

19-3 Diseases Caused by Bacteria and Viruses

Have you ever heard a teacher say that when a few people misbehave, they ruin it for everybody? In a way, that saying could be applied to bacteria and viruses. Bacteria and viruses are everywhere in nature, but only a few cause disease. However, these **pathogens**, or disease-causing agents, get all the attention.

Disease can be considered a conflict between the pathogen and the host. All viruses reproduce by infecting living cells, and disease results when the infection causes harm to the host. All bacteria require nutrients and energy; however, disease results when bacteria interfere with the host's ability to obtain enough of those elements to function properly.

Bacterial Disease in Humans

Many bacteria live on and within our bodies, and some bacteria even help us to perform essential functions, such as digesting our food. The growth of pathogenic bacteria, on the other hand, disrupts the body's equilibrium by interfering with its normal activities and producing disease.

The French chemist Louis Pasteur, shown in **Figure 19-12**, was the first person to show convincingly that bacteria cause disease. Pasteur helped to establish what has become known as the germ theory of disease when he showed that bacteria were responsible for a number of human and animal diseases.

Key Concept Bacteria produce disease in one of two general ways. Some bacteria damage the cells and tissues of the infected organism directly by breaking down the cells for food. Other bacteria release toxins (poisons) that travel throughout the body interfering with the normal activity of the host.

Using Cells for Food The bacterium *Mycobacterium tuberculosis*, which causes tuberculosis, is inhaled into the lungs, where it destroys the lung tissue. The bacterium also may enter a blood vessel and travel to new sites in the body where it destroys more tissue.

Releasing Toxins Bacterial toxins can travel throughout the body. For example, the *Streptococcus* bacterium that causes strep throat can release toxins into the bloodstream. These toxins can cause scarlet fever. A red rash appears on the skin of someone infected with scarlet fever. Diphtheria, another disease caused by the *Corynebacterium diphtheriae* bacterium, infects the tissues of the throat. *C. diphtheriae* releases toxins into the bloodstream, where they destroy tissues. Diphtheria can lead to breathing problems, heart failure, paralysis, and death.

Guide for Reading

Key Concepts

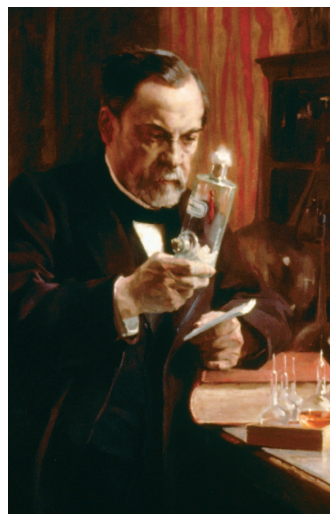
- How do bacteria cause disease?
- How can bacterial growth be controlled?
- How do viruses cause disease?

Vocabulary

pathogen
vaccine
antibiotic
viroid
prion

Reading Strategy:

Outlining Before you read, use the headings of this section to make an outline about disease. As you read, fill in subtopics. Then, add phrases or a sentence after each to provide key information.



▲ **Figure 19-12** By testing multiple hypotheses, Louis Pasteur was able to show that bacteria cause disease.

Section 19-3

1 FOCUS

Objectives

19.3.1 Explain how bacteria cause disease.

19.3.2 Describe how bacterial growth can be controlled.

19.3.3 Explain how viruses cause disease.

Guide for Reading

Vocabulary Preview

Have students write the Vocabulary words, dividing each into its separate syllables as best they can. Remind students that each syllable usually has only one vowel sound. The correct syllabifications are: path•o•gen, vac•cine, an•ti•bi•ot•ic, vir•oid, pri•on.

Reading Strategy

Before they read, have students rewrite the blue headings as questions about bacteria and viruses. Then, as they read the section, they should write brief answers to those questions using the main ideas from the text.

