Waste

CHAPTER 19

READING WARM-UP

Before you read this chapter, take a few minutes to answer the following questions in your ***EcoLog.***

1. Which one of the following materials do you think makes up the largest percentage of household and business waste: plastic, glass, or paper?
2. What actions do you now take to reduce the amount of waste you produce? What else could you do to reduce the waste you produce?

This landfill in New Jersey stores municipal solid waste that people throw away on a day-to-day basis. Every year, the United States generates more than 210 million metric tons of municipal solid waste.

SECTION 1

Solid Waste

It is lunchtime. You stop at a fast-food restaurant and buy a burger, fries, and a soda. Within minutes, the food is gone, and you toss your trash into the nearest wastebasket. **Figure 1** shows what might be in your trash: a paper bag, a polystyrene burger container, the cardboard carton that held the fries, a paper cup with a plastic lid, a plastic straw, a handful of paper napkins, and several ketchup and mustard packets. Once you throw away your trash, you probably do not give it a second thought. But where does the trash go?

The trash from the wastebasket probably will be picked up by a collection service and taken to a landfill, where the trash will be dumped with thousands of tons of other trash and covered with a layer of soil. That trash will not bother anyone anymore, will it? Maybe not, unless the landfill fills up next year and the city has no place to put the garbage. What would happen if rainwater ran down into the landfill, and leached a harmful chemical, such as paint thinner, and it seeped into the groundwater? Suddenly, the trash that was not bothering anyone is causing an environmental problem.

Objectives

- Name one characteristic that makes a material biodegradable.
- Identify two types of solid waste.
- Describe how a modern landfill works.
- Name two environmental problems caused by landfills.

Key Terms

solid waste
biodegradable
municipal solid waste
landfill
leachate

The Generation of Waste

Imagine multiplying the waste disposal problems that come with your lunch by the number of things that you and everyone else throw away each day. Every year, the United States generates more than 10 billion metric tons of solid waste. **Solid waste** is any discarded solid material. Solid waste includes everything from junk mail to coffee grounds to cars. Many products that we buy today are used once and then thrown away. As a result, the amount of solid waste each American produces each year has more than doubled since the 1960s.

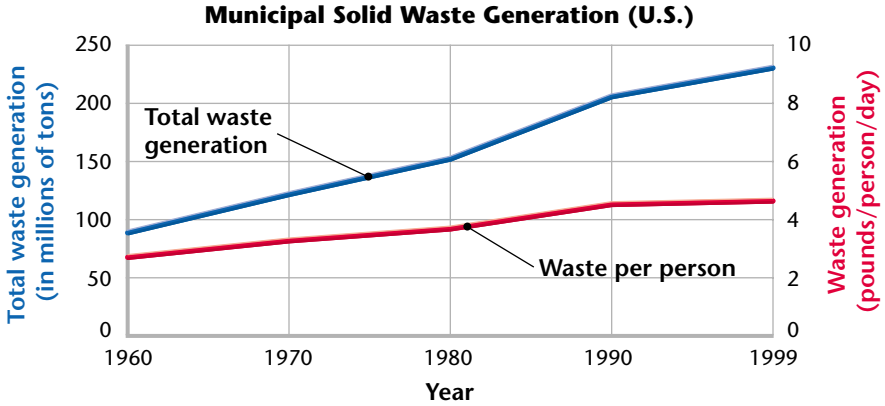
Figure 1 ▶ Where does your trash go when you throw it away?

Figure 2 ▶ The barge *Mobro* (right) from Islip, New York, sailed up and down the East Coast and to the Gulf of Mexico for five months looking for a place to dump its load of garbage. The map below shows its route.

Space and Waste Today, many towns are running out of space to dispose of the amounts of waste that people create. For example, in 1987, the barge shown in **Figure 2** was loaded with 3,200 tons of garbage and left the town of Islip, New York, in search of a place to unload its waste. The barge sailed along the Atlantic coast to the Gulf of Mexico for more than five months in search of a state that would be willing to dispose of the waste. When no one would accept the garbage, it was finally burned in New York, and the 430 tons of ash was sent to Islip to be buried.

Population and Waste While the Earth's human population and the amount of waste we produce grows larger, the amount of land available per person becomes smaller. Thousands of years ago, in the time of hunter-gatherer societies, the human population was smaller and the waste created consisted mostly of animal and vegetable matter. This type of waste combined with a large amount of land made disposing the waste much easier. However, today, the average person living in the United States produces 4.4 pounds of solid waste per day, as shown in **Figure 3.** Because the human population and the amount of waste we create is increasing and the amount of land available is decreasing, it is getting harder to dispose of the waste we create.

Figure 3 ▶ The total amount of municipal solid waste generated in the United States has doubled in the past 40 years.



Source: U.S. Environmental Protection Agency.

Not All Wastes Are Equal

Problems are caused not only by the amount of solid waste but also by the type of solid waste. There are two basic materials that wastes are made of: wastes made of biodegradable materials and wastes made of nonbiodegradable materials. A material is **biodegradable** if it can be broken down by biological processes. Plant and animal matter are examples of biodegradable materials that can be broken down and absorbed by the environment. Products made from natural materials are usually biodegradable. Examples of biodegradable products include newspapers, paper bags, cotton fibers, and leather.

Many products made from synthetic materials are not biodegradable. A *nonbiodegradable material* cannot be broken down by biological processes. Synthetic materials are made by combining chemicals to form compounds that do not form naturally. Some examples of synthetic materials are polyester, nylon, and plastic.

Plastic Problems Plastics illustrate how nonbiodegradable materials can cause problems. Plastics are made from petroleum or natural gas. Petroleum and natural gas consist mostly of carbon and hydrogen, which are the same elements that make up most molecules found in living things. But in plastics, these elements are put together in molecular chains that are not found in nature. Over millions of years, microorganisms have evolved the ability to break down nearly all biological molecules. However, microorganisms have not developed ways to break down the molecular structures of most plastics. Therefore, some plastics that we throw away may accumulate and last for hundreds of years.

