The 3M Corporation, headquartered in Minnesota, is a model of corporate ingenuity and foresight. In 1975, the company started a Pollution Prevention Pays program designed to reduce solid and hazardous waste generated by the company. By substituting less toxic or nontoxic chemicals for solvents, by recycling everything they could, and by modifying manufacturing processes, 3M has made substantial cuts. From 1990 to 2009, 3M has cut global emissions of carbon dioxide by 77%. They have reduced the emission of volatile organic chemicals (VOCs) by 96% since 1990. VOCs contribute to photochemical smog and many are toxic to humans and other species. The company has reduced solid waste by 68%. They have made great strides in reducing water pollution, too. All in all, the company has eliminated the release of more than 3 billion pounds of
CRITICAL THINKING

Exercise
As a hazardous-waste manager of a chemical company, you are faced with a dilemma. Your company produces over 400,000 pounds of highly toxic waste annually. The cost of disposal is several million dollars. An official from a new waste disposal firm contacts you and says that he can dispose of the waste at half the cost. When you ask him where it is going, he says that it will be shipped to a developing nation, where it will be incinerated. He tells you that pollution controls on the incinerator where the waste will be burned are not as sophisticated as those on the one owned by the U.S. disposal company you’ve always used, but it doesn’t really matter because there’s so little toxic waste burned in the country anyway. What choice do you make? What factors will affect your choice?

pollutants. These and other actions taken by the company saved more than $1.4 billion between 1975 and 2009.

Although interest in reducing waste by recycling and using resources more efficiently is increasing, businesses are a long way from tapping into the full potential of this strategy. Many continue to throw away millions of tons of perfectly usable material, including cardboard, wood, office paper, and metals. Moreover, some companies continue to illegally and irresponsibly dump hazardous waste into the air, water, and soil.

This chapter discusses solid and hazardous wastes. Like other chapters in this book, it shows how individuals, businesses, and governments have traditionally addressed the problem of waste and how limited these strategies are. It will also show more sustainable approaches, measures that make sense from social, economic, and environmental perspectives.

23.1 Hazardous Wastes: Coming to Terms with the Problem

Hazardous wastes are waste products of homes, factories, businesses, military installations, and other facilities that pose a threat to people and the environment. They are toxic, carcinogenic, or mutagenic. For many years, pollution like hazardous waste was seen as a sign of progress. Today, many individuals view pollution in general and hazardous waste in particular as signs of unsustainable technologies or unsustainable industrial systems (FIGURE 23-1).

Love Canal: The Awakening
The severity of the U.S. hazardous-waste problem caught the attention of the American public in the 1970s when toxic chemicals began to ooze out of a hazardous-waste dump known as Love Canal in Niagara Falls, New York. The story of Love Canal began in the 1880s, when William T. Love began digging a canal that would run from the Niagara River just above Niagara Falls to a point on the river below the falls. The canal was built to divert water to an electric power plant to supply future industrial facilities that would be built along its banks. Unfortunately for Love, the canal was never completed. Only a small remnant of the canal remained in the early 1900s. In 1942, the Hooker Chemical Company signed an agreement with the canal’s owner to dump hazardous wastes into the abandoned canal. In 1946, Hooker bought the site, and from 1947 to 1952 it disposed of over 20,000 metric tons (22,000 tons) of highly toxic and carcinogenic wastes, including dioxin.

In 1952, the story took an ironic twist. In that year the city of Niagara Falls began condemnation proceedings on the property. This legal maneuver would allow the city to acquire the land to build an elementary school and residential community. Hooker sold the land to the city for $1 in
exchange for a release from any future liability. Hooker insists that it warned against construction on the dump site itself, but it allegedly never disclosed the real danger of building on it. Before turning the land over to the city, Hooker sealed the pit with a clay cap and topsoil, once thought sufficient to protect hazardous-waste dumps.

Troubles began in January 1954, however, when workers removed the clay cap during the construction of the school. In the late 1950s, rusting and leaking barrels of toxic waste began to surface. Children playing near them suffered chemical burns; some became ill and died. Hooker said that it had warned the school board not to let children play in contaminated areas, but the company apparently made no effort to warn local residents of the potential problems.

The problem continued for years. Chemical fumes took the bark off trees and killed grass and plants in vegetable gardens. Smelly pools of toxins welled up on the surface. In the early 1970s, after a period of heavy rainfall, basements in homes near the dump began to flood with a thick, black sludge of toxic chemicals. The chemical smells in homes around the dump site became intolerable.

Tests in 1978 on water, air, and soil in the area detected 82 different chemical contaminants, a dozen of which were known or suspected carcinogens. In that same year, the state health department found that nearly one of every three pregnant women in the area had miscarried, a rate much higher than expected. Birth defects were observed in 5 of 24 children. Another study, released in 1979 by Dr. Beverly Paigen of the Roswell Cancer Institute, showed that over half of the children born between 1974 and 1978 to families living in areas where groundwater was leaching toxic chemicals from the dump had birth defects. In this study, the overall incidence of birth defects in the Love Canal area was 1 in 5, compared with a normal rate of less than 1 in 10. The miscarriage rate was 25 in 100, compared with 8 in 100 for women moving into the area. Asthma was four times as prevalent in contaminated areas as in uncontaminated areas in the region; the incidence of urinary and convulsive disorders was almost three times higher than expected. The incidence of nasal and sinus infections, respiratory diseases, rashes, and headaches was also elevated.

As a result of public outcry, the school was soon closed. The state fenced off the canal and evacuated several hundred families (FIGURE 23-2). President Carter declared the site a disaster area. In May 1980, a new study revealed high levels of genetic damage among residents living near the canal. An additional 780 families were evacuated from outlying areas.

In 1987, the EPA announced plans to clean the sewers and dredge two creeks in the Love Canal area to remove sediments contaminated with toxins. In 1988 and 1989, the creeks were diverted so they would dry. Bulldozers then removed the top 18 inches of mud, which was burned by the company in a special incinerator built especially for this project. All told, about 35,000 cubic meters of sediment was burned, making this the largest single application of thermal destruction in modern history. The removal of the sediments cost $13 million, and sewer cleanup added another $5 million to the price tag. Incineration of the sediment cost over $26 million. Love Canal cost the state of New York and the federal government approximately $272 million for cleanup, relocation of residents, and other expenses.

A 1980 study by the EPA showed that chemical contamination was pretty much limited to the canal area (the actual dump), an area immediately south of it, and two rows of houses on either side of the canal (FIGURE 23-3). The last group of residents to be evacuated, the report said, were probably moved out unnecessarily. The EPA study also showed that the dump had contaminated shallow groundwater but not deeper aquifers. The EPA concluded that further migration of toxic chemicals was highly unlikely. Based on this study and other work, the EPA and the state of New York declared two-thirds of the evacuated Love Canal site “habitable” and proposed to sell the houses. Over 260 homes were renovated and sold to new owners. Approximately 150 acres east of the site have been sold for light industrial use. Lois Gibbs, the Love Canal resident largely responsible for drawing public attention to the disaster and getting the state and federal governments to take action, argues that the decision to resettle the area was improperly made. In fact, she claims that in assessing the habitability of the Love Canal site, the New York State Health Department compared it to only two other sites, both badly contaminated by industrial wastes, and deemed it suitable for resettlement. Gibbs warns that resettling Love Canal will put more people at risk. According to Gibbs, 18,000 metric tons (20,000 tons) of hazardous waste still remain at the site. It will take 20,000 years for these wastes to decompose. So far, there have been no medical concerns among new residents.
In the years following the Love Canal incident, health officials found that Love Canal was not an isolated incident, but just the tip of an enormous hazardous-waste iceberg. In 1989, the EPA announced that the number of hazardous-waste sites was approximately 32,000. The General Accounting Office estimated that the number of hazardous-waste sites could be much higher, perhaps 100,000 to 400,000. These estimates do not include the 17,000 hazardous-waste hot spots on U.S. military bases. Hazardous wastes have also been mixed with oils that are sprayed on dirt and gravel roads in rural areas to prevent dust. Tens of thousands, perhaps hundreds of thousands, of badly contaminated sites may exist in Europe, especially in the former Eastern Bloc nations and the nations that once were part of the Soviet Union. Canada is home to many contaminated sites, too. One of the worst of all is the Sydney steel plant in Nova Scotia. For nearly 100 years, the plant’s operators dumped waste from its operations in a nearby creek. Today, 34 hectares (85 acres) of the tidal flats where the creek opens onto the ocean contain an estimated 500,000 metric tons (454,000 tons) of toxic coal-tar from the facility. Cleanup was estimated to cost $35 million, but the task proved far more difficult and far more costly than anticipated. At this writing, the federal and provincial governments have spent over $52 million cleaning up the site and are still not finished. Findings such as these have fueled widespread concern about cancer.

Making matters worse, each year U.S. factories create an estimated 32 million metric tons (35 million tons) of hazardous waste from large facilities—about one metric ton for every man, woman, and child.1 But the United States is not alone. European countries and many less developed nations also produce tens of millions of tons of hazardous waste each year. In 1985, 90% of the hazardous wastes in the United States were improperly disposed of, according to one estimate. This waste ended up in abandoned warehouses; in rivers, streams, and lakes; in leaky landfills that contaminate groundwater; in fields and forests; and along highways. No current estimates are available, but the percentage is now believed to be much lower.

Nevertheless, improper waste disposal has left behind a long list of costly effects: (1) groundwater contamination, (2) well closures, (3) habitat destruction, (4) human disease, (5) soil contamination, (6) fish kills, (7) livestock disease, (8) sewage treatment plant damage, (9) town closures, and (10) difficult or impossible cleanups. Irresponsible and ill-conceived waste disposal continuing today will create a legacy of polluted groundwater and contaminated land that could persist for decades, perhaps centuries.

Three decades after the United States first awakened to the hazardous-waste issue, most experts believe that the nation is in for a much longer, more difficult battle than once was anticipated. Why? There are many more sites that are far more difficult to deal with than anybody ever anticipated. The price tag could also be much higher than expected. The U.S.

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1 This includes only facilities that produce over 1,000 kilograms (450 pounds) of hazardous waste per year. Thousands of smaller facilities also generate hazardous waste but are not required to report it.
Office of Technology Assessment (OTA) estimates that it will cost $100 billion to clean up the 10,000 sites in the United States that pose a serious threat to health. Researchers at the University of Tennessee estimate the cleanup of all hazardous-waste sites in the United States by state and federal programs will cost $750 billion.

**KEY CONCEPTS**

**LUST—It’s Not What You Think**

You feel dizzy. Your head spins. Your insides ache. You haven’t been yourself for weeks. What may be ailing you is LUST—but not the usual kind. Your symptoms may be caused by the latest in a long list of hazardous chemical problems: groundwater pollution from a leaking underground storage tank, which EPA’s top acronymists dubbed LUST. Some time later, no doubt responding to complaints from citizens vigilant for political correctness, they dropped the L, leaving UST: underground storage tanks.