2 INSTRUCT

Bacterial Disease in Humans

Use Visuals

Figure 19-12 Ask a student volunteer to recall for the class the experiment Louis Pasteur carried out that disproved the theory of spontaneous generation. If no student can recall this experiment, have the class turn back to Section 1-2 and review the details of his work. Explain that this experiment was one of many that Pasteur carried out with microorganisms. Also, direct students' attention to Pasteur's place on the Biology and History time line on pages 12-13. **L1 L2**



SECTION RESOURCES

Print:

- **Laboratory Manual A**, Chapter 19 Lab
- **Teaching Resources**, Section Review 19-3
- **Reading and Study Workbook A**, Section 19-3
- **Adapted Reading and Study Workbook B**, Section 19-3
- **Lesson Plans**, Section 19-3

- **Biotechnology Manual**, Lab 16
- **Investigations in Forensics**, Investigation 6

Technology:

- **iText**, Section 19-3
- **Transparencies Plus**, Section 19-3

Word Origins

A carcinogen is a substance that causes cancer. **L2**

Build Science Skills

Applying Concepts Ask students: **What are antibiotics?** (*Antibiotics are compounds that block the growth and reproduction of bacteria.*) Explain that, although antibiotics have proved amazingly effective in combating bacterial diseases, many bacteria have become increasingly resistant to most antibiotics, worrying medical authorities. Ask: **What is the process among living things that results in the appearance of such resistant bacteria?** (*Natural selection*) Call on students at random to describe the process of natural selection that results in antibiotic resistance. Then, have students reread the description of antibiotic resistance on page 403 in Chapter 16. **L2**

Bacterial Disease in Animals

Build Science Skills

Observing Point out that bacteria are almost everywhere in nature, but only a few cause disease. Have students investigate where on the body are the most bacteria. Ask pairs of students to prepare six petri dishes of sterile nutrient agar. Have the students choose one of the pair for the investigation. The other student should use separate sterile cotton swabs to rub a 2-centimeter area at six different places on the first student's body: forehead, side of nose, cheek, back of hand, palm of hand, and ankle. For each rubbing, the student should roll the cotton swab over the agar in one of the dishes and throw the swab away. Have the students cover the dishes, label them, and place them in an incubator or a warm spot in the room for 48 hours. Then, have the student pairs observe and compare the growth on each of the dishes. Have all students report their findings to the class. **L2 L3**

Word Origins

Pathogen comes from the Greek words *pathos*, meaning "suffering," and *-genes*, meaning "born" or "produced." So a pathogen is something that produces suffering. The Greek word *karkinos* means "cancer." What do you think a carcinogen is?

Preventing Bacterial Disease Figure 19-13 shows some common bacterial diseases, the pathogens that cause them, and their effects on the body. Many bacterial diseases can be prevented by stimulating the body's immune system with vaccines. A **vaccine** is a preparation of weakened or killed pathogens. When injected into the body, a vaccine sometimes prompts the body to produce immunity to the disease. Immunity is the body's ability to destroy new pathogens. You will learn more about immunity in Chapter 40.

If a bacterial infection does occur, a number of drugs can be used to attack and destroy the invading bacteria. These drugs include antibiotics, such as penicillin and tetracycline.

Antibiotics are compounds that block the growth and reproduction of bacteria. They can be used to cure many bacterial diseases. One of the major reasons for the dramatic increase in human life expectancy during the past two centuries is an increased understanding of how to prevent and cure bacterial infections.

CHECKPOINT What is the effect of antibiotics on bacteria?

Bacterial Disease in Animals

Animals are also affected by bacterial diseases, requiring farmers and ranchers to take precautions to protect their livestock from infection. Adding to the danger is the fact that many bacteria can affect both humans and animals. One example of such a bacterium is *Bacillus anthracis*, which causes the disease known as anthrax. Anthrax infections are often found in sheep, sometimes spreading to farmers and wool workers who have contact with the animals. Anthrax can be fatal to both humans and animals. The bacterium produces tough, resistant spores that can last for years. These properties have led some groups to develop anthrax as a biological warfare agent.

The deadly nature of anthrax as a biological weapon is clear. Hundreds of people died in the city of Sverdlovski when anthrax was accidentally released from a Soviet research facility in 1979. About 20 years later, letters laced with anthrax caused several deaths in the United States.

Figure 19-13 Bacteria cause disease in the body. Some of the diseases caused by pathogenic bacteria are listed in the table.

