CONCEPT 1
A micro-organism is an organism that can only be seen with a microscope.

Activity
Reflecting on Micro-organisms
Each of the living things in Figure 1.15 is a micro-organism. Record at least five observations and five questions that occur to you as you compare these photos.

One thing that the organisms in Figure 1.15 have in common is that they are too small to see with the unaided eye. Anything that is smaller than 1 mm requires technology such as a microscope to see clearly. Micro-organisms are all smaller than 1 mm, so they can only be seen with a microscope. For example, each bacterium in Figure 1.15 has a length of about 1 μm. This means that thousands of them could fit in an area the size of the period at the end of this sentence. The phytoplankton are even smaller, with a length of only 0.1 μm. The *Euglena* is a bit larger, with a length of about 10 μm.

Micro-organisms, or microbes for short, live in every place you can possibly imagine. They live inside and on other living things. Many live freely in the air, in large and small bodies of water, and even in small puddles. No matter where you travel in the world—along sandy beaches, in coastal and inland forests, into the mountains, across prairie grasslands, in the freezing Arctic, and in dry, hot deserts—there are microbes.

**Figure 1.15** These single-celled organisms are found in various ecosystems, some on land and some in the water.

* Spirillum volutans; Bacteria; LM Magnification: 1000x
* Various Species of Phytoplankton; Magnification: Unknown
* Euglena gracilis; Protist; LM Magnification: 200x
The Importance of Microbes

Microbes have important roles in ecosystems. Figure 1.16 shows how bacteria and phytoplankton are important to other living things in an ecosystem.

Many types of bacteria are decomposers. They break down (decompose) dead or waste materials such as rotting wood, dead animals, and animal wastes. The action of decomposers returns nutrients to the soil. Plants and other organisms use these nutrients to grow and carry out their life processes.

For example, nitrogen is a nutrient that plants and other organisms need. Nitrogen gas makes up about 78 percent of the atmosphere, but it is in a form that plants cannot use. Certain kinds of bacteria make nitrogen available to plants. The bacteria live and grow on the roots of plants such as peas, beans, and alfalfa. As part of their own life processes, the bacteria change nitrogen into a form that the plants are able to use. This usable nitrogen is transferred to other organisms when they eat the plants.

In oceans and lakes, phytoplankton are the main producers. These microbes have chloroplasts, so they carry out photosynthesis. As well, phytoplankton produce about 50 percent of the oxygen in the atmosphere.

Figure 1.16 Forests and other environments could not function without the action of decomposer microbes.

Before you leave this page . . .

1. Explain why a microscope is needed to see micro-organisms.
2. You read about roles that bacteria and phytoplankton play in ecosystems. Suggest two other roles that you think microbes play in ecosystems.
CONCEPT 2
Humans have both negative and positive interactions with microbes.

Activity
Microbes on the Move
The pie chart shows results of an experiment in which microbe samples were collected from surfaces in the New York City subway system. The pie chart shows the sources of the microbes collected. What questions do you have about these data? What would be your next step in the process of scientific inquiry?

Negative Interactions with Microbes
Under favourable conditions, phytoplankton can reproduce very quickly. They form huge, colourful masses called red tides. The red-tide microbes produce toxins that make shellfish such as clams poisonous. First Peoples know to observe the behaviour of coastal animals during red tides. Animals avoiding clams is a sign that they are unsafe to eat. Elders along the coast observe that red tide is becoming more common now than in the past (Figure 1.17).

Red-tide microbes are examples of pathogens—microbes that can make people sick. You may have heard of bacteria such as E. Coli, Listeria, and Botulism. These pathogens can cause food poisoning, which can lead to vomiting, diarrhea, and fever.

Causing sickness is not our only negative interaction with microbes. For example, bacteria and other microbes such as mould cause food to spoil. Mould can also cause wood to rot, which can affect the structural stability of homes and other buildings that are made with wood.