Generally concentrated in heavily developed urban and suburban areas, underground storage tanks are used primarily to store petroleum products such as gasoline, diesel fuel, and fuel oil. They’re found at gas stations, factories, and homes. Some are used to store hazardous wastes, too.

The problem with tanks is that moisture and soil acidity gradually corrode the steel they’re made of, causing them to deteriorate over time and leak petroleum byproducts, toxic chemicals, and hazardous wastes. The main concern is the potential effect on groundwater and human health. Even a small leak can contaminate large quantities of groundwater. For example, 1.5 cups of hazardous liquid leaking out of a tank per hour can contaminate nearly 4 million liters (over 1 million gallons) of groundwater in a day. Contaminated groundwater is very difficult—sometimes impossible—and expensive to clean up.

Contaminated groundwater poses a problem to people and animals (such as livestock) that drink it. Contaminated drinking water used for baths and showers can also be dangerous. Benzene, a component of gasoline that can cause cancer, is absorbed through the skin when bathing. Showering generates dangerous vapors that can cause skin and eye irritation.

Although there are many sources of groundwater contamination, according to the U.S. EPA, leaking underground storage tanks are the number one cause of groundwater pollution, followed by landfills (FIGURE 23-4). A small leak can go undetected for long periods, causing considerable contamination. According to the EPA, the most significant effects are seen in the shallow aquifers, the ones domestic water is typically drawn from. A report by the New York Department of Environmental Conservation suggests that at least half of the state’s underground steel tanks containing petroleum products that are over 15 years old may be leaking. Nationally, 3 to 5 million underground storage tanks containing hazardous materials dot the United States. Since the underground storage program began, 488,000 leaky tanks have been discovered. As of the end of 2009, about 80% or more than 388,000 have been cleaned up, leaving 100,000 to be addressed. In 2009, however, an additional 7,000 leaking tanks were

**FIGURE 23-4** Source of groundwater pollution. Groundwater is contaminated by a variety of sources such as septic tanks, farms, and abandoned industrial sites.

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**GO GREEN**

Take unwanted paint, stains, finishes, and other hazardous chemicals to recycling or disposal facilities.
discovered, but the number of new leaking tanks discovered each year has dropped dramatically since the program began.

Major oil companies have already spent millions to clean up polluted groundwater and soil and to install new tanks at gas stations. The cost of such actions can be exorbitant. Chevron alone estimates its replacement costs at about $100 million. Unfortunately, half of U.S. service stations are owned by independent dealers who generally are not financially able to replace the leaking tanks.

About 90% of the cleanup and replacement of leaking underground storage tanks is being financed and performed by private industry. The rest falls on the shoulders of the states. The EPA sets guidelines for cleanup and replacement and also provides financial assistance to help states. Today, all 50 states have created funds to pay for their part of the cleanup cost. State and federal funds are derived from taxes on gasoline.

### KEY CONCEPTS

Hundreds of thousands of underground storage tanks have been installed in industrial nations and are used to store many potentially toxic substances such as gasoline, diesel fuel, hazardous waste, and heating oil. Over time, steel tanks corrode and begin to leak, contaminating groundwater used for cooking food, drinking, and bathing.

#### 23.2 Managing Hazardous Wastes

Two hazardous-waste problems face virtually all industrial nations and, to a lesser extent, the less developed countries (LDCs). First, how do they clean up existing hazardous-waste sites, leaking storage tanks, and polluted groundwater? Second, how do they deal with the enormous amounts of hazardous waste produced each year to avoid creating new sites and further contamination of groundwater?

The first problem requires immediate action. It’s one place where the Band-Aid approach is appropriate. That said, all solutions that fall into this category must be sustainable; they must not merely shift the problem from one location (a contaminated factory site) to another (a landfill where the hazardous wastes are dumped). The second problem calls for long-term preventive measures that eliminate the production of wastes.

### KEY CONCEPTS

Addressing the issue of hazardous waste requires both plans to clean up contaminated sites and preventive actions to greatly reduce or eliminate hazardous-waste production in the first place.

#### The Superfund Act: Cleaning Up Past Mistakes

In June 1983, the 2,400 residents of the town of Times Beach, Missouri, agreed to sell their 800 homes and 30 businesses to the federal government for $35 million. Why? The roads in Times Beach, like those elsewhere, had been sprayed with oil containing hazardous wastes, including dioxin. How did the oil get contaminated?

As noted earlier in the chapter, unscrupulous hazardous-waste disposal companies had mixed toxic chemical wastes with waste oil and then spread it on dirt roads to control dust. In Times Beach, the dioxin levels in the soil were 100 to 300 times higher than levels considered harmful during long-term exposure. The town had to go, and the federal government bought it. Today, Times Beach is a ghost town bordered by a tall chain-link fence. Its only occupants are occasional EPA officials or scientists from companies that are exploring ways to detoxify the soil.

The $35 million purchase price for this contaminated piece of real estate came from a special fund known as the Superfund. It was created in 1980 by the Comprehensive Environmental Response, Compensation and Liability Act, CERCLA for short. Commonly called the Superfund Act, it and its two amendments (1986 and 1990) established a $16.3 billion fund financed by state and federal governments and by taxes on chemical and oil companies. In 1995, though, the tax on businesses expired and continued funding (about $1.2 billion/year) has come from general tax revenues and from companies responsible for hazardous-waste sites. The money is earmarked to clean up both leaking underground storage tanks that are deemed a threat to human health and abandoned and inactive hazardous-waste sites, including hazardous-waste dumps, landfills, and contaminated factories, mines, and mills. Unfortunately many regions still lack the money required to clean up sites, so a lot of work is on hold.

Under CERCLA, the EPA is authorized to collect fines from parties responsible for the contamination—totaling up to three times the cleanup cost. Thus, this law makes owners and operators of hazardous-waste dump sites and contaminated areas, as well as their customers, responsible for cleanup costs and property damage. Under the law, all businesses, hospitals, schools, cities, and other parties that deposited hazardous waste at a site are liable for a portion of the cleanup cost, based on the type and the volume of waste they deposited. CERCLA requires a sharing of costs even at licensed hazardous-waste disposal facilities where hazardous wastes were legally disposed of in previous years. As one industry representative put it, “You are liable for your waste forever.” If a company or party is no longer in business, the remaining parties must pay the cost.

Superfund has clearly had an impact. As of 2007, over 347 sites have been cleaned up and work continues on another 1,156 sites.

### KEY CONCEPTS

The Superfund Act provides money to clean up hazardous-waste dumps and other contaminated sites. This money comes from a tax on oil and petrochemicals and is replenished by fees charged to those responsible for the contamination, including the owners and operators of waste sites and the companies that paid to have their waste disposed of in them.

#### Problems with the Superfund Program

Despite these successes, the Superfund program has been riddled with problems. One of the most significant is cost. Stabilizing a leaking
pond designed to hold hazardous wastes costs the EPA $500,000. A study to determine what chemicals are leaking from a site can cost $800,000.

A second problem is that it has created a legal nightmare, described as a “massive web of litigation between the EPA, waste depositors, and insurance companies.” Of the funds paid in the years the program has been operating, nearly 60% have been for legal fees. This money has largely been spent on identifying liable parties to get them to pay their fair share—not on cleanup.

Initial mismanagement by top EPA officials also delayed serious action by the agency in the early years. Officials negotiated with owners of hazardous-waste dumps to begin private cleanups, but critics say that they let some companies off too easily and required only superficial cleanups. Officials waived future liability in some cases. Thus, if problems develop in the future, companies will bear no responsibility. Investigations conducted in 1983 led the EPAs top leadership to resign or be fired because of the issue. One EPA official went to jail for perjury.

The Superfund Act has also been criticized because, although it provides money for cleanup and financial compensation for property damage, it fails to provide avenues for victims of illegal dumping of hazardous wastes and their families to be compensated for personal injury or death. According to former senator George Mitchell, “Under the legislation, it’s all right to hurt people, but not trees.” Many people believe that a fund similar to worker’s compensation is needed for victims.

According to the OTA, the EPA has often opted for quick-fix solutions to clean up areas. Three-quarters of the cleanups, they say, are inadequate in the long term. In Love Canal, for instance, the EPA simply put a clay cap over the dump site and dug a ditch around it to collect hazardous wastes that escape. In other sites, contaminated soil was excavated and hauled off to another landfill. Incineration and biological destruction of the wastes might have been more long-lasting solutions.

**KEY CONCEPTS**

The cleanup of hazardous-waste sites under the Superfund Act has proven extremely slow, costly, and litigious. Much of the money spent has gone to legal fees. The Superfund Act has been criticized because it provides money for cleaning up property but no compensation for health damage. Many of the cleanups are considered inadequate.

Alternative Cleanup Funding Options

Some critics of CERCLA argue that the law has created an adversarial relationship among many parties that is counterproductive and inefficient. Too much money is spent on litigation and too little on cleanup. Although critical of CERCLA, these individuals do not suggest we abandon the program, only that we find options that put the money to better use.

One proposal calls for a federal hazardous-waste tax levied on each ton of hazardous waste disposed of, incinerated, or treated. This money would generate revenue for cleanup of the most heavily contaminated sites. There would be no need to try to assign responsibility for contamination and no need for the lengthy litigation that often results.

The American Association of Property and Casualty Insurers has proposed funding cleanup via a small fee on each new commercial insurance policy written in the United States. Their calculations suggest that this would generate more than $4 billion a year that could be used for cleanup. Both this and the previous alternative might allow the EPA to redirect its efforts to cleanup.

**KEY CONCEPTS**

Rather than spending millions of dollars to identify responsible parties, the Superfund program might work better with a no-fault policy—one that provides funds to clean up sites regardless of who is liable.

**What to Do with Today’s Waste: Preventing Future Problems**

The high cost of cleanup strongly suggests the need for active preventive measures to avoid further contamination. Several possibilities exist.

The Resource Conservation and Recovery Act: Preventing Improper Disposal

Cleaning up hazardous-waste sites is an essential first step in protecting health and creating a sustainable future. It should help reduce further contamination of groundwater. Efforts are also needed to prevent illegal and improper waste disposal. In 1976, the U.S. Congress passed the Resource Conservation and Recovery Act (RCRA). This law is designed to monitor hazardous waste to eliminate illegal and improper waste disposal.

Under RCRA, the EPA was designated the nation’s hazardous-waste watchdog. The EPAs first role was to determine which wastes were hazardous. RCRA also called on the agency to establish a nationwide reporting system for all companies handling hazardous chemicals. This requirement created a trail of paperwork that follows hazardous wastes from the moment they are generated to the moment they are disposed of—a so-called cradle-to-grave tracking. Congress believed that this requirement would make it difficult for waste generators to dump hazardous wastes improperly. RCRA also directed the EPA to set industry-wide standards for packaging, shipping, and disposing of wastes. Only licensed facilities could receive wastes.

