TOPIC 1.5

# How does the body protect us from pathogens?

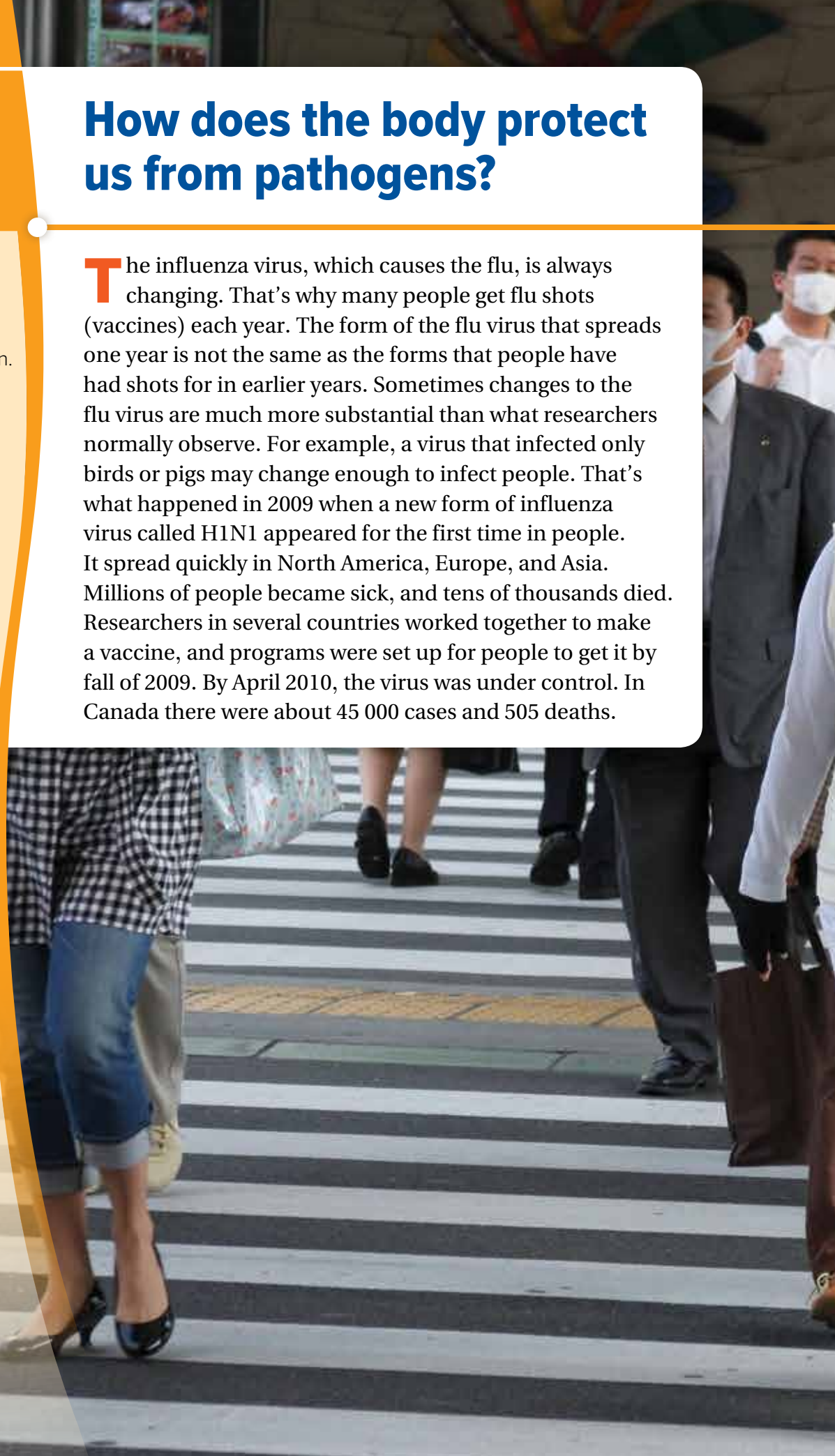
## Key Concepts

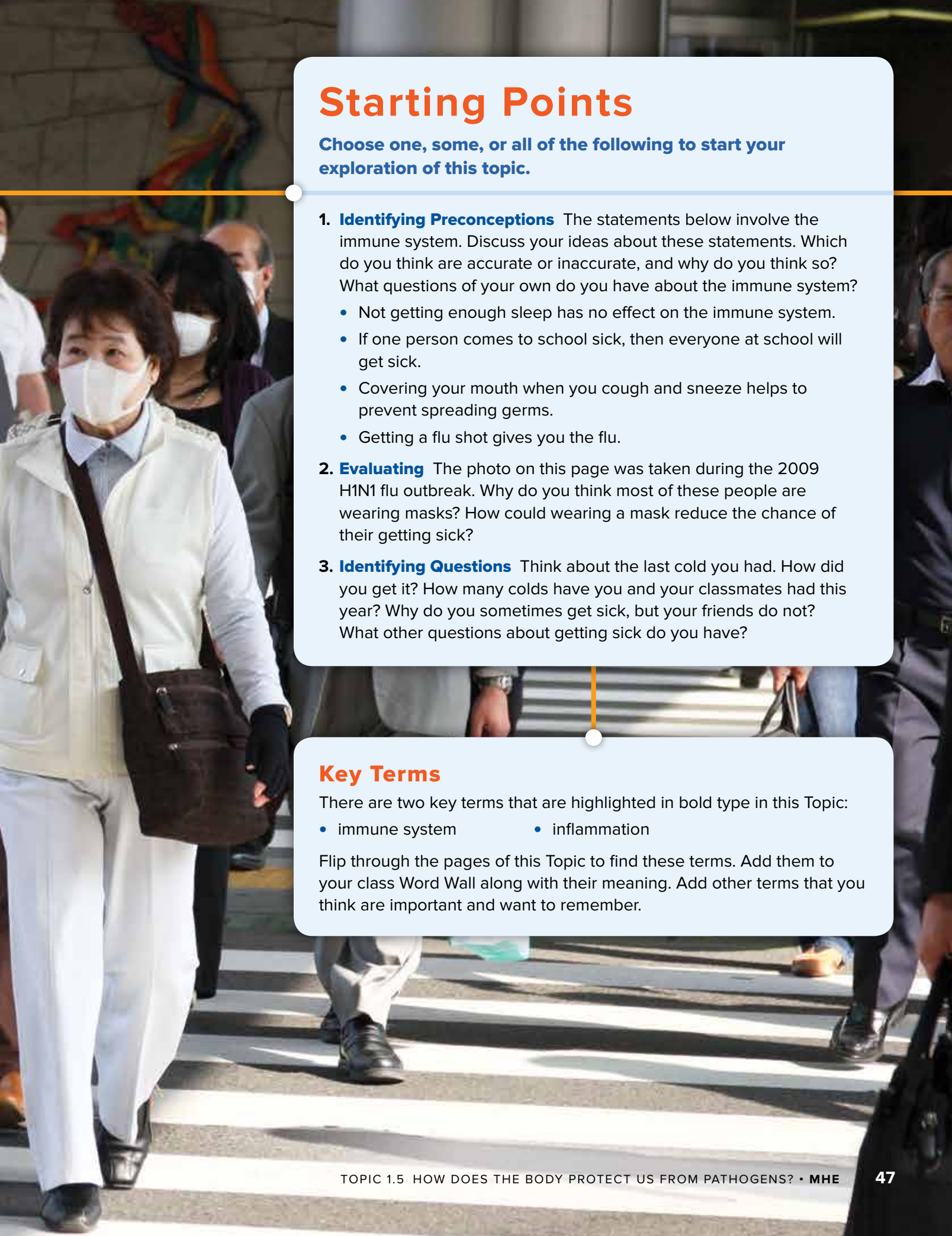
- The immune system helps protect us from pathogens and infection.
- Outbreaks of disease can have an impact on populations.

## Curricular Competencies

- Identify a question to answer or a problem to solve through scientific inquiry.
- Collaboratively plan a range of investigation types to answer questions you have identified.
- Consider social, ethical, and environmental implications of the findings from your own and others' investigations.
- Contribute to care for self, others, community, and world through personal or collaborative approaches.

The influenza virus, which causes the flu, is always changing. That's why many people get flu shots (vaccines) each year. The form of the flu virus that spreads one year is not the same as the forms that people have had shots for in earlier years. Sometimes changes to the flu virus are much more substantial than what researchers normally observe. For example, a virus that infected only birds or pigs may change enough to infect people. That's what happened in 2009 when a new form of influenza virus called H1N1 appeared for the first time in people. It spread quickly in North America, Europe, and Asia. Millions of people became sick, and tens of thousands died. Researchers in several countries worked together to make a vaccine, and programs were set up for people to get it by fall of 2009. By April 2010, the virus was under control. In Canada there were about 45 000 cases and 505 deaths.





