Toxic Substances and Health

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THE ENVIRONMENTAL HEALTH AND MEDICINE field is taking on immensely increased importance for two reasons. First, it is abundantly clear that the major disease and health problems facing the United States and other advanced nations of the world, to some extent, are caused or aggravated by environmental factors. And second, I think that it is equally clear that preventive rather than curative medicine and health offer the more promising approach toward solution of most of these disease and illness problems.

As we are acutely aware, providing care for the sick is an enormously expensive enterprise; it cost the American people more than $100 billion in 1977, and it will surely cost more in years to come.

A focus on preventive health care is intervention early in the process. Intervention is concerned not so much with specific disease entities or groups of entities (cancer, heart disease, mental illness, and so forth), but rather with environmental and societal factors that contribute to illness—smoking, drinking, or eating habits; occupational hazards; genetic factors; and societal and psychological stress. Indeed, these factors have a greater impact on health status than does medical care. Almost daily, we come upon new evidence linking illness and death with a wide range of environmental factors—typically, chemical substances at work, in the community, or at home.

This is the age of chemicals—in our air, our water, and our food. Many chemicals have become essential to our lives, and their production contributes significantly to our national economy. But, for far too many of these substances we have little or no knowledge of the adverse effects they might cause after many years of exposure.

The development of synthetic organic chemicals has surged dramatically during the past three decades. An estimated 2 million recognized chemical compounds with more than 30,000 chemical substances are in commerce, and approximately 1,000 new ones are introduced each year.

Chemicals help to protect, prolong, and enhance our lives. Synthetic fibers are used to replace human tissues and, less dramatically, to create many of the things we use in transportation, communication, manufacture, and in our leisure time. From our golf balls to our leisure suits to our desk tops to our styrofoam coffee cups, we deal in synthetics. The chemical industry employs millions of workers—an important contribution to our economy.

Why is the environmental and health situation with regard to chemicals and toxic substances so difficult to understand and to discuss? A maze of scientific, economic, and social issues and the number of overlapping legislative statutes, directives, regulatory rules and requirements, and legal decisions by the courts make it inevitably complex and controversial. That same maze is a fairly accurate representation of the countervailing interests in the field.

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This paper is based on one presented to the Association of State and Territorial Health Officers in Dallas, Tex., April 4, 1977.

Top left: Kill van Kull, New Jersey, with Staten Island to the north. *Right:* New Jersey Turnpike; oil refinery in background. *Bottom left:* River flowing into Arthur Kill, New Jersey; storage tanks of oil refinery in background. *Right:* Dead fish covered a 4-mile stretch when contents of a chemical storage plant destroyed by fire spilled into an Ohio river.

Legislation and Regulation

In attempting to assess the effects of all this on the environment, one must consider at least two levels of impact in terms of the bottom line—legislation and regulation.

First, a large number of broadly based pieces of legislation and regulation affect many industries and organizations concerned with chemicals and environment. Antitrust matters, the patent system, trade restrictions or requirements, transportation regulations, taxation, labor laws, equal employment opportunity laws, currency controls, security regulations, and many others bear on the chemical industry. Intended as aids to problem solving, such measures strongly influence and control the chemical industry.

Second, there is the more specific legislation and regulation such as the food and drug laws, environmental pollution control laws, utility regulation laws, packaging laws, resources and conservation laws or controls as applied to specific industries, laws relating to mining, and a variety of health standards and many others.

The difference between the effect of these two major action levels upon society and industry is not clear but, in discussing the impact on a given segment of society or industry, one is basically limited to a discussion of specific legislation and implementing regulations rather than broadly based legislation and regulation.

Only recently have we come to understand the complexity in the problems caused by toxic materials and in the methods society must choose to regulate their use and limit exposure to them, and only recently have our responses reflected this understanding.

In the past 6 or 7 years, Congress has passed a substantial body of broad and powerful laws. For example:

1. The Clean Air Act
2. Amendments to the Federal Insecticide, Fungicide and Rodenticide Act
3. Federal Water Pollution Control Act
4. Occupational Safety and Health Act
5. Consumer Product Safety Act
6. Hazardous Substances Act
7. Hazardous Materials Transportation Act
8. Drinking Water Act
9. Resource Conservation and Recovery Act of 1976
10. The Toxic Substances Control Act of 1976

These and other Federal laws now regulate the chemical industry and propose to protect the persons involved in the full chain of the industrial process, including the workers who produce chemicals from basic materials to final products, the persons and bystanders engaged in the handling and distribution process, and the consumer of the products. The effect on the environment is regulated also in each stage of this commercial progression. The full scope of the regulatory requirements that will be developed under this already existing legislation is not presently known since much of it is in early stages of implementation.