Ecofact

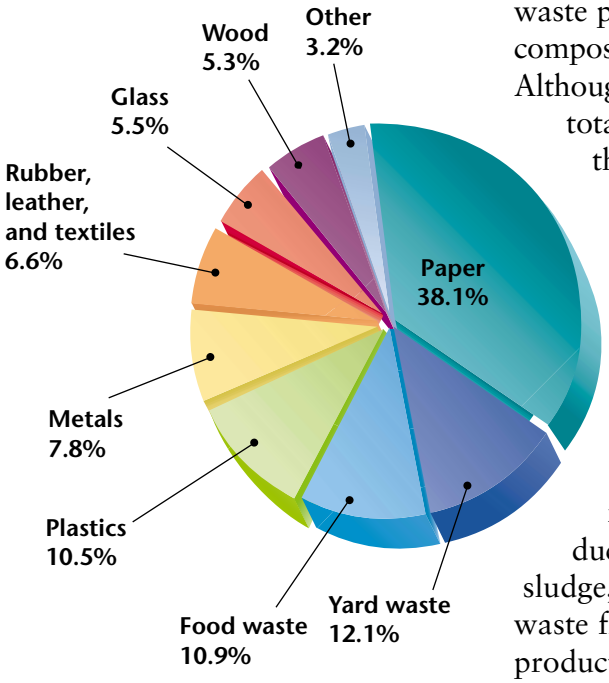
Breaking Down Biodegradable Material Decomposers, such as fungi and bacteria, are examples of organisms that break down biodegradable material. Once these materials are broken down, they can be reused by other organisms. Scavengers, such as vultures, and insects, such as dung beetles, also help recycle organic waste.

Types of Solid Waste

Most of what we throw out on a day-to-day basis is called municipal solid waste. Manufacturing waste, such as the computers shown in **Figure 4,** and mining waste make up about 70 percent of the other types of solid waste produced in the United States.

Figure 4 ▶ These discarded computers have been exported from the United States and disposed of in China. Unwanted computers, televisions, audio equipment, and printers, are types of electronic waste.

United States Municipal Solid Waste (Percentage by Weight)



Source: U.S. Environmental Protection Agency.

Figure 5 ▶ Paper makes up most of the municipal solid waste in the United States. How much of the waste shown in this graph could be recycled?

Municipal Solid Waste About 2 percent of the total solid waste in the United States is made up of **municipal solid waste,** which is the waste produced by households and businesses. **Figure 5** shows the composition of municipal solid waste in the United States. Although municipal solid waste makes up only 2 percent of the total solid waste in the United States, this amounts to more than 210 million metric tons each year. That is enough waste to fill a convoy of garbage trucks that would stretch around the Earth about six times. Furthermore, the amount of municipal solid waste is growing much faster than the amount of mining or agricultural waste.

Solid Waste from Manufacturing, Mining, and Agriculture Solid waste from manufacturing, mining, and agriculture make up the rest of the total solid waste produced in the United States. Solid waste from manufacturing makes up 56 percent of the total solid waste produced and includes items such as scrap metal, plastics, paper, sludge, and ash. Although consumers do not directly produce waste from manufacturing, they indirectly create it by purchasing products that have been manufactured.

Waste from mining consists of the rock and minerals that are left over from excavation and processing. This waste is left exposed in large heaps, is dumped in oceans or rivers, or is disposed of by refilling and landscaping abandoned mines. Agricultural waste makes up 9 percent of the total solid waste produced and includes crop wastes and manure. Because agricultural waste is biodegradable, it can be broken down and returned to the soil. However, the increasing use of fertilizers and pesticides may cause agricultural waste to become more difficult to dispose of because the waste may be harmful if returned to the soil.

MATH PRACTICE

Municipal Solid Waste
The United States generated approximately 229.9 million tons of municipal solid waste in 1999. In 1998, the United States generated approximately 223 million tons of municipal solid waste. What was the percent increase in municipal solid waste generation from 1998 to 1999?

Solid Waste Management

Most of our municipal waste in the United States is sent to landfills such as the one shown in **Figure 6.** However, some of our waste is incinerated, and more than 28 percent of our waste is recycled. By comparison, in 1970, we recycled only 6.6 percent of our waste.

Figure 6 ▶ Modern landfills are lined with clay and plastic and have a system for collecting and treating liquid that passes through the compacted solid waste.

Landfills More than 50 percent of the municipal and manufacturing solid waste created in the United States ends up in landfills as shown in **Table 1.** A **landfill** is a permanent waste-disposal facility where wastes are put in the ground and covered each day with a layer of soil, plastic, or both. The parts of a modern landfill are shown in **Figure 7.** The most important function of a landfill is to contain the waste that is buried inside and to keep the waste from causing problems with the environment. Most importantly the waste inside a landfill must not come into contact with the soil and groundwater that surrounds the landfill.

Problems with Landfills One problem with landfills is leachate. **Leachate** is a liquid that has passed through compacted solid waste in a landfill. Leachate forms when water seeps down through a landfill and contains dissolved chemicals from decomposing garbage. Leachate may contain chemicals from paints, pesticides, cleansers, cans, batteries, and appliances. Landfills typically have monitoring wells and storage tanks to measure and store leachate. Stored leachate can then be treated as waste water. However, if landfills are not monitored properly, leachate can flow into groundwater supplies and make water from nearby wells unsafe to drink.

Another problem with landfills is methane. As organic waste decomposes deep in the landfill where there is no oxygen, it produces methane, a highly flammable gas. Methane gas is usually pumped out of landfills and used as fuel. However, if methane gas production is not monitored safely, it may seep through the ground and into basements of homes up to 300 m from a landfill. If the methane is ignited by a spark, it can cause dangerous explosions.

Table 1 ▼

Where Waste in the United States Goes

Waste-disposal method	Percentage of waste by weight
Stored in landfills	57
Recycled	28
Incinerated	15

Figure 7 ▶ This landfill generates electricity by burning methane gas that is produced by decomposing garbage.