Diseases Caused by Bacteria		
Disease	Bacterium	Effect on Body
Lyme disease	<i>Borrelia burgdorferi</i>	"Bulls-eye" rash at site of tick bite, fever, fatigue, headaches, muscle aches, joint aches
Tetanus	<i>Clostridium tetani</i>	Severe muscle spasms, paralysis, death
Tuberculosis	<i>Mycobacterium tuberculosis</i>	Fatigue, weight loss, mild fever, night sweats, chronic cough
Diphtheria	<i>Corynebacterium diphtheria</i>	Sore throat, low-grade fever
Bacterial meningitis	<i>Neisseria meningitidis</i>	High fever, headache, stiff neck, nausea, fatigue
Strep throat	<i>Streptococcus pyogenes</i>	Fever, sore throat, swollen glands
Tooth decay	<i>Streptococcus mutans</i>	Destruction of tooth enamel

Differentiated

Instruction

Solutions for All Learners

Less Proficient Readers

Engage students' interest in the difference in the uses of vaccinations and antibiotics by leading a discussion about students' experiences with each. Most students will know that they began receiving vaccinations as babies. Use this to emphasize that vaccines are used to prevent disease by activating the immune response. Students' experiences with antibiotics can also be useful as a way of distinguishing between bacteria and viruses. **L1**

Advanced Learners

Ask students who need an extra challenge to research one of the bacterial or viral diseases listed in Figure 19-13 or Figure 19-15. Ask them to prepare a report on the disease, including detailed information on the specific pathogen involved as well as the symptoms, transmission, treatment, and prevention of the disease. Ask these students to prepare a brief presentation to the class, with visual aids that could include photos, drawings, and graphic organizers. **L3**

Careers in Biology

Epidemiologist

Job Description: work for a university, health department, research or health organization, or medical corporation to identify and track diseases and develop programs that prevent or control the spread of disease

Education: master's or doctoral degree in epidemiology, including course work in statistics, demography, research design, and public health

Skills: good communication skills, strong computer skills, knowledge of health and medical conditions

Highlights: You get to ask lots of questions and travel. You can work on infectious diseases such as tuberculosis. Some epidemiologists work on specific issues such as tobacco addiction.



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Controlling Bacteria

Careers in Biology

- Epidemiology focuses on where, when, and how often diseases occur; on how diseases are transmitted; and on how diseases can be controlled.
- Epidemiologists collect and analyze data that are relevant in describing the occurrence of a disease under study and its probable cause.
- When investigating a disease epidemic, an epidemiologist may collect information about the gender, age, occupation, socioeconomic status, personal habits, and history of immunization of those who have contracted the disease. **L2**

Resources All states and many large cities employ epidemiologists in their public health departments.

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You can have students write a more extensive job description as well as list the educational requirements for a career in this field.

Controlling Bacteria

Although most bacteria are harmless, and many are beneficial, the risks of bacterial infection are great enough to warrant efforts to control bacterial growth. **There are various methods used to control bacterial growth, including sterilization, disinfectants, and food processing.**

Sterilization by Heat One method used to control the growth of potentially dangerous bacteria is sterilization. Sterilization destroys all bacteria by subjecting them to great heat. Most bacteria cannot survive high temperatures for a long time, so most can be killed by exposure to high heat.

Disinfectants Another method of controlling bacteria is by using disinfectants—chemical solutions that kill pathogenic bacteria. Disinfectants are used in the home to clean bathrooms, kitchens, and other rooms where bacteria may flourish.

Today, some manufacturers of soaps, cleansers, and even kitchen utensils have added antibacterial chemicals to their products. If you wash your hands properly, ordinary soaps do a good job of removing bacteria. Overuse of antibacterial compounds increases the likelihood that common bacteria will eventually evolve to become resistant to them—and therefore much more dangerous and difficult to kill.

Build Science Skills

Designing Experiments Challenge groups of students to design an experiment to test the hypothesis that washing hands with antibacterial soap reduces the number of bacteria on the hands. A typical experiment will suggest dragging a washed and an unwashed finger across agar in separate petri dishes and then comparing bacterial growth on the agar.

L2 L3



TEACHER TO TEACHER

When the class is ready to discuss antibiotic resistance, I try to tie in the topics of genetics and natural selection, which the class has already discussed. For instance, I review Frederick Griffith's experiment dealing with transformation of DNA, as well as the concept of natural selection. This review helps lead into a discussion of how some bacteria have become resistant to

antibiotics and makes the topic more understandable. (If your class has not yet covered DNA transformation and natural selection, you may wish to give a brief overview of the topics to the class.)