Unfortunately, RCRA’s implementation has been slow. It was not until 4 years after Congress adopted the law that the EPA came up with its first hazardous-waste regulations. To the dismay of many, the regulations were full of loopholes, and about 40 million metric tons (44 million tons) of pollutants annually escaped control.

Because of public pressure, in 1984, Congress passed a set of amendments to eliminate RCRA’s loopholes and ensure proper waste disposal. For example, under the original law, if a company produced under 1,000 kilograms...
(2,200 pounds) of hazardous wastes per month, it could dump them in a local landfill. The amendments changed the rules so that any individual or company that generated more than 100 kilograms (220 pounds) of hazardous waste a year must follow the same guidelines imposed on large waste producers.

The 1984 amendments also declared a national policy to reduce or eliminate land disposal of hazardous waste. Congress made it clear that land disposal technologies must be a last resort. The 1984 amendments gave preference to reuse, recycling, detoxification (such as incineration), and other measures discussed shortly. These approaches are bringing the United States closer to a sustainable waste management system.

The 1984 amendments to RCRA also addressed leaking underground storage tanks. After May 1985, for example, all newly installed underground tanks had to be protected from corrosion for the life of the tank. The lining of the tank must consist of materials compatible with stored substances. Furthermore, owners and operators must have methods for detecting leaks, must take corrective action when leaks occur, and must report all actions.

### Weaknesses in RCRA

Despite these changes, RCRA still has many loopholes. Some critics believe that its definition of hazardous wastes is too narrow. Michael Picker of the National Toxics Campaign, for example, thinks that municipal waste (garbage) should be classified as hazardous waste because it contains toxic chemicals such as pesticides, ore, and heavy metals like lead (from batteries). Leachates (water containing contaminants) seeping from some municipal landfills are as toxic as those coming from regulated hazardous-waste facilities. According to John Young of the Worldwatch Institute, more than one of every five hazardous-waste sites on the U.S. Superfund cleanup list is a municipal landfill.

Picker also thinks that sewage and untreated wastewater handled by publicly owned sewage treatment plants should be considered a hazardous waste. Toxic chemicals in the sewer system, released by factories (legally and illegally) and homeowners, can escape into the air and into waterways. Agricultural wastes, mostly pesticides, are also not regulated. In California, for example, rules require that leftover pesticides be diluted and sprayed into the environment. Mill and mine tailings are also excluded from most regulatory control. By expanding the definition of what is toxic and by instituting better controls, the government could greatly cut back on the influx of hazardous materials into the environment.

One lesson environmentalists have learned in the past 4 decades is that passing a law is not a guarantee of protection. Why not? For one thing, agencies responsible for administering and enforcing new laws don’t always perform as they are instructed. Some drag their feet because they don’t approve of the law. Additionally, agencies may be so underfunded and so overworked that they can’t take on new responsibilities or, if they do, they do a shoddy job. The EPA is a case in point. Understaffed and underfunded, the EPA today struggles to implement RCRA and the handful of other laws aimed at protecting public health and the environment. Since the agency was formed, its workload has more than doubled, but funding has until quite recently remained at more or less the same level (adjusted for inflation). EPA’s funding was drastically scaled back under the Bush administration.

### Exporting Toxic Troubles

Another lesson we’ve learned in the last few decades is that tough environmental legislation often has unanticipated effects elsewhere. For example, regulations that add to the cost of disposing of hazardous wastes have caused some companies to find ways to prevent waste production, but the very same regulations have caused unscrupulous companies to illegally dump their wastes or to export toxic wastes (including incinerator ash) abroad. In the 1980s, these wastes often ended up in cash-hungry LDCs or Eastern Bloc nations, neither of which had adequate laws requiring proper hazardous-waste disposal. Today, European and U.S. companies are believed to be the most heavily involved in illegally exporting toxic wastes. Because the trade is presumed to take place illicitly, no reliable records exist regarding the quantities of materials being exported. In the United States, the export of hazardous wastes is not only common, it is on the rise, according to Hilary French of the Worldwatch Institute. The problem with exporting waste is that many of the countries that receive waste don’t know what is in it, don’t know how toxic the materials really are, and don’t have facilities to store it or dispose of it properly.

In 1986, Congress amended RCRA by establishing procedures to notify importing countries and obtain prior written consent. However, these regulations may be insufficient and EPA officials think that hundreds of tons of hazardous wastes are still being exported illegally.

Exporting hazardous waste to a nation without its full consent goes against principles of international law. Accordingly, numerous African nations have passed laws banning the import of hazardous wastes. In some countries, importing hazardous wastes is punished by stiff jail terms and multimillion-dollar fines. In Nigeria, an importer can be put...
to death. The Organization of Eastern Caribbean States and 22 Latin American countries have also joined forces to stop the dumping of hazardous wastes on their soils.

In 1990, the European Economic Community (EEC) (a coalition of European nations) agreed to ban exports of toxic and radioactive waste to 68 former European colonies. Many of the less developed nations who were part of the accord also agreed not to import hazardous wastes from non-EEC members. As of September 2010, 175 nations have signed an agreement (the Basel Convention) that bans the transfer of hazardous wastes to less developed nations, including Canada, Mexico, and 13 European nations. The United States has signed the agreement but our participation has not been ratified by Congress. Although these are important steps forward, many less developed nations are still open to imports, representing a potentially huge repository for hazardous wastes from the industrial nations. Signing an agreement will also not stop the illegal flow.

Many options exist for getting rid of waste. The most sustainable approaches involve steps that reduce or eliminate hazardous-waste output. You don’t have waste if you don’t make it.

**KEY CONCEPTS**

Tighter regulations for the disposal of hazardous wastes in the United States and other nations have led to commendable efforts to reduce waste production by some companies, but to illegal dumping by less scrupulous ones. Some companies export hazardous wastes to less developed nations with little or no oversight of such practices. Although many less developed nations ban such activities, many still accept wastes.

**Dealing with Today’s Wastes: A Variety of Options**

In 1983, the National Academy of Sciences (NAS), a prestigious body composed of the nation’s leading scientists, issued a report outlining options for handling hazardous wastes (FIGURE 23-5). This section discusses the various options and illustrates some of the most effective means of dealing with the problem, notably reducing or eliminating hazardous waste, showing that you don’t have waste if you don’t make it.

**Process Manipulation, Recycling, and Reuse**

As illustrated in Figure 23-5, at the top of the NAS list are in-plant options, generally relatively simple and cost-effective changes that reduce hazardous-waste production. All qualify as highly sustainable practices because they reduce hazardous-waste output—avoiding the need to dispose of waste.

In-plant options include three general actions. The first, **process manipulation**, involves alterations in manufacturing processes to cut waste production. One alteration of manufacturing is known as substitution. **Substitution** involves the use of nontoxic or less toxic substitutes in manufacturing. Cleo Wrap, the world’s largest producer of gift wrap, for example, switched to nontoxic inks and cut its annual production of hazardous waste by 140,000 kilograms (300,000 pounds). Industries can also change the chemical composition of their products, eliminating those that are harmful or that might produce harmful byproducts during manufacturing. Nontoxic household cleaners are a good example. Another type of process manipulation in-
volves the monitoring of manufacturing processes to locate and fix leaks that are emitting toxic chemicals into the environment. Exxon Chemical, for example, installed floating lids over vats that contained volatile organic compounds, greatly reducing losses from evaporation. According to OTA, U.S. industries could reduce or prevent more than 50% of their hazardous-waste generation through process manipulation.

The second and third in-plant options are the **reuse and recycling strategies**. In some instances, companies can capture toxic wastes and, with little or no purification, reuse them to manufacture other products or sell them to other companies for reuse. In metal finishing, nickel that’s left behind in rinse water can be recovered and reused or sold. For plants that cannot afford onsite technologies, shared facilities or third-party recyclers can provide an economical alternative. Regional waste exchanges—including both private and government-operated facilities that put waste producers in touch with companies that need their waste—can assist in the exchange of potentially hazardous wastes, save companies money, and protect the environment.

The reuse and recycling strategies help cut the output of waste by putting perfectly good materials to use. These strategies may save companies millions of dollars a year in materials costs. In addition, they eliminate the cost of waste disposal, cut down on potential environmental and health damage, and eliminate costly cleanups.

**KEY CONCEPTS**

Changes in manufacturing processes such as substitution and process manipulation are often the simplest and most cost-effective means of reducing or eliminating hazardous wastes. Waste output can also be dramatically reduced by recycling and reusing wastes.

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**Conversion to Less Hazardous or Nonhazardous Substances**  
Waste reduction, recycling, and reuse can make a significant dent in waste production. Unfortunately, not all waste can be eliminated, reused, and recycled. Some waste will always be produced. The NAS recommended that, where appropriate, remaining wastes be destroyed or detoxified—that is, converted to less hazardous or nonhazardous materials.

**Detoxification** can be accomplished for certain types of waste by **land disposal**, applying them to land. When mixed with the top layer of soil, some waste materials can be broken down by chemical reactions, by oxidation from sunlight, or by bacteria and fungi in the soil. Some nondegradable wastes may be absorbed onto soil particles and held there indefinitely (we think). Others may migrate into deeper layers. A word of caution: Land treatment is an expensive option, requiring care to avoid polluting ecosystems, poisoning cattle and other animals, and contaminating groundwater. Also, studies show that changes in conditions that bind toxins to soil particles may change, causing a sudden and unanticipated release into the environment. Plants can also remove toxic materials from contaminated soil, as explained in **Spotlight on Sustainable Development 23-1**.

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Another option available for organic wastes is **incineration**. High-temperature furnaces at stationary waste disposal sites, on ships that burn wastes at sea, and on mobile incinerators can be used to burn toxic organic wastes such as PCBs, pesticides, and dioxin (FIGURE 23-6). In these facilities, oil and natural gas are used as fuels. Hazardous substances are injected into the furnace or mixed with the fuel before combustion.

Mobile hazardous-waste incinerators can be used to clean up contaminated sites or to deal with wastes stored in warehouses. Permanent hazardous-waste incinerators can also be established to deal with wastes from a variety of producers. Such facilities may also be used to provide energy for communities and factories. However, many communities object to hazardous-waste incinerators, fearing the release of toxicants from spills during transport or leaks at the plants. Incinerators may not always perform adequately, and operating personnel may bypass regulations. Low-level releases from smokestacks may also result in a long-term exposure to hazardous chemicals. Recent studies also show that when hazardous waste is burned, unburned waste and other chemical compounds in the exhaust may combine to form toxic air pollutants. Incinerators also require fuel and produce carbon dioxide, a greenhouse gas.

