SECTION 3

Hazardous Waste

Many of the products we use today, from laundry soap to computers, are produced in modern factories that use thousands of chemicals. Some of these chemicals make up parts of the products, while other chemicals are used as cleansers or are used to generate electricity for the factories. Large quantities of the chemicals used are often leftover as waste. Many of these chemicals are classified as **hazardous waste,** which is any waste that is a risk to the health of humans or other living things.

Types of Hazardous Waste

Hazardous wastes may be solids, liquids, or gases. Hazardous wastes often contain toxic, corrosive, or explosive materials. Some examples of hazardous wastes include substances such as cleansers used to disinfect surfaces or lubricants used to help machines run smoothly. More examples of hazardous wastes are listed in **Table 3.**

The methods used to dispose of hazardous wastes often are not as carefully planned as the manufacturing processes that produced them. One case of careless hazardous waste disposal that had horrifying results occurred at Love Canal, in Niagara Falls, New York. At Love Canal, homes and a school were built on land that a chemical company had used as a site to dump toxic waste. Problems started when the toxic waste began to leak from the site.

The events at Love Canal shocked people into paying more attention to how hazardous wastes were being disposed of and stored throughout the United States. In other places throughout the country, improperly stored or discarded wastes—such as those shown in **Figure 14**—were leaking into the air, soil, and groundwater. Federal laws were passed to clean up old waste sites and regulate future waste disposal.

Objectives

- Name two characteristics of hazardous waste.
- Describe one law that governs hazardous waste.
- Describe two ways in which hazardous waste is disposed.

Key Terms

hazardous waste
deep-well injection
surface impoundment

Table 3 ▼

Types of Hazardous Waste
• dyes, cleansers, and solvents
• PCBs (polychlorinated biphenyls) from older electrical equipment, such as heating systems and television sets
• plastics, solvents, lubricants, and sealants
• toxic heavy metals, such as lead, mercury, cadmium, and zinc
• pesticides
• radioactive wastes from spent fuel that was used to generate electricity

Figure 14 ▶ An improperly maintained hazardous waste site can leak toxic wastes into the air, soil, and groundwater.

Connection to Law

Resource Conservation and Recovery Act The Resource Conservation and Recovery Act (RCRA) was passed by Congress in 1976 and amended in 1984. The RCRA created the first significant role for federal government in waste management. The act was established to regulate solid and hazardous waste disposal and to protect humans and the environment from waste contamination.

The primary goals of the RCRA include protecting human health from the hazards of waste disposal, conserving energy and natural resources by recycling and recovering, reducing or eliminating waste, and cleaning up waste, which may have spilled, leaked, or been improperly disposed of.

Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) requires producers of hazardous waste to keep records of how their wastes are handled from the time the wastes are made to the time the wastes are placed in an approved disposal facility. If the wastes cause a problem in the future, the producer is legally responsible for the problem. RCRA also requires all hazardous waste treatment and disposal facilities to be built and operated according to standards that are designed to prevent the facilities from polluting the environment.

The Superfund Act

Because the safe disposal of hazardous wastes is expensive, companies that produce hazardous wastes may be tempted to illegally dump them to save money. In 1980, the U.S. Congress passed the Comprehensive Environmental Response, Compensation, and Liability Act, more commonly known as the Superfund Act. The Superfund Act gave the U.S. Environmental Protection Agency (EPA) the right to sue the owners of hazardous waste sites who had illegally dumped waste. Also, the EPA gained the right to force the owners to pay for the cleanup. The Superfund Act also created a fund of money to pay for cleaning up abandoned hazardous waste sites.

Cleaning up improperly discarded waste is difficult and extremely expensive. At Love Canal alone, $275 million was spent to put a clay cap on the site, to install a drainage system and treatment plant to handle the leaking wastes, and to relocate the residents. Now, more than 20 years after Love Canal was evacuated, many Superfund sites still need to be cleaned up, as shown in **Figure 15.** Cleanup has been completed at only 75 of the roughly 1,200 approved or proposed Superfund sites.

Figure 15 ▶ This map shows the number of approved and proposed Superfund sites as of 2001. These sites are some of the most hazardous areas in the United States.

