

Environmental History of the United States (Chapters 3, 9, 10, 12, 13, 18, 22, 24, 25)

The Four Major Eras of U.S. Environmental History

We can divide the environmental history of the United States into four eras. During the *tribal era*, people (now called Native Americans), representing several hundred tribes, distinguished by language and culture, occupied North America for at least 13,000 years before European settlers began arriving in the early 1600s. These hunter-gatherers generally had sustainable, low-impact ways of life because of their relatively limited numbers and modest resource use per person.

Next was the *frontier era* (1607–1890) when European colonists began settling North America. Faced with a continent offering seemingly inexhaustible resources, the early colonists developed a **frontier environmental worldview**. They saw a wilderness to be conquered and managed for human use.

Next came the *early conservation era* (1832–1870), which overlapped the end of the frontier era. During this period, some people became alarmed at the scope of resource depletion and degradation in the United States. They argued that part of the unspoiled wilderness on public lands should be protected as a legacy to future generations. Most of these warnings and ideas were not taken seriously.

This period was followed by an era—lasting from 1870 to the present—featuring an increased role of the federal government and private citizens in resource conservation, public health, and environmental protection. **Explore More:** Go to www.cengage.com/login to see timelines of major events that occurred during the environmental history of the United States from 1832 to the present.

The Frontier Era (1607–1890)

During the frontier era, European settlers spread across the land by clearing forests for cropland and settlements. In the process, they displaced the Native Americans who, for the most part, had lived on the land sustainably for thousands of years.

The U.S. government accelerated this settling of the continent and use of its resources by transferring vast areas of public land to private interests. Between 1850 and 1890, more than half of the country's public land was given away or sold cheaply by the government to railroad, timber, and mining companies, land developers, states, schools, universities, and homesteaders to encourage settlement. This era came to an end when the government declared the frontier officially closed in 1890.



Figure 1 Henry David Thoreau (1817–1862) was an American writer and naturalist who kept journals about his excursions into wild areas in parts of the northeastern United States and Canada, and at Walden Pond in Concord, Massachusetts. He sought self-sufficiency, a simple lifestyle, and a harmonious coexistence with nature.

Early Conservationists (1832–1870)

Between 1832 and 1870, some citizens became alarmed at the scope of resource depletion and degradation in the United States. They urged the government to preserve part of the unspoiled wilderness on public lands owned jointly by all people (but managed by the government), and to protect it as a legacy to future generations.

Two of these early conservationists were Henry David Thoreau (1817–1862) and George Perkins Marsh (1801–1882). Thoreau (Figure 1) was alarmed at the loss of numerous wild species from his native eastern Massachusetts. To gain a better understanding of nature, he built a cabin in the woods on Walden Pond near Concord, Massachusetts, lived there alone for 2 years, and wrote *Life in the Woods*, an environmental classic.*

In 1864, George Perkins Marsh, a scientist and member of Congress from Vermont,

*I (Miller) can identify with Thoreau. I spent 10 years living in the deep woods studying and thinking about how nature works and writing early editions of the book you are reading. I lived in a remodeled school bus with an attached greenhouse. I used it as a scientific laboratory for evaluating environmental technologies such as passive and active solar energy technologies for heating the bus and any hot water I needed, waste disposal (composting toilets), natural geothermal cooling (earth tubes), ways to save energy and water, and biological control of pests. It was great fun and I learned a lot. In 1990, I came out of the woods to find out more about how to live more sustainably in urban areas, where most people live.

published *Man and Nature*, which helped legislators and citizens see the need for resource conservation. Marsh questioned the idea that the country's resources were inexhaustible. He also used scientific studies and case studies to show how the rise and fall of past civilizations were linked to the use and misuse of their soils, water supplies, and other resources. Some of his resource conservation principles are still used today.

What Happened between 1870 and 1930?

Between 1870 and 1930, a number of actions increased the role of the federal government and private citizens in resource conservation and public health. The *Forest Reserve Act of 1891* was a turning point in establishing the responsibility of the federal government for protecting public lands from resource exploitation.

