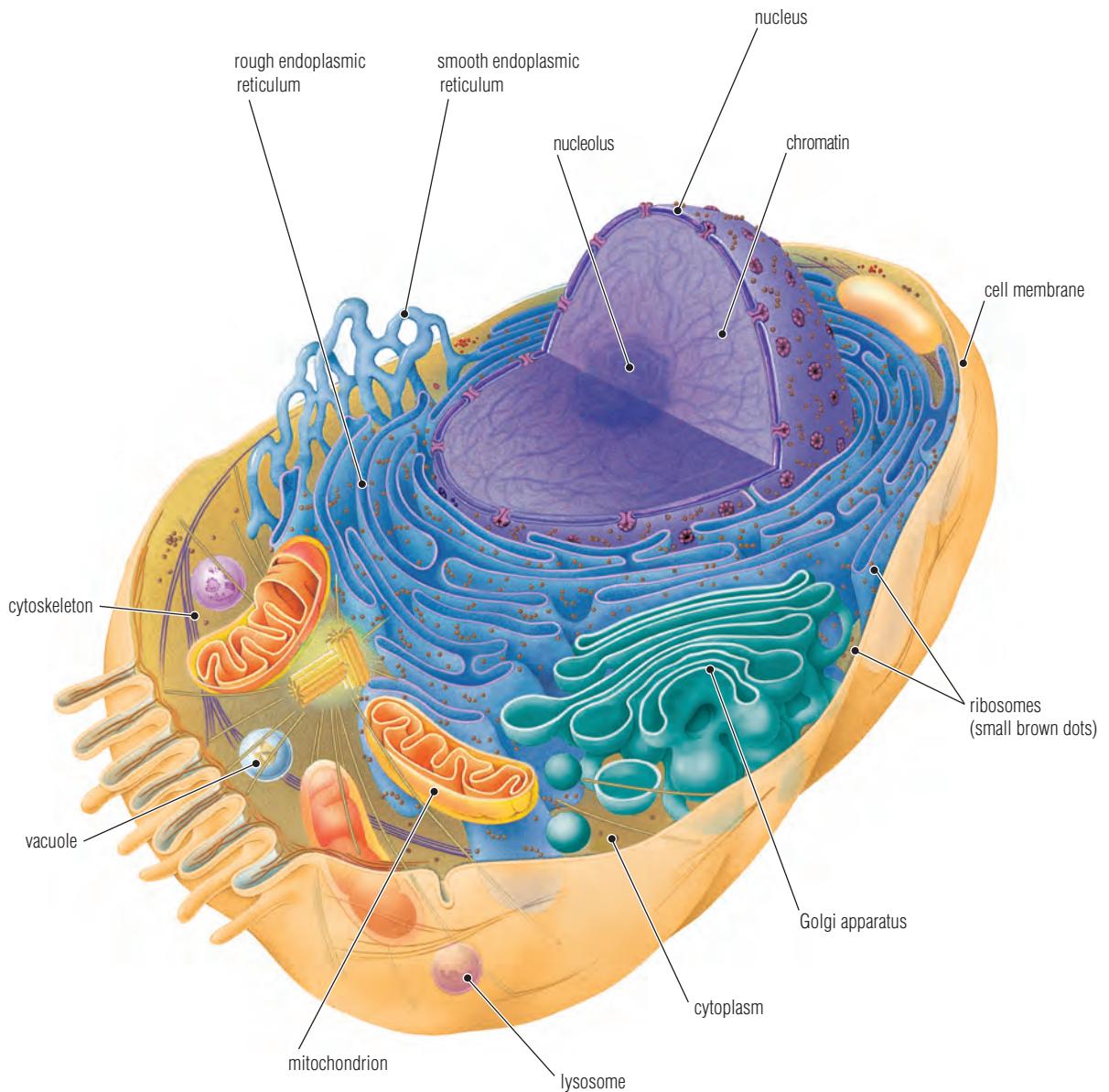


Figure 1.6 An animal cell

Structures and Organelles in Cells

A cell contains structures and organelles that carry out various functions. Although all cells must perform the tasks that maintain life, not all cells are identical. Therefore, some structures and organelles are the same in both plant and animal cells while other structures and organelles differ between plant and animal cells.

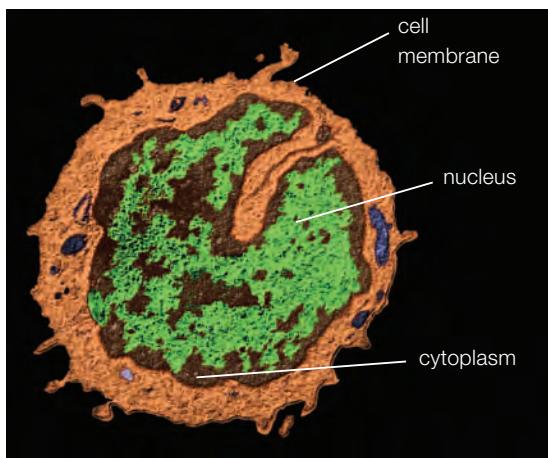


Figure 1.7 A cell showing the cell membrane, cytoplasm, and large nucleus (magnification 6000 \times)

Cell Membrane

Every cell has a **cell membrane** that forms a protective barrier around the cell (Figure 1.7). The cell membrane is made of a double layer of lipids. A lipid is a fat-like molecule that does not dissolve in water. The cell membrane is designed to allow different substances to move through it.

One process for moving substances across the cell membrane is called **diffusion**. Diffusion depends on the concentration of the substance on both sides of membrane. The amount of dissolved particles, called solutes, in a solution is the **concentration**. When a substance is present in different concentrations on either side of the cell membrane, the particles will diffuse, or move, from an area of high concentration to an area of lower concentration (Figure 1.8).

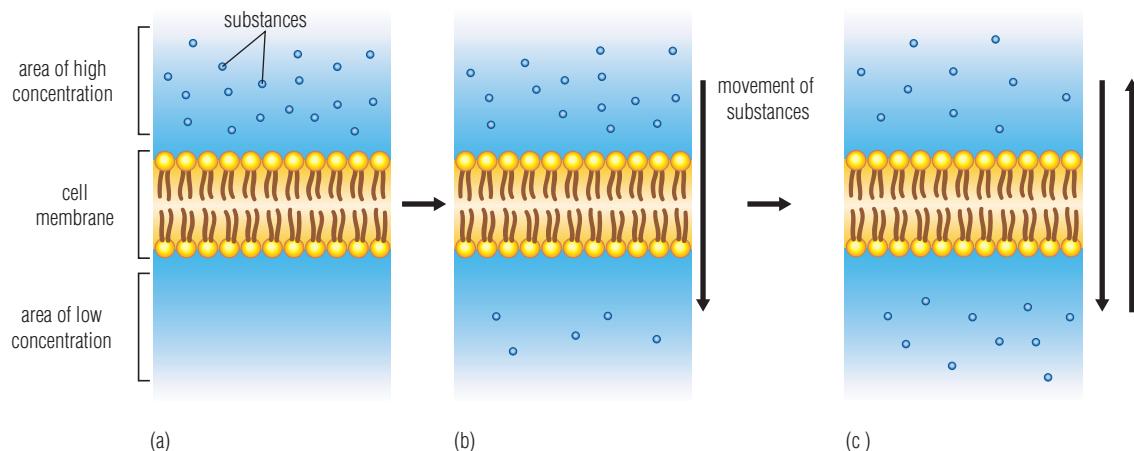


Figure 1.8 (a) There is a higher concentration of substances on one side of the cell membrane. (b) The substances move to the side that has a lower concentration until a balanced state, called equilibrium, is attained. (c) When equilibrium is reached, the substances diffuse across the cell membrane in both directions.

Cytoplasm

All cells contain **cytoplasm**, a jelly-like substance that fills the cell and surrounds the organelles (Figure 1.7). Cytoplasm contains the nutrients required by the cell to carry on its life processes. The organelles are suspended in the cytoplasm. The physical nature of the cytoplasm allows the nutrients and organelles to move within the cell.

Nucleus

The **nucleus** is the control centre organelle of the cell (Figure 1.7). It controls all the activities in a cell, including growth and reproduction. The nucleus is surrounded by the nuclear envelope, which contains pores to allow the transport of materials. Most nuclei also contain a small dense area called the nucleolus.

The nucleus contains nearly all of the cell's DNA. DNA stands for deoxyribonucleic acid. Most of the time, the DNA is bound to proteins and appears as a granular substance known as chromatin (Figure 1.9). However, when a cell divides, the chromatin condenses to form chromosomes.

DNA is very important to the cell because it contains the coded information for making proteins and other molecules. Proteins serve many purposes and are found in various locations in the cell.

Vacuoles and Vesicles

Vacuoles and **vesicles** are membrane-bound organelles that store nutrients, wastes, and other substances used by the cell (Figure 1.10). In plant cells, the central vacuole stores water for the cell. When water enters the cell, the central vacuole swells, causing the plant cell to become firm. Vesicles transport substances throughout the cell.

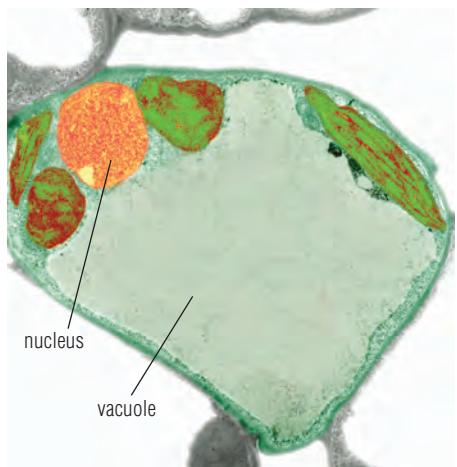


Figure 1.10 A leaf cell showing a large vacuole (pale green) and nucleus (orange) (magnification 11 000 \times)

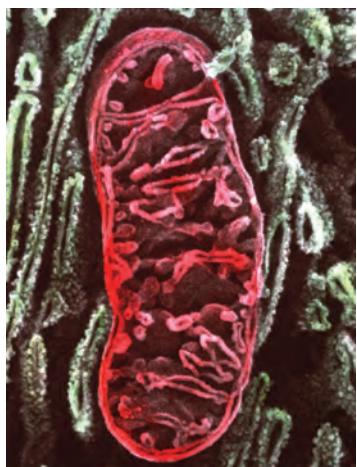


Figure 1.11 A mitochondrion, as seen through an electron microscope (magnification 80 000 \times)

Mitochondria

All cells require a source of energy: the organelles known as **mitochondria** supply that energy. Mitochondria are the powerhouses of the cell. Reactions occur in these organelles to convert the chemical energy in sugar into energy that the cell can use. Figure 1.11 shows a single mitochondrion.

Lysosomes

Lysosomes are organelles where digestion takes place. They are small organelles that are filled with enzymes. An enzyme is a protein that can speed up chemical reactions in the cell. Lysosomes also break down invading bacteria and damaged cell organelles. Essentially, they work as the clean-up system in the cell. Figure 1.12 shows a lysosome.

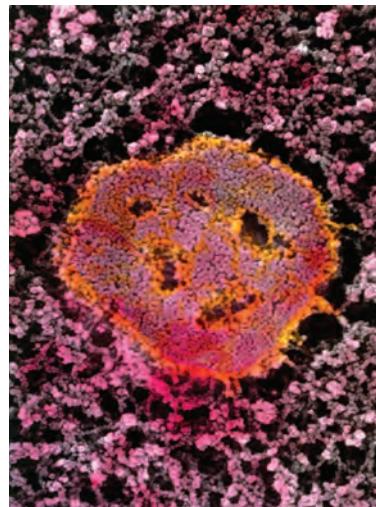


Figure 1.9 The nucleolus and chromatin in a human cell, as seen through an electron microscope

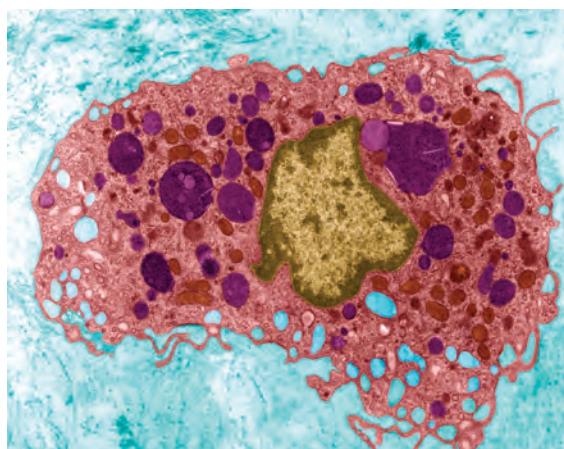


Figure 1.12 Lysosomes (purple) in a white blood cell. The cell's nucleus is light brown.

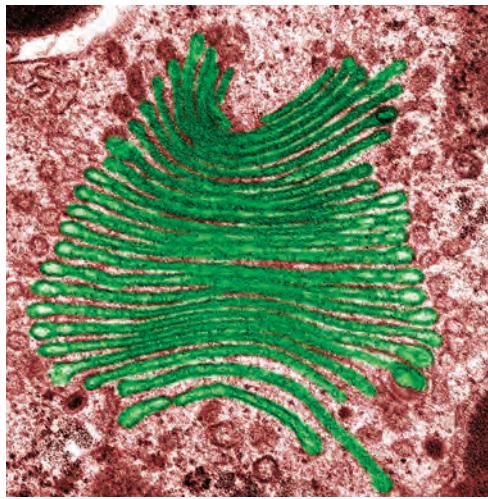


Figure 1.13 The Golgi apparatus is named after Camillo Golgi, who first identified it in 1898.

Golgi Apparatus

The **Golgi apparatus** receives proteins from the endoplasmic reticulum. The function of the Golgi apparatus is to modify, sort, and package these proteins for delivery throughout the cell or outside of the cell. The Golgi apparatus looks like a stack of flattened membranes (Figure 1.13).

Endoplasmic Reticulum

The endoplasmic reticulum is an organelle that is made of a series of interconnected small tubes that carry materials through the cell. **Rough endoplasmic reticulum** is associated with making proteins (Figure 1.14). **Ribosomes** are small, dense-looking organelles that may be attached to the rough endoplasmic reticulum or free in the cytoplasm. Ribosomes are the sites where proteins are assembled. **Smooth endoplasmic reticulum** is associated with the production of fats and oils (Figure 1.15). Smooth endoplasmic reticulum does not have ribosomes.

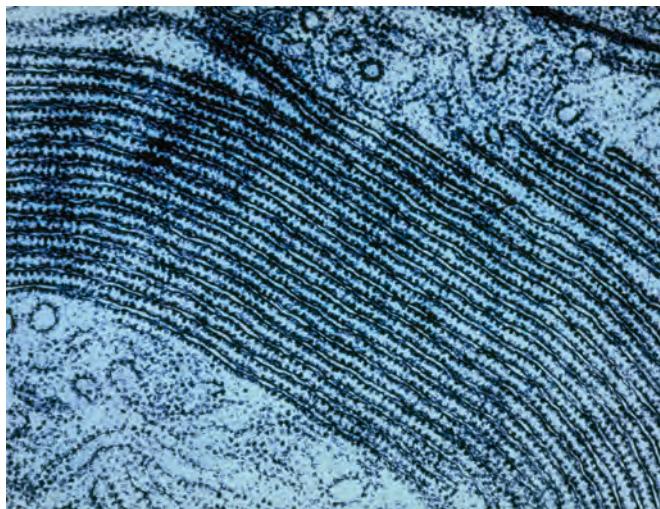


Figure 1.14 Rough endoplasmic reticulum and ribosomes

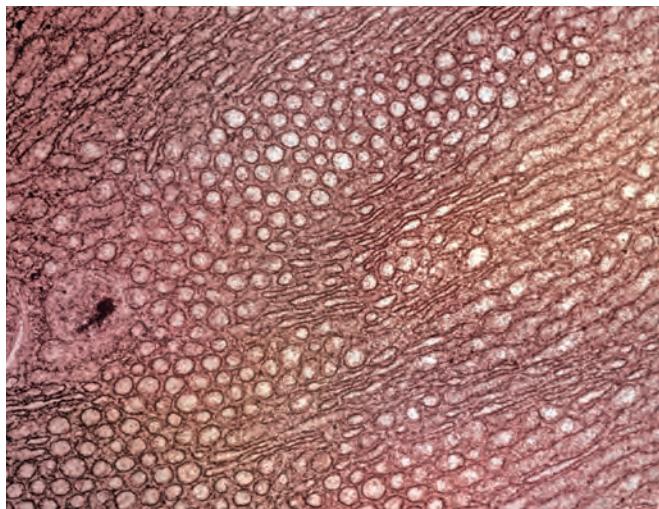


Figure 1.15 Smooth endoplasmic reticulum

Cytoskeleton

All cells have an internal network of fibres, called the **cytoskeleton**. The cytoskeleton is made up of protein filaments. It helps maintain the cell's shape.

Organelles in Plant Cells

Some organelles are found only in plant cells.

Cell Wall

Only plant cells, bacteria, fungi, and some algae have a cell wall. The **cell wall** is a rigid frame around the cell that provides strength, protection, and support (Figure 1.16).

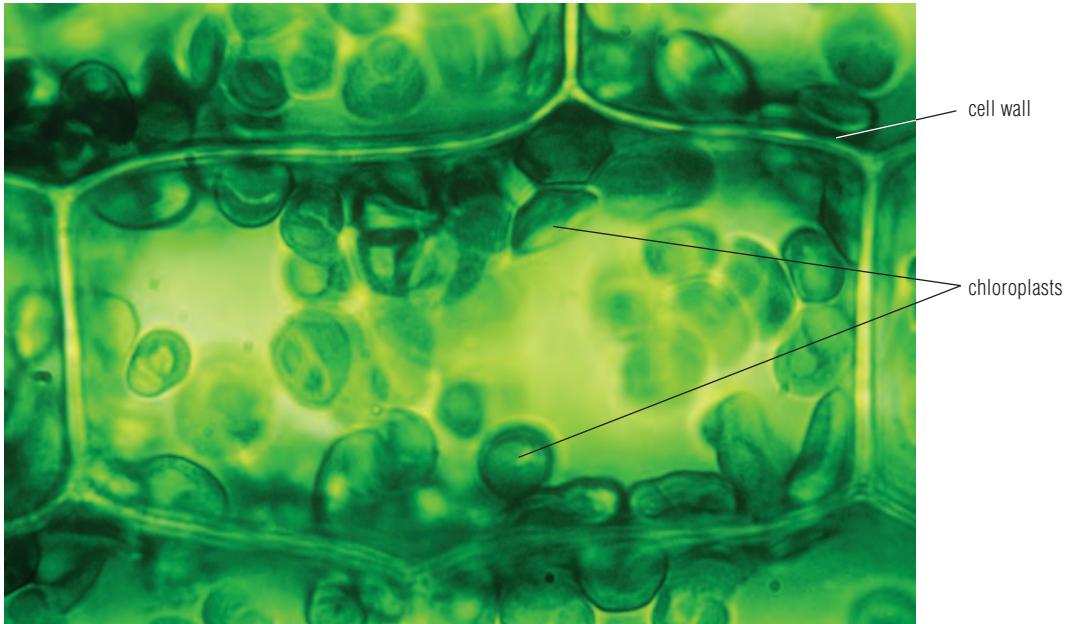


Figure 1.16 A leaf cell showing the cell wall and many chloroplasts (magnification 1000×)

Chloroplasts

Chloroplasts are found only in plant cells and some algae. These organelles contain a green substance called chlorophyll. Chlorophyll uses energy from the Sun to convert carbon dioxide and water into sugar and oxygen in a process called photosynthesis. Figure 1.17 shows the internal structure of a chloroplast. The chloroplast is made up of little sacs known as **thylakoids**. Thylakoids are stacked together in a way that resembles a stack of coins. They are surrounded by a thick fluid called stroma. A stack of thylakoids is called a **grana**; chloroplasts may have many grana. You can think of the thylakoids as being “solar collectors.” They collect light energy from the Sun, which is used during the process of photosynthesis to produce carbohydrates. The carbohydrates are used for the growth of the plant.

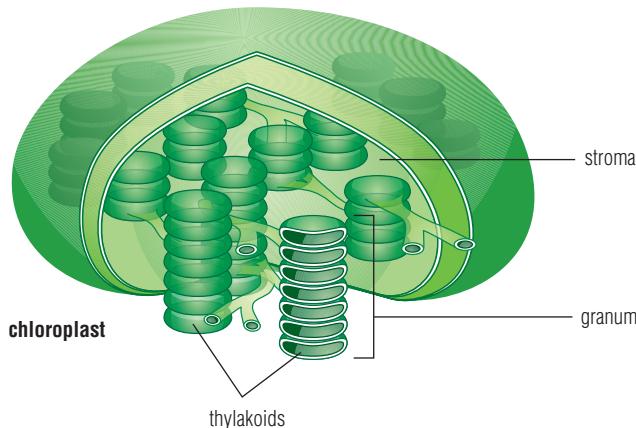


Figure 1.17 Photosynthesis takes place in the chloroplast in a plant cell.

During Reading

Thinking Literacy

One Word Connects to Another Word

In the passage on chloroplasts, note the way in which each term is connected to another term. Create a concept map to show the connections. Begin with a top bubble with the term “chloroplast,” and then connect the other terms as you read the paragraph. Try this strategy with another paragraph that contains new terms.

Suggested Activities •••••

- A6 Inquiry Activity on page 24
- A3 Quick Lab on page 21
- A4 Quick Lab on page 21

Differences between Plant and Animal Cells

Cell walls and chloroplasts are only found in plant cells. However, there are other differences between plant and animal cells:

- Plant cells contain a specialized chemical compound called chlorophyll, a pigment that makes photosynthesis possible.
- Plant cells have a large central vacuole. Vacuoles in animal cells tend to be small.
- Some plant cells store energy in the form of starch or oils, such as cornstarch and canola oil. Animal cells store energy in the form of glycogen, a carbohydrate, or as lipids in the form of fats.
- Some animal cells have specialized compounds: for example, hemoglobin in red blood cells and cholesterol in other cells.
- Animal cells have **centrioles**, which are paired structures that are involved in cell division. Plant cells do not have centrioles.

Learning Checkpoint

1. What is an organelle?
2. What is the function of vacuoles and vesicles?
3. Describe the relationship between the functions of the endoplasmic reticulum and the Golgi apparatus.
4. Explain the role of the thylakoids in the process of photosynthesis.
5. State two similarities and two differences between plant and animal cells.

The Microscope as a Tool for Cell Research

The cell is very small — too small to be seen with the unaided eye. Once the microscope was developed, scientists were able to see and study the cell. Today, biologists use different types of microscopes to explore cell structure and function. This knowledge is useful in assessing our health because cells can be viewed under a microscope to look for abnormalities.

Compound Light Microscope

A compound light microscope uses light focussed through different lenses to form a magnified image of a specimen or object. Figure 1.18 shows a compound light microscope.

Table 1.1 Parts of a Microscope

Part	Function
1. Tube	Separates the ocular lens from the objective lens
2. Revolving nosepiece	Holds the objective lenses
3. Objective lenses	Magnify specimen; three lenses are usually 4 \times , 10 \times , and 40 \times
4. Stage	Supports the slide for observation
5. Diaphragm	Allows light to pass through the specimen
6. Condenser lens	Focusses light onto the specimen
7. Lamp	Supplies the light that passes through the specimen
8. Base	Provides a stable platform for the microscope
9. Fine adjustment knob	Sharpens an image
10. Coarse adjustment knob	Moves the stage up or down to focus on the specimen
11. Stage clips	Hold the slide in position on the stage
12. Arm	Holds the tube in place and is used to carry the microscope
13. Eyepiece or ocular lens	Magnifies the specimen, usually by 10 \times ; single lens

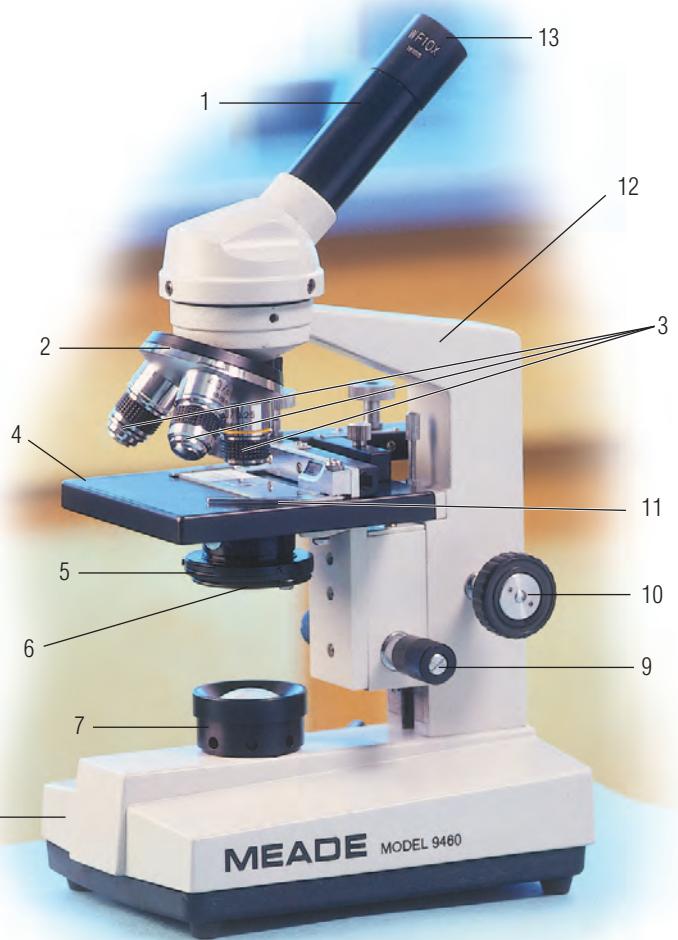


Figure 1.18 This compound light microscope is commonly found in science classrooms.