# Starting Points

**Choose one, some, or all of the following to start your exploration of this topic.**

1. **Identifying Preconceptions** The statements below involve the immune system. Discuss your ideas about these statements. Which do you think are accurate or inaccurate, and why do you think so? What questions of your own do you have about the immune system?
   - Not getting enough sleep has no effect on the immune system.
   - If one person comes to school sick, then everyone at school will get sick.
   - Covering your mouth when you cough and sneeze helps to prevent spreading germs.
   - Getting a flu shot gives you the flu.
2. **Evaluating** The photo on this page was taken during the 2009 H1N1 flu outbreak. Why do you think most of these people are wearing masks? How could wearing a mask reduce the chance of their getting sick?
3. **Identifying Questions** Think about the last cold you had. How did you get it? How many colds have you and your classmates had this year? Why do you sometimes get sick, but your friends do not? What other questions about getting sick do you have?

## Key Terms

There are two key terms that are highlighted in bold type in this Topic:

- immune system
- inflammation

Flip through the pages of this Topic to find these terms. Add them to your class Word Wall along with their meaning. Add other terms that you think are important and want to remember.

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.

**immune system** the body system that defends against pathogens and infection

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.


**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.

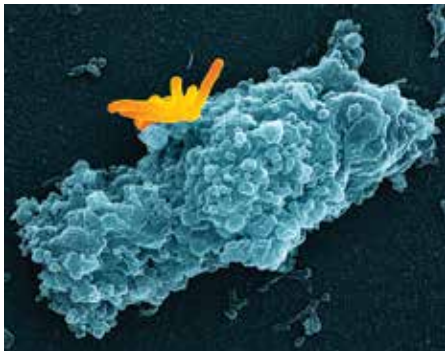


**Figure 1.19** A white blood cell (coloured blue) engulfs bacteria (coloured yellow) that have made it past the first line of defence.

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.

**inflammation** a process that causes a part of the body to become red and swollen

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.

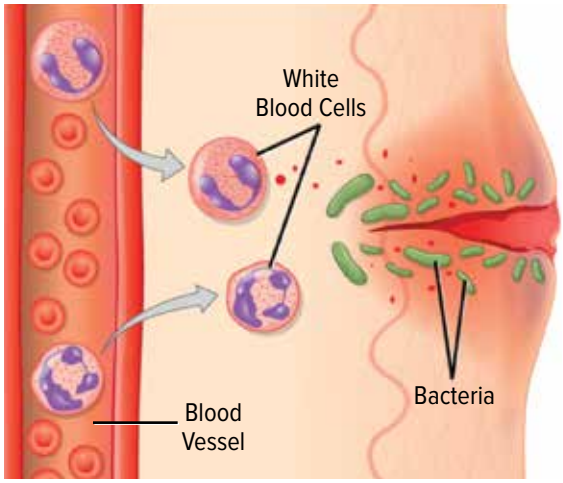



**Figure 1.20** When a part of the body is inflamed, it becomes hot and red as blood flow increases. It becomes swollen as fluid floods the tissues. And it becomes painful as nerve endings are stimulated.

### 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**

| Epidemic | Outbreak | Pandemic |
|---|---|---|
| the occurrence of disease cases above the normal amount expected for a population in a defined area | same definition as an epidemic, but often used to refer to a limited geographic area | an epidemic that has spread over several countries or continents, or around the world |

## 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.

**Figure 1.22** Vampire bats in the Peruvian rain forest carry rabies. The disease can be passed to humans if they are bitten by an infected bat.

## 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.

# AT ISSUE

# How can you evaluate claims about products that boost the immune system?

## What's the Issue?

Many products, such as vitamin C or $B_6$, echinacea, garlic, and ginseng claim to boost or support the immune system. How do you know if the claims these products make are accurate and valid?

For example, some companies make and market garlic pills to boost immunity. These pills come in different dosages, such as 400 mg, 1000 mg, and 2000 mg. Some are mixed with other products, such as parsley or vitamin C or chlorophyll. Do these pills work? Based on laboratory studies, there is evidence that garlic has antibacterial and antiviral properties. However, there are few studies that have been conducted on humans to determine the effectiveness of garlic as an immune system booster.