In 1892, nature preservationist and activist John Muir (Figure 2) founded the Sierra Club. He became the leader of the *preservationist movement*, which called for protecting large areas of wilderness on public lands from human exploitation, except for low-impact recreational activities such as hiking and camping. This idea was not enacted into law until 1964. Muir also proposed and lobbied for creation of a national park system on public lands.

Primarily because of political opposition, effective protection of forests and wildlife on federal lands did not begin until Theodore Roosevelt (Figure 3), an ardent conservationist,



Figure 2 John Muir (1838–1914) was a geologist, explorer, and naturalist. He spent 6 years studying, writing journals, and making sketches in the wilderness of California's Yosemite Valley and then went on to explore wilderness areas in Utah, Nevada, the Northwest, and Alaska. He was largely responsible for establishing Yosemite National Park in 1890. He also founded the Sierra Club and spent 22 years lobbying actively for conservation laws.



Figure 3 Theodore (Teddy) Roosevelt (1858–1919) was a writer, explorer, naturalist, avid birdwatcher, and twenty-sixth president of the United States. He was the first national political figure to bring conservation issues to the attention of the American public. According to many historians, Theodore Roosevelt contributed more than any other U.S. president to natural resource conservation in the United States.

became president. His term of office, 1901–1909, has been called the country's *Golden Age of Conservation*.

While in office he persuaded Congress to give the president power to designate public land as federal wildlife refuges. In 1903, Roosevelt established the first federal refuge at Pelican Island (see Figure 9-21, p. 211) off the east coast of Florida for preservation of the endangered brown pelican, and he added 35 more reserves by 1904. He also more than tripled the size of the national forest reserves.

In 1905, Congress created the U.S. Forest Service to manage and protect the forest reserves. Roosevelt appointed Gifford Pinchot (1865–1946) as its first chief. Pinchot pioneered scientific management of forest resources on public lands. In 1906, Congress passed the *Antiquities Act*, which allows the president to protect areas of scientific or historical interest on federal lands as national monuments. Roosevelt used this act to protect the Grand Canyon and other wilderness areas that would later become national parks.

Congress became upset with Roosevelt in 1907, because by then he had added vast tracts to the forest reserves. Congress passed a law banning further executive withdrawals of public forests. However, on the day before the bill became law, Roosevelt defiantly reserved another large block of land. Most environmental historians view Roosevelt as the country's best environmental president.

Early in the 20th century, the U.S. conservation movement split into two factions over how public lands should be used. The *wise-use*, or *conservationist*, school, led by Roosevelt and Pinchot, believed all public lands should be managed wisely and scientifically to provide needed resources. The *preservationist* school, led by Muir, wanted wilderness areas on public lands to be left untouched. This controversy over use of public lands continues today.

In 1916, Congress passed the *National Park Service Act*, which declared that parks are to be maintained in a manner that leaves them unimpaired for future generations. The act also established the National Park Service (within the Department of the Interior) to manage the park system. Under its first head, Stephen T. Mather (1867–1930), the dominant park policy was to encourage tourist visits by allowing private concessionaires to operate facilities within the parks.

After World War I, the country entered a new era of economic growth and expansion. During the administrations of Presidents Harding, Coolidge, and Hoover, the federal government promoted increased sales of timber, energy, mineral, and other resources found on public lands at low prices to stimulate economic growth.

President Herbert Hoover went even further and proposed that the federal government return all remaining federal lands to the states or sell them to private interests for economic development. But the Great Depression (1929–1941) made owning such lands unattractive to state governments and private investors. The Depression was bad news for the country. But some say that without it we might have little if any of the

public lands that today make up about one-third of the total land area of the United States (see Figure 24-5, p. 644).

What Happened between 1930 and 1960?

Along with a second wave of national resource conservation, improvements in public health also began in the early 1930s as President Franklin D. Roosevelt (1882–1945) strove to bring the country out of the Great Depression. He persuaded Congress to enact federal government programs to provide jobs and to help restore the country's degraded environment.

During this period, the government purchased large tracts of land from cash-poor landowners, and established the *Civilian Conservation Corps* (CCC) in 1933. It put 2 million unemployed people to work planting trees and developing and maintaining parks and recreation areas. The CCC also restored silted waterways and built levees and dams for flood control.