Magnification

The first microscope had a magnification of $20\times$, which meant that it produced an image that was enlarged by about 20 times. A compound light microscope has a series of lenses, which permits a higher level of magnification. For example, the compound light microscope has a maximum magnification of $1000\times$ to $2000\times$; this means that the image is 1000 to 2000 times bigger than the actual object. To find the total magnification, you multiply the power of the objective lens by the power of the ocular lens (eyepiece).

A photo taken through a microscope is called a micrograph. A micrograph shows the magnified image of a specimen. To produce a micrograph, either a camera is attached to a microscope in place of the eyepiece or a special microscope that has a camera and an eyepiece is used.

Suggested Activity •

A5 Inquiry Activity on page 22

Practice Problems

1. Determine the total magnification of a microscope with an objective lens of $100\times$ and an ocular lens of $10\times$.
2. Determine the total magnification of a microscope with an objective lens of $4\times$ and an ocular lens of $10\times$.
3. Determine the total magnification of a microscope with an objective lens of $40\times$ and an ocular lens of $10\times$.

Example Problem 1.1

Determine the total magnification of a microscope if the magnification of the objective lens is $10\times$ and the magnification of the ocular lens is $10\times$.

Given

Magnification of objective lens = $10\times$
Magnification of ocular lens = $10\times$

Required

Total magnification = ?

Analysis and Solution

Multiply the magnification of the objective lens by the magnification of the ocular lens to get the total magnification.
 $(10\times)(10\times) = 100\times$

Paraphrase

Therefore, the total magnification is $100\times$.

Resolution

Regardless of the magnification, being able to see clear detail in an image depends on the resolution, or resolving power, of the microscope. Resolution is the ability to distinguish between two objects that are very close together. For example, look at Figure 1.19. You may be able to see the individual dots in A and B, but it is hard to see the dots in D. This is because most people can only see dots that are 0.1 mm or larger. Using a compound light microscope, we can see individual objects that are closer together than 0.1 mm.

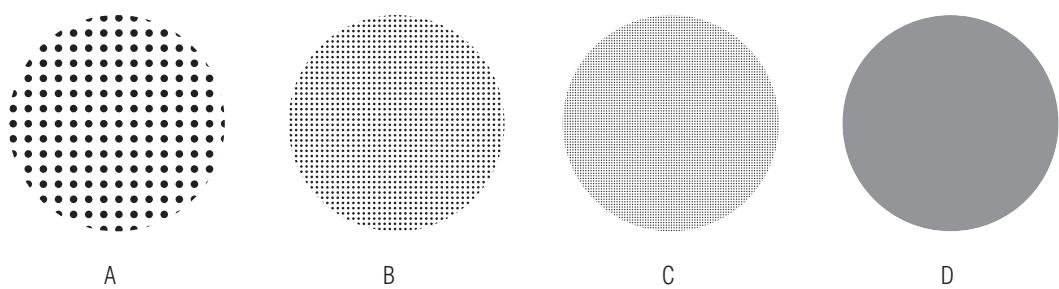


Figure 1.19 Can you see the individual dots that make up the circles in A, B, C, and D?

Contrast

It can be difficult to see the cell parts because both the cell and its background may be pale or transparent. Scientists use stains to improve the contrast between a cell's structures and the background and to produce better images. Two common stains are methylene blue and iodine. In fluorescence microscopy, fluorescent substances are added to the cells. When the cells are placed in ultraviolet light, the fluorescent substances glow (Figure 1.20).

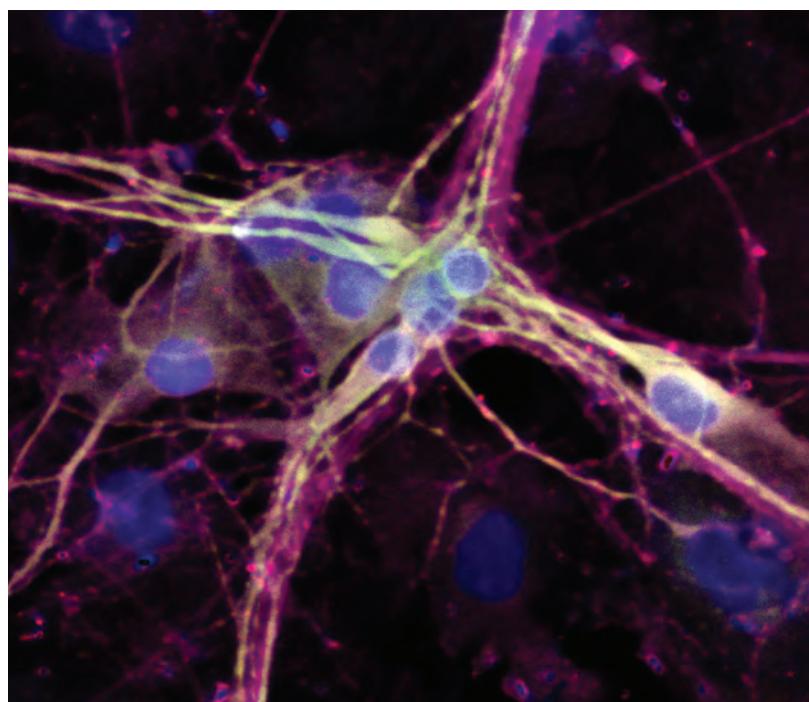


Figure 1.20 A micrograph showing nerve cells that have been stained with a fluorescent stain.

Electron Microscopes

An electron microscope uses a beam of electrons instead of light. The transmission electron microscope (TEM) is capable of magnifications of up to $1\,500\,000\times$ (Figure 1.21). Since a beam of electrons can pass through thin slices, only thin sections of cells can be examined. This means that an electron microscope cannot be used to look at living cells — only dead cells can be observed.

A scanning electron microscope (SEM) provides information about the surface features of a specimen (Figure 1.22). The SEM operates up to a magnification of $300\,000\times$ and produces three-dimensional images of cells.

A photograph taken through either a TEM or an SEM is called an electron micrograph. An electron micrograph provides detailed information about the surface and texture of a cell, the shape and size of the particles in the cell, and the arrangement of the materials in a cell.

As a result of new technology, research on cells has led to major breakthroughs in medicine and industry. For example, the scanning tunnelling microscope (STM) and the atomic force microscope (AFM) produce images of molecules within cells, which help scientists understand the structure and function of molecules within the cell.

Take It Further

Take a closer look at either the mitochondrion or the lysosome. Briefly describe the function of the organelle. Find out how the electron microscope has improved the understanding of the structure and function of this organelle. Use a graphic organizer to record your thoughts and your sources. Begin your research at *ScienceSource*.



Figure 1.21 In a transmission electron microscope, the electrons travel down the microscope column and pass through the specimen. An image forms on a fluorescent screen at the bottom of the column.



Figure 1.22 A researcher using a scanning electron microscope

A3 Quick Lab

Cells on Display

Purpose

To create a model of a plant or an animal cell

Materials & Equipment

- coloured modelling clay

Procedure

1. Select the type of cell — plant or animal — that you will model.

2. You will work in partners. Decide which of the cell parts you will include in your model. For each cell part, decide on the shape, size, and texture.
3. Create your model using the modelling clay, and share it with the class.

Questions

4. How do you think that the shape and structure of a specific cell part relates to its function? Explain your answer.
5. In this activity, you created a scientific model of the cell. What are some limitations of your model?

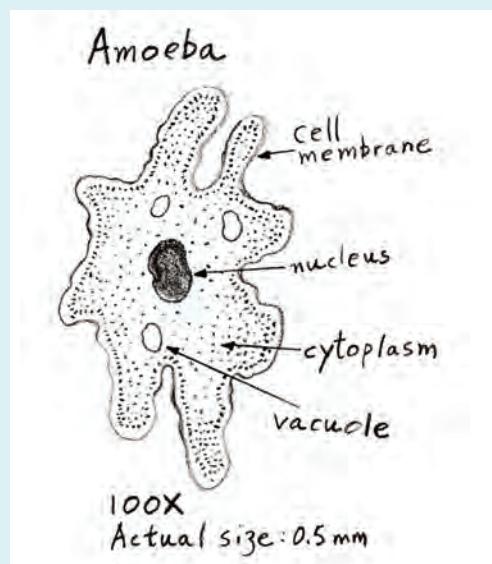
A4 Quick Lab

Practice Makes Perfect!

It is useful to record your observations when using a microscope. A sketch is a basic drawing that provides little detail but is accurate in scale and in proportion (Figure 1.23).

Purpose

To practise drawing sketches of cells



Materials & Equipment

- | | |
|-------------------|---------------------|
| • LCD projector | • pen and/or pencil |
| • prepared slides | • transparent ruler |
| • paper | |

Procedure

1. Your teacher will display a prepared slide on an LCD projector. Study the cell carefully.
2. Draw a sketch of the cell showing the external structures. Make sure that your sketch reflects accurate scale and proportion.
3. Repeat step 2 for the other slides. Be sure to include a title for each sketch.

Questions

4. What aspects of sketching did you find easy? What aspects did you find difficult?
5. What could you do to improve your sketches?

Figure 1.23 A labelled sketch of an amoeba

- Using equipment, materials, and technology accurately and safely
- Communicating ideas, procedures, and results in a variety of forms

Creating Biological Diagrams of Plant and Animal Cells

A compound light microscope magnifies the image of a specimen. The magnification depends on the combination of lenses used. While it is interesting and informative to view objects under a microscope, it is difficult to know the actual size of the object being observed. To learn how to estimate the size of an object, you will compare it with something you already know — the diameter of the field of view, which is the entire area that you see when you look through the ocular lens. You will then estimate the size of plant and animal cells. You will record your observations in the form of a labelled biological diagram.

Question

How can a compound light microscope be used to estimate the size of a plant or animal cell?



Materials & Equipment

- compound light microscope
- pen and/or pencil
- paper
- transparent metric ruler
- prepared slides of plant and animal cells

CAUTION: Practise proper techniques in handling the microscope and slides.

Procedure

Part 1 — Determining the Size of the Field of View

1. Review the proper handling and use of the microscope in Skills Reference 10.
2. Copy Table 1.2 in your notebook. Record the magnification for each power.

Table 1.2 Microscope Magnification and Field Diameter

Field	Magnification	Field Diameter (mm)	Field Diameter (μm)
low power			
high power			

3. Set up your microscope and place a transparent metric ruler on the stage, so that it covers about half of the stage, as shown in Figure 1.24.

4. Observe the ruler under low power. Move the ruler so that you are measuring the diameter (width) of the low-power field of view from left to right. Set one of the millimetre divisions at the edge of the field of view, as shown in Figure 1.25.



Figure 1.24 Set-up for measuring the diameter of the field of view

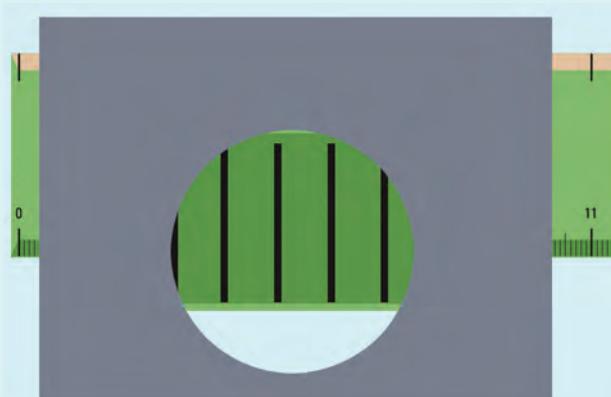


Figure 1.25 Move the ruler so that you can measure the diameter of the field of view. Line up a millimetre mark at the edge of the circle.

A5 Inquiry Activity (continued)

5. Measure the diameter of the low-power field of view to the nearest tenth of a millimetre. Record this measurement in your table. Convert the diameter from millimetres to micrometres, and record the measurement in your table. Remember that $1\text{ mm} = 1000\text{ }\mu\text{m}$.
6. You cannot measure the diameter of the high-power (HP) field of view because it is less than 1 mm. However, you can use the following ratio to calculate the field diameter under high power.

$$\frac{\text{high-power field diameter}}{\text{low-power field diameter}} = \frac{\text{low-power magnification}}{\text{high-power magnification}}$$

Show your work. Record the high-power field diameter both in millimetres and micrometres in your table.

Part 2 — Estimating Cell Size

7. Examine a prepared slide of a plant cell through the low- and high-power objective lenses.
8. Draw what you see in the field of view on low power. Calculate the scale of your drawing by comparing the diameter of the circle in your drawing with the field diameter that you obtained in step 5. For example, if the field diameter of the low-power objective was 3 mm and the diameter of the circle on your drawing was 3 cm (30 mm), the scale of the drawing would be 10:1.
9. Estimate the size of the cells that you view under the microscope by comparing them with the diameter of the field of view. For example, a cell that takes up $\frac{1}{5}$ of a field of view that is 500 μm has a size of about $\frac{1}{5}$ of 500 μm , or 100 μm , while a cell that takes up $\frac{1}{2}$ of a field of view that is 500 μm in diameter has a size of about $\frac{1}{2}$ of 500 μm , or 250 μm .

10. Examine a prepared slide of an animal cell through the low- and high-power objective lenses. Repeat steps 8 and 9.
11. Clean up your work area. Make sure to follow your teacher's directions for safe disposal of materials. Wash your hands thoroughly.

Analyzing and Interpreting

12. How many times is the magnification increased when you change from the low-power to the high-power lens?
13. State two observable characteristics that you can use to distinguish an animal cell from a plant cell based on what you saw using the compound light microscope.

Skill Practice

14. When using a microscope to view living cells, it is sometimes difficult to obtain a good image of the object. What two things can you do to ensure optimal viewing of the image?

Forming Conclusions

15. How can you use a compound light microscope to estimate the size of a plant or animal cell?
16. If an object under low power had an actual cell length of 30 μm , what would the cell length be under high power?
17. When you changed from low to high power, the image also changed. State three ways in which the image changed as the magnification was increased.
18. How would you estimate the size of an object viewed under the high-power objective lens (40 \times) if you were given the size of the field diameter when using the low-power objective lens (4 \times)?

- Conducting inquiries safely
- Observing, and recording observations

Examining Plant and Animal Cells

There are some similarities and some differences between plant cells and animal cells that can be seen using a compound light microscope. You will look at cells from the human body and from an onion to see the similarities and the differences.

Question

What similarities and differences between plant and animal cells can be seen using a microscope?



Materials & Equipment

- clear adhesive tape
- compound light microscope
- methylene blue stain
- microscope slides and cover slips
- onion epidermis
- iodine stain
- paper
- paper towel
- pen and/or pencil
- tweezers

CAUTION: Practise proper techniques in handling the microscope and slides. Use care when staining. Cover your staining work area with a paper towel.

Procedure

Part 1 — Examining Animal Cells

1. Review the proper handling and use of the microscope in Skills Reference 10. Set up your microscope.
2. Take a small piece of clear adhesive tape, and stick it on the inside of your wrist. Remove the tape, and place it sticky side up on the slide.
3. Verify that cells are present by looking at your slide at low power and medium power.
4. Make a wet mount of your cells. Add a drop of methylene blue stain to the slide at one edge of the cover slip.
5. Place a piece of torn paper towel against the edge of the cover slip on the side opposite that of the stain. The stain should move under the cover slip toward the paper towel. When all of the cells are stained, remove the paper towel.

6. Place the slide on the microscope, and observe the cells.
7. Create a labelled diagram of your skin cells. Include the magnification and scale.

Part 2 — Examining Plant Cells

8. Obtain a small section of onion. Use the tweezers to pull off a thin transparent layer of cells.
9. Prepare a wet mount of the onion cells. Add a drop of iodine stain, and follow the staining procedure in step 5.
10. Place the slide on the microscope, and observe the cells.
11. Create a labelled diagram of the onion cells. Include the magnification and scale.
12. Clean up your work area. Make sure to follow your teacher's directions for safe disposal of materials. Wash your hands thoroughly.

Analyzing and Interpreting

13. Both the plant and animal cells used in this activity are specialized cells that form the outer layer of the organism. Describe how the appearance and shape of the cells enable them to accomplish their task of covering and protection.
14. Explain how the cells appeared to be different when viewed at different magnifications.
15. Explain why it is necessary to use onion membrane that is only one cell in thickness.

Skill Practice

16. Explain how the use of contrast (light levels and use of stain) improved your understanding of the cells that you were viewing.

Forming Conclusions

17. Describe the similarities and differences that you observed between the plant and animal cells.

1.1 CHECK and REFLECT

Key Concept Review

1. What five life processes do cells perform?
2. List the five organelles that are common to plant and animal cells. What are their functions?
3. What are three differences between plant and animal cells?
4. Why can the granum and thylakoid structures be described as “solar collectors”?
5. Prepare a table that summarizes the organelles and structures found in plant and animal cells.
6. Explain how fluorescence microscopy works.
7. Name two types of electron microscopes that are used by cell biologists.
8. What is the name of the image created by an electron microscope?
9. Explain why the cell can be considered to be the “building block” of life.
10. Explain the importance of contrast in microscopy.
11. What two things can you do to create contrast when you use a compound light microscope to study a specimen?

Connect Your Understanding

12. Explain why a cell biologist would choose to use an electron microscope rather than a light microscope. When would a light microscope be preferred?
13. What details of a microscope would you need to know to determine the total magnification of the system?
14. Explain why you would expect the cells of a desert plant, such as a cactus, to have thickened cell walls.

15. Think about the function of the mitochondria. You have been asked to view cells taken from the leg muscle of an athlete and cells taken from the skin of an elderly individual. What differences in the number of mitochondria would you see in the two samples? Explain your thinking.
16. Explain how a microscope may be used to assess human health.
17. Write a short paragraph that compares and contrasts plant and animal cells by considering structures, presence of specialized compounds, and forms of energy storage.
18. The scientist shown below is looking at cells through a fluorescent microscope. How has the development of technology aided our understanding of cells?



Question 18

Reflection

19. Describe three things about plant and animal cells that you did not know before you started working on this section.

For more questions, go to *ScienceSource*.

Here is a summary of what you will learn in this section:

- The life cycle of a cell has four phases.
- Growth and repair of cells is accomplished by mitosis.
- Cancer cells have an abnormal rate of cell division.

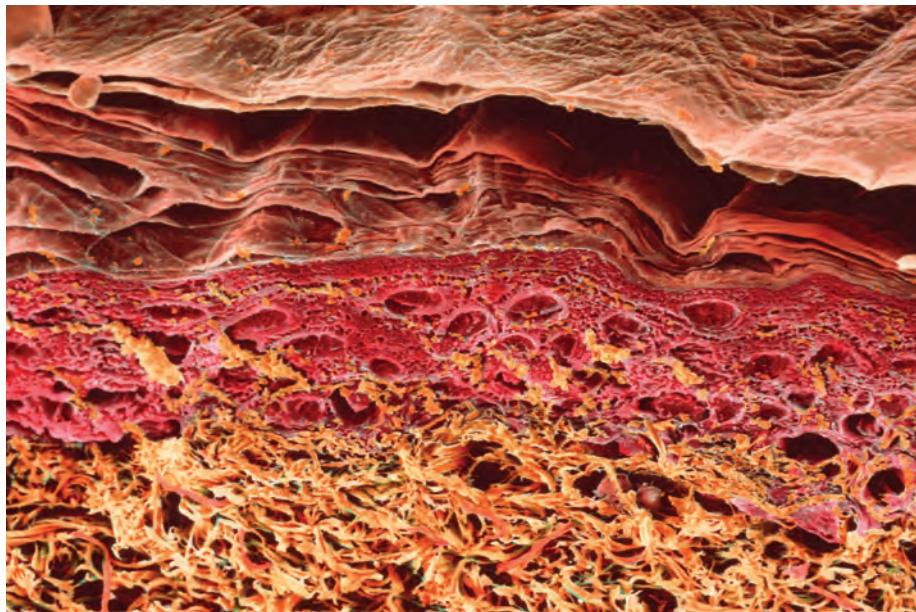


Figure 1.26 An electron micrograph of the skin shows the different layers of cells.

The Life and Death of Skin Cells

Stare at your face in the mirror. Your eyes are bright and alive, and your skin looks . . . dead? Actually, when we look at our skin, we are viewing dead cells. You lose about 30 000 to 40 000 skin cells every minute. If you collected all the dead cells that you shed over a day, you would collect 0.5 g of dead cells. If you collected those cells over a year, you would have about 3 kg of skin cells.

Since we lose so many skin cells every day, it is surprising that our skin does not simply wear away. However, our skin is made of different layers of cells (Figure 1.26). Skin cells are produced in the deeper layers of the skin and, in young people, mature over a period of about four weeks. During this time, the cells travel to the surface, where they are eventually sloughed off, leaving younger cells behind.

The cells on the surface are old, dead cells that have become toughened and flattened. This change in structure enables them to form a good protective layer for your body. These surface cells are continuously being replaced by cells from the layer below.

The time taken for the process of cell renewal changes as individuals age, or with changes in hormone or vitamin levels. For example, in older people, surface cells are held in the skin for up to 75 days, resulting in skin that is thicker and duller in appearance.

People apply products to their skin to keep it healthy, attractive, and young looking (Figure 1.27). The best way to keep skin healthy is to stay out of the Sun. Exposure to the Sun is responsible for damaging skin cells. Much of the damage is associated with premature skin aging, including the appearance of wrinkles and discoloured areas. Excessive exposure to the ultraviolet (UV) radiation in sunlight can also cause skin cancer: each year, about 30 000 Ontarians are diagnosed with skin cancer. The UV radiation changes the genetic information that is coded in the skin cells' DNA. This affects the functions of the cell, including the ability to reproduce and to repair itself. You can protect your skin from UV damage by wearing protective clothing (long-sleeved shirts and hats) and sunglasses, limiting your time in the Sun, and applying sunscreen to exposed skin.



Figure 1.27 People use skin creams to keep their skin looking healthy.

A7 STSE Quick Lab

Taking Protective Actions

The Sun is necessary for all life on Earth, but it is also the source of ultraviolet (UV) radiation, which is harmful to skin cells. There are things that you can do to protect your skin.

Purpose

To survey your class about Sun protection behaviours and to compare the class data with national data

Procedure

1. Think about your typical Sun protection behaviours during the summer.
2. Create a table in your notebook in which to record the results of your survey. Your table should indicate the total number of students responding to the survey and the total number of "yes" and "no" responses.
3. Participate in a survey of three questions of your class members.
 - Do you regularly practise Sun protection behaviours in the summer?
 - Have you suffered at least one major sunburn in the summer?
 - How many hours per day do you spend in the Sun during the summer?

4. Use the number of positive responses and the total number of students surveyed to calculate the percentage of students who practise Sun protection behaviours during the summertime.

Questions

5. Do your data suggest that youth are practising Sun protection behaviours?
6. How do your class data compare with the data in Table 1.3?

Table 1.3 National Sun Survey 2006

Percent of Canadians who:	16–24 years old	
	Male	Female
• spent at least 2 h in the Sun daily	47%	32%
• practised Sun protection behaviours	42%	58%
• acquired a tan from the Sun	28%	49%

7. What is one action that you could take to encourage your friends and family to practise Sun protection behaviours?
8. What Sun protection behaviours should people who work outside every day practise?

The Cell Cycle

Every hour, about one billion (10^9) cells die and one billion cells are made in your body. Through careful observation, scientists have identified a repeating cycle of events in the life of a cell. This cycle of events is called the **cell cycle**. During much of the cell cycle, the cell grows and prepares for cell division. In fact, although the main goal of the cell cycle is division, the cell spends most of its time preparing for division. The cell is in **interphase** when it is preparing for cell division. Cell division involves packaging the genetic information in the nucleus into two equal portions; this process is called **mitosis**. Then, the cytoplasm is split into two portions so that the original parent cell divides to form two new “daughter cells.” Cells use mitosis in the processes of growth and repair.

We can visualize the cell cycle by considering Figure 1.28. There are four phases in the cell cycle: first growth phase (G_1), synthesis phase (S), second growth phase (G_2), and mitosis (M).

