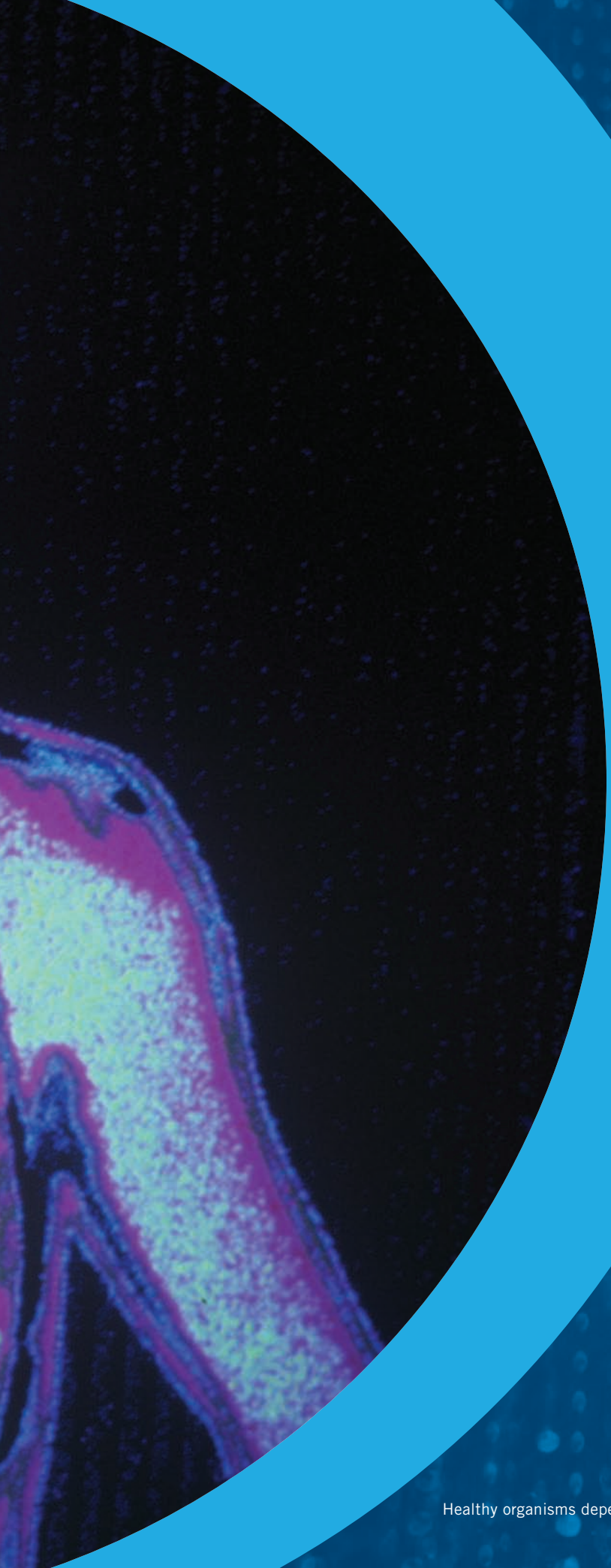
3.0

Healthy organisms depend on the interaction of healthy cells, tissues, and organs.

Magnetic resonance images (MRIs) like this one can be used by doctors to determine if a person's lungs are healthy or damaged.



What You Will Learn

In this chapter, you will:

- explain the roles of cells in plant and animal tissues and organs
- explain the roles of tissues and organs in plants and animals
- evaluate the role of technology in studies of cell biology and the social impact of these studies

Skills You Will Use

In this chapter, you will:

- use analytic skills to evaluate issues
- use appropriate science and technology vocabulary
- use a variety of forms to communicate

Why This Is Important

Understanding the interactions of cells, tissues, and organs helps researchers develop new technologies to fight disease and repair cellular damage that may threaten our health.

Before Writing

Thinking Literacy

Preparing to Write a Newspaper Article

Newspapers include articles on current issues, including science. Journalists reporting the stories often present both facts and opinions to readers.

Find examples of science news in your local newspapers. Highlight the facts and opinions being presented by using a different colour for each. Create a definition explaining the difference between facts and opinion..

Key Terms

- tissue
- organ system
- tumour
- organ
- paralysis

3.0 Getting Started

Figure 3.1 In order to be successful, a team requires healthy players who can fulfil their designated roles.

Figure 3.2 Arriving at school on time and ready to work involves a lot of co-ordinated activity.

When Toronto FC (Football Club) plays a soccer game, you see 11 players on the field: a goalkeeper, four defenders, four mid-fielders, and two strikers. Each player has a job to do, but the team requires a lot more than these 11 individuals. There are coaches, managers, team doctors, physiotherapists, trainers, accountants, marketing experts, sponsors, media consultants, and more. All the elements in the team's organization work together. Without the individual parts, there would be no team. Without a team, the parts would have no purpose. And without co-ordination among the parts, the team would be in chaos.

The body of a multicellular organism, like the human body, is much more complex than a soccer team. Your body is made up of trillions of cells that are organized into tissues that make up organs (such as lungs) and organ systems (such as the respiratory system).

Most of your body's functions happen without your being aware of them. This co-ordinated activity among cells, tissues, and organs keeps you (the organism) functioning.

You co-ordinate events in your life every day, beginning with the not-so-simple task of getting ready for school in the morning, balancing activities with family and friends, and scheduling homework and recreation. Keeping track of everything can be difficult. Like you, your body keeps track of all of its activities, but at the cellular level. Scientists are still learning how all of the cells and parts of the human body work together to keep you healthy.

A35 *Quick Lab*

Amoeba Race

The amoeba is the unicellular organism that moves from place to place by sending out pseudopods (false feet). Simulating how an amoeba co-ordinates its life activities can help you understand how any cell co-ordinates its functions to survive.

Purpose

To simulate the movement and the eating habits of an amoeba

Materials & Equipment

- open area
- 5 soccer balls
- outdoor play area (optional)

Procedure

1. Form three groups:
   - Group 1, about 1/2 of the class, will be the cytoplasm.
   - Group 2, about 1/2 of the class, will be the cell membrane.
   - Group 3 will consist of two people who will act as the nucleus.
2. The nucleus pair must link elbows in order to stay together.
3. The cytoplasm group crowds around the nucleus.
4. The cell membrane group links hands and surrounds the nucleus and the cytoplasm.
5. Try these amoeba challenges.
   (a) Move like an amoeba across the room.
   (b) Move from the classroom into the hall.
   (c) Divide to form two identical cells. The nucleus will have to separate.
   (d) Move around the schoolyard to collect soccer balls on the ground. The schoolyard represents a pond, and the soccer balls represent food. A cell can touch the food only with its feet. See which cell can collect the most food.

Questions

6. Describe any difficulties you experienced while being part of a cell.
7. How do you think it is possible for a simple unicellular organism to co-ordinate its movements?

3.1 From Cells to Tissues to Organs

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

- Most multicellular animals and plants are made up of cells that are organized into tissues and organs.
- There are four main types of animal tissues — connective, muscle, nervous, and epithelial.
- There are three main types of plant tissues: protective, transport, and photosynthetic.

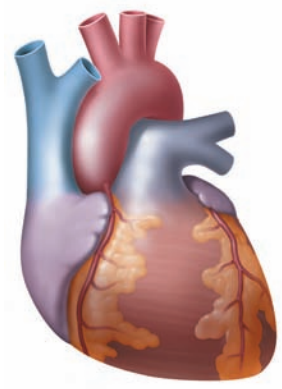


Figure 3.3 The heart is the organ that pumps blood through the veins and arteries. Heart muscle tissue is made up of specialized muscle cells.