The government built and operated many large dams in the Tennessee Valley as well as in the arid western states, including Hoover Dam on the Colorado River (see Figure 13-1, p. 317). The goals were to provide jobs, flood control, cheap irrigation water, and cheap electricity for industry.

In 1935, Congress passed the Soil Conservation Act. It established the *Soil Erosion Service* as part of the Department of Agriculture to correct the enormous erosion problems that had ruined many farms in the Great Plains states during the Depression and created a large area of degraded land known as the *Dust Bowl*. Its name was later changed to the *Soil Conservation Service*, now called the *Natural Resources Conservation Service*. Many environmental historians praise Franklin D. Roosevelt (a Democrat) for his efforts to get the country out of a major economic depression and to help restore environmentally degraded areas.

Federal resource conservation policy changed little during the 1940s and 1950s, mostly because of preoccupation with World War II (1941–1945) and economic recovery after the war.

Between 1930 and 1960, improvements in public health included establishment of public health boards and agencies at the municipal, state, and federal levels; increased public education about health issues; introduction of vaccination programs; and a sharp reduction in the incidence of waterborne infectious diseases, mostly because of improved sanitation and garbage collection.

What Happened during the 1960s?

A number of milestones in American environmental history occurred during the 1960s. In 1962, biologist Rachel Carson (1907–1964) published *Silent Spring*, which documented the pollution of air, water, and wildlife from the use of pesticides such as DDT (see Chapter 12, *Individuals Matter*, p. 298). This influential book helped to broaden the concept of resource conservation to include preservation of the *quality* of the planet's air, water, soil, and wildlife.

Many environmental historians mark Carson's wake-up call as the beginning of the modern **environmental movement** in the United States. It flourished when a growing number of citizens organized to demand that political leaders enact laws and develop policies to curtail pollution, clean up polluted environments, and protect unspoiled areas from environmental degradation.

In 1964, Congress passed the *Wilderness Act*, inspired by the vision of John Muir more than 80 years earlier. It authorized the government to protect undeveloped tracts of public land as part of the National Wilderness System, unless Congress later decides they are needed for the national good. Land in this system is to be used only for nondestructive forms of recreation such as hiking and camping.

Between 1965 and 1970, the emerging science of *ecology* received widespread media attention. At the same time, the popular writings of biologists such as Paul Ehrlich, Barry Commoner, and Garrett Hardin awakened Americans to the interlocking relationships among population growth, resource use, and pollution.

During that period, a number of events increased public awareness of pollution, such as the realization that pollution and loss of habitat were endangering well-known wildlife species such as the North American bald eagle, grizzly bear, whooping crane, and peregrine falcon.

During the 1968 U.S. Apollo 8 mission to the moon, astronauts photographed the earth for the first time from lunar orbit. This allowed people to see the earth as a tiny blue and white planet in the black void of space, and it led to the development of the *spaceship-earth environmental worldview*. It reminded us that we live on a planetary spaceship that we should not harm because it is the only home we have.

What Happened during the 1970s? The Environmental Decade

During the 1970s, media attention, public concern about environmental problems, scientific research, and action to address environmental concerns grew rapidly. This period is sometimes called the *environmental decade*, or the *first decade of the environment*. Figure 24-4, p. 643 summarizes some of the major U.S. environmental laws passed during this decade and in the 1980s and 1990s.

The first annual *Earth Day* was held on April 20, 1970. This event was proposed by Senator Gaylord Nelson (1916–2005) and organized by Denis Hayes (see Chapter 24, Core Case Study, p. 637). Some 20 million people in more than 2,000 U.S. communities took to the streets to heighten the nation's environmental awareness and to demand improvements in environmental quality.

The *Environmental Protection Agency (EPA)* was established in 1970. In addition, the *Endangered Species Act of 1973* greatly strengthened the role of the federal government in protecting endangered species and their habitats.

In 1978, the *Federal Land Policy and Management Act* gave the *Bureau of Land Management (BLM)* its first real authority to manage the public land under its control, 85% of which is

in 12 western states. This law angered a number of western interests whose use of these public lands was restricted for the first time.

