SECTION 2

Biological Hazards

Some of the damage to human health in which the environment plays a role is not caused by toxic chemicals but by organisms that carry disease. Today, we have outbreaks of diseases that did not exist or that few people had heard of 100 years ago, such as AIDS, ebola, West Nile virus, hanta virus, and mad cow disease. In addition, diseases that have killed people for centuries, such as malaria, tuberculosis, yellow fever, and hookworm, kill many more people today than they did 50 years ago. All these diseases are caused by organisms. One of the reasons these diseases are now widespread is that we have altered our environment in ways that encourage them to spread.

Objectives

- Explain why the environment is an important factor in the spread of cholera.
- List two changes to the environment that can lead to the spread of infectious diseases.
- Explain what scientists mean when they say that certain viruses are emerging.

Key Terms

pathogen
host
vector

The Environment's Role in Disease

Infectious diseases are caused by **pathogens,** organisms that cause disease. Some of these diseases, such as tuberculosis and whooping cough, are spread from person to person through the air. Other diseases are spread by drinking water that contains the pathogen. Still other diseases are transmitted by a secondary host, such as a mosquito. A **host** is an organism in which a pathogen lives all or part of its life. **Table 2** lists the most deadly infectious diseases worldwide.

Table 2 ▼

Deaths from Infectious Diseases in 2000, Estimated by the World Health Organization

Disease and examples	Cause	Estimated deaths per year (in millions)
Total infectious and parasitic diseases	bacteria, viruses, and parasites	10.5
Respiratory infections (pneumonia, influenza, and whooping cough)	bacteria, viruses	4.0
AIDS	virus	2.9
Diarrheal diseases (cholera, typhus, typhoid, and dysentery)	bacteria, viruses, parasites	2.1
Tuberculosis	bacteria	1.7
Childhood diseases (measles and diphtheria)	virus	1.5
Malaria	parasitic protist	1.1
Tetanus	bacteria	0.3
Tropical diseases (trypanosomiasis, Chagas' disease, schistosomiasis, and leishmaniasis)	bacteria, viruses, and parasites	0.1

QuickLAB

Simulating an Epidemic

Procedure

1. Obtain one **test tube** of **water** from your teacher. Your teacher has "contaminated" one of the test tubes with an invisible substance.
2. Pour half your water into the test tube of a classmate. Your classmate will then pour an equal amount back into your test tube. Exchange water with three classmates in this way.
3. Your teacher will now put a small amount of a **test chemical** into your test tube. If your water turns cloudy, you have been "contaminated."

Analysis

1. Who had the test tube that started the "infection"?
2. Name a disease that could be spread in this way. Explain your answer.

