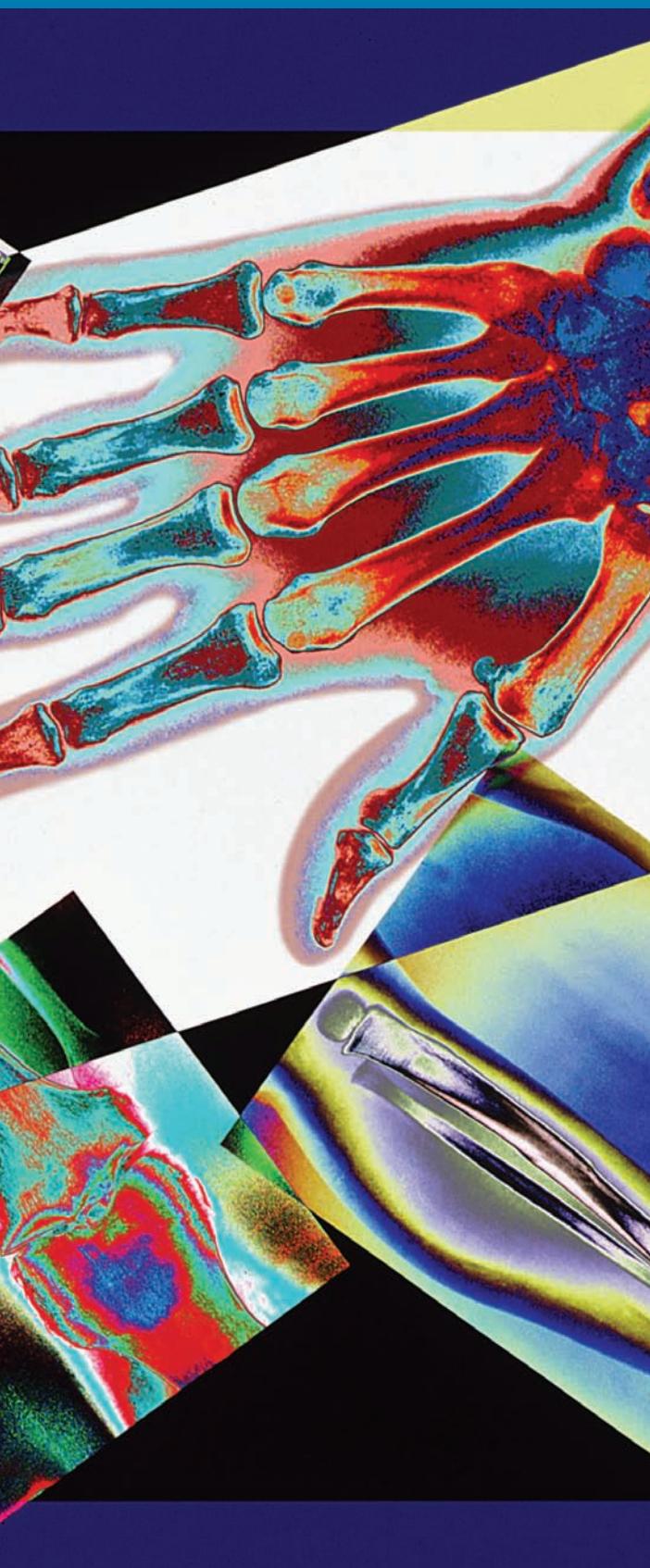


# 3

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





Different medical imaging technologies are used in diagnosing and treating abnormalities in tissues, organs, and organ systems.

## Skills You Will Use

In this chapter, you will:

- use appropriate terminology related to cells, tissues, organs, and systems of living things
- formulate scientific questions about observed relationships, ideas, problems, and issues, make predictions, and formulate hypotheses to focus inquiries or research
- identify and locate print, electronic, and human sources that are relevant to research questions
- select, organize, and record relevant information on research topics from various sources, including electronic, print, and human sources

## Concepts You Will Learn

In this chapter, you will:

- analyze, on the basis of research, ethical issues related to a technological development in the field of systems biology
- assess the importance to human health and society of medical imaging technologies
- describe public health strategies related to systems biology and assess their impact on society

## Why It Is Important

Technology plays an important role in your life. You use technology to send messages to your friends, to play video games, or to research material on the Internet. However, a special kind of technology, called medical imaging technology, also plays an important role in your life. Medical imaging technologies allow doctors to see inside your body so that they can accurately diagnose and treat health problems.

### Before Writing

Thinking Literacy

#### Writing a Report

The purpose of a report is to convey information and make recommendations. Writers organize reports with headings and subheadings to make the information very clear to the reader. Skim section 3.1 to see how the headings and subheadings relate to each other.

### Key Terms

- DNA screening • immunization • medical imaging
- public health strategies

# 3.1

## Medical Imaging Technologies

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

- Medical personnel use technology to diagnose and treat abnormalities in tissues, organs, and organ systems.
- Medical imaging technologies, including X-ray, CT scan, MRI, and ultrasound, have wide application and are used in diagnosis and treatment.
- Other useful medical imaging technologies include PET, nuclear medicine, gamma cameras, and fluoroscopy.
- The choice of appropriate technology may be based on a variety of factors including effectiveness, cost, level of access, and safety.



**Figure 3.1** Bicycle injuries can be serious.

### Seeing the Problem

Accidents can happen. Most of the time, a fall from a bike results in simple scrapes or bruises. However, sometimes, a fall from a bike can lead to serious injury or even death. Every year in Ontario, about 13 000 people go to hospital with cycling-related injuries. Fortunately, diagnostic imaging tests can be used to determine the extent of a cyclist's injuries. For example, the cyclist shown in Figure 3.1 was taken by ambulance to hospital and had magnetic resonance imaging (MRI) to check for head injury. An X-ray was taken to check for broken bones, and an ultrasound of the legs was used to check for torn ligaments. After the results of the tests were gathered, the appropriate treatment was administered, a rehabilitation plan was created, and the cyclist was released from hospital.

However, not everyone in Canada has equal access to such diagnostic imaging tests. For example, if the cyclist lived in a rural or remote area, the story might have had a different ending. Individuals from these areas often need to travel long distances to access potentially life-saving technologies. Living close to areas that have advanced medical technologies can mean the difference between life and death. For that reason, government agencies are investigating new ways of providing equal access to medical imaging technologies for everyone.

## Diagnostic Testing

Diagnostic tests provide information about the structure and function of organs, tissues, and cells. **Medical imaging** produces images of organs and tissues within the body for use in diagnosis and treatment. Using medical imaging has allowed for more accurate diagnosis of a wide range of conditions.

The cost and effective use of technologies for diagnosis and treatment present a major challenge to health-care systems around the world. Development of sophisticated and specific technologies that can enable the doctor to more effectively diagnose and tailor the method of treatment to the individual needs of the patient is ongoing.

### A24 Quick Lab

#### Looking at Your Hand Bones

X-rays are used to form an image of the bones in our bodies.

6. How accurate was your prediction?
7. What is one benefit associated with using X-rays?

#### Purpose

To observe the human hand and compare it with a radiograph of a hand

#### Materials & Equipment

- pen and/or pencil
- paper
- radiograph of human hand

#### Procedure

1. Trace the outline of your hand on a piece of paper.
2. Observe your hand closely, and predict the number, size, and placement of bones in the hand.
3. Add detail to your traced hand so that the number, size, and placement of bones is clear.
4. Obtain a picture of a radiograph of a human hand from your teacher or look at Figure 3.2. Compare your drawing with the radiograph.

#### Questions

5. Describe the process that you used in making a prediction about the number, size, and placement of the bones in your hand.



Figure 3.2 An X-ray of a normal hand



**Figure 3.3** The glass frog has translucent skin that makes it possible to see its organs through its skin.

## Producing Images of Organs and Tissues

Unlike the glass frog, shown in Figure 3.3, we cannot see through our skin to look at our organs. The skin that covers our bodies and protects our organs makes it difficult for doctors to see what is going on inside our bodies. Medical imaging allows doctors to see within the human body so that they can diagnose and treat diseases. Doctors can see a broken bone or changes within internal organs and blood vessels. Doctors can even explore the whole human body. There are several important medical imaging technologies including X-ray, ultrasound, computed tomography (CT) scan, magnetic resonance imaging (MRI), positron emission tomography (PET), and biophotonics.

### X-Ray

The most common form of medical imaging is the X-ray. An X-ray is high-energy radiation that can easily penetrate materials such as skin and tissues but cannot easily penetrate metals and bone. A radiograph is produced when X-rays pass through the body to produce an image (Figure 3.4). Since X-rays are absorbed by dense structures such as bone, the bones appear whiter than other structures. Radiologists view the radiograph either as a photographic film or on a computer screen. A radiologist is a doctor who has been trained to diagnose diseases or problems by recognizing abnormalities in the radiograph.

Radiographs can be used to check for cancer and to diagnose problems in the cardiovascular and respiratory systems. A mammogram uses X-rays to check breast tissue for the presence of cancer. A chest radiograph can reveal abnormalities in the lungs and show the size of the heart and the structure of associated blood vessels (Figure 3.5). Radiographs are also used by dentists to check for cavities in your teeth.



**Figure 3.4** A radiograph shows any breaks or fractures in bones, such as in this broken hand.



**Figure 3.5** A chest radiograph. The air-filled lungs appear dark, while the bones are white.

Using X-rays to image the body is quick, virtually painless, and non-invasive. However, because an X-ray is high-energy radiation, it can cause changes and mutations to DNA. When a radiograph is taken, parts of your body may be covered with a protective lead apron because X-rays cannot penetrate certain thicknesses of lead. Technologists who take radiographs may also wear lead aprons or go behind walls to protect themselves from exposure to X-rays.

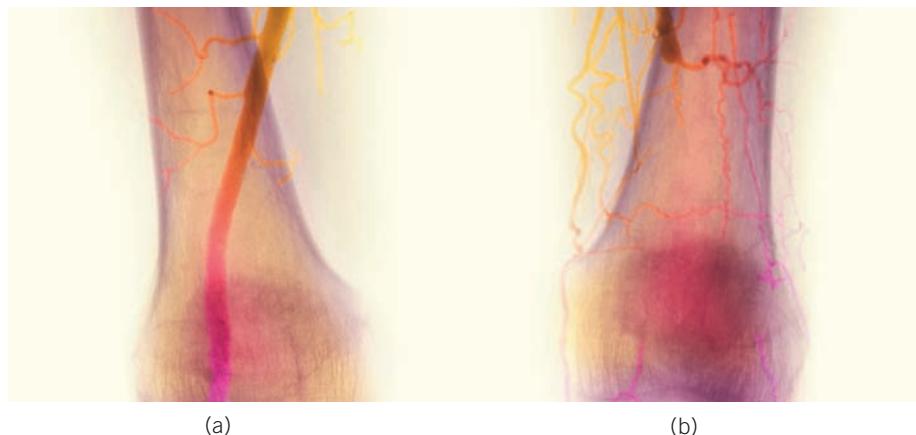
## Fluoroscopy

Fluoroscopy is a technique that uses a continuous beam of X-rays to produce images that show the movement of organs, such as the stomach, intestine, and colon, in the body (Figure 3.6). The patient may be required to ingest a contrast liquid, such as barium or iodine, to help the doctor see the organ clearly.

Fluoroscopy is also used to study the blood vessels of the heart and the brain. The image of the blood vessels is called an angiogram. In a coronary angiogram, a special dye is injected into an artery in the groin. This dye enables doctors to visualize the blood flow. The angiogram shows any narrowing of the arteries (Figure 3.7). A cerebral angiogram shows any blockages in the blood vessels in the brain, which can lead to a stroke.



**Figure 3.6** A fluoroscopic X-ray of a healthy large intestine



(a)

(b)

**Figure 3.7** An angiogram shows if any arteries are blocked. (a) This angiogram shows a normal femoral artery. (b) This angiogram shows a blocked femoral artery. A blockage can starve the tissue of nutrients and oxygen and lead to the death of the organ.

## Radiotherapy

In addition to using X-rays to see structures in the body, X-rays are also used to treat cancer. This type of therapy is known as radiotherapy. The X-rays damage the DNA and either kill the cancer cells or prevent them from multiplying. During radiotherapy, a beam of X-rays is directed at a tumour so that there is minimal damage to healthy normal cells. Radiotherapy may be combined with other forms of cancer therapy, including surgery and chemotherapy.

## Ultrasound

Ultrasound imaging uses high-frequency sound waves to produce images of body tissues and organs. A device called a transducer produces the sound waves. The transducer is placed on the skin. Soundwaves enter the body and are reflected back — much like an echo — to the transducer by internal body structures. This reflection makes an image of the body structure, which is recorded on a screen and viewed by a technician. Because images can be blurred by the presence of air or gas, ultrasound is not recommended for imaging the intestinal area.

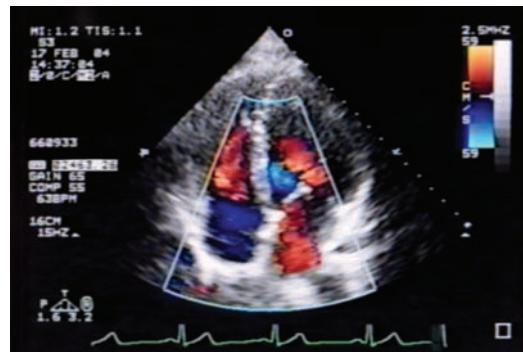
Ultrasound is used to study soft tissues and major organs in the body. It is not recommended for studying bone because the sound waves cannot penetrate bone. Ultrasound is also used to guide the needle when performing a needle biopsy of tissue.