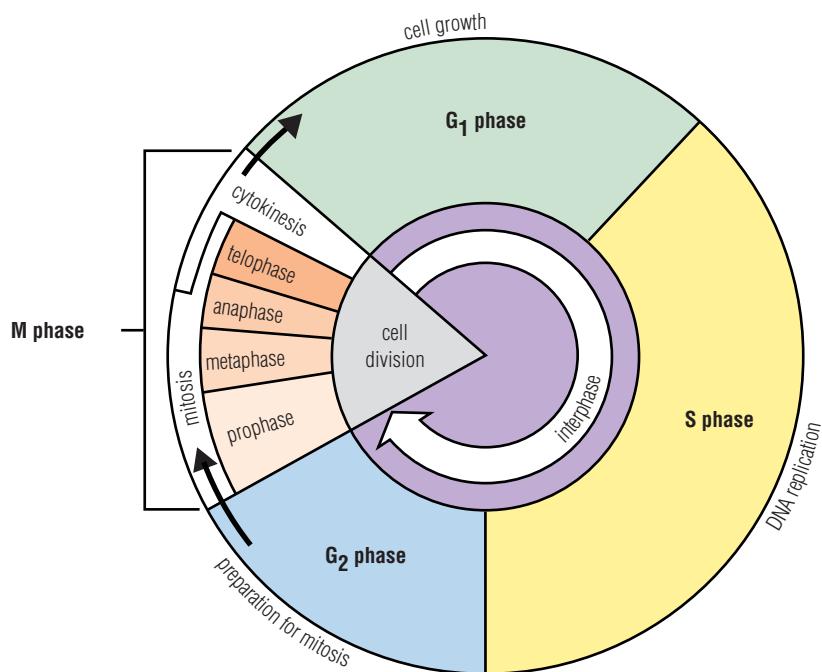


Figure 1.28 The cell cycle has four phases. During most of the cell cycle, the cell is growing, replicating its DNA, and preparing for cell division.

Chromosomes

Every cell contains chromosomes. Each **chromosome** is a long piece of coiled DNA and proteins. The number of chromosomes in each cell differs between organisms. For example, a horse has 64 chromosomes, while a hermit crab has 254 chromosomes. The typical human cell has 46 chromosomes — 23 matching pairs of chromosomes.

Chromosomes are visible only when the cell is dividing. When the cell is not dividing, the DNA and proteins that make up the chromosomes are spread throughout the cell in the form of chromatin. At the beginning of cell division, the chromosomes condense into visible structures. Before cell division can occur, each chromosome is copied. As shown in Figure 1.29, the chromosome consists of two identical copies, called **sister chromatids**. When the cell divides, one chromatid goes to each of the new cells.

A Closer Look at Interphase

A cell spends about 90 percent of its time in interphase. During interphase, the cell is growing. However, there is a limit to how big a cell can become. As a cell increases in size, the relationship of the surface area of the cell membrane to the amount of volume of cytoplasm changes. The volume of a cell's cytoplasm increases faster than the surface area of a cell's membrane. This affects how well a cell can absorb substances from its environment or expel wastes into its environment. When a cell reaches a certain size, it is healthier for the cell to undergo division. On average, the cells of an adult human are the same size as the cells in a child — however, there are more cells in an adult.

During interphase, the cell takes in nutrients, grows, and conducts other normal cell functions. There are three phases of interphase.

First Growth Phase (G_1)

This phase is a period of growth for the cell. During this phase, the cell also produces new proteins and organelles. If the cell is healthy and conditions are favourable, the cell moves into the next phase.

Synthesis Phase (S)

During this phase, the cell makes (synthesizes) an entire copy of the DNA of the cell. Key proteins that are associated with chromosomes are also produced during this phase.

Second Growth Phase (G_2)

Once the DNA has been copied, the cell moves into the second growth phase. During this phase, the cell produces the organelles and structures needed for cell division. This phase is the shortest of the phases of interphase.

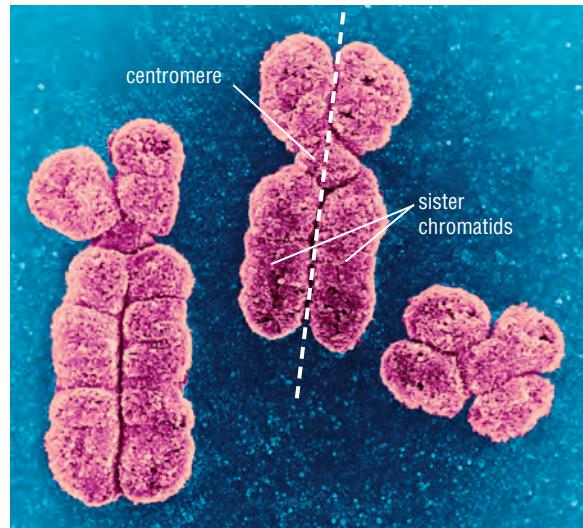
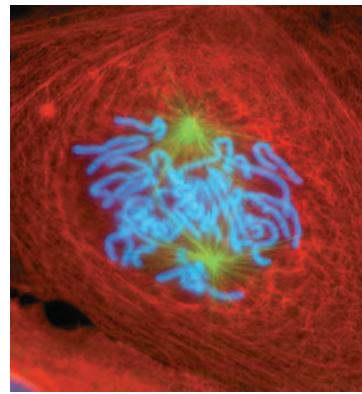
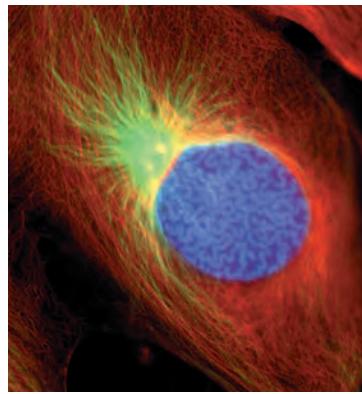
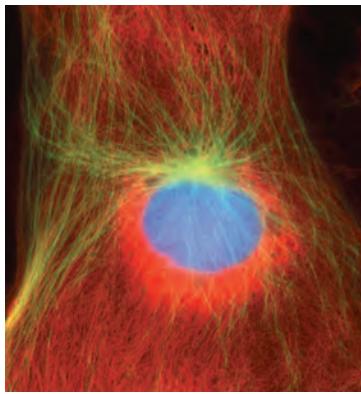


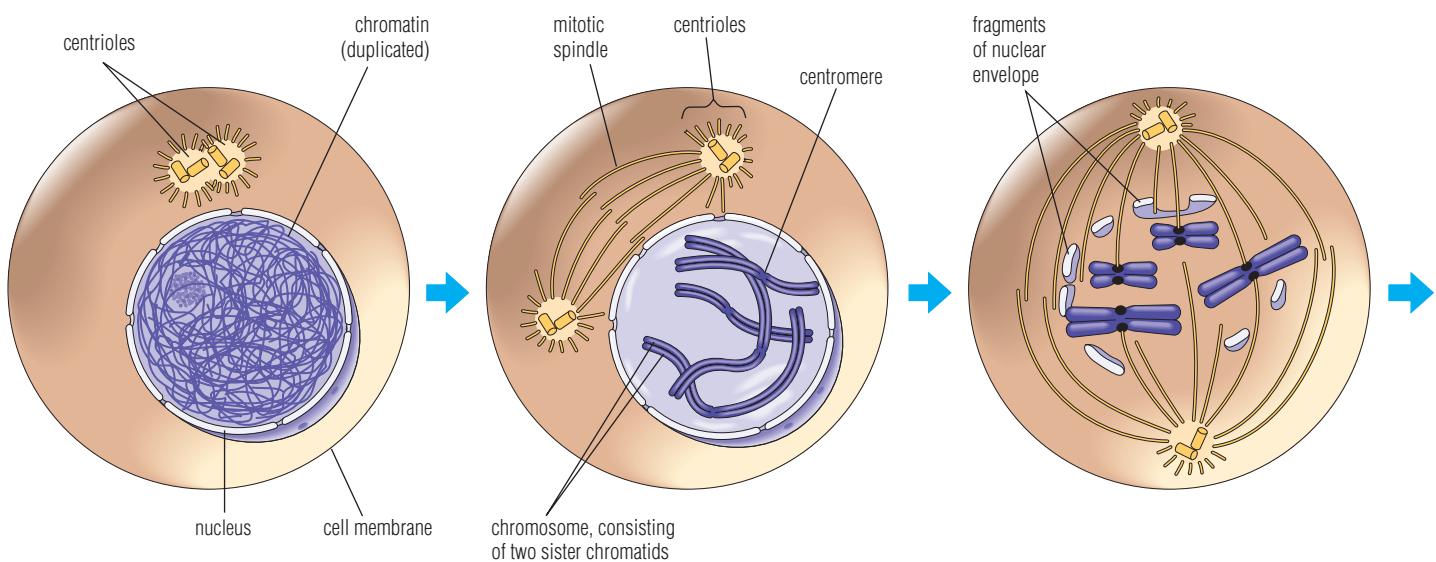
Figure 1.29 Each chromosome consists of two identical sister chromatids (shown magnified 8,300 \times).



interphase

early prophase

late prophase



DNA has been duplicated in the S phase and appears as threads in the nucleus.

The chromatin condenses to form chromosomes. The centrioles move toward the poles. Spindle fibres form.

The nuclear envelope breaks down. Each chromosome is connected to a spindle fibre at its centromere.

WORDS MATTER

Many of the words associated with cells come from Greek words. “Mitosis” comes from the Greek word *mitos*, meaning thread. The words “meta,” “ana,” and “telo” come from the Greek words for between, renewal, and end.

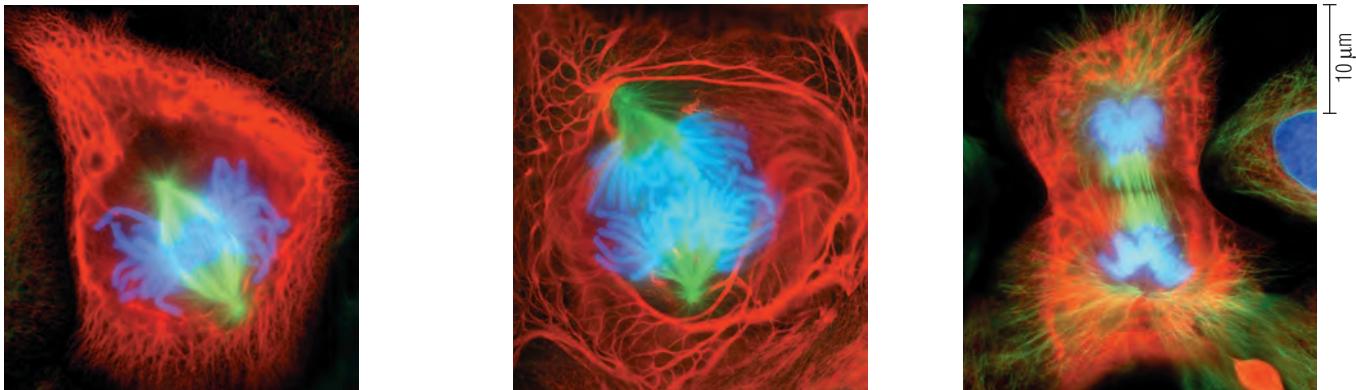
A Closer Look at Mitosis

During most of the cell cycle, the cell is in interphase — it is growing, synthesizing DNA, and repairing itself. Once the cell is ready to divide and make two new identical cells, it enters mitosis (M phase). Before cell division can be accomplished, the cell must undergo great change. Therefore, during the M phase, the cell’s energy must be entirely devoted to the process of cell division.

There are four phases in mitosis: prophase, metaphase, anaphase, and telophase. At the end of telophase, two daughter cells, each containing identical genetic information, are formed.

Suggested Activity •

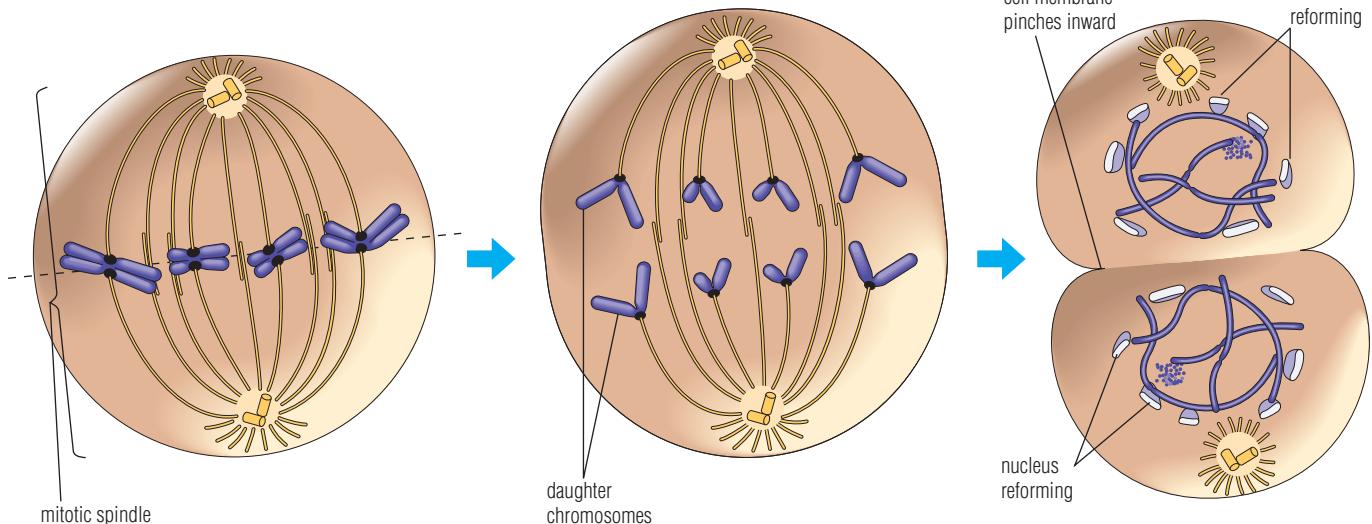
A8 Inquiry Activity on page 35



metaphase

anaphase

telophase and cytokinesis



The chromosomes line up at the centre of the cell.

The sister chromatids separate into individual chromosomes and move to opposite poles.

The mitotic spindle breaks down, and two new nuclei form. The chromosomes lose their distinct shape. The cytoplasm and the cell membrane pinch in half to form two new daughter cells.

Prophase

During the first phase of mitosis, called **prophase**, the chromatin (DNA and proteins) that makes up the chromosomes condenses. At this stage, the chromosome is actually two identical copies called sister chromatids attached together at a centromere. These sister chromatids will eventually separate and move to opposite sides of the cell. To enable the movement of the chromatids within the cell, the nuclear structures and nuclear envelope disintegrate. In addition, a framework called the mitotic spindle forms to move the chromatids around in the cell. Chromatids are attached to the spindle at their centromeres. In animal cells, a pair of organelles called centrioles moves to each end of the cell, forming the poles of the mitotic spindle.

Metaphase

As the cell moves into the second stage of mitosis, called **metaphase**, each chromosome becomes completely condensed. The chromosomes move toward the centre of the cell and line up at the middle of the cell. The mitotic spindle is complete and is made of tiny tubes that extend from each pole to the middle of the cell. These tubes connect the centromere of each chromosome to the two poles.

Anaphase

During **anaphase**, the sister chromatids separate at the centromere. Each chromatid is now a complete chromosome. The separated chromosomes are pulled to opposite ends of the cell.

Telophase and Cytokinesis

During the last phase of mitosis, known as **telophase**, the cell divides the cytoplasm into two portions. The process of splitting the cytoplasm is known as **cytokinesis**. In animal cells, the cell membrane pinches inward, eventually splitting the one cell into two cells. In plant cells, the cell plate forms the cell wall and inner plasma membrane in each of the new cells. At the end of cytokinesis, the two new cells return to interphase conditions. Two nuclei form where each pole of the parent cell was. The mitotic spindle disappears. Each of the new cells enters the G₁ phase of the cell cycle, and the cell cycle is repeated.

Learning Checkpoint

1. What is the purpose of the cell cycle?
2. Define the term “interphase” and describe its purpose.
3. (a) What is mitosis?
(b) Why is mitosis important to the cell?
4. Define and distinguish between the following terms: chromosome, centromere, and sister chromatids.
5. Explain the meaning and importance of the term “cytokinesis.”

Cell Growth and Repair

Multicellular organisms are made up of many different cells. These different cells all undergo cell growth and cell division at different rates. For example, in the human body, nerve cells do not undergo mitosis once they mature. Other cells, such as skin cells and cells in the digestive tract, undergo cell division regularly. Cell division provides new cells to replace cells that wear out or break down. After observing rates of cell division, scientists concluded that differences in rates of cell division reflect the internal control systems of the cell cycle.

In a growing organism, there is rapid mitosis of cells in areas of growth. Cells that are likely to be damaged or injured as they function also have high rates of mitosis. For example, your intestinal cells divide every three days and are then broken down by the digestive process, whereas your red blood cells may last for four months. In plants, growth occurs in the meristem region (Figure 1.30). The cells in the meristem region of a root tip appear to divide every 12 to 36 h.

Factors That Affect Mitosis

The environment impacts the rate of mitosis. For example, if you travelled to a part of the world where you were exposed to a change in environmental conditions, such as a change in altitude, the rate of mitosis in your blood cells would increase. Plants may also respond to environmental changes by altering their rates of mitosis: a plant will bend toward the light because the cells in the stem opposite the light grow more rapidly than those facing the light (Figure 1.31).

Antibiotics can also affect the rate of mitosis of a cell. Antibiotics are drugs given to combat bacterial infections. Some antibiotics, called bacteriostatic drugs, temporarily stop bacteria from growing by interfering with mitosis. Some bacteriostatic drugs inhibit the replication of DNA. Other drugs, called cytostatic drugs, also interfere with mitosis and are used in chemotherapy.

Will Cells Live Forever?

The cell cycle regulates how long a cell lives. Sometimes, cells die because they have suffered injury or damage that cannot be repaired. For example, cells that are exposed to a poison may absorb the poison and die. This type of death is known as cell necrosis.

A cell also dies as a normal part of the functioning of healthy multicellular organisms. This regulated, or controlled, cell death is known as **apoptosis**. Apoptosis is the death of cells that are no longer useful (Figure 1.32). For example, when your body fights a viral infection, your body produces many cells to fight that infection. When the virus has been removed from your body, these cells are no longer needed and they are removed by apoptosis. Apoptosis also removes cells that have lost their ability to perform efficiently.

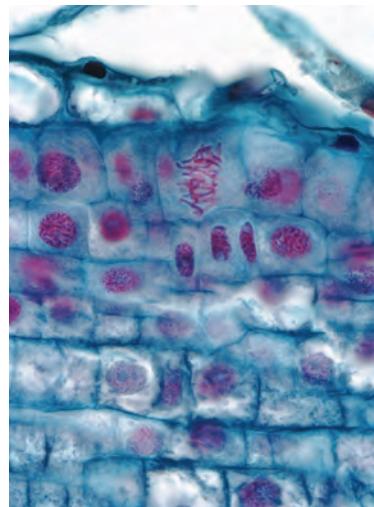


Figure 1.30 Cells in the meristem region in an onion root tip undergoing mitosis (magnification 350 \times)



Figure 1.31 A field of sunflowers in Ontario

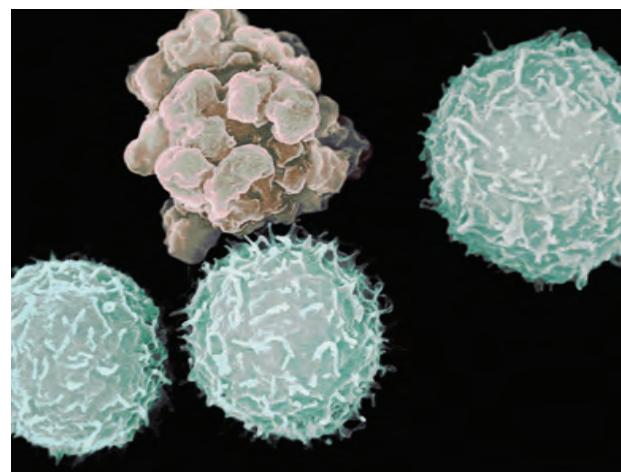


Figure 1.32 Scanning electron micrograph showing normal cells surrounding a cell undergoing apoptosis (magnification 3000 \times)

Cancer Cells

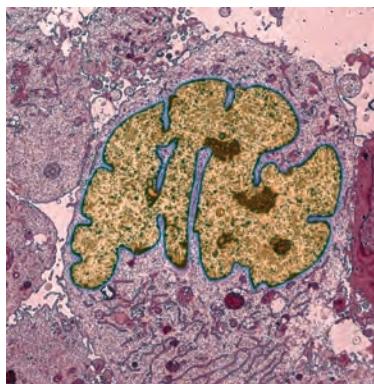


Figure 1.33 A transmission electron micrograph of a lung cancer cell. The nucleus (beige) is enlarged and irregularly shaped (magnification 1000 \times).

Suggested Activity •
A9 Quick Lab on page 36

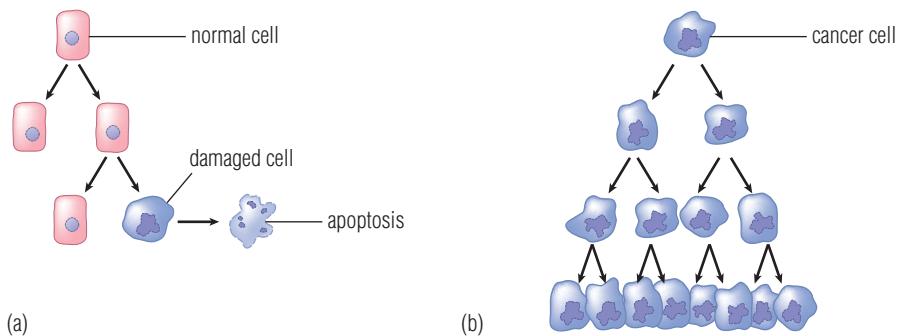


Figure 1.34 (a) Cell division and cell death in normal cells. (b) Cell division in cancer cells

Table 1.4 Comparing Normal Cells with Cancer Cells

Normal Cells	Cancer Cells
• make exact copies of themselves through mitosis	• make exact copies of themselves through mitosis
• reproduce for about 50–60 cell divisions	• do not stop reproducing
• stick together to form masses of cells as appropriate	• do not stick to other cells • behave independently
• self-destruct when too old or too damaged	• may move to another location of the body

Take It Further

HeLa cells have been used in cancer research for over 50 years. Research the history of HeLa cells. Be prepared to report on your findings. Begin your research at *ScienceSource*.

A8 Inquiry Activity

Skills References 2, 6, 10

SKILLS YOU WILL USE

- Observing, and recording observations
- Interpreting data/information to identify patterns or relationships

Identifying the Stages of Mitosis in Plant and Animal Cells

To understand and identify the different stages of mitosis, you need to examine plant and animal cells undergoing mitosis.

Question

What similarities and differences between plant and animal cell mitosis can you see using a microscope?



Materials & Equipment

- compound light microscope
- pen and/or pencil
- paper
- prepared slides of plant and animal cells in mitosis

CAUTION: Practise proper techniques in handling the microscope and slides.

Procedure

Part 1 — Examining Plant Cell Mitosis

1. Review the proper handling and use of the microscope in Skills Reference 10. Set up your microscope.
2. Place a prepared slide of plant cells on your microscope.
3. View this slide and scan to see its contents using low power. Adjust the light so that you can see the cell contents clearly.
4. Find the section of small cells near the top of the root cap. Move the slide so that these cells are in the centre of your field of view.
5. Look at the cells using the low-, medium-, and high-power lenses. Identify cells that are in each phase of mitosis.
6. Make sketches of cells in each phase of mitosis. Count the number of cells that are in each phase in one field of view.
7. Remove the plant cell microscope slide, and return the microscope to low power.

Part 2 — Examining Animal Cell Mitosis

8. Place a prepared slide of animal cells on your microscope.
9. View this slide and scan to see its contents using low power. Adjust the light so that you can see the cell contents clearly.
10. Find a section of cells that appear to be in mitosis. Look at the cells using the low-, medium-, and high-power lenses. Identify cells that are in each phase of mitosis.
11. Make sketches of cells in each phase of mitosis. Count the number of cells that are in each phase in one field of view.
12. Clean up your work area. Make sure to follow your teacher's directions for safe disposal of materials. Wash your hands thoroughly.

Analyzing and Interpreting

13. Was there a difference in the frequency of cells in the various stages of mitosis? If so, what stage of mitosis did you find most frequently?
14. Based on your observations, which phase do you think takes the longest? Why?

Skill Practice

15. Explain how the use of contrast (light levels and use of stain) improved your understanding of the cells that you were viewing.

Forming Conclusions

16. What similarities and differences did you observe between the plant cells and the animal cells undergoing mitosis?

Comparing Cancer Cells and Normal Cells

The main difficulty in detecting cancer is that the appearance of symptoms depends on how fast the cancer cells are dividing. The rate of cancer growth is measured in doubling times. One doubling time is the length of time it takes for the cancer cells to double in number. Doubling times for different types of cancer cells vary from 10 days to several years. The average doubling time for a cancer cell is four months.