**Low-temperature decomposition** of some wastes, including cyanide and toxic organics such as pesticides, offers some promise. In this technique, wastes are mixed with air and maintained under high pressure while being heated to 450° to 600°C (840° to 1100°F). During this process,
organic compounds are broken into smaller, biodegradable molecules. Valuable materials can be extracted and recycled. One advantage of this process is that it uses less energy than incineration.

Chemical, physical, and biological agents can also be used to detoxify or neutralize hazardous wastes. For example, lime can neutralize sulfuric acid. Ozone can be used to break up small organic molecules, nitrogen compounds, and cyanides. Toxic wastes can be encapsulated in waterproof plastic and disposed of in landfills. Many bacteria can degrade or detoxify organic wastes and may prove helpful in the future. New strains capable of destroying a wide variety of organic wastes may be developed through genetic engineering.
Hazardous wastes can be converted to nontoxic or less toxic substances by chemical, physical, and biological means, such as neutralization, combustion, low-temperature thermal decomposition, and bacterial decay. Such measures, although effective, present some problems and are clearly not as desirable as preventive measures.

Perpetual Storage  In-plant modifications and conversion techniques that destroy or detoxify wastes cannot rid us of all of our hazardous waste. By various estimates, 25 to 40% of the waste stream will remain even after the best efforts to reduce, reuse, recycle, and destroy it—although some companies have achieved far better reductions.

Residual hazardous waste could be stored by one of a half dozen options (Figure 23-5). For example, residual waste could be dumped in secured landfills, excavated pits lined by impermeable synthetic liners and thick, impermeable layers of clay. To lower the risk of leakage, landfills should be placed in arid regions—neither over aquifers nor near major water supplies. Special drains must be installed to catch any liquids that leak out of the site. Groundwater and air should be monitored regularly to detect leaks.

Growing public opposition to this strategy makes it more difficult for companies to find dump sites. Some observers have labeled this the NIMBY syndrome: Get rid of the stuff, but Not In My BackYard. Paradoxically, it seems that most of us want the products available in an industrial economy that inadvertently generates waste, but few of us want the wastes dumped (or even burned) nearby.

Even though the EPA has issued tough regulations for hazardous-waste landfills, critics argue that landfills are only a temporary solution. No matter how well constructed they are, they will eventually leak. In an attempt to reduce problems for future generations, the EPA has drawn up a list of chemicals that cannot be disposed of in landfills.

Landfills are one of the cheapest waste disposal options today and are therefore often favored by industry. The savings they offer today are very likely to be charged to future generations, though.

Other methods of perpetual storage include (1) use of surface impoundments and specially built warehouses that hold wastes in ideal conditions and prevent any material from leaking into the environment; (2) deposition in geologically stable salt formations; and (3) deposition deep in the ground in arid regions where groundwater is absent.

Not all waste can be eliminated by prevention, recycling, or detoxification. Perpetual storage remains the final, yet least sustainable, option.

Disposing of Radioactive Wastes

High-level radioactive wastes are some of the most hazardous of all wastes, but they have long been ignored by many countries. High-level radioactive waste is generated by commercial nuclear power plants and weapons production facilities. Lower-level wastes come from research laboratories and hospitals. Many radioactive wastes have a long lifetime. Others can concentrate in animal tissues. Virtually all pose a serious threat to human health, as described in Chapter 14.

High-level radioactive waste is not a problem that will go away, even though the nuclear power industry and nuclear weapons manufacturing are declining (Chapter 14). The waste already produced and now stockpiled at nuclear reactors and the continued operation of the existing power plants, fuel processing facilities, and nuclear weapons facilities necessitates long-term, low-risk storage of nuclear wastes.

Recognizing the need to do something with nuclear wastes rather than continuing to stockpile them at power plants or weapons facilities, Congress passed the Nuclear Waste Policy Act in 1982. This law established a timetable for the Department of Energy (DOE) to select a deep underground disposal site for high-level radioactive wastes. The DOE focused its attention on a site in Nevada called Yucca Mountain. Located on federal land about 160 kilometers (100 miles) northwest of Las Vegas, Yucca Mountain was proposed to someday be home to a huge underground storage site excavated in the volcanic rock, costing an estimated $7 to $8 billion (FIGURE 23-7).

The DOE had hoped to open the site in 2010. In order for federal decision makers to approve the site, though, they must be relatively sure that earthquakes and volcanic eruptions will not threaten the stability of the repository. In 2009, the Senate passed a bill to close Yucca Mountain after 25 years and $13.5 billion spent.

Several other options are available to deal with high-level radioactive waste. Radioactive waste, for example, can be bombarded with neutrons in special reactors to convert some of it into less harmful substances. However, existing reactors do a poor job of altering cesium-137 and strontium-90, two of the more dangerous byproducts of nuclear fission.

Seabed disposal has been used in the past by the United States and European countries, but is now forbidden. Still, some scientists suggest that the seabed may provide a site for radioactive wastes; the effects are difficult to predict.

The problems of disposal suggest to some that nuclear power should be phased out. Cleaner, less costly measures to produce energy should be developed. As noted earlier, though, we need to establish cost-effective and low-risk methods to dispose of (safely store) the vast amounts of waste that have already been generated.

In the United States, low-level radioactive waste from hospitals and research laboratories is packaged and shipped to three disposal sites—in Nevada, Washington, and South Carolina—where it is buried in the ground. Medium-level waste from nuclear power plants and weapons facilities is another matter altogether. In the 1980s, the DOE began construction on a medium-level radioactive waste depository called WIPP (Waste Isolation Pilot Plant). WIPP is the first geological repository for the disposal of radioactive waste produced by the U.S. defense programs—nuclear weapons research and production. It also houses waste from the disassembly of nuclear weapons. The waste slated for disposal in the site consists mostly of protective clothing, tools, glassware, and equipment contaminated with waste. It does not
house high-level radioactive waste or spent nuclear fuels.

WIPP is an experimental project of DOE monitored and regulated by the Environmental Protection Agency. This $700 million facility was carved out of a thick salt deposit 630 meters (2,100 feet) below the ground in southeastern New Mexico near Carlsbad. Radioactive waste is held in steel canisters.

In 1993, the DOE started receiving wastes to test the safety of the site. The facility will eventually hold 6.2 million cubic feet of radioactive waste. In 1998, the EPA gave final approval for the site, saying that it complies with disposal regulations and is safe to contain wastes for 10,000 years.

Although the site has been opened for 12 years, many citizens are concerned about accidents that could occur as radioactive waste is shipped to WIPP from federal weapons facilities in California, Colorado, Idaho, Illinois, Nevada, New Mexico, Ohio, Tennessee, South Carolina, and Washington. Most of the waste disposed of at the site is generated as nuclear weapons are disassembled. To reduce the risk of transportation accidents, DOE requires wastes to be shipped in special casks certified by the Nuclear Regulatory Commission and subjected to a series of tests to demonstrate their ability to survive severe crashes and punctures followed by fires or immersion in water.

Unlike many other hazardous wastes, most nuclear wastes cannot be reused or recycled. Process modification can help reduce waste output, but for the most part the problem has to be addressed at the end of the pipe. The end of the cold war and the decline in the nuclear arsenals of the United States and the former Soviet Union have dramatically reduced production at nuclear weapons facilities. Nuclear waste from power plants could also decline as they are phased out in the United States and elsewhere, as discussed in Chapter 14. Nonetheless, huge volumes of waste already exist and must be dealt with somehow.

**KEY CONCEPTS**

Disposing of radioactive waste will be a problem for a long time, even though nuclear power and nuclear weapons production are on the decline. Safe, permanent repositories are needed to store huge amounts of waste produced by power plants and other facilities.
The push to reduce hazardous waste release into the environment has stirred considerable interest in incinerators. Incinerators are equipped with pollution control devices and can remove many of the chemical pollutants. They can also be used to generate energy and reduce environmental pollution by hazardous materials. In rural areas, they provide employment. Companies that want to locate them in rural areas often offer help in financing schools, roads, water supply systems, and other needed projects as incentives to local communities.

One person's solution, however, often becomes another person's problem. Incinerators often require landfills to dispose of highly toxic residues. Leaks may pollute the site and seep into groundwater, which is used for irrigation and drinking. Although plants typically have state-of-the-art pollution control equipment, small amounts of toxic substances may be emitted and over time could accumulate in the soil, ecosystems, and crops downwind. An incinerator becomes a hazardous-waste magnet, drawing shiploads in by truck and train from neighboring cities and states. Accidents could cause spills, environmental damage, injury, and evacuations.

Although proponents of incineration think that the rural siting strategy may be shrewd business, it ultimately diverts attention from finding permanent solutions, such as process modification, reduction, recycling, and reuse. These are environmentally more acceptable and, in the long run, are more sustainable strategies for dealing with a nation's hazardous wastes.

Individual Actions Count

As with all environmental issues, individuals can participate in many ways. For example, each of us can contribute by recycling oil, not dumping it in sewers or in vacant lots. We can properly dispose of paints, paint thinners, and other potentially toxic wastes. Many cities and counties provide toxic roundups, periodic collection dates during which they will take toxic household products for disposal free of charge. Some of these products, such as paints, can be reclaimed and used again.

One of the best strategies is to avoid toxic chemicals such as pesticides and cleaning agents in the first place. You can cut back on potentially hazardous materials by purchasing environmentally safe cleaning products and insecticides. Reducing your consumption of nonessential goods, whose production invariably creates toxic wastes that poison our land and water, also helps.

You can also learn about waste sites in your area and become active in grassroots organizations working on reduction, recycling, and safer disposal methods. Together, millions of Americans using resources wisely can make significant inroads into the hazardous-waste problem.
every year. The composition of the U.S. municipal waste stream is shown in FIGURE 23-9.

Municipal solid waste production has increased sharply since 1980, but growth slowed in the 1990s. From 1990 to 2008, for instance, municipal solid waste production only grew by about 22% while resource recovery (recycling and composting) climbed to around 150%. Despite the large quantity of municipal solid waste produced by Americans, municipal solid wastes still make up only about 4 to 5% of the total solid waste discarded in the United States each year. Nonetheless, the continued growth and the sheer volume of waste create major problems in many cities, where land for disposal is growing scarcer and more costly by the day.

Garbage disposal is also of concern to those interested in building a sustainable future because it squanders the Earth’s resources. The more that is thrown away, the more minerals that must be mined. The more we throw away, the more trees that must be cut. The more plastic we discard, the more oil wells that must be drilled. Each of these activities produces enormous waste itself and equally impressive amounts of environmental damage.