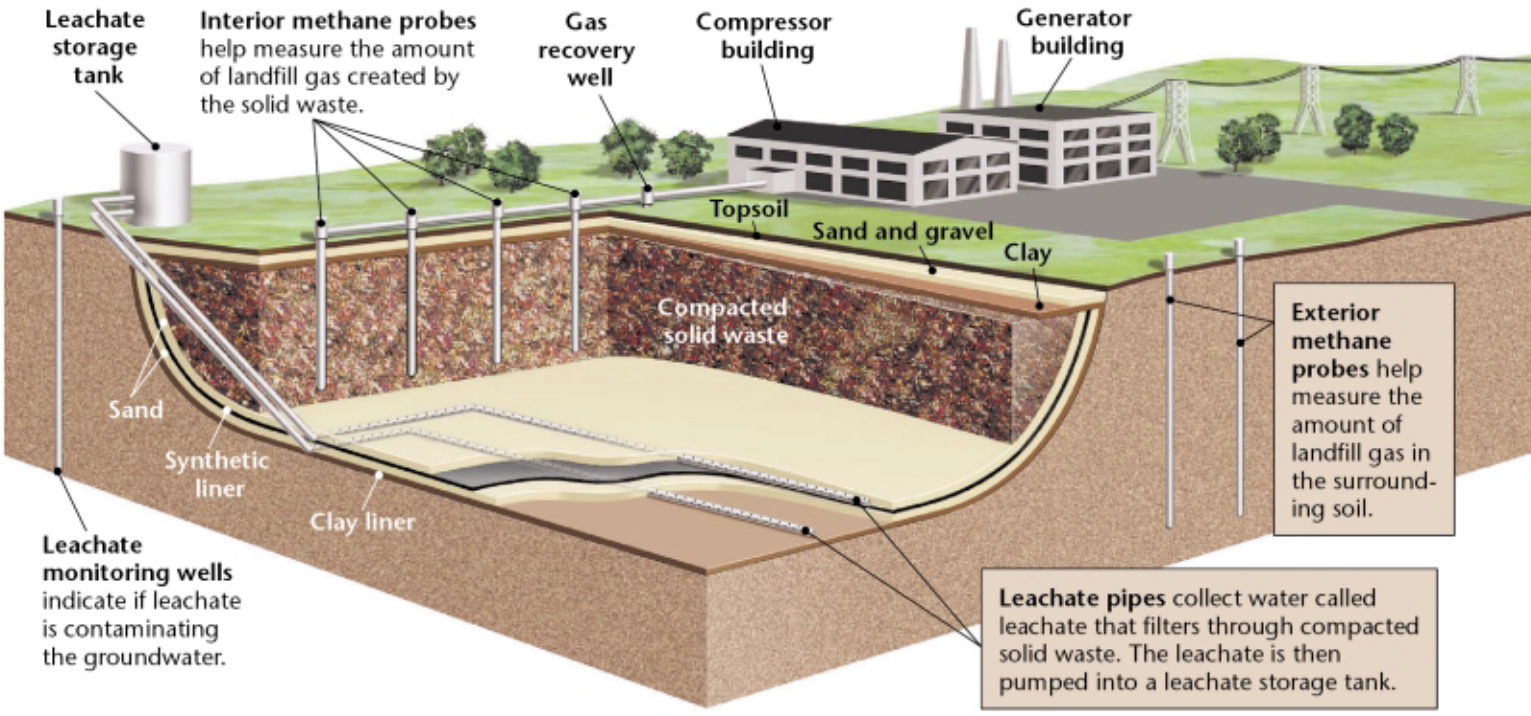


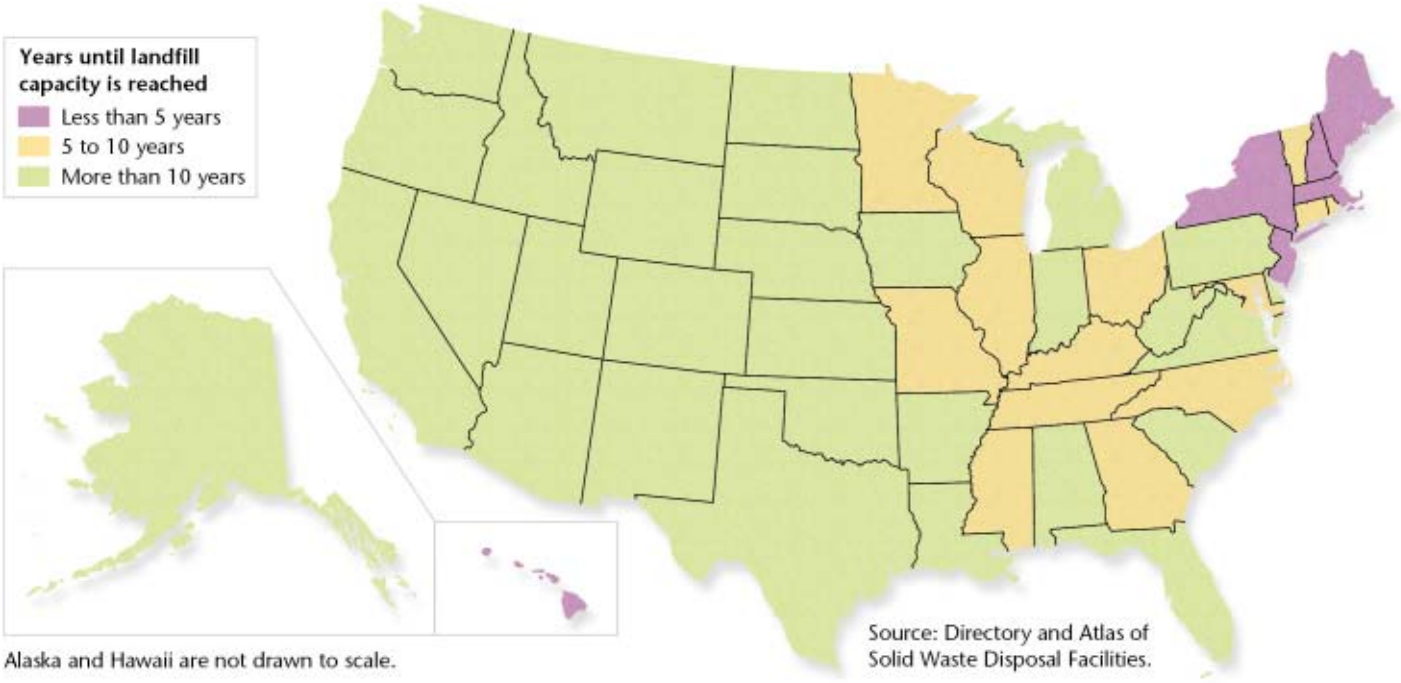
Figure 8 ▶ Biodegradable materials do not degrade quickly in modern landfills. This newspaper was put in a Tempe, Arizona landfill in 1971 and was removed in 1989.

Safeguarding Landfills The Resource Conservation and Recovery Act, passed in 1976 and updated in 1984, requires that new landfills be built with safeguards to reduce pollution problems. New landfills must be lined with clay and a plastic liner and must have systems for collecting and treating leachate. Vent pipes must be installed to carry methane out of the landfill, where the methane can be released into the air or burned to produce energy.

Adding these safeguards to landfills increases the cost of building them. Also, finding acceptable places to build landfills is difficult. The landfills must be close to the city producing the waste but must be far enough from residents who object to having a landfill near their homes. Any solution is likely to be expensive, either because of the legal fees a city must pay to fight residents' objections or because of the cost of transporting garbage to a distant site.

Building More Landfills Although we can build safer landfills, we are currently running out of space that we are willing to develop for new landfills. The materials we bury in landfills are not decomposing as fast as we can fill landfills. Even biodegradable materials, such as the newspaper in **Figure 8**, take several years to decompose. The total number of active landfills in the United States in 1988 was 8,000. By 1999, the total number of active landfills decreased to 2,300 because many landfills had been filled to capacity. The U.S. Environmental Protection Agency (EPA) estimates that the active landfills in 20 states will be filled to capacity within 10 years as shown in **Figure 9.**

Figure 9 ▶ The map below shows the number of years until landfill capacity is reached in each state.

