CHAPTER

19

A Clean Environment: The Basis of Public Health

An Environmental Hazard

Humans are designed by eons of evolution to live on the earth: to breathe the earth's air, to drink the earth's water, to eat the plants and animals that grow on the earth's surface. People are adapted to the earth's environment. While there is considerable variation in that environment in different parts of the planet, and while humans have found ways to live in many different climates and habitats, people's health depends on the presence of these basic ingredients of life—air, water, and food. There are also natural phenomena in the environment that can harm human health: extremes of heat and cold, ultraviolet rays of the sun, toxic minerals and plants, and other living organisms, from pathogenic bacteria to predatory mammals.

Human beings are social creatures, dependent upon other people to help them navigate the earth's environment. All humans in all parts of the world live in groups, from small bands of hunters and gatherers to the residents of teeming cities. When groups of people settle down to live together in one place, they change their shared environment: the larger the group, the greater the effect on the environment. Some of these changes may be made deliberately, to improve life for everyone; some are the inadvertent results of crowding, with harmful effects on people's well-being.

Archaeological evidence shows that the earliest cities were designed with consideration for the health of their inhabitants. As early as 2000 B.C., cities in India, Egypt, Greece, and South America had devised ways of providing clean water and draining wastes. These ancient systems of water supply, drains, and sewers are the first evidence of public health measures: organized community efforts to provide healthy conditions for the population.

Ensuring a clean water supply and the safe disposal of wastes—functions that fall into the category of environmental health—are still among the most important responsibilities of government. Other environmental health functions necessary in industrial countries are measures to ensure clean air and safe food. All these concerns arise because of the human tendency to live in groups. Most people do not have the means or the desire to grow their own food, draw water from their own well, and dispose of wastes in their own yard. Because people live together in cities and suburbs, they rely on others to provide their food and water and to dispose of their wastes. Because there are so many people on earth today, and because of the prodigality of the modern lifestyle, the wastes people produce have unprecedented potential to pollute the air and litter the earth.

Role of Government in Environmental Health

Environmental health is clearly the responsibility of government. Many environmental exposures, such as air pollution, are beyond the control of the individual. Others can be avoided only at significant trouble and expense, for example, if people grow their own vegetables, or buy

them from farmers whose agricultural methods they have inspected themselves. Governments ensure a healthy environment by various means, sometimes providing services directly, in other cases by setting standards and regulating how the services should be provided.

Traditionally in the United States, local governments have provided water for their citizens. They are required by law to meet standards set by state and federal governments. Local governments also traditionally provide sewage systems to dispose of wastes from individual households and to handle runoff from the land.

In the 1960s, Americans became increasingly aware that the environment was deteriorating. Lakes and streams were choked with sewage and chemical wastes that killed fish and other wildlife. Cities were overhung with smog. Citizens were outraged by news stories of neighborhoods poisoned by long-dormant toxic waste dumps. State and federal governments were pressured to assume more responsibility for the environment. In the late 1960s and early 1970s, many new laws set standards for air, water, and waste disposal. The first Earth Day, celebrated in the United States on April 22, 1970, marked the beginning of the modern environmental movement with coast-to-coast rallies and teach-ins.

Perhaps the most difficult environmental health issue people face today is the threat that human activities worldwide are changing the climate of the earth. The major concerns are depletion of the earth's ozone layer and the accumulation of "greenhouse gases" in the atmosphere. These problems, both of which may significantly affect human health, transcend national boundaries. While the United Nations has sponsored international meetings on these issues and governments have signed treaties designed to bring the problems under control, there is no way of enforcing these agreements.

Identification of Hazards

A major role of the federal government in environmental health is to identify hazards in the environment and to set safety standards that must be met by industry and by state and local governments to protect people from these hazards. Both the identification of a substance as hazardous and the setting of standards are often difficult and controversial. The risks posed by most synthetic chemicals that are discharged into the environment by industrial processes or that are disposed of by consumers are unknown. Testing for potential harmful effects is expensive and time-consuming, and the choice of chemicals to test may be politically controversial. Even in cases where the health risk is obvious—such as the discharge of raw sewage into waterways or the air pollution caused by America's dependence on the private automobile—local governments, industry, and even the average citizen may resist requirements to meet standards because of the expense and inconvenience of cleaning up the environment.

Radiation is an environmental health hazard that people tend to worry about only when it is artificially produced. However, all people are exposed to cosmic radiation in varying amounts depending on where they live, and natural radioactive materials are found in soils and rocks in many parts of the world. Radon gas, produced by the natural radioactive decay of uranium, is present in many homes, a fact that was recognized only in the mid-1980s. Prolonged exposure to radon is potentially a cause of lung cancer, although the risks from radon in the home are not well understood. Ultraviolet radiation from the sun is a significant cause of skin cancer and melanoma. There is no way these exposures can be regulated by government, except for some testing requirements concerning radon, discussed in Chapter 20.