Purpose

To compare the rate of cell division in cancerous cells and non-cancerous cells

Procedure

1. Identify which diagram in Figure 1.35 represents cancerous cells.

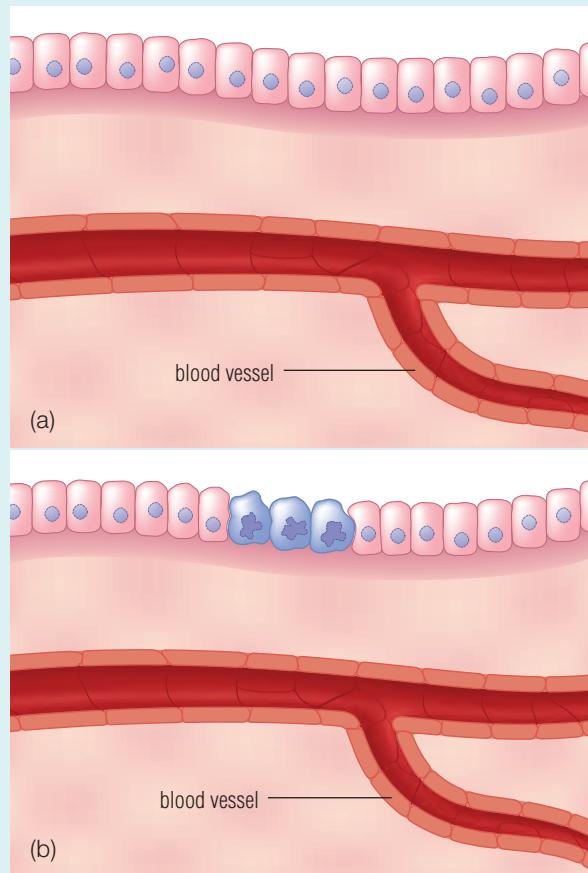


Figure 1.35

2. It takes about 30 doubling times for a cancer cell to form a tumour that is large enough to be felt through the skin with hands. Calculate how many months it would take for the cells in Figure 1.36 to form a tumour that could be felt if the doubling rate is two months.

Questions

3. Explain how you know which diagram in Figure 1.35 shows cancerous cells.
4. What do you think is happening in Figure 1.36?
5. If the cancerous cells were left untreated, what do you predict would happen?
6. What are the limitations of visual inspection as a diagnostic tool for cancer?

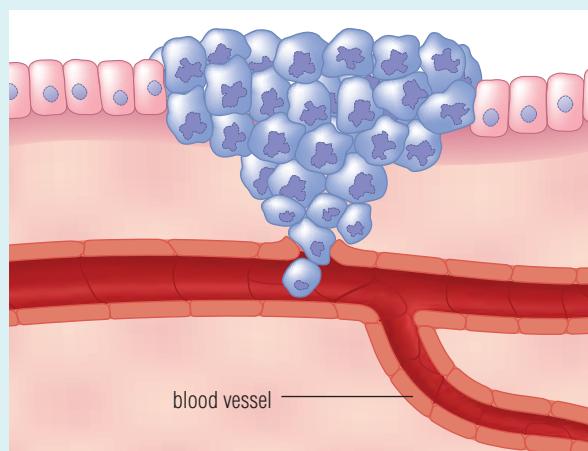


Figure 1.36

1.2 CHECK and REFLECT

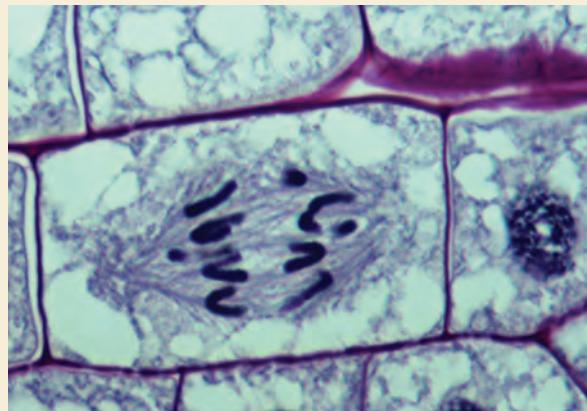
Key Concept Review

1. Describe the events in the cell cycle.
2. Compare mitosis in plant and animal cells.
3. Describe the meaning of the term “apoptosis,” and state its importance.
4. State one similarity and one difference between plant and animal mitosis.
5. What is a cancer cell?
6. Explain how mitosis ensures genetic continuity.
7. How does mitosis make the growth and repair of cells possible in an organism?
8. Why would you expect cells to spend the greatest percentage of their cycle in interphase?
9. What happens to the chromosomes as a cell prepares to divide?
10. How is a cancer cell different from a normal cell? Give three differences.

Connect Your Understanding

11. Describe the differences between mitosis in an animal cell and a plant cell.
12. Why must cell division be controlled or regulated for cells to remain healthy? Explain your answer.
13. A certain antibiotic affects cells by preventing the formation of spindle fibres. Explain how this drug would affect mitosis in cells.
14. A drug used in chemotherapy causes chromosomes to move incorrectly during mitosis. As a result, the daughter cells that are produced have either too much or too little genetic information. Predict why this treatment causes the cancer cells to die.

15. Identify the stage of mitosis shown in the photo below. Explain your thinking.



Question 15

16. The nerve cells in our bodies rarely undergo mitosis. Use this information to explain why complete recovery from injuries to our nervous system may not occur.
17. Sunscreens protect your skin by blocking types of ultraviolet radiation. Explain why the Canadian Cancer Society advises Canadians to apply sunscreen.
18. Suggest reasons why cancer researchers may be interested in using their learning about the processes of cell division to develop new forms of cancer prevention and treatment.
19. Three samples of cells from three different patients were unlabelled. One sample was from an 85-year-old man, one was from a 5-year-old boy, and one was from a person with skin cancer. How could you determine to which patient they belonged?

Reflection

20. How did your understanding of cell division change after you viewed cells under a compound light microscope?

For more questions, go to **ScienceSource**.

Here is a summary of what you will learn in this section:

- Unspecialized cells can become specialized through interactions with their environments.
- Specialized cells group together to function as a tissue.
- Specialization of cells allows for diversity of function in multicellular organisms.
- Current research is focussed on the function and use of unspecialized cells, known as stem cells, in treating disease.



Figure 1.38 The regeneration of a newt's limb over 6 to 8 weeks. The newt is a type of salamander. The lighter colour represents the newly formed forelimb.



Figure 1.37 The axolotl is a type of salamander that has an amazing ability to regenerate missing limbs.

Regeneration

In scientific laboratories around North America, scientists study the superstar of regeneration — the salamander (Figure 1.37).

Regeneration is the process whereby a body part is replaced or regrown. The salamander has the unique ability to regrow not only limbs that have been amputated but also tails, lenses in eyes, and parts of the heart (Figure 1.38). In the salamander, the process of mitosis is responsible for regenerating the cells that will eventually specialize and create a newly formed limb.

Although regeneration has been studied in organisms such as the salamander, it is not often thought to occur in humans. However, examples of regeneration in humans do exist. The human liver is the only human organ that has an ability to naturally regenerate. Additionally, human fingertips have a limited ability to regenerate. In young children, an amputated fingertip that is cleaned and covered with a simple dressing can regenerate. The new fingertip has the same fingerprint pattern and sensations of the original fingertip.

Research into Regeneration

In 2008, scientists reported some astonishing progress in the field of regeneration. A powder stimulated a human adult fingertip that had been severed to regrow. The powder, made from pigs' bladders, is called

an extracellular matrix. Although regenerating a fingertip is not the same as regenerating a limb, scientists hope that the knowledge they gain from researching the extracellular matrix will lead to further developments.

Another development in the field of regeneration is the creation of body parts in the lab. In one example, a patient's bladder cells were isolated and grown on a prepared surface called a scaffold. In two months, the cells had formed a functioning bladder that was implanted into the patient (Figure 1.39). This technology has also been used to create functioning blood vessels and heart valves. In the future, scientists believe it may be possible to grow a functioning human heart.

Scientists do not fully understand why a salamander can regenerate certain body parts but not others, even though all salamander cells contain the same DNA. With the success in developing technologies to regenerate human bladders or blood vessels, it may be possible to grow all body parts through regeneration in the future.



Figure 1.39 An artificial bladder held by gloved hands. The bladder was grown from cultured bladder cells.

A10 STSE Quick Lab

Tailor-Made Body Parts

In 2008, Dr. Anthony Atala, from Wake Forest University, North Carolina, reported that he and his team had successfully grown 18 different tissues outside of the body using the techniques of regeneration. One particularly successful experiment involved the creation of a human bladder that was grown in the lab from the patient's own bladder cells and then transplanted into the patient. Growing replacement organs in the lab would meet the needs for replacement organs. Some businesses have recognized the opportunities that this new technology provides. For example, in the future, if you were in need of a replacement organ, you could simply order a tailor-made replacement body part made using your own cells.

Purpose

To consider the social and ethical issues connected with using technology to make human body parts

Procedure

1. Work with a partner. Prepare a T-chart with the headings "Social Issues" and "Ethical Issues."
2. Brainstorm about how the production of human body parts using regenerative technologies could affect society. Think about both the positive and negative ways. List your ideas in the T-chart under the heading "Social Issues."
3. Continue to brainstorm about the ethical issues related to the production of body parts using regenerative technologies. List your ideas in the T-chart under the heading "Ethical Issues."

Questions

4. With the development of regenerative technologies, there has been interest in the mass production and commercialization of human organs. Discuss two positive outcomes and two negative outcomes of this action.
5. Why do you think this technology would be of interest to the military?



Figure 1.40 Meerkats have different specialized jobs. The sentinel meerkat looks for any dangers to the clan.

The Process of Cell Specialization

Meerkats are small mammals that live in the desert regions of southern Africa. Meerkats live in groups, called clans or mobs, of 5 to 20 animals. Members of the clan work together to find food, care for the young, and defend themselves against predators. Scientists have observed that there are certain specialized roles that meerkats may play within in the clan. In each clan, there is a dominant, or alpha, pair of animals that lead the group. The other adult meerkats are subservient to the alpha meerkats and leave the clan when they are three years old. During the day, there is always at least one adult meerkat acting as a sentinel, or lookout, and watching for predators while the rest of the clan plays or searches for food (Figure 1.40). Using a bark, the sentinel signals to the rest of the clan when danger approaches. Other meerkats serve as babysitters for the young. The success of the meerkat clan depends on each meerkat doing his or her specialized job.

Much like a meerkat clan is a collection of different meerkats doing specialized jobs, a multicellular organism is a collection of different types of cells doing specialized jobs. Although all cells have the same DNA information, they are not all alike. Cells develop in different ways to perform particular functions in a process called **cell specialization**. For example, animal cells may become specialized to form lung cells, skin cells, or brain cells. Plant cells become specialized to form a variety of specialized cells including xylem or phloem in the root, stem, or leaf.

During Reading

Thinking Literacy

Sketch to Stretch Your Understanding

When reading comprehension gets difficult because of unfamiliar terminology, good readers find it helpful to visualize ideas, and they may even draw or sketch as they read to try and understand the text. Choose one paragraph and sketch as you read, then check your understanding. Did the sketches help you to make sense of what you were reading?

Stem Cells

Every cell in your body originally came from a small group of stem cells. A **stem cell** is an unspecialized cell. Stem cells can form specialized cells when exposed to the proper environmental conditions, or they can remain unspecialized and actively dividing for long periods.

Scientists are studying stem cells in animals and plants so that they can understand the process of cell specialization. They believe that stem cells may be used to treat injuries and diseases by regenerating organs. Figure 1.41 shows how stem cells are produced in the lab for stem cell research. These stem cells are capable of becoming any cell — including nerve cells, blood cells, or muscle cells — in the human body.

Embryonic and Adult Stem Cells

There are two types of stem cells: embryonic stem cells and adult stem cells. As the name suggests, embryonic stem cells are found in embryos. Embryonic stem cells are able to undergo **differentiation**, which means that the cells look different from one another and perform different functions. Embryonic stem cells differentiate into other cell types. As these cells divide, further specialization occurs, leaving cells with a limited ability to create a variety of cell types. These cells are called adult stem cells.

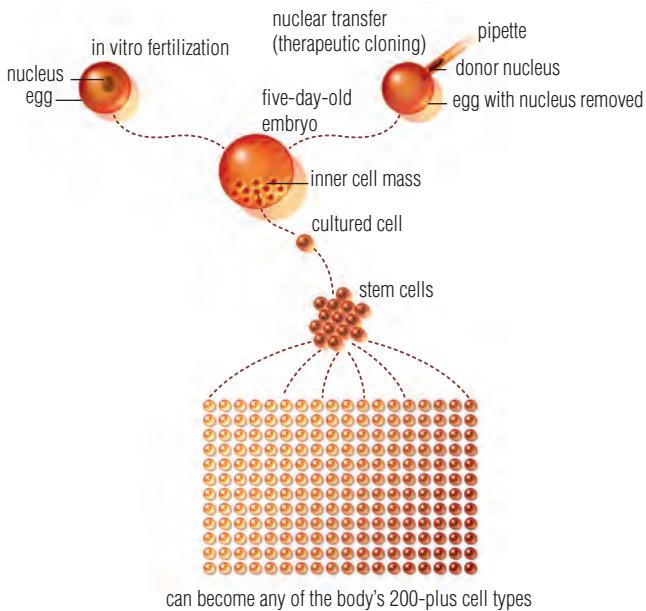


Figure 1.41 Most stem cells used for research are taken from embryos created by in vitro fertilization. The process occurs when the egg is fertilized under laboratory conditions. Scientists are also working on getting cells from embryos produced by therapeutic cloning, in which the nucleus of a skin cell, for example, is inserted into an egg whose nucleus has been removed. Either way, after five days scientists transfer the embryo's inner cell mass — with its 40 or so stem cells — to a lab dish where the cells can reproduce. After many months, the original stem cells have grown into millions of healthy cells without beginning to differentiate into specialized cells.

As an organism matures, stem cells become specialized. In adult organisms, therefore, there are few examples of stem cells; most adult stem cells are involved in the replacement of damaged tissue. For example, adult stem cells are found in skin, blood, and neural tissue. Recent studies have found that adult stem cells from the tissue of one organ can regenerate tissue in another organ. For example, adult blood stem cells have regenerated liver, kidney, and brain cells.

Current research involves the use of stem cells in the treatment of such diseases as cancer, Parkinson's disease, Alzheimer's disease, stroke, heart disease, diabetes, and rheumatoid arthritis. There is much public debate about the use of embryonic stem cells. It is possible to harvest a few embryonic stem cells from the umbilical cord or placenta, but to collect larger amounts of embryonic stem cells, it is necessary to destroy the embryo.

Meristematic Cells

Stem cells are also found in plants. Plant stem cells are called **meristematic cells**. They are found in the growing tips of roots (Figure 1.42) and stems and also in a layer in the stem known as the cambium. Plant meristematic cells are active throughout the life of a plant, which means that they continually produce new cells of various types.

Learning Checkpoint

1. Define the term "stem cell."
2. Explain how stem cells can become specialized.
3. Compare and contrast embryonic stem cells and adult stem cells.
4. State one practical use of stem cell research.
5. What are meristematic cells?

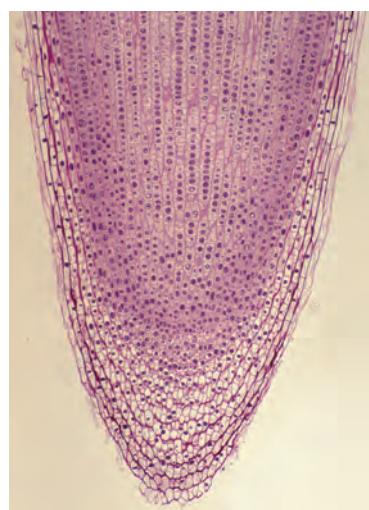


Figure 1.42 Meristematic cells in an onion root tip (magnification 25×)

Specialized Cells and Tissues

Imagine being stranded on a deserted island with a group of your family and friends. You could look out only for yourself and be responsible for all of your own needs, including food and shelter. Or you could work with the other people on the island and form teams: one team may be responsible for building the shelter, while another team would look for food. In the second scenario, each team works for the good of the whole group: everything does not depend on one person.

We can use this analogy to understand how a multicellular organism accomplishes its life processes. A multicellular organism is made of many cells. Since it would be difficult for each cell in a multicellular organism to perform all of the necessary life processes independently, cells group together and become specialized. Just as it makes sense for you to work together as a team on the deserted island, it makes sense for groups of cells to function together. Groups of cells that function together to perform specialized tasks are called **tissues**.

Animal Tissues

In animals, cells specialize to form four types of tissues (Table 1.5). The cells in each tissue work together to accomplish important tasks.

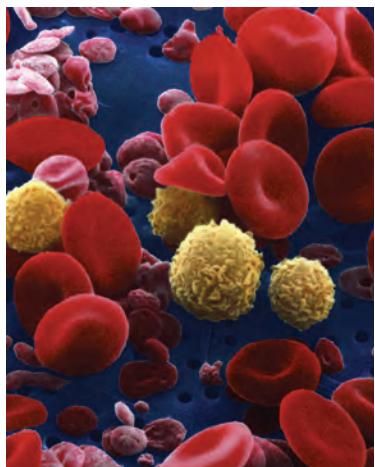


Figure 1.43 Scanning electron micrograph showing human red blood cells, white blood cells (yellow), and platelets (pink)

Epithelial and Connective Tissue

Epithelial tissue is made of cells that are tightly packed together to form a protective barrier. Epithelial tissue may be one cell thick or consist of several layers of cells.

The main function of connective tissue is to join other tissues together. There are different types of connective tissue including tendons and ligaments, bones, cartilage, and blood. Tendons connect muscles to bones, and ligaments connect bones to bones. Blood is made of plasma, red blood cells, white blood cells, and platelets (Figure 1.43).

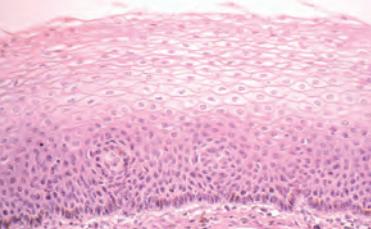
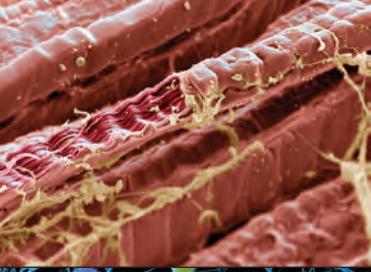
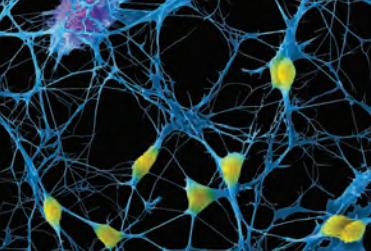
Red blood cells contain hemoglobin, a protein that can absorb and release oxygen. White blood cells protect the body from bacteria and viruses and fight infection. Platelets are cells that help in the process of blood clotting.

Muscle and Nervous Tissue

There are three types of muscle tissue: skeletal, smooth, and cardiac. When you move your arm or leg, you are using skeletal muscle. Smooth muscle occurs in blood vessels, the stomach, and other organs. Cardiac muscle is only found in the heart. Skeletal muscle is voluntary, which means that it is controlled by will. Smooth muscle and cardiac muscle are involuntary, which means they move without conscious control.

Nervous tissue is made of nerve cells which are capable of creating messages, called impulses, and transmitting them throughout the body. Nerve cells receive information from inside and outside the body.

Table 1.5 Animal Tissues and Their Functions

Tissue Type	Micrograph	Major Function(s)
epithelial tissue		<ul style="list-style-type: none"> • lines body cavities and outer surface of body • protects structures • forms glands that produce hormones, enzymes, and sweat
connective tissue		<ul style="list-style-type: none"> • supports and protects structures • forms blood • stores fat • fills empty space
muscle tissue		<ul style="list-style-type: none"> • allows for movement
nervous tissue		<ul style="list-style-type: none"> • responds to stimuli • transmits and stores information

Plant Tissues

There are four types of tissues in plants: epidermal tissue, vascular tissue, ground tissue, and meristematic tissue (Figure 1.44). All plant tissues are formed from groups of meristematic cells known as **meristematic tissue**. Table 1.6 (on the next page) describes and illustrates the different types of plant tissues.

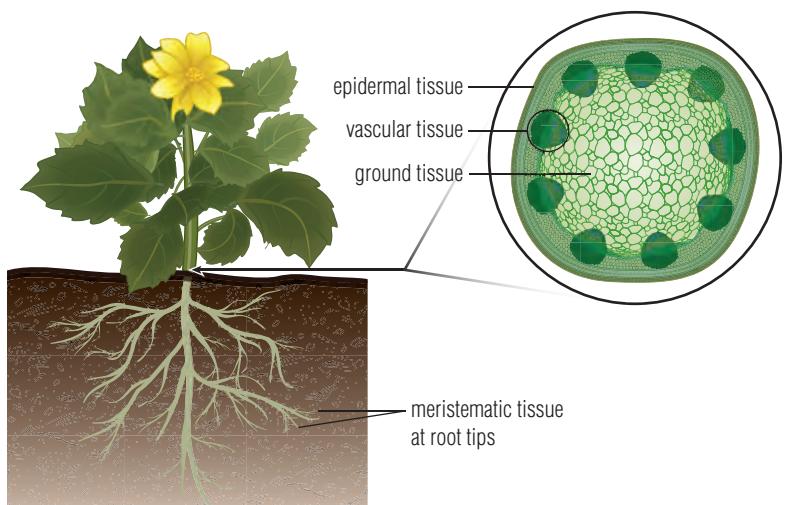
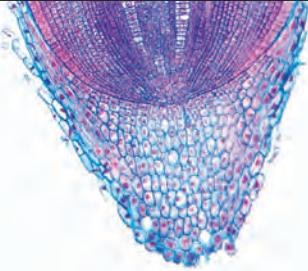
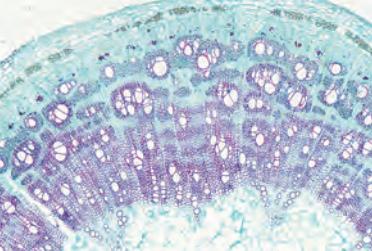
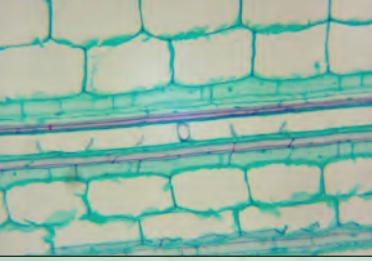


Figure 1.44 Location of plant tissues

Table 1.6 Plant Tissues and Their Functions

Tissue Type	Micrograph	Major Function(s)
meristematic tissue		<ul style="list-style-type: none"> • unspecialized tissue capable of dividing by mitosis • found in several locations in the plant • responsible for growing new parts of the plant
epidermal tissue*		<ul style="list-style-type: none"> • forms the protective outer covering • allows the exchange of materials and gases into and out of the plant
ground tissue		<ul style="list-style-type: none"> • in the stem: provides strength and support • in the roots: stores food and water • in the leaves: where photosynthesis occurs
vascular tissue		<ul style="list-style-type: none"> • moves substances from the roots to the leaves • transports sugars from the leaves to other parts of the plant

Suggested Activity •

A12 Inquiry Activity on page 46

Epidermal and Ground Tissue

The epidermal tissue on both the top and underside of the leaf is clear and very thin. Specialized guard cells form a tiny opening, or pore, called a **stomate**, that allows carbon dioxide, water vapour, and oxygen to move into or out of the leaf easily. Most stomata are found on the underside of the leaf.

Most of the plant is made of ground tissue. The function of the ground tissue depends on where it is found in the plant. For example, in the roots, ground tissue is involved in food and water storage. In the leaves, photosynthesis and gas exchange occurs in specialized ground tissues called **mesophyll**. During photosynthesis, carbon dioxide and water are converted into sugar and oxygen.

Vascular Tissue

Vascular tissue plays an important role in transporting water and nutrients throughout the plant. There are two types of vascular tissue in the plant: xylem and phloem. **Xylem** is responsible for the movement of water and minerals from the roots up the stem to the leaves, where these substances are used in photosynthesis. **Phloem** transports the sugar produced during photosynthesis from the leaves to other parts of the plant, where it is used to provide energy for all cellular processes.

WORDS MATTER

"Xylem" comes from the Greek root *xyl*, meaning wood. Phloem comes from the Greek root *phloe*, meaning bark.

Learning Checkpoint

1. Define the term "tissue."
2. What is the link between specialized cells and tissues?
3. Compare the structure and functions of epithelial tissue and epidermal tissue.
4. What are four types of animal tissues?
5. What are four types of plant tissues?

