ENVIRONMENTAL HEALTH

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Preface

This book is an outgrowth of a survey course, "Principles of Environmental Health," that I have taught at the Harvard School of Public Health for the past twenty-five years and, in modified form, at the Harvard University Extension School.

Although the literature abounds with monographs on particular aspects of environmental health (air pollution, water pollution, solid waste disposal, and so on), and although more and more courses are being offered on the subject, there are few textbooks that provide comprehensive coverage of the field. In this book I present topics from both local and global perspectives, and in relation to both short- and long-range impacts. In my review of individual segments of the environment—such as air, water, and food—I highlight the necessity to consider the interrelationships of these and other segments in the development and application of controls. I also examine health hazards in the workplace; the control of insects and rodents; the disposal of solid, radioactive, and hazardous wastes; the effects, uses, and management of ionizing and nonionizing radiation; accidents as a cause of injuries and deaths; environmental monitoring; risk assessment as applied to the development of environmental standards; response preparedness for natural and man-made disasters; and the occupational and environmental impacts of energy use. Often in my general coverage of various aspects of environmental health I use examples pertaining to ionizing radiation to illustrate important concepts. I do so not only because this is my area of expertise, but also because approaches to controlling occupational and environmental health problems associated with ionizing radiation are, in some respects, more advanced than the approaches used in other fields of environmental health.

As would be expected for an undertaking of this magnitude, I am grateful to a host of fellow environmental and public health professionals for sharing their talents and expertise with me. Special thanks to my colleagues at the Harvard School of Public Health, William A. Burgess, Melvin W. First, Peter Goldman, David Hemenway, John B. Little, Jacob Shapiro, R. Jeremy Sherwood, and Andrew Spielman. Other associates who provided invaluable support include Gerard Bertrand, Douglas J. Crawford-Brown, Thomas S. Crowther, Paul M. Newberne, Cynthia Palmer, Howard Peters, Floyd B. Taylor, Julian A. Waller, and Ellen Wasserman. I also thank Harvey V. Fineberg, Dean of the Harvard School of Public Health, for his support and encouragement. Finally, I deeply appreciate the editorial suggestions of Ann Hawthorne at Harvard University Press.

And God pronounced a blessing upon Noah and his sons and said to them, be fruitful and multiply and fill the earth.

And the fear of you and the dread and terror of you shall be upon every beast of the land, every bird of the air, all that creeps upon the ground, and upon all the fishes of the sea. Into your hands they are delivered.

Genesis 9:1–2

Abbreviations

AAEE	American Academy of Environmental Engineers
ACGIH	American Conference of Governmental Industrial Hygienists
AMA	American Medical Association
ASME	American Society of Mechanical Engineers
BEIR	Committee on the Biological Effects of Ionizing Radiation, National Research Council
BRWM	Board on Radioactive Waste Management, National Research Council
CDC	Centers for Disease Control, U.S. Department of Health and Human Services
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
FEMA	Federal Emergency Management Agency
ICRP	International Commission on Radiological Protection
IRPA	International Radiation Protection Association
NCRP	National Council on Radiation Protection and Measurements
NRC	U.S. Nuclear Regulatory Commission
OSHA	Occupational Safety and Health Administration
UNESCO	United Nations Educational, Scientific, and Cultural Organization

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The Scope of Environmental Health

Many aspects of human well-being are influenced by the environment, and many diseases can be initiated, sustained, or exacerbated by environmental factors. For that reason, understanding and controlling people's interactions with their environment is an important component of public health. In its broadest sense, environmental health is the subfield of public health concerned with assessing and controlling the impacts of people on their environment (including vegetation, other animals, and natural and historic landmarks) and the impacts of the environment on them.

The field of environmental health is defined more by the problems faced than by the specific approaches used. These problems include the treatment and disposal of liquid and airborne wastes, the elimination or reduction of stresses in the workplace, purification of drinking-water supplies, the impacts of overpopulation and inadequate or unsafe food supplies, and the development and use of measures to protect hospital and other medical workers from being infected with diseases such as acquired immune deficiency syndrome (AIDS). Environmental health professionals also face long-range problems, including the effects of toxic chemicals and radioactive waste, acidic deposition, depletion of the ozone layer, and global warming. The complexity of these issues requires multidisciplinary approaches for their evaluation and control. A team coping with a major environmental health problem may include scientists, physicians, epidemiologists, engineers, economists, lawyers, mathematicians, and managers. Input from all these experts is essential to the development and success of broad strategies that take into account both lifestyles and the environment.