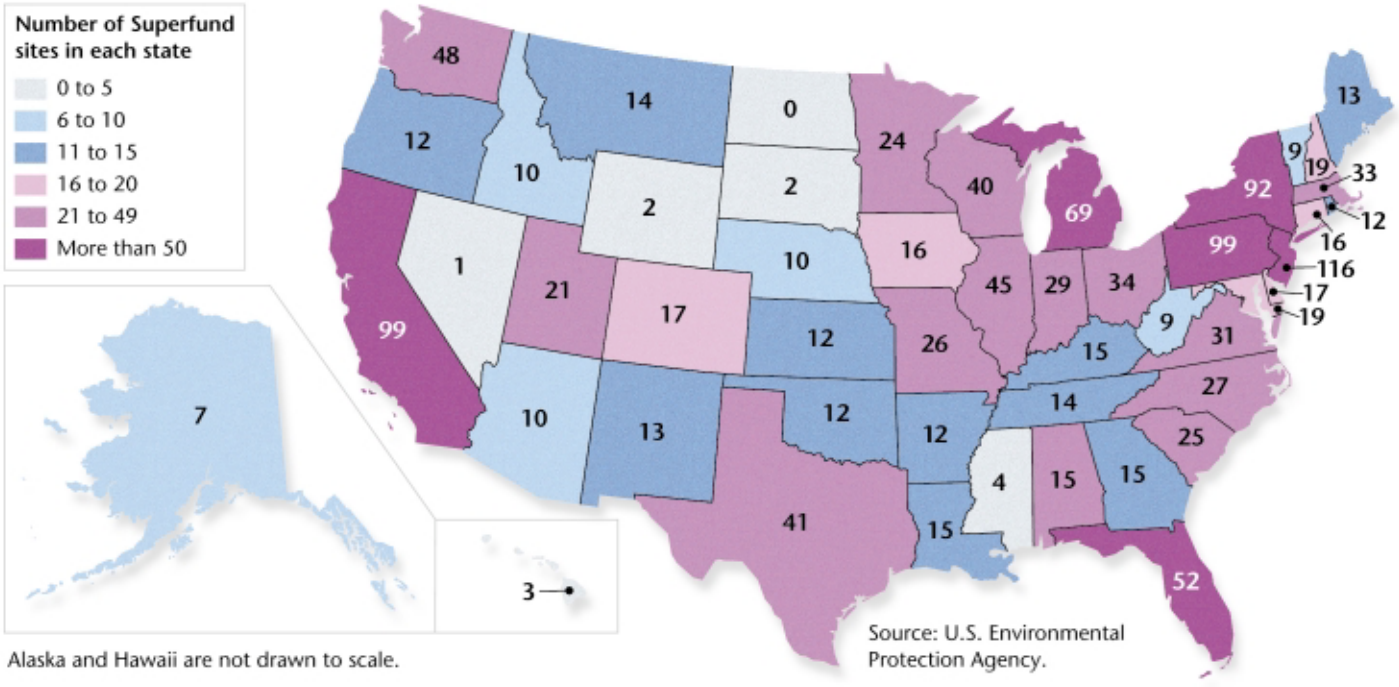

Figure 16 ▶ Safely transporting hazardous waste is an important part of hazardous waste management.

Hazardous Waste Management

Each year, the United States produces about 252 million metric tons of hazardous waste, and this amount is growing each year. It is difficult to guarantee that the disposal techniques used today will not eventually pollute our air, food, or water.

Preventing Hazardous Waste One way to prevent hazardous waste is to produce less of it. In recent years, many manufacturers have discovered that they can redesign manufacturing methods to produce less or no hazardous waste. For example, some manufacturers who used chemicals to clean metal parts of machines have discovered that they can use tiny plastic beads instead. The beads act like a sandblaster to clean the parts, can be reused several times, and are not hazardous when disposed. Often, such techniques save the manufacturers money by cutting the cost of materials as well as in cutting the cost of waste disposal.

Another way to deal with hazardous waste is to find a way to reuse it. In the United States, more than 50 programs have been set up to help companies work with other companies that can use the materials that they normally throw away. For example, a company that would usually throw away a cleaning solvent after one use can instead sell it to another company. The company that buys the used solvent may produce a product that is not harmed by small amounts of contamination in the solvent.

Conversion into Nonhazardous Substances Some types of wastes can be treated with chemicals to make the wastes less hazardous. For example, lime, which is a base, can be added to acids to neutralize them. A base is a compound that can also react with acids to convert acids into salts, which are less harmful to the environment. Also, cyanides, which are extremely poisonous compounds, can be combined with oxygen to form carbon dioxide and nitrogen. In other cases, wastes can be treated biologically. Sludge from petroleum refineries, for example, may be converted by soil bacteria into less harmful substances.

internet connect

www.scilinks.org
Topic: Hazardous Waste
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QuickLAB

Neutralizing Hazardous Waste

Procedure

1. Using a **measuring spoon,** obtain about a teaspoon of **baking soda,** and place it in a **500 mL beaker.** The baking soda will act as the base which will neutralize the acid.
2. In a separate **500 mL beaker,** pour approximately **200 mL of vinegar.** The vinegar is a weak acid.
3. Add the vinegar (acid) to the baking soda (base).

Analysis

1. What happened when you added the vinegar to the baking soda?
2. How is this lab similar to the technique used to convert some hazardous wastes into nonhazardous substances?

Connection to Chemistry

Hazardous Chemical Reactions After a material is thrown away, it may become more hazardous as a result of a chemical reaction with other discarded wastes. For example, metallic mercury is considered to be toxic. Metallic mercury is often used in thermometers and computers. If it is buried in a landfill, the bacteria in a landfill can cause it to react with methane to form methyl mercury. Methyl mercury, which is more toxic than metallic mercury, can cause severe nerve damage.

Land Disposal Most of the hazardous waste produced in the United States is disposed of on land. One land disposal facility, illustrated in **Figure 17,** is called deep-well injection. During **deep-well injection,** wastes are pumped deep into the ground, where they are absorbed into a dry layer of rock below the level of groundwater. After the wastes are buried below the level of groundwater, the wastes are covered with cement to prevent contamination of the groundwater. Another common land disposal facility is a **surface impoundment,** which is basically a pond that has a sealed bottom. The wastes accumulate and settle to the bottom of the pond, while water evaporates from the pond and leaves room to add more wastes.

Hazardous wastes in concentrated or solid form are often put in barrels and buried in landfills. Hazardous waste landfills are similar to those used for ordinary solid waste, but these landfills have extra safety precautions to prevent leakage.

In theory, if all of these facilities are properly designed and built, they should provide safe ways to dispose of hazardous wastes. However, if they are not properly maintained, they can develop leaks that may result in contamination of the air, soil, or groundwater.

CASE STUDY

Love Canal: A Toxic Nightmare

To someone who has never heard of it, Love Canal may sound like a pleasant place for a picnic. But in the minds of people familiar with the abandoned canal site in Niagara Falls, New York, the area is synonymous with chemicals, disease, and financial loss.