Take It Further

Find out how stem cells are used in the treatment of a disease such as diabetes or Parkinson's disease. Create a concept map to show the details of your findings. Begin your research at *ScienceSource*.

A11 STSE *Science, Technology, Society, and the Environment*

Receiving Mixed Messages

We have an almost unlimited access to various sources of information. The Internet gives us the opportunity to interact with others and exchange information on a global scale. Scientific inquiry is now a collaborative international process. The ability to communicate electronically over the Internet using text, sound, and pictures is a powerful tool for the scientist. However, effective and accurate communication of information is important to the success of the process of scientific inquiry.

We have the opportunity to receive scientific information in various forms of media including journals, newspapers, TV shows, movies, books, lectures, and interviews. Recent scientific advancements are commonly used in the story lines of television programs and movies. The problem is that sometimes these messages about science are not entirely correct. For example, some movies have plots based on a scientific theme but may not be scientifically accurate. Although media with science-based themes may increase the level of public

awareness of an issue, it is also possible that they could misinform the public. In addition, it is also possible that some messages are delivered in a manner that reflects the bias of a particular interest group or corporate sponsor.

In this activity, you will discuss examples in which you received media messages about cell biology.

1. With a partner, make a list of situations where you have received media messages about cells. Remember to consider different types of media including radio, advertisements, newspapers, TV, magazines, websites, blogs, wikis, music, videos, and movies.
2. Share your responses with the whole class and compile a class list.
3. As a class, identify any trends that emerge.
4. As a class, predict how corporate sponsorship of scientific research may affect the nature of the scientific messages that are delivered in the media.

SKILLS YOU WILL USE

- Justifying conclusions
- Communicating ideas, procedures, and results in a variety of forms

Examining Plant and Animal Tissues

If you offered to shovel snow for a neighbour, you would be sure to use the proper equipment. You would not use a dustpan or a mop but rather a snow shovel. You would also be sure to be dressed in the appropriate clothing so that you would stay warm and dry while on the job. Groups of cells must also have the proper equipment if they are to perform efficiently as tissues. In this activity, you will observe groups of cells and infer how their structures allow them to perform their specialized tasks.

Question

How do cell structures enable the tissue to accomplish its function?



Materials & Equipment

- prepared slides of plant tissue (epidermal tissue, ground tissue, vascular tissue)
- pencil or pen
- ruler
- prepared slides of animal tissue (epithelial tissue, nervous tissue, muscle tissue)
- paper
- compound light microscope

CAUTION: Practise proper techniques in handling the microscope and slides.

Procedure

Part 1 — Examining Plant Tissue

1. Review the proper handling and use of the microscope in Skills Reference 10.
2. Set up your microscope, and place a prepared slide of plant tissue on your microscope.
3. View the slide under low power, and scan to see its contents. Adjust the light using the diaphragm so that you can see the cell contents clearly.

4. Find the section of the slide of cells that you wish to examine.
5. Use the low-, medium-, and high-power lenses to study the cells.
6. Draw a labelled diagram of the plant tissue. Remember to include the magnification and scale in your drawing.

Part 2 — Examining Animal Tissue

7. Repeat steps 2 to 6 using a prepared slide of animal tissue.
8. Clean up your work area. Make sure to follow your teacher's directions for safe disposal of materials. Wash your hands thoroughly.

Analyzing and Interpreting

9. Describe the structure of the cells in the plant tissue that you examined. How does the structure relate to its function?
10. Describe the structure of the cells in the animal tissue that you examined. How does the structure relate to its function?
11. What information about the tissues could be found through examination using a compound light microscope?

Skill Practice

12. Was the section of the slide that you chose to examine a good representation of the entire tissue?

Forming Conclusions

13. Would you expect plant and animal tissues with similar functions to share some common structural features? Support your answer with evidence from your observations.

1.3 CHECK and REFLECT

Key Concept Review

- What are two characteristics of stem cells?
- What are stem cells called in plants?
- Name the four types of specialized animal tissues, and state the general function of each tissue.
- Name three types of specialized plant tissues, and state the general function of each tissue.
- Specialized tissues in the cactus, shown below, help it to survive in the harsh desert climate. Why are epidermal tissues so important to plant survival?



Question 5

- Explain the location and function of ground tissue.
- Describe the function and importance of mesophylllic tissue.
- Define the term “regeneration,” and give an example of regeneration in animals.

Connect Your Understanding

- In this section, you learned about organ regeneration. Predict two social, political, or economic implications that would result if organ regeneration were possible for every organ in your body.

- What are some advantages and disadvantages of cell specialization?
- What is the relationship between specialized cells and tissues in animals?
- The muscles in the heart are said to be “involuntary.” Explain the meaning of this term, and then state why this characteristic of heart muscle is necessary.
- Explain how the different types of plant tissues are involved in photosynthesis.
- (a) Define the term “xylem.”
(b) Describe how the xylem and phloem work together as a transport system.
- Plants are often called “nature’s air purifiers.” Explain the meaning of this term.
- A cross section of a tree trunk reveals rings. These annual rings are made of xylem tissue. Scientists use the size of the tree rings to infer the climate of the year in which the tree grew. Use your knowledge of the function of xylem tissue to explain why wide rings could indicate that the tree grew in an environment with plenty of moisture while narrow rings could indicate that the tree grew in an environment that was unusually dry.

- Compare animal tissues and plant tissues that have similar functions.

Reflection

- Explain why you think that it is important for you to learn about stem cells and stem cell research.

For more questions, go to *ScienceSource*.

Great CANADIANS in Science**Sheela Basrur**

Figure 1.45 Dr. Basrur calms the fears of the public during the SARS outbreak.

In March 2003, a 44-year-old man went to the emergency room (ER) at Scarborough Hospital with an unknown respiratory illness. During the time he was in the ER, he transmitted the illness to two other patients and sparked a chain of infection that ultimately killed 44 people and sickened 330. Although no one knew it at the time, he had severe acute respiratory syndrome, or SARS.

SARS is a severe pneumonia-like respiratory disease that was first seen in Southeast Asia in late February 2003. By the time the disease had run its course, over 8000 people around the world were sick and 800 had died.

During the SARS epidemic, Dr. Sheela Basrur provided skilled leadership that earned her the respect of the people of Toronto as well as the rest of Canada (Figure 1.45). Dr. Basrur was Toronto's Chief Medical Officer of Health. Dr. Basrur and other medical officials put various procedures in place to control the epidemic. Rigid infection-control procedures were installed in 22 hospitals in Toronto: people who were exposed to SARS were put in quarantine, and people who had the disease were isolated. Dr. Basrur ultimately showed that the epidemic was under control.

In addition to calming a nation's fears about SARS, Dr. Basrur helped develop anti-pesticide and anti-smoking laws. After she showed leadership during the SARS crisis, she was appointed Ontario's Chief Medical Officer of Health and Assistant Deputy Minister of Public Health in 2004. She helped develop a post-SARS action plan for Ontario, which included stockpiling 55 million respirator masks for health-care workers and hiring 10 disease-tracking experts at public health labs. She resigned in 2006 to undergo treatment for cancer. In April 2008, Dr. Basrur received the Order of Ontario (Figure 1.46). On June 2, 2008, Dr. Basrur died; she was 51 years old. The headquarters for the newly formed Ontario Agency for Health Protection has been named in Dr. Sheela Basrur's honour.

Questions

1. Describe the role that Dr. Basrur played in controlling the SARS epidemic of 2003.
2. **ScienceSource** Research to learn how Ontario prepared itself for any future pandemic or epidemic.



Figure 1.46 Dr. Basrur admires the Order of Ontario that she received for her work during the SARS crisis.



Figure 1.47 A medical technologist draws blood from a patient's arm for testing.

Having the technology to diagnose and treat diseases is useful only if there are people qualified to use the technology. A medical laboratory technologist works individually or as part of a team in a laboratory to analyze specimens taken from a body. Common specimens sampled include blood, urine, fetal tissue, amniotic fluid, bone marrow, and tumours (Figure 1.47). A technologist uses sophisticated techniques and instruments to obtain necessary information about these specimens that will help doctors make medical decisions.

Since technology is constantly changing, a technologist must be capable of learning new information and techniques. Technologists need to be detail oriented and must demonstrate strong critical and creative thinking skills. Technologists must also possess strong motor skills and eye-hand coordination. They must know how to use a great variety of lab instruments and techniques and when to use each appropriately (Figure 1.48).

However, technical skill is not sufficient in itself. Analyzing lab specimens and recording lab results must be done accurately so that the decisions based upon the laboratory work are valid. The technologist must also remember that lab information will affect the present and future medical care of the patient.

Usually, technologist training requires two years at a post-secondary institution. In Ontario, the Michener Institute offers a great variety of specialty courses in medical laboratory technology. Some specialty areas require additional preparation at the university level.

Questions

1. Describe some of the skills needed to be a successful medical laboratory technologist.
2. **ScienceSource** Research three of the different areas in which medical laboratory technologists can work.



Figure 1.48 A technologist works with petri dish cultures of amniotic cells. Tests done on the cells will determine if the developing fetus has genetic disorders, such as Down syndrome or cystic fibrosis.

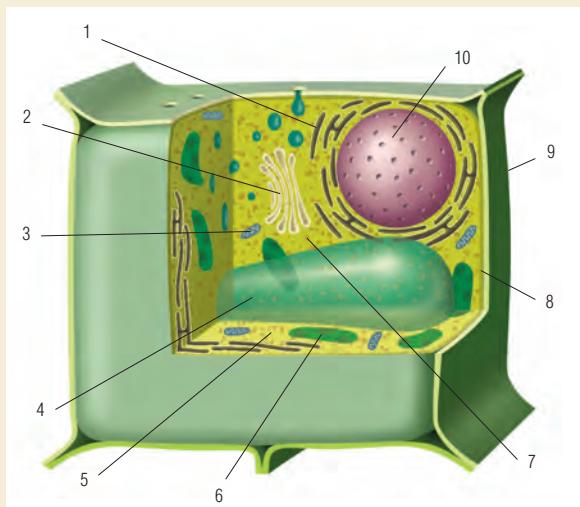
1 CHAPTER REVIEW

ACHIEVEMENT CHART CATEGORIES

- | | |
|--------------------------------------|-------------------------------------|
| k Knowledge and understanding | t Thinking and investigation |
| c Communication | a Application |

Key Concept Review

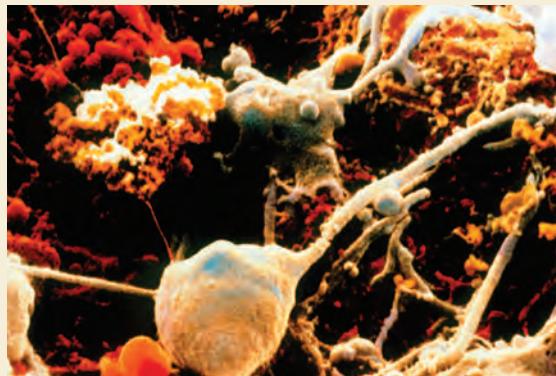
1. (a) Identify the type of cell shown below. **k**
- (b) Name all the numbered parts. **k**
- (c) Describe the function of parts 2, 3, 6, and 10. **k**



Question 1

2. Describe the cell cycle in plant and animal cells. **t**
3. What significant events occur during interphase? **k**
4. Describe the phases of mitosis using sketches and words. **t**
5. Describe some factors that affect the rate of mitosis in plants and in animals. **k**
6. Define the term “apoptosis.” **k**
7. Distinguish between embryonic stem cells and adult stem cells. **k**

8. Explain why cells, such as the brain cells shown below, undergo specialization. **t**



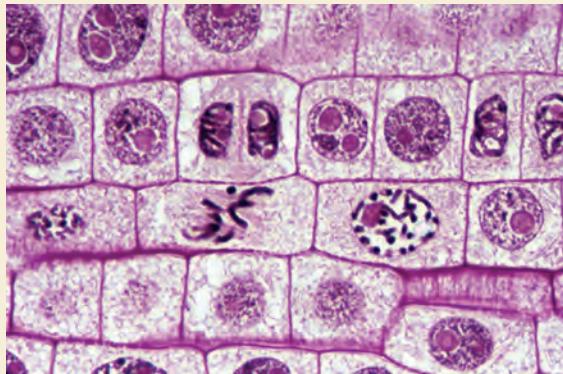
Question 8

9. How do cancer cells differ from normal cells? **k**
10. List the four types of animal tissues. **k**
11. What is the function of meristematic tissue in plants? **k**

Connect Your Understanding

12. Explain the role that magnification, resolution, and contrast play when using a microscope to find out about cell structure and function. **a**
13. Why do plant and animal cells have some of the same organelles? Describe these organelles. **t**
14. Why do plant cells have different organelles than those found in animal cells? Describe these organelles, and explain their functions. **t**
15. Write a short paragraph that defines the words and shows the relationships among the following terms: cell membrane, concentration, water, and solutes. **c**
16. Explain how the development of microscopy has led to an understanding of the cell. **a**

- 17.** For a cell to be able to perform the life processes, it must be able to move materials in and out of the cell. Explain how substances tend to move across the cell membrane. **t**
- 18.** Select one of the life processes of the cell and explain how cell organelles are used to accomplish the process. **t**
- 19.** What stages of mitosis do you see in the following photo? Explain your thinking. **t**



Question 19

- 20.** Explain the role of mitosis in the growth and repair of tissues in plants and animals. **t**
- 21.** Explain the role of cell specialization in the development of tissues. **t**
- 22.** What is a stem cell (shown below)? Explain why these cells are of great interest to researchers. **a**



Question 22

- 23.** Explain the link between the regeneration of tissues and stem cells. **t**
- 24.** Write a short paragraph that shows the relationship between the following terms: embryonic stem cells, adult stem cells, differentiation, and cell specialization. **c**
- 25.** Choose two advances in imaging technology, and explain how they have led directly to a new understanding of cell structure and function. **a**
- 26.** How are adult stem cells used in the process of tissue regeneration? Give examples in your answer. **a**
- 27.** What type of tissue would you expect to find in the stem of a plant? Explain your answer. **t**

Reflection

- 28.** Reflect on what you learned in this chapter. What interested you most about cells, the cell cycle, and tissues? Explain why this topic interested you. **c**

After Reading

Thinking Literacy

Reflect and Evaluate

List the reading strategies recommended in this chapter. Two of them involved using a graphic organizer, and two used pictures or graphics in some way. Rate the helpfulness of each strategy from 1 to 4. Which was most helpful in learning new ideas and terms? Compare your ratings with a partner's, and explain your reasons for the ratings.

Unit Task Link

Review your notes to find information about how the following aspects of cell biology have affected society: cell cycle, cancer cells, and stem cells. You may wish to record your ideas and classify them under the headings "Plus," "Minus," and "Interesting."

2

An organ consists of groups of tissues and works with other organs to form organ systems.



Skills You Will Use

In this chapter, you will:

- investigate, using a microscope, specialized cells in the human body or in plants, focussing on different types of cells, and draw labelled biological diagrams to show the cells' structural differences
- investigate, through laboratory or computer-simulated dissection of a plant, worm, fish, or frog, the interrelationships between organ systems of a plant or an animal
- use a research process to investigate a disease or abnormality related to tissues, organs, or systems of humans or plants

Concepts You Will Learn

In this chapter, you will:

- explain the links between specialized cells, tissues, organs, and systems in plants and animals
- explain the primary functions of a variety of systems in animals
- explain the interaction of different systems within an organism and why such interactions are necessary for the organism's survival

Why It Is Important

In this chapter, you will learn how the tissues in your body work together as organs and how your organs work together as organ systems. Understanding your body will help keep you as healthy as possible.



Before Reading

Thinking Literacy

Synthesizing: Putting the Pieces Together

Good readers know that often they have to read several paragraphs or pages of text to put together a whole picture of a topic. They know that each subtopic is really a piece of the puzzle. Preview the headings and subheadings in section 2.1, and write the ones that seem to go together in your notebook.

Key Terms

- absorption • capillaries • homeostasis • interdependent
- organ • organ system

2.1

Organs in Animals and Plants

Here is a summary of what you will learn in this section:

- In animals, tissues combine in special ways to form organs.
- In plants, tissues combine in special ways to form leaves, stems, and roots.



Figure 2.1 The organs were removed from Egyptian mummies before the body was preserved and wrapped.

What Is an Organ?

In ancient times, the Egyptians believed that all parts of a body were required in the afterlife. They developed special procedures to preserve the dead body in the form of a mummy so that it would not decay. They would cleanse the body and remove most of its internal organs because they would decay rapidly. Only the heart was left in place. An **organ** is an organized group of tissues that performs a specific function. The body was preserved with a drying agent and stuffed with linens and sawdust. The body was then wrapped from head to foot in linen (Figure 2.1).

Four organs — the stomach, intestines, liver, and lungs — were placed in special canopic jars, which prevented the organs from decaying (Figure 2.2). The lids of the jars were decorated with four protective spirits known as the four sons of Horus, who was one of the most important Egyptian gods. Each spirit protected a specific organ. Because the ancient Egyptians believed that the heart contained the spirit of the dead person, it was left inside the body. The brain was either left inside the skull or removed through the nose and discarded. The mummy was buried with the canopic jars so that the body could be complete in the afterlife.



Figure 2.2 Four canopic jars contained human organs.

The ancient Egyptians believed that only four organs were important. However, there are many organs in the human body: the kidneys, the eyes, the pancreas, the brain, and the skin are all organs. Each organ is made of a group of tissues that work together to perform a specific purpose. For example, the stomach, liver, and intestines are all organs that are involved with the digestion of food and the absorption of nutrients. The lungs are the site of gas exchange involving the intake of oxygen and the output of carbon dioxide. The skin, which is the largest organ in the human body, serves as a barrier against disease. Your kidneys filter wastes from your blood. All of our organs play a vital role in maintaining the health of our bodies.

It is important to keep our organs healthy and functioning properly. For example, eating a healthy diet and doing about 30 minutes of physical exercise a day strengthens your heart and lungs. Wearing sunscreen protects your skin from damage caused by the Sun.

When an organ does not work properly because of disease or injury, it is sometimes possible to transplant a healthy organ or part of an organ from a donor. Organs that are most often transplanted include the kidney, liver, lungs, and heart.

A13 Quick Lab

Mapping the Organs

The human body is made up of many organs that work together to accomplish all of the tasks required in a healthy functioning organism. Some of the organs are located on the outside of the body, while others are found internally. To understand the function of organs, you need to know where they are found in the human body.

Purpose

To predict the location, relative size, and shape of some organs of the human body, and to record your prediction in the form of a diagram

Materials & Equipment

- large piece of paper
- pen and/or pencil
- ruler

Procedure

1. Work with a partner, and obtain a large piece of paper from your teacher.
2. Have your partner trace an outline of your body on the large piece of paper.
3. Brainstorm for two minutes with your partner about the location, relative size, and shape of the following organs of the human body: stomach, lungs, intestines, liver, kidneys, and heart.
4. Draw and label the organs on the traced outline of your body.

Questions

5. Compare your completed labelled diagram with the answer key provided by your teacher. Which organs were the easiest to locate correctly? Which organs were the hardest to locate correctly?
6. Explain how so many organs in the human body fit in such a relatively compact space.

Animal Organs

Suggested STSE Activity •••••
A14 Decision-Making Analysis Case
Study on page 61

Recall that there are four types of animal tissues: epithelial, connective, muscle, and nervous tissue. Tissues join together to form organs that have specialized functions. For example, skin is an organ that covers and protects your body, while the heart transports materials around your body. Most organs are made of several different tissues. For example, the heart is made of muscle tissue, connective tissue, nervous tissue, and epithelial tissue.

Skin

WORDS MATTER

The word “epidermis” comes from the Greek word *epi*, which means on the outside, and the word *derma*, which means skin.

The largest organ in your body is the **skin**. The skin protects the inner cells from damage, acts as a defence against disease organisms, insulates, releases heat, and excretes bodily wastes. The skin is made up of two different layers of tissues: the epidermis and the dermis (Figure 2.3). The epidermis is the outer protective layer that is made up of epithelial tissue. The epidermis prevents bacteria and viruses from entering your body. The epidermis is also able to make vitamin D when the skin is exposed to ultraviolet radiation from the Sun. Vitamin D is essential for bone development.

The dermis is the inner layer of the skin and is made up of connective tissue, nervous tissue, and muscle tissue. Connective tissues provide structure and support. Blood and blood vessels are types of connective tissue. When you are hot, the blood vessels in your skin dilate, or become bigger, so that they can release excess heat. Pores in the skin secrete sweat produced in sweat glands to cool the body. Layers of fat, another type of connective tissue at the base of the dermis, provide insulation (Figure 2.4). The dermis contains nerves that sense pain, pressure, heat, and cold and send information to the brain. Muscle tissue in the dermis produces “goosebumps.”

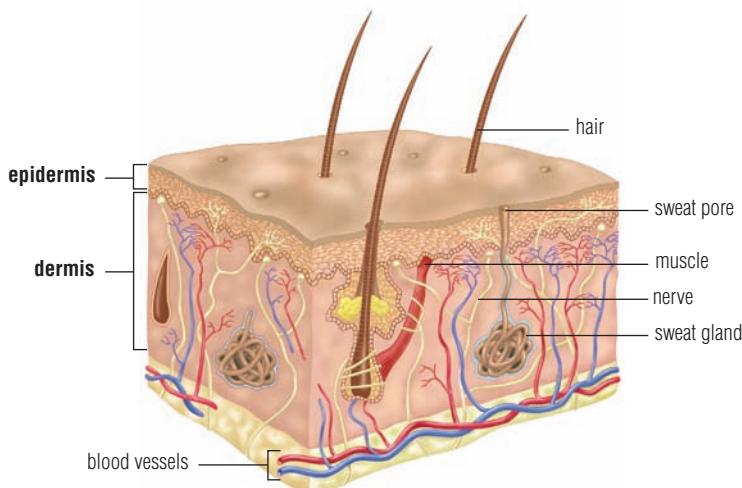


Figure 2.3 A cross section of skin showing the tissues and some of the accessory structures, such as hair and sweat glands.



Figure 2.4 Mammals, like these harp seals, that live in the Arctic have thick layers of fat in the dermis to provide insulation.

Lung

The **lungs** are a pair of organs involved in respiration (Figure 2.5). Your lungs allow you to breathe in oxygen and breathe out carbon dioxide. Cells need oxygen to function. In an adult human, one lung is about 1 kg. The lung is made of connective and epithelial tissue. Humans have two lungs that sit in a cavity in the chest area. The lungs are coated with two sacs of connective tissue separated by a thin layer of fluid. This not only protects the lungs but also reduces the effects of friction when the lungs move.

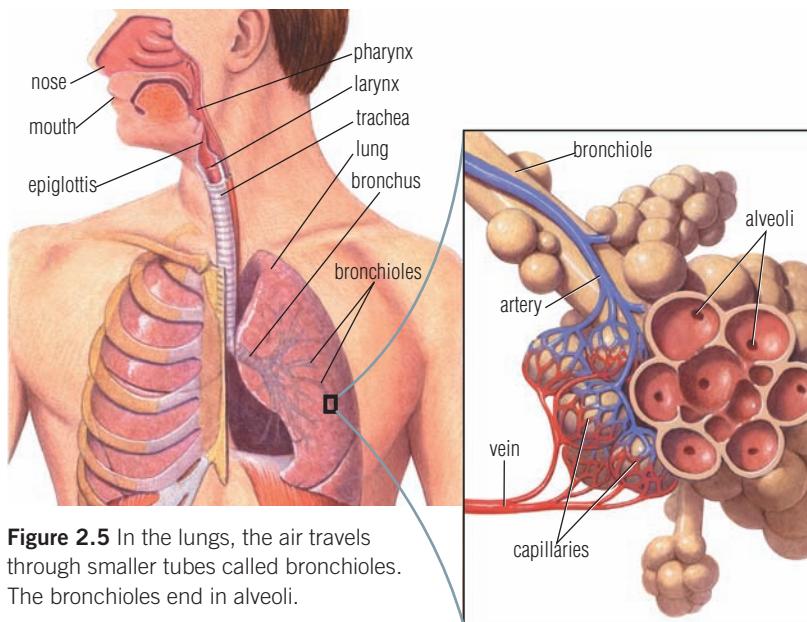


Figure 2.5 In the lungs, the air travels through smaller tubes called bronchioles. The bronchioles end in alveoli.

When you breathe in air through your nose or mouth, the air passes through the pharynx into your trachea. The trachea is a flexible tube that is ringed with cartilage. Air moves down the trachea to the bronchus, into smaller bronchial tubes, and then into tiny air sacs, called alveoli, which are made of a thin layer of epithelial tissue. Alveoli are surrounded by thin-walled blood vessels called **capillaries** (Figure 2.5). Each lung contains about 150 million alveoli. Oxygen travels from the alveoli through the capillaries into the blood. Carbon dioxide travels from the bloodstream across the alveoli to the air in the alveoli.