Ultrasound is used during pregnancy to study the developing fetus (Figure 3.8). If the ultrasound indicates the presence of abnormalities or if the mother is over 35 years old, an amniocentesis is recommended. In this test, ultrasound is used to guide a needle that is inserted through the abdomen of the mother into the uterus so that a sample of amniotic fluid can be withdrawn and studied. Amniocentesis can detect Down syndrome, cystic fibrosis, and spina bifida.

Ultrasound is also used in the diagnosis of heart problems. An echocardiogram (Figure 3.9) is used to find out if there is any abnormality in the heart or blood vessels that could lead to problems such as stroke.



**Figure 3.8** An ultrasound of a fetus. Some abnormalities, such as spina bifida and heart defects, can be detected using ultrasound. Some conditions may be treated with surgery before birth while the fetus is still in the womb.



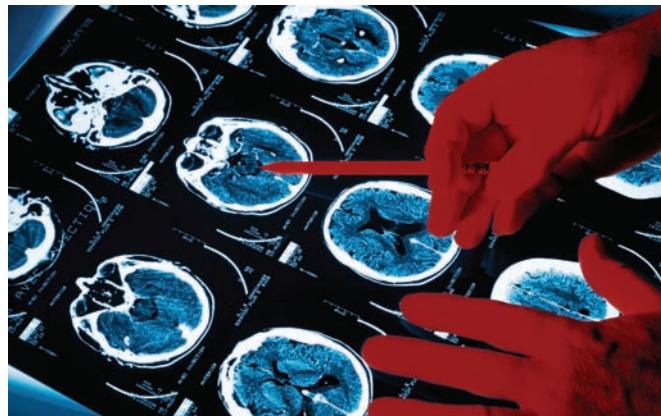
**Figure 3.9** An echocardiogram is used to see how the heart valves are functioning, to see the movements of the heart, and to detect any blood clots in the heart. If a blood clot moves from the heart to the brain, it can cause a stroke.

### Learning Checkpoint

1. What is medical imaging?
2. Name and describe the most common form of medical imaging.
3. Explain how a transducer is used in the process of ultrasound.
4. Compare and contrast the technologies of X-ray and ultrasound.
5. How is ultrasound used in the diagnosis of heart disease and stroke?

## Computed Tomography (CT)

Computed tomography (CT), sometimes known as computer assisted tomography (CAT), involves using X-ray equipment to form a three-dimensional image from a series of images taken at different angles of the body (Figure 3.10). Since a CT scan provides a detailed cross-sectional view of structures, it is frequently used to diagnose cancer, abnormalities of the skeletal system, and vascular diseases. CT can be used to image bone, soft tissue, and blood vessels at the same time. This test is frequently used in emergency rooms because it is relatively quick, causes no pain, and can provide detailed information. CT of the head can readily detect bleeding in the brain.



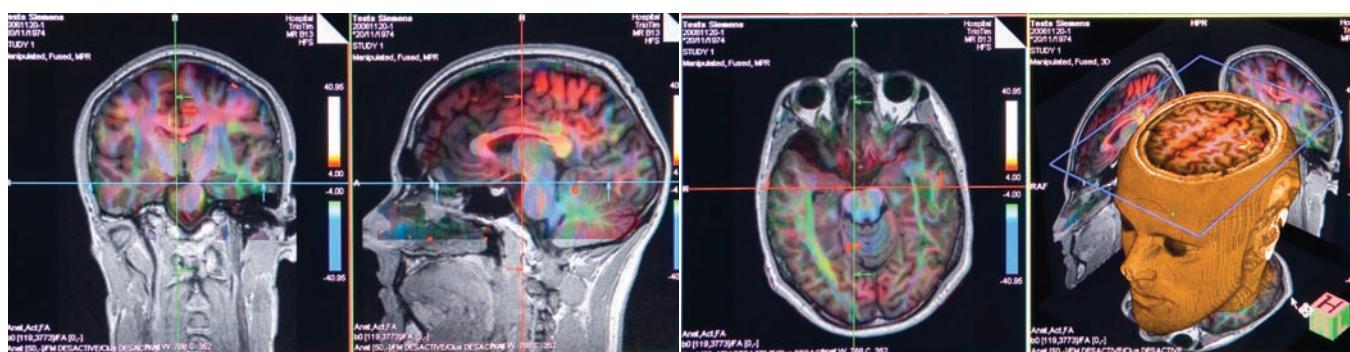
**Figure 3.10** A series of CT scans of the head are examined by a radiologist.

## Magnetic Resonance Imaging (MRI)

Magnetic resonance imaging (MRI) uses powerful magnets and radio waves to produce detailed images of the body. The human body is mostly water, which contains hydrogen atoms. The magnet in an MRI machine produces a strong magnetic field that interacts with the hydrogen atoms. A combination of the magnetic field and different radio frequencies makes it possible for a specialized computer to generate an image (Figure 3.11).

MRI is useful for imaging the structure and function of the brain, heart and liver, soft tissues, and the inside of bones. It is also used to diagnose forms of cancer, brain diseases, and cardiovascular conditions.

An MRI machine is about the size of a car and looks like a hollow cylinder. An open MRI machine is open on all sides, which allows the patient to be less confined while testing occurs. Open MRI permits easier testing for people who are disabled or who are overly anxious.



**Figure 3.11** Three different views of a human head taken with MRI. The image on the far right shows a three-dimensional representation of the MRI scan.



**Figure 3.12** A nuclear medicine bone scan. The darker areas can indicate abnormalities such as cancer.

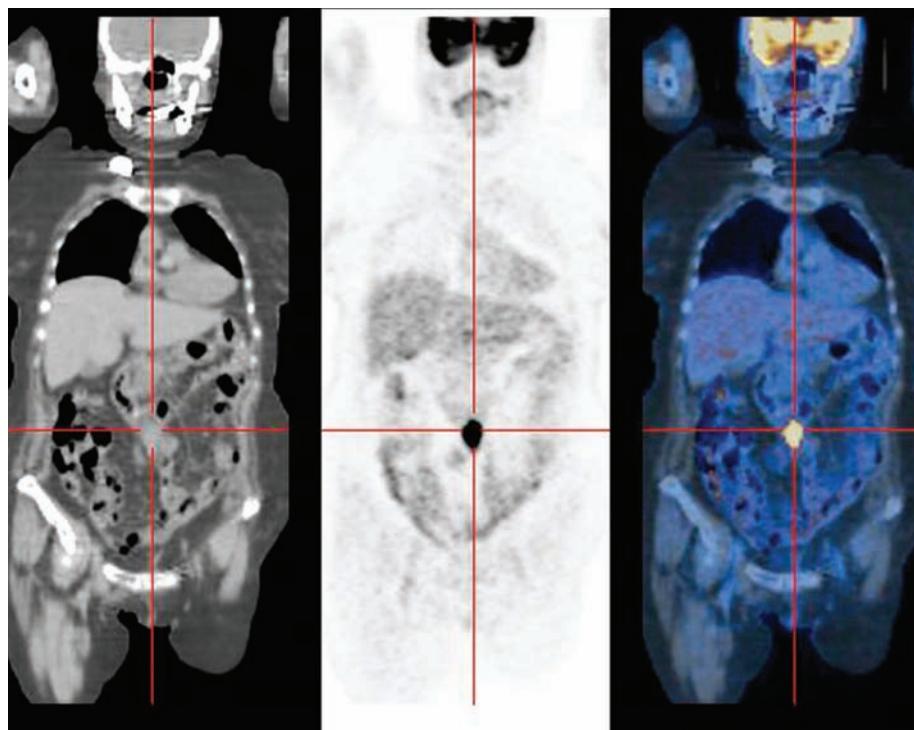
## Nuclear Medicine

Doctors use nuclear medicine to diagnose cancer, investigate blood circulation, and evaluate disorders in organs. Nuclear medicine uses radioisotopes to provide images of how tissues or organs function. A radioisotope is a radioactive form of an element that emits radiation. The radioisotope is attached to a chemical that is absorbed by certain tissues or organs. As the radioisotope emits radiation, a special camera and computer detect the radiation and convert it into an image (Figure 3.12).

Radioisotopes are also used to treat disease. For example, radioactive iodine is used to treat thyroid cancer. Since iodine is used by the thyroid, the radioactive iodine is taken up by the thyroid tissue. The radiation of the iodine kills the cancer cells. After a few days, the iodine decays to a non-radioactive element or is excreted by the body. Radioisotopes are also used to treat prostate and breast cancers.

## Positron Emission Tomography (PET)

Positron emission tomography (PET) is a type of nuclear medicine. A patient is given a radioisotope that emits particles called positrons. PET is used most often to detect cancer in tissues or to examine the effects of cancer treatments. PET is also used to detect heart disease and some brain disorders, such as Alzheimer's disease and epilepsy. PET may be combined with a CT scan to produce cross-sectional images (Figure 3.13).



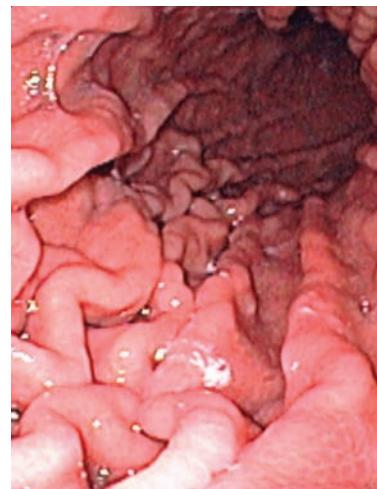
**Figure 3.13** A CT scan (left), a corresponding PET scan (middle), and a combination of the images produce a PET–CT image (right).

## Biophotonics

Biophotonics imaging uses the interactions of light with cells and tissues to diagnose and treat abnormalities. For example, when light shines on cells, the particles of light are scattered by atoms in the molecules of the cells. A special imaging device records these scatter patterns. The molecules in abnormal cells create different scatter patterns than normal cells.

Doctors are able to view tissues deep within the body using light. For example, doctors can use an endoscope to examine the digestive tract. An endoscope is a thin, flexible tube that has a bright light and a video camera. During a gastrointestinal endoscopy or a colonoscopy, the doctor looks at the lining and collects tissue samples as the endoscope moves down or up the digestive tract (Figure 3.14).

Biophotonics is also being used in developing some very useful surgical techniques. For example, endoscopic surgery has been used to remove gallbladders and repair knees. During endoscopic surgery, a small incision is made so that the endoscope and surgical instruments, such as a scalpel and forceps, can be inserted. The surgeon views the surgical area through the endoscope.



**Figure 3.14** A gastrointestinal endoscopic view of the bottom of a normal stomach

## Decisions, Diagnosis, and Treatment

Medical imaging technologies have greatly improved the quality and type of information that can be gathered about a person's condition. However, there are factors involved in making a diagnosis and in determining the appropriate treatment. These factors include:

- the doctor ordering the most appropriate test
- the patient understanding what the test is for, and preparing for and following directions during the test
- the technician administering the test properly
- the radiologist properly reading and understanding the image
- the administrators allocating adequate funding for technology

The development of medical imaging technologies has been extremely important to the advancement of both the diagnosis and treatment of disease. For example, diagnostic medical imaging technologies are increasingly being used as part of surgical procedures so that more invasive surgery may be avoided. However, the impact of these technologies on the health care of individuals must be seen in the context of society. As the needs of society change, the technologies developed to meet those needs may also change. Equal and fair access to appropriate medical imaging technology may be a major challenge for Ontarians who live in rural or remote areas.

### Suggested STSE Activity •.....

A25 Decision-Making Analysis on page 100

### Take It Further

As people age, organs and tissues can change. To assess these changes, doctors use medical imaging tests. Learn more about the bone mineral density test, the angiogram, and the Amsler grid eye test. Identify how the test works, why the test is needed, and when the test should be done. Place your findings in a 5 Ws graphic organizer. Begin your research at *ScienceSource*.

- Defining and clarifying the research problem
- Drawing conclusions

## Taking a Closer Look

### Issue

Sometimes, we fall off bikes, play sports too hard or for too long, or are involved in other types of accidents. When these things happen, we may need to see a doctor who may order imaging tests to determine if there has been any damage done to tissues or bones. But what happens if you do not have access to the medical imaging techniques that you need?

Imagine that you are a member of a group formed by your local or regional government. Your group's task is to research and write a report about which technologies should be bought for the local hospital.

### Background Information

In this section, you learned about different medical imaging technologies. These technologies make it easier for doctors to diagnose and treat diseases. However, there may be barriers that prevent you from accessing these technologies. For example, if you live in a rural or remote community, you may not live close to a medical centre that can perform certain imaging tests. Living in a large urban centre may mean that you live close to centres with imaging technology, but you may have a long wait time.

The supply of imaging technologies, such as MRI and CT scanners, has increased over the past few years. A study in 2006 found that there were 92 CT exams and 33 MRI exams per 1000 population. However, there are relatively long wait times for MRI and CT scans. Wait times occur because there are more patients than the system can treat at the same time. The number of technicians able to administer the test also affects the wait times (Figure 3.15). The problem is that although the supply of medical imaging technologies is increasing, the demand for the technology is also increasing.