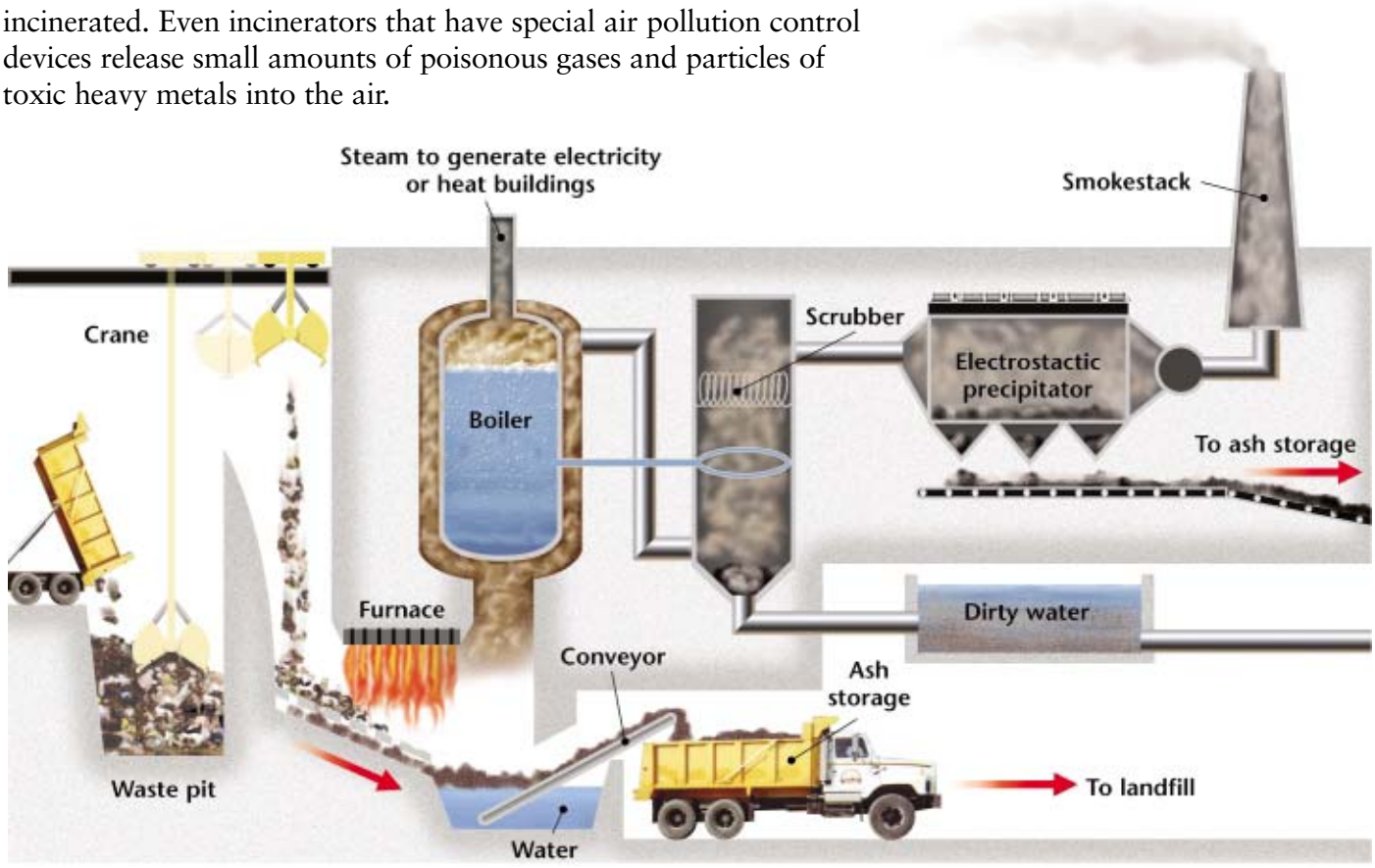


Alaska and Hawaii are not drawn to scale.

Incinerators One option for reducing the amount of solid waste sent to landfills is to burn it in incinerators, as shown in **Figure 10.** In 1999, the United States had 102 operational incinerators that were capable of burning up to 94,000 metric tons of municipal solid waste per day. However, the waste that is burned does not disappear. Although incinerators can reduce the weight of solid waste by 75 percent, incinerators do not separate materials that should not be incinerated before burning the waste. So, some materials such as cleansers, batteries, and paints that should not be burned, end up in the air as polluting gases. The rest of the solid waste is converted into ash that must be disposed of in a landfill.

Incinerated materials take up less space in landfills, but the incinerated material can be more toxic than it was before it was incinerated. Even incinerators that have special air pollution control devices release small amounts of poisonous gases and particles of toxic heavy metals into the air.

Figure 10 ▶ A solid-waste incinerator reduces the amount of trash that goes to landfills and can be used to generate electricity. However, the material that is created by the incinerator can be toxic.



SECTION 1 Review

1. **Explain** what makes a material biodegradable.
2. **Compare** municipal solid waste and manufacturing solid waste.
3. **Describe** how a modern landfill works. Write a short paragraph to explain your answer. List two environmental problems that can be caused by landfills.
   WRITING SKILLS
4. **Describe** one advantage and one disadvantage of incinerating solid waste.

CRITICAL THINKING

5. **Identifying Relationships** Name two nonbiodegradable products that you use. What makes these products nonbiodegradable? Name two biodegradable products that you can use instead.
6. **Identifying Alternatives** What can you do to help reduce the amount of solid waste that you throw away? What can you do to help people in your neighborhood reduce the amount of solid waste that is thrown away?

SECTION 2

Reducing Solid Waste

Objectives

- Identify three ways you can produce less waste.
- Describe how you can use your consumer buying power to reduce solid waste.
- List the steps that an item must go through to be recycled.
- List two benefits of composting.
- Name one advantage and one disadvantage to producing degradable plastic.

Key Terms

source reduction
recycling
compost

If landfills and incinerators can pollute the environment and are expensive to operate, what else can we do to safely reduce solid waste? This section examines ways to reduce solid waste through producing less waste, recycling, and changing the materials and products we use. All of these techniques help reduce waste before it is delivered to landfills or incinerators. This method of reducing solid waste is known as source reduction. **Source reduction** is any change in design, manufacture, purchase, or use of materials or products to reduce their amount or toxicity before they become municipal solid waste.

Reducing Solid Waste

If we produce less waste, we will reduce the expense and difficulty of collecting and disposing of it. Many ideas for reducing waste are common sense, such as using both sides of a sheet of paper and not using unneeded bags, napkins, or utensils at stores and restaurants.