Heart

The **heart** is a muscular pump that supplies blood to all parts of the body. An adult human heart is about 300 g and is the size of a fist. In an average lifetime, the heart beats about 3.5 billion times. The heart is divided into four chambers: the left and right atria, and the left and right ventricles. The heart serves as a pump to deliver blood to the lungs, to the heart itself, and to the rest of the body (Figure 2.6).

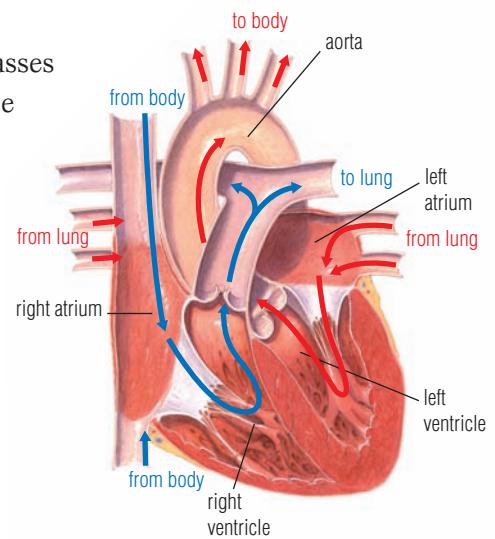


Figure 2.6 The right side of the heart (right atria and right ventricle) pumps blood to the lungs so that the blood can pick up oxygen. The left side of the heart (left atria and left ventricle) pumps the oxygenated blood through the aorta to the rest of the body.

Organs of Digestion

When you eat, various organs assist with the digestive functions to break down the food (Figure 2.7). For example, your mouth takes in food and begins digestion. The mouth is lined with epithelial tissue. There are also glands, made of specialized epithelial cells, that secrete mucus, saliva, and enzymes. The tongue is made of epithelial tissues and glands, connective tissues, and muscle tissue. Once the food enters your body, it travels from the mouth down a tube called the **esophagus**. The food moves along the esophagus because of the rhythmic constriction and relaxation of the smooth muscles that line the esophagus. This movement is known as peristalsis. The esophagus is lined with a protective layer of epithelial tissue. Further down the canal, food enters the **stomach**, which is made of epithelial, connective, nervous, and muscle tissues (Figure 2.8). The stomach churns food and mixes it with digestive juices and enzymes. Finally, the digested nutrients and undigested waste products move into the small and large **intestines**, which are areas of chemical digestion and removal of wastes. Solid wastes are stored in the rectum and exit the body through the anus.

During Reading

Thinking Literacy

Reread to Synthesize

Reread the subtopics about animal organs. Think about how these subtopics fit together and how one organ connects to another. Create a mind map of the organs, using lines and arrows to show which organs connect. Label the arrows with explanations of the connections.

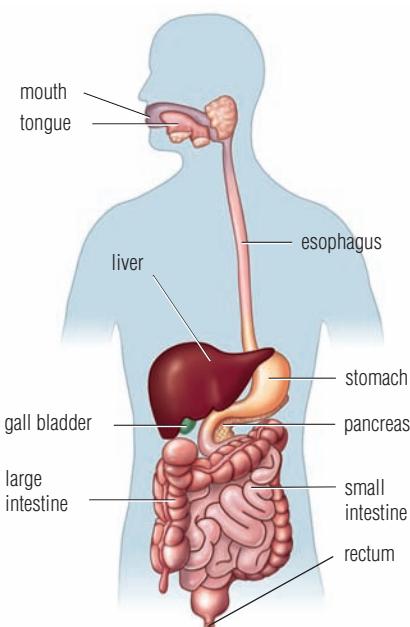


Figure 2.7 Organs of digestion

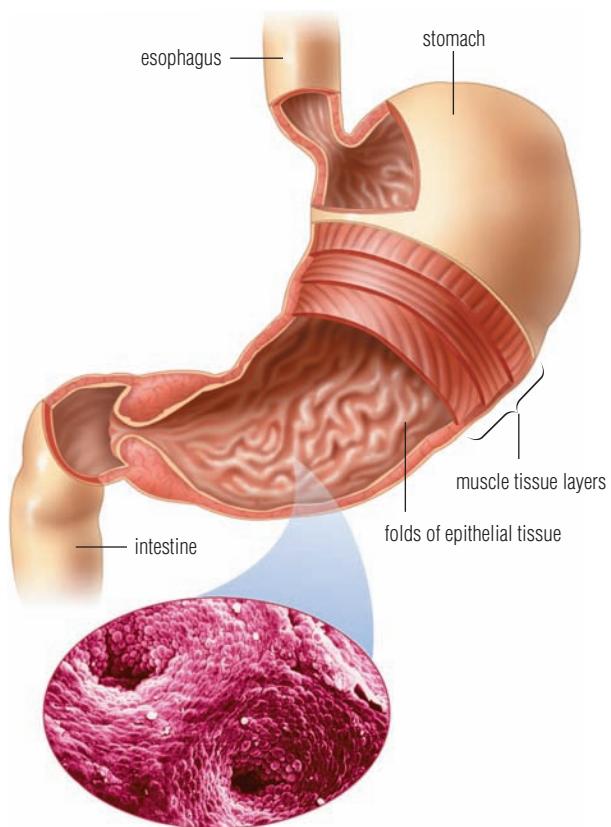


Figure 2.8 The stomach is made of smooth muscle and epithelial tissue as well as connective tissue and nervous tissue (not shown).

Plant Organs

A flowering plant is made up of four types of plant tissues: epidermal, ground, vascular, and meristematic. These plant tissues group together to form organs that perform special functions for the plant. The organs in a plant are the roots, the leaves, the stem, and the flower or fruit (Figure 2.9).

The Roots

The roots anchor the plant in the soil, which permits the plant to grow above the soil without toppling over. Roots also collect water from the surrounding soil and transport it to the stem, and store food that is made in other parts of the plant. Different tissues in the root work together to accomplish these functions. The bottom of the root is covered with protective epidermal tissue known as the root cap. Just below the epidermal tissue is a layer of meristematic tissue, which allows the root to grow. There are also layers of ground tissue and vascular tissue that make up the centre of the root.

The Leaf

The tissues in a leaf work together to accomplish photosynthesis, a chemical reaction in which carbon dioxide and water are converted into sugar and oxygen. The vascular tissue carries water needed for photosynthesis from the root up the stem to the leaf. The sugar produced is carried by the vascular tissues to the rest of the plant. Carbon dioxide enters, and oxygen and excess water exit through openings in the leaf epidermal tissue called stomata. These openings are controlled by special cells known as guard cells. Most of the leaf is made of a specialized ground tissue called mesophyll. Photosynthesis takes place in the mesophyll. Figure 2.10 shows the tissues in a leaf.

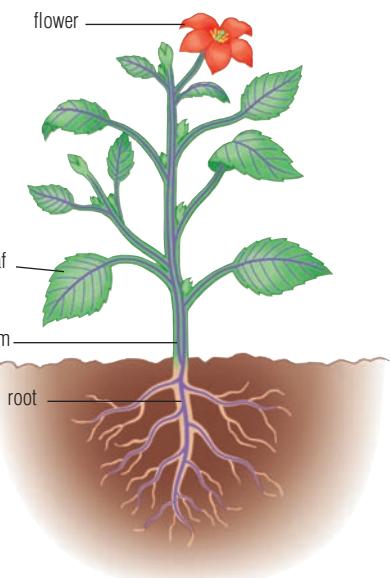


Figure 2.9 Groups of plant tissues form organs that perform specialized functions in a plant.

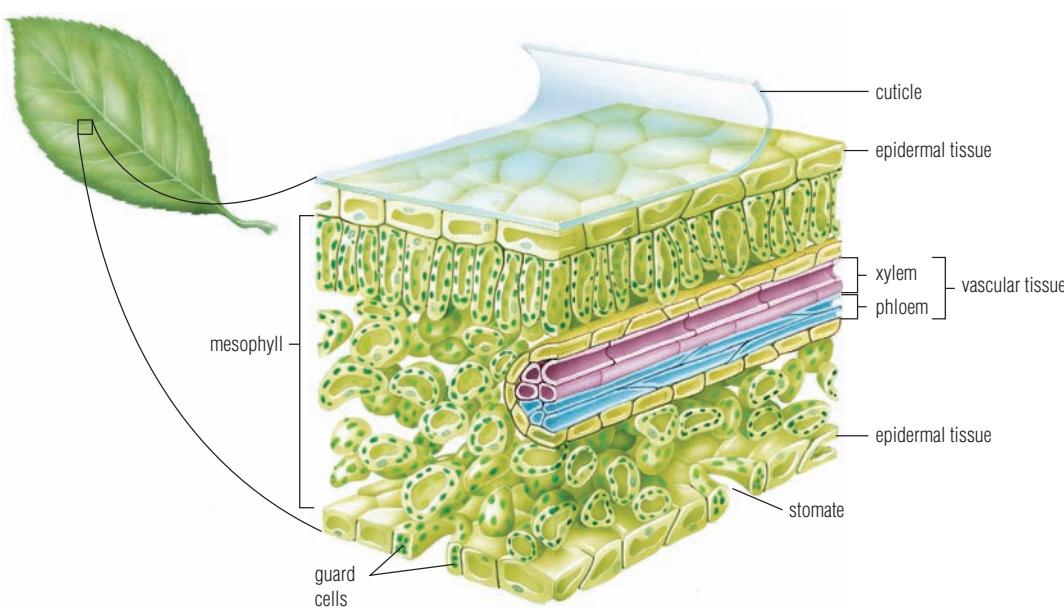


Figure 2.10 A cross section of a leaf showing the tissues

The Stem

The stem performs two major functions:

- transports water and nutrients throughout the plant
- supports the leaves and flowers

Suggested Activity •

A15 Inquiry Activity on page 62

The tissues that make up the stem reflect these functions.

Epidermal tissue provides a protective covering and allows for the exchange of gases and water vapour. In most plants, the epidermal tissue secretes a waxy substance known as the cuticle that forms a protective coating and reduces water loss. Ground tissue provides the stem with strength and support. Vascular tissue transports substances around the plant.

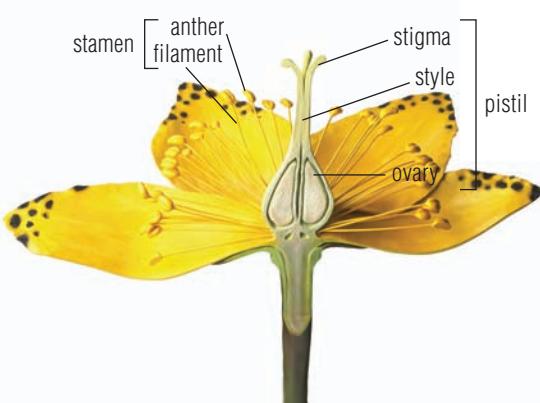


Figure 2.11 A flower's reproductive organs

The Flower

The flower is the reproductive structure of the plant. The main function of the flower is to produce seeds through sexual reproduction. The flower contains male organs, called stamens. Each stamen consists of a filament with an anther at the tip. The anther produces pollen, which are the male sex cells. The flower also contains female organs, called the pistil, which consists of the ovary, style, and stigma. Female sex cells, called eggs, are located in the ovary. Figure 2.11 shows the reproductive organs of a plant.

When the pollen and an egg unite, the fertilized egg becomes a seed. Some seeds are surrounded by flesh and are called the fruit. Other types of seeds have no fleshy covering but are encased in a hard shell. Like other parts of the plant, new cells are made from meristematic tissue. As the flower structures develop, the unspecialized meristematic tissue differentiates to form the other parts of the flower, such as the sepals and the stamen.

Take It Further



Carnivorous plants have the unique ability to capture and digest prey. The interactions of the cells, tissues, and organs are intriguing. Select a carnivorous plant to study. Explain how the plant captures, digests, and processes the nutrients in the prey. Report your findings to the class. Begin your research at *ScienceSource*.

Learning Checkpoint

1. What are the three functions of the roots?
2. Describe the major job of the leaf, and explain how two tissues in the leaf work together to accomplish this job.
3. Describe two functions of a stem, and explain how the tissues in the stem work together to accomplish one of the stem functions.
4. What is the major function of a flower?
5. Sketch a plant showing the root, stem, leaves, and flower. Use a system of colour coding or symbols to indicate the location of epidermal tissue, vascular tissue, and ground tissue.

- Identifying issues to explore
- Justifying conclusions

A Look at Stem Cells

Issue

Over 40 years ago, Canadian researchers Dr. James Till and Dr. Ernest McCulloch discovered the existence of stem cells in the blood. Stem cells are unspecialized cells (Figure 2.13). They have the ability to become any type of cell and, thus, can form skin, bones, and organs. This ability makes stem cells perfect to repair or replace cells that are damaged or defective. Scientists believe that stem cells may be used to cure diseases of tissues and organs, such as Parkinson's and Alzheimer's disease, multiple sclerosis, cancer, diabetes, and heart and lung disease. However, controversy surrounds the use of stem cells because the human embryo is the best source for stem cells.

Background Information

Michael J. Fox is a Canadian actor who is best known for the *Back to the Future* series of movies. In 1998, Fox revealed that he had Parkinson's disease, which affects the nervous system and causes people to lose control over their muscles. In 2001, Fox launched the Michael J. Fox Foundation for Parkinson's Research to raise funds and awareness about Parkinson's disease. Fox is hopeful that embryonic stem cells may cure Parkinson's disease.

Canada has developed strict guidelines surrounding the use of stem cells. Only embryos that are less than 14 days old and that are no longer wanted for reproduction may be used. This means that, in Canada, creating human embryos for stem cell research is not allowed.

So far, stem cell research has been done only on lab animals. Using stem cells has improved stroke recovery in rats, treated a disease similar to Parkinson's in mice, and caused new brain cells to grow in birds. In 2007, a Canadian research team led by Dr. Freda Miller used skin-derived stem cells to repair spinal cord injuries in rats.

Analyze and Evaluate

1. Identify the different types of stem cells (from Chapter 1), and explain how stem cells can be used in the treatment of diseases.
2. There are many different viewpoints about the use of stem cells. Prepare a graphic organizer that presents the position from one of the following points of view:
 - a research scientist
 - Michael J. Fox
 - a pharmaceutical company/biotech company owner
 - a public health official
3. **ScienceSource** Research how stem cells are used in the treatment of a specific disease or disorder. Include both the advantages and the disadvantages that are associated with the use of stem cells in the treatment of the disease or disorder.
4. **Web 2.0** Develop your research as a Wiki, a presentation, a video, or a podcast. For support, go to **ScienceSource**.

Skill Practice

5. Explain how the ethical issues associated with the use of adult stem cells are different than those associated with the use of embryonic stem cells.



Figure 2.13 Stem cells

A15 Inquiry Activity

Skills References 2, 6

SKILLS YOU WILL USE

- Using equipment, materials, and technology accurately and safely
- Observing, and recording observations

Dissecting a Flower

Flowers vary greatly in their structure and appearance. For centuries, flowers have been prized for their beauty and also used as a source of food and medicine. The flower is the reproductive organ of a flowering plant.

Question

How is the flower designed for reproduction?

Materials & Equipment

- flower, such as a lily, tulip, daffodil, or gladiolus
- tweezers
- pen and/or pencil

CAUTION: If you are allergic to plants or pollen, let your teacher know.

Procedure

1. Obtain a single flower, and observe the parts carefully. Compare your flower with the labelled diagram (Figure 2.12). Make a sketch of each part of the flower, and include notes about the appearance of each part.
2. Locate the sepals. Using the tweezers, gently remove the sepals and place them on a paper.
3. Petals are found directly under the sepals. Gently remove the petals, and place them on the paper next to the sepals.
4. Locate the stamens. They may be attached to the ovary or petals. Identify the anther and any pollen sacs that are visible. Make notes about the appearance of each part.
5. Locate the pistil. Identify the stigma, style, and ovary. Make notes about the appearance of each part.
6. Clean up your work area. Make sure to follow your teacher's directions for safe disposal of materials. Wash your hands thoroughly.

Analyzing and Interpreting

7. Describe the appearance of the petals. Explain how flower petals are adapted to attract pollinators to the plant.
8. The pollen of grasses and trees is usually carried by the wind. Explain how the structure of grass pollen may differ from the pollen of a rose.
9. Describe the appearance of the stigma. Explain how the structure and location of the stigma is important to the process of reproduction.

Skill Practice

10. Explain how dissecting a flower helps you to understand its function.

Forming Conclusions

11. Give evidence from your observations to show how the flower's structure is suited to the task of reproduction.

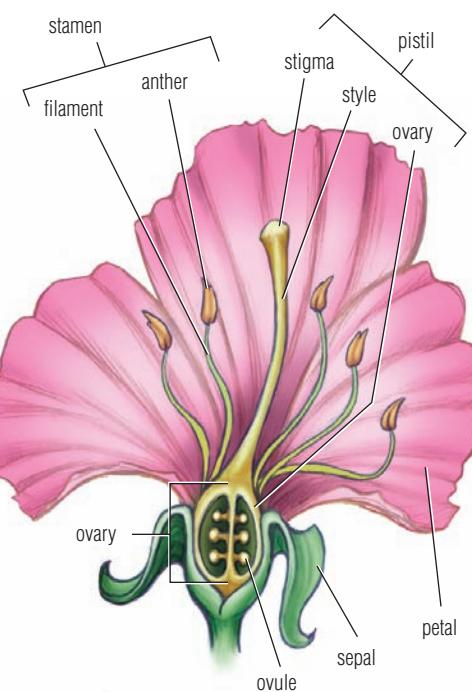


Figure 2.12 The parts of a flower

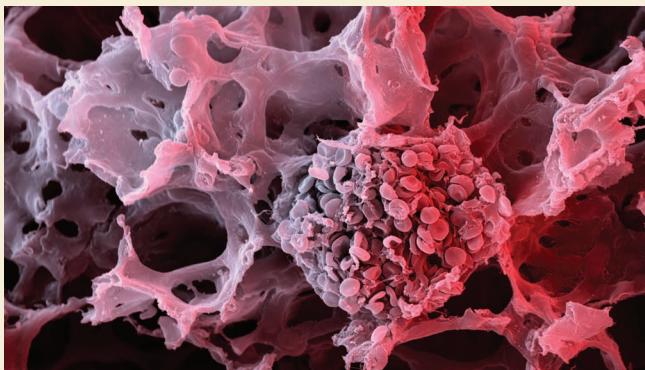
2.1 CHECK and REFLECT

Key Concept Review

1. What is an organ? Give an example of an animal organ and a plant organ.
2. (a) What tissue in the skin provides a layer of protection?
(b) Explain how the tissues in the dermis work together to permit you to respond to environmental changes.
3. (a) What tissues are found in the lung?
(b) What is their function in the lung?
4. (a) What is the function of the heart?
(b) Explain how the heart performs this function.
5. What are the functions of the stomach and intestines?
6. What is a fruit?
7. Describe the function of a flower in a flowering plant.

Connect Your Understanding

8. The photo below shows an electron micrograph of lung tissue. In the upper centre of the micrograph, you can see a capillary filled with red blood cells. The ducts surrounding the capillary are the endings of the bronchioles. Explain how the structure of the lung allows for the exchange of oxygen and carbon dioxide.



Question 8

9. Why are so many organs made of connective tissue and epithelial tissue?
10. In what three organs would you expect to find muscle tissue?
11. Explain why Canadians may be advised to take a vitamin D supplement during the winter months.
12. Why would a serious lung infection make you feel tired?
13. Explain why it is beneficial to have the heart and the lungs in close proximity.
14. Give a reason why plants have only a few organs while animals have many organs.
15. Use a flowchart to show how gas is exchanged in a leaf. Be sure to name specific tissues.
16. You wish to move a plant from one location in your garden to another location. Explain what would happen to the plant if the roots were damaged during the move.
17. You may be familiar with the job of a security guard or a bodyguard. Explain why the name “guard cell” is appropriate for these cells in the leaf.
18. Explain what would happen if plants were not covered with epidermal tissue.

Reflection

19. State two facts that you learned in this section that will influence your choices and behaviour in the coming year.

For more questions, go to *ScienceSource*.

2.2

Organ Systems in Animals and Plants

Here is a summary of what you will learn in this section:

- Organs function together to form organ systems.
- Organ systems perform one or more functions in the human body.
- Organ systems work together to accomplish movement, support, protection, communication, transport, reproduction, digestion, gas exchange, and waste removal.
- Plants have two organ systems that function in an interdependent fashion.



Figure 2.14 The star-nosed mole is an efficient predator because its organ systems work together.

Organs Working Together

The star-nosed mole (Figure 2.14) may be one of the strangest-looking creatures on Earth, but it is also one of the most efficient predators. It can find and eat prey — including worms and insects — in less than one second!

The mole is built not only to be able to find and obtain food quickly but also to escape from harm and danger quickly. The star-nosed mole can be found in eastern North America. In Canada, the star-nosed mole's range is from Atlantic Canada to eastern Manitoba. In the U.S., the mole ranges along the Atlantic coast to northern Florida. However, people rarely see the star-nosed mole because it lives only in marshes and wetlands. The body of the mole is elongated and covered in dark fur. This body shape is ideal for moving through the soil and the water. The dark colour of fur traps heat and keeps the mole warm while it is swimming in icy water. The limbs of the mole are strong and enable the mole to dig and swim effectively.

The mole finds food by digging tunnels in the soil. While digging, the mole is able to move quickly in complex ways by kicking, brushing, and pushing dirt with its back legs. The unusual star on the nose of this mole is a touch organ, formed from 22 tentacles (Figure 2.15). Each tentacle is covered with sensory receptors, called Eimer's organs. The tentacles are used to touch objects near the mole. When a mole touches something that may be food, it needs less than a quarter of a second to identify it, decide if it is edible, and eat it.



Figure 2.15 A star-nosed mole blowing a bubble from its nose. The mole will then inhale the bubble to smell underwater.

The star-nosed mole is a good example of how different organs work together in an organism to accomplish the many varied tasks needed for survival. Organs that function together form **organ systems**, such as the nervous system or the muscular system. Each organ system consists of a group of organs that work together to carry out specific duties in the body. For example, for the star-nosed mole to find food quickly, the nervous system, which for the mole includes its star appendage, works with its muscular system and its skeletal system to enable the mole to move quickly and efficiently. In other words, the brain coordinates the movements of the muscles and bones so that the mole can react quickly to messages picked up by its star appendage.

A16 Quick Lab

Moving Materials

The process of digestion involves several organs. Each of the organs plays a special role in the digestive process (Table 2.1). To understand the digestive process and how materials move through the digestive organs, we can use a model of the digestive system.

Table 2.1 Digestive Organs and Their Functions

Digestive Organ	Function
mouth	<ul style="list-style-type: none">physical digestion through action of teeth, tongue, and salivachemical digestion of sugars using salivary enzymes
esophagus	<ul style="list-style-type: none">movement of food in rhythmic waves known as peristalsis
stomach	<ul style="list-style-type: none">physical digestion through churning action and mixing with digestive juices (acids and enzymes)chemical digestion of protein through the action of enzymes
liver	<ul style="list-style-type: none">secretes bile, which breaks up fat to aid absorption, into the intestine
pancreas	<ul style="list-style-type: none">secretes pancreatic juice, insulin, and enzymes into the intestine
intestines	<ul style="list-style-type: none">completes chemical digestion of food using enzymesreabsorbs waterabsorption of nutrients through large surface area
rectum and anus	<ul style="list-style-type: none">storage of waste material until elimination occurs

Materials & Equipment

- nylon stocking (open at both ends)
- an orange

Purpose

To investigate a model of the digestive system to understand how materials move through the digestive tube

Procedure

- Form small groups of three to four students. Obtain the materials from your teacher.
- Review the function(s) of the digestive organs listed in Table 2.1.
- Place the orange in the stocking, and attempt to move the orange through the stocking efficiently.
- Record the strategies that you and your group used to move the orange from one end of the stocking to the other.

Questions

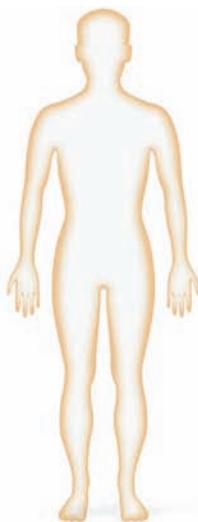
- What problems did you encounter when you were moving the orange from one end of the stocking to the other?
- The orange and the stocking can be used as a model of how digested food moves through the digestive system. How is this model similar to the movement of materials through the digestive tube? How is this model different?

Animal Organ Systems

You may have gone to a potluck dinner where every guest brings something that contributes to the meal. For example, someone may bring the salad, while another person brings the main dish, and someone else brings the dessert. The success of the dinner depends on everyone bringing something to the dinner.

We can think of an organ system as being similar to a potluck dinner. Just as each person contributes something to the dinner, each organ performs a function in an organ system.

Biologists categorize organ systems according to their main functions. There are 11 main organ systems in the human body (Figure 2.16). Table 2.2 summarizes the basic functions of these organ systems. In this section, we will concentrate on the following five organ systems: integumentary, digestive, respiratory, circulatory, and excretory.