Science fiction writer Arthur C. Clarke once noted that “solid wastes are the only raw materials we’re too stupid to use.” In the United States, 54% of the municipal solid waste is buried in landfills. Nearly 32% of America’s trash is currently recycled and composted. Another 13.6% is burned in incinerators. Landfill disposal not only wastes valuable resources, it costs communities millions of dollars each year. Landfilling the disposable diapers used in the United States, for example, costs the nation an estimated $350 million a year. For most local governments, the cost of trash disposal is usually exceeded only by the costs of education and of highway construction and maintenance.

Like so many other problems, municipal solid waste is the product of many interacting factors: (1) large population growth; (2) high per capita consumption; (3) low product durability; (4) our heavy dependence on disposable products; (5) low reuse and recycling rates; (6) a lack of personal and governmental commitment to reduce waste; (7) widely dispersed populations, in which producers of recyclable and reusable items are separated from those willing to purchase these materials; and (8) relatively cheap energy and abundant land for disposal.

## 23.4 Solving a Growing Problem Sustainably

Actions to reduce our output of solid waste generally fall into three broad categories (FIGURE 23-10). The traditional response to solid waste is known as the output approach. It consists of ways to deal with trash flowing out of cities and towns. Most often, this means incinerating trash or dumping it in landfills. A more sustainable strategy is known as the input approach. This consists of activities that reduce the amount of materials entering the production–consumption cycle—for example, efforts to reduce consumption and waste, say, by increasing product durability. The third approach, also essential to building a sustainable society, is the throughput approach. It consists of ways to direct materials back into the production-consumption system, creating a closed-loop (cyclic) system akin to those found in nature. Reuse and recycling fall under this category.

### Key Concepts

**Solving a Growing Problem Sustainably**

More developed nations produce enormous amounts of solid waste each year, much of which is burned or landfilled, squandering precious resources and creating an enormous and costly waste disposal problem in urban areas. Waste production is increasing in many countries such as the United States; recovery rates (recycling and composting) are growing much faster, a trend that bodes well for the future.

**Worldwide, most trash is still dumped in landfills.**

**The Traditional Strategy: The Output Approach**

The most widely used strategy throughout the world is the output approach, landfilling and incineration. Landfilling and incineration are end-of-pipe controls. Like many others discussed in this book, they are not sustainable in the long run.
FIGURE 23-10 Strategies for reducing solid waste. There are many ways of dealing with waste. The strategies fall within one of three groups: output, input, and throughput. In most cases, a combination of all three must be applied to alleviate the solid waste problem. Efforts should concentrate on the input and throughput solutions, which will go a long way in helping to create a sustainable society.

Dumps and Landfills Until the 1960s, garbage dumps were prevalent features of the American landscape. Public objection, however, to wafting odors, rat- and insect-infested midden heaps, and dark plumes of smoke that billowed out of burning dumps forced cities to look for other ways to deal with their growing trash problem. The federal government contributed to the demise of the dump by passing RCRA, discussed earlier. Besides addressing hazardous waste, RCRA also required all open dumps to be closed or upgraded by 1983.

The open dump has been replaced by the sanitary landfill. A sanitary landfill is a natural or humanmade depression into which solid wastes are dumped, compressed, and daily covered with a layer of dirt. Because solid wastes are no longer burned, as they were in many open dumps, air pollution is greatly reduced. Because trash is covered each day with a layer of dirt, odors, flies, insects, rodents, and potential health problems are eliminated or sharply reduced.

Despite their immediate benefits, landfills have some notable problems. First and most important, landfills require land. In the United States, the trash from 10,000 people in a year will cover one hectare (2.47 acres) about 1.2 meters (4 feet) deep. Around many cities, usable land is in short supply or is expensive. Second, landfills, like dumps, require a great deal of energy for excavation, filling, and hauling trash. Third, they can pollute groundwater. Toxic household wastes (paint thinner, pesticides, and other poisons) and feces (from disposable diapers, kitty litter, and backyard cleanup of Rover’s messes) are discarded in municipal landfills, where they can leak into groundwater. Landfills are a major source of groundwater contamination and many retired landfills are listed as Superfund sites, as you learned earlier in the chapter. Fourth, they produce methane gas from the decomposition of organic materials. Methane can seep through the ground into buildings built over or near reclaimed landfills. Methane is explosive at relatively low concentrations. Fifth, landfills sink or subside as the organic trash decays, requiring additional regrading and filling. Buildings constructed on top of reclaimed landfills may suffer serious structural damage. Sixth, they have low social acceptability. Quite understandably, most people don’t want the noise, traffic, and blowing debris that come with even the best-managed landfills.

Although landfilling is ultimately an unsustainable strategy, there are many ways to make it more environmentally acceptable. Energy requirements, for example, can be cut by new methods of waste collection. Packer trucks now reduce waste volume by 60%, meaning that fewer trucks are needed to haul garbage to landfills. This saves on fuel consumption and pollution.

Vacuum collection systems can also be used to save energy in dense urban settings, especially apartment complexes. Solid waste is dumped into pipes that carry it to a centralized collection point. One such system is in operation in Sundbyberg, Sweden. Garbage is whisked away from wall chutes to a central collection facility, where the glass and metals are removed by an automated process. The burnables are incinerated, providing heat for the 1,100 apartments using the system. A similar system handles 45 metric tons (50 tons) of waste per day at Disney World in Florida. Today, over 400 such systems are in operation in Europe in hospitals, apartment buildings, and housing tracts.

Water pollution problems can be reduced by locating landfills away from streams, lakes, and aquifers. Test wells around the site can be used to monitor the movement of pollutants, if any, away from the site. Special drainage systems and careful landscaping can reduce the flow of water over the surface of a landfill, thus reducing the amount of water penetrating it. Impermeable clay caps and liners can reduce water infiltration and the escape of pollutants. In addition, pollutants leaking from the site can be collected by specially built drainage systems and then detoxified. The toxic seepage is shipped to hazardous-waste facilities.

Methane gas produced in landfills can be drawn off and sold as fuel, supplementing natural gas. Subsidence damage to buildings built on reclaimed sites can be reduced by removing organic wastes before disposal and by allowing organic decay to proceed for a number of years before construction.
Unfortunately, many other countries continue to view the States burns nearly 14% of its solid waste. Sweden both burn about one-third of theirs. The United used in many industrial countries. In Denmark, 60% of the tion can also be used to produce heat and electricity. Because Incineration is another output control widely used in many industrial countries. In Denmark, 60% of the municipal solid waste is incinerated. The Netherlands and Sweden both burn about one-third of theirs. The United States burns nearly 14% of its solid waste.

Burning trash can reduce the waste volume by two-thirds, cutting requirements for landfill space. Incineration can also be used to produce heat and electricity. Because of this, incinerators are often called waste-to-energy (WTE) plants. One ton of garbage is equivalent to about one barrel of oil. But even with the energy gain, WTE plants cost more to build and operate than landfills. WTE plants are also much more expensive than recycling programs. Nationally, recycling projects cost about one-third as much as incinerators. Each incinerator must be individually designed to accommodate the local mixture of burnable (leaves) and nonburnable refuse (steel cans). Operating these incinerators is made more difficult because the mixture varies from season to season. In the spring and fall, for example, yard and garden waste increases dramatically. But all yard waste does not behave the same. Wet leaves, for example, do not burn well. To avoid problems caused by wet leaves and other similar materials, municipalities may require homeowners to separate combustible material (dry branches) from wet organic matter (grass clippings).

Another problem with incinerators is that they may emit toxic pollutants, especially when plastics are burned. Another major problem with garbage incinerators is that the ash they produce may be hazardous to human health. Test data show that the ash from incinerators contains dioxins and toxic metals, such as lead and cadmium, in concentrations that may be harmful to humans. Consequently, some scientists and environmentalists argue that ash from garbage incinerators should be reclassified as a hazardous substance and disposed of in hazardous-waste facilities, which is much more costly than dumping in ordinary landfills.

Ash disposed of in ordinary landfills may, over the years, begin to leak into groundwater, polluting public and private drinking water supplies. Cleaning up these sites could cost many millions of dollars.

Many municipalities are opting for incinerators in which nonburnable materials such as glass and steel cans are removed before combustion, rather than for mass burn facilities, in which the entire waste stream is burned without separation. Separation of noncombustible wastes permits recycling and increases the combustion efficiency of incinerators. It is also much cleaner and is more efficient than mass burn, although it still produces hazardous materials.

KEY CONCEPTS

Ocean dumping of sewage sludge has declined significantly in recent years. Other waste dumping was largely brought to a halt in the early 1980s.

### FIGURE 23-11 Signs of improvement

Ocean dumping of sewage sludge has declined significantly in recent years. Other waste dumping was largely brought to a halt in the early 1980s.
WTE plants are a step in the right direction, but they are not as cost-effective and sustainable as waste management programs that rely on waste reduction, composting, and recycling. Incinerators also rank low on the social acceptability scale. Residents of Lowell, Massachusetts defeated an incinerator that its city council was planning to build because they found, among other things, that Lowell produced only 225 metric tons (200 tons) of waste per day, whereas the plant would require 1,350 metric tons (1,215 tons) to operate. That meant that the city council would have had to enter into agreement with neighboring towns to accept their trash to meet the needs of the plant. Lowell would have become a municipal solid waste magnet. Citizens in Spokane, Washington were not so lucky. Their city council approved a massive incinerator that requires a considerable amount of outside trash to keep it running.

Incinerators may seem like a good way to solve the growing trash problem, but critical thinking suggests the need for a long-term view of the problem. The most important question today is not just how to reduce landfilling, but how to cut our waste; conserve valuable resources; protect our air, water, and land; and ensure vital wildlife habitat. In short, how do we create a sustainable system of waste management? Clearly, incinerators reduce trash but don’t contribute significantly to the goals of sustainability.

**KEY CONCEPTS**

Garbage can be burned in incinerators, which greatly reduces trash. This option, however, even when linked to energy production, is viewed by many as an unsustainable way of dealing with municipal solid waste.

**Sustainable Options:**

**The Input Approach**

In Chapter 3, you learned that sustainable solutions are those that often approach problems by addressing their root causes—that is, by confronting them at their source. In solid waste, as in hazardous waste, the most effective and sustainable strategies are those that seek to reduce the amount of materials entering the production–consumption system in the first place. This strategy is called **source reduction**. The three main source reduction strategies include measures that (1) increase product life span, (2) reduce the amount of materials in goods and their packaging, and (3) reduce consumption (demand for goods).

**KEY CONCEPTS**

Source reduction techniques reduce the amount of waste entering the waste stream and represent the most sustainable waste management strategy.