The problems began in 1942 when a chemical company bought the area and used it as a dump for toxic wastes. Over the next 11 years, the company buried almost 20,000 metric tons of hazardous chemicals in the canal. At the time, disposing of chemical wastes in this way was legal. It was thought that the thick clay that lined the canal would prevent the wastes from escaping into the surrounding soil.

By 1953, the site was full. It was covered with a cap of clay and soil and was sold to the school board of Niagara Falls. The school board ignored warnings from the chemical company and built an elementary school and playgrounds on top of the canal. In addition, hundreds of homes were built on the canal. Roads and sewer lines were also constructed across the site, which disturbed its clay cap and occasionally exposed barrels of waste. The new homes attracted many new residents, who were not warned about the hazardous waste dump nearby.

By the late 1950s, problems started occurring. Children playing near the school were burned by chemicals that leaked from the

▶ Toxic waste that leaked from the barrels buried at Love Canal leaked into this man's basement.

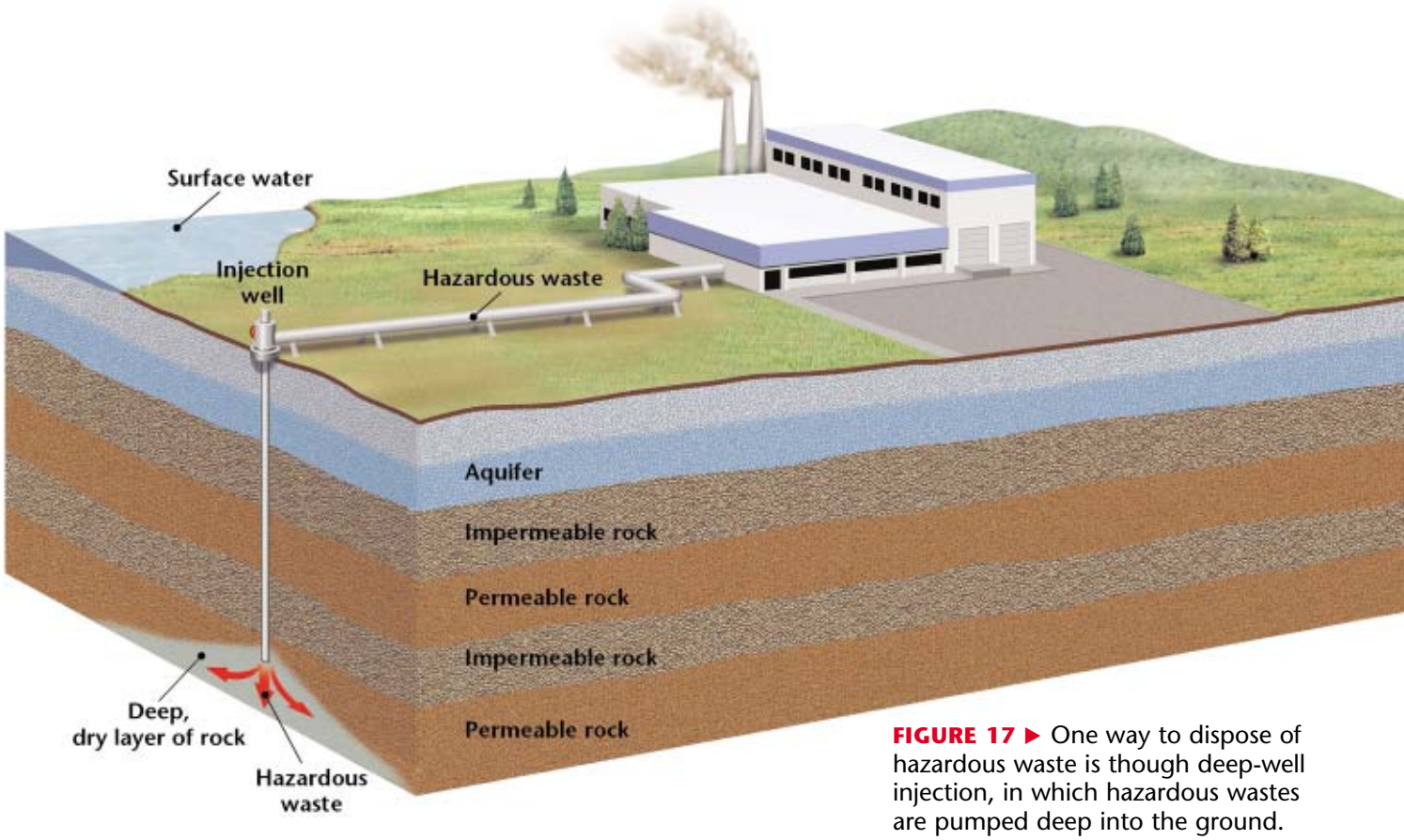


FIGURE 17 ▶ One way to dispose of hazardous waste is though deep-well injection, in which hazardous wastes are pumped deep into the ground.

▶ This chemical plant buried almost 20,000 metric tons of hazardous chemicals in Love Canal.

ground. In the 1960s and 1970s the chemical leaks became more obvious. Puddles of chemicals appeared in backyards. Thick, black sludge oozed into basements. Health problems, such as asthma, dizziness, blurred vision, seizures, miscarriages, stillbirths, and birth defects, became more common among the residents.

Local, state, and federal officials began to take notice of the problems at Love Canal in the mid-1970s. Water-, soil-, and air-quality tests showed chemical contamination. In 1978, the governor of New York ordered the 239 families living closest to the chemical dump to evacuate. The state purchased their homes and paid for their relocation. In 1980, Love Canal was declared a federal disaster area, and another 710 families were relocated.