In one study, a group of people took garlic supplements for three months during cold season. Another group was used as a control. They took a treatment that had no effect on the body. The garlic group got fewer colds. This result appears to support the claim that garlic helps the immune system. But other questions remain unanswered. For example, how do the results of this study and others translate into how much garlic supplements to take, when to take them, and in what form?

## Dig Deeper

Collaborate with your classmates to explore one or more of these questions—or generate your own questions to explore.

1. Choose a product that claims to boost or support the immune system.
   - **a)** Investigate the claims made by the maker of the product. Consider the sources you use for your research. Summarize the results of your findings.
   - **b)** If you find the claims to be valid, how does the product boost or support the immune system? What is the best form in which to take the product, what dose, and for how long? What, if any, side effects are there?
   - **c)** If you find the claims to be invalid, what do you think should be done? What would you like to do?
2. What factors influence your opinions about the products you use or want to use? How can you use scientific competencies and knowledge to help you make decisions about the products you choose to buy?

AT ISSUE

# How Do Travel Restrictions Protect People's Health?

## What's the Issue?

Consider this scenario. You are part of a group that has been fund-raising and gathering school supplies for students in a developing country. Now your trip to deliver the supplies has been postponed. It may even be cancelled. An epidemic involving a rapidly spreading virus is occurring in the place you plan to visit. The Public Health Agency of Canada has issued a Level 3 Travel Health Notice for your destination. Such a notice is issued when an outbreak affects many people over a large area.

You're disappointed, and you wonder if your trip really does have to be put on hold. You investigate and find that studies of illnesses such as influenza and SARS show that restrictions are not that effective in preventing the spread of these diseases. They may briefly delay the spread to another country. But they do not prevent the disease from crossing international borders. You discuss these results with your teacher sponsor. She argues that, despite your findings, the restrictions still protect the health of the travellers themselves. She challenges you to dig deeper and consider the issue from multiple perspectives.

## Dig Deeper

Collaborate with your classmates to explore one or more of these questions—or generate your own questions to explore.

1. The Public Health Agency of Canada issues four levels of alerts when a disease outbreak or epidemic occurs in another country.
   - **a)** Create a graphic organizer that compares the four levels of alerts.
   - **b)** Identify three ways the alerts help protect travellers.
   - **c)** Which alert(s) would make you decide to avoid travel to a restricted country? Explain your decision.
2. SARS stands for Severe Acute Respiratory Syndrome. It can cause serious, life-threatening illness. Early this century, an outbreak of SARS occurred in Canada. As a result, some countries advised that citizens restrict their travel to Canada.
   - **a)** Imagine that you lived in another country during the outbreak and were planning a trip to Canada. What other information would you have wanted to know before you decided to cancel your trip?
   - **b)** How do you think the foreign travel restrictions may have affected Canada and Canadians?

# Check Your Understanding of **Topic 1.5**

QP Questioning and Predicting PC Planning and Conducting PA Processing and Analyzing E Evaluating
AI Applying and Innovating C Communicating

## Understanding Key Ideas

**1.** A sneeze is certainly nothing to sneeze at. One sneeze can eject a cloud of microbe-filled, microscopic droplets at speeds of more than 300 km/h.

**a)** List at least three science-related questions that you have, based on this information.

**b)** Choose one of your questions, and describe how you would plan an investigation to answer it. QP PC

**2.** What is the function of the human immune system? PA

**3.** Identify three examples of the first line of defence of the immune system. Choose one and describe how it works. PA C

**4.** Explain what inflammation is, which line of defence it is part of, and the role it plays to protect you from microbes. PA C

**5.** Explain how some people in a population might be immune to a disease. Use an example to help demonstrate your understanding. PA C

**6.** If you were to build a castle with the best possible defence system, what would you include? Why? How is a castle's defence system like your immune system? PA AI E C

## Connecting Ideas

**7.** There were three flu pandemics during the 20th century. The number of deaths is shown in the table below. (The name of each flu is based on the place where the flu was first reported.)

| Years | **Spanish Flu** 1918–1919 | **Asian Flu** 1957–1958 | **Hong Kong Flu** 1968–1969 |
|---|---|---|---|
| Canadian deaths | 50 000 | 2000 | 3400 |
| Global deaths | 20–40 million | 2 million | 1–4 million |

**a)** Which pandemic was the most deadly?

**b)** For which pandemics was a flu vaccine likely available? Why do you think so?

**c)** Why might a flu pandemic eventually stop on its own, instead of eliminating all human life? AI E C

## Making New Connections

**8.** Engineers often design systems so that important parts or functions are duplicated. This is called redundancy. It helps make a system more secure and reliable. If a part or a function fails to work, there is a backup to protect the whole system.