Figure 1.17 First Peoples along the Pacific coast have created clam gardens for millenia. These beach-extending structures are a sustainable source of food and have served as places for Elders to share knowledge and teach skills to the young.
Positive Interactions with Microbes

There are more than 400 types of bacteria in your intestine right now, but they are not making you sick. These bacteria help keep you healthy and are a natural part of your digestive system. Some help you digest food, and some help prevent infection. Certain bacteria in your large intestine help you absorb the nutrient vitamin K, which helps your blood clot properly. Table 1.3 lists more examples of the positive interactions humans have with microbes.

Table 1.3 Some Positive Interactions With Microbes

<table>
<thead>
<tr>
<th>Interaction</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food production</td>
<td>Bacteria are used to make foods such as cheese, yogurt, pickles, soy sauce, and chocolate.</td>
</tr>
<tr>
<td>Medicine production</td>
<td>Bacteria are used to make antibiotics and the insulin that people with diabetes need.</td>
</tr>
<tr>
<td>Agricultural production</td>
<td>Bacteria are used to genetically modify crops so that they are better protected against insects or disease. Scientists also continue to study the importance of bacteria in soil and for the health of crops.</td>
</tr>
<tr>
<td>Waste management</td>
<td>More than 300 species of bacteria are used in water treatment plants to decompose wastes.</td>
</tr>
<tr>
<td>Disaster recovery</td>
<td>Bacteria can be used to help clean up oil spills and areas contaminated by chemical spills or radioactive waste.</td>
</tr>
</tbody>
</table>

Before you leave this page . . .

1. Make a T-chart to list the positive and negative interactions between humans and microbes.

2. Some medicines people take to treat an infection also kill bacteria that are naturally found in the intestines. Why is this a concern?
CONCEPT 1

The immune system helps protect us from pathogens and infection.

Activity

Introducing the Immune System

Most microbes are harmless to us and many are helpful. However, some cause disease, and we are constantly exposed to them. Why, then, are we not always sick? How does the body protect us? Share and discuss your ideas.

The immune system has several lines of defence that help protect us from pathogens. The first line of defence is the skin and the linings of internal body systems. Figure 1.18 shows how different body systems work together to fight against pathogens.

The skin is a physical barrier to keep pathogens from entering the body. As well, sweat and natural body acids kill some pathogens on the surface of the skin. Your skin is waterproof, so you can easily wash pathogens from it.

As you breathe, some pathogens enter the body through the respiratory system. Hairs and hair-like structures in your nose and throat work to trap some pathogens and move them back out of your body. Pathogens also get caught in the sticky mucus produced by your respiratory system. When you cough, sneeze, and swallow, you remove the mucus, and therefore the pathogens, from your body.

If you eat food that contains pathogens, your digestive system can help stop you from getting sick. Strong acids in your stomach kill many types of pathogens. Mucus in the digestive system traps pathogens, and vomiting removes them from the body.

Figure 1.18  Other body systems work with the immune system to help protect us from infection.
The Second and Third Lines of Defence

The immune system has ways to attack pathogens that get by the first line of defence. White blood cells can surround and kill them (Figure 1.19). Some white blood cells release chemicals that make it easier for other white blood cells to kill pathogens.

If you have an injury or infection, your body responds by getting inflamed. Inflammation causes the affected area to become red and swollen like the cut finger in Figure 1.20. White blood cells move to the area, killing pathogens and keeping infection from spreading.

A third line of defence uses specialized white blood cells to fight a pathogen. In future, if the same pathogen enters the body, these cells can respond quickly so you don’t get sick again.

Extending the Connections
Exploring the Third Line

Find out about the third line of defence of the immune system. Some keywords to use as a starting point are antigen, antibody, B cells, and T cells.

Before you leave this page . . .

1. Trace the path of a pathogen that encounters and gets by the first line of defence but is successfully killed by the second line of defence.

2. How could washing your hands regularly protect you from pathogens?
CONCEPT 2

Outbreaks of disease can have an impact on populations.

Activity
What Do You Do If There’s Flu?
The BC Center for Disease Control tracks incidents of influenza and puts out bulletins to communicate its findings. During winter, when flu outbreaks are more common, this information helps inform the public of health threats. If an outbreak were severe, health authorities would share information through the media and your school. Have you experienced changes to your lifestyle or routine due to a flu-related illness? When you hear about an outbreak of flu, what do you think that means? Discuss your ideas with your classmates.