—Leon Lange
Biology Teacher
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Answer to . . .

CHECKPOINT They block the growth and reproduction of bacteria.

Viral Disease in Humans

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Science News provides students with the most current information on bacteria and viruses.

Build Science Skills

Making Judgments Prepare a display of advertisements and packages of cold remedies. Ask students: **What is the purpose of these products?** (To relieve cold symptoms) **How do they relieve cold symptoms?** (Lower fever, relieve aches and pains, reduce congestion, stop cough, and so on) **Is this a sign that you are cured?** (No. Point out that these medications merely provide relief from symptoms. A cure would have to disable the virus that causes the cold.) **L2**

Use Visuals

Figure 19-14 After students have studied the information in the table, ask: **What is droplet inhalation?** (Most students won't know. Some may suggest it has something to do with sneezing.) Explain that droplets of saliva or mucus can be spread through the air by sneezing and coughing—and also by laughing and talking. Usually, these droplets spread less than 1 meter before dissipating. Point out that this kind of transmission is different from transfer by contact, by bodily fluids, or by insects. Ask: **Which of the viral diseases listed are spread by droplet inhalation?** (Common cold, influenza, smallpox, chickenpox, measles, and polio) **How is AIDS spread?** (By contact with contaminated blood or bodily fluids; by pregnant women to babies during delivery or breast-feeding) Emphasize that AIDS is not spread by droplet inhalation, casual contact, or insects. Then, discuss specific ways that AIDS is spread. **L1 L2**


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Food Storage and Processing As you read earlier, bacteria can cause food to spoil. One method of stopping food from spoiling is storing it in a refrigerator. Food that is stored at a low temperature will stay fresh longer because the bacteria will take much longer to multiply. In addition, boiling, frying, or steaming can sterilize many kinds of food. Each of these cooking techniques raises the temperature of the food to a point where the bacteria are killed.

Viral Disease in Humans

Like bacteria, viruses produce disease by disrupting the body's normal equilibrium. In many viral infections, viruses attack and destroy certain cells in the body, causing the symptoms of the disease. Poliovirus infects and kills cells of the nervous system, producing paralysis. Other viruses cause infected cells to change their patterns of growth and development. Some common diseases caused by viruses are listed in **Figure 19-14**.

Unlike bacterial diseases, viral diseases cannot be treated with antibiotics. The best way to protect against most viral diseases lies in prevention, often by the use of vaccines. Several decades of childhood vaccination against smallpox have virtually eliminated this disease. Most vaccines provide protection only if they are used before an infection begins. Once a viral disease has been contracted, it may be too late to control the infection. However, sometimes the symptoms of the infection can be treated.

▼ **Figure 19-14**  **Viruses produce disease by disrupting the body's normal equilibrium.** Some common human diseases caused by viruses are listed in this table.

Diseases Caused by Viruses		
Disease	Effect on Body	Transmission
Common cold	Sneezing, sore throat, fever, headache, muscle aches	Contact with contaminated objects; droplet inhalation
Influenza	Body aches, fever, sore throat, nasal congestion, headache, dry cough, fatigue	Contact with contaminated objects; droplet inhalation
Smallpox	High fever, fatigue, head and back aches, rash	Contact with contaminated objects; droplet inhalation
AIDS	Helper T cells, which are needed for normal immune system function, are destroyed	Contact with contaminated blood or bodily fluids; pregnant women to babies during delivery or during breastfeeding
Chickenpox	Fever and weakness, red, itchy rash	Contact with rash; droplet inhalation
Measles	High fever, sore throat, cough, rash, sneezing, swollen eyelids, white spots on cheek lining	Droplet inhalation
Hepatitis A	Jaundice, fatigue, abdominal pain, appetite loss, nausea, diarrhea, fever	Human wastes, contaminated water and food
Hepatitis B, Hepatitis C	Jaundice, fatigue, abdominal pain, appetite loss, nausea, diarrhea, joint pain	Contact with contaminated blood or bodily fluids
West Nile	Fever, headache, body ache	Bite from an infected mosquito



FACTS AND FIGURES

Extremely poisonous exotoxins

Bacterial toxins are usually divided into two groups: exotoxins and endotoxins. Exotoxins are produced and released as part of the normal metabolism of certain bacteria. Endotoxins are typically lipopolysaccharides that were originally

part of the cell wall and that are released by the lysis of the bacterium. In general, exotoxins are much more potent than endotoxins. Diseases caused by exotoxins include botulism, cholera, diphtheria, gas gangrene, food poisoning, scarlet fever, tetanus, and toxic shock syndrome.