The discovery in the mid-1890s of X-rays, which could pass through flesh and reveal bones, aroused great public excitement and led to extensive human exposures before the danger was recognized. During the early decades of the 20th century, X-ray treatments were popular as cure-alls for a variety of ailments, and radioactive ingredients were added to patent medicines. The first alarm was raised in the mid-1920s, with the deaths from kidney and bone disease of a number of workers who painted watch dials with radium so they would glow in the dark. They had been touching the paintbrushes to their lips to sharpen the points, thereby ingesting toxic quantities of the chemical. Then in 1932, a rich, socially prominent businessman died agonizingly from the same mysterious ailment, which was diagnosed on autopsy as radium poisoning. He had been dosing himself over a five-year period with hundreds of bottles of Radithor, a radium-containing patent medicine. The publicity surrounding the Radithor scandal led to strengthened Food and Drug Administration (FDA) powers to regulate patent medicines as well as specific limitations on radioactive pharmaceuticals.[1]

Evidence that chronic exposure to low levels of X-radiation caused cancer came from epidemiologic studies that began in the 1930s. One study compared death rates of radiologists with those of other medical specialists and found that the average age at death for radiologists was five years younger than that of other specialists.[2] Radiation's damaging health effects were confirmed by long-term follow-up studies of survivors of the atomic bombings of Hiroshima and Nagasaki, Japan, which ended the Second World War. The incidence of leukemia and other cancers was significantly increased among these people. Today, medical and dental X-rays constitute the largest source of nonbackground radiation exposure, although equipment has been continuously improved to reduce the hazard. Since about one-third of the medical and dental X-rays that Americans receive are estimated to be unnecessary, patients are advised to question whether each exposure is essential.

That some metals have harmful health effects has been common knowledge for decades or longer. This is the case with mercury, which was recognized in the 19th century to cause neurological damage in workers who made felt hats—the origin of the expression "mad as a hatter" and the inspiration for the character the Mad Hatter in Lewis Carroll's *Alice in Wonderland.* The devastating effects of the mercury discharged by a plastics factory into Japan's Minamata Bay in the 1950s caused some 700 deaths and varying degrees of paralysis and brain damage in 9000 other people (see Chapter 12). The mercury accumulated in fish, which were the staple of the community's diet. Another well-known episode of mercury poisoning occurred in Iraq in 1972, when the substance was used as a fungicide on seed grain. The contaminated wheat was turned into bread, which poisoned more than 6500 people, 459 of whom died.[3]

In the United States, mercury enters the environment mainly by emissions from coal-burning power plants. The heavy metal falls to earth and becomes a hazard to humans mainly by getting into fish. Because the developing brain is most sensitive to the toxic effects of mercury, pregnant women and women who may become pregnant, as well as nursing mothers and young children are advised to avoid eating fish species that have the highest average amounts of mercury in their flesh: tilefish, swordfish, king mackerel, and shark. Up to twelve ounces per week of other species of fish are considered safe. Mercury is regulated under both the Clean Air Act and the Safe Drinking Water Act (see Chapters 20 and 21).

People may be exposed to mercury when the liquid metal is spilled, releasing toxic vapors, for example after a glass thermometer breaks. Mercury may also be found in equipment used in school science labs, and exposure may occur if the equipment breaks or is mishandled. The Environmental Protection Agency (EPA) recommends that mercury-containing products be removed from homes and schools. The sale of mercury-containing fever thermometers is banned in many states; safer alternatives are available. Cleanup of mercury spills requires great caution in order to prevent droplets of the metal from accumulating in small spaces and releasing vapors into the air. The EPA cautions against trying to clean up mercury with a vacuum cleaner or broom, or pouring it down a drain, because these methods are likely to put more of the toxic vapors into the air.[4]

Lead is another metal known to harm the brain and nervous system, especially those of children. It also damages red blood cells and kidneys. Lead is believed to be the single most important environmental threat to the health of American children, who may be exposed to it from a variety of sources. Over the past three decades, evidence has accumulated that even low levels of lead can slow a child's development and can cause learning and behavior problems. The federal government recommends that all young children poor enough to be eligible for Medicaid be screened for lead in the blood, and some states have extended the mandate to children of all income levels. Permissible levels of lead have been steadily lowered from sixty micrograms per deciliter of blood in 1970 to ten micrograms at present.[5]

Lead has been used—and has been causing lead poisoning—since the time of the Roman Empire, when it was a component of wine casks, cooking pots, and water pipes. In fact, the Latin word for lead is "plumbum," the origin of the English word "plumbing." Even today, a major source of lead exposure for millions of Americans is water contaminated with lead from lead pipes or from lead solder used with copper pipes. The use of lead in pipes was phased out in the 1980s, and newer homes use plastic plumbing.

Until the 1980s, lead was a significant air pollutant, emitted from the tailpipes of motor vehicles that burned leaded gasoline. As a result of the phasing out of leaded gas, lead levels in the air have dropped to negligible amounts. Lead was also a component of paint, both interior and exterior, until its use was banned in 1977. Children—especially those who live in old, substandard housing—are still significantly exposed when they chew on chips of old peeling paint or when they put dirty hands in their mouths if the dirt is contaminated with dust from deteriorating paint. Attempts to remove old lead-containing paint can sometimes be even more hazardous if it turns to airborne dust as it is sanded or sandblasted off a surface and is inhaled.

New alarms about lead surfaced in 2007, when the Consumer Product Safety Commission recalled millions of wooden toys that had been painted with lead paint, including the popular Thomas the Tank Engine. It turned out that the toys had been manufactured in China, which produces 70 percent to 80 percent of the toys sold in the United States. Consumer advocates note that toy safety is largely the responsibility of the companies that import them. The Commission suffered cuts during the Bush administration, and has not had the staff to monitor the safety of so many imports.[6] Lead in toys is of special concern because young children often put them in their mouths.