In 2014, the largest and longest outbreak of Ebola virus disease (EVD) to date occurred in West Africa. Symptoms include fever, muscle pain, diarrhea, vomiting, and internal bleeding. EVD is often fatal if left untreated. It is transmitted through direct contact with body fluids of an infected person. Almost 30,000 cases were reported and about 12,000 people died in six countries. Was this considered an outbreak, an epidemic, or a pandemic? Table 1.4 outlines the differences among these three terms, which are used when a disease becomes a concern to society.

Table 1.4 Terms Used to Describe Disease Occurrence

<table>
<thead>
<tr>
<th>Epidemic</th>
<th>Outbreak</th>
<th>Pandemic</th>
</tr>
</thead>
<tbody>
<tr>
<td>the occurrence of disease cases above the normal amount expected for a population in a defined area</td>
<td>same definition as an epidemic, but often used to refer to a limited geographic area</td>
<td>an epidemic that has spread over several countries or continents, or around the world</td>
</tr>
</tbody>
</table>

Activity
Demonstrate the Difference
Find an example of each term, epidemic, outbreak, and pandemic, from distant or more recent history. Create a presentation to explain how your examples fit the definitions. Share your presentation and compare your examples to those of your classmates. Ask your classmates any questions you have, and be ready to answer their questions.
The Effects of Epidemics and Pandemics on Human Populations

Epidemics and pandemics can have both social and economic impacts on human populations. Figure 1.21 shows some examples.

**Figure 1.21** Diseases have social and economic consequences. Classify each of these four cases as a social impact, an economic impact, or both.

- HIV has killed more than 25 million people since it was first identified in 1984. In just the first two decades of the 21st century, more than 1 million people have died due to diseases such as SARS, H1N1, measles, and typhoid.
- Some livestock animals can pass on diseases to people. In 2015, an outbreak of bird flu forced poultry producers to kill about 50 million chickens and turkeys. The price of eggs increased, and farmers lost millions of dollars.
- Sick days take their toll. Flu alone results in losses of half a billion dollars each year to the Canadian economy.
- Taking extra precautions, as well as concern about fear and panic, can lead governments to restrict travel as well as the importation of certain foods.

Connect to Investigation 1-D on pages 56–59
Connect to Investigation 1-E on pages 60–63
Different Populations Have Different Immunities

Deadly diseases have struck human populations throughout history all over the world. Examples are plague, smallpox, measles, HIV/AIDS, and SARS. However, no matter where or when a disease outbreak occurs, there are always some people who have a natural resistance to the pathogen and survive.

For example, starting around 300 CE, there were repeated outbreaks of measles and smallpox over hundreds of years in Europe. Many people died in each outbreak. But over time, people’s ability to fight the pathogens increased. Populations of people in Europe had built up immunity to these diseases.

Elsewhere, such as North and South America, people had not been exposed to these same pathogens. When Europeans first came here, First Peoples had never been exposed to these pathogens that cause measles and smallpox. Europeans had hundreds of years to build up immunity to these diseases. But people here had no such immunity, and large numbers died.

Natural Immunity in Human Populations

Scientists are always searching for populations that have natural immunity. For example, rabies is caused by a virus that affects the nervous system. If left untreated, rabies is fatal. In 2012, scientists learned that people in a remote part of the rain forest in Peru had a natural immunity to rabies (Figure 1.22). In the small population, about 10 percent had immunity. In Gabon, in west-central Africa, scientists discovered a population with a natural immunity to Ebola. Cases like these help scientists learn more about diseases, how to treat them, and perhaps how to prevent them.

Extending the Connections

Considering Cultural Practices

Each culture has its own ways of caring for people who are dead or dying during an outbreak of a deadly disease. But during the Ebola epidemic in 2014, cultural practices played a role in spreading the disease. How can a public health agency help reduce the spread of disease and still respect local cultures and customs?

Before you leave this page . . .

1. Give examples of a disease with a social impact and an economic impact.

2. Explain how a population can develop immunity to a disease.
CONCEPT 1
Traditional First Peoples medicines and treatments come from resources in nature.