After years of protests and court cases, a federal judge ruled that the chemical company was responsible for the Love Canal disaster. The company agreed to pay $98 million to the state of New York and agreed to reimburse the state and federal governments for the cleanup.

CRITICAL THINKING

1. Analyzing Ideas Use the Love Canal situation to explain why when we throw something away, it is never really gone.

2. Evaluating Conclusions Now that you have read about Love Canal, how might you change the ways in which we dispose of hazardous waste?

Figure 18 ▶ Chemicals can be used to clean up hazardous wastes. This tractor is spreading chemicals to help break down the oil from an oil spill on a beach in Wales, United Kingdom.

Biologically Treating Hazardous Waste

Some hazardous wastes can be absorbed, broken down, or their toxicity can be reduced when they are treated with biological and chemical agents. Certain bacteria can be used to clean up an area in the environment that has been contaminated with hazardous substances, such as mercury, arsenic, and cyanide. Scientists can grow bacteria in a lab and apply the bacteria to a contaminated area in the environment to break down the hazardous substances. Flowering plants and trees that absorb heavy metals can also be planted in contaminated areas. Chemicals can also be used to neutralize and absorb hazardous wastes. In **Figure 18,** chemicals were applied to an oil spill to help absorb the oil and help prevent harm to the plants and animals that live in and around the beach by hazardous waste.

Incinerating Hazardous Waste Some hazardous wastes are disposed of by burning, often in specially designed incinerators. Incinerators can be a safe way to dispose of waste, but they have several problems. Incineration is generally the most expensive form of waste disposal because they require a lot of energy to operate. Incinerators also need pollution-control devices and need to be carefully monitored so that hazardous gases and particles are not released into the air. Also, after hazardous waste is incinerated, the leftover ash needs to be buried. This ash is usually buried in a hazardous waste landfill.

When we put hazardous waste into disposal facilities for long-term storage the wastes do not disappear. Instead, they must be closely monitored. For example, disposal of radioactive wastes from nuclear reactors is an especially difficult storage problem. The only way to make the radioactive wastes nonhazardous is to let them sit for thousands of years until the radioactivity decreases to safe levels. Therefore, engineers and geologists search for disposal sites that probably will not be damaged by movements of the Earth for thousands of years.

Exporting Hazardous Waste Until recently, only local laws regulated waste disposal in the United States. Companies would often get rid of hazardous wastes by sending them to landfills in other states, especially the less populated southern states. In the 1980s, as southern populations grew, these southern states began to refuse hazardous wastes from other states.

Hazardous wastes are also exported through international trade agreements. Some hazardous wastes are exported to other countries because there may be a facility in another country that specializes in treating, disposing of, or recycling a particular hazardous waste.

Geofact

Biomining Bacteria are not only used to break down hazardous wastes, but they are also used to extract copper and gold from ore. This technique is called *biomining.* Currently, 25 percent of the world's copper is produced through biomining. Today, scientists are attempting to bioengineer bacterial strains that can mine poisonous heavy metals such as arsenic, cadmium, and mercury from ore.

Hazardous Wastes at Home

You may think of hazardous waste management as a problem that only big industries face. However, everyday household products can also create hazardous waste. Chemicals, including house paint, pesticides, and batteries all create hazardous waste and are used in homes, schools, and businesses. Additional hazardous household products are listed in **Table 4.** Hazardous materials poured down the drain or put in the trash end up in solid-waste landfills. These hazardous wastes should instead be disposed of in a specially designed hazardous waste landfill.

Table 4 ▼

Common Hazardous Household Products	
• motor oil	• pesticides
• paints	• fertilizers
• batteries	• cleaners
• computers	• antifreeze
• mobile phones	

Disposing of Household Hazardous Waste To make sure that household hazardous waste is disposed of properly, more and more cities around the country have begun to provide collection for household hazardous waste. Some cities collect materials only once or twice a year, while other cities have permanent facilities where residents can drop off hazardous waste. Trained workers sort the hazardous materials and send some materials for recycling and pack other materials into barrels for disposal. Used batteries and motor oil are recycled. Paint may be blended and used for city park maintenance or to clean up graffiti.

Motor Oil If you have ever changed the oil in your car yourself, you have probably wondered what to do with the old, dirty oil. It is illegal to pour it on the ground or throw it in the trash. But, you may be surprised to find out that people in the United States throw away about 700 million liters (185 million gallons) of used motor oil every year. This amount does not include the oil disposed of by service stations and automobile repair shops.

So what can people do with the oil? One option is to take it to an automobile service station, where it will be turned in for recycling. Some cities have designated oil-collection receptacles as shown in **Figure 19.** These cities recycle the used oil turned in by citizens. If you do not know what services your community provides, you can call your local city government and find out.

Figure 19 ▶ Used motor oil should be disposed of at an automobile service station or in an oil-collection receptacle.

SECTION 3 Review

1. **Name** two characteristics of hazardous waste.
2. **Identify** one law that governs hazardous waste.
3. **Describe** two common ways to dispose of hazardous waste in the United States. What is one advantage and one disadvantage of one of these methods?
4. **Describe** how bacteria could be used to degrade hazardous wastes. Write a short paragraph to explain your answer. WRITING SKILLS

CRITICAL THINKING

5. **Evaluating Ideas** Suppose that a surface impoundment site for hazardous waste is planned for your community. Would you oppose locating the site in your community? Explain your answer.
6. **Applying Ideas** Suppose someone dumped leftover motor oil on a driveway. Could this disposal method contaminate the air, water, or soil? Explain your answer.

