Key Terms
biophotonics
public health strategy
vaccination
cancer screening

3.3 Maintaining Healthy Systems

Throughout history, people from around the world have had ways to prevent and treat various diseases and conditions. For example, Chinese acupuncture has been used for centuries to treat ailments such as headaches and chronic pain. First Nations people in North America helped Europeans cure scurvy, a deficiency of Vitamin C, by giving them a tea made by boiling the bark of the white cedar. They also had many other medical treatments using various plants and herbs from their environment. Many traditional treatments, such as acupuncture, are now being studied by scientists.

Advances in Medical Technologies

Many of today's medical imaging technologies—examples of which you have seen in this chapter—have greatly advanced the diagnosis and treatment of disease. The human body has many ways to keep infection out, including its layer of skin. Opening the body for any reason, even in a sterile modern hospital, is best avoided.

biophotonics all procedures and devices that use various light technologies to work with living systems, including humans

Some of today's technologies, such as those that use **biophotonics**, have advanced a wide range of minimally invasive surgeries that result in fewer complications and less discomfort for patients than traditional surgeries, which often required large incisions. For example, endoscopy, which you saw used for diagnosis on page 95, can also be used to conduct surgeries as shown in **Figure 3.30**. Endoscopy is a form of biophotonics. Surgical lasers, as shown in **Figure 3.31**, are another form of biophotonics. Using lasers allows pinpoint accuracy for operations involving delicate tissue such as the eye.

Figure 3.30 Endoscopes help physicians see inside the body and even perform some surgeries without having to cut the body open.

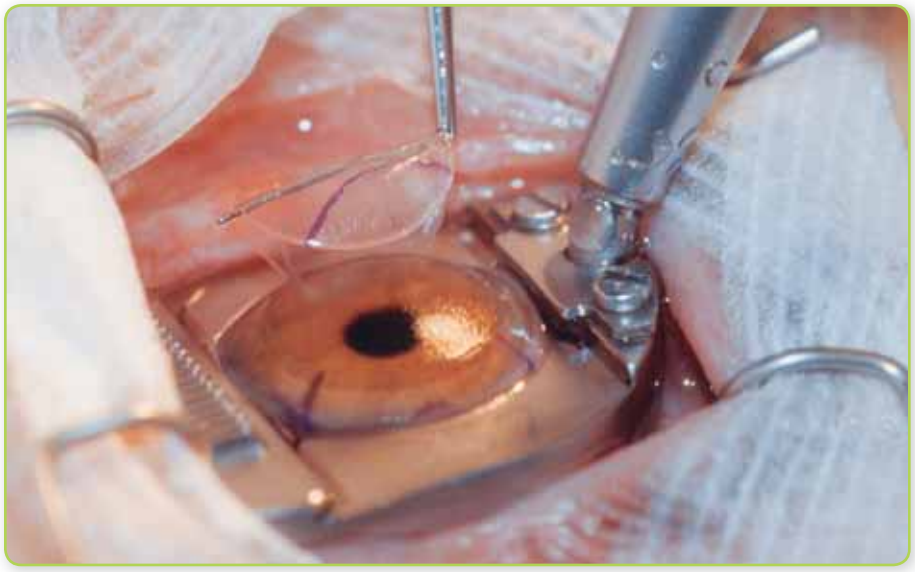

Figure 3.31 Using a high-energy carbon dioxide laser, eye surgeons can take a tiny slice off the front of the cornea. This form of eye surgery, a type of biophotonic technology, can correct a patient's near-sightedness.

Prenatal Care and Ultrasound

Prenatal care has also benefitted from advances in medical imaging technologies. Because sound waves do not penetrate deeply into tissues, they are generally considered safe, even for a developing fetus. Ultrasound is commonly used in the first few months of pregnancy to make sure a fetus's heart is beating normally and that it has its major organs. As you can see in **Figure 3.32**, it is also used to correct some abnormalities before birth.

Pregnant women are usually advised to avoid X rays and other kinds of diagnostic tests. Since there have been few studies on the long-term effects of the use of ultrasound, the medical community advises that ultrasound, like any other medical procedure, should be performed only when necessary.