Activity
Ask an Elder or Medicine Person about Medicinal Plants
Which native plants are used as medicines in the place where you live?
If possible, invite an Elder or medicine person from a local First Nation to speak to your class about the use of medicinal plants. Your teacher will help you follow the right protocol for when you invite and prepare for a First Nation visitor.

Whether it is using valerian root to help with sleep problems or boiled willow bark to treat an injury, First Peoples in British Columbia have a strong tradition of using resources from nature for medicinal purposes. For generations, First Peoples have relied on plants, animals, and even clay deposits to treat various illnesses and conditions. Figure 1.23 shows some examples of medicinal plants used by First Peoples of British Columbia.

**Figure 1.23** First Peoples have a long history of using plants for medicinal purposes.

Indian hellebore (*Veratrum viride*) can be found in open forests in much of the province. The plant is used by the Nuxalk Nation, for example, to treat skin and scalp conditions. When the plant is burned, the smoke is used as a decongestant.

Devil's club (*Oplopanax horridus*) grows along the coast, as well as in the interior, of British Columbia. Many First Peoples use this plant to treat breathing and digestive disorders, as well as arthritis and diabetes.

Pacific yew (*Taxus brevifolia*) is a small tree found along the coast of British Columbia. Many First Peoples make tea from the needles and bark to treat pain and internal injuries. The tree also has a cancer-fighting chemical in its bark.

Before you leave this page . . .

1. Demonstrate an understanding of how nature can be used to heal.

2. Why might it be important to identify and preserve plants used for medicinal purposes?
**Activity**

**What Do You Know About Vaccines?**

Many babies get vaccines to protect them against diseases such as tetanus, whooping cough, measles, hepatitis B, and chicken pox. What do you know about vaccines? What questions do you have about vaccines? Discuss your ideas with your classmates.

**vaccine** a substance that causes a response in the body that protects it against a specific disease

A **vaccine** is a substance that is given to a person or animal to protect against a specific disease. Vaccines may be injected or taken orally. They are usually given to babies and children according to a schedule based on age.

Vaccines cause an immune response from the body, which results in the immune system “remembering” the exposure to the pathogen. If a person is exposed to that same pathogen after being vaccinated, the immune system recognizes it and immediately begins to defend the body against it. A vaccinated person does not get sick from exposure to the pathogen and is said to have immunity against the disease. **Table 1.5** describes several types of vaccines.

**Table 1.5** Types of Vaccines

<table>
<thead>
<tr>
<th>Type of Vaccine</th>
<th>How It Works</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live, attenuated vaccine</td>
<td>The vaccine contains living microbes that have been weakened in a laboratory so that they cannot cause disease. The immune system responds as if the body has been infected, providing strong, often lifelong, immunity against the disease after only one or two doses.</td>
<td>Used against microbes that cause measles, mumps, chickenpox, and yellow fever are made this way.</td>
</tr>
<tr>
<td>Inactivated vaccines</td>
<td>The vaccine contains microbes that have been killed with heat, chemicals, or radiation. This vaccine results in a weaker response from the immune system. To keep immunity, a person has to get booster shots periodically.</td>
<td>Used against hepatitis A, rabies, and whooping cough.</td>
</tr>
<tr>
<td>Subunit vaccines</td>
<td>Only specific pieces of microbes are used to make the vaccine. These pieces are separated from the microbe or made in a laboratory. Immunity is provided after several doses.</td>
<td>Vaccines include those for hepatitis B and a flu vaccine called H1N1.</td>
</tr>
<tr>
<td>Toxoid vaccines</td>
<td>The vaccine is made using toxins that some types of bacteria produce. The toxins are inactivated in a laboratory so they no longer cause disease. Booster shots are usually needed to keep immunity strong.</td>
<td>Vaccines include those for diphtheria and tetanus.</td>
</tr>
</tbody>
</table>
Vaccines and Public Health

Many health agencies in Canada and around the world make strong arguments in favour of people getting vaccines. There are several reasons. For example, vaccines help protect each person who receives them against deadly diseases and diseases that can cause permanent damage, such as blindness, muscle paralysis, heart damage, and infertility. Vaccines can also help stop the spread of disease. The more people who receive vaccines against an infectious disease, the less the disease can spread from person to person.