Arsenic, "the king of poisons," is well known as a common means of homicide through the centuries. It was not recognized as an important environmental toxin until the United Nations Children's Fund inadvertently turned it into one in the 1970s in India and Bangladesh.[7] Concerned about epidemics of cholera, dysentery, and other waterborne diseases, the organization led a campaign to drill millions of wells so that the population would no longer need to drink contaminated surface water. However, it soon became apparent that people began to develop symptoms such as abdominal pain, vomiting, diarrhea, pain and swelling in the hands and feet, and skin eruptions. In some cases, symptoms progressed to progressive nervous system deterioration and death. Children of poor nutritional status proved to be especially susceptible to these problems. The well water, while free of disease-causing bacteria, was found to contain very high concentrations of arsenic. With 80 percent of Bangladeshis affected, the World Health Organization has labeled this "the worst mass poisoning in history."[7(p.A386)] Developing effective strategies for mitigating the effects of arsenic has been called one of the most important environmental health challenges of our time.

Studies have shown that, at somewhat lower concentrations, long-term exposure to arsenic in drinking water increases risk of diabetes and cancer. In the United States, regulations call for public water systems to contain no more than ten micrograms per liter of arsenic, well below levels known to cause harm. However, people in some parts of the country who have private wells may be drinking water that contains fifty to ninety micrograms per liter of arsenic. The risks from chronic exposure to these amounts are not known.[7]

Asbestos is a fibrous mineral valuable for a variety of uses because of its strength and fire resistance. The hazards of asbestos were first recognized in an occupational setting: Inhalation of high concentrations of asbestos dust caused stiffening and scarring of the lungs of miners and other asbestos workers, a condition known as asbestosis, which can be disabling and eventually fatal. Regulations limiting exposure were instituted, but as workers began to live longer, many of them developed cancer. They were especially likely to get lung cancer or mesothelioma, a rare cancer of the lining of the chest or abdominal cavity that seems to be caused exclusively by inhalation of asbestos. As a result of a succession of lawsuits brought by injured workers and their families in the 1960s and 1970s, the Manville Corporation—the largest asbestos company in the United States—filed for bankruptcy in 1982.[8] Once the dangers of asbestos were recognized, many uses of the material were banned, and standards for occupational exposure were tightened. However, asbestos can still be found in brake linings and a number of construction materials.[3]

The general public is most likely to be exposed to asbestos fibers released into the air in the dust from crumbling walls and ceilings of old, deteriorating buildings. This is a special concern in schools, since all schools built or renovated between 1940 and 1973 were required to install asbestos insulation as a fire safety measure. Children's exposure is of special concern because they would live for many years with the fibers lodged in their lungs, and the likelihood of developing cancer would increase with time. In 1986, the Asbestos Hazard Emergency Response Act was passed. It required all primary and secondary schools to be inspected and, if loose asbestos was found, to carry out plans for removing, enclosing or encapsulating material. Unfortunately, the removal was often done improperly, causing more asbestos to be released into the air than if the material had been left intact. Other schools, unable to afford the expense of asbestos removal, ignored the rulings.[3] There is no evidence thus far that exposure to asbestos has been a significant cancer risk to the general population.

However, the population of Libby, Montana, was clearly harmed by decades of exposure to asbestos. The vermiculite ore that had been mined in the Libby area since the 1920s was heavily contaminated with asbestos. A study by the National Institute of Occupational Safety and Health found that among 1675 Libby workers, 15 died of mesothelioma, a very rare disease, and the death rate from asbestosis was 165 times higher than expected. Death rates from asbestosis among residents of the area were approximately forty times higher than the

rest of Montana and sixty times higher than the rest of the United States.[9] Follow-up studies found abnormalities in the chest X-rays of household contacts of asbestos workers who presumably were exposed to asbestos dust brought home on the clothes of the workers. Abnormalities were also found in the X-rays of children who had played in piles of vermiculite at the processing facilities.[10]

The fallout from the Libby crisis continues. A disease registry has been established to track individuals who were exposed, in order to learn more about asbestos-related illnesses, and to share information on new therapies and diagnostic tools. A community health center has been established with federal funds to provide medical services. Libby has been declared a Superfund site and is being cleaned up (see Chapter 22). In fact, in June 2009 the EPA declared a public health emergency under the Superfund law, the first time such an emergency has been declared.[11] W. R. Grace, the company that operated the mine, has been overwhelmed with lawsuits by injured residents, and the company filed for bankruptcy protection in 2001.[12] It has been ordered to pay $250 million to the EPA for environmental cleanup. The EPA has warned that asbestos-containing vermiculite from Libby was used as insulation in millions of homes and businesses across the country and that asbestos fibers could pose a health threat if the insulation is disturbed.