In response, a coalition of ranchers, miners, loggers, developers, farmers, some elected officials, and other citizens in the affected states launched a political campaign known as the *sagebrush rebellion*. It had two major goals. *First*, sharply reduce government regulation of the use of public lands. *Second*, remove most public lands in the western United States from federal ownership and management and turn them over to the states. After that, the plan was to persuade state legislatures to sell or lease the resource-rich lands at low prices to ranching, mining, timber, land development, and other private interests. This represented a return to President Herbert Hoover's plan to get rid of all public land, which had been thwarted by the Great Depression. This political movement continues to exist.

In 1977, Congress created the Department of Energy in order to develop a long-range energy strategy to help reduce the country's heavy dependence on imported oil. In 1980, Congress created the *Superfund* as part of the *Comprehensive Environmental Response, Compensation, and Liability Act* (see Chapter 21, p. 578). Its goal was to clean up abandoned hazardous waste sites, including the Love Canal housing development in Niagara Falls, New York, which had to be abandoned when hazardous wastes from the site of a former chemical company began leaking into school grounds, yards, and basements.

During this period the area of land in the National Wilderness System tripled and the area in the National Park System doubled (primarily by adding vast tracts in the state of Alaska).

What Happened during the 1980s? Environmental Backlash

During this decade, farmers, ranchers, and leaders of the oil, coal, automobile, mining, and timber industries strongly opposed many of the environmental laws and regulations developed in the 1960s and 1970s. They organized and funded multiple efforts to defeat environmental laws and regulations—efforts that persist today.

In 1980 the United States led the world in research and development of wind and solar energy technologies. Between 1981 and 1983, however, Congress slashed by 90% government subsidies for renewable energy research and for energy efficiency research, and eliminated tax incentives for the residential solar energy and energy conservation programs enacted in the late 1970s. As a result, the United States lost its lead in developing and selling the wind turbines and solar cells that are rapidly becoming two of the biggest and most profitable businesses of this century. Thus, Americans now buy many of their solar cells from Japan, Germany, and China, and much of the components for wind farms from Denmark, Germany, and China. During the 1980s, Congress, influenced by a growing backlash against many environmental laws enacted in the 1970s, also increased private energy and mineral development and timber cutting on public lands, lowered automobile gas mileage standards, and relaxed federal air and water quality pollution standards.

In 1988, an industry-backed coalition called the *wise-use movement* was formed. Its major goals were to weaken or repeal most of the country's environmental laws and regulations, and destroy the effectiveness of the environmental movement in the United States. Politically powerful coal, oil, mining, automobile, timber, and ranching interests helped back this movement. They argued that environmental laws had gone too far and were hindering economic growth.

What Happened from 1990 to 2010?

Between 1990 and 2010, opposition to environmental laws and regulations gained strength. This occurred because of continuing political and economic support from corporate backers, who not only argued that environmental laws were hindering economic growth, but also helped elect many members of Congress who were generally unsympathetic to environmental concerns. Since 1990, leaders and supporters of the environmental movement have had to spend much of their time and funds fighting these efforts to discredit the movement and weaken or eliminate most environmental laws passed during the 1960s and 1970s.

During the 1990s, many small and mostly local grassroots environmental organizations sprang up to help deal with environmental threats in their local communities. Interest in environmental issues increased on many college and university campuses resulting in the expansion of environmental studies programs at these institutions. In addition, there was growing awareness of critical and complex environmental issues, such as sustainability, population growth, biodiversity protection, and threats from atmospheric warming and projected climate change.

■ CASE STUDY

The Return of the American Bison

In 1500, before Europeans settled North America, 30–60 million North American bison (Figure 4)—also commonly called buffalo—grazed the plains, prairies, and woodlands of much of the continent. A single herd on the move might take hours to move past one point.

Numerous Native American tribes depended heavily on bison, using virtually every part of the animal for food, clothing, shelter, and a wide variety of tools and weapons. Typically, they killed only the number of animals they needed. However, by 1906 the once-vast range of the bison had shrunk to a tiny area, and the species had been driven nearly to extinction.