The Systems Approach

One of the major goals of environmental health professionals is to understand the various ways in which humans interact with their environment. Comprehensive and accurate evaluations require an integrated "systems approach" that assesses an environmental problem in its entirety. At least four steps are involved:

1. Determine the source and nature of each environmental contaminant or stress.
2. Assess how and in what form it comes into contact with people.
3. Measure the effects.
4. Apply controls when and where appropriate.

Instead of focusing on a single pollutant facility by facility, environmental health professionals gather data on all the discharges from a given facility, as well as all the sources of a given pollutant and all the pollutants being deposited in a region, regardless of their nature, origin, or pathway (Train, 1990).

While tracing the source of a contaminant and its pathways, environmental health professionals conduct studies to determine its effects on human health. Working with biologists, toxicologists, respiratory physiologists, epidemiologists, and other public health personnel, they establish to the extent possible quantitative relationships between the exposure or dose and its effects. On the basis of these data, they set acceptable limits for exposures to the contaminant or stress.

To assess the effects of exposures correctly, environmental health workers must take into account not only the fact that exposures may derive from multiple sources and enter the body by several routes, but also the fact that elements in the environment are constantly interacting, so that in the course of transport or degradation, agents that were originally not toxic to people may become so, and vice versa. If the concentration of a contaminant is relatively uniform (for example, a substance in the air), local or regional sampling may provide adequate data to estimate human exposures. If concentrations vary considerably over space and time and the people being exposed move about extensively, it may be necessary to measure exposures to individual workers or members of the public by providing them with small, lightweight, battery-operated portable monitoring units. Development of such monitors and the specifications for their use requires

the expertise of air pollution engineers, industrial hygienists, chemists and chemical engineers, electronics experts, and quality-control personnel. Once the levels of exposure are known, these can be compared with existing standards, and controls can be applied when and where warranted.

Defining the Environment

To do their work effectively, environmental health professionals must keep in mind that there are many ways of defining the environment. One approach, used in Chapter 2, considers the indoor versus the outdoor (ambient) environment. Another, used in Chapter 3, narrows the focus to the workplace. Although every definition has deficiencies, each offers a different perspective that can broaden understanding of the complexities involved in potential threats to environmental health. Consideration of the full range of existing environments is also necessary if a systems approach is to be used in controlling associated problems.

The Inner versus Outer Environment

From the standpoint of the human body, there are two environments, the one inside and the one outside. Separating these environments are three principal barriers: the skin, which protects the body from contaminants outside it; the gastrointestinal (GI) tract, which protects the inner body from contaminants that have been ingested; and the lungs, which protect the inner body from contaminants that have been inhaled (Table 1.1). Each of these barriers is vulnerable under certain conditions. Contaminants can penetrate to the inner body through the skin by dissolving the layer of wax provided by the sebaceous glands. Airborne materials of respirable size can be deposited in the lungs and, if they are soluble, absorbed. Soluble compounds that make their way into the GI tract can be readily absorbed and taken into the cells. The lungs are by far the most fragile and susceptible barrier. An average adult breathes about 800 cubic feet (20 cubic meters), or more than 50 pounds (24 kg), of air per day. Because people cannot be selective about the air that is available, the lungs are considered to be the most important pathway for the intake of environmental contaminants.

Table 1.1 Characteristics of the principal barriers between the outer and inner body

	Area		Thickness		Weight		Daily exposure	
Barrier	ft^2	m^2	in.	μm	lbs	kg	lbs	kg
Skin	21	2	4×10^{-3}	100	30	12–16	Variable	
GI tract	2,150	200	4×10^{-4}	10–12	15	7	4–6	2–3
Lungs	1,500	140	1×10^{-5}	0.2–0.4	2	0.8–0.9	50	24

Fortunately, the body also has protective mechanisms to deal with many contaminants that do penetrate its barriers. For the GI tract, these include vomiting through the mouth or rapid excretion through the bowels (as in the case of diarrhea). Similarly, materials entering the circulatory system can be detoxified in the liver or excreted through the kidneys. Mechanisms for protecting the lungs range from simple coughing to cleansing by macrophages that engulf and promote the removal of foreign materials.