**a)** In what ways is the immune system a redundant system?

**b)** Do you find it helpful for your own understanding to compare the biological immune system to a technological system? Give reasons why you do or don't find it helpful. AI E C

INVESTIGATION
# 1-D

STRUCTURED INQUIRY

## Modelling the Spread of Disease

### Skills and Strategies

- Processing and Analyzing
- Evaluating
- Applying and Innovating

### Safety

- Never eat or drink anything in the laboratory.
- If you spill the contents of your cup, notify your teacher immediately.

### What You Need

- paper cup provided by your teacher
- plastic dropper
- "infection indicator" solution (teacher only)

Pathogens can spread from one person to another in several ways, including through the air (when someone sneezes or coughs), through objects, or through insects, such as mosquitoes or ticks. When an outbreak of a disease occurs, public health authorities begin tracking the spread of the disease, trying to find out where it started and who was the first person to get sick. Tracking the origin and spread of an outbreak can help health authorities decide the best way to respond to the outbreak and minimize the number of people infected.

### Question

How can you model the spread of disease?

## PART A: PROCEDURE

1. Take a paper cup from the cups provided by your teacher. Each cup contains about 10 mL of liquid. One cup contains a fake "pathogen."
2. When your teacher tells you, walk around the classroom until you are told to stop.
3. Use your dropper to pull some liquid from your cup. Then squeeze three drops into the cup of the person standing nearest to you. Remove the drops from your cup before either of you exchange any drops. After the exchange, place any of your own remaining dropper liquid back into your cup.
4. The dropper of liquid represents a potential passing of the pathogen to another person. Record the name of the person you exchanged drops with in a table like the one below.

**My Contact Chart**

| Your Name | Contact 1 | Contact 2 | Contact 3 |
|---|---|---|---|
| | | | |

5. Repeat Steps 3 and 4 two more times.
6. Your teacher will put a drop of "infection indicator" in everyone's cup.
7. If you are "infected," the liquid in your cup will turn pink.
8. Record whether you are infected or not.
9. Dispose of your cup and liquid according to your teacher's instructions.

## PART B: PROCEDURE

10. Figure out who "patient zero" is. "Patient zero" is a term used by public health agencies to indicate the first person that was infected and passed the pathogen to others.

11. Make a class chart like the one shown below. Fill in the name of each student in the class in the top row. In the columns on the left side, fill in the number of contacts that were made. (A contact was made each time you put drops from your cup into someone else's cup.) In each column below a student's name, fill in the people with whom they made contact.

**Patient Zero Tracking Chart**

| Names of Students in Class | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Emma** | **Mason** | **Logan** | **Harper** | **Benjamin** | **Jun** | **Etc.** |
| Contact 1 | Jun | Chloe | Nabhitha | | | | |
| Contact 2 | I-Wen | Taress | Benjamin | | | | |
| Contact 3 | Joshua | Zoe | Haani | | | | |

12. Highlight the names of people in the table who became infected.

13. Track the names of the infected people. Look for people who were infected and all of the people they made contact with and were also infected. These people are possible patient zeroes. In the example above, Mason and Logan can be eliminated as patient zero. Although they each infected their first contact, neither of them infected his second contact.

14. If possible, make a diagram that shows the route of the pathogen being passed from one person to another.

## Process and Analyze

1. At first, only one person in the class was infected. By the end of the investigation, how many people in the class were infected?
2. Explain how this investigation models the spread of a disease.
3. Were you able to determine who patient zero was? Why or why not?

## Evaluate, Apply, and Communicate

4. How do you think tracking the spread of a disease during an outbreak and determining patient zero help public health authorities stop the spread of disease?
5. Suppose that someone could pass on a pathogen without appearing to be infected. How might that affect the public health authorities' ability to track the spread of the pathogen?
6. Suppose a scientist working in a lab is accidentally and unknowingly exposed to a pathogen. The scientist then leaves work, exposing people to the pathogen and leading to an outbreak. What steps could be taken to avoid a situation like this happening again?