CHAPTER 19

Highlights

1 Solid Waste

Key Terms

solid waste, 481
biodegradable, 483
municipal solid waste, 484
landfill, 485
leachate, 485

Main Ideas

- Every year, people in the United States generate more than 10 billion metric tons of soild waste.
- Materials that are biodegradable, such as newspapers and cotton fibers, can be broken down by biological processes. Materials that are not biodegradable such as plastics, are a major cause of disposal problems.
- Municipal solid waste makes up only a small fraction of the total solid waste generated, but it still amounts to over 210 million metric tons per year.
- Landfills and incinerators are two facilities used for disposing solid waste.

2 Reducing Solid Waste

source reduction, 488
recycling, 489
compost, 490

- Source reduction is a method by which we can produce less waste, recycle, and reuse materials.
- Recycling is the process of reusing materials or recovering valuable materials from waste or scrap.
- A compost pile made from plant and animal matter can be spread on gardens and fields to enrich the soil.
- Degradable plastic is a type of plastic that is partially made from living things.

3 Hazardous Waste

hazardous waste, 493
deep-well injection, 496
surface impoundment, 496

- Hazardous waste is any waste that is a risk to the health of humans or other living things.
- The Resource Conservation and Recovery Act (RCRA) and the Superfund Act were established to regulate solid and hazardous waste disposal and to protect humans and the environment from waste contamination.
- Activities at home can create hazardous waste. Household hazardous wastes should be properly disposed of at designated collection sites.

CHAPTER 19 Review

Using Key Terms

Use each of the following terms in a separate sentence.

1. *source reduction*
2. *leachate*
3. *municipal solid waste*
4. *biodegradable*
5. *recycling*

Use the correct key term to complete each of the following sentences.

6. _____ is any waste that is a risk to the health of humans or other living things.
7. A dark brown, crumbly material made from decomposed vegetable and animal matter is called _____.
8. A _____ is a waste disposal facility where wastes are put in the ground and covered each day with a layer of dirt, plastic, or both.

STUDY TIP

Increase Your Vocabulary To learn and remember vocabulary words, use a dictionary for words you do not understand and become familiar with the glossaries of your textbooks.

Understanding Key Ideas

9. Solid waste includes all of the following *except*
   a. newspaper and soda bottles.
   b. food scraps and yard clippings.
   c. ozone and carbon dioxide.
   d. junk mail and milk cartons.
10. If your shirt is made of 50 percent cotton and 50 percent polyester, what part is biodegradable?
    a. cotton
    b. polyester
    c. both (a) and (b)
    d. none of the above
11. Microorganisms are unable to break down plastics because plastics
    a. are made from oil.
    b. are too abundant.
    c. are made of elements not found in any other substance.
    d. do not occur in nature.
12. Municipal solid waste is approximately what percentage of all solid waste?
    a. 2 percent
    b. 20 percent
    c. 60 percent
    d. 90 percent
13. Leachate is a substance that
    a. is produced in a compost pile.
    b. is a byproduct of bacterial digestion.
    c. is produced by incinerators.
    d. contains dissolved toxic chemicals.
14. Which of the following is not a benefit of incinerating waste?
    a. It reduces the amount of material sent to the landfill.
    b. It produces energy in the form of heat.
    c. It can be used to produce electricity.
    d. It neutralizes all of the toxic materials in the waste.
15. Manufacturers could reduce waste and conserve resources by making products that
    a. use more materials.
    b. are more durable.
    c. are difficult to repair.
    d. are disposable.
16. Which of the following is one way to reduce an over-supply of recyclable materials?
    a. build more recycling plants
    b. limit the amount of recyclable materials that can be collected
    c. increase the demand for products made from recycled materials
    d. put the excess materials in landfills
17. Most of the municipal solid waste in the United States is
    a. stored in landfills.
    b. recycled.
    c. incinerated.
    d. None of the above

CHAPTER 19 Review

Short Answer

18. Do you think incineration is an efficient disposal method for glass and metal wastes? Write a short paragraph that explains why or why not. WRITING SKILLS

19. How do plastic liners and layers of clay help protect the environment around a landfill?

20. What are the materials that make up compost? List at least three benefits of composting.

21. How does the Superfund Act allow the federal government to ensure proper disposal of hazardous waste?

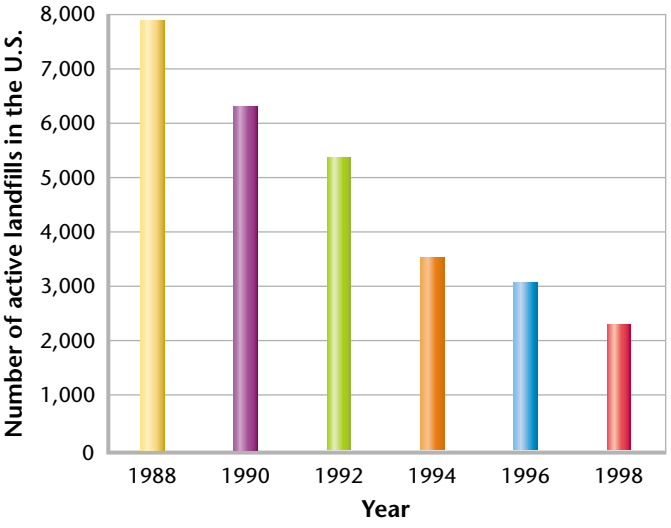
Interpreting Graphics

The graph below shows the number of landfills in the United States from the year 1988 to the year 1998. Use the graph to answer questions 22–24.

22. Approximately how many landfills existed in 1988? in 1998?

23. During the span of 10 years, did the overall number of landfills increase or did the number decrease? What may have caused this change? Explain your answer.

