

- 1 Solid Waste
- 2 Reducing Solid Waste
- 3 Hazardous Waste



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.

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.



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

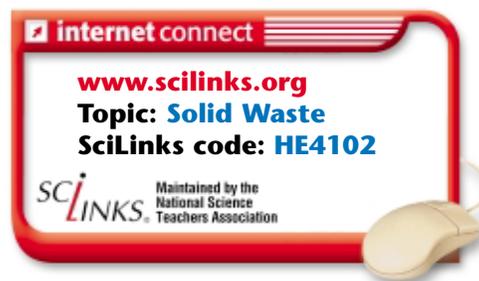


Figure 1 ▶ Where does your trash go when you throw it away?

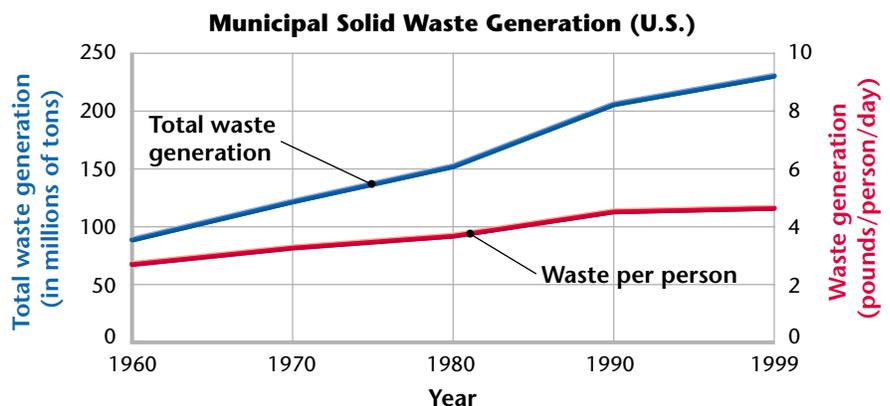
Figure 2 ▶ The barge *Mobro* (right) from Islip, New York, sailed up and down the East Coast and to the Gulf of Mexico for five months looking for a place to dump its load of garbage. The map below shows its route.



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.

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.



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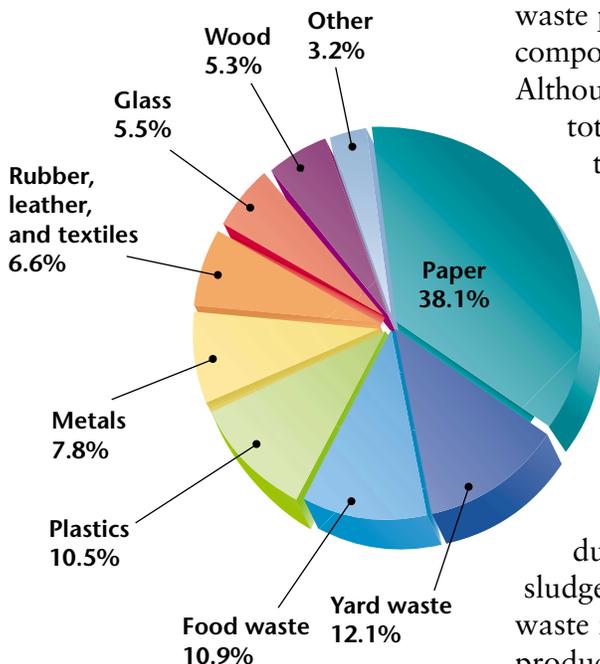
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Breaking Down Biodegradable Material

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.

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.



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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.