## Skills and Strategies

- Questioning and Predicting
- Planning and Conducting
- Processing and Analyzing
- Evaluating
- Applying and Innovating
- Communicating

## What You Need

- access to information resources (for example: online, in-print, interviews)

# Detecting, Monitoring, and Responding to an Outbreak

In 2004, there was an outbreak of bird flu (avian influenza) on a poultry farm in British Columbia. It is caused by a virus that infects birds, and it also can be transferred to humans. Health authorities at all levels of government responded to the outbreak. They put measures in place to reduce the risk of people being infected. For example, workers who came in contact with farmed poultry were monitored for symptoms of illness and treated if they got sick. So were their families. By the end of the outbreak, only two people had been infected. Both were treated successfully.

A successful outcome to a disease outbreak requires a coordinated effort. Health officials at all levels of government—local, provincial, territorial, and federal—work together to plan how to monitor and respond to an outbreak. They also plan how outbreaks may be detected.

## PART A: DETECTING AND RESPONDING TO AN OUTBREAK—GUIDED INQUIRY

### Question

How are outbreaks detected, monitored, and responded to?

### Procedure

1. Collaborate to decide how you will plan, conduct, and process the research that you will do. Your goal is to find out and communicate how disease outbreaks in the province are detected, monitored, and responded to.

2. Find answers to the questions below. Also keep a record of any new questions you have as you do your investigation, and research those as well. Then use the questions at the top of the next page to reflect on your findings.

- What is the role of health care professionals during an outbreak of an infectious disease? What agencies may be involved?
- How do local public health authorities monitor and respond to an outbreak?
- What resources can be used to help confirm, monitor, and respond to an outbreak?
- How do factors such as the type of pathogen, how it is transmitted, or the location of the outbreak affect the ways that public health authorities respond to an outbreak?
- What steps do local public health authorities take to control the spread of the pathogen and contain the outbreak?
- At what point may other levels of government get involved?
- What protocols (plans) are in place to notify patients and/or the public about an outbreak?
- How is the public notified of an outbreak? (For example, what news and other media may be used?)
- How is the public informed about best practices to follow to help stop the spread of the disease?
- How are updates provided to the public, and who provides them?
- How do health agencies reflect on what they have learned from an outbreak to better respond to the next outbreak?

3. Decide how you will process, evaluate, and communicate the results of your research. For example, you may find an organizer such as a KWL chart helpful.

### Analyze and Interpret

1. Why is it important for health care professionals to report any incidences of notifiable diseases to the proper authorities?
2. Why is it important for public health authorities to monitor an outbreak?
3. What role does the public play in helping to reduce the spread of a pathogen and reduce the size of an outbreak?

### Conclude and Communicate

4. Why is communication an important part of monitoring and responding to an outbreak?
5. How do social, economic, or ethical factors influence public health authorities when deciding when and how to notify the public of an outbreak?

## PART B: DETECTING AND RESPONDING TO AN OUTBREAK—OPEN INQUIRY

### Question

You will determine your own question to investigate. See step 3 of the Procedure.

### Procedure

1. Find an example of an outbreak of a disease that has occurred in or near your region.
2. Write out any questions you have about the outbreak. Use the 5 W's (Who, What, Where, When, and Why?) to help you brainstorm questions.
3. Decide which question or questions you will investigate, and plan how you will answer them.
4. Carry out your plan.

## Process and Analyze

1. You can show patterns or relationships in your findings using tables, graphs, and digital technologies. Choose the methods that help you organize and examine your findings best.
2. Identify patterns and connections in your findings to make science-based inferences, interpretations, and conclusions.

## Evaluate and Communicate

3. Do you think the public health authorities monitored and responded to the outbreak in a satisfactory manner? Give examples and reasons to justify your opinion.
4. What has been and could be done to prevent future outbreaks like the example you chose?

## Apply and Innovate

5. Consider the example you chose. Assume that the outbreak has progressed to the point that the public needs to be notified. Create a notification, in a form of your choice, for the public about the outbreak. Include basic information about the disease, the current status of the outbreak, and best practices to follow to help reduce the spread of the pathogen. Consider your audience when creating your notification. For example, "the public" includes people of different ages and backgrounds. How can you tailor your notification to reach the broadest possible audience?