Buying Less As a consumer, you can influence manufacturers to reduce solid waste. If you buy products that have less packaging and products that last longer or that can be used more than once, manufacturers will produce more of those products to satisfy the demand of the consumer. For example, you can buy products such as dish towels instead of paper towels, as shown in **Figure 11.** You can also buy rechargable batteries instead of regular batteries to help reduce solid waste.

Until about 1965, nearly all bottled beverages were sold in bottles that were designed to be returned to stores when empty. The empty bottles were then collected, washed, and refilled at bottling plants. Today, there is a demand for disposable bottles rather than for refillable bottles. If consumers began to use more refillable bottles, beverage manufacturers would begin producing the refillable bottles, similar to those used in the past.

Lasting Longer Manufacturers could also reduce waste and conserve resources by redesigning products to use less material. A return to products that last longer and that are designed to be easily repaired would both save resources and reduce waste disposal problems.

Figure 11 ▶ You can help reduce solid waste by purchasing items that have less packaging. Purchasing items that last longer, such as dish towels, can also reduce solid waste.

Recycling

In addition to reducing waste, we need to find ways to make the best use of all the materials we throw away. **Recycling** is the process of reusing materials or recovering valuable materials from waste or scrap. Making products from recycled materials usually saves energy, water, and other resources. For example, 95 percent less energy is needed to produce aluminum from recycled aluminum than from ore. About 75 percent less energy is needed to make steel from scrap than from ore. And about 70 percent less energy is needed to make paper from recycled paper than from trees.

Recycling: A Series of Steps When most people think about recycling, they probably think of only the first step of bringing their bottles, cans, and newspapers to a recycling center or putting these things at the curb in specially marked containers. However, as shown in **Figure 12,** recycling actually involves a series of steps that must happen for recycling to work.

First, the discarded materials must be collected and sorted by type. Next, each type of material must be taken to a facility where it can be cleaned and made ready to be used again. For example, glass is sorted by color and is crushed, and paper is sorted by type and made into a pulp with water. Then the materials are used to manufacture new products. Finally, the new products are sold to consumers. If more people buy products made from recycled materials, there will be an increase in the demand for these products. This demand encourages manufacturers to build facilities to make recycled products. When such facilities are built, it becomes easier for communities to sell the materials they collect from residents for recycling.

FIELD ACTIVITY

Is It Really Recyclable?
Conduct a survey of the plastic containers in your household that are recyclable. Note the number of plastic containers found in your household. Now look at the number printed on the bottom of each container. The plastics industry has established a system of designating which plastics are recyclable. Types 1 and 2 are most commonly recycled by most communities. Type 4 is less commonly recycled, and types 3, 5, 6, and 7 are most likely not to be recycled. In your ***EcoLog,*** record the total number of plastic containers for each type of plastic that you find in your household. How many Type 1 and Type 2 plastic containers did you find in your household?

Figure 12 ▶ The steps of recycling include ❶ collecting and sorting discarded materials by type, ❷ taking the materials to a recycling facility, ❸ cleaning the discarded materials so that they can be shredded or crushed, and ❹ reusing the shredded or crushed material to manufacture new products.

Table 2 ▼

Benefits of Composting
• keeps organic wastes out of landfills
• provides nutrients to the soil
• increases beneficial soil organisms, such as worms and centipedes
• suppresses some plant diseases
• reduces the need for fertilizers and pesticides
• protects soil from erosion

Composting Yard waste often makes up more than 15 percent of a community's solid waste. None of this waste has to go to a landfill. Because yard waste is biodegradable, it can decompose in a compost pile. Many people also put fruit and vegetable trimmings and table scraps in their compost piles. The warm, moist, dark conditions inside a large pile of biodegradable material allow bacteria to grow and break down the waste rapidly. Eventually the material becomes **compost,** a dark brown, crumbly material made from decomposed plant and animal matter that is spread on gardens and fields to enrich the soil. Compost is rich in the nutrients that help plants grow. More benefits of composting are listed in **Table 2.**

Some cities collect yard waste from homes and compost it at a large, central facility. Although most city composting facilities in the United States collect only yard wastes, several European cities also collect and compost food wastes in municipal facilities. Composting can also be an effective way of handling waste from food-processing plants and restaurants, manure from animal feedlots, and municipal sewage sludge. If all biodegradable wastes were composted, the amount of solid waste going to landfills could be reduced.

CASE STUDY

Paper or Plastic?

The following question may sound familiar: Do you want paper or plastic? If you have ever stood in the checkout line of a grocery store, it probably is. Almost every grocery store today offers a choice between either paper or plastic bags for sacking grocery items. Many people make their choice based on convenience. But what is the best choice for someone who is concerned about the environment?

On the surface, it may seem that paper is the better choice. Paper comes from a renewable resource—trees—and is biodegradable. Plastic, on the other hand, comes from petroleum or natural gas, which are usually considered nonrenewable resources. In addition, plastic bags are not biodegradable.

Upon closer examination, however, the decision may not be as simple as it seems. Removing large numbers of trees from forests to manufacture paper can disrupt woodland ecosystems. Plus, a tremendous amount of energy is required to convert trees into pulp and then manufacture paper from the pulp.

To make the best decision about which product is better for the environment, the following questions should be considered.

- How much raw material, energy, and water is needed to manufacture each bag?
- What waste products will result from the manufacture of each bag, and what effect will those wastes have on water, the atmosphere, and land?

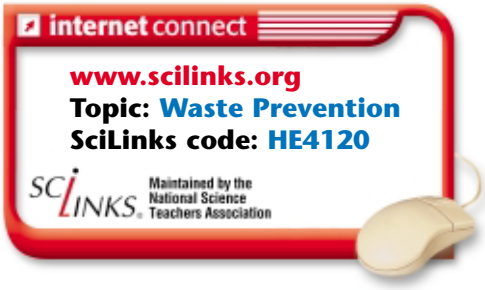
▶ Making an educated decision at the grocery store will help reduce solid waste.

- Can recycled materials be used in the manufacture of the bag? If so, to what degree will the use of recycled materials reduce the amount of raw materials, energy,

Changing the Materials We Use

Simply changing the materials we use could eliminate much of the solid waste we produce. For example, single-serving drink boxes are made of a combination of foil, cardboard, and plastic. The drink boxes are hard to recycle because there is no easy way to separate the three components. More of our waste could be recycled if such products were no longer made and if all drinks came in recyclable glass, cardboard, or aluminum containers.