24. If this trend continues, what might the graph look like for the year 2028?



Source: *BioCycle*.

Concept Mapping

25. Use the following terms to create a concept map: *solid waste, hazardous waste, landfills, types of waste, surface impoundment, methods of waste disposal, incineration,* and *deep-well injection.*

Critical Thinking

26. Understanding Concepts During the 1970s, the production of municipal solid waste decreased. An economic recession was also occurring. How might the reduction in waste have been related to the recession?

27. Making Comparisons Read the description of recycling in this chapter and compare the benefits of buying a product that has been recycled to the benefits of buying a brand new product. Which product would you prefer to buy? Explain your answer. READING SKILLS

28. Evaluating Information How would a ban on the production of plastics affect both the environment and society?

29. Identifying Relationships When we purchase hazardous household products, such as motor oil, bleach, and pesticides, what happens to the containers when they are empty? What happens to the hazardous waste that these products create?

30. Predicting Consequences How might a person's current shopping habits affect the quality of the environment 100 years in the future?

Cross-Disciplinary Connection

31. Social Studies Use an almanac to determine which five states have the greatest number of hazardous waste sites. What factors do you think might account for the number of hazardous waste sites located in a state?

Portfolio Project

32. Make a Display Do a special project about recycling in your community. Determine what types of materials are collected, where they are taken for processing, how they are recycled, and what products are made from them. Display your findings on a poster.

MATH SKILLS

Use the table below to answer questions 33–35.

Paper Products in Municipal Solid Waste		
Product	Generation (tons)	Percentage recycled
Newspapers	13,620	56.4
Books	1,140	14.0
Magazines	2,260	20.8
Office papers	7,040	50.4

33. **Evaluating Data** How many tons of paper products were generated according to the table?
34. **Making Calculations** How many tons of newspapers were recycled? How many tons of newspapers were not recycled?
35. **Making Calculations** How many tons of office papers were recycled? How many tons of office papers were not recycled?

WRITING SKILLS

36. **Writing Persuasively** Pretend that you work for a company that sells degradable plastics. Write an advertising campaign that would persuade consumers to buy materials made from your company's brand of degradable plastic.
37. **Outlining Topics** Describe the various ways in which hazardous waste can be disposed. List the advantages and disadvantages of each way.

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.

All organisms need nitrogen to make proteins and nucleic acids. The complex pathway that nitrogen follows within an ecosystem is called the nitrogen cycle. Most living things cannot use nitrogen gas directly from the atmosphere. The process of converting nitrogen gas to compounds that organisms can use is called nitrogen fixation. Organisms rely on the actions of bacteria that are able to transform and "fix" nitrogen gas into these compounds. Nitrogen-fixing bacteria convert nitrogen gas into ammonia, which plants can absorb and use to make proteins. Nitrogen-fixing bacteria live in the soil and in the roots of some kinds of plants, such as beans, peas, clover, and alfalfa.

Decomposers break down the wastes of organisms and release the nitrogen they contain as ammonia. This process is known as ammonification. Through ammonification, nitrogen that would otherwise be lost is reintroduced into the ecosystem.

1. After nitrogen-fixing bacteria convert nitrogen gas into ammonia,
   - **a.** nitrogen fixation occurs.
   - **b.** plants can absorb the ammonia to make proteins.
   - **c.** nitrogen-fixing bacteria absorb the ammonia.
   - **d.** decomposers absorb the ammonia.
2. If decomposers did not break down the waste that organisms create,
   - **a.** nitrogen would be released into the atmosphere as ammonia.
   - **b.** ammonification would occur.
   - **c.** nitrogen-fixing bacteria would not convert nitrogen gas into ammonia.
   - **d.** nitrogen would not be released into the atmosphere as ammonia.

CHAPTER 19

Skills Practice Lab: CONSUMER

Objectives

- **Recognize** various categories and amounts of solid waste produced.
- **Compute** percentages of waste, by category, produced per person in a single meal.
- **Generalize** data from a small sample for a large population using calculations.
- USING SCIENTIFIC METHODS **Infer** from small data samples the impact that waste production has on a large population.
- USING SCIENTIFIC METHODS **Evaluate** how waste data can be used to communicate results and offer solutions.

Materials

balance, triple beam or electronic calculator
paper towels
plastic bags
ruler

Solid Waste in Your Lunch

Are you aware of how much waste you produce during one meal? Various government and private agencies study the amount and types of food waste we produce and are continuously working to solve the problems of waste disposal. In this lab activity, you will determine how much solid waste you produce during a typical lunch. You will also predict through calculations how much solid waste your school population produces during lunch.

Procedure

1. Collect all your lunch waste on the day of the lab activity or the day before the lab activity depending on whether your class meets before or after lunch. Put all of your lunch waste in a plastic bag, including leftover food items, wrappers, napkins, straws, unopened containers of condiments, and disposable trays.
2. Each lab group member should place his or her plastic bag of waste on the worktable. Each member should separate his or her waste on a paper towel into the following categories: paper and cardboard, plastic, metal, glass, wood, and food.
3. Determine the mass of the waste in grams produced for each category for each person in the group. Create a data table similar to the one shown below and record the masses.
4. Detemine the total mass for each category for the lab group. Then, determine the average mass of solid waste per student for each category. Finally, determine the overall total amount of solid waste produced for each student.