Your task is to determine what types of medical imaging technologies are available in your area. After finishing your research, you will prepare a report about your findings and propose a solution to improving access to medical imaging technologies.



**Figure 3.15** An ultrasound exam is used to monitor the development of a fetus during pregnancy. It is recommended that all pregnant women have an ultrasound between 18 and 22 weeks of pregnancy.

### Analyze and Evaluate

1. Doctors use medical imaging technology to diagnose and treat their patients. Brainstorm three possible types of medical imaging technologies that are currently available at the local hospital in your area.
2. Construct a PMI (plus, minus, and interesting points) table for these technologies. Select the most appropriate technology based on your thinking.
3. **ScienceSource** Research the new developments in medical imaging technologies. Incorporate this information into your PMI table.
4. Think about a possible solution to improve access to medical imaging technologies for the people in your community.
5. **Web 2.0** Develop your group's research as a Wiki, a presentation, a video, or a podcast. For support, go to **ScienceSource**.

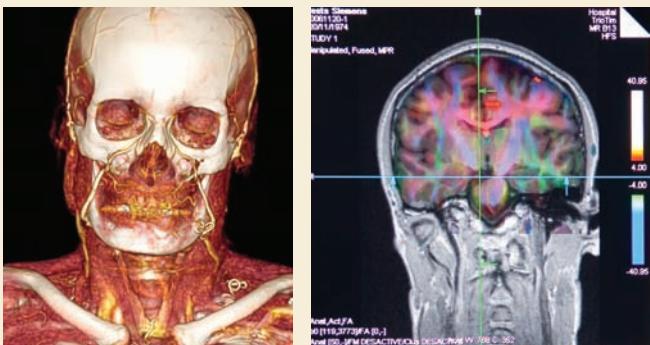
### Skill Practice

6. This activity required you to find information, analyze it, and propose solutions to the problem of barriers to accessing necessary medical technology. What research strategies did you use while accomplishing this task?

## 3.1 CHECK and REFLECT

### Key Concept Review

1. What are some limitations with the use of X-ray technology?
2. Describe three different medical imaging technologies. Give an example of when each technology would be used.
3. What is an angiogram?
4. How are X-rays used in the treatment of cancer?
5. What role does a radiologist play?
6. What information can be provided by a chest radiograph?
7. Why is ultrasound not an appropriate choice for imaging the bowel?
8. Explain how radioactive iodine is used in the treatment of thyroid cancer.
9. (a) What type of imaging is used to monitor the position and development of the fetus?  
(b) Why is this imaging used?
10. Describe several uses of biophotonics.
11. Compare and contrast the three-dimensional CT scan of a head and neck (left) with the MRI scan of a head (right) shown below.



Question 11

### Connect Your Understanding

12. A patient visits a doctor. After a physical exam, some blood is taken for testing. The doctor suggests there may be a problem in the circulatory system and recommends a variety of tests, including medical imaging. What medical imaging do you think the doctor would suggest? Explain why this type of imaging would be used.
13. A patient is suspected of having bone cancer. Explain whether or not ultrasound is a good imaging tool for diagnosing bone cancer.
14. Why do bones appear white on a radiograph?
15. Why are parts of your body covered when you are exposed to X-rays?
16. Describe two criteria that should be considered when deciding on the type of medical imaging to use.
17. Medical imaging is used to detect cancer and other diseases. Explain why everyone does not receive regular medical imaging as a form of preventive medicine. Give two reasons in your answer.
18. Why are diagnostic imaging techniques useful in both biological research and medicine?
19. How might the cost of medical technology influence the choices available to consumers?

### Reflection

20. Which medical imaging technique did you find most interesting? Why?

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

# 3.2

## Public Health Strategies to Prevent Disease

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

- Public health strategies improve the health of residents of Ontario.
- Current strategies include immunization programs, smoke-free environments, healthy lifestyles, screening programs, and health education programs.
- Individuals can make healthy lifestyle choices to improve quality of life.



Figure 3.16 In 1796, Edward Jenner developed the process of vaccination.

### The Father of Vaccination

In the 18th century, smallpox killed 30 percent of the people it infected and left survivors marked with deep-pitted scars called pock marks. In 1796, Edward Jenner, a British country doctor, noticed that young people who milked the cows and contracted a mild case of a related disease called cowpox never got sick from smallpox. He designed an experiment in which he put some pus from cowpox sores into an open wound on a young boy's arm (Figure 3.16). Subsequently, the boy became resistant or immune to the smallpox disease. Jenner used the word “vaccination” to describe the injection of the smallpox vaccine.

Today in Ontario, vaccinations are given for many diseases, including influenza, tetanus, and polio. Vaccinations are also called immunizations, needles, or shots. A vaccine is a substance that is given to boost your body’s defense system, which is called your immune system. Most vaccines contain a small amount of dead or inactivated virus or bacteria. The most common vaccine given each year is the influenza vaccine. The influenza vaccine not only protects individuals from becoming ill but also lessens the impact that influenza has on the health-care system. Ontario was one of the first locations in North



Figure 3.17 Rahima Banu was one of the last known cases of smallpox. She survived.

America to offer the influenza vaccine as part of the Universal Influenza Immunization Program. In 2008, 42 percent of all Ontarians received the influenza vaccine.

Since Jenner's discovery, vaccinations are used around the world. Smallpox, once feared as a deadly disease, was eliminated in 1979 because of Jenner's vaccine (Figure 3.17).

## A26 Quick Lab

### Catch Me If You Can



**Figure 3.18** Virus particles from a sneeze spread quickly and contaminate surfaces they touch.

The cold virus is a common virus that can live on household surfaces for up to two days. When a person coughs or sneezes, cold viruses in the droplets are expelled and can contaminate surfaces (Figure 3.18). In one study, a cold virus was found on 25 percent of individuals one hour after they had touched a surface contaminated with the virus.

#### Purpose

To simulate the spread of a virus



#### Materials & Equipment

- paper cups
- distilled water
- a dropper or pipette
- phenolphthalein solution
- 1 M NaOH



**CAUTION:** NaOH and phenolphthalein may irritate the skin and eyes. Use caution when using these liquids.

#### Procedure

1. Each student should obtain a paper cup that is half-filled with liquid from your teacher. Assume that one of the students will have a paper cup that contains the “virus.”
2. Walk around the classroom until your teacher tells you to stop. Trade liquids with the closest student to you. Use your dropper to take some of your liquid and add it to the paper cup of the other student. The other student should take some liquid from his or her cup, and add it to your cup. This is the first “exchange.”
3. Repeat step 2 until at least four exchanges have been made.
4. Your teacher will add a drop of “virus indicator” (phenolphthalein) to each paper cup. If the cup turns pink, it has been infected with virus.
5. Record the number of infections in the class.

#### Questions

6. What process could you use to identify the original source of infection in your simulation? Try to identify the original source using your process.
7. How would the identification process be different if the disease were present in a food source?
8. In this simulation, the individual becomes immediately infected every time that there is a contact (an exchange of liquids). Describe a disease in which the infection does not immediately appear after contact.

## A Look at Some Public Health Strategies

Technology has helped scientists learn about the cell, tissues, organs, and organ systems. This understanding has helped doctors develop strategies to prevent the occurrence of disease. Knowledge has also led to the development of drugs or therapies that are uniquely tailored to act on the whole organism. Public health agencies have also developed strategies to affect the health of an organism.

Keeping Canadians healthy is a priority for the various health agencies at each of the three levels of government: federal, provincial, and municipal. Each level of government contributes to developing public health strategies. For example, the Public Health Agency of Canada is a branch of the federal government that works with each province and territory to support a sustainable health-care system. The Ontario Ministry of Health and Long Term Care provides information on health strategies that are of concern to Ontarians. At the municipal level, public health units in Ontario implement federal initiatives and provincial policies to support the health of citizens.

### Prevention Programs

#### Suggested STSE Activity •••••

A27 Decision-Making Analysis on page 110

There are 36 public health units across Ontario. Each health unit administers **public health strategies** for health promotion and disease prevention programs including immunization, healthy lifestyles, education, and screening services. Rates of cancer and chronic disease, level of nutrition, instances of infectious disease transmission, quality and safety of water, Sun protection behaviours, degree of physical activity, and safe sexual practices all have an impact on the health of Ontarians. These programs teach people how to lead healthier lifestyles.

While public health programs are geared to support and encourage healthy living practices, they are also designed to reduce the cost of health care. The old saying “An ounce of prevention is worth a pound of cure” drives many of the initiatives of public health strategies. Many preventive measures are therefore directed at children and youth to reduce overall health costs and to prevent the development of disease.

### Learning Checkpoint

1. Describe and explain the importance of Edward Jenner’s experiment with cowpox.
2. Name several vaccines that are routinely administered in Ontario.
3. State two reasons why public health units think it is important to administer the influenza vaccine each year.
4. What is the job of a public health unit?
5. Describe the role played by public health units in keeping Ontarians healthy.

## Immunization Programs

**Immunization** involves making a person immune to infection through vaccination. Around the world, immunization saves millions of lives each year. However, thousands of children die every day from diseases that are preventable with vaccines. Most children today in Ontario have never had polio, tetanus, whooping cough, rubella, measles, and bacterial meningitis because of vaccines. Immunization of children for these diseases occurs at several points in their development (Figure 3.19). Even adults require booster shots.

Measles, mumps, and rubella (MMR) are infectious diseases that can have serious complications including mental retardation, sterility, and deafness. Vaccination against these diseases lowers the incidence of these diseases and also of the complications. The MMR vaccine is administered soon after a child's first birthday and again at about 18 months. This vaccine provides protection against measles, mumps, and rubella and is required by law for all school-aged children in Ontario unless an exemption is granted.

However, vaccination is not without controversy. Over the past several years, some parents have chosen not to vaccinate their children because of the suspicion that the vaccine causes autism. There is no scientific evidence that vaccines cause autism. While the decision to vaccinate may appear to be an issue for each individual, in reality the decision affects society as a whole. By becoming vaccinated, you are protecting yourself from disease and preventing the possibility of spreading disease to others in the community.

### Developing an HIV Vaccine

Scientists around the world are currently working to develop an HIV vaccine to address the global problem of HIV/AIDS. Human immunodeficiency virus (HIV) is a virus that attacks a person's immune system (Figure 3.20). Over time, the immune system becomes weak, which leaves the individual susceptible to all types of infections. The most advanced stage of HIV infection is referred to as acquired immune deficiency syndrome (AIDS). The time between HIV infection and an AIDS diagnosis is between 10 and 15 years. Some drugs can slow the disease progression, but there is no cure.

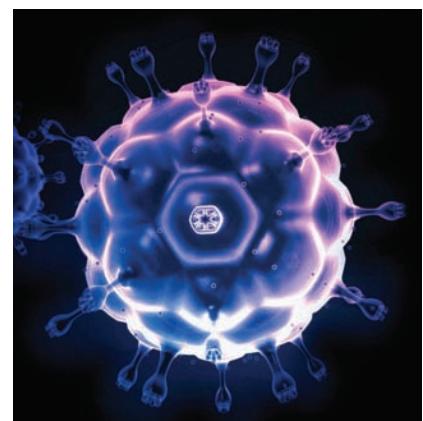
A vaccine would prevent people from becoming infected with HIV. In 2007, there were over 33 million people in the world living with HIV; over 7000 people become infected each day.

### HPV Vaccine

In 2008, Dr. Harald zur Hausen was awarded the Nobel Prize in medicine for his work in discovering the connection between human papilloma virus (HPV) infections and cervical cancer. An HPV vaccine was developed based on his research. HPV is a common family of viruses that is found in both males and females.



**Figure 3.19** Immunization can protect you from diseases, including influenza.



**Figure 3.20** AIDS is caused by the human immunodeficiency virus (HIV).

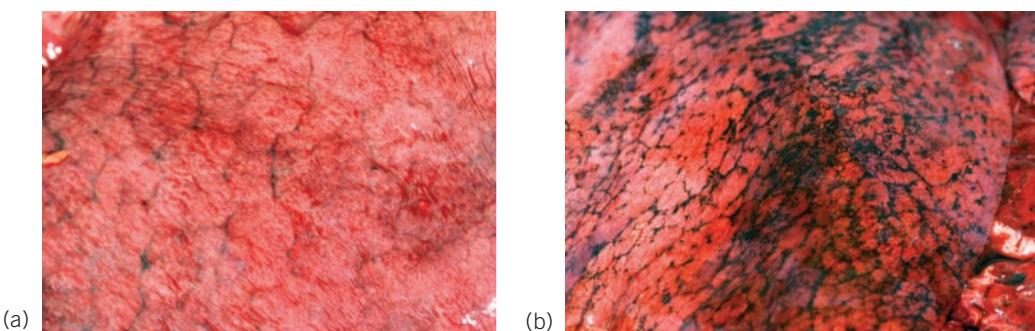
Today, in Ontario, the HPV vaccine has been approved for females aged 9 to 26 years old. The Ontario provincial government has made the HPV vaccine available at no cost for all girls in Grade 8. Zur Hausen believes that it is also important for males to be vaccinated to prevent cervical cancer in their partners. However, the vaccine is currently approved only for females.