What is very clear, however, is that we need these congressional mandates and Executive orders. We have enjoyed the economic and social benefits of chemicals, but we have not always realized the risks that may be associated with them.

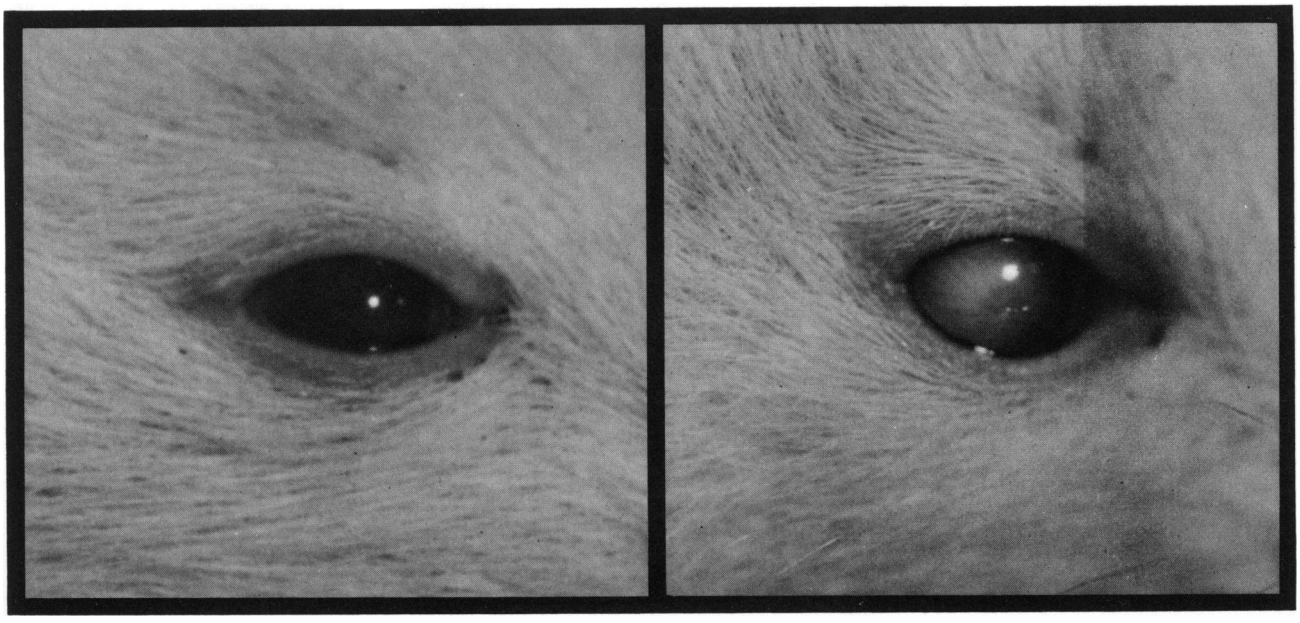
Health and Environmental Threats

In the past few years, many commonly used and widely dispersed chemicals have been found to present significant health and environmental dangers. They can be generally grouped into four families: (*a*) halogenated hydrocarbons and other organics, (*b*) heavy metals, (*c*) nonmetallic inorganics, and (*d*) biological contaminants, animal and human drugs, and food additives.

Halogenated hydrocarbons and other organics. These probably present the greatest environmental problem because of the diversity and quantity of their use; the large numbers of new and old chemicals being synthesized; their long persistence in the environment; the high lipid solubility which often leads to bioaccumulation in food organisms; and their ability even in small quantities, to cause cancer, nervous disorders, and toxic reactions.

Among these organics are probably carcinogenic polychlorinated biphenyls (PCBs); such chlorinated organic pesticides as DDT, kepone, mirex, and endrine—some of these are carcinogenic and some cause nervous system complications; polybrominated biphenyls (PBBs), toxic to animals; and fluorocarbons, suspected of depleting the stratospheric ozone layers. Also, a variety of carcinogenic halogenated hydrocarbons and other organics have been detected in our

Left: Normal weanling rat. *Right:* Weanling rat of dam with pronounced cataract after exposure to 25 ppm mirex in diet for 102 days at time of breeding.