Figure 3.32 Ultrasound helps doctors perform amniocentesis, which you read about in Chapter 1, as well as surgeries. Here a surgeon holds an ultrasound probe to the scalp of a premature baby needing brain surgery.

Preventive Health Care

Preventive health care includes steps individuals can take to guard their own health, such as eating well and exercising regularly. It also includes **public health strategies**, which are co-ordinated efforts to reduce the incidence of various health problems. A public health strategy that has greatly improved human health is the use of **vaccinations** to control the spread of deadly diseases. For example, a worldwide vaccination program for smallpox has virtually eliminated the disease.

The last known naturally occurring case of smallpox was recorded in Somalia in 1977. The disease now exists only in samples stored in scientific labs. How this and other vaccination programs work is discussed in the next section.

public health strategy a co-ordinated effort to track, research, and reduce the incidence of specific health problems in a population

vaccination the process of giving a vaccine by mouth or injection to provide active immunity against a disease

Figure 3.33 This photograph shows a white blood cell attacking *E. coli* bacteria, which are the small pink shapes.

Fighting Infectious Disease

Understanding vaccinations means understanding how the body fights disease. Infectious diseases are caused by *pathogens*. Pathogens are disease-causing agents such as viruses, and some kinds of bacteria and fungi. Organs such as your skin prevent most of these invaders from getting in your body. However, if a pathogen does enter your body, your immune system then tries to attack and destroy the invader, usually successfully.

The body's first response to an invader is to send a flow of fluid containing white blood cells called *phagocytes*, and dissolved substances from the blood to the site of the infection. This causes inflammation, a swelling and redness in the area. The job of the phagocytes is to fight infection, as seen in **Figure 3.33**. Any material that the body considers foreign and that stimulates this response is called an *antigen*. In particular, proteins on the surface of pathogens are antigens that trigger this response.

STSE Case Study

Childhood Vaccinations: Weighing the Risks

Before the vaccine for measles became available, most children contracted the illness. Since then, it has been virtually eliminated in Canada. In 2004, there were only seven cases reported. Any new case of measles has been imported from another country, where the measles vaccine is not given to all citizens.

Vaccines act as antigens, prompting the immune system to produce antibodies. Once the body has produced the antibodies needed to fight a particular disease, the antibodies remain in the body, creating an immunity. Over the years, the antibodies continue to provide protection against stronger forms of the disease, which could be very dangerous.

A public health strategy of vaccinating children has greatly reduced the incidence of common diseases such as measles, mumps, and rubella. Canada's rubella vaccination program began in 1983. By 2004, the number of reported cases of rubella had dropped from 5300 to less than 30 cases per year, a decrease of 99.4 percent.

Concerns about Vaccinations

Some parents are concerned about vaccinating their children. Most common vaccines are produced in animal tissues, such as eggs. Some parents believe the vaccines are contaminated with animal diseases. In addition, some children have reactions to the injections. These reactions may involve minor side effects, such as redness and swelling at the site of the injection. However, more serious allergic reactions can also result. Due to these potential problems, some parents have chosen not to vaccinate their children. Many medical professionals are concerned that a decline in the vaccination rate could lead to a resurgence of potentially deadly diseases.

At this time, there is no accepted scientific evidence that childhood vaccines cause long-term health problems. Most members of the medical community agree that the benefits of getting the vaccines outweigh the risks.

A hundred years ago, many children died of diseases. Today, childhood vaccinations prevent many of these diseases.

Developing Antibodies

Bone marrow is another important part of the immune system. White blood cells and many other disease-fighting molecules are manufactured in the bone marrow. Among these molecules are specialized proteins called *antibodies*. Each antibody identifies and attaches to a specific antigen. This attachment either prevents the invader from infecting the rest of the body or signals to other parts of the immune system that this intruder needs to be destroyed.

Learning Check

5. Give an example of the medical use of biophotonics.
6. What is a public health strategy?
7. You get a splinter stuck in your finger. Explain what happens as your body fights off the bacteria that have probably come through your skin along with the splinter.
8. Use an example of a specific disease to explain how vaccinations have affected human health.