Asbestos exposure is also a concern as a result of the 9/11 attacks on the World Trade Center. Beginning a few days after the collapse of the towers, the EPA and the New York City and New York State Health Departments monitored pollutants in the air, including asbestos. Concentrations near Ground Zero were quite high in the first few days and weeks after 9/11, but they decreased to background levels by January or February 2002.[13] These exposures were most likely to affect the thousands of rescue and recovery workers, who are now being monitored for long-term health effects by the New York City Fire Department and the Centers for Disease Control and Prevention, as discussed in Chapter 29. One study of over 3700 firefighters who worked at the site found that almost 40 percent of them continued to have respiratory symptoms three years later.[14]

Pesticides and Industrial Chemicals

Rachel Carson's best-selling book *Silent Spring*, published in 1962, was a wake-up call to the American public, a warning that chemicals in the environment cause harm. The publication of her book, more than any other single event, launched the environmental movement that led to sweeping legislation in the 1970s. *Silent Spring* called attention to the harmful effects of the virtually ubiquitous pesticide DDT. The chemical could be found in lakes and streams, plants and insects. When eaten or drunk by fish and birds, it accumulated in their flesh, to be eaten in turn by predators, which concentrated these chemicals further in their own bodies. A worldwide sur-

vey measuring chemicals in the body fat of people on six continents found DDT in all of them.[15] The use of DDT was banned in the United States in 1972. A number of other insecticides chemically related to DDT were also banned in the 1970s. These chemicals—including chlordane, aldrin, mirex, and Kepone—shared common features of solubility in fatty tissue and persistence in the environment; they break down very slowly, so they continue to cause harm long after their use is halted.

Studies looking for environmental pesticides discovered that a related group of chemicals, polychlorinated biphenyls (PCBs), also turned up often. Unlike pesticides, these chemicals were used mainly in sealed systems—capacitors, transformers, and heat exchangers—but they were still entering the environment in large quantities and getting into the food chain. PCBs frequently entered the environment through discharge of industrial wastes, a route similar to the mercury at Minamata. The contamination of New York's Hudson River with PCBs, discovered by environmentalists in 1975, was traced to two General Electric Company capacitor plants that had been discharging large volumes of PCBs into the river for more than 25 years.[16] Although the discharge was halted, the chemicals, unless cleaned up, would persist in the soil of the riverbed indefinitely. Fish caught in the Hudson River still contain PCBs at concentrations considered unsafe for women of childbearing age and children under 15 to eat at all, and for others to eat more than once a week.[17] The EPA developed a plan to clean the river by dredging the contaminated soil, a plan that generated controversy both because it will stir up the chemicals and cause more contamination of the river water in the short term, and because of vigorous objections by the communities proposed as disposal sites for the contaminated soil. After years of dispute, the dredging began in May 2009; the contaminated soil is to be transported by train to a hazardous waste landfill in Texas.[18]

Environmental scientists believe that PCBs are the most widespread chemical contaminant worldwide. Although production was halted in the United States in 1977, they and their chemical relatives, called persistent organic pollutants (POPs), are carried to remote regions of the globe, including the Arctic, by air, water, and migratory species. The effects on human health of exposure to these chemicals at the levels commonly found in the environment are still uncertain. However, people exposed to large doses of PCBs by a number of industrial accidents were made ill by the chemicals. In western Japan in 1968 a leak at a cooking oil factory contaminated a batch of the rice oil with heat exchanger fluids containing PCBs and related chemicals. Eighteen hundred people were sickened in what became known as the "Yusho" incident ("Yusho" means oil disease in Japanese).[19] Eleven years later, a similar accident occurred in Taiwan, affecting 2000 people with "Yu-cheng," which means oil disease in Chinese.[20] Two well-known incidents in the United States during the 1970s—a warehouse fire in Puerto Rico that caused PCB

contamination of tuna meal used for animal and fish feeds, and a labeling mixup in Michigan that contaminated cattle feed with polybrominated biphenyls, a chemical similar to PCBs—resulted in human exposure to this type of chemicals through the food supply.[21]

Victims of the Yusho, Yu-cheng, and other accidents have been the subjects of epidemiologic studies tracking the victims' health over the years since their exposure. The most conspicuous and consistent symptom is chloracne, severe skin rashes and discoloration that show up soon after exposure and may persist for years. Other effects include endocrine and immune system defects, fatigue, headaches, and aching joints. Many of these symptoms still persist more than 30 years after the original exposure.[22] An increased risk of some forms of cancer is now becoming apparent; the EPA has declared PCBs to be a probable human carcinogen.[23] Infants born to Yusho and Yu-cheng mothers were small at birth and had dark discoloration of the skin—leading to the nickname "Coca Cola babies"—which faded after a few months.[24] These infants suffered developmental delays and persistent cognitive deficits that were still apparent decades later.[25]

Some of the POPs, including dioxins and furans, are not manufactured intentionally but are byproducts of some industrial processes. They were contaminants of PCBs and may have been responsible for some of the toxic effects observed in the Yusho and Yu-cheng incidents. Common pollutants of air and water, they are also produced by the burning of forests or household trash. They are highly toxic, and even relatively small exposures are thought to cause adverse effects on people's immune, endocrine, and neurological systems. POPs are very stable, remaining in the fatty tissues of fish, animals, and humans indefinitely. Although levels of these chemicals are high in the blood and fatty tissues of people who eat fish from contaminated waters, in most Americans the levels appear to be declining.[26] In 2001, the United States joined ninety other nations in signing the Stockholm Convention on Persistent Organic Pollutants, agreeing to reduce and/or eliminate the production, use, and release of twelve of the POPs of greatest concern. However, the convention has not yet been ratified in the United States Senate.[27]

Other chemicals that have stimulated concern in the last few years are bisphenol A (BPA) and phthalates. Both are components of plastics commonly used in food and drink containers, capable of leaching into the containers' contents and being consumed. Traces of these chemicals are found in the blood of almost everyone in the United States.[28] BPA is found in hard plastics used to make everything from compact discs to baby bottles and linings of soft drink and food cans.[29] Phthalates are used to produce soft and flexible materials such as shower curtains and some water bottles, and they are a common water pollutant in the environment, with harmful effects on fish and other aquatic species.[30] Although government agencies have affirmed the safety of both chemicals at the low levels commonly found in humans, there is evidence that they may be especially harmful to infants and developing fetuses.