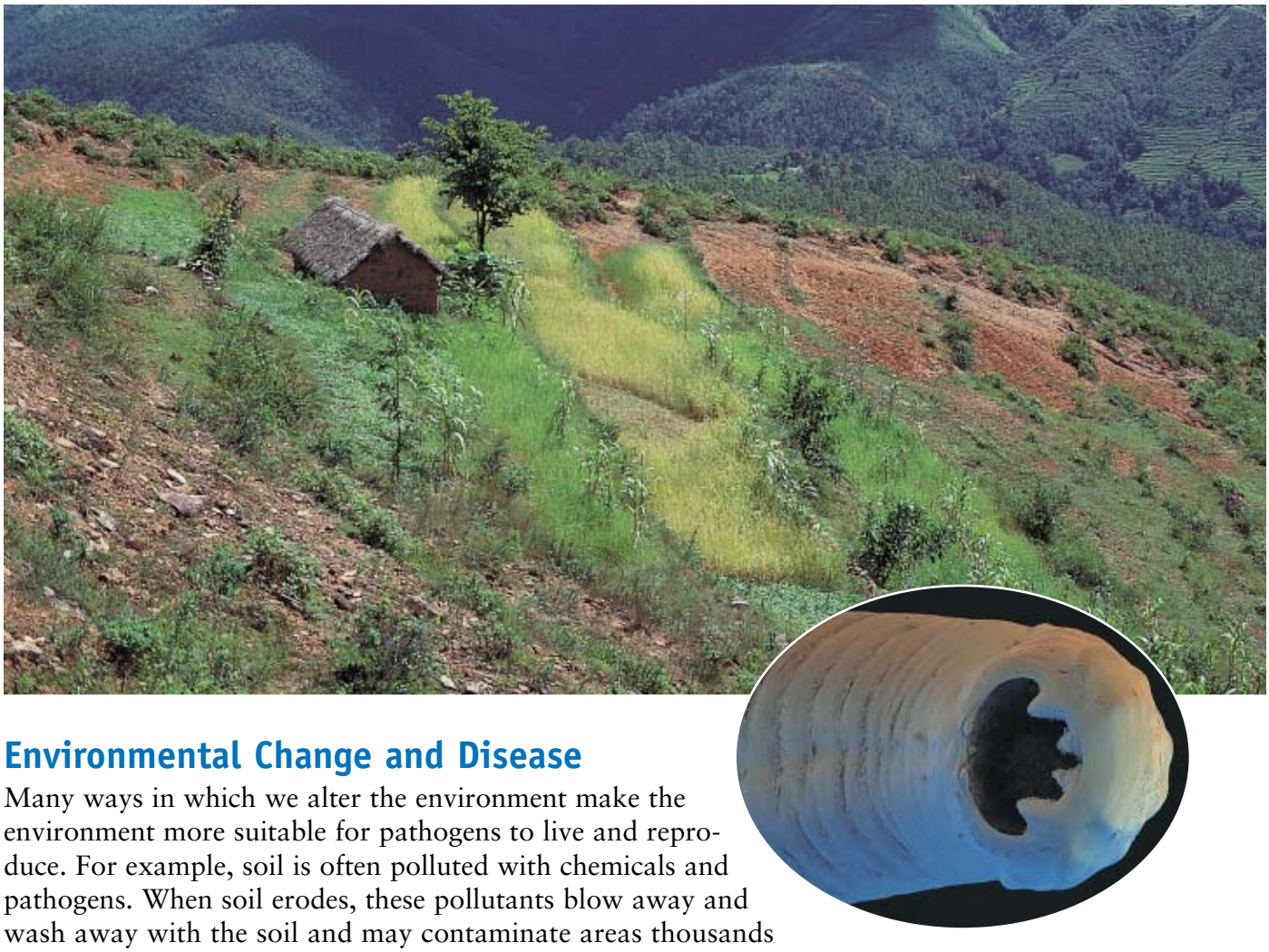
Waterborne Disease

Nearly three-fourths of infectious diseases are transmitted through water. In developing countries, where there is not enough water for basic needs, the local water supply is often used for drinking, washing, and sewage disposal. So, the water is usually very polluted and is a good breeding ground for pathogens. The pathogens breed in water and transfer diseases directly to humans through water, or organisms that carry the pathogens transfer them to humans through the water. Organisms, such as mosquitoes, that transmit diseases to people are called **vectors** of the disease. The widespread construction of irrigation canals and dams, particularly in the tropics, has increased the habitat for vectors. For example, it is dangerous to bathe in tropical ponds. The water might contain the snail vector for schistosomiasis, an incurable disease that kills thousands of people each year.

Cholera The deadliest waterborne diseases come from drinking water polluted by human feces. Pathogens, such as those that cause *cholera* and *dysentery*, enter the water in human feces. These diseases cause the body to lose water by diarrhea and vomiting. These diseases cause most of the infant mortality around the world. A baby's body has less water than an adult's body and therefore suffers more from dehydration. **Figure 10** shows a child being treated for dehydration.

Malaria Another waterborne disease called *malaria* was once the world's leading cause of death. The disease is caused by parasitic protists and is transmitted by a bite from females of many species of mosquitoes. The mosquito vector lays her eggs in stagnant fresh water, which is where the mosquito larva develops. No effective vaccine for malaria exists, but preventative measures are used to control mosquitoes.

Figure 10 ▶ This child is undergoing rehydration therapy during a cholera epidemic in South Africa.



Environmental Change and Disease

Many ways in which we alter the environment make the environment more suitable for pathogens to live and reproduce. For example, soil is often polluted with chemicals and pathogens. When soil erodes, these pollutants blow away and wash away with the soil and may contaminate areas thousands of miles away. Many parasites are spread through soil that is contaminated with feces. Hookworm, which causes acute exhaustion, was once common in the United States. People are infected by walking barefoot on soil that contains human and animal feces or by consuming contaminated food or water. **Figure 11** shows soil erosion in Nepal. In 1984, 87 percent of the population was found to be infected by parasitic worms, which people were exposed to due to widespread soil erosion.

Figure 11 ▶ Soil erosion in Nepal (top) leads to the spread of parasites such as the hookworm (bottom).

Antibiotic Resistance Our actions cause pathogens to evolve resistance to antibiotics that are used to kill them. For example, in the United States, large quantities of antibiotics are fed to livestock each year to speed their growth. As a result, *Salmonella*, *Escherichia coli* (*E. coli*), and other bacteria that live in livestock evolve resistance to antibiotics. These bacteria now make thousands of U.S. citizens sick each year when they eat contaminated meat that has been improperly refrigerated or undercooked.

We also use enormous amounts of antibiotics to treat human illnesses. In 1979, 6 percent of European strains of pneumonia bacteria were resistant to antibiotics. Ten years later, 44 percent of the strains were resistant. Tuberculosis (TB) is another illness treated with antibiotics. The spread of TB in recent years is mostly due to the evolution of antibiotic resistance in the bacterium that causes TB.

Ecofact

Suburbs Spread Lyme Disease
Lyme disease is the most widespread vector-borne disease in the United States. It is caused by a bacterium similar to the one that causes the sexually transmitted disease syphilis. The vector is a tick found on white-tailed deer. The suburbs are a suitable place for deer to grow and reproduce, and their populations have exploded as suburbs have expanded. Lyme disease was first described in 1976. It now infects more than 13,000 people a year in the United States.