Recycling other common household products into new, useable products could also help eliminate solid waste. For example, newspapers can be recycled to make cardboard, egg cartons, and building materials. Telephone books, magazines, and catalogs can also be recycled to make building materials. Used aluminum beverage cans can be recycled to make new beverage cans, lawn chairs, aluminum siding for houses, and cookware. Used glass jars and bottles can be recycled to make new glass jars and bottles. Finally, plastic beverage containers can be recycled to make nonfood containers, insulation, carpet yarn, textiles, fiberfill, scouring pads, toys, plastic lumber, and crates.



and water used and wastes produced in making the bag?
- How will the bag decompose, and what will the environmental impact be if it is incorrectly disposed of?

Although several studies have analyzed these questions, most have been conducted by parties with a vested interest, such as plastic or paper manufacturing companies. As you might expect, the studies done by plastic manufacturers conclude that plastic bags have the least environmental impact, while studies done by paper producers conclude that paper bags have the least environmental impact. Often, these researchers fail to study all of the important factors listed above.

But the plastic versus paper debate has caused both industries to improve the way their products affect the environment. For example, paper bags recently outsold plastic bags because they were considered stronger, better for reusing or recycling, and less harmful in a landfill.

Then, new technology allowed the plastics industry to gain a larger market share. By incorporating recycled plastic into the bags, manufacturers improved the image of plastic bags.

Therefore, the debate continues and environmentally conscious people are still wondering which is better. Right now there seems to be no right answer. However, the following are environmentally sound options.

- Carry your groceries in bags brought from home (paper, plastic, or canvas bags).
- Choose the bag you are most likely to reuse in the future.
- If you have only one or two small items do not use a bag.

▶ A reusable canvas shopping bag may be the best response to the paper-or-plastic question.

CRITICAL THINKING

1. Identifying Relationships
Explain how environmentally conscious shoppers have helped improve paper and plastic bag manufacturing in this country.

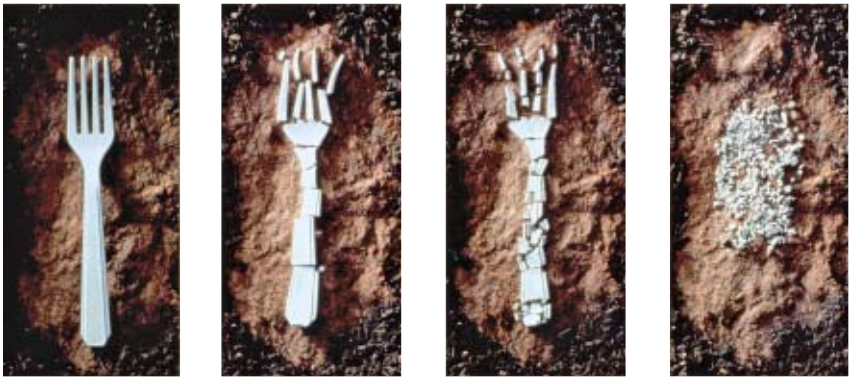
2. Understanding Concepts
Why should a person care which bag he or she is given at the grocery store?

Degradable Plastics As you read earlier, most plastics are not biodegradable. To make plastic products more appealing to people who are concerned about the environment, several companies have developed new kinds of plastics that they say are degradable. One type, called *photodegradable plastic,* is made so that when it is left in the sun for many weeks, it becomes weak and brittle and eventually breaks into pieces.

Another type of degradable plastic, called *green plastic,* is made by blending the sugars in plants with a special chemical agent to make plastic. Green plastics are labeled as green because they are made from living things and are considered to be more environmentally friendly than other plastics. The production of green plastics requires 20 to 50 percent less fossil fuel than the production of regular plastics does. The fork in **Figure 13,** is made of green plastic. This plastic has been engineered to degrade within 45 days of being thrown away. When this plastic is buried, the bacteria in the soil eat the sugars and leave the plastic weakened and full of microscopic holes. The chemical agent then gradually causes the long plastic molecules to break into shorter molecules. These two effects combine to cause the plastic to eventually fall apart into small pieces.

Problems with Degradable Plastics The main problem with these so-called degradable plastics is that although they do break apart and the organic parts can degrade, the plastic parts are only reduced to smaller pieces. This type of plastic can help reduce the harmful effects that plastic litter has on animals in the environment, because the plastic pieces will be too small to get caught in their throats or around their necks. However, the small pieces of plastic will not disappear completely. Instead, the pieces of plastic will be spread around. So, these biodegradable plastics can remain in landfills for many years, just as regular plastics can.

Figure 13 ▶ Green plastics made from living things are biodegradable. The plastic fork below has been engineered to degrade within 45 days of disposal.



DAY 0 DAY 12 DAY 33 DAY 45

SECTION 2 Review

1. **Name** three things you could do each day to produce less waste.
2. **Explain** how buying certain products can help reduce solid waste.
3. **Describe** the steps it takes to recycle a piece of plastic.
4. **List** two benefits of composting.

CRITICAL THINKING

5. **Analyzing Methods** What are the advantages and disadvantages to producing degradable plastics?
6. **Demonstrating Reasoned Judgement** Read the Case Study in this section and decide which type of bag you would choose the next time you go shopping. Explain why you made this choice. What are other uses of the bag you chose? READING SKILLS

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.