Viral Disease in Animals

Viruses produce serious animal diseases as well. An epidemic of foot-and-mouth disease, caused by a virus that infects livestock, swept through parts of Europe in the late 1990s. Thousands of cattle were destroyed in efforts to control the disease. American authorities took special precautions to guard against the spread of the foot-and-mouth virus to North America.

Some animal viruses can even cause cancer. An example of these oncogenic, or tumor-causing, viruses is the Rous sarcoma virus, which infects chickens. Scientists have learned a great deal about cancer by studying the genes of these oncogenic viruses, which disrupt normal controls over cell growth and division.

Viral Disease in Plants

Many viruses, including tobacco mosaic virus, infect plants. These viruses pose a serious threat to many agricultural crops. Farmers in many countries, including the United States, struggle to control them. Like other viruses, plant viruses contain a core of nucleic acid and a protein coat.

Unlike animal viruses, most plant viruses have a difficult time entering the cells they infect. This is partly because plant cells are surrounded by tough cell walls that viruses alone cannot break through. As a result, most plant viruses are adapted to take advantage of breaks in the cell wall caused by even minor damage to plant tissues. Viruses can enter through tears in leaf tissue, breaks in stems or roots, or simply through microscopic cell wall damage caused by human or animal contact with the plant.

Many plant viruses are spread by insects. The feeding action of an insect pest often provides a perfect opportunity for viral infections to spread. Potato yellow dwarf virus is spread by an insect known as the leafhopper. Leafhoppers feed on potato leaves, and they also carry the virus in their tissues. As leafhoppers move from plant to plant, they spread the infection, threatening an entire crop if they are not controlled.

Once inside the plant, many viruses spread rapidly, causing severe tissue damage, mottled leaves, and wilting, and sometimes killing the infected plant as shown in **Figure 19–15**. Plant viruses infect many valuable fruit trees, including apples and peaches, and have caused serious losses in the potato crop.

► **Figure 19–15** The potato plants on the left have been infected with a potato virus, while those on the right are healthy. **Inferring** How might farmers prevent the spread of plant viruses?



Viral Disease in Animals

Use Community Resources

Ask a local farmer or agricultural agent to address the class about bacterial and viral diseases that affect farm animals in your area. Ask the speaker to talk about specific diseases and their symptoms, treatments, and preventive measures. Make sure students have prepared a list of questions in advance to ask the speaker. One topic students might focus on is whether farmers in your area use preventive doses of antibiotics to prevent bacterial diseases. **L2 L3**

Viral Disease in Plants

Build Science Skills

Posing Questions After students have read about viral disease in plants, have them turn back to Figure 19–8 on page 478 and reconsider the disease caused by the tobacco mosaic virus (TMV). Also, have them study the labeled drawing and photo of the virus in Figure 19–9 on page 479. Explain that tobacco mosaic is a common plant disease that has been extensively studied. Then, ask each student to write two questions that could be investigated about this virus. Examples might be: How is the virus spread? How can the disease be prevented? Collect the questions, and ask interested students to find the answers to some of them. **L2 L3**



TEACHER TO TEACHER

When I teach students about bacteria and viruses, I try to give students as many examples that relate to real-life experiences as possible. With such examples, the material becomes more interesting for students and keeps their attention on the subject at hand. For example, we spend a good amount of time on the causes, symptoms, and spread of bacterial and viral diseases. I encourage students to relate their own experiences with such diseases, as well as those of

family members. I also try to provide as many graphic organizers, diagrams, and charts as possible in order to help students organize what they are learning. Finally, I design experiences in which students can actively participate.

—Brenda Waldon
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Answer to . . .