How did this happen? First, settlers moving west after the Civil War upset the sustainable balance that had existed between Native Americans and bison. Many tribes on the Great Plains had begun to trade bison skins to settlers for steel knives and firearms; these items were so valuable that the tribes began killing more bison for their hides. However, much worse damage was done when the new settlers undertook a



Figure 4 This herd of American bison (also called buffalo) is grazing in Custer State Park in the Black Hills of the U.S. state of South Dakota. This once-abundant land mammal, the largest in North America, has been brought back from the brink of extinction. These huge animals look docile but they become nervous and unpredictable when threatened by a predator, and this can result in a stampede, a frantic rush of hundreds or thousands of panicked animals. A mature bison can toss a grizzly bear off its back, and it can kick like a mule.

Jim Parkin/Shutterstock

relentless slaughter of the bison. As railroads spread westward in the late 1860s, rail companies hired professional bison hunters—including Buffalo Bill Cody—to supply meat to their construction crews. Passengers also gunned down bison from train windows for sport, leaving the carcasses to rot.

Commercial hunters shot millions of bison for their tongues (considered a delicacy) and hides, leaving most of the meat to rot. “Bone pickers” collected the bleached bones that whitened the prairies and shipped them east to be ground up as fertilizer.

Farmers shot bison because they damaged crops, fences, sod houses, and telegraph poles. Ranchers killed them because they competed with cattle and sheep for grass. The U.S. Army killed at least 12 million bison as part of their campaign to subdue or eliminate the tribes of the Great Plains by killing off their primary source of food. Without the bison, these tribes began to starve and were forced to abandon the fight to preserve their traditional homelands, moving onto small reservations where they received government food rations. This, in turn, allowed for further westward expansion by European immigrants and their descendants engaged in farming, ranching, and the building of railroads.

By 1892, only 85 bison were left from herds that had numbered in the tens of millions. They were given refuge in Yellowstone National Park and protected by an 1893 law prohibiting the killing of wild animals in national parks.

In 1905, sixteen people formed the American Bison Society to protect and rebuild the captive population. Soon thereafter, the federal government established the National Bison Range near Missoula, Montana, and later, the Tallgrass Prairie National Reserve in Oklahoma as part of the U.S. National Park system. Today there are an estimated 500,000 bison, about 97% of

them on privately owned ranches and the rest in protected parks and reserves.

The story of the American bison's comeback shows that even a severely endangered species can recover if a few people care enough to help them.

■ CASE STUDY

Air Pollution in the Past: The Bad Old Days

Modern civilization did not invent air pollution. It probably began when humans discovered fire and used it to burn wood in poorly ventilated caves for warmth and cooking, and inhaled unhealthy smoke and soot.

During the Middle Ages (from about the 5th to the 16th centuries, AD) a haze of wood smoke hung over densely packed urban areas in Europe. The Industrial Revolution (from the 18th to the 19th centuries,) brought even worse air pollution as coal was burned to power factories and heat homes. As a result, there were great increases in respiratory diseases such as asthma and bronchitis, as well as allergies. Many people died from these ailments, especially children and the elderly.

By the 1850s, dense mixtures of coal smoke and fog as “thick as pea soup,” sometimes referred to as yellow fog, engulfed London in a sunless gloom during winter months. In 1880, a prolonged coal fog killed an estimated 2,200 people. In 1905, a physician used the word *smog* to describe the deadly mixture of smoke and fog that afflicted London. Another episode in 1911 killed more than 1,100 Londoners.

In December 1952, an even worse yellow fog lasted for 5 days and killed 4,000–12,000 Londoners. Visibility was so low that people walking outside during the day could not see their feet. So many people died that undertakers ran out of coffins.

This tragedy prompted the British Parliament to pass the Clean Air Act of 1956. Before the beneficial effects of the law could be realized, additional air pollution disasters in 1956, 1957, and 1962 killed 2,500 more people. Because of strong air pollution laws, London's air today is much cleaner, and “pea soup” fogs are a thing of the past. Now the major threat is from air pollutants emitted by motor vehicles.

The Industrial Revolution, powered by coal, brought air pollution to the United States. Large industrial cities such as Pittsburgh, Pennsylvania, and St. Louis, Missouri, were known for their smoky air. By the 1940s, the air over some cities was so polluted that people had to turn their automobile headlights on during the day.