BPA and phthalates, as well as some POPs, have been shown to be endocrine disruptors in humans and wildlife, meaning that they interfere with normal hormone action in the body. BPA can mimic estrogen, causing early puberty in females and abnormalities in male and female sex organs. Phthalates interfere with testosterone synthesis in males, causing low sperm counts and abnormalities in the development of male sex organs. Some endocrine disruptors may interfere with the activities of the pancreas and thyroid glands, increasing the risk of obesity and diabetes.[28] A study using 1999–2002 data from the National Health and Nutrition Examination Survey found that concentrations of phthalates in the urine of adult American men were associated with increased waist circumference and insulin resistance. Although this does not prove cause and effect, the finding adds to evidence that exposure to phthalates may contribute to the growing prevalence of obesity and diabetes.[31]

The Endocrine Society, the world's oldest and largest organization devoted to research on hormones and the clinical practice of endocrinology, has issued a Scientific Statement on Endocrine-Disrupting Chemicals that details known evidence about the health effects of these substances and strongly recommends that more research should be done to understand their role in the chronic diseases that are so common in the world today.[28] In a shift from its previous stance, the FDA announced in January 2010 that it would investigate the health risks from BPA.[32]

Occupational Exposures—Workers as Guinea Pigs

Workers are regularly exposed to larger amounts of toxic substances on the job than most of the population is ever likely to encounter. Consequently, workers tend to be the first and foremost to suffer from any harmful health effects caused by their exposures. Many chemicals that all people encounter in everyday life may have unrecognized effects at low doses, causing unexplained cancer, neurological disorders, and reproductive disorders in susceptible individuals. Workers, exposed to larger quantities, may inadvertently serve as the guinea pigs that call attention to the dangers.

That certain occupations carry an increased risk of certain kinds of cancer has long been known, and the information has been helpful in understanding some of the causes of cancer. The first environmentally caused cancer to be recognized was from an occupational exposure: scrotal cancer was common in 19th century English chimney sweeps. The soot to which they were exposed contained the same carcinogens found in tobacco smoke—chemicals that are now known to cause lung cancer. Few other cancers can be clearly linked to specific causative agents. Because most exposures are relatively low, and because the time lag between exposure and the development of cancer is long, cause and effect are difficult to establish. Workers are effective

though unintentional guinea pigs because exposure on the job is likely to be much higher than that in the general environment. An obvious increase in the rate of a specific cancer in a group of workers who have all been exposed to the same substance clearly throws suspicion on that substance as the cause.

Chemicals identified as carcinogens through occupational exposures include benzidine, which caused bladder cancer in dye factory workers; arsenic, which caused lung and lymphatic cancer in copper smelters; and vinyl chloride, used to make some plastics, which causes angiosarcoma, a rare cancer of the liver.[3] Evidence that radiation exposure causes cancer came from the higher incidence of cancer among radiologists, as discussed earlier. Mesothelioma occurs almost exclusively in asbestos workers, who were also found to have high rates of lung cancer.

Neurotoxins, like carcinogens, may be hard to recognize because they act over a long period of time. In fact, nerve poisons may be even more insidious than carcinogens, because the damage they do—deterioration of vision, muscle weakness, failure of memory—may mimic common aspects of aging. Neurological disorders that typically strike workers with specific exposures call attention to those chemicals as neurotoxins. Starting with Mad Hatter's disease from mercury, nerve damage was found in shoemakers exposed to hexane-containing solvents, dry cleaners exposed to trichloroethylene, pesticide applicators, and many other workers exposed to neurotoxins.[33]

New Source of Pollution—Factory Farms

Over the past few decades, there has been a revolution in farming that threatens to overwhelm the system for regulating environmental pollution. Thousands of hogs, cattle, and poultry are crowded into confined spaces where they can be fed and tended to by automated systems. The environmental problems caused by this approach to farming are the huge volumes of waste produced by these animals, which must be disposed of on a relatively limited amount of land. According to the Sierra Club, factory farms produce an estimated 500 million tons of manure every year, 3 times the total waste produced by the U.S. human population.[34]

The farms deal with waste by creating "lagoons" in which the liquids are allowed to evaporate or from which they are sprayed on fields. Lagoons at many of these operations have broken, failed, or overflowed. They emit gases—including ammonia, hydrogen sulfide, and methane—that can be toxic to humans. People living near the farms suffer from symptoms caused by the lagoon gases: headaches, runny noses, sore throats, coughing, respiratory problems, nausea, diarrhea, dizziness, burning eyes, depression, and fatigue. Seepage from the lagoons pollutes groundwater that feeds wells used for drinking water. After heavy rains, lagoons may overflow or burst, spilling thousands of gallons of manure into rivers, lakes, streams, and estuaries; such spills have caused massive fish kills in at least ten states.[34]

Most of these farms are owned by a very few major corporations, which have great economic and political power. Some state legislatures have passed laws protecting the industry from regulation. State universities receive funding from the industry and may discourage research that makes the companies look bad.[35] Under the Bush administration, the EPA and the Department of Agriculture halted enforcement investigations of the farms and suppressed research results unfavorable to the industry.[36] The farms should be regulated under the Clean Air Act, but the law has never been enforced. The Clean Water Act requires large livestock operations to obtain permits, but this law has also been widely ignored.