The many specialized cells in a multicellular organism are not scattered randomly throughout the organism. Specialized cells that are similar in structure and function are grouped together in **tissues**. **Organs**, such as the heart, are made of tissues that work together to perform a specific task (Figure 3.3).

There are four main types of animal tissue and three main types of plant tissue. The cells in each type of tissue share the same basic design and perform the same function. Each tissue cell works with and depends on the others as it performs its own tasks. The way in which the various types of tissue cells perform their basic processes may vary, and those cells may have a special role, but all cells transform and transmit energy, expel wastes, and reproduce during their existence.

A36 *Starting Point*

Skills A C

Your Body Can Heal Itself

What happens when you get a cut on your skin?

What to Do

1. With a partner, write down all the things that you remember happening when you last got a cut. List sensations, such as pain, as well as activities, such as bleeding. What happened after that?

Consider This

2. How long did it take your cut to heal?
3. How much of the activity related to the healing of your cut did you control consciously?
4. How do you think your skin cells "know" what to do?

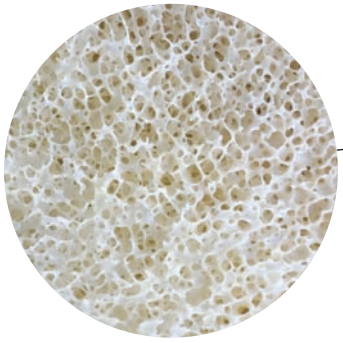
Animal Tissues in Organs

The four main types of animal tissue are connective, muscle, nervous, and epithelial (tissue that forms the outer layer of a structure). The cells in these tissues work together to support their own lives as well as the life of the whole organism.

The four types of tissues are found in different combinations in most of the organs in your body (Figure 3.4). The organs made of these tissues work together in a number of organ systems.

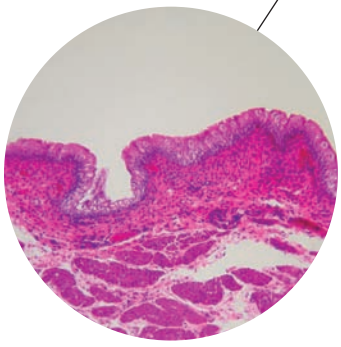
Take It Further

Many animals, including humans, have hair on their bodies. Choose one hair-covered animal. Find out how the hair is structured and describe its function. Report your findings to your class. Begin your research at ScienceSource.

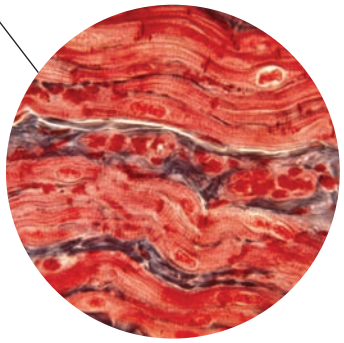


Connective tissue supports and connects different parts of the body. Blood is a connective tissue. Fat, cartilage, tendons, and bone (shown above) are also connective tissues.

Nervous tissue transmits and receives nerve impulses. The brain, spinal cord, and nerves are all made of nervous tissue.



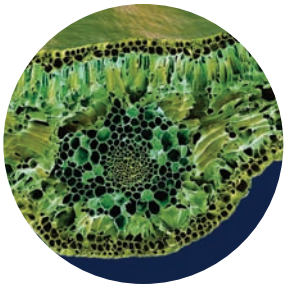
Epithelial tissue covers the surface of your body. It also lines the inside of organs such as the small intestine.



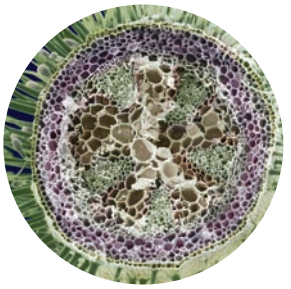
Muscle tissue contracts to cause motion. One type of muscle allows your body to move. Cardiac muscles (shown above) contract rhythmically to pump blood. The contraction of smooth muscles helps move food along your intestines.

Figure 3.4 There are four main types of tissue in the human body.

Figure 3.5 Plant organs contain three different types of tissues: protective, transport, and photosynthetic.



(a) Leaf



(b) Stem

(c) Root

Plant Tissues in Organs

The three types of plant tissue are protective, transport, and photosynthetic (Figure 3.5). All of these types of tissue are found in the three organs of a plant: leaves, roots, and stems (Figure 3.6). As in animals, the organs of the plant interact and depend on each other. One organ cannot live without the substances and activities provided by the other two organs. Plant organs make up two organ systems: the root system (which is below ground) and the shoot system (which is made up of anything that is above ground).

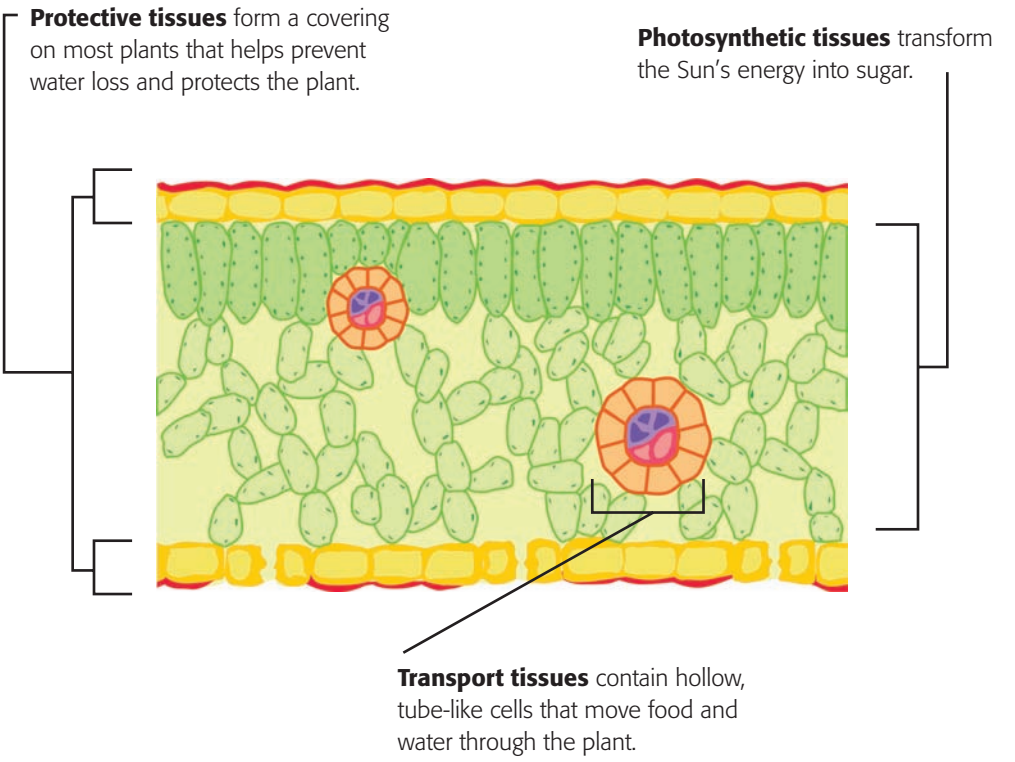


Figure 3.6 The tissues of a leaf

A37 *Learning Checkpoint*

Note Taking

Summarizing information in your notes is an important step in comprehending and recalling text. Create a chart with two rows to summarize the information about animal and plant tissues. Use three columns to list the type of tissue, its function, and where it can be found. Do you think this three-column chart would work better here than a Venn diagram? Explain your reasoning.

SKILLS YOU WILL USE
- Modelling
- Communicating

Special-Effects Technician

Recognize a Need

A new science fiction movie is being filmed in your area, and the director has put a job posting in the local newspaper for special-effects technicians. Technicians will need to create realistic representations of creatures from a variety of planets in our solar system.