## Smoke-Free Environments

Smoking tobacco kills about 13 000 people in Ontario each year. Tobacco smoke contains more than 1000 chemicals — one-fifth of those are toxins. Many of the chemicals have been proven to cause cancer and are called carcinogens. Inhaled smoke deposits carcinogens in the body. These carcinogens affect cells, tissues, and organs, particularly the lungs (Figure 3.21). Second-hand smoke is smoke from a burning cigarette or cigar or the smoke exhaled by a smoker. Second-hand smoke can affect the heart rate and blood pressure and can increase the cellular levels of poisonous gas. In addition to causing cancer, smoking aggravates other conditions such as heart disease, liver disease, and emphysema. Unborn babies of mothers who smoke have a higher incidence of neurological damage and lower birth weights.

As of May 2006, smoking has been prohibited in all workplaces and enclosed public places. As part of the Smoke-Free Ontario Strategy, the government is committed to reducing tobacco consumption and increasing the proportion of smoke-free homes. The strategy also encourages young people not to smoke, provides programs to quit smoking, and protects people from second-hand exposure to smoke. In January 2009, the Ontario government enacted further legislation that banned smoking in cars when children under 16 years are present.

**Figure 3.21** (a) A lung from a non-smoker. (b) A lung from a smoker. The black areas are tar deposits from cigarette smoke, which damage the lungs and can cause lung cancer, bronchitis, and emphysema.



## Promoting Public Awareness: Healthy Lifestyles Outdoors

Most of us enjoy being outside on a nice sunny day. Some public health strategies involve campaigns to make the public aware of ways to practise healthy lifestyles when outside. These campaigns include protecting yourself from the Sun and from the West Nile virus.

The Sun produces vast quantities of energy; much of this energy is ultraviolet (UV) radiation, which is classified as a carcinogen because it can cause skin cancer. UV radiation can cause a mutation in a cell's DNA. Over 62 000 Canadians develop skin cancer each year.

Various health strategies are aimed at reducing the number of people developing skin cancer. Programs have been developed to provide information about the links between exposure to UV radiation and skin cancer, to promote Sun protection behaviours, which include limiting sun exposure, wearing protective clothing and sunglasses, and using sunscreen (Figure 3.22).

### West Nile Virus

The West Nile virus is spread by mosquitoes and can affect birds, humans, horses, and other animals. A mosquito becomes infected when it feeds on the blood of a bird carrying the virus. Within two weeks, the mosquito can transmit the virus to people and animals (Figure 3.23). The virus causes a range of symptoms in humans from mild influenza-like symptoms to serious paralysis, seizure, or even death. About 80 percent of people who contract the virus have no symptoms at all.

Currently, there is no vaccine for the West Nile virus. However, public awareness campaigns suggest measures that we can take to protect ourselves from the virus, including:

- Minimize exposure to mosquitoes from dusk to dawn when mosquitoes are most active.
- Remove all sources of standing water and dense brush to limit the breeding ground for mosquitoes.
- Apply insect repellent that contains no more than 30 percent DEET (N,N-diethyl-meta-toluamide) to clothes and exposed skin.
- Wear light-coloured clothing that covers arms and legs.

Local health authorities monitor the spread of the West Nile virus in particular areas. Workers determine if pesticides need to be used to control mosquito larvae or adults in storm drains, ditches, or wetland areas.



**Figure 3.22** Wearing a hat and sunscreen and limiting your time in the Sun are some behaviours that reduce your risk of developing skin cancer.



**Figure 3.23** Mosquitoes can carry the West Nile virus (magnification 10×).

### Learning Checkpoint

1. How do vaccination programs reduce the incidence of certain diseases?
2. What is the Smoke-Free Ontario Strategy?
3. Describe three Sun protection behaviours.
4. What is the West Nile virus?
5. Describe three ways to limit your risk of contracting the West Nile virus.

### Reliable Sources

A report makes references to authority — organizations or individuals — whose information is usually reliable and based on research. Advertising may also refer to authority, but often in vague terms, using phrases such as “More doctors recommend ...” or “Tests confirm ...” You never find out which tests! Note the reliable sources referenced in this chapter. When writing a report, ensure that your facts and information come from reliable sources.

## Screening Programs

Screening programs apply a relatively simple, inexpensive test to a large number of people to identify those people who have risk factors for cancer. The goal of screening is to reduce the incidence of disease through early detection. There are two types of screening programs: cancer screening programs and DNA screening programs.

### Cancer Screening

Cancer affects almost every organ in the body, from the skin to the colon. There are several cancer screening initiatives that are currently available in Ontario.

- The Ontario Cervical Cancer Screening Program recommends that women have a Pap test annually once they become sexually active. The Pap test can detect abnormalities or changes in the cervix before cancer develops. If the test is normal for three years in a row, the woman should have a Pap test every two to three years.
- The Ontario Breast Screening Program provides mammograms and breast examinations to women between the ages of 50 and 74 years. The goal is to reduce the mortality from breast cancer.
- The ColonCancerCheck Program provides funding to screen for colorectal cancer, which is a leading cause of cancer death in Ontario. All adults over 50 years of age are screened using the fecal occult blood test (FOBT) every two years. This simple screening tests the feces for blood.

### DNA Screening

Today, we have technology that allows biologists to investigate diseases by looking at the genetic information contained within our DNA. The information coded in DNA is used to make proteins. Each section of DNA that codes for a particular protein is called a **gene**. Tests have been developed that can indicate if an individual may have a series of genes that are related to diseases such as heart disease and types of cancers. This is known as **DNA screening** (Figure 3.24).

There are sections of DNA that scientists can follow throughout the process of cell division. These sections are called DNA markers. Since scientists noticed that some of the markers changed during the cell’s life, they believed that the cell’s DNA was changing. They concluded that this change was related to changes in the cell’s environment. This finding had implications for the study of disease. For example, if an individual has a gene that increases the likelihood of developing a disease, it might be possible to change that gene by altering the cell’s environment by making alterations in lifestyle.



**Figure 3.24** A scanning electron micrograph of a cancer cell (white) and an autoradiogram showing the genetic code of a section of DNA. The presence or absence of particular sections of DNA, called genes, has been linked to the development of certain forms of cancer.

DNA screening may become part of the diagnosis and treatment of diseases within the decade. Even the treatment of cancer may involve DNA screening. For example, if a woman carries a specific version of the gene for breast cancer, she may also have an increased risk for ovarian cancer. Treatment may include removing the ovaries, as well as treating the breast cancer. However, DNA screening is not without controversy. For example, although DNA screening will detect if a person is at risk of getting cancer, some individuals may not want to know if they are at risk. Other individuals may want to know as much information as possible so that they can take steps to reduce their risk.

## Health Education Programs

Many public health strategies implement education programs to promote health. These programs involve communicating information using numerous brochures, websites, posters, and television commercials (Figure 3.25). Examples of health education programs include HIV/AIDS education and nutrition education.

HIV/AIDS is considered to be one of the most serious public health problems in the world. Experts believe that education and awareness of HIV/AIDS is vital to reducing the spread of HIV. Ontario has over 80 organizations and initiatives that deliver HIV/AIDS education and support to groups across the province. In addition, HIV/AIDS education is part of the Ontario curriculum.

Another area of health education is in nutrition. Research has shown that there is a link between good nutrition, school performance, and development of a healthy body. Programs have been created to provide opportunities for families to develop awareness of healthy eating habits. Some of the programs are associated with schools. For example, The NutriSTEP™ Program is a screening program to identify nutritional problems in children aged three to five years.

## Public Programs and Personal Choices

Public health agencies use immunization programs, advertising campaigns, partnerships with medical and educational groups, and other strategies to promote healthy living. The reality is that healthy living is still a personal choice. Some of the choices appear to be easier than others. For example, vaccination is considered by the World Health Organization to be one of the most cost-effective health investments. In Ontario, most vaccinations are provided without cost. Vaccinations have greatly reduced the incidence of diseases such as mumps, measles, and rubella. Other choices, such as committing to Sun protection behaviours or healthy eating patterns, may be more difficult for some individuals. Despite the presence of programs that raise awareness about these issues, the incidence of skin cancer is still on the rise.



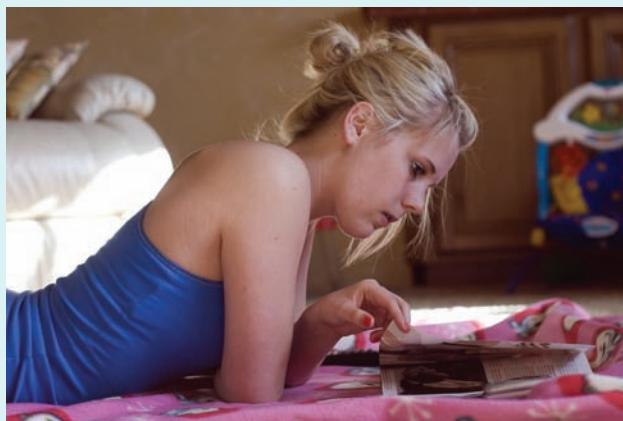
**Figure 3.25** Your local public health unit provides information about many different programs.

### Take It Further

Many diseases can be prevented through the use of vaccination. The World Health Organization has identified six diseases that they believe should be targeted through universal immunization programs. These diseases include whooping cough, tetanus, diphtheria, polio, tuberculosis, and measles. Find out more about the use of vaccines to fight these diseases and the impact the use of vaccines has on global health. Begin your research at [ScienceSource](#).

- Thinking critically and logically
- Identifying bias

## Media Messages: Short-Term Gain for Long-Term Pain?



**Figure 3.26** What types of messages about health and lifestyle do we read in magazines?

### Issue

Each day, we make many decisions that impact our lives. We choose what and how much to eat, when and how to exercise, and when to go to sleep. Studies show that teenagers identify the media as one of the top sources of information about health and lifestyle (Figure 3.26). Whether we realize it or not, our choices are often influenced by the media. How accurate is media information about lifestyle choices of teenagers?

In this activity, you will investigate the accuracy of the media's messages about the choice of lifestyle habits made by some teens. Begin your task by choosing a current lifestyle "habit," such as type of diet, level of exercise, drug use, smoking, sexual activity, and suntanning. For example, in the area of "diet," some teens may choose to eat fast food in the school cafeteria every day. Survey different forms of media including TV, print (newspapers, magazines), video, and music to find messages about the teen lifestyle habit that you have chosen to research.

### Background Information

Using the media to portray lifestyle choices is not new. In the 1950s, soap manufacturers sponsored television shows that told stories about typical families. The shows came to be known as "soap operas." In North America, the shows began to influence culture.

The use of the media to influence our behaviour has continued and still goes on today. In 1997, the

House of Commons passed the Tobacco Act, which put standards in place for the advertising of and access to tobacco products. Ultimately, tobacco companies were prohibited from sponsoring major sporting events and changes were made to how products could be displayed in stores.

Product placement of beer, soft drinks, and snacks in advertising spots for sporting events such as the Super Bowl bombard a captive audience.

Research in the United States showed that teen girls' exposure to advertisements about alcohol increased by 40 percent during a five-year period.

Many TV shows, movies, and video games have an online presence that, in some cases, is interactive. Participation in message boards or blogs enables the exchange of ideas. Sponsorship of these sites may involve companies that sell certain products and, therefore, the viewpoints of the moderator may be biased toward the sponsoring company.

### Analyze and Evaluate

1. Identify the messages that are sent by the media about the habit you chose to research, and describe the implied benefits of this habit as suggested by the media.
2. **ScienceSource** Research your topic to determine if this lifestyle choice has any known positive or negative consequences. Record your information.
3. Decide on the level of accuracy of the media's messages about the lifestyle choice that some teens make.
4. You will communicate your findings to the class in the form of a presentation, which can be an oral report or electronic (video, website, PowerPoint). Your teacher will provide more details about how to present your information.

### Skill Practice

5. How can you be sure that the health-related information that you receive from the media is credible and free of bias?

## 3.2 CHECK and REFLECT

### Key Concept Review

1. (a) What type of public health program is shown in the following photo?  
(b) Suggest reasons why this program is held in this type of location.



Question 1

2. What is the most commonly administered vaccine in Ontario?
3. Define and explain the importance of the MMR vaccine and the HPV vaccine.
4. Define the terms “HIV” and “AIDS,” and show the relationship between these two terms.
5. Why is HIV/AIDS education important?
6. Describe how tobacco smoke affects the cells, tissues, and organs in people.
7. Explain what might happen to you if you were bitten by a mosquito carrying the West Nile virus.
8. What are three examples of cancer screening programs?
9. (a) What is DNA screening?  
(b) Explain how DNA screening may be used in the future.
10. Describe some public health strategies used to promote healthy living in Ontario.

### Connect Your Understanding

11. Ontario was one of the first locations to become part of the Universal Influenza Immunization Program. Give two reasons why the Ontario government offers free influenza immunization.
12. Describe ways in which all three levels of government work to keep Ontarians healthy.
13. Describe some factors that public health agencies must consider to protect the community through immunization for infectious diseases.
14. There is no evidence that childhood immunizations cause autism. However, some people choose not to immunize their children because they believe there is a risk. Explain how this decision affects not only their children but also society.
15. (a) What are the advantages and disadvantages to each type of prevention program discussed in this section?  
(b) How would you improve one of the prevention programs? Explain your answer.
16. One goal of public health is to cut health-care costs in Ontario. Explain why this is an important concern for our province.
17. Some public health strategies try to raise awareness of the issues. Why is this a necessary step in changing the behaviours of Ontarians?