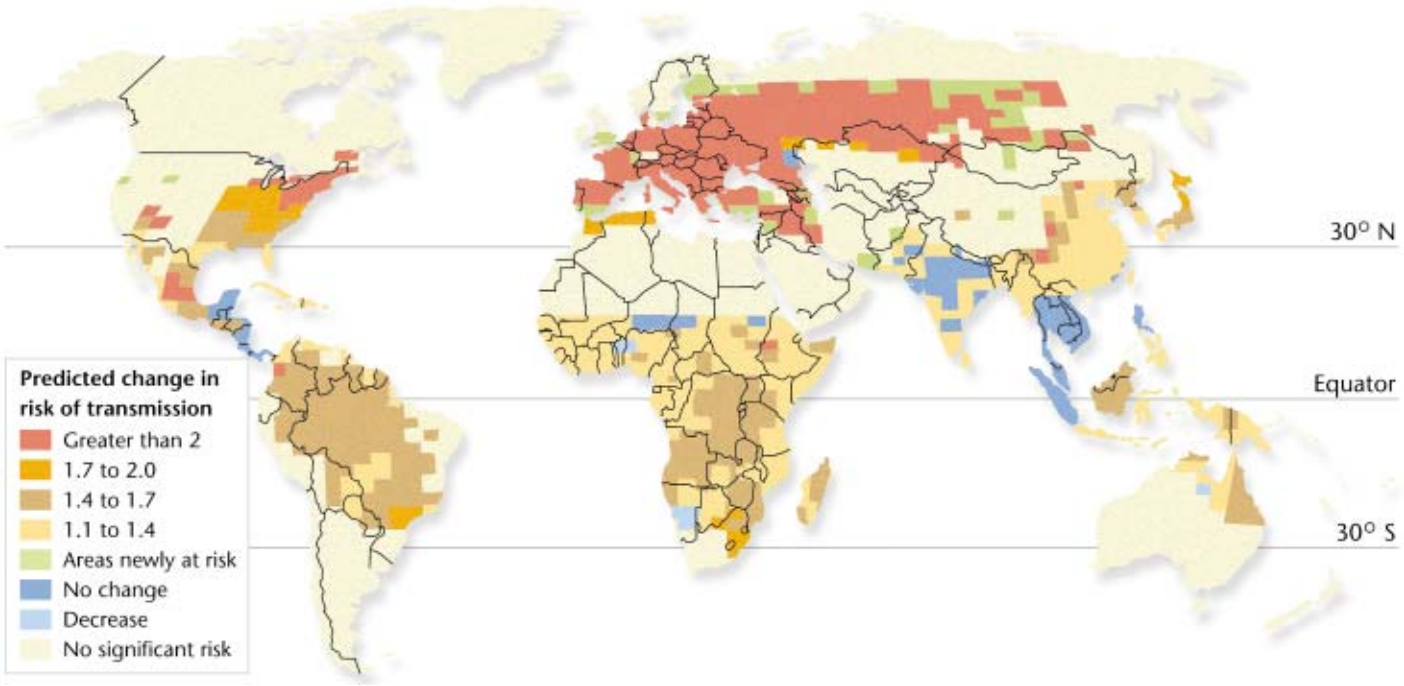


Figure 12 ▶ This computer model shows how malaria might spread under specific global warming conditions.

internet connect

www.scilinks.org
Topic: Emerging Viruses
SciLinks code: HE4030

SCILINKS Maintained by the National Science Teachers Association

Connection to Biology

The Viral Advantage Antibiotics kill bacteria but not viruses, such as those that cause colds and flu. Antibiotics kill bacteria by interfering with their cellular mechanisms. Viruses do not have cellular mechanisms. Many antibiotics destroy the system a bacterium uses to make proteins. Viruses do not make their own proteins. Instead, they take over the cellular machinery of the cells they invade and use the cell to make proteins.

Malaria on the March Insects that breed in water are the secondary hosts that transmit malaria. The mosquitoes that transmit malaria are found in the warmer parts of the world. Epidemiologists believe that global warming may increase the area where malaria occurs. **Figure 12** shows that malaria might spread across large areas of Central America, South America, Africa, and Asia.

Malaria was common in much of the United States and Europe before the days of mosquito control. Now, it is most common in tropical countries. Historically, malaria was controlled by draining marshes and rice paddies where the mosquitoes breed and by spraying with pesticides. Since the 1970s, however, mosquitoes have evolved resistance to most of the pesticides. Newer methods for controlling mosquitoes involve spreading growth regulators that prevent mosquito larvae from maturing into adults or that sterilize the female mosquitoes.

Emerging Viruses In recent years, medical scientists have been focusing on previously unknown viruses, the so-called emerging viruses that were unknown 100 years ago. One example is AIDS (acquired immune deficiency syndrome), which is caused by HIV (human immune deficiency virus). Other examples of emerging viruses include the hanta virus, the ebola virus, and the West Nile virus. Most viral diseases spread directly from one person to another. Often, the virus invades the body through a cut or through mucus membranes. We do not have many effective drugs to treat viral diseases, and the drugs that we have are only effective against a certain virus. Our main defense against viral diseases is vaccination. The problem with vaccines is that they are very specific, and viruses evolve rapidly, so when a new strain of a viral pathogen evolves, a new vaccine must be developed.