Problem

Design, draw, and label a realistic creature from another planet in our solar system.

Materials & Equipment

- print and media resources, including the Internet (ScienceSource)
- blank drawing paper
- coloured pens and pencils

Criteria for Success

- Your creature must be adapted to the physical conditions on its home planet.
- You must refer to your knowledge about cells, tissues, and organs when you describe how your creature is adapted to its environment.

Brainstorm Ideas

1. Decide which planet in our solar system will be the creature's home planet.
2. What features and processes of cells should be considered when you create your creature?
3. Which tissues and organs will your creature have?

Make a Drawing

4. Draw and label a diagram of your creature that shows how its cells, tissues, and organs are adapted to the conditions on its home planet.

Test and Evaluate

5. Review the criteria for success and the planet's physical conditions to determine if you have met the criteria.

Communicate

6. Prepare an oral report to present your creature to the film's director. This presentation will be part of the "job interview." Good luck!

Figure 3.7
The creator of this creature took the physical conditions on the proposed home planet into account when deciding what its cells and tissues would be like.

3.1 CHECK and REFLECT

Key Concept Review

1. Create a two-column chart. In the left-hand column, name four types of animal tissue. In the right-hand column, describe their functions.
2. Create a two-column chart. In the left-hand column, name three types of plant tissue. In the right-hand column, describe their functions.
3. Name a plant organ, and identify the tissues that make up this organ.
4. Give two examples of:
   (a) connective tissue in animals
   (b) muscle tissue in animals
   (c) nervous tissue in animals

Connect Your Understanding

5. How does the distribution of animal tissues in an organism differ from the distribution of tissues in a plant?
6. Describe the relationship between organs, cells, and tissues.
7. Do you think multicellular organisms could function without specialized cells? Explain your reasoning.

Practise Your Skills

8. Draw a diagram of the tissues in a leaf.

For more questions, go to ScienceSource.

A39 *Thinking about Science, Technology, and Society*

X-Rays and Magnetic Resonance Imaging

X-ray technology uses electrons to produce an image of dense tissue. Magnetic resonance imaging (MRI) uses protons to produce images of the body. MRI technology excels at imaging soft tissue and organs such as the heart, the brain, the muscles, and the tendons and cartilage of joints like the knee. Each of the knees shown below has a form of arthritis.

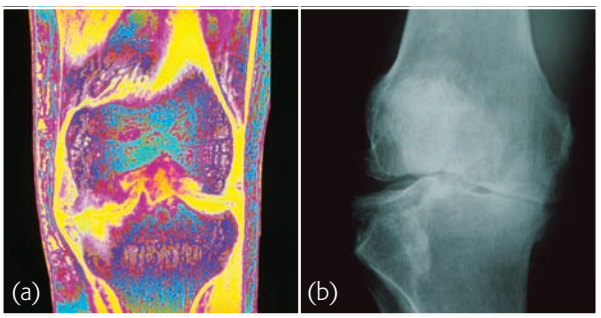


Figure 3.8 (a) MRI (b) X-ray

Consider This

With a classmate or as a whole class, discuss the following questions.

1. X-ray technology is older than MRI technology. Are new technologies always better than old ones? Explain your reasoning.
2. Many professional athletes have to wait a few days or less to have an MRI done on their injuries. Wait times for most other people are far longer. Do you think this should be the case? Explain.
3. Should the Ontario government allow private MRI clinics to open in the province? What are the benefits and drawbacks?

3.2 Interdependent Organ Systems

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

- Individual organs perform specific functions.
- Organ systems are made of two or more different organs working together to do a task.
- Organ systems work together to keep an organism functioning properly.

Your organs do not work in isolation. It is true that your lungs deliver oxygen to your blood, but without blood vessels and a heart it would be difficult to keep muscle cells in your foot alive. They would not get enough oxygen to survive. Organs must be linked to other organs in order to carry out all of the functions required within an organism. The linking of organs to form organ systems is the next level of biological organization (Figure 3.9). As with tissues, humans have many different organ systems: the respiratory system, the circulatory system, and the skeletal system, to name a few.

The healthy functioning of organ systems, organs, and tissues depends on the health of the cells in the tissues. Cells that receive the materials they need through the organ systems sustain the organism.

In the next activity, you will discover how your muscles and blood circulation are connected.

Figure 3.9 In a multicellular organism, there is a highly structured organization of the different body parts. All parts work together to make sure the organism functions properly.

A40 *Starting Point*

Skills A C

An Open and Shut Case

When muscles work very hard, they need a constant supply of blood to deliver oxygen and remove wastes such as carbon dioxide.

Try this with a partner.

1. One partner uses a watch and acts as the timer.
2. The other partner squeezes a clothespin between index finger and thumb (the other three fingers must be extended straight out) as fast as possible for 30 s, counting the number of squeezes. Rest for 10 s. Repeat two more times.
3. Switch roles and repeat steps 1 and 2.

What do you notice about your performance over the three trials?

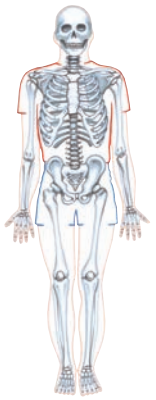


Figure 3.10 Skeletal system

Figure 3.11 Muscular system

Figure 3.12 Circulatory system

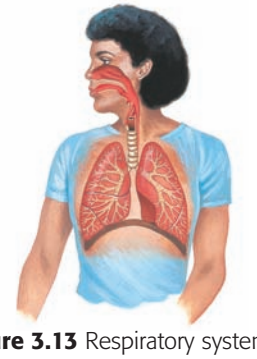


Figure 3.13 Respiratory system

Human Organ Systems

Organ systems are made up of more than one organ and perform one or more specific functions in the body. The organs in an organ system work together. Over the course of your life, these systems work very closely with each other.

The **skeletal system** is made up of bones and cartilage (Figure 3.10). This system provides support for movement, attachment points for other tissues, and protection of other organs (for example, the spine protects the spinal cord).

The **muscular system** is made up of skeletal muscles, including tendons and ligaments (Figure 3.11). This system enables you to move from place to place. It also moves substances through your body. For example, swallowing food involves a series of muscle contractions to force food down the esophagus and into the stomach.

The **circulatory system** is made up of the heart (an organ), plus blood vessels and blood (Figure 3.12). Its main purpose is to deliver nutrients, move gases, and remove waste products.

The **respiratory system** is made up of the nose, trachea, and lungs (Figure 3.13). This system allows oxygen from the air to enter the body and waste carbon dioxide to exit the body. This process is called **respiration**.

The **nervous system** is made up of the brain, spinal cord, and nerves that exist in every part of the body (Figure 3.14). This system sends and receives nerve messages throughout the body. It also controls behaviour, movement, and processes such as digestion and circulation.

The **digestive system** is made up of the mouth, salivary glands, esophagus, stomach, liver, gall bladder, pancreas, and small and large intestines (Figure 3.15). This system breaks food down so that nutrients can be absorbed by the blood and transported to all cells. The colon also expels all solid waste from the body.

The **excretory system** is made up of the kidneys, ureters, bladder, and urethra (Figure 3.16). This system filters the blood and removes liquid waste and extra water from the body.

The **integumentary system** is made up of skin, hair, nails, and sweat glands (Figure 3.17). The skin, hair, and nails cover and protect the body. Sweat glands are involved in maintaining normal body temperature.