### Reflection

18. This chapter has discussed several risk factors that may influence your susceptibility to disease. What are two things that you can do to control these risk factors?

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

# 3.3

## Social and Ethical Issues in Systems Biology

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

- Technological developments in cell biology include gene therapy, cloning, transgenic techniques, and reproductive technologies.
- A systems biology approach views technological developments in the context of social and ethical issues.



Figure 3.27 A surgical team performs a kidney transplant on a patient.

### Transplanting Organs

Throwing the first pitch at a major league baseball game is an honour that few people experience. However, on an April day in 2008, 13-year-old Ian Smyth threw the first pitch at the Toronto Blue Jays game in Toronto in recognition of National Organ and Tissue Donation Awareness Week. Ian was seriously ill and had been waiting for a lung transplant for four months. Unfortunately, Ian was just one of 1665 patients in Ontario on the transplant waiting list. Fortunately for Ian, a donor was found and, in May 2008, Ian received a double lung transplant. In 2007, 4195 Canadians were waiting for organ transplants and 193 of those people died while waiting.

### The Need for Organs

In Canada, there are about 14 organ donors per 1 million people. Canada's low rate of organ donation is not because Canadians are selfish but because Canadians live relatively healthy lives and have access to better health care. Strategies to obtain more organs for transplants include expanding the acceptable criteria for organ donors and using living donors. For example, since a person can lead a normal life with just one kidney, donating a kidney is the most common living organ donation. Kidney transplantation is the best treatment for people with kidney failure (Figure 3.27). Dialysis, which uses a machine to clean the blood, is the only other treatment (Figure 3.28).

The liver, lung, small bowel, and pancreas can also be donated through living donations. Another strategy to obtain more organs for transplant is using animal-to-human transplants.

There is a shortage of tissues and organs needed for transplantation in all parts of the world. The supply of willingly donated organs simply does not meet the demand. In some countries, individuals are encouraged to sell their organs. For example, in India, poor and destitute people can sell a kidney to patients who are desperate for an organ transplant. The World Health Organization estimates that in 2006, about 6000 people received kidney transplants using kidneys obtained in this manner. The need for organs is so great that some people's organs have been removed without their consent.

**Figure 3.28** A person with kidney failure must undergo dialysis or receive a kidney transplant. During dialysis treatment, the blood is passed through a machine to be cleaned.



## A28 STSE Quick Lab

### Organs for Sale?

In 2004, British broadcaster Alistair Cooke died at the age of 95 in New York City. His body was placed in a casket in a local funeral parlour so that friends could visit the parlour and pay their respects to the family. Secretly, the funeral parlour owner had made a deal with a company, known as Biomedical Tissue Services, to sell Mr. Cooke's body parts. His bones were removed and ground up, and used in orthopedic, dentistry, and cosmetic treatments.

Mr. Cooke was actually one of over 1000 cadavers taken from funeral parlours and cemeteries across the Eastern U.S.A. over a period of four years. Since techniques of organ transplantation have improved and the procedure has become more common, the practice of stealing human organs and selling them for profit has been increasing.

In this activity, you will find out current statistics about this practice and consider some of the ethical and social issues that are involved in stealing and selling organs.

#### Purpose

To describe some of the ethical and social issues involved in the practice of stealing and selling organs

#### Procedure

1. Your teacher will give you information on the stealing and selling of human organs, such as kidneys.
2. Use your information to complete a 5 Ws graphic organizer.
3. Working in a group of two to four students, discuss your findings. Brainstorm some social and ethical issues that are involved in this practice.

#### Questions

4. The practice of harvesting organs for sale may involve risky surgery performed in secretive ways. Some people have suggested that legalizing the sale of organs would prevent the physical risks to the organ donor. Comment on this argument.
5. What do you think of the argument that selling and buying organs is a “win-win situation” because it provides money for the donor (seller) and an organ for the buyer? Is this a reason to approve the sale of organs? Explain your answer.

## Advances in Cell Biology Technology

Recent advances in cell biology technology have enabled scientists to develop new strategies to treat disease. These advances include gene therapy, cloning, and transgenic and reproductive techniques (Figure 3.29).

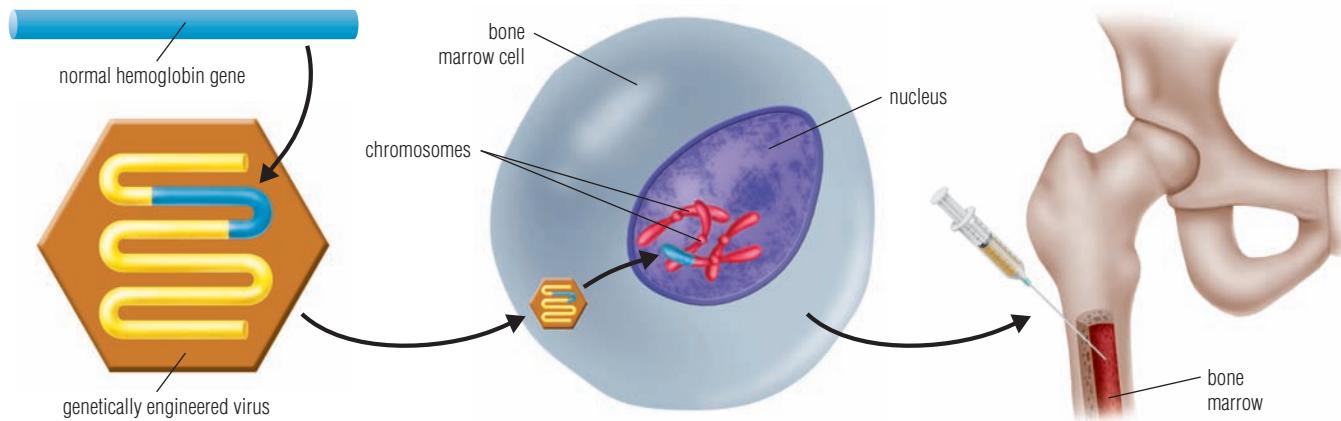
There are many points of view that must be considered when applying these advances. Analysis of the societal and ethical implications of each process is an important task for both the scientist and the individual. Society must be continually vigilant to ensure the safe and ethical practices of science. Each of us must learn to think and listen carefully and to speak and act in a moral and responsible fashion.

### Gene Therapy

The Human Genome Project (HGP) identified 20 000 to 25 000 genes in human DNA, providing information that makes it possible to cure genetic disorders using gene therapy. Gene therapy involves replacing an absent or faulty gene with a normal gene. For example, gene therapy may be useful in the treatment of cystic fibrosis, a disease in which cells in the lungs produce abnormal secretions that make breathing difficult. **Gene therapy** involves inserting healthy genes so that the cells in the lung function normally.

Currently, gene therapy is an experimental procedure. In the future, gene therapy may be used to treat cancer, inherited diseases, and some viral infections. For example, genes that cause apoptosis could be introduced into cancer cells and cause them to die.

Figure 3.30 shows how gene therapy is supposed to work to correct a genetic abnormality. A virus is used to carry the gene into the cell. The virus is modified so that it cannot cause disease, and the replacement gene is added to its DNA. The modified virus is injected into the patient to carry the gene into cells to correct the defect.



**Figure 3.30** Using gene therapy to treat a hemoglobin disease: a virus is used to carry a gene for normal hemoglobin into bone marrow, which is the tissue inside the bone that makes blood cells.

## Cloning

Although you may not realize it, you have probably eaten clones — most apples are actually clones. **Cloning** creates a genetically identical organism that is an exact copy of a gene, cell, tissue, or organism.

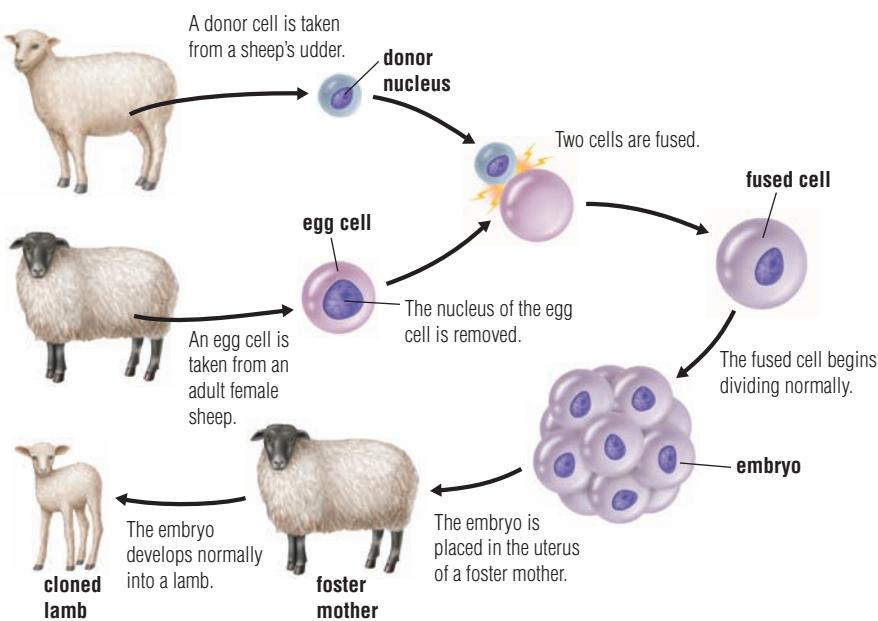
### Cloning in Plants

The cloning of plants has been done for many years. For example, vegetative propagation involves taking a cutting from a plant and allowing it to root and produce another plant (Figure 3.31). It is also possible to take cells from a root and grow them in culture media to produce cloned plants. Fruit growers have also used cloning in the form of grafting for many years to produce fruit of consistent quality. In grafting, the roots of one type of apple tree are attached to the shoots of another more desirable type of apple tree. Grafting produces trees that all bear the same type of apple.

### Cloning in Animals

Much controversy surrounds the cloning of animals. For example, there is research that suggests that cloned animals have genetic diseases. Cloning humans, while theoretically possible, raises additional moral and ethical issues. For example, some people wonder if potential parents would be able to choose, or design, their offspring through the process of cloning.

There are three ways to clone animals: reproductive cloning, gene cloning, and therapeutic cloning. Reproductive cloning involves the transfer of a nucleus from a donor body cell into an egg cell that has no nucleus (Figure 3.32). The egg is transferred to the womb of a mother and begins to grow. The embryo contains genetic information that is identical to the original body cell. This type of cloning may be useful in cloning endangered animals.



**Figure 3.31** Planting geranium cuttings

**Figure 3.32** In 1997, Dolly the sheep was the first clone of an adult mammal. Monkeys, cows, pigs, dogs, cats, mice, and rats have been cloned using this method.

Gene cloning involves the transfer of a gene into bacteria so that the gene can be reproduced multiple times. By cloning genes, scientists are able to make copies of the gene so that they can do experiments easily. Gene therapy uses this type of cloning.

Therapeutic cloning is similar to reproductive cloning, but the purpose is to harvest embryonic stem cells from a developing embryo. Recall that embryonic stem cells have the ability to produce different types of cells. It is also possible to harvest adult stem cells from bone marrow. The harvested stem cells are used to regrow healthy tissue in place of damaged tissue. This type of cloning may be used to create tissue that is a close match to the patient's tissues. The cells that would be cloned would have the same genetic information as the original tissue. As a result, the newly cloned cells would match the other cells in the tissues and would not be rejected.

#### WORDS MATTER

The prefix “xeno-” is from the Greek word *xénos*, which means stranger.

#### Learning Checkpoint

1. What is gene therapy?
2. How can gene therapy be used to treat or prevent disease?
3. What is cloning?
4. Explain how plants are cloned.
5. Distinguish between the three types of cloning of animals.

#### Transgenic Techniques

##### Suggested STSE Activity •••••

A30 Decision-Making Analysis  
on page 119

Goats that produce spider silk in their milk and fish that glow in fluorescent colours (Figure 3.33): these are just two examples of transgenic animals. **Transgenic organisms** contain the genes from other species. Bacteria were the first transgenic organisms. There are many transgenic animals including cows, pigs, mice, rats, chickens, and fish.

There are several uses for transgenic organisms.

Transgenic animals can be used to study the effects of diseases. Transgenic animals can also produce organs that can be used in human organ transplants in a process called xenotransplantation. Transgenic livestock may have extra growth hormone to make them grow faster and have leaner muscle.

Transgenic plants have been developed to have an increased resistance to disease or environmental challenges. For example, transgenic crops have been developed to produce a natural insecticide. Some plants, such as golden rice, contain extra nutrients. Transgenic trees contain genes that increase the amount of cellulose, making the timber more desirable to the paper mills.



**Figure 3.33** These fluorescent zebrafish, called Glofish™, contain a natural fluorescence gene that causes them to glow.

## Reproductive Technologies

Reproductive technologies include a wide range of techniques that can be used to solve fertility problems in domesticated animals, zoo animals, and humans. Reproductive technologies include artificial insemination (AI) and in vitro fertilization (IVF).

Artificial insemination (AI) involves collecting sperm from a male and placing it in the reproductive system of a female. Sperm from human males may be donated and stored in “banks.” The use of human sperm and the process of anonymous donation are controlled by government policies. AI is routinely used on dairy and cattle farms. AI has also been used in zoos with some success in Asian elephants and rhinos (Figure 3.34).