Your Turn

1. Identify the different stakeholders affected by routine vaccinations. Write a statement describing the issues regarding vaccines from the viewpoint of each of the stakeholders.
2. Identify the kinds of information you think a public health strategy needs to communicate for it to be successful. Justify why you think these pieces of information are important.
3. Research one childhood disease for which there is now a vaccine. Write a pamphlet to inform the public about the disease and the vaccine. Make sure your pamphlet presents the kinds of information you identified in step 2. Include a list of answers to questions you expect people would ask.

Vaccines are produced in a sterile environment.

Common Vaccines in Canada

- diphtheria
- tetanus
- pertussis (whooping cough)
- polio
- Haemophilus influenzae type B (Hib)
- measles
- mumps
- rubella (MMR)
- hepatitis B
- chickenpox
- pneumococcal disease
- meningococcal disease
- influenza (flu)

Stopping the Spread of Disease

Many other infectious diseases do not have vaccinations available to control them. These diseases need to be controlled with different kinds of public health strategies, which are usually focussed on containing the spread of the disease. Three such diseases will be examined next: SARS, AIDS and the West Nile virus.

SARS

Go to **scienceontario** to find out more

In the spring of 2003, severe acute respiratory syndrome (SARS) entered Canada when a person who was infected in Hong Kong brought the virus back home to Toronto. SARS causes fluid to fill a patient's lungs, making it nearly impossible for the person to get enough oxygen. Because the SARS virus is readily transferred to others through the air, the disease quickly spread and caused a public health crisis in Ontario, as shown in **Figure 3.34**. By the end of an epidemic that lasted four months, the SARS virus had spread to 432 people, 44 of whom died.