Figure 3.14 Nervous system

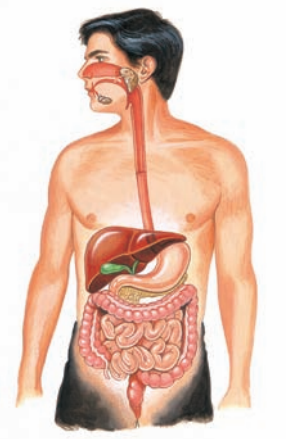


Figure 3.15 Digestive system

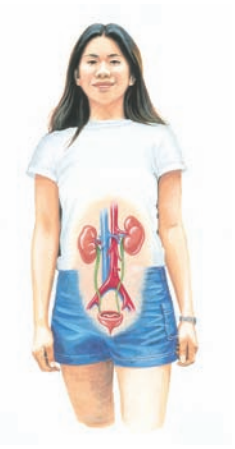


Figure 3.16 Excretory system

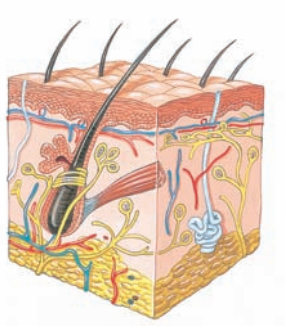


Figure 3.17 Skin segment of the integumentary system

The **endocrine system** is made up of several glands that produce hormones. Hormones are chemicals that regulate every bodily function. Glands such as the pituitary, thyroid, and pancreas all produce hormones that carry messages to other parts of the body. In the brain, the hypothalamus acts as the control centre for the endocrine and nervous systems.

The **lymphatic system** is made up of lymph, lymph nodes, lymph vessels, and lymphoid tissue. This system protects the body. It is responsible for destroying and removing any invading organisms and abnormal cells.

The **reproductive system** is made up of organs for producing offspring.

Take It **Further**

Organ transplant techniques are continually improving. An increasing number of human parts and organs can be transplanted successfully. Make a list of all of the parts and organs that are currently available for transplant. Which ones are most commonly transplanted? Report your findings to your class. Begin your research at ScienceSource.

A41 *During Writing*

Thinking Literacy

The Structure of a Newspaper Article

Cell biology is a rapidly growing field of study that looks at challenges, developments, and technologies that affect the health of both plants and animals. Newspapers often report on the latest research and developments.

Revisit the newspaper science articles you collected and look at the structure of this form of writing. What information is presented in the first paragraph? How are the next paragraphs different? How are facts and opinions reported? What does the writer do in the last paragraph of the news article? Share your observations with the class to develop a framework for your writing.

As you read section 3.3, think about which area of research is of most interest to you as you prepare to write a newspaper article.

SKILLS YOU WILL USE
- Reporting results
- Drawing conclusions

Flower Power

No one organ system in an animal's body, such as yours, is more important than another. If your circulatory system is working fine, but your immune system does not work properly, you could become ill.

Plants are multicellular organisms. Their organs also work together in organ systems. In this activity, you will determine if the root system that draws water up into a plant is more important than the shoot system, which is responsible for photosynthesis.

Question

Is one organ system more important for plant survival than the other?

Materials & Equipment

- 3 white carnation plants in pots (each plant must have at least 5 blooms)
- 2 balloons
- 2 elastic bands
- blue food colouring
- four 400-mL beakers
- water

Procedure

1. Place one plant in regular light and give it enough water.
2. Place a second plant in total darkness and give it enough water.

Figure 3.18

3. Take cuttings from the third plant following these instructions:
   - Place 1 flower and stem in plain water.
   - Place 1 flower and stem in water with 10 drops of blue food colouring.
   - Place 1 flower and stem, with a balloon placed over the end of the stem, in plain water. (Use the elastic band to make sure the balloon does not fall below the level of the liquid in the beaker.)
   - Place 1 flower and stem, with the other ballon over the end of the stem, in water with 10 drops of blue food colouring. (Use the elastic band to make sure the balloon does not fall below the level of the liquid in the beaker.)
4. Leave the plants for about one week.
5. Write a paragraph describing the health of the plants in regular light and total darkness after one week.
6. Write a paragraph describing the health of the cuttings after one week.

Analyzing and Interpreting

7. What was the purpose of putting one plant in regular light and one plant in total darkness?
8. What was the purpose of the set-up for the four different cuttings?

Skill Builder

9. Describe another way to record and report the results of this activity.

Forming Conclusions

10. Which organ system, the root system or the shoot system, is more important for the health of a plant? How do you know?

3.2 CHECK and REFLECT

Key Concept Review

1. Create a chart to summarize the human organ systems and their key functions.
2. Name the plant organ systems and explain their function.
3. What are hormones? What is their function?

Connect Your Understanding

4. You arrived at science class today! Write a paragraph that explains how 10 of your organ systems contributed to your arrival.
5. "The brain is the most important organ in your body." Do you agree or disagree with this statement? Explain your reasoning.
6. Explain how the health of cells in your lungs could affect the health of the rest of your body.
7. List at least three different organ systems that you used to read the words on this page. Justify your choices.

Practise Your Skills

8. The ability to conduct a fair test is an important scientific skill. List five things that were done in the Flower Power Inquiry Activity (A42) that helped to make it a fair test.

For more questions, go to ScienceSource.

A43 *Thinking about Science, Technology, and Society*

How Loud Is "Too Loud"?

Hearing damage can be caused by many factors, but one of the main contributors to the problem is the use of earbud-style headphones. Excessively loud music played for a long time can damage the delicate nerve cells in the inner ear. These cells transmit sound impulses to the brain. If they are damaged, irreversible hearing loss will occur.

Using volume-limiting technology, reducing the amount of time spent listening to a music system, or using over-the-ear headphones are all ways to help reduce the chances of doing permanent damage to hearing.

Consider This

With a classmate or as a whole class, discuss the following questions.

1. What volume setting do you usually use on your listening device?
2. How long do you usually listen to your music?
3. Do you use volume-limiting technology to protect your hearing from permanent damage?
4. Would you use the 60-60 rule, which means no more than 60 minutes at 60 decibels (6 on the dial or 60 percent of the scale)? Why or why not?

3.3 The Impact of Research in Cell Biology

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

- Improved understanding of cellular processes requires improved technology for studying cells.
- Advances in knowledge of cell biology will have an impact on human health, agriculture, and the environment.
- As our ability to manipulate cells increases, society will need to decide what will be allowed.

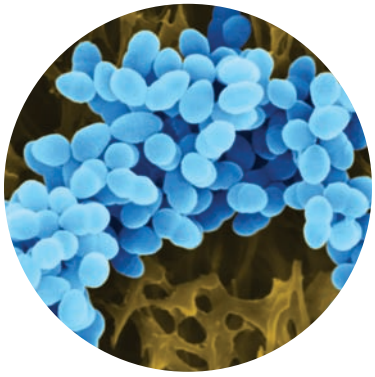


Figure 3.19 *Staphylococcus aureus* is a common bacterium that lives in many places, including on human skin and in nostrils. This bacterium can cause serious infection if it enters the body. (Look closely at the photo. The bacteria that look pinched in the middle are in the process of reproducing.)

As microscope technologies become more effective, researchers are able to see and understand more about cellular processes. They can also gain more insight into the roles that different types of cells play in some of the world's biggest health and environmental challenges. Research projects in cell biology include working to:

- stop the development of cancers
- regenerate nerve cells to repair spinal cord injuries
- develop vaccines to prevent disease
- discover biological tools to clean up pollution
- prepare to stop the spread of infectious diseases not yet known
- increase world food production

A44 *Starting Point*

Skills A C

Simple Solutions

Technology has helped medicine solve many serious health issues. Sometimes, however, the solution to a health problem is simple.

In the past 50 years, bacteria, such as the staphylococcus shown in Figure 3.19, that live on skin or in nostrils have become common in and outside of hospitals. While on the skin, the bacterium does no harm. However, if it gets inside the body through a cut, it can cause very serious infection called a "staph" infection.