In IVF, sperm and eggs are collected and placed in a test tube or petri dish so that fertilization occurs (Figure 3.35). The developing embryos are implanted in the uterus of a female. Multiple embryos are implanted because the chance of success is less than 50 percent.

### Ethical Considerations about Reproductive Technologies

Reproductive technologies have brought new ethical considerations, including questions of legal rights and responsibilities. For example, in 2007, a Quebec woman froze some of her eggs so that her daughter could use the eggs to have children in the future. Her daughter is not able to have her own children. The outcome would be that the daughter would bear her mother’s children, or her own siblings. Some people argue that it would be wrong for the daughter to bear the child of her mother. Others see nothing harmful in this action. No laws currently exist to provide guidance in this area.

#### During Writing

Thinking Literacy

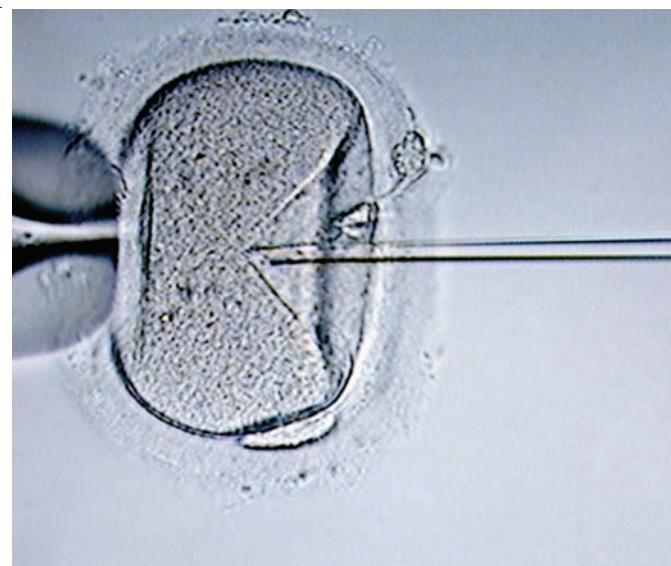
#### Consider the Options

A report presents concise information on a number of options and often makes one or more recommendations.

Recommendations allow the reader to consider one option that might be better than another and to trace the reasons for choosing that option back through the information in the report.



**Figure 3.34** This white rhinoceros calf was born in October 2008 in the Budapest Zoo. His mother, Lulu, was the first rhino to produce a calf through artificial insemination.



**Figure 3.35** A micrograph showing a needle (on the right) about to inject human sperm into a human egg cell.

## Take It Further

Dolly was the first mammal cloned from an adult cell. She eventually was able to reproduce. Why is it important that a cloned animal be able to reproduce? Research what happened to Dolly, and learn more about cloned animals. Begin your research at *ScienceSource*.



Another ethical consideration involves whether frozen eggs would be capable of normal growth and development. There is currently not enough research about whether freezing eggs causes genetic damage. In addition, only 5 percent of the frozen eggs used in IVF have resulted in pregnancy. Although companies that promote egg freezing promise that a baby can be made at any time, the statistics do not back that claim.

The use of reproductive technology is associated with various social and ethical considerations including:

- whether the use of the technology is safe
- who owns the technology and the products of the technology
- the standards and codes of practice that are in place for the development and use of the technology
- the definition of life

### Learning Checkpoint

1. Define the term “xenotransplantation.”
2. What are reproductive technologies?
3. (a) What is artificial insemination?  
(b) Explain how artificial insemination is used.
4. Explain the meaning of “in vitro fertilization.”
5. Describe some social and ethical considerations of the use of reproductive technologies.

## A29 STSE *Science, Technology, Society, and the Environment*

### Accessing Public Health Programs

You have learned about a variety of public health strategies including programs for immunization and HIV/AIDS education. Public health agencies are concerned with ensuring that programs are accessible and appropriate for everyone.

In this activity, you will complete a “placemat” activity in which you will identify the barriers to accessing appropriate public health services.

1. Working in a group, select one public health strategy to consider. Consider programs such as influenza vaccinations, HPV vaccinations, MMR vaccinations, or HIV/AIDS education.
2. Each member of the group will choose a perspective, such as social, economic, political, environmental, or economic to look at when

reviewing the health strategy. For example, if you are looking at the influenza vaccination program, one student will look at the social implications, while another student will look at the political implications.

3. **ScienceSource** Use the links provided to research information about your chosen health strategy. All students in the group will then share their ideas orally with the other members.
4. Write the ideas that are common to the group in the centre of the placemat.
5. Share your findings with the class and your list of “barriers” to accessing appropriate services. As a class, brainstorm some solutions to these problems.

- Identifying issues to explore
- Gathering, organizing, and recording relevant information

## A Look at Transgenic Issues

### Issue

Transgenic techniques have been used in biomedical research for many years. Transgenic organisms contain DNA that has been inserted experimentally.

In this activity, you will research the potential benefits and risks of using transgenic organisms and form an opinion about the topic. You should consider all aspects of the issue including the ethical and social implications of using transgenic organisms. Answer the question “Do the potential benefits of transgenic techniques outweigh the risks?”

### Background Information

Since the early 1970s, scientists have been “engineering” new organisms by inserting a gene from one organism into the cells of another organism. In 1978, a company called Genentech produced bacteria that had been engineered to produce human insulin. Today, there is a variety of transgenic bacteria, plants, and animals.

**Transgenic bacteria:** Some of these organisms produce insulin and other hormones.

**Transgenic plants:** Much of our food supply is made of transgenic, or genetically modified (GM), plants. Many transgenic plants have been modified for improved taste, nutritional value, yield, or hardiness. For example, certain transgenic plants produce a natural insecticide so that the crops do not have to be sprayed with chemical pesticides.

**Transgenic animals:** Although not engineered for human consumption, there have been transgenic experiments involving fish, cows, and pigs (Figure 3.36). Transgenic mice have been produced that have immune systems that are similar to humans. Scientists use these mice to study the effects of disease on the immune system. Recently, several companies have investigated the use of genetically altered pigs as organ donors.

### Analyze and Evaluate

1. You will work in a group of three to four members. Each member of the group should research one example of a transgenic organism (bacteria, plant, or animal).
2. **ScienceSource** Research the social and ethical implications of transgenic organisms.
3. Complete a research organizer with information from your research. You may find that point form notes are best.
4. Share your information with the group. As a group, answer the question “Do the potential benefits of transgenic techniques outweigh the risks?” Support your answer with evidence from your research. Each member should record the answers to the questions.
5. Would you use a transgenic organ if you needed a transplant? Why or why not?

### Skill Practice

6. Why is it important to understand the social and ethical aspects of this issue to make an informed decision?



**Figure 3.36** These transgenic piglets produce omega-3 fatty acids, which are necessary for human health. The pigs are being used for cardiovascular research.

### 3.3 CHECK and REFLECT

#### Key Concept Review

1. Explain the meaning of the term “gene therapy.”
2. Define the term “grafting.”
3. Define the term “gene cloning.”
4. Snuppy, shown below surrounded by puppy clones, was the first dog cloned in the world.
  - (a) What type of cloning would have been used to produce Snuppy’s clones?
  - (b) Describe that cloning process.



Question 4

5. Explain the meaning of the term “transgenic.”
6. Describe three uses of transgenic plants.
7. Discuss some potential uses of gene therapy.
8. Describe several uses of AI in animals.
9. What is one type of reproductive technology used in humans?

#### Connect Your Understanding

10. Explain how transgenic animals are used as models for human disease.
11. Explain how transgenic techniques could be used to help solve food shortages in the world.
12. Some genetically modified plants and trees are designed to grow in a specific climate. These plants are to be cloned and planted in a forest. What could happen to the forest if the climate changed or if a new pest or disease were introduced to the forest? Explain your answer.
13. Gene therapy and transgenic therapy allow the possibility of correcting errors in the genetic code. How can these technologies be abused or misused?
14. Why do you think some people feel that the use of adult stem cells is more acceptable than the use of embryonic stem cells in cloning experiments? Explain your answer.
15. Explain one reason why someone needing an organ transplant might hesitate to use a transgenic organ.
16. Give one reason why an infertile couple might hesitate to use reproductive technologies to conceive a baby.

#### Reflection

17. What is your definition of life?

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



## The Five-Second Rule

You may have heard of the “five-second rule.” According to this “rule,” food that has been dropped on the floor is still safe to eat as long as you pick it up within five seconds. The idea is that it takes time for bacteria on the floor to contaminate the food, and as long as you beat them to the punch, the food is okay to eat. But is it really? To verify the five-second rule, scientists performed an experiment using *Salmonella* bacteria (Figure 3.37). *Salmonella* bacteria are responsible for thousands of cases of food poisoning every year. Three different surfaces — carpet, tiles, and wood — were contaminated with the bacteria.

After the surfaces were contaminated, slices of bologna and bread were put on the surfaces and allowed to sit there for anywhere from 5 seconds to 60 seconds. The food was not pressed down or swirled around but was just placed gently on the surface and then lifted off. Any bacteria that

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had been transferred from the surface to the bologna or bread were then cultured in the lab. And there were plenty of them (Figure 3.38).

The experiment showed that the five-second rule is nonsense. *Salmonella* were found on both the bologna and bread — in significant numbers — even when the food was only in contact for five seconds. Although the type of flooring made a difference on how many bacteria were transferred to the food, it does not really matter. There were still enough bacteria to make life very unpleasant for anyone who made a bologna sandwich out of the food that had fallen to

the floor. The next time food falls on the ground, do not take a chance: throw it out!

### Question

1. Why is it never a good idea to eat food that has fallen on the floor (Figure 3.39)?



**Figure 3.39** Whether your bread lands jelly side down or not, bacteria will contaminate it.



**Figure 3.37** A scanning electron micrograph of *Salmonella* bacteria



**Figure 3.38** A scanning electron micrograph of *Salmonella* bacteria on a piece of meat

## ACHIEVEMENT CHART CATEGORIES

|                                      |                                     |
|--------------------------------------|-------------------------------------|
| <b>k</b> Knowledge and understanding | <b>t</b> Thinking and investigation |
| <b>c</b> Communication               | <b>a</b> Application                |

## Key Concept Review

1. (a) Define the term “medical imaging.”  
(b) Why is medical imaging important to maintaining health? **k**
2. What is an X-ray, and how is it used to image structures in the body? **k**
3. How is fluoroscopy used to assess the health of the heart? **k**
4. (a) What is radiotherapy?  
(b) How is it used to treat cancer? **k**
5. What is a radioisotope? **k**
6. What information does an ultrasound of a developing fetus provide? **k**
7. Describe the different roles of the physician, technician, and radiologist in diagnosing a medical condition. **k**
8. Explain how an endoscope is used to diagnose diseases of the digestive system. **k**
9. (a) What is a vaccine?  
(b) State three vaccines that are commonly administered to Ontarians. **k**
10. How have health authorities responded to the threat of the West Nile virus? **k**
11. What strategies are included in public health initiatives aimed at reducing the incidence of smoking-related diseases? **k**
12. Define the term “reproductive technologies.” **t**

## Connect Your Understanding

13. What are some advantages and disadvantages of using X-rays for medical imaging? **t**
14. Explain why a doctor may need to order several imaging tests to diagnose a condition such as breast cancer. **t**
15. Use an example to show how radioisotopes are used in the treatment of disease. **a**
16. Why do emergency room doctors frequently order a CT scan? **t**
17. Compare and contrast a coronary angiogram and an echocardiogram. **t**
18. Having a medical condition can often cause great stress in a patient. What information can you present to a patient about each medical imaging technique to help reduce the patient’s stress? **t**
19. Choose one public health program. Explain how that program affects the health of people who live in Ontario. **a**
20. Explain why the World Health Organization thinks that vaccination is one of the most cost-effective health investments. **a**
21. A new virus is suspected to be affecting the population of a major city. What could government and medical professionals do to limit the spread of the virus? **a**
22. Design a poster to encourage people to get immunized. The poster should indicate the benefits of immunization. Explain why you chose the format you used to present this information. **c**
23. Write a paragraph that describes two types of reproductive technologies. Include a discussion of some of the social and ethical issues involved. **c**
24. Use an example to explain how zoos may use reproductive technologies. **a**

- 25.** Explain why scientists believe that a personalized approach to the treatment of disease includes a consideration of both the nature of disease and how the body nurtures the disease. **t**
- 26.** Explain the significance of Edward Jenner's work to the field of medicine. **a**
- 27.** (a) Describe the Smoke-Free Ontario Strategy. **c**  
(b) Explain why the government of Ontario chose to implement this type of strategy. **t**
- 28.** Why do you think the influenza vaccine is provided free of charge in Ontario? **t**
- 29.** Select one public health program that we have discussed and that is available in your community. State one ethical or social consideration that is associated with that health program. **a**
- 30.** Write a short paragraph that defines and shows the relationships between the following terms: DNA, gene, protein, disease, and DNA screening. **c**
- 31.** Explain how cloning is used in the agricultural industry. **a**
- 32.** Would you be able to tell the difference between wheat and transgenic wheat (shown below)? Is there a need to raise the level of public awareness about transgenic plants? Give reasons to support your opinion. **t**
- 33.** Create a mind map showing relationships between the following words: DNA, gene, protein, DNA screening, transgenic techniques, gene therapy, cancer, and X-rays. Include definitions with each term. **c**

## Reflection

- 34.** Which topic interested you more: medical imaging techniques or cell biology techniques? Why? **c**

### After Writing

Thinking Literacy

#### Reflect and Evaluate

As a group, review the report you wrote on imaging technologies for A25 Decision-Making Analysis. Check to see how well you followed the suggestions in the Before and During Writing strategies in this chapter. Discuss as a group what you did well and any aspects of your report that you would improve if you were given the opportunity.