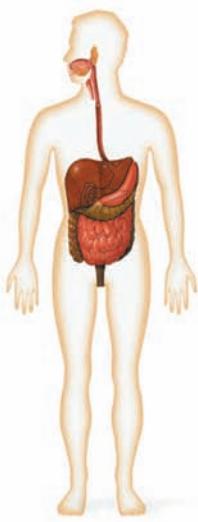
Integumentary System



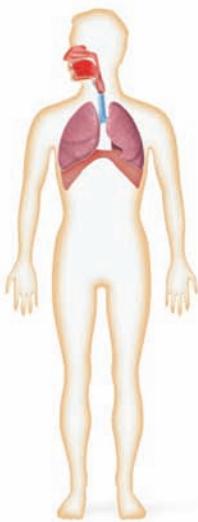
Skeletal System



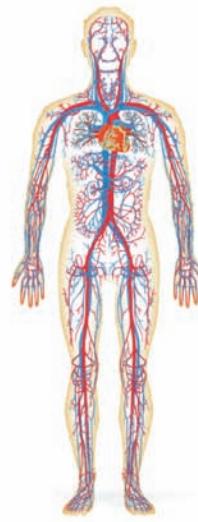
Muscular System



Digestive System



Respiratory System



Circulatory System



Nervous System

Figure 2.16 The 11 organ systems in the human body

Table 2.2 Basic Functions of Organ Systems

Organ System	Organs Involved	Basic Function
integumentary system	skin, hair, nails, glands	<ul style="list-style-type: none"> • covers and protects body • glands help control body temperature
skeletal system	bones, cartilage	<ul style="list-style-type: none"> • supports body • allows movement • protects the body
muscular system	skeletal muscle, smooth muscle, cardiac muscle, tendons, ligaments	<ul style="list-style-type: none"> • works with skeletal system to provide movement • moves materials within body
digestive system	mouth, esophagus, stomach, pancreas, gall bladder, liver, intestines, rectum	<ul style="list-style-type: none"> • ingestion • digestion • absorption of nutrients • elimination of solid wastes
respiratory system	nose, mouth, trachea, lungs, bronchi, bronchioles, alveoli, diaphragm	<ul style="list-style-type: none"> • exchange of gases
circulatory system	heart, blood vessels, blood	<ul style="list-style-type: none"> • transportation of materials (such as oxygen, nutrients, hormones, and wastes) within body
nervous system	brain, nerves, spinal cord	<ul style="list-style-type: none"> • controls body functions • coordinates responses and activities
endocrine system	glands (pituitary, hypothalamus, thyroid, adrenals), pancreas, ovaries (in females), testes (in males)	<ul style="list-style-type: none"> • controls growth and development • controls metabolism
excretory system	skin, kidney, bladder, ureter, urethra	<ul style="list-style-type: none"> • elimination of wastes
reproductive system	ovaries, fallopian tubes, vagina, uterus (in females); testes, epididymis, vas deferens, penis, urethra (in males)	<ul style="list-style-type: none"> • reproduction
lymphatic system	white blood cells, thymus, spleen, lymph nodes, lymph vessels	<ul style="list-style-type: none"> • protects body from disease • circulates fluid called lymph • absorbs and transports fats

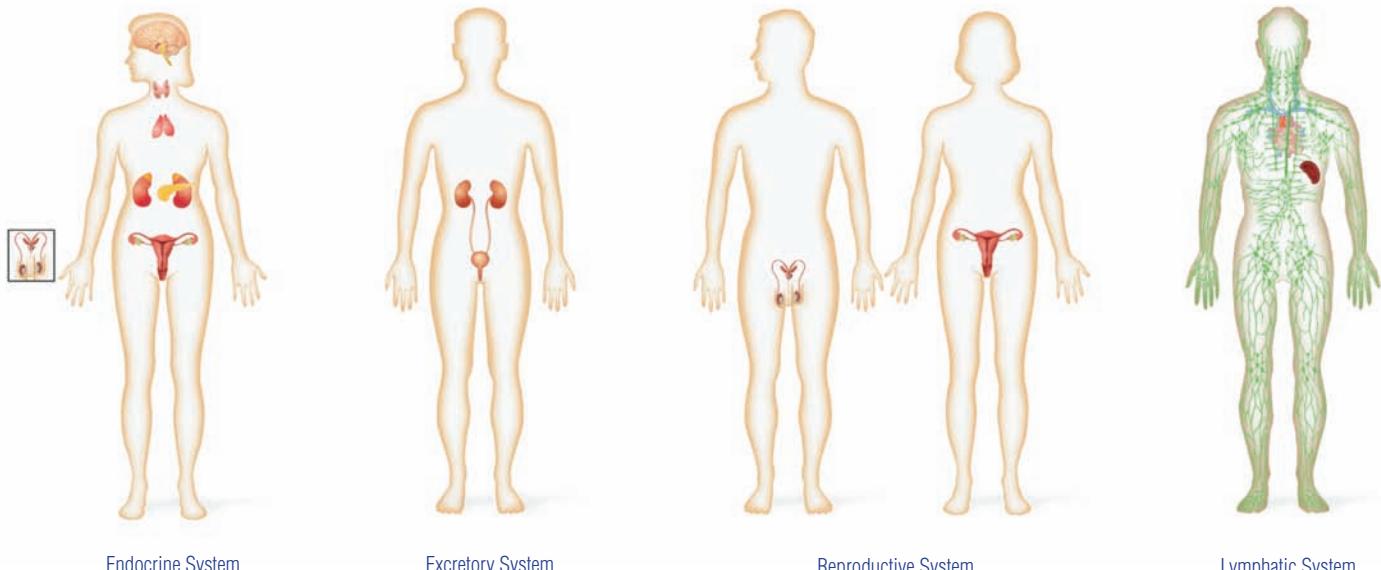




Figure 2.17 The integumentary system

Suggested Activity •
A18 Inquiry Activity on page 74

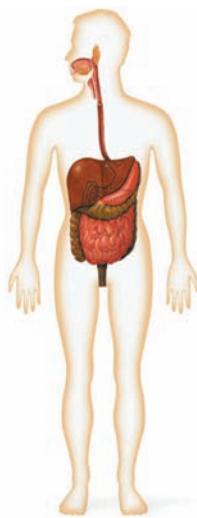


Figure 2.18 The digestive system

The Integumentary System

The most visible organ system is the **integumentary system**. It is made up of skin (epidermis and dermis) and accessory structures. Accessory structures include horns, antlers, hooves, quills, claws, hair, and nails. Various glands, including sweat glands, sebaceous (oil) glands, and scent glands are also part of the integumentary system. Figure 2.17 shows the human integumentary system.

Skin glands produce fluids that serve different purposes. For example, sweat glands secrete sweat, a clear fluid made of water and body salts. Evaporation of sweat cools the body when it is overheated. Sebaceous glands produce oil that lubricates, waterproofs, and helps prevent skin infections. When the sebaceous glands become plugged with dirt and excess oil, a blackhead forms.

The Digestive System

In humans, the **digestive system** is essentially a tube that extends from the mouth to the anus (Figure 2.18). The digestive system transports nutrients through the body. In humans, the food passes from the mouth, down the esophagus, into the stomach, through the small and large intestine, to the rectum. The major function of the digestive system is the absorption of nutrients. **Absorption** is the process by which food that has already been broken down passes through the walls of the intestine into the bloodstream. Absorption takes place mainly in the small intestine. Refer to Table 2.1 on page 65 to review the roles that the various organs play in human digestion.

The Digestive System of an Earthworm

Not all animals have a digestive system that is similar to humans. For example, earthworms are segmented worms that live in soil (Figure 2.19). As an earthworm moves through the soil, it takes in dirt through its mouth. The food is pushed by muscular contractions through the esophagus to the crop. The food then moves into the muscular gizzard, which grinds the food into smaller pieces. The food is then pushed into the intestines, where digestion and absorption of nutrients occur. Waste material is expelled through the anus.



Figure 2.19 An earthworm



Figure 2.20 Yellow perch



Figure 2.21 North American bullfrog

The Digestive System of a Fish

Fish have a unique digestive system. For example, the yellow perch eats insects and other small organisms (Figure 2.20). The perch's mouth has small sharp teeth that enable it to grasp its prey. Food passes from the mouth down the esophagus into the stomach, where the food is broken down. Some fish have a special pouch, called the pyloric caecum, which further breaks down the food and absorbs the nutrients. Digestion is completed in the intestine.

The Digestive System of a Frog

Adult frogs are carnivores that will eat anything that they can catch (Figure 2.21). A frog's tongue is attached to the front of the mouth so that it can capture flying insects effectively. It has two sets of teeth that it uses to hold prey. When the frog swallows, it closes its eyes and pushes its eyes downward. This action causes pressure on the roof of the mouth, which forces the food to move into the gullet. The food travels down the esophagus to the stomach and then to the intestines. Waste materials exit the body through an opening called the cloaca.

The Respiratory System

Each cell in your body requires oxygen to carry out various life processes including growth, movement, and reproduction. Oxygen is also required to break down food to produce energy: this chemical process is known as cellular respiration.

The function of the **respiratory system** is to obtain oxygen and release carbon dioxide. When you inhale, you take in air through either your nose or mouth. The air passes down the trachea into the bronchus to the bronchioles. The bronchioles empty into the alveoli, which are surrounded by thin-walled blood vessels. The alveoli are the sites of gas exchange. Figure 2.22 shows the organs involved in the human respiratory system.

During Reading

Thinking Literacy

A Venn Diagram Synthesizes Similarities and Differences

Every living creature has a digestive system. Create a triple Venn diagram for the earthworm, the fish, and the frog. In the overlapping part of the circles, put the features or actions of the digestive systems that are similar. In the outer parts of the circles, put the features or actions that are different.



Figure 2.22 The respiratory system

Suggested Activities •••••

- A19 Quick Lab on page 76
- A20 Quick Lab on page 76

Breathing

Your lungs are housed in your chest cavity, which is enclosed by the ribs, chest muscles, and the diaphragm. When you inhale, your rib cage rises and your diaphragm contracts and moves downward, which increases the size of your chest cavity. An increase in the volume of the cavity causes a decrease in the internal air pressure in the cavity. Because the internal air pressure of the cavity is less than the air pressure in the environment, air rushes into your lungs to equalize the pressure.

When you exhale, your rib cage lowers and your diaphragm relaxes and moves upward, decreasing the size of your chest cavity. The decrease in the volume of the cavity causes an increase in the internal air pressure in the cavity. Since the internal air pressure is higher than the pressure in the environment, air moves out of your lungs. Figure 2.23 shows the movement of the diaphragm during breathing.

Figure 2.23 During inhalation, the chest cavity expands as the rib cage rises and the diaphragm contracts. During exhalation, the rib cage lowers and the diaphragm relaxes, which decreases the size of the chest cavity.

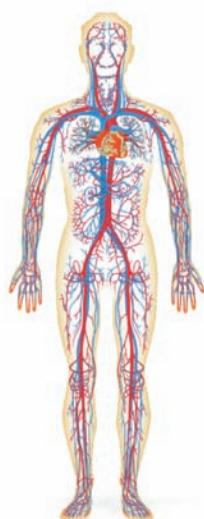
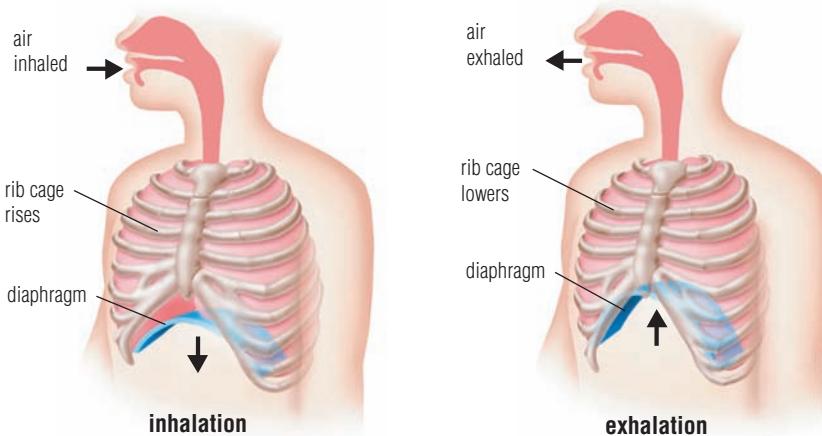


Figure 2.24 The circulatory system

The Circulatory System

The **circulatory system** is the blood's transportation system (Figure 2.24). The circulatory system includes the heart, blood, and blood vessels. The heart acts as a pump to transport and regulate the flow of blood through a series of blood vessels: arteries, veins, and capillaries.

Arteries are thick-walled vessels that carry blood away from the heart to the tissues. The thickened muscular walls of the arteries allow them to withstand the force of the blood that is pumped from the heart. Veins carry blood back to the heart. The blood flowing through the veins is at a lower pressure than that in the arteries. Therefore, veins have thinner walls than arteries. Veins also contain valves so that the blood does not flow backward. Arteries do not contain valves because the blood flow is pushed along by the blood pumped by the heart. A network of capillaries connects veins and arteries.

Capillaries

Capillaries are the smallest blood vessels in your body; they are about one cell thick. Oxygen (O_2) and carbon dioxide (CO_2) flow in and out of capillaries by the process of diffusion (Figure 2.25). Diffusion is the movement of a substance from an area of high concentration to an area of low concentration. If the blood has more oxygen than the tissues, oxygen will diffuse across the capillary walls and enter the tissues. Carbon dioxide and other wastes are also removed from tissues by diffusion. If the tissues have more carbon dioxide than the blood, the carbon dioxide diffuses across the capillary walls and enters the blood. The blood then carries the carbon dioxide to the lungs, where it is released as you exhale.

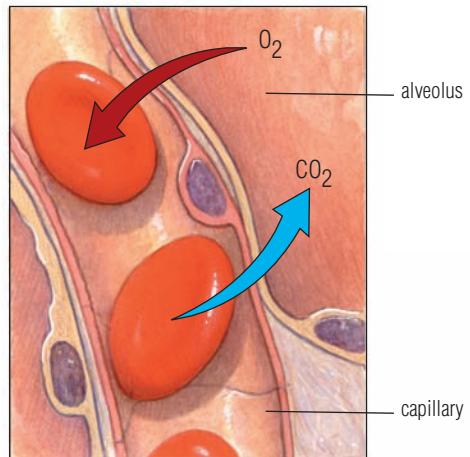


Figure 2.25 Gas exchange between a capillary and the membrane of an alveolus

The Excretory System

The **excretory system** consists of the kidneys, ureters, urinary bladder, urethra, and skin (Figure 2.26). This system filters waste products from the blood and maintains the proper levels of water and electrolytes in the body. As blood flows through your kidneys, wastes such as urea, carbon dioxide, and water are removed by filters called nephrons. These wastes form a fluid called urine. The urine moves out of the kidneys down the ureters to the urinary bladder, where it is stored until it can be eliminated. Elimination occurs when urine travels through the urethra and out of the body. The skin is considered to be part of the excretory system because it excretes water, salts, and urea in sweat.

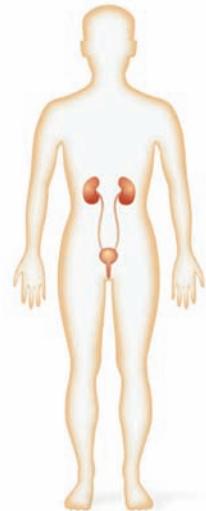


Figure 2.26 The excretory system

Learning Checkpoint

1. What organs in the digestive system are common to the earthworm, perch, and frog?
2. Name one structure that is unique to the digestive system of the earthworm, perch, and frog.
3. What is the diaphragm, and how is it involved in breathing?
4. Explain the role of diffusion in the process of gas exchange.
5. Explain how the excretory system eliminates waste.

Plant Organ Systems



Figure 2.27 A tomato plant's organ systems

A plant has two organ systems: a shoot system and a root system (Figure 2.27). The shoot system is everything that is above ground: the stem, leaves, buds, flowers, and fruits. The root system is everything underground, as well as aerial roots even though they are above ground.

To understand the interdependence between the shoot and root system, consider how water is transported through the plant. Both the roots and the shoots play a role in moving water through a plant.

A plant's roots can push water up the stem. However, the roots can only push the water a few metres and many plants are over 100 m tall. Water enters the root hairs and travels to the xylem. Once the water is in the xylem, it is moved against gravity up the stem to the leaves through transpiration. **Transpiration** is the evaporation of water through the stomata in the leaves. As each water molecule evaporates, it creates a transpiration pull on the adjacent water molecules, which pulls the water up the xylem to the leaves. Once the water reaches the leaf, the transpiration pull is enough to move the water from the xylem into the ground tissue. The leaves lose a high proportion of the water because of evaporation through the stomata. This evaporation maintains the transpiration pull, and water is continuously drawn up the stem. Figure 2.28 shows the direction of water movement.

The organs of a plant also work together to ensure that the plant survives changes in the environment. For example, some specialized cells record changes in the exposure to light. When the length of daylight increases, chemical messages are delivered to tissues to stimulate the production of a flower. Sometimes, in times of drought and excessive heat, a plant may decrease its production of leaves.

Take It Further

The tobacco mosaic virus is responsible for severe damage to many Ontario crops. The virus causes changes to a plant's shoot system including the formation of a mosaic pattern on the leaves. The damage to the leaves stresses the plant and results in stunted plant growth. The study of this virus has helped scientists to learn about diseases of plant organ systems and viruses. Learn more about which Ontario food crops are affected by this virus and how this virus affects Ontario food crops. Report back to the class. Begin your research at *ScienceSource*.

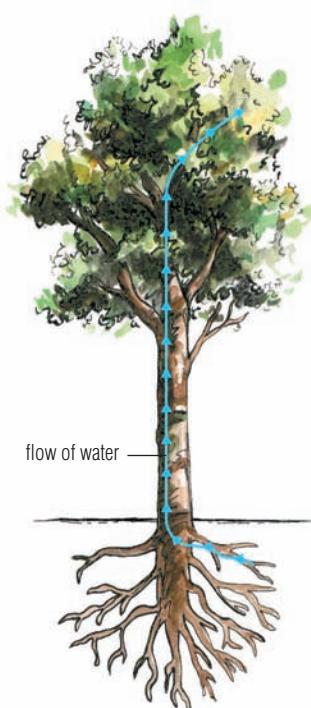


Figure 2.28 Water in a tree flows from the roots to the leaves.

A17 Skill Builder Activity

Dissection Essentials

There are some important terms that are used in dissection. You will learn these terms while dissecting a vegetable.



Materials & Equipment

- cucumber
- paper towel
- paper
- pen and/or pencil
- scalpel

CAUTION: If you are allergic to plants or pollen, let your teacher know. To avoid injury, use proper techniques when using the scalpel.

Procedure

1. Obtain a cucumber, and cut out two holes in one side. These holes represent the eyes. The top of the cucumber is known as the anterior, or cranial. The other end of the cucumber is the posterior, or caudal. Refer to Figure 2.29(a).

anterior (cranial)



(a)

2. The front-facing side of the cucumber is the ventral side. The back side of the cucumber is called the dorsal side. We can think of the ventral side as the stomach side. Refer to Figure 2.29(b).

3. Locate the anterior end, and use a scalpel to make a shallow cut along the ventral side of the cucumber to the posterior end. This is known as a sagittal cut. If you cut the cucumber all the way through, you would make a sagittal section.

4. Make a shallow cut that is midway on the ventral side. Extend the cut from left to right. This type of cut is known as transverse. If you were to cut all of the way through the cucumber, you would make a transverse section of the cucumber.

5. Make a sketch of your cucumber, and label with the terms that you have learned.

6. Clean up your work area. Make sure to follow your teacher's directions for safe disposal of materials. Wash your hands thoroughly.

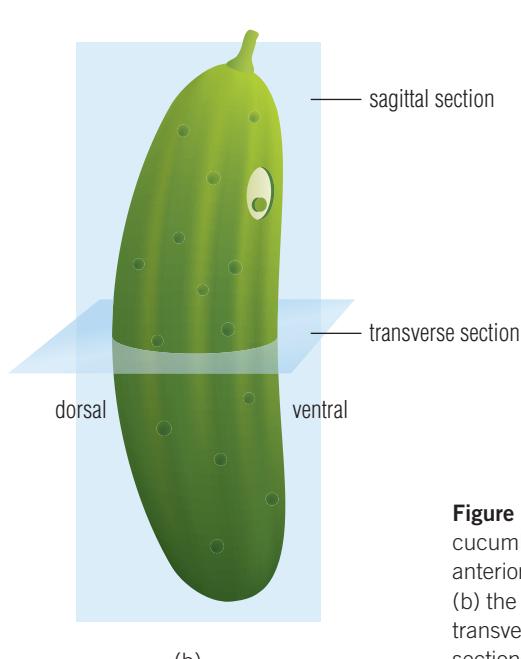


Figure 2.29 A view of a cucumber showing (a) the anterior and posterior end and (b) the orientation of the transverse and sagittal sections.

A18 Inquiry Activity

Skills References 2, 6

SKILLS YOU WILL USE

- Adapting or extending procedures
- Interpreting data/information to identify patterns or relationships

The Digestive System of an Animal

An animal is able to process and absorb nutrients in the food using its digestive system. Digestive systems vary in animals. Biologists have found that particular animals, such as the earthworm, perch, and frog, are good representatives of the increasing complexity in digestive systems.

In this activity, you will study these three digestive systems through dissection. You may do the dissection with preserved specimens of an earthworm and perch or use a virtual dissection program. You may choose to do only one dissection, or you may do all three to compare the systems.

Question

How does the digestive system of the earthworm, the perch, and the frog accomplish the process of digestion?



Materials & Equipment

- paper towels
- dissecting pins
- preserved specimens of earthworm and perch
- forceps
- hand lens
- virtual dissection program for earthworm, perch, and frog
- scalpel or dissecting scissors
- pen and/or pencil
- probe
- paper
- dissecting tray
- setae

CAUTION: To avoid injury, use proper techniques when using the scalpel.

Procedure

Part 1 — Digestive System of the Earthworm

1. Since the organs are small, it is helpful if you are familiar with their position in the earthworm before you begin your dissection. Complete a diagram of the earthworm digestive system based on Figure 2.30. When you are finished with your diagram, complete a virtual dissection of an earthworm by following the instructions in the program, or obtain a preserved specimen of an earthworm, dissection tools, and dissection pan. Rinse your specimen with water, and pat dry.
2. Using the hand lens, examine the external structure of the earthworm so that you can identify the prostomium, clitellum, setae, and anus. The prostomium is in front of the mouth. The clitellum looks like a saddle and is on the dorsal side of the earthworm. The setae are tiny bristles found on the ventral side. The anus is found on the ventral side of the last segment of the worm.
3. Place the earthworm so that the dorsal side is facing up. Using your scissors, make a shallow cut on the dorsal side from the clitellum to the prostomium.

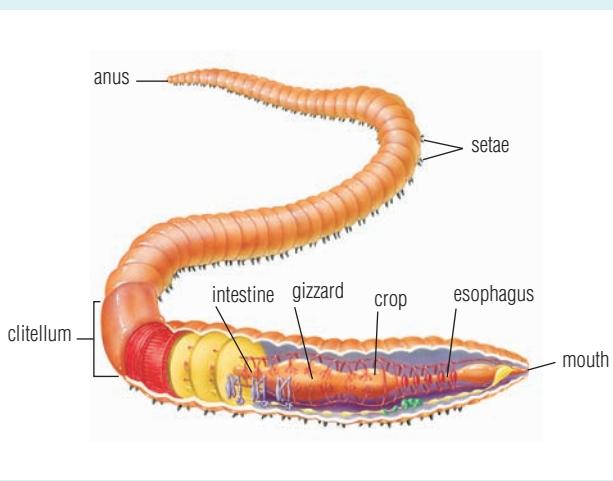


Figure 2.30 The external and internal anatomy of the earthworm

A18 Inquiry Activity (continued)

4. Separate the tissue, and use dissecting pins to pin the body wall down to the tray. You may need to cut through the tissue that holds the body wall.
5. Locate the mouth, esophagus, crop, gizzard, intestine, and anus using Figure 2.30.
6. Clean up your work area. Make sure to follow your teacher's directions for safe disposal of materials. Wash your hands thoroughly.

Part 2 — Digestive System of the Perch

7. Complete a diagram of the perch digestive system based on Figure 2.31. When you are finished with your diagram, complete a virtual dissection of a perch or obtain a preserved specimen of a perch, dissection tools, and dissection pan. Rinse your specimen with water, and pat dry.
8. Observe the external structure of the perch. Note the position and number of fins. Find the lateral line, and locate the gill cover and anal opening.
9. Examine the mouth of the perch.