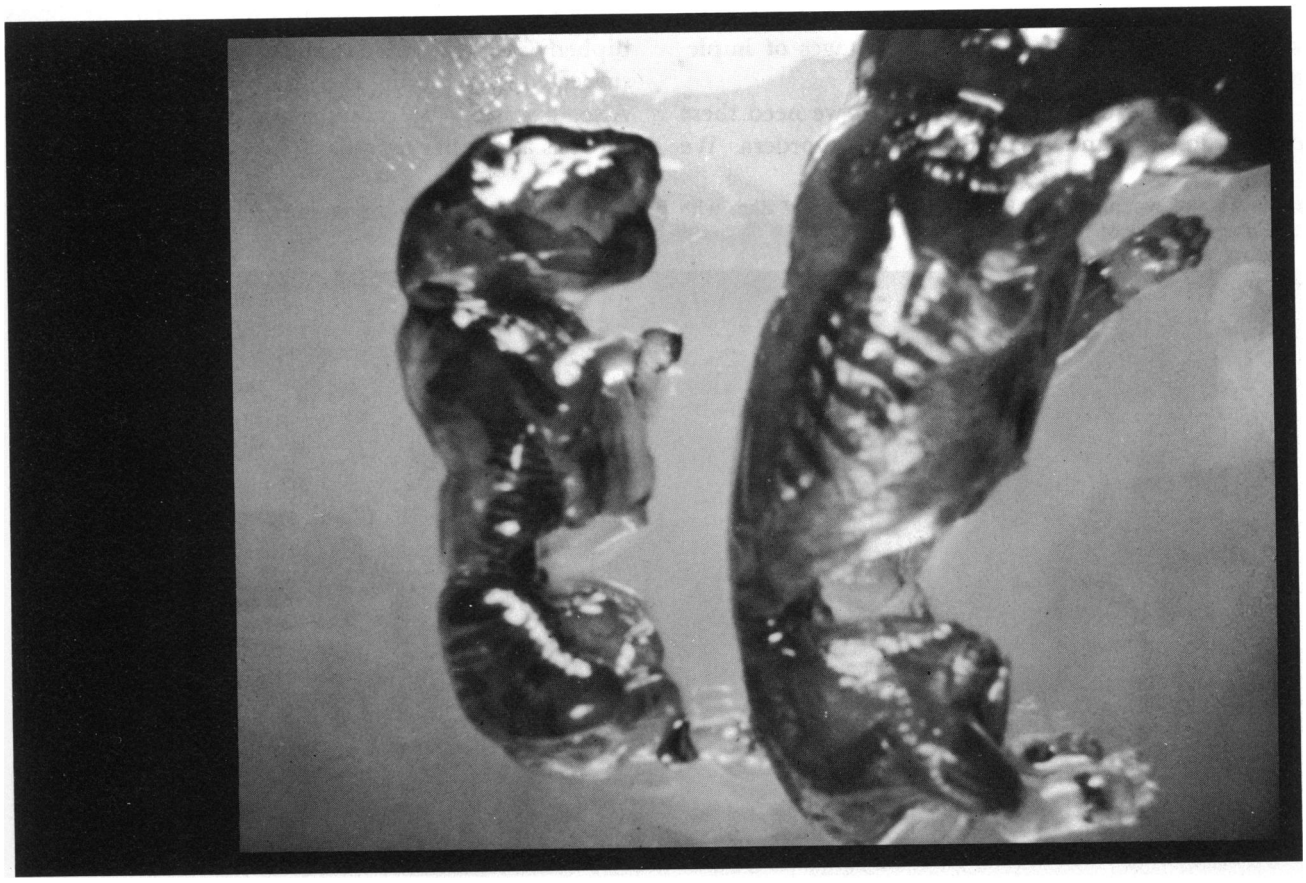
water supplies and in the air in large enough quantities to be of concern; these include chloroform in water and vinyl chloride in the air. The propensity for some of these substances to concentrate in food and water is of major concern.