Congress has repeatedly attempted to protect the corporations against enforcement of existing laws on clean air, clean water, and toxic chemicals. For example, the 2009 bill in the House of Representatives that appropriated funds for the EPA included provisions to block the Agency from requiring factory farms to report greenhouse gas emissions.[37] Meanwhile, a number of environmental advocacy organizations, including the Sierra Club, the National Audubon Society, and the Natural Resources Defense Council, have teamed up with organizations that promote family farming and sustainable agriculture to urge the government to force agribusiness to obey environmental laws.[38]

Setting Standards—How Safe Is Safe?

Tens of thousands of synthetic chemicals have been manufactured since World War II and, in the United States alone, three to four billion pounds of them are released into the environment each year. Most have not been tested for the capacity to cause cancer, birth defects, neurological damage, or other harmful effects on health. Because of the sheer number of chemicals, it is unrealistic to require testing them all.

The environmental legislation of the 1960s and 1970s tried to establish guidelines for identifying environmental hazards and required standards to be set that protected human health and the environment. Standard setting was required for air quality, water quality, radiation safety, food and drug safety, and the disposal of hazardous wastes. The Occupational Safety and Health Act of 1970 empowered the federal government to set standards for workers' exposure to toxic substances, and the Toxic Substances Control Act of 1976 allowed the government to require testing of potentially hazardous substances before they go on the market and to ban them in certain instances. The Federal Insecticide, Fungicide, and Rodenticide Act, originally passed in 1947 and amended several times since, requires government approval of these substances before they can be used. Congress required a variety of federal agencies to set standards for exposure to toxic substances via various routes: the EPA, the FDA, the

Department of Agriculture, the Department of Transportation, the Nuclear Regulatory Commission, the Consumer Product Safety Commission, and the Occupational Safety and Health Administration (OSHA) are among those responsible for various aspects of environmental health.[3]

Standard setting has progressed very slowly, however, since these laws were passed. For example, the Clean Air Act of 1970 required the EPA to develop a list of industrial pollutants that can cause serious health damage and set emission standards for them; as of 1993, only eight had been regulated.[3] As of 2008, the National Institute for Occupational Safety and Health had identified 132 substances and groups of substances as potential occupational carcinogens; of these, specific exposure standards for workers had been set for only 26 by OSHA, the agency with the authority to set these standards.[39,40]

There are a number of reasons why regulation has progressed so slowly. One factor is the sheer volume of potentially toxic chemicals being manufactured in the United States. Today there are more than 80,000 chemicals registered for use, with about 2000 new ones introduced each year.[41] Another problem is that toxicity testing on any single chemical can be expensive and time-consuming. The EPA has information suggesting that 10 to 15 percent of the newly introduced chemicals each year need more extensive toxicological evaluation. The National Toxicology Program (NTP), an interagency program within the Department of Health and Human Services, can test only a few dozen agents each year, based on the extent of human exposure and/or suspicion of toxicity. One of the NTP's major goals for the 21st century is to develop and validate improved testing methods that will reduce the need for animal testing, as described in Chapter 11.

Another reason for the delays in standard setting is that each chemical must be regulated separately, each with the potential for controversy, legal challenge, and extensive litigation over each proposed regulation. Each standard is likely to have significant economic impact on some industry, whose members will naturally fight against the potential threat to their businesses and jobs. Emotions on the part of the public often run high, since citizens believe that their health and the health of their children is endangered, and their demands for safety may be perceived as unreasonable.

Risk–Benefit Analysis

The question "How safe is safe?" has been debated in connection with one potential health threat after another. Increasingly, policy analysts have come to agree that absolute safety is an impossible goal and that attempting to avoid risk of one sort may increase risks of other kinds. Furthermore, as one analyst asks and answers in the affirmative, "Does overregulation cause underregulation?"[42] He argues that too much effort is expended setting very strict standards for

too few substances. By battling to achieve zero exposure to one carcinogen, for example, public health agencies may be neglecting to investigate other chemicals that are potentially more hazardous. Public health may be better served by aiming for looser, more easily achieved standards. This approach would generate less controversy and opposition, allowing for a stepped-up pace of standard setting.

The argument is also made that prevention of risk must be balanced against other societal goals, including economic well-being. Until recently, the public health approach has been to ignore economic factors in seeking risk reduction. However, an increasing understanding of the fact that economic factors are significant to people's health and well-being (see Chapter 14) has led to greater willingness on the part of public health advocates to consider costs as well as benefits in evaluating risks. Risk assessment and cost–benefit analysis are discussed in Chapter 7.

The Republican Congress elected in 1994 tried to roll back all kinds of regulations under the argument that they were irrational and expensive, examples of government interference that had negative economic impacts on business. The fact that most of these initiatives failed demonstrated that most Americans want the government to protect their health and environment. But the initiatives made people ask how regulations could become more rational, less cumbersome, and more balanced. During the Clinton administration, the political debate focused on how to achieve effective environmental protection while minimizing red tape and government intrusiveness. The Bush administration was even more inclined to favor economic and business interests in policy making on environmental and public health issues. There is hope that President Obama will again place a priority on the health of the population and the environment.