Cross-Species Transfers In recent years, scientists have discovered an increasing number of pathogens that have made a *cross-species transfer,* or have moved from one species to another. For example, HIV and West Nile virus fall into this category. The pathogens that cause these diseases have lived for centuries in some species of wild animals and have done little damage. When the pathogens invade humans, the pathogens cause serious diseases. Some ecologists think that the ways in which we are altering the environment and destroying habitats ensure that diseases like these will become more common in the future.

Examples of Cross-Species Transfers One example of pathogens that made a cross-species transfer occurred in Argentina. Herbicides were sprayed on crops in Argentina. The herbicide killed the native grasses and allowed other plants to invade the farmland. These new plants attracted a species of rodent that feeds on them. The rodents were carrying viruses for a hemorrhagic fever, which infected many of the agricultural workers. Hemorrhagic fevers cause hemorrhages, or internal bleeding, by breaking blood vessels. Hanta virus is an example of a virus that causes hemorrhagic fever.

Influenza, or flu, is highly contagious. The flu virus passes from humans to animals (particularly birds) and back to humans again. Hong Kong flu gets its name from the fact that the virus was transmitted to humans from ducks bred in Hong Kong for food. **Figure 13** shows a poultry market, where the Hong Kong flu virus probably transferred from birds to people. Because flu is so easily spread from one person to another, epidemiologists predict that the greatest threat to human health may be the outbreak of a new, very virulent strain of influenza virus, which would spread rapidly through crowded urban populations.

Figure 13 ▶ Poultry markets, such as this one in Hong Kong, can contribute to the cross-species transfer of viruses from birds to humans.

SECTION 2 Review

1. **List** two changes to the environment that can lead to the spread of infectious diseases.
2. **Explain** why some diseases are likely to spread as a result of global warming.
3. **Explain** why the environment is an important factor in the spread of cholera.
4. **Explain** the term *emerging virus.*

CRITICAL THINKING

5. **Understanding Concepts** Read the information under the heading "Antibiotic Resistance." How is the use of antibiotics by humans increasing antibiotic resistance in pathogens? READING SKILLS
6. **Analyzing Relationships** How do human activities cause pathogens to move from one species to another? Give examples of cross-species transfer to help explain your answer.

CHAPTER 20

Highlights

1 Pollution and Human Health

Key Terms

toxicology, 512
dose, 512
dose-response curve, 512
epidemiology, 513
risk assessment, 513
particulates, 514

Main Ideas

- Toxic chemicals from both natural sources and human activities that pollute air, soil, water, and food may damage human health.
- Toxicology is used to determine how poisonous a substance is.
- After an outbreak of illness occurs, epidemiologists attempt to find its origin and try to find ways to prevent future epidemics.
- Most pollutants come from human activities, but some pollutants occur naturally.
- Improperly disposed of wastes may leak hazardous pollutants into the environment.

2 Biological Hazards

pathogen, 519
host, 519
vector, 520

- Most human diseases that have an environmental component are caused by pathogens.
- The environment provides breeding grounds for pathogens and for their secondary hosts and vectors.
- The transmission of many infectious diseases includes water. We increase the areas where organisms that carry these diseases can reproduce when we create irrigation canals and inadequate sewage systems.
- Environmental changes that help spread infectious diseases include global warming and the spread of suburbs and farmland.
- Many emerging diseases are caused by pathogens that have made cross-species transfers from animals to humans.

CHAPTER 20 Review

Using Key Terms

Use each of the following terms in a separate sentence.

1. *dose*
2. *vector*
3. *risk assessment*
4. *particulates*
5. *epidemiology*

For each pair of terms, explain how the meanings of the terms differ.

6. *pathogen* and *host*
7. *response* and *dose*
8. *toxicology* and *epidemiology*

STUDY TIP

Vocabulary Practice To practice vocabulary, write the terms and definitions on a piece of paper and fold the paper lengthwise so that the definitions are covered. First, see how many definitions you already know. Then, write the definitions you don't know on another piece of paper, and practice again until you know all of them.

Understanding Key Ideas

9. Which of the following is *not* a true statement about the effects of pollution on health?
   a. It is difficult to determine how pollution affects health because many factors often contribute to a disease.
   b. The toxic effects of a pollutant depend upon the dose to which you are exposed.
   c. Many pollutants cause chronic diseases that result from exposure to the pollutant over the course of many years.
   d. Persistent chemicals are less toxic than chemicals that break down rapidly.
10. Which of the following is an emerging disease that was unknown 50 years ago?
    a. malaria
    b. dengue fever
    c. Lyme disease
    d. schistosomiasis
11. Cholera is usually transmitted from person to person by water because
    a. it is caused by a snail that breeds in water.
    b. it is usually contracted by someone drinking water polluted with human feces that contain the cholera pathogen.
    c. it is transmitted by mosquitoes.
    d. it is caused by a virus.
12. Tuberculosis (TB), which was once almost eradicated, is becoming more common, even in developed countries, because
    a. new varieties of the tuberculosis pathogen have evolved in rodents.
    b. livestock are given antibiotics.
    c. the pathogen that causes TB breeds in polluted water.
    d. some populations of the pathogen that causes TB are resistant to the antibiotics.
13. Which of the following statements about environmental pollutants is true?
    a. Our environment contains fewer toxic chemicals than it did 50 years ago.
    b. Hormone mimics in our water supply pose no danger to humans
    c. There is no health risk from pollutants in indoor air.
    d. The bodies of people who live in the United States contain lower levels of some toxic chemicals than they did 20 years ago.
14. Which of the following actions is most likely to prevent yellow fever, which is transmitted by mosquitoes, from becoming epidemic?
    a. preventing dehydration in patients by treating them with oral rehydration therapy
    b. taking antibiotics
    c. encouraging people to empty water out of old cans, tires, plant saucers, and other areas that contain standing water
    d. spraying the area repeatedly with pesticides