How can you protect yourself? Wash your hands. Clean and protect cuts and scrapes.

Consider This

With a classmate or as a whole class, discuss the following questions.

1. When should you wash your hands? How many times a day do you wash your hands?
2. What is the proper way to wash your hands? Why would it be effective?
3. What procedures can you use to protect cuts and scrapes against infection?

Ongoing Research in Cell Biology

Cell biology is a growing and highly varied field of study. New technologies have opened new areas of study. As well, new health challenges have required the development of new technologies.

Working to Stop Cancers

Cancer is a disease related to the uncontrolled and rapid reproduction of cells through cell division (Figure 3.20). Normal, healthy cells proceed with their activities. They divide and reproduce at certain times according to signals issued by their organelles.

Cancerous cells continue to reproduce rather than carrying out their required cellular activities. The result is a **tumour**, a mass of cells that are continually reproducing but are otherwise non-functional. Tumours can appear in any organ in the body and can spread from one organ to another.

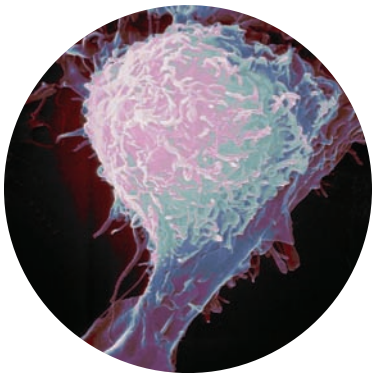


Figure 3.20 A cancer cell. Cancer is the result of the uncontrolled reproduction of cells.

The work of cell biologists and other specialists has focussed on a number of areas, including how to turn off the cells' non-stop reproduction, how to destroy tumours, and finding out why the process begins. Research on prevention has looked into factors related to characteristics that can be inherited, lifestyle choices such as smoking, and environmental issues such as chemical pollution in air and water.

Successful studies have led to the development of effective treatments for some cancers, improved technology for the detection of many cancers, and insights into lifestyle choices that can help us protect ourselves from some cancers.

Repairing Damaged Spinal Cords

The body's spinal cord includes cells that transmit nerve impulses from the senses to the brain and carry impulses from the brain to various muscles to instruct them to move. The spinal cord is located in the body's spine, connecting to nerves branching out into various parts of the body.

Damage to the nerves branching out into the body can create problems with numbness and problems sending sensory information to the brain. Damage to the spinal cord that severs it results in a loss of both information from the senses and the means of instructing the muscles to move. **Paralysis** is the inability to move muscles. If the spinal cord is severed below

Figure 3.21 Improved technologies related to mobility have helped people with spinal cord injuries.

the shoulders, the lower body and legs are paralyzed. If the spinal cord is severed in the neck area, all four limbs can be paralyzed.

Successful technologies have been developed to compensate for the lack of mobility. Wheelchairs have improved (Figure 3.21). Access to buildings and transportation has been redesigned to assist those who have been paralyzed. Cell biologists, however, continue to work to solve key problems relating to regenerating the cells in spinal tissue that transmit the impulses. While skin, bone, and muscle cells can repair themselves, finding a way to trigger similar repair in cells in spinal tissue is a challenge.

Preparing for New Infectious Diseases

Improvements in technologies for studying cells and cellular processes have led to successful treatments for many infectious diseases. Smallpox, polio, malaria, and tuberculosis have been brought under control in much of the world. The challenge for researchers in cell biology and related fields is to know how bacteria and viruses are adapting to create new infectious diseases.

Figure 3.22 Once the transmission of SARS was understood, staff treating SARS patients were given a variety of protective gear and practices in order to prevent the spread of the disease.

Researchers have recently solved some of the mysteries related to diseases such as West Nile virus and Lyme disease, which are transmitted to humans through insect bites. A bigger challenge was the emergence of severe acute respiratory syndrome (SARS), which was first reported in November 2002 and lasted until July 2003. Documented cases of infection totalled 8096, and 774 deaths were attributed to the disease.

Researchers around the world struggled to discover how the disease was transmitted from one human to another. Until they understood that, it was difficult to control (Figure 3.22). Researchers eventually concluded that SARS was a virus transmitted through contact either with airborne water droplets or with contaminated surfaces. They did not find a successful treatment.

Health officials around the world remain on alert for the next outbreak of an unknown infectious disease.

Improving World Food Production

Plants are at the beginning of every food chain, and the successful cultivation of healthy plants is the key to feeding the world's population. In the past, farmers experimented with techniques such as crossbreeding to increase the amount of food their crops produce. Cell biologists changed plants so they can grow in different conditions, such as regions that are colder or drier than the original plant could tolerate or regions with a shorter growing season.

More recently, researchers have found ways to modify plant cells to improve an organism's resistance to insects and the chemicals that are used to kill weeds, rodents, and bugs. For example, a form of corn, known as Bt corn, can kill an insect known as the European corn borer (Figure 3.23). The insect has destroyed millions of dollars worth of crops each year.

Cell biologists have also changed plants to increase their nutritional value. In 2000, Swiss researchers announced the development of a modified type of rice, which they named golden rice. This rice has higher vitamin A and iron content than other rices. It was created by introducing genes and enzymes from beans, wild rice, daffodils, and a fungus called aspergillus. It is now grown and eaten in a number of countries (Figure 3.24).

Supporters believe that this kind of research will solve many of the world's problems with the supply of nutritious food. Critics are concerned that this kind of food contains modified cells that animals and humans have never digested before. They fear that the food may affect human cells in ways that no one has anticipated.

Figure 3.23 Infestations of the European corn borer have ruined acres of crops in the Atlantic provinces, Quebec, and as far west as the Rockies.

Figure 3.24 Dr. Swapan Datta, a plant biotechnologist, inspects golden rice plants in the Philippines.

Take It Further

Many farmers and consumers are concerned about the use of chemicals on food crops. Organic food is grown without using chemicals. Find out what techniques are used instead. Report your findings to your class. Begin your research at ScienceSource.

A45 *During Writing*

Thinking Literacy

What's your opinion?

Choose one of the topics discussed in this section and create a plus, minus, interesting (PMI) chart. Share your chart with a classmate who chose the same topic and add one point that your partner had. Write a summary sentence that expresses your opinion on this topic now. Use the information in your PMI chart, as well as what you have learned about the topic and the structure of a newspaper science article, to write your own newspaper article. Remember to include your classmate's opinion in your writing.

A46 Decision-Making Analysis

Toolkit 4

SKILLS YOU WILL USE
- Identifying ethical issues
- Communicating

Stopping the Spread of Infectious Disease

Issue

While researchers work to find causes of and cures for new infectious diseases, some procedures for stopping the spread of disease are well known. However, many, including personal and public hygiene practices or isolation, can be very disruptive to personal lives as well as to economic activity. Should a community or society be able to force individuals to comply with orders relating to the spread of infectious disease?

Background Information

- Before health officials understood the cellular processes of disease, they knew that disease could be transmitted through physical contact. As early as the 1500s, public officials tried to stop the spread of infectious disease through the use of quarantines, publicly enforced periods of isolation of individuals who had or might have had certain illnesses.
- Quarantines have been used throughout Canada's history. In the 1890s, Canada strengthened its quarantine procedures for new immigrants in an effort to avoid a repeat of four previous outbreaks of deadly cholera.
- Quarantine of individuals and families continued well into the 1940s for a variety of illnesses. The practice was increasingly felt to be an infringement on personal freedom, and eventually, it was thought that isolation should be voluntary.
- During the SARS outbreak in 2002, individuals suspected of coming into contact with the infection were asked to stay home. Many health-care workers did isolate themselves from the public and their families. Other members of the public refused and insisted on continuing to go about their business.
- Many people have suggested that if everyone suspected of coming into contact with infected people was quarantined, there would be a huge disruption of economic activities such as the distribution of food and water, as well as great financial losses.
- In today's world, travel by air and other means moves goods, animals, and people from almost anywhere in the world to another location in a matter of hours or days.
- Quarantines are currently enforced for live animals being brought into Canada, as well as for animals that have shown signs of diseases.