The first documented air pollution disaster in the United States occurred on October 29, 1948, in the small industrial town of Donora in Pennsylvania's Monongahela River Valley south of Pittsburgh. Pollutants from the area's coal-burning factories, steel mills, zinc smelters, and sulfuric acid plants became trapped in a dense fog that stagnated over the valley for 5 days. This killer fog resulted from a combination of mountainous terrain surrounding the valley and weather conditions that trapped and concentrated deadly pollutants. About 6,000 of the town's 14,000 inhabitants became sick, and 20 of them died.

In 1963, high concentrations of air pollutants in New York City killed about 300 people and injured thousands. Incidents like these finally resulted in city, state, and federal air pollution control programs in the United States, with the U.S. state of California leading the way. As a result, air quality has dramatically improved throughout the country.

However, many major urban areas in less-developed countries, such as China (see Figure 18-2, p. 465), India (see Figure 15-16, p. 383), and parts of Eastern Europe that depend on burning coal in industries, power plants, and

homes, face air pollution levels similar to those in London, England, and in American industrial cities in the 1950s.

THINKING ABOUT
Outdoor Air Pollution—Past and Present

Explain why you agree or disagree with the statement: "Air pollution in the United States should no longer be a major concern because of the significant progress made in reducing outdoor air pollution since 1970."

■ CASE STUDY
Trash Production and Recycling in New York City: Past, Present, and Future

You might guess that trash production in New York City has been rising steadily. You would be wrong. In 2002, Columbia University adjunct professor Daniel C. Walsh discovered some surprising facts when analyzing detailed records about what residents of New York City threw away between 1900 and 2000.

He found that the per person output, by weight, of trash dumped by New Yorkers was higher between 1920 and 1940 than it is today—mostly because of the coal ash produced by people burning coal for heat and cooking. The city's highest trash output per person was in 1940, when the rate was more than two times today's output.

During 1962 and 1963, the trash output per New Yorker was at its lowest level for the 20th century, as household coal burning was phased out and paper became the largest component of trash. Between 1964 and 1974, the city's trash output per person rose to slightly above today's levels as returnable, refillable bottles were phased out and the use of throwaway items increased. Since 1975, the weight of trash thrown away per New Yorker has remained about the same because of lighter products and an increase in recycling.

In 1999, New York City passed a mandatory recycling law, but it was not the city's first

experience with such recycling. Between 1896 and 1914, the city had a recycling program that required mandatory curbside separation of trash. But this recycling effort faded and died before World War I.

Professor Walsh also found that trash output per person rose in good economic times when people could buy more and fell in bad times as people reduced their spending.

Despite some progress, New York City was one of the first U.S. cities to run out of landfill space for its garbage. Until 2001, most of the city's garbage was buried in its Fresh Kills landfill on Staten Island, the world's largest public landfill. At its peak in 2001, this huge manmade structure, a monument to a throw-away mentality, was taller than the city's Statue of Liberty. However, after filling up in 2001, it was closed. Now it is being transformed into recreational facilities, restored wetlands, and public parkland.

Since 2001, the city has been hauling its massive amounts of garbage to landfill sites in New Jersey, Pennsylvania, and Virginia. Each day, some 600 energy-inefficient and polluting tractor trailer trucks, which if lined up would form a convoy nearly 14 kilometers (9 miles) long, haul trash out of New York City to landfills, some as far as 480 kilometers (300 miles) away.

As oil prices rise and concerns over CO₂ emissions increase, it may become too expensive at some point for New York (and for other cities) to haul garbage long distances to burial sites. Then what?

Instead of focusing mostly on what to do with its garbage (an output approach), environmental scientists urge New York City officials to think more about how to avoid producing so much trash (an input approach). The city could reduce its solid waste output by 60–80% and become a global model of how to shift from a throwaway, urban economy to a reduce-reuse-recycle, urban economy. This transition could be spurred by a *pay-as-you-throw* garbage collection system in which households and businesses pay for the solid wastes they throw away but not for those they recycle or compost.