CHAPTER 20 Review

Short Answer

15. How do scientists determine the toxicity of a chemical?

16. How can land use change contribute to the spread of infectious disease?

17. What role does the environment play in the transmission of infectious diseases?

18. Why would lung disease be more common in a large urban area than in a remote rural area?

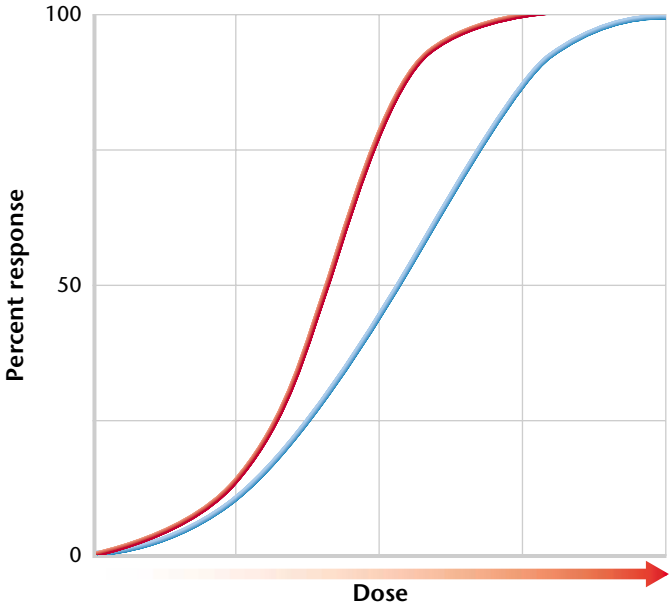
Interpreting Graphics

The graph below shows the dose-response curves for two chemicals. Use the graph to answer questions 19–21.

19. Which chemical is more toxic at a lower dose?

20. Which chemical is more toxic at a very large dose?

21. Can you tell from the graph which chemical is more likely to be a problem if it persists in the environment?



Concept Mapping

22. Use the following terms to create a concept map: *habitat destruction*, *pathogen*, *animal*, *vector*, and *human disease*.

Critical Thinking

23. Making Comparisons In what ways does a disease such as lung cancer, which is caused by breathing pollutants over a long period of time, differ from a disease such as malaria, which is caused by a pathogen?

Cross-Disciplinary Connection

24. History In 1775, Percival Pott noted that chimney sweeps had a high rate of cancer of the scrotum. What further investigations might be performed to find out what occupational hazard might be causing the cancer? How many of these would have been possible at the time, and how many require modern technology?

25. Economics Write a proposal to reduce the mosquito population of an area. How might you encourage the public to assist in this effort? WRITING SKILLS

26. Biology Read about mosquitoes under the heading "Malaria." How would you design an irrigation system to minimize the chances that mosquitoes would breed in it? READING SKILLS

Portfolio Project

27. Collect half a dozen pesticide containers that still have their labels. Make a table that has three columns. List the names of the pesticides in one column. Then read the label on each container. Use this information to decide which pesticide is the most dangerous and which pesticide is the least dangerous. In the second column, label the pesticides as most to least dangerous. In the third column, list the most important safety precautions required of anyone who uses the pesticide. **CAUTION:** Do not get pesticide on your face, and wash your hands thoroughly after handling the pesticide cans.

MATH SKILLS

The table below shows four diseases and the number of cases of each disease that were reported to the United States Centers for Disease Control in 1990 and 1998. Use the table below to answer questions 28–29.

Disease	1990	1998
Cryptosporidiosis	2	3,793
Lyme disease	2	16,801
Malaria	1,292	1,611
Typhoid fever	552	375

28. **Analyzing Data** Malaria cases increased between 1990 and 1998. What other facts would you want to know before deciding that the United States has a growing malaria problem?

29. **Making Calculations** By what percentage did the number of typhoid fever cases decline between 1990 and 1998?

WRITING SKILLS

30. **Communicating Main Ideas** Why do sewage systems that overflow when it rains need to be replaced with modern systems that do not overflow?

31. **Writing Persuasively** Write a letter to a newspaper. In the letter, argue either for or against homeowners' use of pesticides on their lawns and gardens.

READING FOLLOW-UP

Now that you have read the chapter, take a moment to review your answers to the **Reading Warm-Up** questions in your ***EcoLog.*** If necessary, revise your answers.

STANDARDIZED TEST PREP

Read the passage below, and then answer the questions that follow.