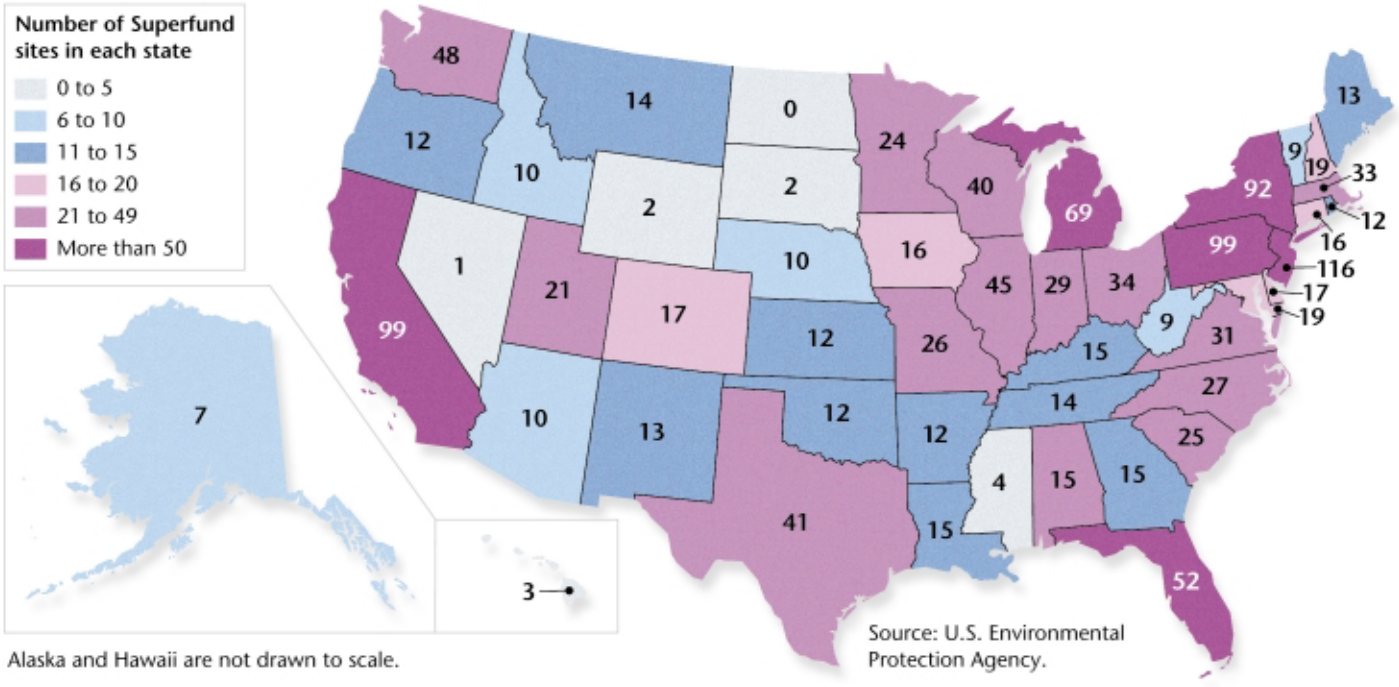


Figure 16 ▶ Safely transporting hazardous waste is an important part of hazardous waste management.

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
SciLinks code: HE4054

SCILINKS Maintained by the National Science Teachers Association

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.

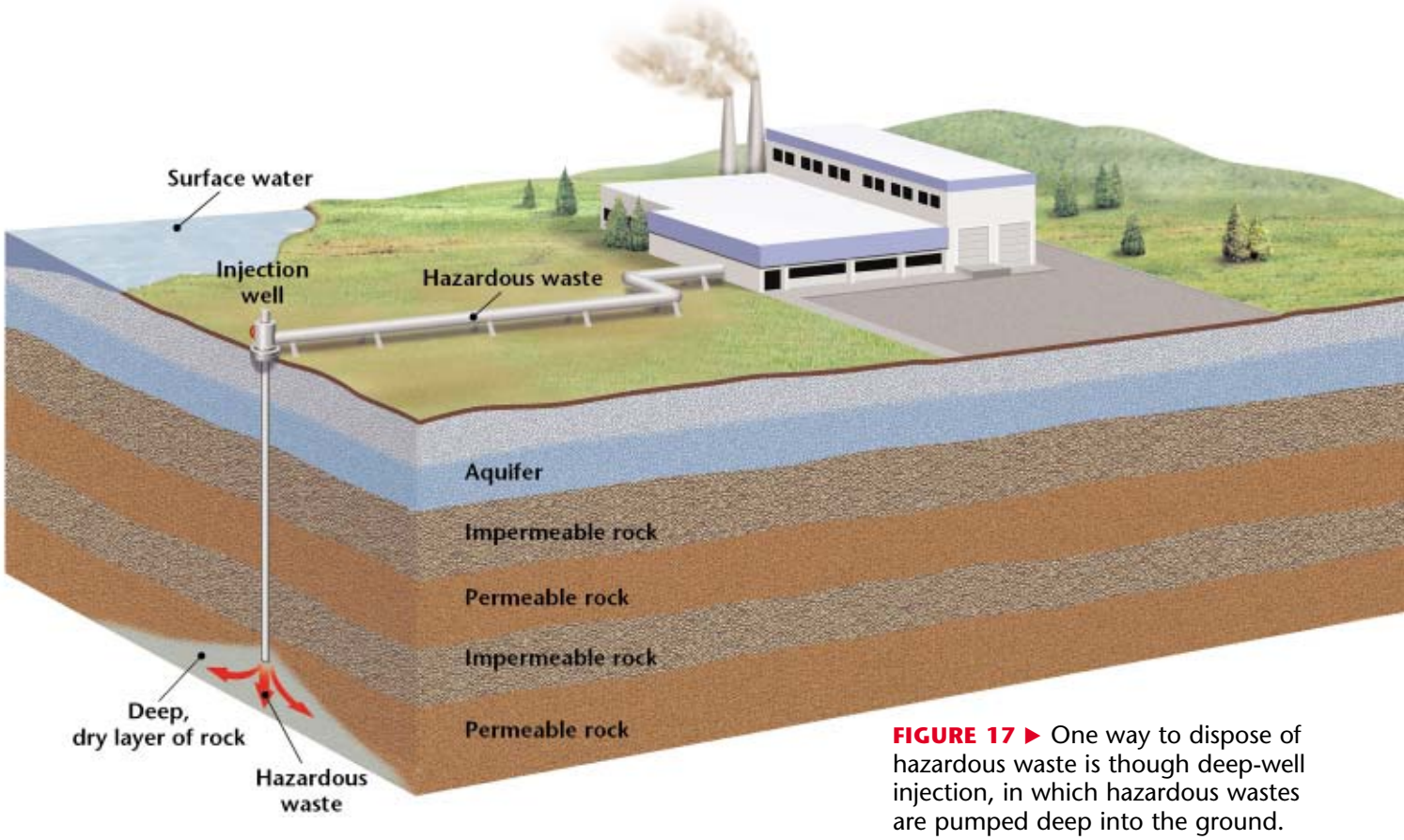


FIGURE 17 ▶ One way to dispose of hazardous waste is though deep-well injection, in which hazardous wastes are pumped deep into the ground.

▶ 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?