Waste category	Student 1	Student 2	Student 3	Total mass of lab group	Average mass/student
Paper and cardboard					
Plastic					
Metal					
Glass					
Wood					
Food					
Total					

Analysis

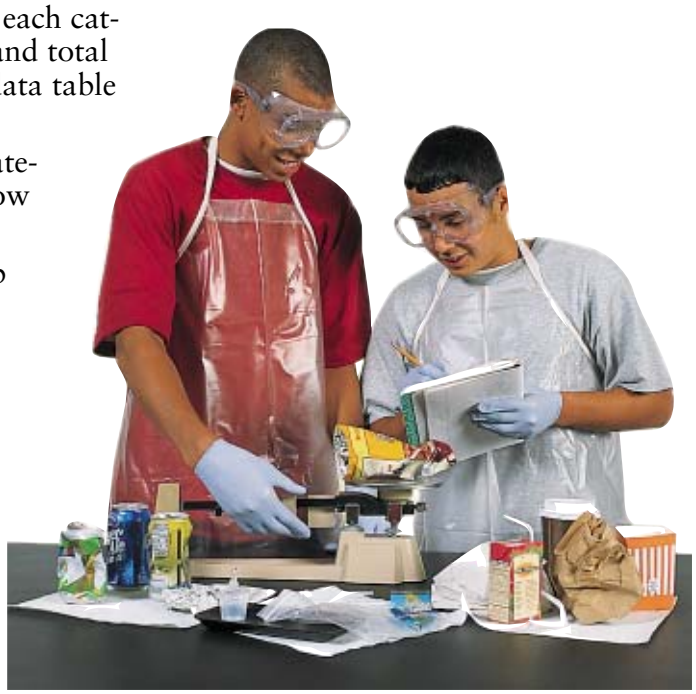
1. **Organizing Data** Use the equation below to determine the percentage for each waste category that makes up your total waste as an individual. Add another column to your data table to record this value.

$$\frac{\text{Mass (in grams) of waste category}}{\text{Mass (in grams) of total waste}} \times 100 = \text{waste category's percentage of total waste}$$

2. **Organizing Data** Use the equation above to determine the percentage for each waste category that makes up the total waste for your lab group. Divide the total waste for each category from the table on the previous page by the grand total and multiply by 100. Add another column to your data table to record these values.
3. **Examining Data** Compare your averages for each category and the total with other groups in the class. How and why are the data different or similar?
4. **Examining Data** Which category of waste makes up the greatest percentage of the total waste? Explain your answer.

Conclusions

5. **Making Predictions** How can you calculate the lunch waste produced in each category and overall by your entire school's student body in a day? Use your equation to make this calculation.
6. **Applying Conclusions** How can you use the knowledge you have acquired by doing this calculation exercise to reduce the amount of waste you produce?



▶ **Step 4** Determine the mass of the waste produced in grams for each category of waste.

Extension

1. **Research and Communications** Write a letter to the editor of your school's newspaper, the editor of the local newspaper, or your school's principal or cafeteria manager sharing the data your class has gathered and calculated. Offer creative solutions to eliminate and reduce some of the waste.

POINTS of view

SHOULD NUCLEAR WASTE BE STORED AT YUCCA MOUNTAIN?

Yucca Mountain, in Nevada, has been chosen as the location for the nation's first permanent storage site for nuclear waste. Nuclear fuel is used to generate electricity. Nuclear waste is created after nuclear fuel can no longer be used to generate electricity. This waste is called high-level radioactive waste. High-level radioactive waste includes solids, liquids, and gases that contain a high concentration of radioactive isotopes that take thousands of years to decay. The idea is to seal 77,000 tons of radioactive waste in steel canisters and store the canisters in underground tunnels designed to last 10,000 years. Yucca Mountain is scheduled to receive its first shipment of nuclear waste by 2010.

Construction of the facility has already begun. But the debate continues about whether it would be safer to store radioactive wastes at Yucca Mountain or to keep them where they are now—in temporary storage facilities at each nuclear power plant.

For the Yucca Mountain Site

Those who support construction of the facility point out that there are two major advantages to the plan. First, Yucca Mountain is located in a remote region that is far from large populations of people. Second, the climate is extremely dry. Yucca Mountain usually receives less than 20 cm of precipitation a year, most of which evaporates before it can soak into the ground. Therefore, this dry climate means that precipitation is unlikely to cause the water table to rise and come in contact with the stored nuclear waste. Water is the primary way by which radioactive material could move from the storage facility.

Many opponents of the site worry that changes in the climate might cause the water table to rise. They say groundwater could then reach the stored nuclear waste and become contaminated. However, supporters of the site point to several scientific studies, which determined that no significant rise or fall of the water table has occurred in the past.

Operators of nuclear power plants are anxious for the Yucca Mountain facility to be completed. Currently, each power plant stores its nuclear waste near the plant. Many of these storage sites have been in use for decades and are approaching their maximum capacity.

Some people believe that storing wastes in one location will be safer than storing them at the individual power plants. In addition, some of the nuclear waste is contained in pools of water rather than in underground containers. Some people fear that the hazardous wastes could leak into neighborhoods around the country.

Supporters of the Yucca Mountain storage facility think that this isolated location in Nevada is a suitable place for permanent nuclear-waste disposal.

Against the Yucca Mountain Site

Perhaps the fiercest outcry against the Yucca Mountain site comes from Nevada residents. They fear that if tons of highly toxic waste are stored in one place, some of it might eventually leak. Because some of this waste is so toxic that a tiny amount could be lethal, a major environmental disaster could result if small quantities of waste reach the environment.