### Unit Task Link

In this chapter, you learned about the advancements in cell biology such as gene therapy, cloning, and transgenic and reproductive techniques, as well as public health strategies such as immunization. Create a table in which you identify the name of the advancement or public health strategy, its potential uses, associated ethical issues, and how it affects society.



Question 32

# UNIT A Summary

## KEY CONCEPTS

## CHAPTER SUMMARY

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

- Plant and animal cells
- Organelles and their functions
- Cell cycle
- Cell specialization
- Tissue formation
- Cancer cells

- Cells have special structures that enable them to perform important life functions. (1.1)
- Scientists use technology like the microscope to understand more about the cell. (1.1)
- The life cycle of a cell has four stages. (1.2)
- Growth and repair of cells is accomplished by mitosis. (1.2)
- Cancer cells have abnormal rates of cell division. (1.2)
- Stem cells divide to form specialized cells. (1.3)
- Specialized cells group together to function as a tissue. (1.3)

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

- Organ formation in animals and plants
- Organ systems in animals and plants
- Interaction of organ systems

- In animals, tissues combine to form organs. (2.1)
- In plants, tissues combine to form flowers/fruits, leaves, stems, and roots. (2.1)
- Organs associate together to form organ systems. (2.2)
- Each organ system may contain several organs. (2.2)
- Organ systems work together to accomplish movement, support, protection, transport, reproduction, digestion, gas exchange, and waste removal. (2.2)
- Organ systems are interdependent organized groups of tissues and organs. (2.2)
- Healthy organ systems work together to maintain homeostasis. (2.3)

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

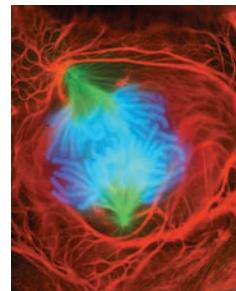
- Medical imaging techniques
- Public health strategies for disease prevention
- Developments in systems biology

- Medical personnel use technology to study, analyze, diagnose, and treat abnormalities in tissues, organs, and systems. (3.1)
- Medical imaging technologies provide information for diagnosis and treatment of problems in tissues, organs, and organ systems. (3.1)
- Public health agencies have developed strategies to improve the health and reduce health-care costs of Ontarians. (3.2)
- Examples of technological developments of systems biology include gene therapy, cloning, transgenic techniques, and reproductive technologies. (3.3)
- Developments in systems biology should be viewed in the context of social and ethical issues. (3.3)

## VOCABULARY

## KEY VISUALS

- |                               |                               |  |                     |
|-------------------------------|-------------------------------|--|---------------------|
| • anaphase (p. 32)            | • cytoplasm (p. 12)           | • mitochondria (p. 13)                 | • stem cell (p. 40) |
| • apoptosis (p. 33)           | • cytoskeleton (p. 14)        | • mitosis (p. 28)                      | • stomate (p. 44)   |
| • cancer cell (p. 34)         | • differentiation (p. 40)     | • nucleus (p. 12)                      | • telophase (p. 32) |
| • cell (p. 10)                | • diffusion (p. 12)           | • organelle (p. 10)                    | • thylakoid (p. 15) |
| • cell cycle (p. 28)          | • Golgi apparatus (p. 14)     | • phloem (p. 45)                       | • tissue (p. 42)    |
| • cell membrane (p. 12)       | • granum (p. 15)              | • prophase (p. 31)                     | • vacuoles (p. 13)  |
| • cell specialization (p. 40) | • interphase (p. 28)          | • red blood cells (p. 42)              | • vesicles (p. 13)  |
| • cell wall (p. 14)           | • lysosomes (p. 13)           | • regeneration (p. 38)                 | • xylem (p. 45)     |
| • centriole (p. 16)           | • meristematic cells (p. 41)  | • ribosomes (p. 14)                    |                     |
| • chloroplast (p. 15)         | • meristematic tissue (p. 43) | • rough endoplasmic reticulum (p. 14)  |                     |
| • chromosome (p. 28)          | • mesophyll (p. 44)           | • sister chromatids (p. 29)            |                     |
| • concentration (p. 12)       | • metaphase (p. 32)           | • smooth endoplasmic reticulum (p. 14) |                     |



The anaphase stage in mitosis

- |                              |                              |                         |
|------------------------------|------------------------------|-------------------------|
| • absorption (p. 68)         | • interdependent (p. 80)     | • stomach (p. 58)       |
| • capillaries (p. 57)        | • intestines (p. 58)         | • transpiration (p. 72) |
| • circulatory system (p. 70) | • lung (p. 57)               |                         |
| • digestive system (p. 68)   | • organ (p. 54)              |                         |
| • esophagus (p. 58)          | • organ system (p. 65)       |                         |
| • excretory system (p. 71)   | • respiratory system (p. 69) |                         |
| • heart (p. 57)              | • skin (p. 56)               |                         |



Circulatory system

- cloning (p. 115)
- DNA screening (p. 108)
- gene (p. 108)
- gene therapy (p. 114)
- immunization (p. 105)
- medical imaging (p. 93)
- public health strategies (p. 104)
- transgenic organism (p. 116)



X-rays are used to image broken bones.

# UNIT A Task

## Your Opinion Matters!

### Getting Started

In this unit, you have learned about medical and technological advancements in the area of systems biology. You have also learned how these advancements have improved our understanding of cells, tissues, organs, and organ systems. In this task, you will select a particular technological advancement and evaluate its importance. You will support your opinion using evidence gained from your learning in this unit.

### Your Goal

You will evaluate the impact of medical and technological advancements upon society. You will communicate your opinion with supporting evidence in a creative manner. You may choose to present your opinion and supporting evidence in the form of a collage, comic, video, PowerPoint presentation, monologue, or brochure. Remember to use both graphics and text to create an effective presentation.

#### Criteria for Success

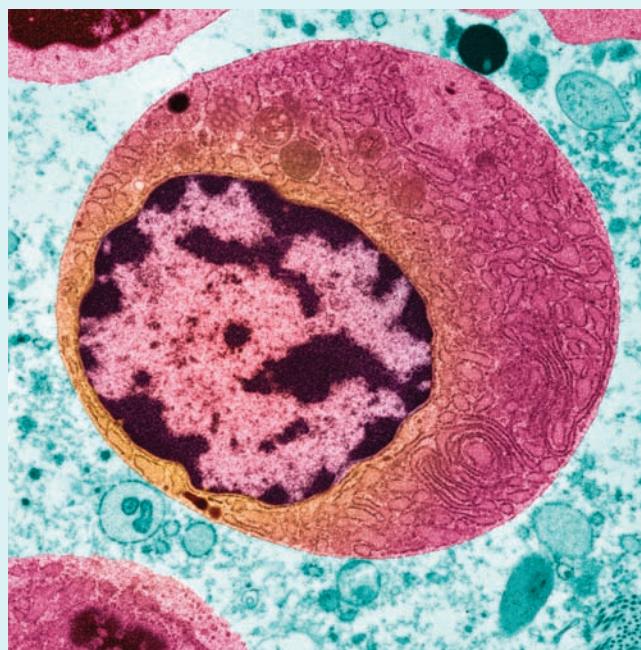
- Your presentation must include supported information from at least three sources on your chosen technological advancements.
- Your presentation should use both graphics and text to convey your message.
- Your graphic organizers need to clearly show your learning about your chosen technological advancement, including supporting evidence.

### What You Need to Know

You have learned about plant and animal cells and how meristematic cells or stem cells become specialized. You have learned how specialized cells group together to form tissues, how tissues group together to form organs, and how organs work together to form organ systems. At each level of biological organization, our understanding has been enhanced by the development of technologies.

As you were learning about cells, you learned about various technological innovations that have affected or changed the world in which we live. For instance, you learned that the development of a variety of microscopes, including the transmission electron microscope, has enabled scientists to study cells and their organelles. You learned that developments in microscopy enable doctors to identify cell abnormalities such as cancer (shown below). In addition, developments in microscopy have allowed for the development of reproductive technologies.

You have also learned about various medical imaging technologies that are used to provide information about tissue and organ structure and function. In addition, you studied how techniques such as DNA screening provide information about the level of risk for certain inherited diseases. Other specialized technologies, including cloning, gene therapy, and reproductive technologies, can affect our society in complex ways.



A transmission electron micrograph of a thyroid cancer cell. The nucleus (black) contains chromatin (pink). The nucleus is very large and the cancer cell is very spherical (magnification 4000 $\times$ ).

You have learned about several medical and technological developments related to systems biology. Some of these medical imaging technologies are shown in the photo below. These advancements have improved our understanding of cells, tissues, organs, and organ systems. However, some of these medical and technological developments have also affected society; there are many social and ethical issues associated with these developments. You may have formed your own opinions about these matters.

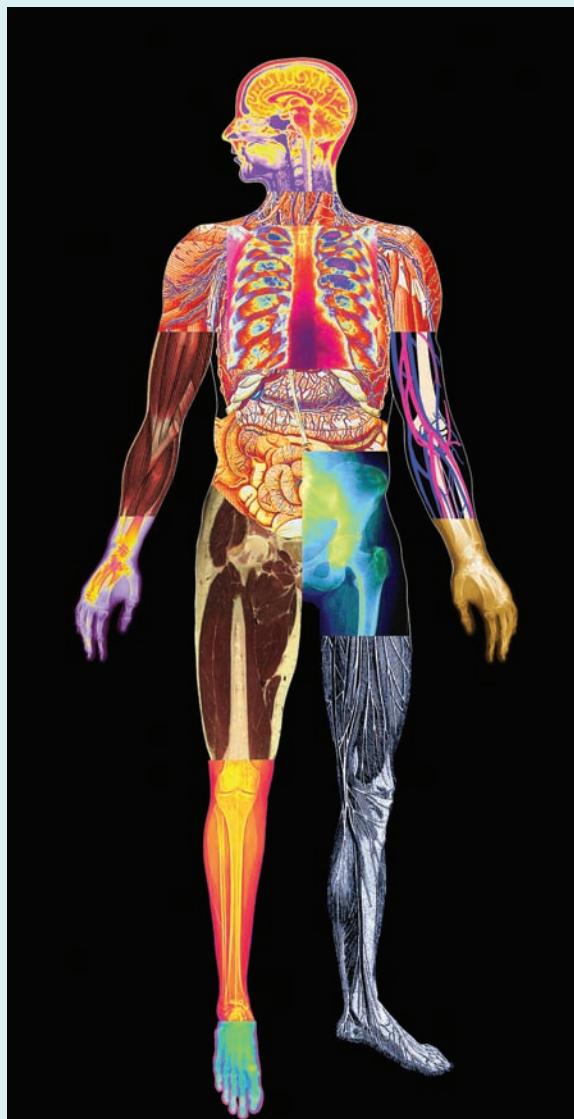
Review your notes to find information about medical and technological advancements and their impact upon society. Consider how you will use the information to support your opinion.

## Procedure

- 1. ScienceSource** Choose one technological advancement. You may wish to review your notes, textbook, and other resources to identify medical and technological advancements that have improved our understanding of cells, tissues, organs, and organ systems. Research how your chosen technological advancement has affected society from different perspectives including social, economic, ethical, and political perspectives.
- 2.** Using a consequence map, record your learning in two organizers. Complete a Medical and Technological Advancements Describing Wheel graphic organizer to describe the details of the chosen technology. Complete a PMI graphic organizer to show your personal opinion about the societal impact of the advancement. Remember to include supporting evidence.

## Assessing Your Work

- What criteria did you use to evaluate the importance of the medical and technological advancements in society?
- What aspects of the task were the easiest to complete? What aspects of the task were the most difficult to complete? Suggest reasons for your choices.