Analyze and Evaluate

1. If there is an outbreak of another new infectious disease like SARS somewhere in the world, what do you think Canadian officials should do? What should world health officials do? What might be the social impact of their actions?
2. Should people in the area where the new disease has been found be allowed to leave? Where could they go?
3. Do you think governments should be able to restrict travel and personal activities during outbreaks of a new infectious disease? How could the restrictions be enforced?
4. Prepare a report or presentation that outlines your ideas on the types of actions communities should take during an outbreak of a new infectious disease.

SKILLS YOU WILL USE
- Gathering information
- Communicating

Growing Bt Corn and Other Modified Plants

Issue

Scientifically modified plants are developed for specific purposes. For example, *Bacillus thuringiensis*, or Bt, corn was developed to save corn crops that were being destroyed by an insect called the European corn borer. Scientists altered the cells of the plant to add a toxin that kills the insect.

A number of people have concerns about these kinds of modifications, fearing that the new product may cause unintended harm or become an invasive species. How can we decide if modifying plants scientifically is a safe practice?

Background Information

- The larvae of the European corn borer eat the leaves and ears of corn. Bt corn contains a toxin that allows lethal bacteria such as *E. coli* to enter the larvae's digestive tracts and kill them.
- Some people do not support the development of new varieties of plants such as Bt corn. They believe that natural cross-pollination of the modified plants and native plants may affect the seeds of native plants.
- Some countries have banned the import of grains and other foods that have been modified scientifically. Officials in others have suggested that such grains and foods must be labelled so that consumers can decide whether to buy them or not.
- Some researchers are concerned that there may be unintended consequences of the scientific modification of plants, such as the development of new allergies, or there could be an unknown, longer-term harmful animal or human health impact resulting from consuming these plants.

Analyze and Evaluate

1. Consider one of the following three viewpoints about the use of scientifically modified organisms.
   (a) The practice should be banned because of known or potential environmental and social risks.
   (b) Scientifically modified plants should be used wherever possible.
   (c) The use of scientifically modified plants can be approved for social benefit, but it should be closely regulated.
2. Develop some specific questions that relate to the issue and your chosen point of view.
3. Go to ScienceSource to conduct your electronic search for information.
4. Summarize your opinion on the issue in a short report for presentation to your class or for use in a debate. Be sure to include only information that supports your viewpoint or refutes the opposing views.

Figure 3.25 A field of Bt corn looks much the same as a field of non-Bt corn. Do you think it should be labelled?

3.3 CHECK and REFLECT

Key Concept Review

1. What are five examples of research projects in cell biology?
2. What is the relationship between cancerous cells and a tumour?
3. What causes paralysis?
4. List three ways in which scientific research has improved the production of food crops.
5. What is the main challenge faced by biologists researching infectious diseases?
6. Describe how officials tried to prevent the transmission of infectious diseases before they understood how disease was transmitted. Explain why you think it would or would not work.

Connect Your Understanding

7. "The study of cell biology is directly linked to technology." Do you agree or disagree with this statement? Explain your answer.
8. What is the role of scientific research in solving human health problems? Explain your answer.
9. List three societal issues that are related to microbiology. Write a brief paragraph to explain why one of them is the most important one and should receive public funding for research.

Practise Your Skills

10. Describe the steps you would take in order to analyze and evaluate an issue.

For more questions, go to ScienceSource.

A48 *Thinking about Science, Technology, and Society*

What Kind of Testing Should Be Done?

Scientists in labs can use cells in test tubes to test their ideas about a new treatment for a disease or a condition such as paralysis. They can consult their colleagues from around the world to get their opinion on whether it will work or not. They can also create computer models that might suggest whether the treatment will be successful.

At some point, however, they have to test it on living organisms. For many years, such tests were done using animals. Some people feel that this practice is inhumane and should be stopped. How can researchers find out if their ideas for treatments will work on people?

Consider This

With a classmate or as a whole class, discuss the following questions.

1. Should researchers be allowed to test new treatments or procedures on animals?
2. If your group decides the answer is "no," how will researchers find out if their treatments will work on people?
3. If your group decides the answer is "yes," should there be any rules or restrictions? Who should enforce the rules?

DAILY PLANET

Making Connections

Jay Ingram

Jay Ingram is an experienced science journalist and is the host of *Daily Planet* on Discovery Channel Canada.

Wow! Bacteria

It will probably surprise you to know that human cells are not the most plentiful cells in your body – bacterial cells are. There are an estimated 500 different species of bacteria in each one of us, and their total population is something like 100 000 000 000 000. Or maybe it's 1 000 000 000 000 000. There might be as many as 100 bacterial cells in your body for every 1 of your human cells.

Most people react to this news by thinking, "Ewwwwwww!" But they're wrong. The vast majority of those bacteria do not cause disease. Instead they help us by doing things like making food easier to digest or producing valuable vitamins in our intestines.

We're not the only ones that provide a home for bacteria: every single creature does, and some of them make use of bacteria in the strangest ways. My favourite is an animal called the bobtail squid. It's a small squid – you could hold one easily in the palm of your hand – and it has a typically squiddy appearance, with tentacles extending from a short little body. But if you saw one of these squid at night, you'd be impressed.

The bobtail squid glows. It emits a blue-green light from a pit in its belly as it swims near the surface of the ocean collecting food. Scientists think the light confuses predators lurking below, who think they are seeing starlight or moonlight. That is clever enough, but the nature of that light is simply astonishing. It is not produced by the squid the way that fireflies produce their own cold light. Instead, a living colony of bacteria, nestled in the squid's light organ, generates the light.

Immediately after hatching, the squid trap these bacteria in a special bacteria-collecting organ. Funnily enough, even though there are millions of different bacteria in the ocean, only this one, light-generating species can colonize the organ. Once the bacteria have been taken in, the collecting organ is changed – *by the bacteria* – into a *light* organ! In a way, the squid is not a squid until it has collected its bacteria.

Back to us. Remember, we each have trillions of bacteria in us. Are we, in some as-yet-undiscovered way, the product of the bacteria in our gut or on our skin? If so, "Ewwwwww!" should really be "Wow!"

Figure 3.26 Bobtail squid

3.0 Chapter Review

Assess Your Learning

Key Concept Review

1. What types of systems do living things have, and how are they organized? (k)
2. Why is the co-ordination of activities among organs important to multicellular organisms? (k)
3. Could you survive without any of your organ systems? Why or why not? (t)
4. How would the health of an organ be affected if many of its cells were damaged? Give reasons to support your opinion. (t)
5. (a) Name a plant organ. (k)
   (b) Identify the tissues that make up this organ.
   (c) Describe the cells that make up each of the tissues in this organ.
6. Create a concept map to show how three organ systems noted in this chapter are related. (k)
7. What key areas are cell biologists focussing on for cancer research? (k)

Connect Your Understanding

8. Flu shots are available each year. Explain why you think researchers have not developed a one-time vaccination for this illness. (t)
9. Diffusion happens throughout your body. Use the concept of diffusion to explain how oxygen gets from the air around you to a cell in your foot. List the organs and organ systems that help deliver the oxygen. (a)
10. Explain how an understanding of cells and cellular processes can help in diagnosing and treating disease. (a)
11. Human understanding of cellular processes has potential for both benefit and harm to human health and the environment.