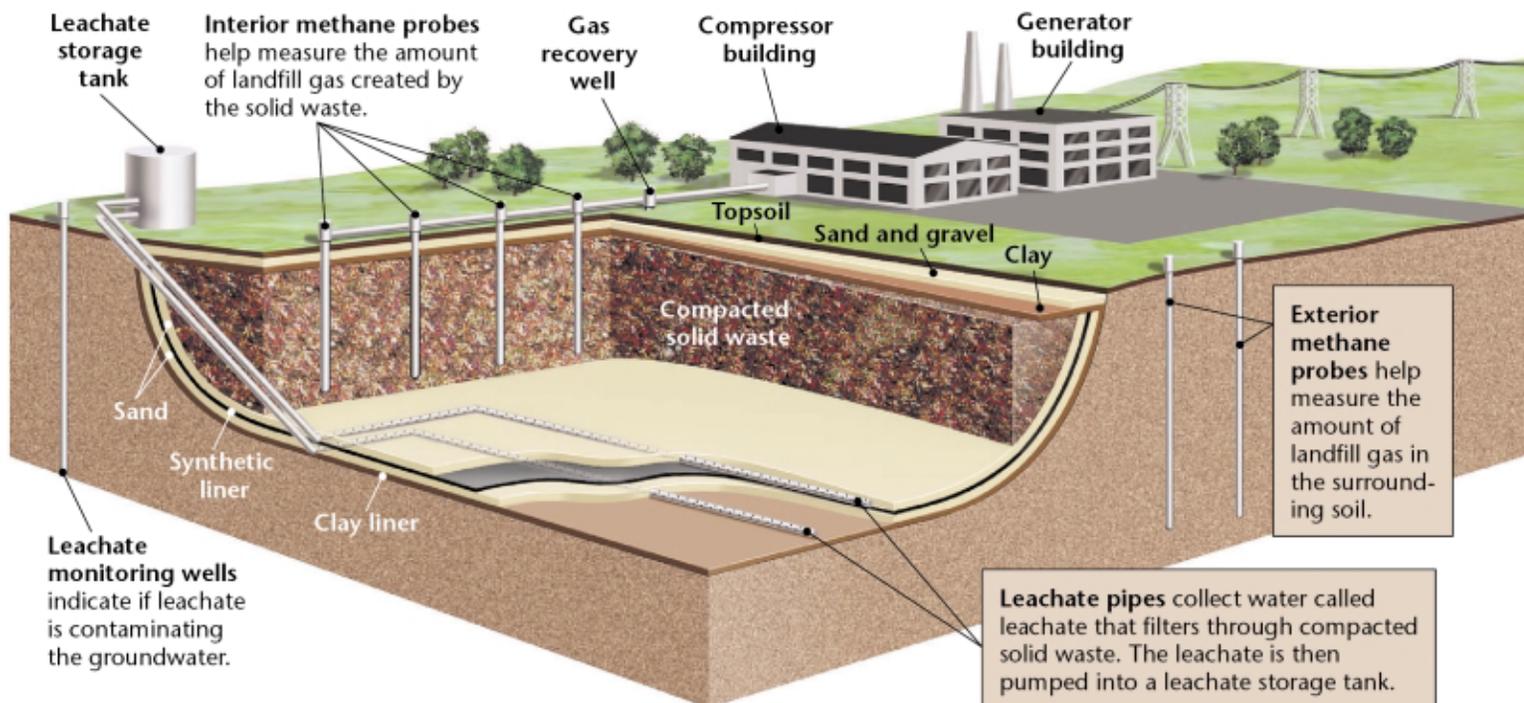




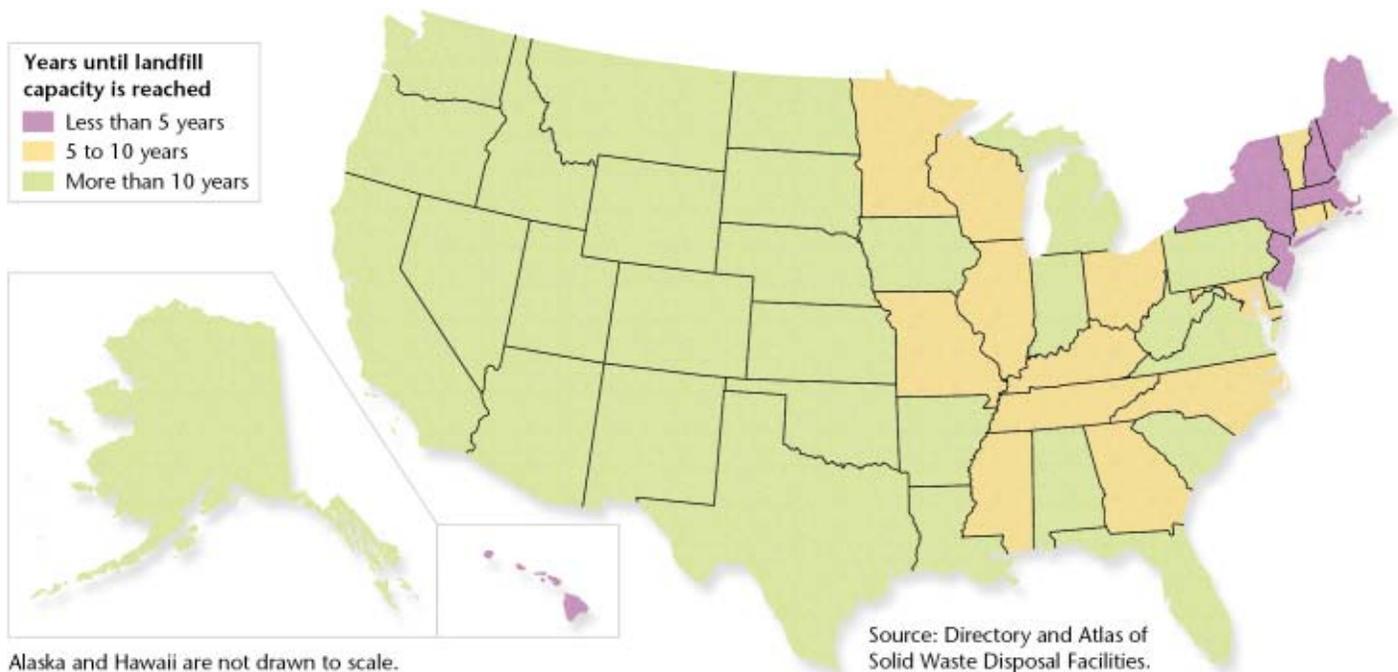
Figure 8 ► Biodegradable materials do not degrade quickly in modern landfills. This newspaper was put in a Tempe, Arizona landfill in 1971 and was removed in 1989.