**Increasing Product Life Span: Making More Durable Products**

The trouble with today’s products is that, as writer John Ruskin noted, “There is hardly anything in the world that some man cannot make a little worse and sell a little cheaper.” In the long run, however, cheaply made goods end up costing consumers more than well-made and slightly more expensive goods. The rapid turnover may be profitable to businesses, but it is unsustainable from an ecological standpoint. Planned obsolescence of products destroys the air, water, and land. More durable toys, garden tools, cars, and clothing require less frequent replacement and thus decrease resource use. It’s a great personal strategy and also can be a profitable business strategy because consumers who are fed up with shoddy products will gravitate to well-made ones.

**KEY CONCEPTS**

Higher quality, more durable goods last longer and consequently reduce the amount of waste. Manufacturers and consumers can play significant roles by making and buying more durable products.

**Reducing the Amount of Material in Products and Packaging**

In the United States, packaging (including bottles) uses 90% of the glass, 50% of the paper, 11% of the aluminum, and 8% of the steel consumed, according to Concern, Inc., a citizens’ group based in Washington, D.C. All told, 31% of the municipal solid waste (by weight) is discarded containers and packaging.

Of course, packaging is necessary, but much of it is superfluous and wasteful. (Consider the package containing the latest software you bought.) The Campbell Soup Company realized this and redesigned its soup cans; today, they use 30% less material than they did in the 1970s. Some beverage companies now package drinks in **aseptic containers**, boxes constructed of several thin layers of polyethylene, foil, and paper (FIGURE 23-12). The containers hold milk, juices, and wine and keep them fresh for several months without refrigeration. Aseptic containers require less energy, too. Canned drinks, for instance, must be pasteurized for 45 minutes, whereas the contents of aseptic packages are sterilized out of the package for only 1 minute. This not only greatly reduces energy demand but preserves flavor. Furthermore, beverages in aseptic containers like soy milk do not require refrigeration during transportation and storage, which also lowers the energy demand. Being lighter than cans also helps cut down on transportation costs. Aseptic containers can be recycled, but access to recycling programs that handle them is fairly limited.

Virtually all products can be redesigned to reduce waste. Many large newspapers, for example, have gone to a more economical design that has cut the use of newsprint by 5%. Smaller cars and trucks emerged in the 1970s and early 1980s in the United States and are popular in many countries. In the United States, however, the trend in the 1990s and 2000s has been toward larger and larger vehicles such as the Ford Expedition and Chevy Suburban (FIGURE 23-13). Not only do they consume more minerals, they are less efficient and consume much more energy to operate. Smaller computers and calculators have also helped save valuable materials. Smaller houses could help as well.

**KEY CONCEPTS**

Efforts to make products smaller and more compact can significantly reduce resource demand.
Reducing Consumption

H. W. Shaw once wrote, “Our necessities are few, but our wants are endless.” Critics of modern-day society argue that ceaseless efforts to satisfy our endless wants are a big part of the solid waste dilemma the United States, Canada, and other countries face. By cutting back on consumption, individuals can help reduce solid wastes and many other problems described in this book.

Reductions in consumption will require shifts in our attitudes. The attitude that “new is always better” leads many consumers to purchase new goods when old ones still work. The fashion industry thrives on its ability to convince the public that new fashions are “in”—and that anyone wearing the old is “out of fashion.” Advertisers capitalize on this strategy as well, and many consumers fall into the trap. Chapters 3 and 24 detail other attitudinal factors that contribute to the solid waste dilemma.

Another way to reduce consumption is through outright bans. Some cities, for example, have taken steps to reduce waste by banning objectionable materials—notably plastics. Minneapolis and St. Paul, Minnesota; Berkeley and Palo Alto, California; Newark, New Jersey; and other cities have passed ordinances to ban many plastics, prompting the plastics industry to take measures to develop recycling facilities.

Each of us can make a personal effort to reduce consumption with little noticeable change in lifestyle. There are limitless possibilities; all we have to do is try them.

KEY CONCEPTS

One of the most effective means of reducing solid waste is to reduce consumption—buy what you need.

The Throughput Approach: Reuse, Recycling, and Composting

In natural systems, all waste is food material for other organisms. In short, there is no waste. Everything is recycled. Creating a sustainable society, say many experts, will require steps to greatly increase recycling efforts to emulate nature.

Recycling is part of the throughput approach. The second part of this approach is reuse. Both strategies remove useful materials from the waste stream and channel them back to manufacturers (in the case of recycling) or to end users (in the case of reuse) (Table 23-1).

KEY CONCEPTS

The throughput approach diverts waste from the waste stream for recycling and reuse.

The Reuse Option  

Reuse is the return of operable or repairable goods into the market system for someone to use. In most cities, organizations such as Goodwill and the Disabled American Veterans pick up used products, including clothes, shoes, silverware, plates, pans, books, tools, bicycles, and appliances. Many of them provide drop-off stations or pick up goods at your home. These products are cleaned and then resold to the needy and the frugal. Profits go to help the needy. For-profit secondhand stores also provide consumers with options for buying children’s clothing and toys, furniture, appliances, plumbing supplies, and a host of other products. Check them out. You can often get great bargains!

Packaging materials—such as cardboard boxes, bottles, and grocery bags—can also be reused, saving both energy and materials. Shopping bags can be reused by individuals. Reusable beverage containers can be sterilized, refilled, and returned to the shelf, sometimes completing the cycle as many as 50 times. Disposable and recyclable bottles and cans have virtually eliminated the reusable container from the market in more developed countries, although this technique is popular in less developed nations.

FIGURE 23-12

Aseptic container. Aseptic containers like this one are convenient and energy efficient but are fairly difficult to recycle.

FIGURE 23-13

An oversized SUV. This sport utility vehicle, like many other models on the market today, uses an incredible amount of resources to build and gets about 12 miles per gallon.
Table 23-2 compares the energy demand of refillable glass bottles (used 10 times) with various other packaging options. As illustrated, when it comes to energy demand, recycling is generally more efficient than one-time use (compare the energy required to make an aluminum can from raw ore versus recycled scrap). Reusing glass bottles only 10 times, though, is four times more efficient than recycled glass.

Besides saving energy, the reuse option (1) reduces the land area needed for solid waste disposal, (2) provides jobs, (3) provides inexpensive products for the poor and the thrifty, (4) reduces litter, (5) decreases the amount of materials consumed by society, and (6) helps reduce pollution and environmental degradation.

Aluminum recycling offers great benefits as well. As noted in two previous chapters, aluminum recycling requires 95% less energy than making aluminum from raw ore (bauxite). Thus, a manufacturer can make 20 aluminum cans from recycled metal with the same energy it takes to make one can from bauxite ore. Aluminum recycling produces 95% less air pollution as well. Similar environmental benefits are available from recycling other metals and plastics.

Japan is a world leader in recycling. Currently, about one-half of that nation’s waste is composted and recycled. In the United States and many other countries, however, recycling efforts are a long way from achieving their full potential, although there are exceptions. One exception is the automobile. In the United States, approximately 90% of all cars are recycled. Lead in car batteries is another exception, with about 95% of all batteries making their way back into the manufacturing process. Despite these impressive statistics, in 2008, nationwide only about 7% of the plastic, 23% of the glass, 56% of the paper and cardboard, and 21% of the aluminum was recycled. Recycling rates for many products could easily double or triple. Plastic recycling could increase 10 to 20 times.

### Table 23-1

<table>
<thead>
<tr>
<th>Material</th>
<th>Reuse and Recycling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper</td>
<td>Repulpmed and made into cardboard, paper, and a number of paper products. Incinerated to generate heat. Shredded and used as mulch or insulation.</td>
</tr>
<tr>
<td>Organic matter</td>
<td>Composted and added to gardens and farms to enrich the soil. Incinerated to generate heat.</td>
</tr>
<tr>
<td>Clothing and textiles</td>
<td>Shredded and reused for new fiber products or burned to generate energy. Donated to charities or sold at garage sales.</td>
</tr>
<tr>
<td>Glass</td>
<td>Returned and refilled. Crushed and used to make new glass. Crushed and mixed with asphalt. Crushed and added to bricks and cinder blocks.</td>
</tr>
<tr>
<td>Metals</td>
<td>Remelted and used to manufacture new metal for containers, buildings, and other uses.</td>
</tr>
</tbody>
</table>


### Table 23-2

<table>
<thead>
<tr>
<th>Container</th>
<th>Energy Use (BTUs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum can, used once</td>
<td>7050</td>
</tr>
<tr>
<td>Steel can, used once</td>
<td>5950</td>
</tr>
<tr>
<td>Recycled steel can</td>
<td>3880</td>
</tr>
<tr>
<td>Glass beer bottle, used once</td>
<td>3730</td>
</tr>
<tr>
<td>Recycled aluminum can</td>
<td>2550</td>
</tr>
<tr>
<td>Recycled glass beer bottle</td>
<td>2530</td>
</tr>
<tr>
<td>Refillable glass bottle, used 10 times</td>
<td>610</td>
</tr>
</tbody>
</table>

KEY CONCEPTS
Many products can be returned to recycling facilities, where they are shipped to factories to be used to make new products—a process that offers many social, economic, and environmental benefits. Although recycling is on the rise, most countries have barely tapped the full potential of recycling.

Recycling’s Growing Popularity Recycling is widely practiced in Europe and Japan. Many major U.S. cities have developed recycling programs to reduce landfilling. In 2008, there were over 8,659 curbside recycling programs, down from 9,704 in 2001. Seven states—Minnesota, New Jersey, New York, Maine, South Carolina, South Dakota, and Virginia—report total recycling rates of 40% or more. Sixteen states report recycling rates of 30 to 39% (Table 23-3). Impressive as this is, many other countries are doing much better. Japan, for example, currently recycles about half of its garbage. One suburb of Tokyo, for instance, currently recycles and composts 90% of its garbage.

Types of Recycling Programs Cities and towns offer a variety of recycling options. Some use drop-off sites, where residents can deposit their recyclables on the way to work or to the grocery store (Figure 23-14). In some locations, recycling companies will actually pay for some materials such as aluminum and copper. Drop-off centers can be successful, but generally only if containers are conveniently placed—for example, at train stations, near parks, or near heavy-use intersections. Many colleges and universities also offer recycling programs with recycling containers located in the hallways of classroom buildings.

Curbside recycling, in which recyclables are periodically picked up by trash haulers at the curb, is by far the most successful type of recycling program (Figure 23-15). Participation rates as high as 60 to 80% can be expected if recyclables and trash are picked up on the same day. One study in Canada showed that curbside recycling requires about 10% less energy than a drop-off program.

Unsorted trash can also be collected and shipped to resource recovery centers, where it is separated by machines or people. This technique, called end-point separation, is generally more costly than source separation in which people sort recyclables at home or in the office. Moreover, complete separation may not be possible at these facilities, thus lowering the value of recyclable materials.

A growing number of recycling programs are being run by private haulers. Toronto, for example, is home to a program run by Waste Management, Inc. In my area, all three private trash haulers offer curbside recycling.