The Personal versus Ambient Environment

Another definition contrasts the "personal" environment, over which people have control, with the working or ambient environment, over which they may have essentially no control. Although people commonly think of the working or ambient environment as posing the greater threat, environmental health experts estimate that the personal environment, shaped by hygiene, diet, sexual practices, exercise, use of drugs and alcohol, and frequency of medical checkups, often has much more influence on well-being. Table 1.2 summarizes the estimated contributions of these various factors. According to public health experts, the personal environment may contribute to 75 percent or more of cancer deaths in the general U.S. population (Doll and Peto, 1981). Smoking plays the largest single role, accounting for more than one in every six deaths in the United States (Surgeon General, 1989). The amount of pollution taken into a smoker's lungs as a result of inhaling the various products from cigarettes is several orders of magnitude greater than the amount normally inhaled as a result of industrial airborne pollution.

The Solid, Liquid, and Gaseous Environments

The environment can also be considered as existing in one of three forms—gaseous, liquid, or solid. Each of these is subject to pollution, and people interact with all of them (Figure 1.1). Examples include releases of particulates and gases into the atmosphere; the discharge of wastes into water; and the disposal of solid waste, particularly plastics and toxic chemicals. Often attempts to control pollution in one form can create pollution in another. For example, the incineration of solid waste causes atmospheric pollution; the use of scrubbers and other types of air-cleaning systems can produce large amounts of solid waste; chemical treatment of liquid waste can produce large quantities of sludge; and sulfur and nitrogen oxides discharged into the atmosphere can be brought down to the earth in the form of acidic deposition. Such shifts or transfers can have significant effects; for example, wastewater treatment plants in Philadelphia are estimated to generate 25 percent of that region's airborne toxic organic pollutants (Hahn and Males, 1990).

Clearly, what is done to the environment in one form will almost certainly affect it in others. A systems approach ensures that each

Table 1.2 Proportion of cancer deaths attributable to various factors

	% of all cancer deaths	
Factor	Best estimate	Range of acceptable estimates
Diet	35	10–70
Tobacco	30	25–40
Reproductive and sexual behavior	7	1–13
Occupation	4	2–8
Alcohol consumption	3	2–4
Geophysical factors	3	2–4
Infections	10?	1–?
Medicines and medical procedures	1	0.5–3
Food additives, pollution, and industrial products	< 4	< 2–7

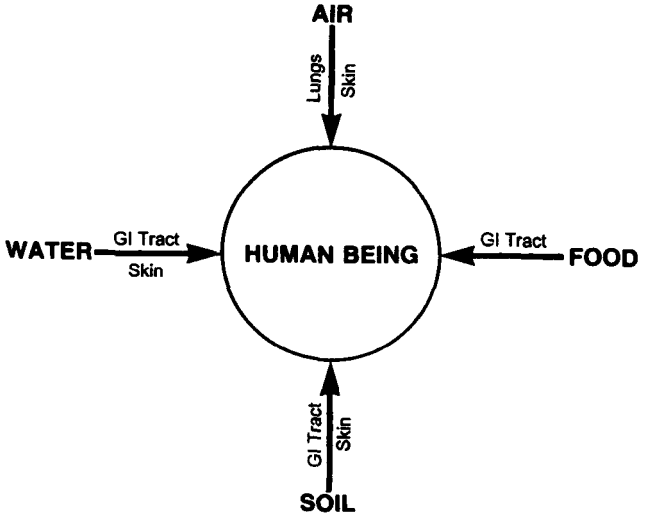

Figure 1.1 Routes of human exposure through the solid, liquid, and gaseous environments

problem is examined not in isolation but in terms of how it interacts with and can affect other segments of the environment and people's daily lives.

The Chemical, Biological, Physical, and Socioeconomic Environments

Another perspective considers the environment in terms of the four avenues or mechanisms by which various factors affect people's health. Thus, *chemical* constituents and contaminants include toxic waste and pesticides in the general environment, chemicals used in the home and in industrial operations, and preservatives used in foods. *Biological* contaminants include various disease organisms that may be present in food and water, those that can be transmitted by insects and animals, and those that can be transmitted by person-to-person contact. *Physical* factors that influence health and well-being range from workplace or traffic accidents, to excessive noise, heat, and cold, to ionizing and nonionizing radiation. Though perhaps more difficult to measure than the others, *socioeconomic* factors significantly