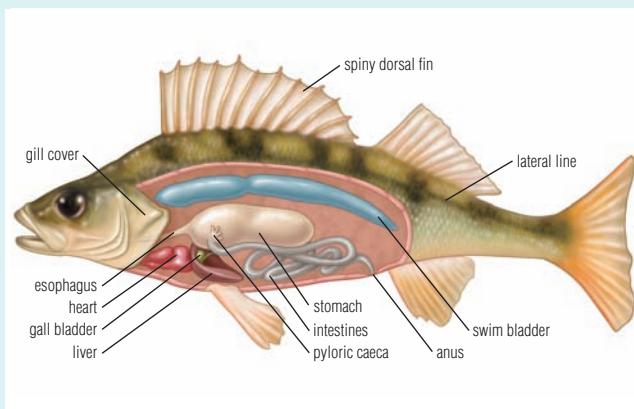


Figure 2.31 The external and internal anatomy of the perch

10. Create a flap through the muscle wall. Make an incision from the bottom of the gill cover along the ventral side to the anal opening. Continue the incision up from the anal opening to the lateral line and then along that line to the head of the fish. Finish your flap by extending your incision back to the base of the gill cover.
11. Lift the flap of muscle wall to look at the organs of the perch. If you have a female perch, the area may be filled with eggs. If this is the case, you should remove the mass of eggs before proceeding. If the perch is male, the testes will be smaller and lighter in colour. Locate the liver (light brown), gall bladder (olive colour), esophagus, stomach, pyloric caeca, and intestines.
12. Clean up your work area. Make sure to follow your teacher's directions for safe disposal of materials. Wash your hands thoroughly.

Part 3 — Digestive System of the Frog

13. Complete a virtual dissection of a frog. Identify the mouth parts, liver, gall bladder, stomach, pancreas, small and large intestine, and cloaca.

Analyzing and Interpreting

14. How is the mouth specialized?
15. Explain how the structure of the intestines is related to their role in digestion.
16. Why do you think the gall bladder is located so close to the liver? Explain your answer.

Skill Practice

17. Describe one problem that you encountered in performing the dissection, and explain how you solved the problem.

Forming Conclusions

18. How is the digestive system of the worm, the perch, and the frog each suited to its habitat?

A19 Quick Lab

A Look at Breathing

When you breathe, you move about 500 mL of air in and out of your lungs. Usually we are not aware of our breathing. What can you learn about how you breathe if you concentrate on your breathing?

Materials & Equipment

- pen and/or pencil
- stopwatch

Purpose

To observe the movements of your body as you breathe and to count the number of breaths that you take when you breathe normally

Procedure

1. Work in pairs. One partner sits in a chair and breathes normally. The other person observes and records any breathing movements that occur in the chest, shoulders, and abdomen.
2. While breathing normally, your partner counts the number of breaths that you take in one minute and records the number.
3. Change places with your partner, and repeat steps 1 and 2.

Questions

4. Explain how the chest and abdomen change during breathing.
5. Explain why the number of breaths per minute may change when exercising.

A20 Quick Lab

Inquiring about Heart Disease

Heart disease is a major cause of death in Canada. There are several known risk factors for heart disease, including high blood pressure, high blood cholesterol, stress, being overweight, diabetes, excessive alcohol consumption, smoking, physical inactivity, and unhealthy diets.

Purpose

To research the risk factors associated with heart disease

Procedure

1. Work in a group of 3–4 students.
2. Each member of the group should select one of the risk factors for heart disease to research.

3. **ScienceSource** Research to learn about heart disease and how your chosen risk factor increases the risk of heart disease. Record your information in a table.

4. Share your information with your group so that every member will understand the relationship between risk factors and heart disease.

Questions

5. Describe any common features that exist between the risk factors discussed in your group. Does this suggest that there is a common approach to reducing the risk of heart disease?
6. Your research focusses on the risk factors that can be controlled. Describe one way in which society influences an individual's ability to control his or her risk factors for heart disease.

2.2 CHECK and REFLECT

Key Concept Review

1. Define and give an example of an organ system.
2. What organ system is involved in transporting materials around the body?
3. Name and describe the function of two organs of the digestive system.
4. Name the organ system involved in breathing.
5. Describe the role of muscle tissue in the digestive system of the earthworm.
6. Name and describe the function of three accessory structures of the integumentary system.
7. Look at the organs and job descriptions given in the following table. Match each organ to its proper job description.

Organs and Their Job Descriptions

Organ	Job Description
heart	• filters and cleans blood
teeth	• controls whole body
intestines	• grinds food
skin	• breaks down food and absorbs nutrients
kidney	• exchanges gases
esophagus	• covers and protects surface
bladder	• pumps blood
brain	• stores urine
lungs	• passes food from the mouth to the stomach

8. List the two organ systems that are found in plants.

Connect Your Understanding

9. Explain why the crop and gizzard are important parts in the digestive system of the earthworm.
10. Why is it important to maintain a healthy integumentary system?
11. Using the star-nosed mole as an example, write a paragraph that explains how organs interact with each other to help accomplish the tasks needed for survival.
12. Write a paragraph that explains how chest muscles, ribs, and the diaphragm work together to help you to breathe efficiently.
13. The circulatory system is a transportation system. Use an analogy of a roadway to explain how this system functions.
14. There is a puppet master controlling the puppets shown below. Is there an “organ master” controlling the actions of all the organs in the body? Explain your answer using an example.



Question 14

Reflection

15. Choose an organ system. Identify two questions you have about how that organ system works in your body.
16. Describe three facts that you found most interesting in this section that you did not know before.

For more questions, go to *ScienceSource*.

2.3

Interdependent Organ Systems

Here is a summary of what you will learn in this section:

- Organ systems are interdependent groups of tissues and organs.
- Healthy organ systems work together to maintain homeostasis.
- Healthy organ systems respond to changes in the environment.
- Simple medical tests can provide information about the health of organ systems.



Figure 2.32 Our bodies obtain nutrients from the foods that we eat.

Body Systems Working Together

Each day, your body's cells, tissues, and organs work together to keep you responsive to the environment. Consider the example of eating your lunch. The lunch buzzer sounds just as your stomach is making some rumbling noises. Your brain records the information that the buzzer and time of the day mean you should eat. You proceed down the hall and enter the school cafeteria.

In the cafeteria, your eyes see a poster advertising the daily specials, and your nose senses the odour of freshly made pizza. The message is sent to your brain, and you decide that you should eat pizza for lunch (Figure 2.32). While in the line, you decide to reach out and select a slice of pizza from the warming oven. The muscles in your hand and arm contract and relax, which enables you to pick up the slice of pizza without dropping it.

Once in your seat, you chew and swallow a bite of pizza using your teeth and tongue (Figure 2.33). As the muscles in your digestive system push the food along, a variety of glands add juices to assist in breaking down the food into the necessary nutrients. In several hours, the nutrients in the pizza are absorbed into your bloodstream and carried through your body to the cells. In this example, several organ systems, including the circulatory, digestive, and nervous systems, interact to enable you to obtain, digest, and transport essential nutrients from the pizza to all cells of your body.



Figure 2.33 Eating a piece of pizza involves the interaction of different organ systems.

Maintaining a Steady State

Our body systems function in a way to maintain **homeostasis**, which means “steady state.” Generally, this means that there is an acceptable range of physical and chemical conditions in which body cells, tissues, and organs can operate efficiently. To keep the body within this acceptable range, different organ systems must work together to maintain homeostasis in the body.

WORDS MATTER

The word “homeo” is from the Greek word *homoios*, which means similar. The word “stasis” is from the Greek word meaning standing.

A21 Quick Lab

How Do They Do It?

Athletes must be able to perform tasks consistently to be successful at their sports (Figure 2.34). For example, to make a successful shot on goal, all the organ systems in an athlete’s body must work together in harmony.

Purpose

To identify organs and organ systems that work together

Procedure

1. Think about a particular sport or athlete. Identify the organs and organ systems that work together when an athlete plays sports.



Figure 2.34 (a) Soccer



(b) Hockey

2. Record your ideas in the form of a graphic organizer or mind map.

Questions

3. Explain what would happen to an athlete’s performance if the organ systems were not working together effectively.
4. How do you think that athletic training affects the working relationships of the organs or organ systems? Explain.



(c) Wheelchair racing

How Organ Systems Work Together

Organ systems are **interdependent** because the action of one system contributes to the action of another system. For example, the circulatory system, made up of the heart, blood, and blood vessels, works to supply the body with oxygenated blood. The body cannot survive for more than six minutes if the heart stops beating. However, it is the respiratory system, made of the nose, trachea, and lungs, that supplies the blood with oxygen. Thus, the circulatory system and the respiratory system are interdependent.

We can see the complexity of connections between organ systems by considering what happens to your body when you play a sport outside on a sunny day (Figure 2.35).



Figure 2.35 Your organ systems work together to maintain homeostasis — even when you are outside playing sports.

Integumentary System

As you play in the Sun, you may begin to feel hot. Your skin begins to turn red because the blood vessels dilate so that excess heat can be released to the environment. You also produce sweat that cools your body and keeps you within the acceptable temperature range so that your body cells function efficiently.

Circulatory System

To keep you moving, your muscles use oxygen and glucose and produce carbon dioxide. Your heart rate increases so that more oxygen-rich blood is brought to your muscles and carbon dioxide is removed. The rate at which the blood moves to the lungs also increases. Blood flow to other organs may be reduced. As well, stored glucose is released from the liver and enters the bloodstream to be taken to muscles so that the cells will have the necessary energy.

Respiratory System

To make sure that your muscles receive oxygen and get rid of excess waste products, your rate of breathing increases. At the same time, the blood circulates around the body faster because your heart rate increases. This means that more gas can be exchanged in the alveoli and more oxygen can be picked up by the red blood cells and carried to the tissues of the body.

Skeletal System

As you exercise in the sunshine, the weight placed on your bones causes them to become stronger, assuming that the appropriate nutrients — calcium and vitamin D — are present. Calcium is essential for the formation and maintenance of healthy bones. Vitamin D is formed naturally in the skin after exposure to sunlight. Your body needs vitamin D to absorb calcium.

Muscular System

Your muscles require extra oxygen to provide the energy needed to move. The oxygen is carried to the muscles by the blood. Exercise causes an increase in the flow of blood so that more oxygen is delivered to the muscles. As you play the game vigorously, your muscles generate heat, which your body does not need. To rid the body of the excess heat, blood vessels in the skin dilate so that this heat can be lost quickly. The skin also releases sweat, which cools the body as it evaporates.

Nervous System

When you exercise, your nervous system stimulates an increase in your heart rate. Nervous signals also travel to blood vessels in various parts of the body, causing them to get smaller so that blood flow to those areas will decrease. This diverts blood flow from tissues that do not need it, such as your stomach, to the muscles where it is needed, such as your arms and legs.

Learning Checkpoint

1. Define the term “homeostasis.”
2. Explain, using an example, how organ systems function in an interdependent way.
3. Explain how the integumentary system and the circulatory system work together to maintain homeostasis while you are playing outside.
4. Explain how the respiratory, circulatory, and nervous systems maintain homeostasis while you are playing outside on a sunny day.
5. Explain how the muscular and skeletal systems work together to maintain homeostasis while you are playing outside on a sunny day.

Diagnosing Problems in Organ Systems

The organ systems in our body interact with each other in very complex ways. This makes it difficult to diagnose and treat problems in organ systems. When you go to the doctor's office for a physical examination, you may undergo a few medical tests (Figure 2.36). The doctor may check your eyes and ears and look at your skin, the largest organ. Often the doctor taps your chest and abdomen to determine the size and density of your organs. Using a stethoscope, the doctor listens to sounds made by the heart and the lungs to determine if they are working properly (Figure 2.37). These tests provide information about how well your organs and organ systems are working.



Figure 2.36 During a physical exam, the doctor may look into your eyes for signs of hemorrhage (blood spots) or reduced blood flow.



Figure 2.37 To measure blood pressure, a sphygmomanometer, also called a blood pressure cuff, is used. The cuff is inflated so that the blood flow in the artery is restricted. As the cuff deflates, the doctor listens with a stethoscope to the sounds of the blood pumping through the artery.

Checking on the Circulatory System

Your doctor can determine how well your circulatory system is working by checking your pulse and blood pressure. Your pulse indicates how often your heart is beating. The average pulse ranges from 60 to 80 beats/min, although there are factors that can alter that rate.

Blood pressure is a measure of the pressure of blood against the walls of the arteries and is represented as two numbers, for example 124/84 mm Hg. The first number indicates the pressure when the heart contracts and pushes blood out (systolic). The second number indicates the pressure when the heart relaxes between beats and fills with blood (diastolic). If the numbers are too high — more than 135/85 mm Hg — there is too much blood pressure in the arteries. High blood pressure can cause damage to the arteries, which can lead to heart attacks and heart failure.

Sometimes, samples of blood are taken for testing the levels of red and white blood cells and the amount of sugar in the blood. Hormone levels may also be tested. Hormones are chemicals that carry messages through the body to regulate cells, tissues, or organs. Samples of blood can be taken to check levels of particular hormones to determine if there is an infection or a problem with the function of a gland or organ.

Learning Checkpoint

1. Describe two ways in which doctors can obtain information about the health of your organs during a routine physical examination.
2. What information is provided by the measurement of a pulse?
3. How can the measurement of the blood pressure be used to determine the health of the circulatory system?
4. Use an example to explain what is meant by the term “blood pressure.”
5. What information can be gained from analysis of a blood sample?

Checking on the Excretory System

Your doctor can determine how well your excretory system is working by testing a sample of urine. As blood enters your kidneys, the kidneys remove urea, excess water, and other waste products from the blood. These waste products include the by-products, or chemical products, that are left over after you have metabolized nutrients, poisons, or drugs that you have ingested. In other words, what you eat and drink, as well as how well your kidneys are working, affects what is in your urine. The filtered blood leaves the kidneys and returns to circulation in the body. The waste material, called urine, is stored in the bladder until it can be released from the body. Urine is yellow because it contains bile pigments from the liver.

Doctors can check urine to see if it contains different components. For example:

- If there are white blood cells in the urine, there is probably an infection in the excretory system.
- If too little urine is being produced, it may be possible that the kidneys are not working effectively to clean the blood of wastes.
- If too much urine is being produced, it may indicate that the pancreas is not working properly. Excessive urine production is a symptom of a type of diabetes.

During Reading



Revise to Synthesize

Good readers revise their ideas as they read and learn about new puzzle pieces. They think about the knowledge they had before reading about a topic, add the new information, and let the puzzle reveal a revised picture. Before you read this chapter, what would you have said was the most important organ or organ system? What do you think now that you have read and studied about these organs and systems?

Take It Further



Diabetes is the fourth leading cause of death in the world after heart disease, cancer, and influenza. The increase in cases of diabetes is attributed to the rising levels of obesity. Learn about the two types of diabetes, the history of diabetes, and how it is treated. Begin your research at [ScienceSource](#).

Drugs, including prescription drugs, cannabis, cocaine, and methamphetamine, can be detected in the urine for a period of time. For some jobs and at some sporting events, urine is tested for the presence of drugs, both legal and illegal (Figure 2.38).



Figure 2.38 A technician prepares a urine sample for testing at the Swiss Laboratory for Doping Analysis in Epalinges, Switzerland. Urine testing was conducted during the 2008 Beijing Olympic Games.

A22 STSE *Science, Technology, Society, and the Environment*

Green Livers

Scientists have found that environmental toxins can accumulate in our tissues and organs. A build-up of toxins can cause disease, allergies, environmental sensitivities, and even asthma.

Researchers have found that certain plants can be used to remove environmental toxins from the soil. In fact, the roots of some grasses have been called “green livers” because they store toxins in much the same way as a liver stores toxins in the human body. In one example, plants were grown in soils that contained a high concentration of metals. Over time, the plants absorbed and concentrated the metals in their root systems. At the same time, the plant itself was apparently unaffected by the high concentration of metals. When the plant’s roots were removed, the metal was also removed from the environment.

The process whereby plants are used to remove contaminants from their environment is known as phytoremediation. Scientists have been researching different types of plants that can be used in this process (Figure 2.38). They are also looking for ways to engineer plants that can do the job.

1. Working in a small group, list some environmental toxins that you have heard discussed in the media.
2. Discuss some strategies that are used to lessen our exposure to these toxins.
3. Go to [ScienceSource](#) and find out about how plants are genetically engineered to work as “detoxifiers.”



Figure 2.39 Indian mustard is a plant used for phytoremediation. It has demonstrated an ability to tolerate and accumulate a range of different metals.

- Making predictions, developing hypothesis
- Defining and clarifying the inquiry problem

Responding to Environmental Changes

The heart pumps blood throughout the body. The blood carries necessary nutrients and gases to the cells and takes waste materials away from cells. Several systems of the body interact together to obtain, transport, and process nutrients, gases, and waste. If the environment in the body changes, the body systems respond quickly. The heart responds to meet the new needs of its cells by increasing or decreasing the rate of pumping of blood. The pulse is a measure of the pumping action of the heart. We can use the pulse as a measure of the heart's reaction to environmental changes in the body system.

Question

How does the pulse change with a change in physical activity level?

CAUTION: Do not perform this activity if you are not well or if you have respiratory or cardiovascular problems. Perform this exercise in an open area.

Design and Conduct Your Investigation

1. Determine your resting pulse. To determine your “resting pulse,” you need to have been at rest for 10 min. Select your wrist or your neck as the source of your pulse. Place your index and middle finger on the underside of your wrist near to the base of your thumb or on the hollow of your neck (Figure 2.40). You will need to use a firm pressure. Count the pulse beats for 1 min, or count the beats for 30 s and multiply by 2 to get the number of beats per minute. Note that one pulse is equal to one heartbeat.
2. Identify the experimental variables that could affect the outcome of your experiment.
3. Decide on the variable that you would like to test. Write a hypothesis that indicates how a change in that variable would affect the outcome of the experiment. It may be helpful to write your hypothesis statement in an “if... then...” format.

4. Design a method to test your hypothesis. Remember that you need to indicate how you will measure your results.
5. Prepare a list of your materials, equipment, and safety precautions needed for the experiment.
6. Have your method approved by your teacher before you begin the experiment.
7. Perform the experiment and record your results in an organized and effective manner.
8. Include a discussion of the sources of experimental error.



Figure 2.40 You can feel your pulse in your wrist or your neck.

2.3 CHECK and REFLECT

Key Concept Review

- Explain why it is important for your body to maintain homeostasis.
- What organ systems interact together to supply your cells with needed nutrients?
- Look at the following photo. Describe two things that the doctor would check to determine the health of the young woman's respiratory system and circulatory system.



Question 3

- (a) What is the typical range for the pulse rate of an average teenager?
(b) Explain what the term "pulse rate" means.

Connect Your Understanding

- Explain how organ systems are interdependent. Give an example not used in the textbook to illustrate your answer.
- Explain why a doctor may order a blood test to check the function of your thyroid gland.
- Explain how some organ systems work together to maintain homeostasis. Give an example to illustrate your answer.

- Show how measurements of systolic pressure and diastolic pressure may be used to determine the effectiveness of the circulatory system.
- Sometimes, we are embarrassed when we sweat on a hot day. Explain why sweating is a healthy and necessary response.
- Explain the interactions that occur between the nervous system and the circulatory system during exercise.
- Explain how weight-bearing exercise, such as walking outdoors, can build the skeletal system.
- Describe the interactions that occur between the circulatory system and the muscular system during exercise.
- Give an example that shows how proper amounts of vitamins and minerals are critical to the health of organ systems.
- In previous science courses, you learned how water is treated in water treatment plants to produce fresh drinking water. Explain how the kidney functions in a similar way to a water treatment plant.
- Think about the importance of homeostasis. Why do you think that people who were climbing high altitude mountains, such as Mount Everest, would need to stay at a base camp for a period of time before continuing their climb?
- Give an example in which your body systems were placed under stress. How did your body respond to maintain homeostasis?

Reflection

- Your body is designed to function in a healthy manner and maintain a steady state known as homeostasis. What actions do you take that can affect the healthy functioning of your organs or organ systems?

For more questions, go to *ScienceSource*.

Organ Transplants: Promise or Peril?



Organ transplants occur when all other means of medical treatment have not worked. Organs can be donated after death or through a living donation, in which an organ or a piece of organ is donated by a living person. In 2007, over 2000 organ transplants were performed in Canada. Kidneys are the most transplanted organ, but transplants of livers, heart, lung, and pancreas also occur. Even limbs can be transplanted. In 2008, a German farmer who had lost both arms in a farming accident became the world's first person to receive a double-arm transplant.



People have always been fascinated with organ transplants. In 1818, Mary Shelley wrote the novel **Frankenstein**, a story about Dr. Victor Frankenstein, who created a monster made from selected body parts. The actual transplantation of different tissues and organs has been attempted for over 100 years.



During an organ transplant, an organ or part of an organ is taken from a donor and placed into a recipient. Survival rates are higher for recipients who receive living donations than for recipients who receive an organ from a deceased donor. The most common living donation is a kidney, although it is also possible to transplant a part of the liver, small intestine, and pancreas in a living donation. In a living liver donation, a portion of the liver is taken from the donor. Over a few months, the liver portion grows to form a fully functioning liver.

2 CHAPTER REVIEW

ACHIEVEMENT CHART CATEGORIES

- | | |
|--------------------------------------|-------------------------------------|
| k Knowledge and understanding | t Thinking and investigation |
| c Communication | a Application |

Key Concept Review

1. Prepare a table with two headings: “Salad Ingredient” and “Plant Organ.” Look at the following photo or think about the last salad that you ate. List the ingredients in a salad in the left-hand column in your table and write the name of the organ that corresponds to each ingredient (leaf, root, stem, or flower/fruit) in the right-hand column. **k**



Question 1

2. Describe how vascular tissue is involved in the functions of the root and leaf of a plant. **k**
3. Describe the role of meristematic tissue in the root, stem, and flower of a plant. **k**
4. Describe the function of a flower in a plant. **k**
5. What role does connective tissue play in the human lung? **k**
6. What are the general functions of the skin? **k**

7. Compare and contrast the structure and functions of the dermis and the epidermis. **t**
8. Trace the movement of air from the environment to the alveoli in the human lung. **k**
9. Describe the process of breathing. **k**
10. Explain how diffusion is involved in the process of gas exchange. **k**
11. Using your knowledge of the digestive system, identify structures in the digestive system of the earthworm that are similar to those in humans. **t**
12. Explain how three structures of the respiratory system work together to accomplish the task of breathing. **t**
13. Compare and contrast the structure and functions of the stomach and intestines in the human digestive system. **t**
14. Describe the role of the kidney. **k**
15. State the name and function of the organs in the excretory system. **k**
16. State the primary functions of the following organ systems: integumentary system, circulatory system, and respiratory system. **k**

Connect Your Understanding

17. How are different flowers suited for different environments? **t**
18. Explain how the tissues in the roots work together to collect and transport water for the growing plant. **t**

- 19.** Give an example to show how the root and shoot systems of a plant act in an interdependent fashion. **t**
- 20.** Explain why a person with a low red blood cell count would be likely to experience tiredness and fatigue. **t**
- 21.** (a) Define the term “homeostasis.” **k**
(b) Give an example of how an organ system acts to maintain homeostasis in the human body. **t**
- 22.** Explain how the body releases excess body heat built up during exercise. **a**
- 23.** Explain how the structures of two organs in the digestive system are uniquely suited to the functions they perform. **t**
- 24.** Explain why the human heart is called a double pump. **t**
- 25.** The terms cell, tissue, organ, and organ system are often said to be in a biological hierarchy. A hierarchy is an arrangement of things based on their importance or complexity moving from least important or simplest to the most important or most complex. Explain the meaning of this idea in a short paragraph. **t**
- 26.** Explain how specialized tissues in the mouth work together to perform the first phase of the digestion of a sandwich. **t**
- 27.** Write a paragraph that explains the interrelationship between the following terms: oxygen, cellular respiration, carbon dioxide, food, and energy. **c**
- 28.** Give an example of how your body systems act in an interdependent fashion to sustain your life. **a**
- 29.** Create a concept map that shows how your organ systems respond when you play a vigorous game outside on a sunny day. **t**
- 30.** A person who has worked for many years as a miner underground is diagnosed with weak bones. What may have contributed to the cause of this condition? Explain your thinking. **t**
- 31.** Use an example to show how the respiratory and circulatory systems interact, and explain why the interaction is necessary for the survival of the organism. **a**
- 32.** Use an example to explain the links between organs and organ systems in a plant. **a**
- 33.** Use an example to explain the links between organs and organ systems in a human. **a**
- 34.** Blood doping is an illegal practice in many amateur and professional sports. Explain how blood doping affects two organ systems in the human body. **a**

Reflection

- 35.** Describe an analogy that helps you understand the meaning of homeostasis. **c**

After Reading

Thinking
Literacy

Reflect and Evaluate

Create a tips sheet for someone who gets easily frustrated by large amounts of reading. Recommend strategies that will help the person to synthesize — or put together — the whole puzzle of a chapter topic. Compare your tips with a partner.

Unit Task Link

In this chapter, you learned about the organs and organ systems of animals and plants. Create a table in which you identify an organ and describe the major functions of the organ. Research to learn about some technological advancement or health issue relating to that organ.