Table 23-3

<table>
<thead>
<tr>
<th>State</th>
<th>Recycled (%)</th>
<th>State</th>
<th>Recycled (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minnesota</td>
<td>45</td>
<td>Rhode Island</td>
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</tr>
<tr>
<td>New Jersey</td>
<td>43</td>
<td>New Hampshire</td>
<td>26</td>
</tr>
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<td>New York</td>
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<td>North Dakota</td>
<td>26</td>
</tr>
<tr>
<td>Maine</td>
<td>42</td>
<td>Pennsylvania</td>
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</tr>
<tr>
<td>South Carolina</td>
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<td>Michigan</td>
<td>25</td>
</tr>
<tr>
<td>South Dakota</td>
<td>42</td>
<td>Connecticut</td>
<td>24</td>
</tr>
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<td>Hawaii</td>
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<td>Wisconsin</td>
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<td>Delaware</td>
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</tr>
<tr>
<td>Tennessee</td>
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<td>Utah</td>
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</tr>
<tr>
<td>Texas</td>
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<td>West Virginia</td>
<td>20</td>
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<tr>
<td>Iowa</td>
<td>34</td>
<td>Louisiana</td>
<td>19</td>
</tr>
<tr>
<td>Massachusetts</td>
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<td>Colorado</td>
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</tr>
<tr>
<td>California</td>
<td>33</td>
<td>Arizona</td>
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<td>Ohio</td>
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<td>Washington</td>
<td>33</td>
<td>Mississippi</td>
<td>14</td>
</tr>
<tr>
<td>Kentucky</td>
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<td>Nevada</td>
<td>14</td>
</tr>
<tr>
<td>North Carolina</td>
<td>32</td>
<td>Kansas</td>
<td>13</td>
</tr>
<tr>
<td>Maryland</td>
<td>30</td>
<td>Oklahoma</td>
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</tr>
<tr>
<td>Missouri</td>
<td>30</td>
<td>District of Columbia</td>
<td>8</td>
</tr>
<tr>
<td>Oregon</td>
<td>30</td>
<td>Alaska</td>
<td>7</td>
</tr>
<tr>
<td>Vermont</td>
<td>30</td>
<td>Montana</td>
<td>5</td>
</tr>
<tr>
<td>Nebraska</td>
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<td>Wyoming</td>
<td>5</td>
</tr>
<tr>
<td>Illinois</td>
<td>28</td>
<td>Idaho</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Source: Environmental Protection Agency.

Figure 23-14 Drop-off site. This roadside center is conveniently located so that people can drop off recyclables on the way to nearby shopping centers.

Figure 23-15 Curbside recycling. This roadside center is conveniently located so that people can drop off recyclables on the way to nearby shopping centers.
Obstacles to Recycling. From an energy and resource standpoint, recycling is generally not as good an option as reuse, but it is far better than burning materials and infinitely better than throwing them away. If recycling is such a good idea, why don’t Americans, Canadians, and other people do more of it? The reasons are complex.

First, some industrial societies grew up with abundant resources. Steeped in the frontier notion that “there’s always more,” industrialists and political leaders have traditionally seen little need for recycling, except perhaps in times of war when raw materials were in short supply. Given the seemingly inexhaustible supply of materials, factories were primarily set up to handle virgin material. The entire production–consumption system was built without recycling in mind. Corporate empires were built on the profits of extractive industries, the mining companies, and those companies today wield enormous political power. Changing this ingrained and wasteful system will not be easy.

Second, the nation’s tax laws today support extraction and discourage recycling. As pointed out in Chapter 16, U.S. laws work against recycling. Even today, for example, mining companies receive generous tax breaks (depletion allowances) that give them an unfair advantage over recyclers. These tax breaks often make virgin materials cheaper than recycled ones. Logging companies that supply wood for paper mills (and other uses) are also heavily subsidized by the federal government—and thus by the taxpayer. Logging roads in national forests, for instance, are built with public money, and timber sales on public land have long been made below their cost (Chapter 12), further benefiting virgin paper industry over recycling. Federal subsidies create unfair economics. Hard-rock mining companies can also purchase federal land at $5.00 an acre, thanks to the Mining Act of 1872. They are also not required to pay any royalty to the government for extracted minerals, which artificially reduces the price of minerals and metals.

The traditional extractive industries receive another hidden subsidy that’s far more difficult to quantify. It is called an economic externality—a cost that is passed on to the public from pollution and other harmful effects of these activities. Because the traditional ways of making paper, steel cans, and other products produce more pollution, they have a bigger impact on our health and our environment than does recycling, which uses less energy and produces far less pollution. The higher environmental cost of virgin materials, however, is not completely reflected in the price of the product. It is, instead, paid in federal taxes that go to clean up our air and water. It is paid in higher health bills and in dozens of other ways that few of us are aware of.

Another difficulty is the built-in transportation price differential, mandated by law, for scrap metal and ore. For example, ore travels more cheaply than metal bound for a recycling mill.

In some locations, such as the U.S. West, cheap landfill costs were once a barrier to overcome. In Colorado, for example, landfill tipping fees—the cost to dump a ton of trash in a landfill—once ranged from $4 to $7 per ton. Recycling costs $30 to $50 a ton. On the East and West Coasts, landfill tipping fees ranged from $40 to $100, making recycling far more profitable. As landfills were closed and new, more expensive sites were developed, however, tipping fees began to rise. In the northeastern United States, tipping fees now average $67 per ton. In most of the rest of the nation, where undeveloped land is more abundant, tipping fees now average $42 to $44 per ton. In addition, many interior states are a long way from the nation’s paper recycling mills, making it more expensive and less profitable to recycle paper.

Recycling suffers from an image problem as well. In the 1970s, many recycled paper products were of inferior quality. Many people who used them were dissatisfied and soon returned to virgin materials. Since that time, however, recycled paper products have improved immensely. Recycled office paper, stationery, and computer paper are indistinguishable from virgin stock. Still, the notion that recycled paper is inferior sometimes persists.

Plastics pose a special problem for recycling. Most plastic is perfectly recyclable. The problem is that there are more than 45 different types of plastic commonly used for packaging. Making matters worse, some packages contain two or more types of plastic, making it difficult to recycle. A plastic ketchup bottle, for example, has five layers of plastic.
Overcoming the Obstacles. Despite these barriers, U.S. recycling efforts are on the rise and are bound to increase substantially. In 1988, the U.S. Environmental Protection Agency announced a nationwide goal of reducing the solid waste stream by 25% through waste reduction and recycling by 1994, a goal reached a year early. In 2004, however, the rate had climbed to 29.7%. In 2009, it inched upward to 33.8%.

Lofty government goals are only part of the equation, though. Rising energy prices, decreasing landfill space, and depletion of high-grade ores will all increase recycling in coming years. Public awareness through education from schools, environmental groups, and the media can also help. Policy changes are also needed to eliminate preferential freight rates and subsidies for timber harvesting and mining.

To be successful, recycling programs must also be convenient and cost-effective. Recycling also requires individual commitment and action. Separating trash before collection requires a little effort, but not much more than the effort we expend to separate our white clothes from our colored clothes when we do our laundry. I like to think of source separation as each one different, each one providing a special feature needed to make a perfectly squeezable bottle to deliver our ketchup.

One way plastic manufacturers have helped promote plastic recycling is by placing codes on plastic packaging so that individuals and recyclers can tell exactly what type of plastic it is made of (FIGURE 23-16). In most cities, only two or three of the most widely used plastics are recycled.

Each type of plastic has a different code, making it easier for individuals and recyclers to tell one from another.

FIGURE 23-16 Plastic code. The codes on the bottom of virtually all plastic containers tell the type of plastic the product contains, making it easier for individuals and recyclers to tell one from another.

Procuring Recycled Materials: Closing the Loop. Besides overcoming the barriers just described, to make recycling successful, we must also develop markets for recycled materials. In other words, we must close the loop. What does this mean?

Creating markets for recyclables causes an important shift in the production–consumption system and our impact on the Earth. Most human economies are linear in design, as illustrated in FIGURE 23-17a. They are dependent on resources extracted from the environment, which are then fashioned into products, used, and then disposed of. A sustainable industrial system based on recycling is cyclic (FIGURE 23-17b). It resembles the nutrient cycles in ecosystems. In such a system, materials flow cyclically through the system—from production facility to consumer and back for reuse a lot like carbon or nitrogen in ecosystems.

Although some raw materials will need to be extracted and some wastes will invariably be produced in a sustainable system of production and consumption, the goal of a sustainable economy is to maximize the amount of material that is recycled within the economy. As you shall soon see, this will mean a shift away from employment at both ends of the system and toward the middle, where the recycling occurs (both pickup and remanufacturing).

Building an industrial ecosystem—that is, a system of commerce that is an analog of the natural ecosystems—means even greater increases in the amount of material that is returned by end users; but this is not enough. To create a truly cyclic economy, companies must be willing to use the materials picked up in curbside programs or drop-off sites, as noted above. Financial incentives and disincentives can be used to promote remanufacturing. For instance, Colorado offers a tax credit to companies that purchase equipment that allows them to incorporate recycled materials into the manufacturing process. In addition, people like you and I must be willing to purchase recycled paper and other materials to help support manufacturers. If recyclers cannot find a market for their materials, all the recycling in the world is of no use.
In the past decade, municipalities starting many new recycling programs have discovered that there are no markets for some materials or that the payments they will receive are inadequate to support their programs. When New York State began recycling plastic soft drink bottles, it couldn't find a buyer; the recycling program became an expensive trip to the landfill. Over time, though, markets developed, and the soft drink bottles are now ground up and used to make carpeting, filler for pillows, jackets, and other products. In the late 1980s, many cities found that newsprint recycling efforts were crippled by a dramatic decline in newsprint prices. Over the past 2 decades, gluts of recyclable materials have always seemed to end, as markets develop in response to rising secondary material supplies. In the late 1980s and early 1990s, over 70 paper product mills that rely on recycled paper opened in the United States or were modified to handle recycled paper.

Recycled newsprint can be used to make a variety of useful products besides new newsprint. For instance, it can be used to make egg cartons, cereal boxes, map tubes, drywall, ceiling tiles, animal bedding, and insulation. The insulation filling the rafter spaces in my environmentally sustainable home is 100% recycled newsprint and cardboard. Cities and towns can encourage companies to manufacture these products from waste, thus putting locally available wastes to good use and helping build stable, self-reliant regional or state economies.

Individuals can help expand markets by purchasing recycled products. Governments can also help. When added together, local, state, and federal governments account for an estimated 40% of the U.S. gross national product—that is, the nation's total annual output of goods and services. Government is the single most important purchaser in the U.S. economy. Think of the impact that local, state, and federal governments could have if they all started buying recycled paper. The demand they created would greatly increase production, lower costs, and create supplies for the rest of us.