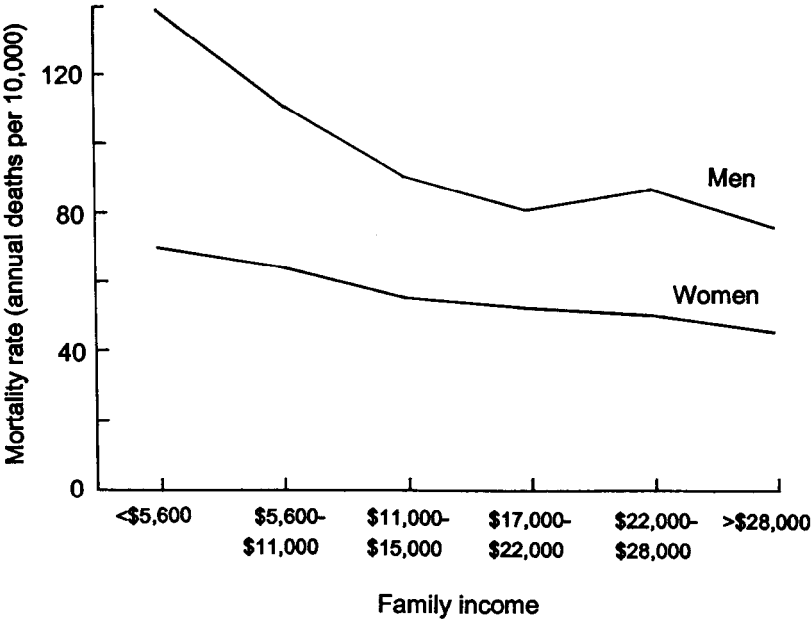

Figure 1.2 Relation of family income to mortality rates for men and women, United States, 1980

affect people's lives and health (Figure 1.2). People who live in economically depressed neighborhoods are less healthy than those who live in more affluent ones. The factors contributing to these differences range from inadequate nutrition and medical care to stressful social conditions.

Addressing Environmental Health Problems

In contrast to physicians, who traditionally deal with one patient at a time, environmental health specialists must consider entire populations. To the extent possible, they must also try to anticipate problems in order to prevent them from developing. In addition, they must recognize that environmental problems may differ in nature and magnitude in different regions; an approach that has proved successful for controlling a problem under one set of circumstances may prove totally inadequate under another.

Environmental health professionals cannot solve these problems by themselves. They need support from legislators to pass laws, mandate regulations, and allocate funds for the development and enforcement of programs to evaluate and control various pollutants. They need support from public health educators to promote public participation in the development of programs and to ensure that regulations and requirements are fully understood by industrial organizations and other groups who are expected to comply. And they need support from program planners and economists to assure that inevitably limited funds will be spent in the most effective way.

Even more, environmental health professionals need support from the society at large. The success of any program depends on the committed action of individuals. These individuals can reduce the production of solid waste by routinely recycling newspapers, plastics, glass bottles, and aluminum cans. They can reduce energy consumption by carpooling and by installing storm windows and other weatherproofing devices. They can conserve water by using low-flow shower heads, adding a brick to the tank of a toilet to reduce the volume of water used per flush, and promptly replacing washers in leaking faucets.

There are many organizations through which people can work to bring about corrective action at the local, state, federal, and international levels. In the United States, these include the Audubon Society, the Environmental Defense Fund, Greenpeace, the League of Women Voters, the National Wildlife Federation, the Natural Resources Defense Council, the Public Interest Research Groups, the Sierra Club, and the Union of Concerned Scientists. The building of grass-roots support is often a major stimulus for actions by state legislatures and the U.S. Congress.

The General Outlook

The 1990s may well become known as the decade of the environment. Oil spills of catastrophic proportions, devastating air pollution in eastern Europe, the fouling of beaches with medical waste, the rapid destruction of rain forests, and growing awareness of the potential impacts of the "greenhouse effect" and the destruction of the ozone layer have focused public and governmental attention on the urgent need to clean up and protect the environment. These events illustrate

how closely the health of humans, other animals, and plants, the survival of historical landmarks, and the beauty of the sky and countryside, depend upon the health of the global environment. These problems have been compounded by other forms of more localized environmental degradation. These range from the presence of airborne contaminants in dwellings to the problems of disposing of solid waste, especially plastic products and nonbiodegradable materials; the cleanup of toxic chemical disposal sites; widespread environmental contamination at various facilities operated by the U.S. Department of Energy; and airborne releases associated with the use of energy and the generation of electricity.

Today, highly sophisticated and sensitive instruments can measure many environmental contaminants at concentrations well below those that have been shown to cause harm to health or the environment; measurements in the parts per billion range are common. But the capability to measure much lower concentrations should not stampede either the public or policy makers into demanding "zero" pollution. This goal is neither realistic nor achievable. Rather, the goal should be an optimal level of human and environmental well-being given the host of factors that are an integral part of our daily lives.

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