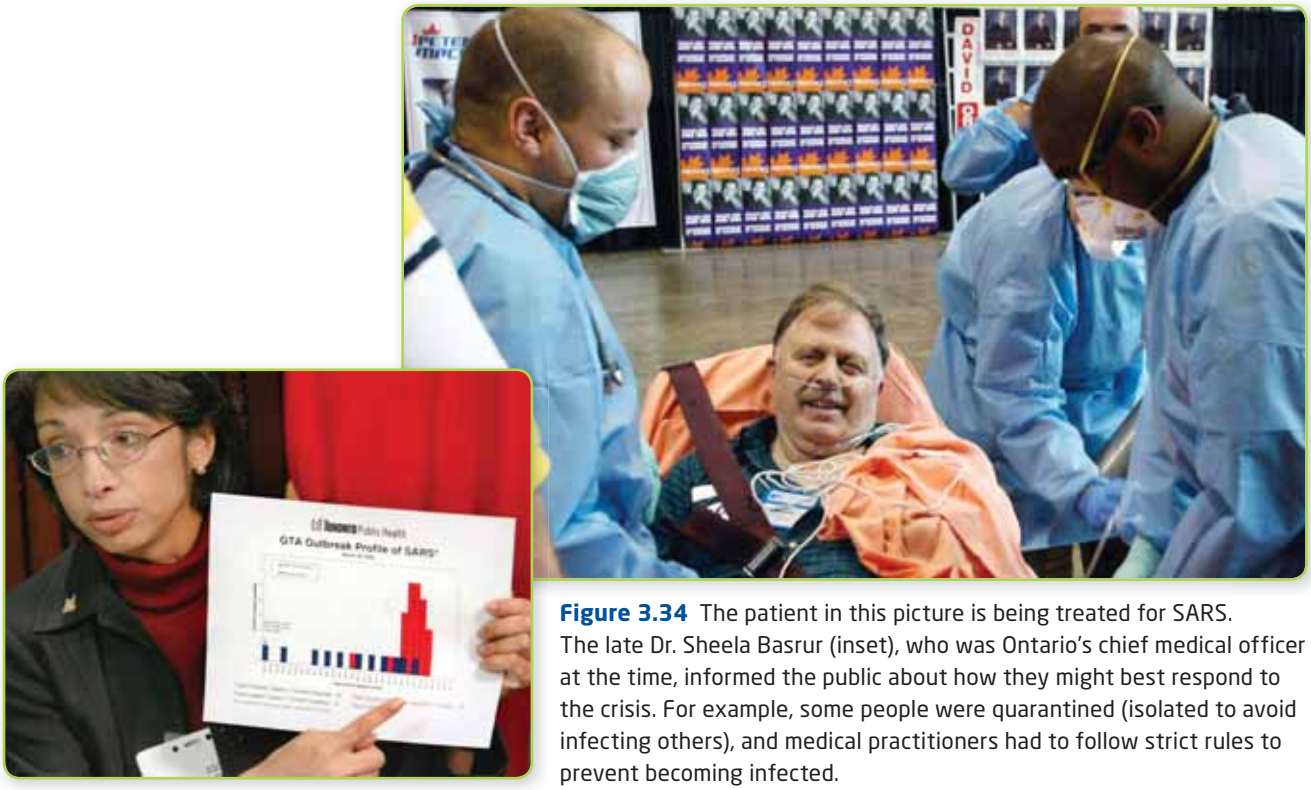

Figure 3.34 The patient in this picture is being treated for SARS. The late Dr. Sheela Basrur (inset), who was Ontario's chief medical officer at the time, informed the public about how they might best respond to the crisis. For example, some people were quarantined (isolated to avoid infecting others), and medical practitioners had to follow strict rules to prevent becoming infected.

AIDS

Acquired immunodeficiency syndrome, (AIDS) is caused by the human immunodeficiency virus (HIV), which attacks the immune system itself. This means that when other pathogens enter the body, the immune system is unable to mount an attack. HIV/AIDS has been directly responsible for the deaths of more than 25 million people worldwide. The federal government's strategy on HIV/AIDS includes keeping track of how many people have the disease. It also includes research, educational programs to prevent more people from acquiring HIV/AIDS, and help for people who have the disease.

Making a Difference

Jerri Clout is on a mission to help raise awareness about HIV/AIDS. At 13, the North Bay student became youth ambassador for Patrick4Life, an organization dedicated to educating people about how to prevent the transmission of HIV/AIDS. Patrick was a local youth who had hemophilia. He got HIV through a blood transfusion and died of AIDS at age 23. Jerri has been co-chair of the annual RUN/WALK for PATRICK for three years and helped design an HIV/AIDS pamphlet. In 2006, she founded Youth4Youth, an AIDS awareness organization. At the request of Ontario's Minister of Health, Jerri welcomed girls and women from around the world to the 2006 Worlds AIDS Conference in Toronto and attended the 2008 World AIDS Conference in Mexico City. In 2008, Jerri was named one of Canada's Top 20 Under 20 by Youth in Motion.

What could you do to raise HIV/AIDS awareness in your community?

West Nile Virus

Canada had its first case of West Nile virus in 2002. Although most people who get infected have no symptoms, a few become seriously ill or die. The Public Health Agency of Canada now co-ordinates a strategy to try to reduce people's exposure to the virus, as suggested in **Figure 3.35**. The strategy involves identifying the presence of the disease in various animals and, where it is present, informing local authorities. Local authorities may then use pesticides to reduce mosquito populations and provide educational programs to the public.

Figure 3.35 Most people with West Nile virus get it from a mosquito bite. The best protection is to avoid mosquito bites by applying insect repellent and covering bare skin.

Suggested Investigation

Data Analysis Investigation 3-C, Who's Stubbing Out?, on page 119

Cancer Prevention

Not all public health strategies are directed at infectious diseases. For example, many public health strategies are directed at a non-infectious disease that two in five Canadians will get at some point in their lives: cancer.

In Chapter 1, you learned about carcinogens and how they can cause the mutations that lead to cancer. Clearly, then, one of the best ways to prevent cancer is to avoid the substances and situations that cause cells to mutate in this way. Many public health strategies encourage these preventive measures, such as not smoking cigarettes in order to avoid lung cancer and avoiding excessive exposure to the sun in order to avoid skin cancer.

However, some situations are not within a person's control. For example, for years, people had no idea that many houses and buildings contained asbestos insulation, which is now known to be carcinogenic. Programs are now in place to remove this insulation wherever it is discovered, but people lived with it for many years before the danger was recognized.