Some people are concerned that the radioactive waste might leak into the groundwater. The waste containers are expected to last 500 to 1,000 years, but they will have to remain isolated and not come into contact with water for 10,000 years. Opponents of the plan say

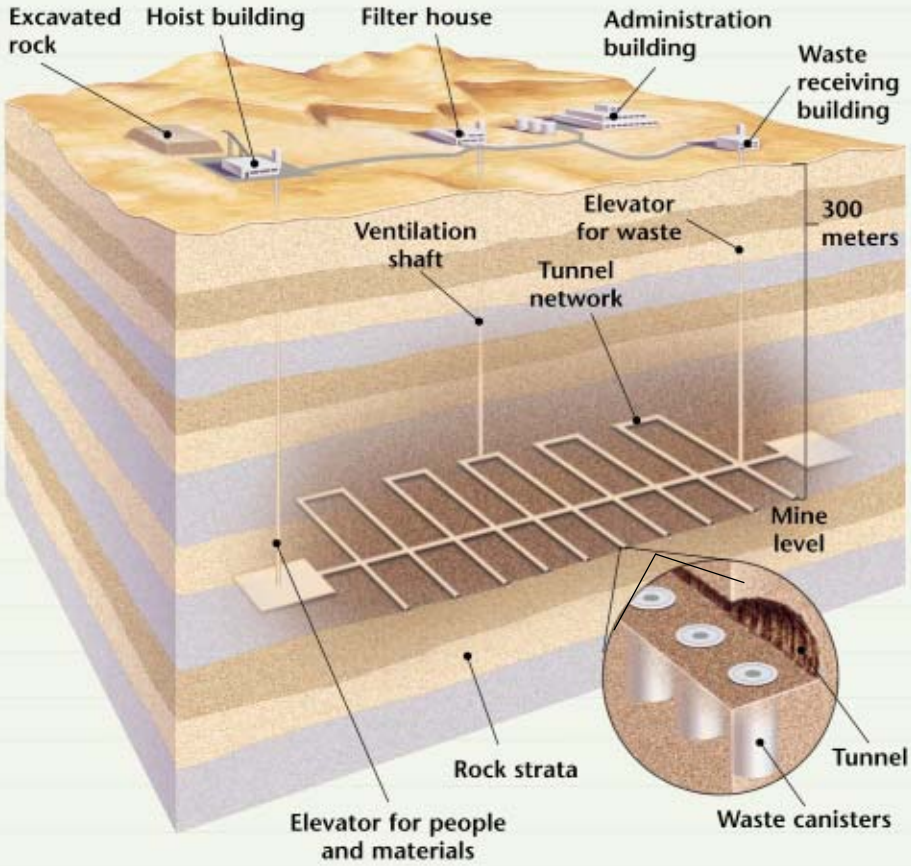
▶ Supporters of the Yucca Mountain storage facility think that this isolated spot in Nevada is a suitable place for permanent nuclear-waste disposal.

that nobody can guarantee that the containers will remain isolated for that long.

If radioactive waste leaked out of the facility, the waste could contaminate the water in wells, springs, and streams. In time, the contamination could spread from the site and into the environment.

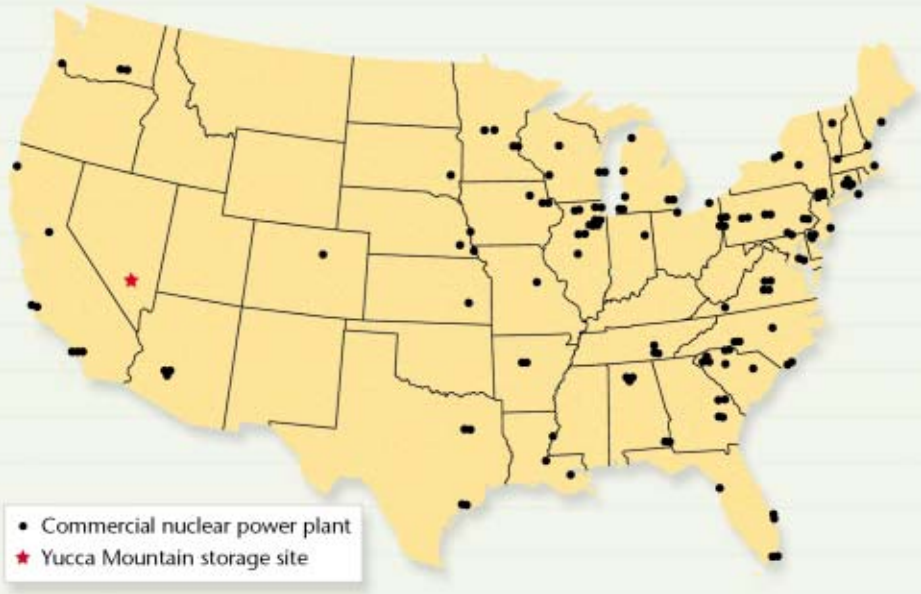
Another worry is that transporting nuclear waste across vast distances to Yucca Mountain is riskier than leaving the material near the facilities where it is produced. Any accident along the way could release radioactivity into the environment.

Most opponents of the Yucca Mountain site agree that current methods of storing nuclear waste are dangerous and should be improved. They suggest that by transferring the waste to solid steel and concrete containers, the waste could be safely stored at each nuclear power facility for 75 to 100 years. By that time, they suggest, more will be known about how to store the wastes safely for thousands of years.



▶ The preliminary plan for the Yucca Mountain nuclear-waste storage facility shows radioactive materials carefully packaged and buried in tunnels deep underground.

▶ This map shows the nuclear power plants around the country that are possible sources of nuclear waste for the Yucca Mountain facility.



What Do You Think?

There are over 100 nuclear power facilities in the United States. Using the Internet, research to find a nuclear power facility near your community. If there is not one near your community, how close is the nearest nuclear power facility? Is this nuclear power plant still in operation? After researching, would you be for or against the Yucca Mountain site?