Dehydration is a serious threat to human survival—as dangerous as a high fever. However, as any athlete knows, drinking water alone is often not an adequate cure for dehydration. Sports drinks contain sugar and electrolytes (minerals) as well as water. This principle also underlies oral rehydration therapy, which is used to treat people suffering from diseases such as cholera and dysentery. These diseases cause water loss from diarrhea and vomiting. Severe dehydration often causes death, particularly in small children. Patients being treated for dehydration are fed a solution of salt, sugar, and water. The sugar and salt help the body absorb the water from the stomach. Sugar and salt also add electrolytes to the body fluids so that these are not diluted. Millions of lives have been saved by rehydration therapy.

1. According to the passage, which of the following statements about oral rehydration therapy is *not* true?
   - **a.** A solution containing sugars and salts is absorbed by the stomach more rapidly than water alone.
   - **b.** The salts replace electrolytes in the bloodstream so that these are not diluted by the water.
   - **c.** Any source of water is adequate to make up the solution of salts and sugar.
   - **d.** Millions of lives have been saved by oral rehydration therapy.

2. According to the passage, which of the following statements about dehydration is *not* true?
   - **a.** It may be fatal.
   - **b.** It is especially dangerous to small children.
   - **c.** It may be caused by diarrhea and vomiting from diseases such as cholera.
   - **d.** It is not often caused by exercising on a hot day without drinking.

CHAPTER 20

Skills Practice Lab: MATH/GRAPHING

Objectives

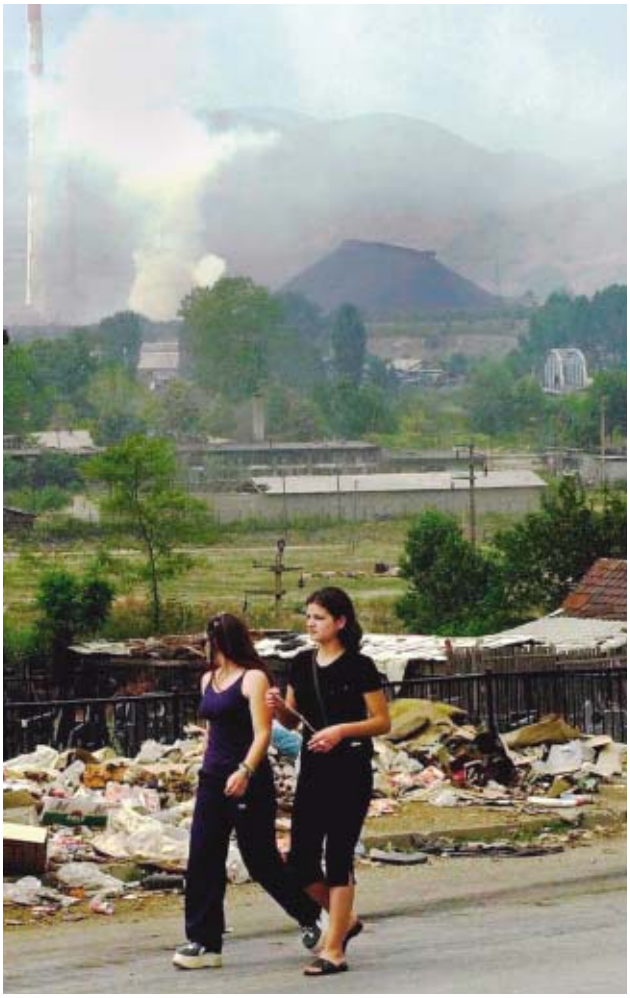
- USING SCIENTIFIC METHODS **Analyze** the relationship between lead poisoning and children's IQ.
- **Graph** experimental data.
- **Interpret** graphical data.

Materials

notebook
pen or pencil

Lead Poisoning and Mental Ability

People are usually exposed to lead in old buildings that were painted with lead paint. The lead can enter your body as dust when you breathe and can permanently damage the brain and nervous system. Lead poisoning can cause aggressive behavior, hyperactivity, headaches, and hearing loss. At high levels, it can cause seizures, coma, and even death. The Centers for Disease Control and Prevention (CDC) state that a lead level of only 10 micrograms per deciliter in the blood can be harmful. (A microgram is one-millionth of a gram, and a deciliter is one-tenth of a liter.) In this lab, you will explore the effect of lead poisoning on the mental ability of children. The children all grew up near a lead smelter, a factory where raw lead ore is processed. Scientists measured the concentration of lead in the children's blood over time. Psychologists also performed tests on the children to determine their IQ. You will analyze the data to see if you can find a pattern.