Figure 19–15 Farmers can prevent the spread of plant viruses by immediately destroying any infected plants.

19-3 (continued)

Viroids and Prions

Build Science Skills

Comparing and Contrasting Ask students to make a table that they can use to compare viruses, viroids, and prions. Column heads might include Particle, Structure, and Method of Infection. After they have created their own tables, call on students at random to help you create a similar table on the board. Advise students to revise their own tables at the end of the discussion. **L1 L2**

3 ASSESS

Evaluate Understanding

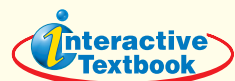
Ask students to write a paragraph explaining why antibiotics are used to treat bacterial diseases but not viral diseases. In their paragraphs, students should demonstrate an understanding of the differences between the two microorganisms as well as an understanding of what antibiotics are.

Reteach

Have pairs of students work together to make a public-health pamphlet that focuses on the prevention and treatment of bacterial and viral diseases.

Writing in Science

A typical story might focus on the carrying of disease-causing bacteria by the travelers from Earth and the lack of immunity to those bacteria by the residents of another planet. The result would be an epidemic of bacterial diseases. Accept all logical explanations relating to protection from disease.



If your class subscribes to the iText, use it to review the Key Concepts in Section 19-3.

Answer to . . .

Figure 19-16 Like viruses, prions can cause diseases. Unlike viruses, prions do not contain DNA or RNA—only protein.



▲ **Figure 19-16** Prions may cause several infectious diseases, including mad cow disease. This cow was killed by mad cow disease. **Comparing and Contrasting** How are prions similar to viruses? How are they different?

Viroids and Prions

Scientists have discovered two other viruslike particles that also cause disease: viroids and prions. Viroids cause disease in plants. Prions cause disease in animals.

Viroids Many plants, including potatoes, tomatoes, apples, and citrus fruits, can be infected by viroids. **Viroids** are single-stranded RNA molecules that have no surrounding capsids. It is believed that viroids enter an infected cell and direct the synthesis of new viroids. The viroids then disrupt the metabolism of the plant cell and stunt the growth of the entire plant.

Prions In 1972, American Stanley Prusiner became interested in scrapie, an infectious disease in sheep for which the exact cause was unknown. Although he first suspected a virus, experiments suggested the disease might actually be caused by tiny particles found in the brains of infected sheep. Unlike viruses, these particles contained no DNA or RNA, only protein. Prusiner called these particles **prions**, short for “protein infectious particles.” Although prions were first discovered in sheep, many animals, including humans, can become infected with prions.

There is some evidence that prions cause disease by forming protein clumps. These clumps induce normal protein molecules to become prions. Eventually, there are so many prions in the nerve tissue that cells become damaged. There is strong evidence that mad cow disease and Creutzfeldt-Jakob disease, a similar disease in humans, may be caused by prions.

19-3 Section Assessment

Writing in Science

Creative Writing

In *War of the Worlds*, Earth is invaded by aliens. No weapons can kill the invaders. Earth is saved when the invaders die from diseases they contract. Write a summary of a story about people from Earth voyaging to another planet. Include information on how the people from Earth might protect themselves from possible new diseases.

1. **Key Concept** What are the two ways that bacteria cause disease?
2. **Key Concept** Describe the three methods of preventing bacterial growth in food.
3. **Key Concept** Describe how viruses cause disease.
4. What are viroids?
5. **Critical Thinking Applying Concepts** You think you might have a bacterial infection. Would you ask for a vaccination against the bacteria? Why or why not?
6. **Critical Thinking Applying Concepts** How might epidemiologists collaborate with scientists who study viruses as they investigate viral diseases?

19-3 Section Assessment

1. Some damage cells and tissues directly by breaking down the host's cells for food. Others release toxins that interfere with the host's normal activity.
2. Students should describe sterilization, disinfectants, and food storage and processing.
3. Viruses cause disease by disrupting the body's normal equilibrium.
4. Single-stranded RNA molecules that have no surrounding capsids
5. It would probably not be a good idea because vaccinations prevent infection rather than attacking and destroying bacteria.
6. Epidemiologists are primarily concerned with tracking and preventing the spread of diseases. They might collaborate with virologists to find out the characteristics of specific viruses, including how they spread and how they infect a host.