THINKING ABOUT
Analyzing Trash

What two lessons can we learn from this analysis of data on New York City's trash?

■ CASE STUDY
Destroying a Great Mass Transit System in the United States

In 1917, all major U.S. cities had efficient electric trolley or streetcar (light-rail) systems. Many people think of Los Angeles, California, as the original car-dominated city. But in the early 20th century, Los Angeles had the largest electric-rail mass transit system in the United States.

That changed when General Motors, Firestone Tire, Standard Oil of California, Phillips Petroleum, and Mack Truck (which also made buses) formed a holding company called National City Lines. By 1950, the holding company had purchased privately owned streetcar systems in 83 major cities. It then dismantled these systems to increase sales of cars and buses.

The courts found the companies guilty of conspiracy to eliminate the country's light-rail system, but the damage had already been done. The executives responsible were each fined \$1, and each company paid a fine of \$5,000—less than the profit returned by replacing a single streetcar with a bus.

During this same period, National City Lines worked to convert electric-powered locomotives pulling commuter trains between cities and suburbs to much more expensive, polluting, and less reliable diesel-powered locomotives. The resulting increased costs contributed significantly to the sharp decline of the nation's railroad system.

THINKING ABOUT
Light-Rail Systems

If National City Lines had not dismantled many light-rail systems, do you think they would still be operating today? Explain.

Some Basic Chemistry (Chapters 1–4, 12, 14, 17–19, 21)

Chemists Use the Periodic Table to Classify Elements on the Basis of Their Chemical Properties

Chemists have developed a way to classify the elements according to their chemical behavior in what is called the *periodic table of elements* (Figure 1). Each horizontal row in the table is called a *period*. Each vertical column lists elements with similar chemical properties and is called a *group*.

The partial periodic table in Figure 1 shows how the elements can be classified as *metals*, *nonmetals*, and *metalloids*. Most of the elements found to the left and at the bottom of the table are *metals*, which usually conduct electricity and heat and are shiny. Examples are sodium (Na), calcium (Ca), aluminum (Al), iron (Fe), lead (Pb), silver (Ag), and mercury (Hg).

Atoms of metals tend to lose one or more of their electrons to form positively charged ions such as Na⁺, Ca²⁺, and Al³⁺. For example, an atom of the metallic element sodium (Na, atomic number 11) with 11 positively charged

protons in its nucleus and 11 negatively charged electrons outside of its nucleus, can lose one of its electrons. It then becomes a sodium ion with a positive charge of 1 (Na⁺) because it now has 11 positive charges (protons) but only 10 negative charges (electrons).

Nonmetals, found in the upper right of the table, do not conduct electricity very well. Examples are hydrogen (H), carbon (C), nitrogen (N), oxygen (O), phosphorus (P), sulfur (S), chlorine (Cl), and fluorine (F).

Atoms of some nonmetals such as chlorine, oxygen, and sulfur tend to gain one or more electrons lost by metallic atoms to form negatively charged ions such as O²⁻, S²⁻, and Cl⁻. For example, an atom of the nonmetallic element chlorine (Cl, atomic number 17) can gain an electron and become a chlorine ion. The ion has a negative charge of 1 (Cl⁻) because it has 17 positively charged protons in its nucleus and 18 negatively charged electrons outside of its nucleus. Atoms of nonmetals can also combine with one another to form molecules in which they share one or more pairs of their electrons.

Hydrogen, a nonmetal, is placed by itself above the center of the table because it does not fit very well into any of the groups.

The elements arranged in a diagonal staircase pattern between the metals and nonmetals have a mixture of metallic and nonmetallic properties and are called *metalloids*.

Figure 1 also identifies the elements required as *nutrients* (black squares) for all or some forms of life and elements that are moderately or highly toxic (red squares) to all or most forms of life. Six nonmetallic elements—carbon (C), oxygen (O), hydrogen (H), nitrogen (N), sulfur (S), and phosphorus (P)—make up about 99% of the atoms of all living things.

THINKING ABOUT
The Periodic Table

Use the periodic table to identify by name and symbol two elements that should have chemical properties similar to those of (a) Ca, (b) potassium, (c) S, (d) lead.