Today, all 50 states and the District of Columbia have procurement programs, purchasing millions of reams of recycled office paper and paper products. New York, for example, allows state agencies to purchase recycled paper if it comes within 5% of the cost of virgin stock; California allows purchase if it comes within 10%. These are called price preference policies. In these two states, about one-fourth
of all the office paper, tissue, paper towels, and cardboard purchased by state agencies are made from recycled stock. On average, the states pay only about 2% more for office paper. Who knows what they saved in reduced pollution and health bills?

In October 1991, President George Bush signed an executive order that required all federal departments and agencies to purchase products made with recycled materials whenever possible. This order also requires federal agencies to name recycling coordinators to increase recycling of discarded items by the nation’s 3 million federal employees.

Unknown to many, the Resource Conservation and Recovery Act called on federal agencies to purchase recycled materials in 1976, but only if the products were reasonably priced. Unfortunately, two problems thwarted progress. First, the law called on the EPA to publish a list of guidelines for a dozen or so recycled products. However, the EPA did not begin drawing up the guidelines for over a decade—and only then after it was sued by environmentalists. The job was not completed until 1989.

The second problem was interpretation of the “reasonable cost” provisions to mean the lowest cost. Given federal transportation policy, the smaller markets, and the failure of current pricing systems to reflect external costs (among other problems), recycled products are often slightly more expensive. Colorado officials, however, have found that some items are cost-competitive or even cheaper. Furthermore, money saved on one product, can be used to pay the slightly higher price of another, thus keeping state spending constant.

As recycling becomes more common, more and more manufacturers are bound to shift to recycled materials. Recycling facilities are bound to open in many states, creating jobs and economic opportunities. In the not-too-distant future, recycling could well be the chief source of materials to make consumer products.

It may be surprising to many, but recycling is much more prevalent in the less developed countries than in the industrialized nations. The poor raid the dumps for food, clothing, and materials for shelter; they also seek out discarded metals and other goods that they can sell. The more developed nations can help promote recycling as they assist less developed nations in their efforts to increase their economic well-being. Information on the energy and material savings, as well as the technologies for recycling, could help convince these countries and businesses to adopt recycling policies.

**KEY CONCEPTS**

One of the most important boosts to recycling is purchasing products made from recycled materials, an activity in which governments, businesses, and individuals can all engage. Governments can help strengthen the markets by providing incentives to companies that use recycled materials or by requiring them to use a certain percentage of recycled content in their products.

Composting. Another valuable throughput strategy that reduces waste and recycles materials is composting, the process in which nutrients from organic wastes such as leaves, grass clippings, cardboard, and paper are returned to the soil. Composting is a form of nutrient recycling.

In most large-scale operations, organic matter is collected from various sources, stockpiled, mixed with some dirt, and then allowed to decompose. The resulting product, compost, is a nutrient-rich, organic material that can be used to build soil fertility. Composting may occur in backyards, in neighborhood facilities, or in large municipal operations.

In 2008, 3,510 municipal composting operations were in business in the United States, up from 3,227 in 2001, according to the EPA. In Seattle, for example, zoo officials compost all of the manure produced by the zoo’s many animals. When decomposed, the manure forms a rich, organic soil supplement they call ZooDoo, which is sold to gardeners and homeowners for use around the yard. Yard waste composting programs exist in virtually every state in the United States. Despite this success, most large-scale composting programs are in Europe—in the Netherlands, Belgium, England, and Italy—and in Israel.

Widespread composting, combined with recycling, can result in substantial reductions in municipal waste. Nationwide, organic wastes such as leaves, grass clippings, and kitchen scraps constitute about 25% of the garbage dumped into landfills or burned in incinerators. During the fall, compostable waste can make up 75% of the waste stream. Composting these wastes would not only reduce landfilling but could save considerable amounts of energy needed to transport wastes to landfills. Composting is often cheaper than landfilling and can help recycle nutrients to farmland, closing the loops of an extremely important nutrient cycle. In New Jersey, composting in Morris County costs municipalities $16 to $32 per ton, much less than landfilling, which costs over $110 per ton. Collecting and composting leaves and yard waste in Minneapolis and St. Paul costs the cities about $65 a ton, compared to landfilling at $90 a ton.

Despite their obvious benefits, large-scale composting operations have some drawbacks. First, they require large tracts of land because they can produce odor and create breeding sites for pests. Because of this, composting facilities are usually sited far from homes. This adds significantly to the transportation costs and energy consumption. Large-scale composting facilities are often expensive undertakings, in part because of the need to sort out the noncompostable materials such as plastics, metals, and glass. They also need to invest in machinery to turn the compost regularly to accelerate decay.

To make municipal composting more cost-effective, cities and counties could rely on labor from convicts, welfare recipients, or the unemployed. Citizens could be required to sort out recyclable metals, plastics, and glass, thus eliminating the cost of separating the wastes later.

Composting can be practiced very successfully at home. Gardeners can make their own compost piles of leaves, grass clippings, and vegetable wastes from the kitchen. By mixing these materials with a little soil (which contains the bacteria that do the breakdown) and by watering the pile from time to time to keep it moist, homeowners can produce a
nutrient-rich soil supplement for lawns and gardens—eliminating the need for artificial fertilizer. A commercially available container or a simple wooden enclosure helps keep neighbors’ dogs or neighborhood raccoons and skunks out of the pile. Home composting also eliminates the need to haul wastes to central facilities.

Another waste product of cities and towns is sewage sludge. As noted in Chapter 21, sludge is typically dumped in landfills, wasting very valuable soil nutrients. Fortunately, sludge can be combined with municipal solid waste (leaves, paper, grass clippings, and so on) and composted. This process, called co-composting, destroys viruses and bacteria in the sludge, so the product can be sold for use on farms or on gardens and lawns. Co-composting is expected to become increasingly popular in the United States and other countries because it costs less and is more ecologically sound than landfilling.

**KEY CONCEPTS**
The Economic Benefits of Recycling, Reuse, and Composting

John Young of the Worldwatch Institute once wrote that “more efficient use of materials could virtually eliminate incineration and dramatically reduce dependence on landfills. It could also substantially lower energy needs. . . . Taken together, source reduction, reuse, and recycling cannot only cut waste but also foster more flexible and self-reliant economies. Decentralized collection and processing of secondary materials can create new industries and jobs.”

In fact, numerous studies show that recycling creates far more jobs than the traditional strategies of landflling and incineration. A study in New York showed that recycling 10,000 tons of trash through curbside recycling programs produced, on average, 36 new jobs. Landfilling or incinerating that trash produced only about one job each. While some jobs will be lost in the front end of the production–consumption system—that is, at the mines and in the forests where raw materials are extracted—many more jobs will be opened up in the middle, the recycling portion. As Young points out, while the economic health of nations is often measured by the amount of materials they consume, prosperity doesn’t have to be so tightly linked to consumption. We can live well and live sustainably.

**KEY CONCEPTS**
We are poisoning ourselves and our posterity.

—Barry Commoner

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**CRITICAL THINKING**

**Exercise Analysis**
This is a clear-cut case of dollars versus environmental protection that hinges on ethics—values. You are fairly sure that the incinerator in the developing country will produce toxic emissions and that spills along the way are also possible. Lax rules may result in considerable environmental contamination. Furthermore, waste from the incinerator will very likely be dumped in an open pit, where it could leak into the groundwater. In essence, your economic savings will be passed on as an economic liability to unsuspecting residents of the receiving nation.

A savings of a million dollars is fairly substantial, however. Your boss will no doubt take notice and may even give you a sizable raise for saving the company so much money. How do you decide? Which is more important: protecting the environment of another country or saving your company money and maybe setting yourself up for a raise? Do you feel a sense of intragenerational equity? What other options are available to you?
CRITICAL THINKING AND CONCEPT REVIEW

1. Summarize the major events occurring at Love Canal. Who was to blame for this problem? What might have been done to avoid it?

2. You are appointed to head a state agency on hazardous-waste disposal. You and your staff are to make recommendations for a statewide plan to handle hazardous wastes. Draw up a plan for eliminating dumping. Which techniques would have the highest priority? How would you put your plan into effect?

3. Discuss the major provisions of the Resource Conservation and Recovery Act (1976) and the Comprehensive Environmental Response, Compensation, and Liability Act (1980), the so-called Superfund Act. What are the weaknesses of each?

4. Describe the pros and cons of hazardous-waste management strategies, including process modification, recycling and reuse, conversion to nonhazardous or less hazardous materials, and perpetual disposal.

5. Debate the following statement: “All hazardous wastes should be recycled and reused to eliminate disposal.”

6. A hazardous-waste site is going to be placed in your community. What information would you want to know about the site? How would you go about getting the information you need? Would you oppose it? Why or why not?

7. List personal ways in which we can each contribute to lessening the hazardous waste problem.

8. Discuss some of the options we have for getting rid of radioactive wastes. Which ones seem the most feasible to you? Why?

9. Debate the following statement: “Victims of improper hazardous-waste disposal practices should be compensated by a victim compensation fund developed by taxing the producers of toxic waste.”

10. Describe the three basic approaches to solving the solid waste problem. Give examples of each one. Which is (are) the most sustainable? Why?

11. Describe the pros and cons of landfilling, incineration, source reduction, composting, reuse, and recycling.

12. What shifts in activities would result from changing the linear production–consumption system to a cyclic one? How will this affect jobs? In your opinion, are the proposed shifts necessary? How can we soften the blow of such a change?

13. Critically analyze this statement: “Recycling is not as great as advocates would have you think. Recycling takes energy, for example, to pick up materials and reprocess them. It produces waste and pollution.”

KEY TERMS

aseptic containers  
co-composting  
compost  
composting  
Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)  
detoxification  
gross national product  
hazardous wastes  
incineration  
input approach  
land disposal  
low-temperature decomposition  
Marine Protection, Research, and Sanctuaries Act  
municipal solid wastes  
NIMBY syndrome  
Nuclear Waste Policy Act  
Ocean Dumping Ban Act  
output approach  
price preference policies  
process manipulation  
recycling  
Resource Conservation and Recovery Act (RCRA)  
reuse  
reuse and recycling strategies  
sanitary landfill  
secured landfills  
source reduction  
substitution  
Superfund  
Superfund Act  
throughput approach  
waste-to-energy (WTE) plants

REFERENCES AND FURTHER READING

To save on paper and allow for updates, additional reading recommendations and the list of sources for the information discussed in this chapter are available at http://environment.jbpub.com/9e/.

Connect to this book’s website:  
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The site features eLearning, an online review area that provides quizzes, chapter outlines, and other tools to help you study for your class. You can also follow useful links for in-depth information, research the differing views in the Point/Counterpoints, or keep up on the latest environmental news.