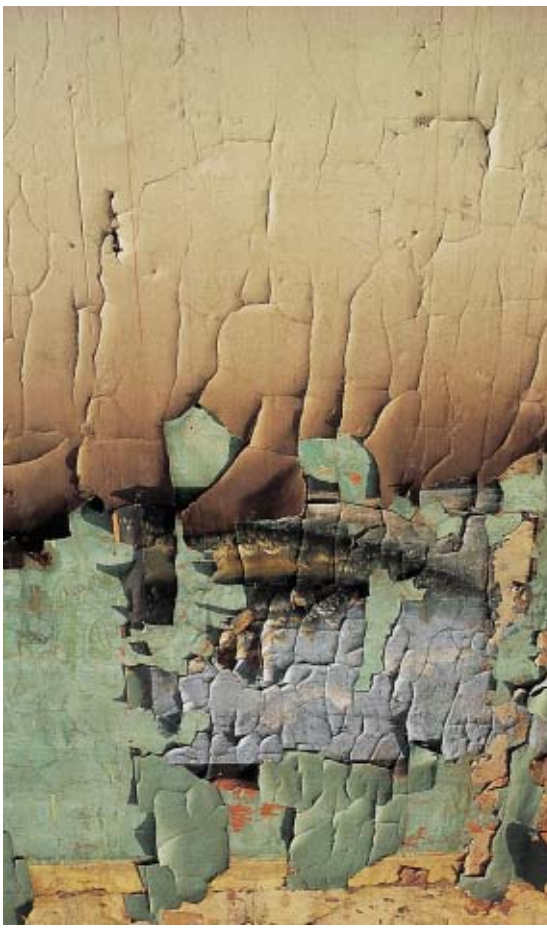


▶ **Effects of Lead** Lead smelters, such as the one below in Yugoslavia, can cause air pollution and lead poisoning.

Procedure

1. Design a hypothesis for the relationship between the lead concentration in the blood, the IQ, and the age of the children. As the blood-lead concentration increases, how would you expect the person's IQ to change? How do you think this relationship would change as the children grow older?
2. The table on the next page lists the blood-lead concentration and IQ data for a group of 494 children. The children were measured five times as they grew up. The first measurement was made when they were six months old, and the last measurement was made when they were seven years old. The children were divided into four groups according to the amount of lead in their blood. Group 1 had the lowest concentration of lead, and group 4 had the highest concentration of lead. Prepare a graph for the data in the table. Plot lead concentration on the *x*-axis and IQ on the *y*-axis. Label each axis with the correct units. Choose an appropriate scale for each axis so that the entire range of data in the table will fit on the graph.
3. Plot the data from the table on your graph. Connect all data points for a single age group with a single line. You should have five lines of data on your graph and have one line for each age group.

Group of children		Average blood-lead concentration (micrograms per deciliter)	Average IQ score
6 mo	1	8.3	109.4
	2	12.6	104.7
	3	16.8	102.9
	4	24.2	100.0
15 mo	1	11.8	109.3
	2	18.6	106.5
	3	24.4	102.9
	4	34.4	101.3
3 yr	1	11.6	110.2
	2	17.4	106.5
	3	22.4	102.2
	4	30.2	100.0
5 yr	1	8.3	109.3
	2	12.6	106.1
	3	17.2	104.1
	4	23.6	98.8
7 yr	1	6.6	109.6
	2	10.1	107.7
	3	13.7	102.7
	4	20.0	98.7



▶ **Lead Paint** Dust from lead paint peelings can cause lead poisoning.

Analysis

1. **Analyzing Data** For a single age group, how does IQ vary with lead concentration? Is this true for all age groups?
2. **Analyzing Data** How does the relationship between lead concentration and IQ change as a child grows older?

Conclusions

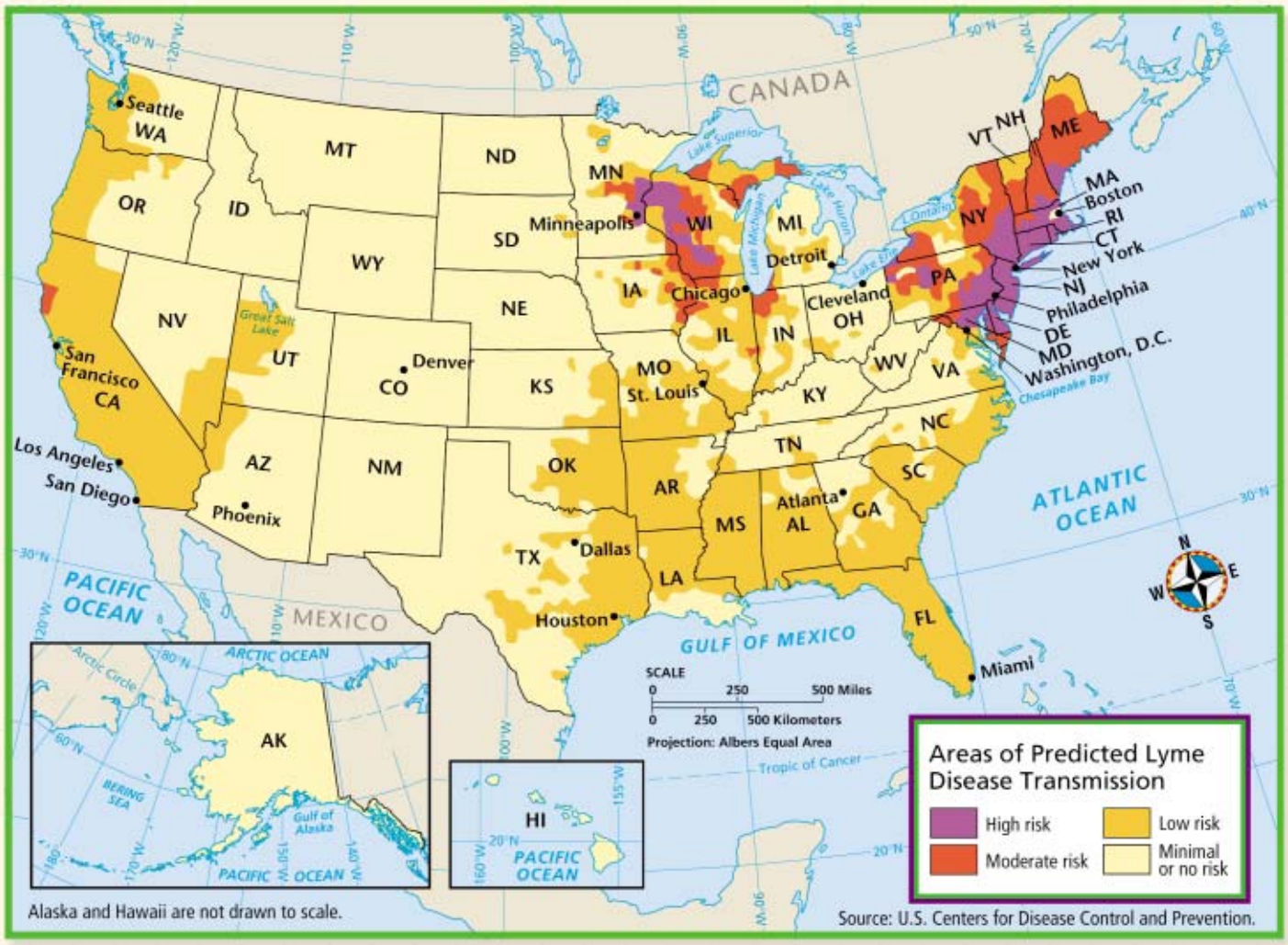
3. **Drawing Conclusions** What conclusions can you draw from your analysis about the effect of lead on IQ?
4. **Applying Conclusions** Based on your conclusions, what long-term effects might lead poisoning have on a community?