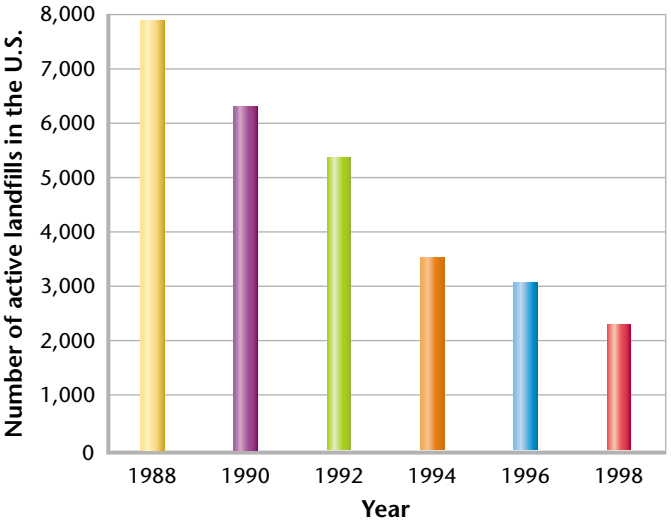
Interpreting Graphics

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

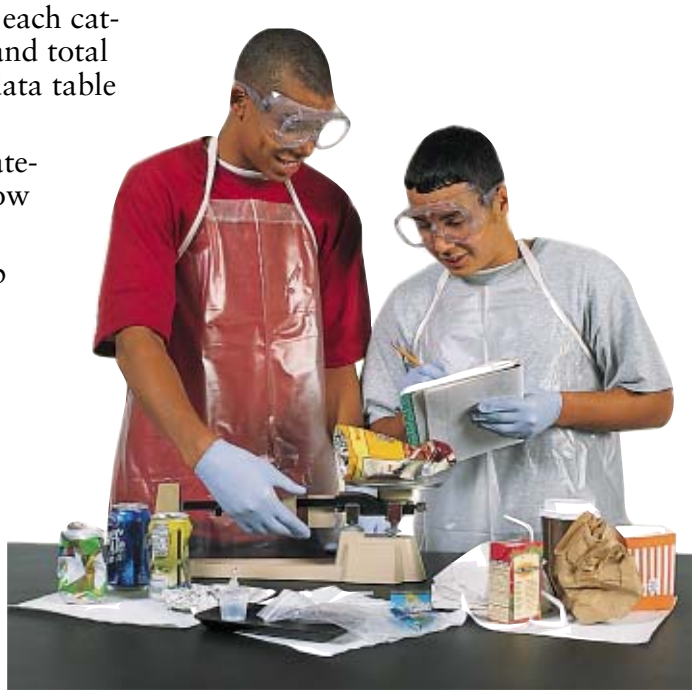
1. **Organizing Data** Use the equation below to determine the percentage for each waste category that makes up your total waste as an individual. Add another column to your data table to record this value.

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

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

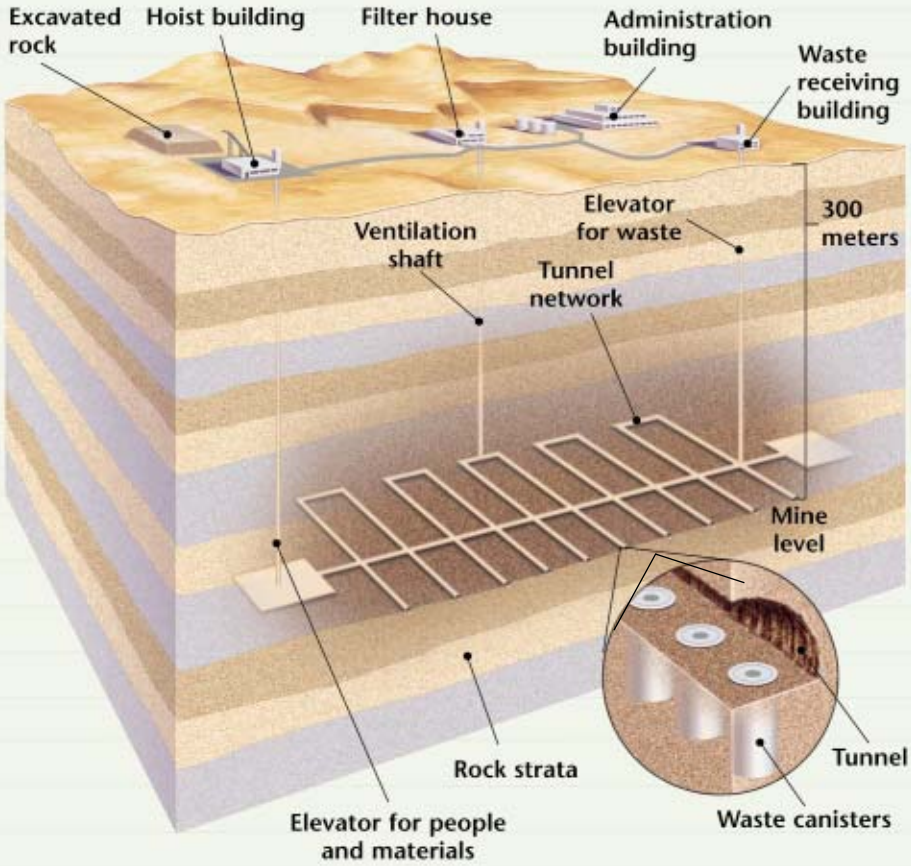
▶ Supporters of the Yucca Mountain storage facility think that this isolated spot in Nevada is a suitable place for permanent nuclear-waste disposal.

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.

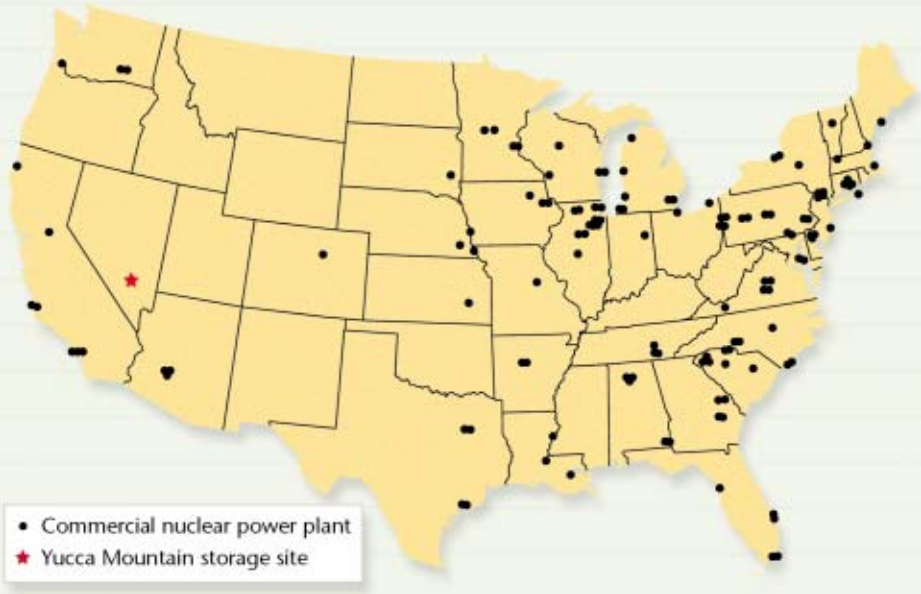
Another worry is that transporting nuclear waste across vast distances to Yucca Mountain is riskier than leaving the material near the facilities where it is produced. Any accident along the way could release radioactivity into the environment.

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?