Vaccines can also help stop an outbreak from turning into an epidemic or pandemic. For example, throughout history, smallpox has been a devastating disease. However, after a worldwide vaccination effort in the 20th century, the disease was declared eradicated in 1980. The last known natural case of smallpox occurred in Somalia in 1977. Many organizations are working to eradicate other diseases, including polio and measles. Table 1.6 shows examples of vaccines that have been effective at preventing diseases.

Table 1.6 Effectiveness of Certain Vaccines

<table>
<thead>
<tr>
<th>Disease</th>
<th>Number of Reported Cases, 1980</th>
<th>Number of Reported Cases, 2014</th>
<th>Percent Decrease in Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diphtheria</td>
<td>97,774</td>
<td>7321</td>
<td>92.5</td>
</tr>
<tr>
<td>Measles</td>
<td>421,431</td>
<td>267,582</td>
<td>93.6</td>
</tr>
<tr>
<td>Polio</td>
<td>57,795</td>
<td>371</td>
<td>99.4</td>
</tr>
<tr>
<td>Tetanus</td>
<td>114,248</td>
<td>11,392</td>
<td>90.0</td>
</tr>
<tr>
<td>Whooping cough</td>
<td>1,982,384</td>
<td>220,504</td>
<td>88.9</td>
</tr>
</tbody>
</table>

Before you leave this page...

1. In your own words, explain what a vaccine is.
2. Make a graphic organizer of your choice to explain how vaccines help protect people against disease.
Antibiotics can treat bacterial infections.

**Activity**

**What Do You Know About Antibiotics?**

Have you ever taken an antibiotic? Can you explain how it helped you? If not, how could you find the answer to this question? What other questions do you have about antibiotics?

Antibiotics are substances that fight infections by interfering with the life processes of bacteria. Either they kill bacteria or they prevent them from growing or reproducing. Each antibiotic is effective against specific types of bacteria. They are not useful against infections caused by viruses or other microbes.

**Penicillin—The First Antibiotic Available on a Global Scale**

As it sometimes happens in science, the discovery of penicillin was an accident. In 1928, a British scientist named Alexander Fleming returned to his laboratory from holiday to find several Petri dishes with *Staphylococcus* bacteria growing on them. One dish also had a large patch of mould growing on it. What caught Fleming’s eye was that no bacteria were growing around the mould. The Petri dish Fleming found is shown in Figure 1.24. The mould had properties that stopped the bacteria from growing near it.

The scientific name of this mould is *Penicillium notatum*. Penicillin is the antibiotic that was derived from this mould. It was used to treat soldiers for bacterial infections during World War II. By 1950, it was widely available to the public, and the development of other antibiotics soon followed. You may have heard some of their names, such as erythromycin, amoxicillin, and tetracycline.

**Figure 1.24** The area near the mould does not have bacteria growing around it. What questions would you have asked if you had seen this Petri dish? Describe a controlled experiment that you would have carried out to answer these questions.
The Development of Antibiotic-Resistant Bacteria

Millions of people have benefited from the use of antibiotics since their discovery. However, a serious problem has arisen from their overuse. Many types of bacteria have become resistant to antibiotics. Some diseases, such as tuberculosis, pneumonia, and meningitis, are now more difficult to treat as a result of antibiotic-resistant bacteria. Figure 1.25 explains how a population of bacteria can become resistant to bacteria.

As time passes, the resistant bacteria will reproduce and become more common. As a result, the antibiotic is no longer effective against those bacteria. When this happens, a different antibiotic must be used to fight the infection. In recent years the term “superbugs” has been used to describe bacteria that are resistant to several types of antibiotics. One of the more common superbugs is methicillin-resistant Staphylococcus aureus (MRSA). Scientists are continuing to research new ways to treat infections caused by antibiotic-resistant bacteria.

Figure 1.25 A population of bacteria can develop resistance to bacteria after being exposed to them over time.

Before you leave this page . . .

1. What are antibiotics? How are they used?
2. Suppose you had to describe to a grade 3 class how antibiotic-resistant bacteria develop. Create a brief presentation in the format of your choice to meet this goal.
3. Why do you think the medical community is concerned about antibiotic-resistant bacteria?