Extension

1. **Analyzing a Viewpoint** Based on the data presented in this lab, do you think the CDC's limit of 10 micrograms per deciliter is reasonable? Explain your answer.

MAPS in action

LYME DISEASE RISK



▶ The map above shows the risk of contracting Lyme disease by geographic location inside the United States.

MAP SKILLS

Use the Lyme disease risk map for the United States to answer the questions below.

1. **Using a Key** Using the map above, determine the risk of contracting Lyme disease in your city or town.
2. **Using a Key** In what general region of the United States is the risk of contracting Lyme disease greatest?
3. **Analyzing Relationships** Can you determine the relationship between the risk of contracting Lyme disease and the concentration of ticks that act as vectors for the disease? Explain your answer.
4. **Analyzing Data** What is the difference between the risk of contracting Lyme disease in rural Massachussetts and the risk of contracting Lyme disease in rural Nevada?
5. **Forming a Hypothesis** What factors might account for the relatively high risk of contracting Lyme disease in the Northeast?

TOXIC MOLD

You may have seen stories in the news with titles such as "Mold Closes Schools" or "Homes Infested with Toxic Mold." In the past 10 years, news stories have reported on school evacuations, strange illnesses, and multimillion dollar lawsuits, all due to mold. What is toxic mold, and why is it a problem?

"Toxic mold" is a popular term for molds that grow indoors and that are suspected of making people sick who are exposed to them.

▶ The mold pictured below, *Stachybotrys,* is commonly implicated in toxic building episodes.

Recall that molds are fungi and are found almost everywhere on Earth. In buildings, molds tend to grow on damp surfaces, especially damp wood, where they appear as a black or dark green fuzzy layer.

Are Molds Toxic?

Some species of mold produce toxins that they use mainly to compete with other molds. These toxins can also harm people. The toxins become airborne attached to spores, the mold's reproductive particles, or on tiny mold fragments. Once the toxins are airborne, people can breathe them in.

The most commonly mentioned toxic mold is *Stachybotrys chartarum*. This mold produces several potent toxins that affect the immune system and cause hemorrhaging in toxicology tests on mice.

People handling material contaminated with *Stachybotrys* report coughing and burning sensations of the throat and nose. Some people have also reported memory loss and bleeding in the lungs. But scientists have not found a firm link between indoor mold and these more serious health problems.

▶ This health worker is removing portions of a house infested with mold that may be toxic.

Molds and Buildings

Molds are especially common in areas with high rainfall. If wood or paper stays damp for any length of time, odds are that mold spores will land on it and begin to grow.

Most of the problems with indoor mold occur in areas between walls or in other rarely seen places. The solution is to fix leaks as soon as possible and improve air circulation so that damp areas dry out.

Scientific Uncertainty

There are only a small number of well-studied cases of toxic mold poisoning, and even in these there exists the possibility of other causes for the illnesses. Scientists see toxic mold as an example of the difficulty of linking environmental exposure with human health. "You can't prove causation from epidemiological studies," notes one doctor. "All you can do is show that there is a correlation."

What Do You Think?

School districts and homeowners have spent millions of dollars replacing moldy parts of buildings. But in many cases the mold had not caused health problems. Should the government require schools and homeowners to repair moldy buildings? Who should pay for it?