Conclusion

Providing a clean environment, a necessity for human health, is one of the most important functions of government. When people began to live together in cities and towns, they were dependent on the government—traditionally the local government—to provide clean drinking water and safe disposal of wastes. As the American population grew, municipalities and industry discharged their wastes into the air, water, and land, and it became apparent that the environment was deteriorating. Pollution tends to spread beyond local areas, requiring state and federal intervention to be effective. In the late 1960s and early 1970s, a number of significant federal laws were passed that set standards for air, water, and waste disposal aimed at protecting human health and cleaning up the environment.

Identification of hazards is an important first step in creating a safe environment. While environmental health has traditionally focused on microbial pathogens, many other phenomena can also threaten human health. Radiation, both natural and manmade, can be highly dangerous to living organisms, something that was not recognized when X-rays were first discovered.

Many metals and minerals, including lead, mercury, and asbestos, are toxic to humans. Pesticides and some industrial chemicals have been widely disseminated in the environment and have been absorbed into the fatty tissues of animals and humans, where they persist indefinitely, sometimes with harmful effects. Recently, concern has been raised about endocrine disruptors, including BPA and phthalates, common contaminants of plastics, which are suspected to cause problems with development in fetuses and infants and to increase the risk of common chronic diseases.

Sometimes hazards of environmental exposures are recognized first in workers who develop occupational illnesses after being exposed on the job. The effects of a number of cancer-causing and neurotoxic substances have been recognized because workers have served as "guinea pigs," the first humans to test the safety of new chemicals.

Federal legislation in the 1960s and 1970s established a number of agencies charged with identifying environmental hazards and setting standards to protect human health. These include OSHA and the EPA. Standard setting was required for air quality, water quality, radiation safety, food and drug safety, the control of toxic substances, and the disposal of hazardous wastes.

Many of these mandates have been politically controversial, in that they have economic impact on various industries. Recent trends have brought greater willingness by public health advocates to weigh costs against benefits in evaluating risks.

Recently, environmentalists have recognized a new hazard—animal wastes from factory farms. These wastes are collected in "lagoons" and may be sprayed on fields, causing air and water pollution. Nearby residents and communities are often powerless to object to the unpleasant odors and, sometimes, toxic fumes. Because of the economic power of agricultural companies, federal and state governments have done little to regulate them.

References

1. R. M. Macklis, "The Great Radium Scandal," *Scientific American* (August 1993): 94–99.
2. R. Seltser and P. E. Sartwell, "The Influence of Occupational Exposure to Radiation on the Mortality of American Radiologists and Other Medical Specialists," *American Journal of Epidemiology* 81 (1965): 2–22.
3. A. Nadakavukaren, *Our Global Environment: A Health Perspective*, 6th ed. (Prospect Heights, IL: Waveland Press, 2005).
4. U.S. Environmental Protection Agency, "Mercury: Spills, Disposal and Site Cleanup," www.epa.gov/mercury/spills/index.htm, June 30, 2009, accessed July 17,2009.

5. U.S. Centers for Disease Control and Prevention, "Preventing Lead Poisoning in Young Children," www.cdc.gov/nceh/lead/publications/prevleadpoisoning.pdf, August 2005, accessed July 17, 2009.
6. E. S. Lipton and D. Barboza, "As More Toys Are Recalled, Trail Ends in China," *The New York Times*, June 19, 2007.
7. M. N. Mead, "Arsenic: In Search of an Antidote to a Global Poison," *Environmental Health Perspectives* 113 (2005): A379–A386.
8. P. Brodeur, *Outrageous Misconduct: The Asbestos Industry on Trial* (New York: Pantheon Books, 1985).
9. U.S. Agency for Toxic Substances and Disease Registry, "Asbestos: Asbestos Exposure in Libby, Montana," www.atsdr.cdc.gov/asbestos/sites/libby_montana/, last updated January 20, 2009, accessed February 13, 2010.
10. L. A. Peipins et al., "Radiographic Abnormalities and Exposure to Asbestos-Contaminated Vermiculite in the Community of Libby, Montana, USA," *Environmental Health Perspectives* 111 (2003): 1753–1759.
11. C. Dean, "U.S. Cites Emergency in Asbestos-Poisoned Town," *The New York Times*, June 17, 2009.
12. J. M. Broder, "$250 Million Settlement Over Asbestos Is Announced," *The New York Times*, March 12, 2008.
13. U.S. Environmental Protection Agency, "Exposure and Human Health Evaluation of Airborne Pollution from the World Trade Center Disaster (External Review Draft)," http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=54667/, October 2002, accessed July 17, 2009.
14. M. P. Webber et al., "Trends in Respiratory Symptoms of Firefighters Exposed to the World Trade Center Disaster: 2001–2005," *Environmental Health Perspectives* 117 (2009): 975–980.
15. M. Wasserman et al., "World PCBs Map: Storage and Effects in Man and His Biologic Environment in the 1970s," *Annals of the New York Academy of Science* 320 (1979): 69–124.
16. E. G. Horn et al., "The Problem of PCBs in the Hudson River System," *Annals of the New York Academy of Science* 320 (1979): 591–609.
17. New York State Department of Health, "2009–2010 Health Advisories," www.health.state.ny.us/environmental/outdoors/fish/docs/specific_advisory_table.pdf, accessed July 17, 2009.
18. A. C. Revkin, "Dredging of Pollutants Begins in Hudson," *The New York Times*, May 15, 2009.
19. Y. Masuda, "The Yusho Rice Oil Poisoning Incident," in A. Schecter, *Dioxins and Health* (New York: Plenum Press, 1994), 633–659.
20. C. C. Hsu et al., "The Yu-cheng Rice Oil Poisoning Incident," in A. Schecter, *Dioxins and Health*, 661–684.
21. M. J. Schneider, *Persistent Poisons: Chemical Pollutants in the Environment* (New York: New York Academy of Sciences, 1979).
22. Y. Kanagawa et al., "Association of Clinical Findings in Yusho Patients with Serum Concentrations of Polychlorinated Biphenyls, Polychlorinated Quarterphenyls, and 2,3,4,7,8-Pentachlorodibenzofuran More Than Thirty Years after the Poisoning Event," *Environmental Health* 7 (2008): 47.