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.

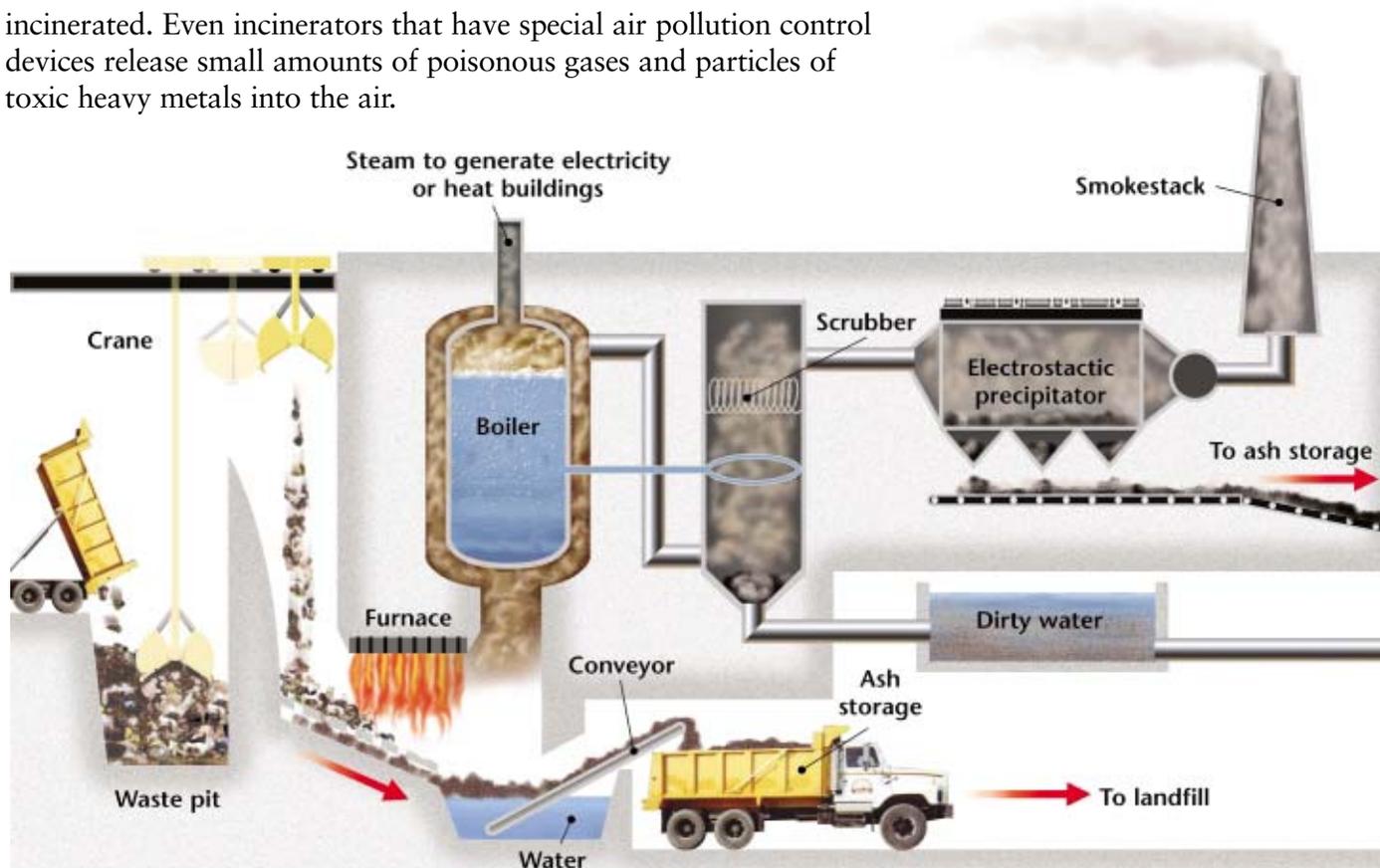
Figure 9 ► The map below shows the number of years until landfill capacity is reached in each state.



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 non-biodegradable 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?