After Writing — Thinking Literacy

Reflect and Evaluate

Review the newspaper article you wrote, then take five minutes to share your article with a classmate who wrote on a different topic. Listen to a reading of your classmate's article. What was the most important information you heard?

Write a paragraph explaining your concerns about possible health challenges in the modern world and how scientific knowledge and discovery can play a role in facing these challenges.

Share your opinions and observations with the class.

ACHIEVEMENT CHART CATEGORIES
(k) Knowledge and understanding (t) Thinking and investigation (c) Communication (a) Application

Give one example of a potential benefit and one of a potential harm. Do you think the potential for benefit outweighs the potential risk of harm? Justify your opinion. a

12. The photo opposite was taken during the SARS crisis in Toronto in 2003. Identify precautions taken to prevent the transmission of the disease. Explain why you think they would or would not be effective. a

Unit Task Link

Make a list of human organ systems and explain the role cells play in those systems.

Practise Your Skills

13. You have been asked to take part in a debate about the use of animal testing in science. Describe the steps you will take to analyze and evaluate the information and prepare your presentation. a

14. Select a discovery related to microbiology that you feel is important. Make a T-chart, and list at least three potential benefits and three potential risks to society. c

A49 Thinking about Science, Technology, and Society

Public Choices Affect the Health of Cells

The lungs are lined with cells that have tiny hairs like the ones seen on the paramecium, and they are also called cilia. In this case, the cilia work like tiny brooms and sweep out the lungs to keep them free of materials that do not belong.

The nicotine in tobacco smoke paralyzes the cilia, and they stop sweeping. Burning tobacco also releases a multitude of other chemicals. The chemicals build up in the lungs and become available to cells throughout the body as the respiratory system passes materials on to the circulatory system. This is why smoking has been linked to a variety of illnesses, including lung cancer, bronchitis, and heart disease.

What to Do

Use the information you have learned about diffusion, osmosis, cells, and organ systems as you consider whether smoking in public should be allowed or should be banned.

Consider This

With a classmate or as a whole class, discuss the following social issue.

Smoking is a personal choice. Smoking is also the cause of many diseases, and second-hand smoke is a problem for many people. Should smoking be allowed in public places? What should be considered a public place?

UNIT A Summary

1.0 Cells are the basic units of all living things.

KEY CONCEPTS

- Cell theory
- Differences between plant and animal cells
- Diffusion and osmosis

CHAPTER SUMMARY

- Cells in all organisms come from existing cells.
- Many organelles in plant and animal cells perform similar functions.
- Plant cells have chloroplasts that contain chlorophyll, a substance involved in photosynthesis.
- Materials flow into and out of cells through the processes of diffusion and osmosis.
- The study of cells was not possible until the microscope was developed and improved.

2.0 Cellular processes sustain living things.

KEY CONCEPTS

- Unicellular and multicellular organisms
- Specialized cells in multicellular organisms
- The basic cellular processes that sustain plant and animal cells

CHAPTER SUMMARY

- Unicellular organisms are essential for the continuance of life on Earth.
- Osmosis and diffusion limit the size of cells.
- Cell specialization helps multicellular organisms meet their basic needs.
- Cellular processes include transforming energy, processing and transporting materials, and reproduction.

3.0 Healthy organisms depend on the interaction of healthy cells, tissues, and organs.

KEY CONCEPTS

- Specialized cells in tissues and organs
- Interdependent organ systems
- The influence of studies in cell biology on human life and health

CHAPTER SUMMARY

- Cells make up four main types of animal tissue and three main types of plant tissue.
- Specialized tissues make up organs.
- Organ systems are made up of two or more organs working together to do a task.
- Organ systems work together to keep an organism functioning and healthy.
- Studies in cell biology lead to breakthroughs in human health-care, agriculture, and the environment.

UNIT A Task

Come and Visit "The Cell"!

Getting Started

You are the marketing director at a theme park. You have been given the task of promoting it to teachers, parents, and students. This is no ordinary theme park, however. You work for the park known as "The Cell." Every organelle, process, and function related to cells is represented at a regular, life-sized theme park.

Visitors will witness the aspects of cell structure and activity that have been presented in this unit. Thrill-seeking visitors will be looking for the excitement that they have come to expect at theme parks. Your challenge is to convince potential visitors that The Cell is a great place.

Your Goal

You will create a marketing brochure for "The Cell" theme park. Using graphics, text, and creative layout strategies, the finished product will clearly relate all aspects of the structure, function, and processes of a cell to matching components of an actual theme park.

What You Need to Know

You have explored the basics of cell structure and function. You are aware of major events and technological innovations that have aided the study of the cell in even greater detail, such as the improvement in microscope capability.

Review your notes to recall the processes that occur within the cell and across the cell membranes. Consider that some cells are specialized in order to carry out specific tasks within tissues.

Steps to Success

1. Gather a variety of marketing brochures in order to familiarize yourselves with this sales tool. Discuss the common features. Focus on those that are particularly effective. (Or not!)
2. Using the Internet or print resources, make yourself familiar with the aspects of a modern amusement park that you could relate to cell structures, functions, and processes. Start your Internet research at ScienceSource.
3. Brainstorm the matching of structures, functions, and processes between the actual cell and the theme park. Remember to stress the visual aspects for the brochure.
4. Collect (or create) pictures, art, or graphics that could be used in your layout. Use magnified images of the actual structures wherever possible.
5. Create text boxes that provide information as well as excite and intrigue the viewer.
6. Don't forget to include a site plan as a final visual reference.

How Did It Go?

7. Do your amusement park features relate to structures and functions that exist in a real cell?
8. Are processes such as osmosis, diffusion, and reproduction reflected in aspects of your theme park?

UNIT A Review

Key Terms Review

1. Create a mind map that shows your understanding of the terms listed below. You may need to add some words of your own to show how the terms are connected. (k)

- animal cell
- cell division
- cell theory
- diffusion
- microscope
- multicellular
- organ
- organ system
- organelle
- osmosis
- plant cell
- selective permeability
- specialized cells
- tissue
- unicellular
- virus

2. Use the words below in a paragraph that explains how materials pass through a cell membrane. (k)

- carbon dioxide
- cell membrane
- diffusion
- organelle
- osmosis
- oxygen

Key Concept Review

1.0

3. Describe one difference between: (k)

(a) plant cells and animal cells

(b) an amoeba and a hydra

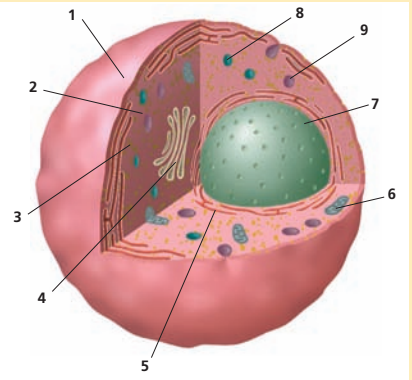
4. "Cells are the basis of life." Do you agree or disagree with this statement? Explain your reasoning. (a)

5. In your own words, state the three key ideas that make up the cell theory. (k)

6. In your notebook: (k)

(a) name all the parts numbered in the cell diagram

(b) explain the functions of three of those parts



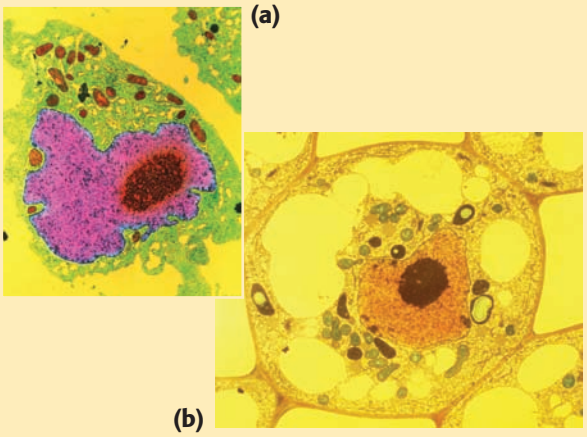
7. Draw a plant cell, label all of the parts, and explain the function of each one. (k)