23. Environmental Protection Agency, "Health Effects of PCBs," www.epa.gov/osw/hazard/tsd/pcbs/pubs/effects.htm, August 8, 2008, accessed July 23, 2009.
24. F. Yamashita and M. Hayashi, "Fetal PCB Syndrome: Clinical Features, Intrauterine Growth Retardation and Possible Alteration in Calcium Metabolism," *Environmental Health Perspectives* 59 (1985): 41–45.
25. Y-L Guo et al., "Growth Abnormalities in the Population Exposed *In Utero* and Early Postnatally to Polychlorinated Biphenyls and Dibenzofurans," *Environmental Health Perspectives* 103 (Supplement 6) (1995): 117–122.
26. U.S. Environmental Protection Agency, *The Foundation for Global Action on Persistent Organic Pollutants: A United States Perspective*, www.epa.gov/nceawww1/pdfs/pops/POPsa.pdf, March 2002, accessed July 20, 2009.
27. S. Goodman, "Enviro Groups Urging Obama Admin to Support Int'l Ban of Pesticides," *The New York Times*, April 8, 2009.
28. E. Diamanti-Kandarakis et al., "Endocrine-Disrupting Chemicals: An Endocrine Society Scientific Statement," The Endocrine Society, www.endo-society.org/journals/scientificstatements/, June 2009, accessed July 24, 2009.
29. Centers for Disease Control and Prevention, "Fact Sheet: Bisphenol A," www.cdc.gov/exposurereport/BisphenolA_FactSheet.html, last updated February 11, 2010, accessed February 13, 2010.
30. Centers for Disease Control and Prevention, "Fact-Sheet: Phthalates," www.cdc.gov/exposurereport/phthalates_FactSheet.html, last updated February 11, 2010, accessed February 13, 2010.
31. R.W. Stahlhut et al., "Concentrations of Urinary Phthalate Metabolites Are Associated with Increased Waist Circumference and Insulin Resistance in Adult U.S. Males," *Environmental Health Perspectives* 115 (2007): 876–882.
32. D. Grady, "U.S. Concerned about the Risks from a Plastic," *The New York Times*, January 16, 2010.
33. P. Spencer and H. H. Schaumburg, eds., *Experimental and Clinical Neurotoxicology* (Baltimore, MD: Williams & Wilkins, 1980).
34. Sierra Club, "Clean Water and Factory Farms: Reports and Factsheets," www.sierraclub.org/factoryfarms/factsheets/protect_communities.asp, 2008, accessed July 24, 2009.
35. S. Wing, "Social Responsibility and Research Ethics in Community-Driven Studies of Industrialized Hog Production," *Environmental Health Perspectives* 110 (2002): 437–444.
36. R. F. Kennedy Jr. and E. Schaeffer, "An Ill Wind From Factory Farms," *The New York Times*, September 20, 2003.
37. R. Bravender et al., "Farm Interests Use EPA Spending Bill to Fight Climate Regs," *The New York Times*, June 19, 2009.
38. Environmental Integrity Project, "Press Release: Family Farms, Rural Communities Threatened by Craig Amendment Unleashing Factory Farm Pollution," www.environmentalintegrity.org/publications/Press_Release_Family_Farms.php, September 21, 2009, accessed February 13, 2010.

39. National Institute for Occupational Safety and Health, "Occupational Cancer: NIOSH Carcinogen List," www.cdc.gov/niosh/topics/cancer/npotocca.html, November 7, 2008, accessed July 26, 2009.
40. U.S. Department of Labor, Occupational Safety and Health Administration, "10/16/2003—OSHA-Recognized Chemicals as Carcinogens or Potential Carcinogens for Hazard Communication Purposes," www.osha.gov/pls/oshaweb/owadisp.show_document?p_table-INTERPRETATIONS&p_id=24730, accessed July 26, 2009.
41. Department of Health and Human Services, National Toxicology Program, "About the NTP," http://ntp.niehs.nih.gov/?objectid=7201637B-BDB7-CEBA-F57E39896A08F1BB, February 17, 2005, accessed July 26, 2009.
42. J. Mendeloff, "Does Overregulation Cause Underregulation? The Case of Toxic Substances," *Regulation* (September–October 1981).