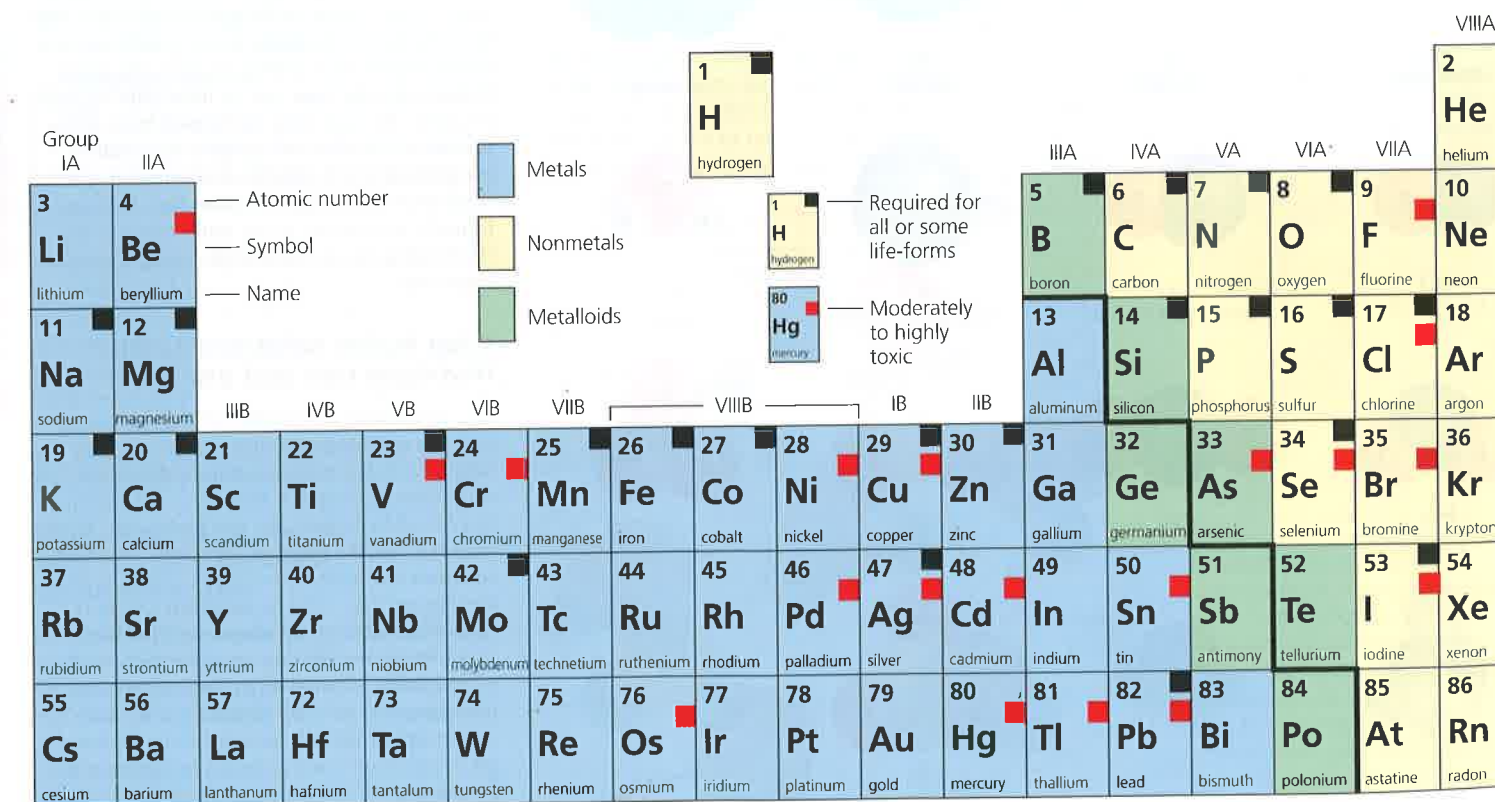


Figure 1 This is an abbreviated periodic table of elements. Elements in the same vertical column, called a *group*, have similar chemical properties. To simplify matters at this introductory level, only 72 of the 118 known elements are shown.