A composite image showing several imaging methods used to visualize the human body

# UNIT A Review

## ACHIEVEMENT CHART CATEGORIES

**k** Knowledge and understanding

**t** Thinking and investigation

**c** Communication

**a** Application

## Key Terms Review

1. Create a concept map that links all of the terms in the list below. Give examples, where applicable, of the various terms. **c**

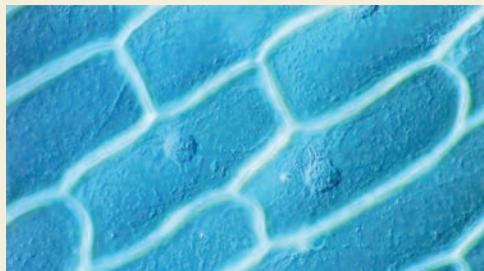
- cell
- organelle
- diffusion
- concentration
- mitosis
- prophase
- anaphase
- regeneration
- differentiation
- meristematic cells
- tissue
- red blood cells
- meristematic tissue
- stomate
- mesophyll
- xylem
- phloem
- organ
- capillaries
- organ system
- absorption
- homeostasis
- interdependent
- medical imaging
- public health strategies
- immunization
- DNA screening

## Key Concepts Review

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

2. Two basic life functions of cells include waste removal and exchange of gases. Use your knowledge of cell organelles to explain how the cell accomplishes these tasks. **k**

3. Classify the cells below as plant or animal cells, and explain your thinking. **k**



Question 3

4. Define the term “electron micrograph.” Explain how an electron micrograph is taken. **k**
5. Describe the sequence of events that occur in the cell cycle. **k**
6. Explain how mitosis ensures genetic continuity from cell to cell in an organism. **t**
7. Explain the importance of mitosis for the growth of cells and the repair of tissues. **k**
8. Describe each of the various stages in mitosis. **k**
9. How do cancer cells differ from normal cells? Give three differences. **k**
10. Describe the structure and function of meristematic tissue in a plant. **k**
11. A tissue is a group of cells that work together to perform a function. Use an example from a plant and an animal to illustrate that definition. **k**

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

12. (a) Give an example of the tissues found in a plant organ. **k**
- (b) How do the tissues help the organ function? **k**

- 13.** (a) Give an example of the tissues found in an animal organ. **k**  
(b) How do the tissues help the organ function? **k**
- 14.** An organ system is a group of organs that work together to perform a function. Use an example from an animal and a plant to illustrate that definition. **t**
- 15.** Describe how the integumentary system responds to various changes in the environment. **t**
- 16.** Compare the digestive systems in a person, an earthworm, a fish, and a frog. **k**
- 17.** Explain the role of the diaphragm in the process of inhalation and exhalation. **t**
- 18.** (a) Describe the structure of the heart.  
(b) Explain how its structure enables the heart to pump blood effectively. **k**
- 19.** The skin is an organ that is made of several tissues.  
(a) What are the functions of the skin? **k**  
(b) Explain how the tissues interact together to enable the organ to perform its required functions. **k**
- 20.** What role do the kidneys play in maintaining homeostasis in the body? **k**
- 24.** Describe how lifestyle choices can affect your health. **a**
- 25.** Describe some of the effects of tobacco smoke on the systems of the human body. **k**
- 26.** Describe some simple lifestyle changes that Ontarians can make to lessen the threat of acquiring West Nile virus. **a**
- 27.** Explain how gene therapy may be used to treat or prevent disease. **k**
- 28.** Describe three types of cloning. **k**
- 29.** Use an example to explain the meaning of the term “transgenic crop.” **k**
- 30.** Use two examples to explain the meaning of the term “reproductive technologies.” **k**

## Connect Your Understanding

**3**

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

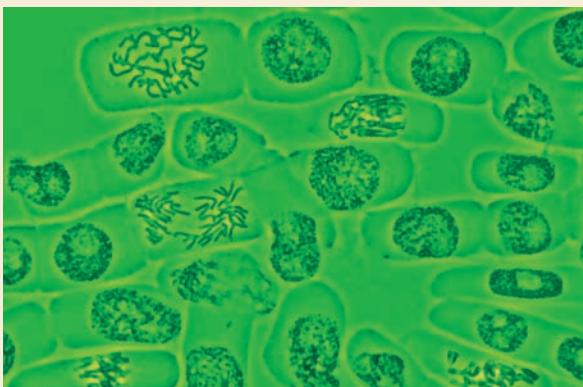
- 21.** Why is the MRI scan such a popular diagnostic tool? **t**
- 22.** How is ultrasound used in the process of amniocentesis? **k**
- 23.** Use an example to help explain how a vaccine can be used to prevent or control the development of disease. **a**
- 31.** Using a city as an analogy for a cell, suggest aspects of a city that perform a function similar to the function performed by an organelle in a cell. **t**
- 32.** Explain why knowledge about the cell cycle is important to cancer research. **t**
- 33.** Describe some factors that may influence the rate of mitosis in an organism. **t**
- 34.** Explain why you would expect muscle cells to have a large number of mitochondria. **t**
- 35.** Describe how the interaction between the vascular tissue and the ground tissue is necessary for the survival of a plant. **a**
- 36.** Create a mind map to show relationships between the following terms: cell, tissue, organ, organ system, and organism. **t**

- 37.** Write a short paragraph to show the relationships between the following structures and processes involved in the transport of materials and gas exchange in plants: roots, root hairs, root epidermis, xylem, phloem, stomate, ground tissue, and transpiration. **c**
- 38.** Why are cell division and cell specialization important for creating new organs in a fetus? **t**
- 39.** Use the terms diffusion, concentration, red blood cells, and capillaries in a paragraph to describe how gas exchange occurs in the alveoli. **c**
- 40.** Why does your heart rate slow down when you sleep? **t**
- 41.** Describe how the interaction between the human respiratory system and the circulatory system ensures survival. **t**
- 42.** Explain why your breathing rate may be higher when you exercise. **a**
- 43.** Explain why a circulatory system is a necessity for complex multicellular organisms. **t**
- 44.** Using a factory as an analogy for an organism, suggest aspects of the factory that perform a function similar to a function provided by an organ system. **t**
- 45.** When you exercise vigorously, your body temperature increases and you may begin to sweat. After rest, your body temperature returns to the normal temperature. Use your understanding of homeostasis to explain how your body reacts. **a**
- 46.** If you take medication to control your heart from beating too quickly and you exercise heavily, what side effects could occur? **t**
- 47.** In the Canadian Arctic, the Inuit people along the coast used to eat beluga whale skin because it was rich in vitamin D.  
(a) Why would this be necessary?  
(b) In recent years, it has been found that the level of cumulative toxins in beluga whale skin has risen to toxic levels. What implications would this have on these people? **t**
- 48.** Write a paragraph to explain how the ability of an organism to exchange gases with its environment is linked to its ability to maintain homeostasis. **c**
- 49.** Alcohol acts as a depressant to the function of the central nervous system. Caffeine is a stimulant that acts to increase the activity of the central nervous system. How can combining alcohol and caffeine influence the body's ability to function efficiently? **a**
- 50.** Alcohol in the bloodstream acts as a depressant on the central nervous system. If someone with alcohol in the bloodstream were injured in an accident, how could alcohol affect that person's ability to survive the injuries caused by the accident? **a**
- 51.** Write a paragraph that outlines five ways in which radiographs are used to provide information about personal health. **c**
- 52.** Compare the kind of diagnostic information provided through the use of ultrasound with the information provided by X-rays. **t**
- 53.** Describe three different public health strategies that are related to systems biology. **t**
- 54.** How can transgenic animals be used in the study and treatment of disease? **a**
- 55.** Describe two ethical issues related to the use of reproductive technologies. **a**
- 56.** Assess the importance of childhood immunizations such as MMR. **t**

- 61.** Vaccinations are given to babies and young children to prevent deadly diseases. However, some parents choose not to vaccinate their children. Assume that you know the parent of a new baby. What information about the vaccination would that parent need to know to make a wise decision about whether to vaccinate the baby? **a**

### Skill Practice

- 62.** Identify the phases of mitosis shown in the photo below. **a**

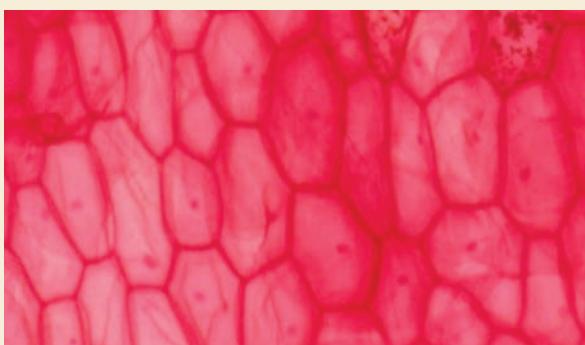


Question 62

- 63.** Complete a Venn diagram that compares plant cells with animal cells. **a**

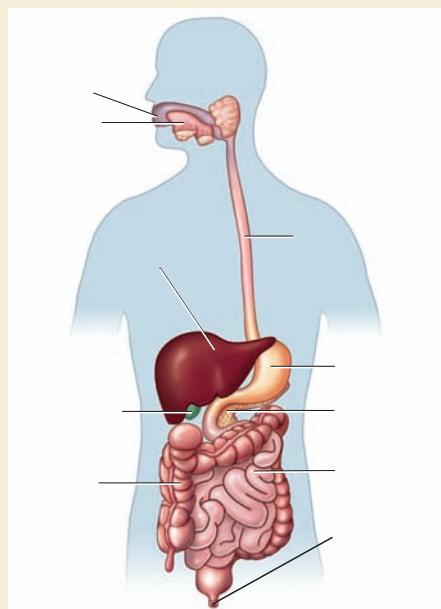
- 64.** Examine the following photo of cells.

- Identify two cell structures that are visible. **k**
- Describe the function of each part. **k**
- Classify these cells as plant or animal cells, and explain your thinking. **a**



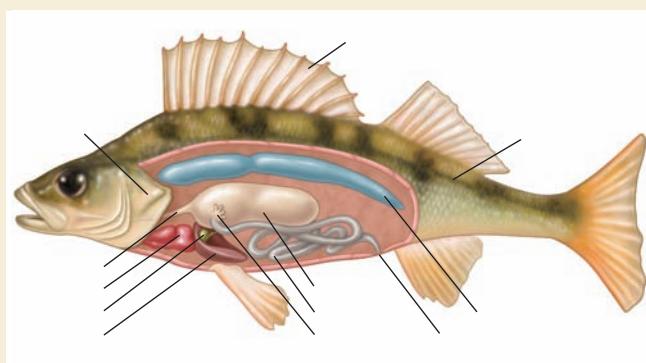
Question 64

- 65.** Name the organs in the human digestive system (shown below). **a**



Question 65

- 66.** Name the structures in the fish shown below. **a**



Question 66

### Revisit the Big Ideas and Fundamental Concepts

- 67.** Explain why biologists describe the following list as a biological hierarchy: cell, tissue, organ, organ system, and organism. **a**

68. Write a paragraph in which you explain how the root system and the shoot system work together in the process of photosynthesis. **c**
69. Although mitosis ensures that all cells have the same genetic information, differentiated cells have unique structures and functions. Explain how this works. **c**
70. Explain how mitosis provides for growth and repair of tissues. **t**
71. Show the importance of the cell cycle by describing the key events in the cycle. **t**
72. “Plants use specialized cells and processes to perform on a larger scale the same functions that a single cell performs alone.” Use examples to illustrate the meaning of this statement. Use the mangrove tree shown below as an example in your answer. **a**



Question 72

73. Use an example to illustrate the meaning of the term “homeostasis.” **a**
74. Explain the primary functions of the circulatory system and the respiratory system, and then show how these two systems interact within the organism. **a**
75. Use an example to show why the interactions of different systems within an organism are necessary for the survival of the organism. **a**

76. Write a paragraph that describes how oxygen reaches each cell of the body. Be sure to use relevant terminology including arteries, concentration, diffusion, capillaries, and red blood cells. **c**
77. Write a paragraph that describes how the following tissues interact to carry out photosynthesis in a plant: mesophyll, phloem, xylem, and stomata. **c**
78. Explain how cancer can affect cells. **t**
79. How have developments in imaging technology contributed to our current understanding of cell parts and function? Give an example in your answer. **t**
80. The following factors are thought to impact the health of Ontarians: rates of cancer, vaccinations, and Sun protection behaviours. Choose one of these factors, and explain how public health programs or initiatives are attempting to encourage and support healthy living practices. **t**
81. Developments in medicine and technology have social and ethical implications. Show your understanding of that statement by creating a PMI organizer (plus, minus, points of interest) for one of the following situations: **t**
- DNA screening
  - stem cell research
  - organ transplantation
  - cloning
  - cancer screening
82. How are medical imaging technologies used in the diagnosis and treatment of heart disease? **t**
83. In this unit, you learned about how technological developments have improved our understanding of cells, tissues, organs, and organ systems. Think about your own experiences, and describe one example in which technology has played an important part in maintaining your own health. **a**

- 84.** The following photo shows two piglets from a transgenic pig. The piglets contain a protein that glows fluorescent green. Predict three ways in which you think that transgenic organisms will be used in the future. **a**



Question 84

### STSE

### Science, Technology, Society, and the Environment

- 85.** Select one medical development that you learned about in the unit. Evaluate the importance of this development by considering its impact on society. **t**
- 86.** In March 2009, President Obama lifted the United States ban on funding stem cell research. This means that researchers, such as Irina Elcheva shown below, can culture stem cells for research. What are the ethical arguments for and against stem cell research? **a**



Question 86

- 87.** Choose one topic from the following list of technological developments. Write a paragraph outlining some of the ethical implications associated with the use of this technological development. **t**

- transgenic techniques
- cloning
- stem cell research

- 88.** In this unit, you learned about how technological developments are related to systems biology. How important do you think these technological developments are to systems biology? Explain your answer. **t**

### Reflection

- 89.** In what two ways do you think what you learned from this unit will affect your life in the next year? **c**
- 90.** Describe one situation in which you have been influenced by your peers or the media to make either a good or a bad choice about your health. **c**
- 91.** In this unit, we have learned about many issues related to the health of Ontarians. Has your learning prompted you to become more involved in programs such as community fund-raising for such causes as the Canadian Cancer Society? Explain the reasoning for your response. **c**
- 92.** As learners, we should be able to apply learning to our lives so that we can make positive changes when necessary. In this unit, you have learned how to maintain the health of your body systems. How healthy is your lifestyle? Provide evidence to support your assessment. **c**