8. If a cell membrane suddenly became permeable to all substances, could the cell remain alive? Explain your answer. (t)

2.0

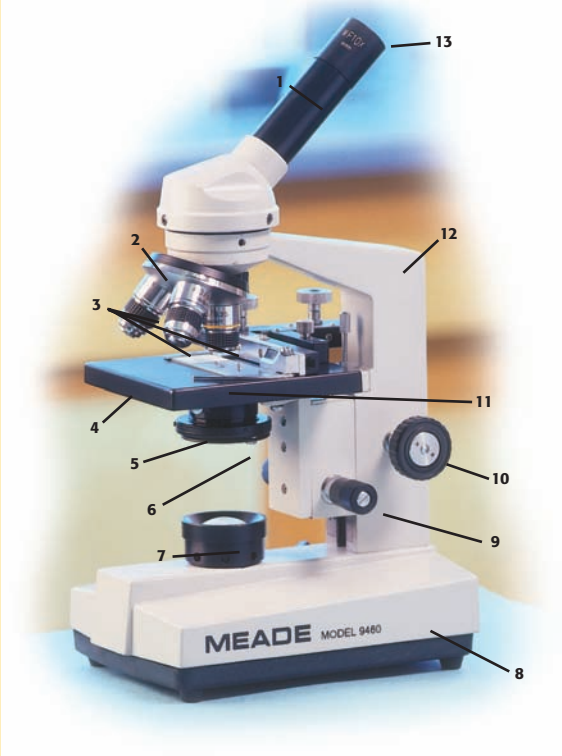
9. Name four characteristics of living things. (k)

10. Examine the two micrographs (a) and (b) below. Identify each one as either a plant or an animal cell. Explain your choice. (k)



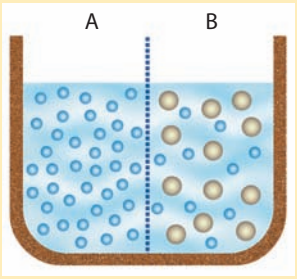
ACHIEVEMENT CHART CATEGORIES
(k) Knowledge and understanding (t) Thinking and investigation (c) Communication (a) Application

11. Name and describe the function of the parts of the microscope numbered in the photograph below. (k)



12. Examine the photograph below. What is the student doing? (a)

13. Examine the diagram on the right. In which direction will the water (smaller particles) move? Explain why. (k)



14. What critical needs of an organism are jaws, limbs, teeth, and eyes necessary for? (k)

15. What role does the environment play in defining the appearance of an organism? (k)

16. What important role do unicellular organisms play in sustaining life on Earth? (k)

17. Volcanic eruptions like the one on the island of Krakatoa in Indonesia in 1883 can send huge quantities of ash into the atmosphere. This ash can partially block out the Sun's rays for days or weeks. What effect would this have on unicellular and multicellular plants? (t)

18. Describe the link between multicellular organisms and the concept of specialized cells. (a)

19. Explain why cells are typically very small. (t)

20. Plants have specialized cells. What is the role of each type of specialized plant cell? (k)

21. Your body sends you signals to tell you when you are hungry. Why do organisms require food? (k)

22. (a) Why is it important for a multicellular organism to have a very efficient waste removal system? (t)

(b) Name one cellular waste product, and describe how it is removed. (k)

23. Use words and pictures to describe basic cell division. (k)

3.0

24. Multicellular organisms are very complex and need to co-ordinate trillions of cells and cellular processses. At the start of Chapter 3, this concept was introduced by comparing it to a soccer team. Make this comparison with a different organization, for example, a school board or a city. (a)

25. Organize the terms shown below from basic to more complex. For each word, name one example. (k)

individual, organelle, tissue, cell, organ system, organ

26. Tissues are collections of similar cells that perform the same function. Can tissue survive on its own? Explain your answer. (t)

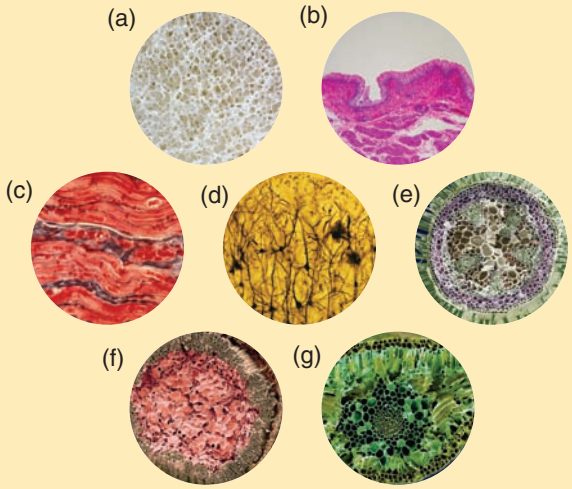
27. Your organ systems do not function independently. Consider the following scenarios, and explain how two different organ systems are working together. (a)

(a) You step on hot pavement in the summer and quickly pull your foot back.

(b) After running up the stairs, you breathe a little harder.

(c) A friend has a cold, and three days later you have a cold too.

28. Look at the photographs below. Name each type of tissue, and state whether it comes from a plant or an animal. (k)



Connect Your Understanding

29. What makes your hands wrinkle after a long bath or shower? (a)

30. The muscle cells responsible for bumblebee flight have a large amount of mitochondria. Explain why. (t)

31. Cell biologists have modified plants so that they can grow in different conditions or have different nutritional value. Do you think cell biologists should alter human cells to make us stronger or faster? Explain your reasoning. (t)

32. Select an organelle. Design and create an advertising poster to promote it as the most important organelle in the cell. (c)

33. Explain why an understanding of cells is essential for making informed decisions about your health. (t)

ACHIEVEMENT CHART CATEGORIES
(k) Knowledge and understanding (t) Thinking and investigation (c) Communication (a) Application

Practise Your Skills

34. Design an experiment using a potato to illustrate the process of osmosis. Include a purpose, hypothesis, materials list, procedure, and data collection chart. (a)

35. With your teacher's permission, carry out the experiment you designed in question 34. (a)

36. List 10 different technologies mentioned or illustrated in this unit that improve our understanding of cells and how they function. (a)

37. You see a skunk on the far side of your schoolyard. Several minutes later, you smell its distinctive aroma. Use words and pictures to describe why this is an example of diffusion. (t)

Revisit the Big Ideas

38. Identify which of the following statements are false. Reword the false statements to make them true. (k)

(a) Organelles are the smallest unit of life.

(b) Healthy cells contribute to healthy organisms.

(c) Cells, tissue, organs, and organ systems work independently of each other.

39. In your own words, explain the meaning of this statement: "Each cell is a system within a system." (t)

40. In what ways has learning about cells changed your thinking with respect to making healthy choices? (a)

A50 *Thinking about Science, Technology, Society, and the Environment*

What's the limit?

This unit began with a discussion of how the discovery of cells and the ability to study them led to an understanding of how living things, including humans, are structured and how they function. This knowledge led to the discovery of cures for some diseases and to the development of special crops to help feed the world.
Cell research has allowed us to change or modify the basic unit of life — changing when and how plants grow, healing wounds, and sometimes ending the development of cancers.

Consider This

With a classmate or as a whole class, discuss the following.

1. Should there be a limit to how far we can go in changing the basic unit of life? If so, what should that limit be? Explain your reasoning.
2. Do you think there should be restrictions on who is allowed to do work that changes the cells of living things? Explain your reasoning.