Screening for Cancer

cancer screening tests used to detect cancer cells at an early stage of the disease so that it can be treated more effectively

Other causes of cancer are not known and therefore cannot be avoided. In these cases, **cancer screening** programs are the next line of defence. Discovering and treating cancer early in its development greatly increases a person's chances of survival. Depending on the type of cancer, early detection and treatment allows 65 to 95 percent of the individuals to survive.

Some cancer screening programs are done routinely as part of a person's annual physical checkup. For example, doctors remove a small sample of cells from a woman's cervix using a technique called a PAP smear (named after Dr. George Papanicolaou, the doctor who invented the technique). Seen in **Figure 3.36**, these cells are then examined for abnormalities that might indicate the presence of cancer.

PAP smears are now part of a regular health checkup for adult women. After PAP tests were introduced in Canada nearly 50 years ago, the incidence of death due to cervical cancer declined dramatically.

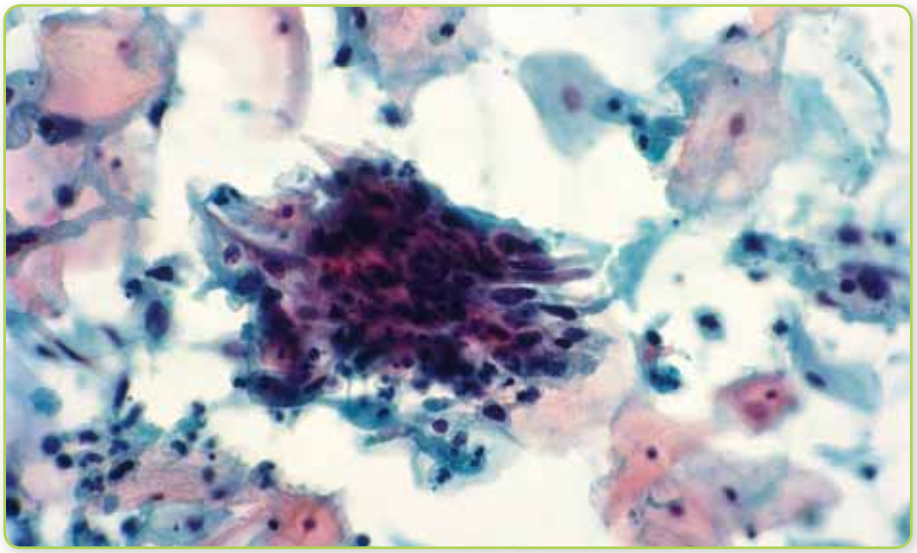

Figure 3.36 By examining epithelial cells from a PAP smear, doctors can see whether the cells show any abnormalities. In this view, you can see a mass of cancerous cells with enlarged nuclei in the centre and normal cells around the edges.

Section 3.3 Review

Section Summary

- Many technologies, such as ultrasound and various forms of biophotonics, have become important for diagnosing and treating abnormalities in tissues, organs, and systems.
- Public health strategies for a variety of diseases and conditions work to improve the health of Canadians by encouraging healthy lifestyle choices and other preventive measures.

Review Questions

A **1.** Place the machines shown at the right in order from most to least likely to be used on a pregnant woman. Explain your reasoning.

K/U **2.** Describe one tissue and one organ that are involved in your body's defence against pathogens.

T/I **3.** A colonoscopy is done on people older than 50 to see if they have any growths on the walls of their colon. How do you think this procedure is done and why might these growths be a concern?

A **4.** According to a 25-year study, obesity in Canadians between 12 and 17 years old increased from 3 percent in 1979 to 9 percent in 2004.

a. What reasons can you give for why this occurred?

b. Even at 9 percent, this is a fairly small proportion of the total population. Why would these data be so alarming to researchers?

K/U **5.** How does a vaccination against a disease help to prevent it?

K/U **6.** Give an example of how cancer screening has led to a reduction in cancer deaths.

K/U **7.** Describe one public health strategy and explain how it tries to alter people's lifestyles.

T/I **8.** Compare and contrast the two approaches to controlling disease: prevention and cure. Give some ways in which each is done in today's world.


CT scanner


endoscope


ultrasound