Heavy metals. Heavy metals are a threat to human health and to the environment, particularly since they do not degrade. Many metals are highly toxic. Heavy metals are being introduced into our environment largely from mining and smelting operations; from industries using metals in manufacturing processes; pesticide applications (including lead, mercury, cadmium, and barium), and the burning of fossil fuels (which exposes lead, vanadium, and other metals). In addition, the practice of using manure for animal feed, sewage sludge for fertilizer, and other such recycling of solid wastes is also recycling our exposure to heavy metals. As a result, elevated levels of toxic metals are being found in plants and in the animals that eat them. Aquatic life, particularly shellfish, inhabiting areas near industrial and municipal disposal sites, are being found to contain high levels of toxic metals. Ecosystem studies have indicated that certain metals may be concentrated in food chains. Thus, people are being chronically exposed through food and water to increasing levels of many heavy metals—the same metals which, in industrial settings, have been shown to cause cancer (nickel and selenium), respiratory diseases (beryllium, nickel, vanadium), cardiovascular diseases (cadmium, lead, mercury), neurological diseases (lead, mercury, barium), and other illnesses.

Nonmetallic inorganics. Some of these minerals are accumulated in soil, plants, and animals, and have adverse health effects. Arsenic, used in a variety of industrial and pesticide applications, and asbestos, widely used as insulating material, are examples of environmental carcinogens.

Biological contaminants, animal and human drugs, and food additives. These materials may be added to food directly during food processing or indirectly through residues in meats or growth of microorganisms on vegetable materials. Aflatoxins and other mycotoxins produced by fungi and bacterial contamination of foods may have severe human

Larger fetus is a control rat. Smaller fetus shows effect of dam's exposure to metepa.



health consequences. The hazards of marine biotoxins in fish, particularly shellfish, are of increasing concern. Drugs and animal feed additives can leave residues in domestic animals which may be unsafe to consume. DES and other synthetic hormones, nitrofurans, and a number of other animal drugs and growth stimulators have been shown to be of concern for human health. The effect of food additives on health has received wide attention, as demonstrated by the recent action against the use of Red No. 2 in foods, drugs, and cosmetics, and currently saccharin.

The following expansion on the impact and threat of a few of these chemicals illustrates the scope of the problem.

Polychlorinated biphenyls (PCBs) is perhaps the most vivid example of the danger of uncontrolled chemical contaminants. Not until tens of millions of pounds of PCBs were produced and released into the environment did scientists realize how toxic and persistent these substances were. Despite limited restrictions imposed in the early 1970s upon industry to reduce production and to restrict use of PCBs to electrical equipment where escape to the environment would be minimal, high levels of PCBs continue to persist in the Great Lakes and other major waters across the nation. During the past few years, we have found PCBs in human bodies and even in the milk of nursing mothers.

Polybrominated biphenyls (PBBs), a close relative of PCBs, has posed a similarly grave threat to human health and the environment. Accidental use of PBBs in animal feed led to the contamination of thousands of Michigan cattle which had to be slaughtered. The health effects of PBBs on the Michigan farming families who were exposed to them and who consumed products contaminated by them are still uncertain.

Kepone found its way into the lower James River and its tributaries after being discharged by the Life Science Products Company plant in Hopewell, Va. Many workers developed symptoms of Kepone poisoning, and the environmental problems generated are enormous.

There are no shortcuts to cleaning up a large river or bay of a toxic chemical or to cleaning up a million or so pounds of contaminated sludge. Legal remedies are fine, but all the sanctions and penalties are not enough to solve the critical problems posed by such events. Crash programs and large resources will not solve these complex problems immediately because too often we do not have the knowledge base or available technology to accurately gauge what is needed, how long a solution will take, or what the price tag might be.

Many diseases resulting from exposure to the chemicals mentioned and other foreign chemicals are delayed in their onset in human beings, and to some extent they are irreversible. Under this condition, the disease continues to progress, or at least does not regress even if the chemical is removed. Mutagenic effects, well documented in laboratory animals but extremely difficult to document in the human population, also fit into this category. Chronic liver, lung, and probably kidney and central nervous system diseases are also long delayed and have an element of irreversibility about them.

A critical question is whether these chronic, irreversible toxic effects are associated with a critical concentration level. Is there a threshold concentration of a toxic chemical or compound below which no ill effects are caused in society or the environment? If a critical concentration or threshold can be determined experimentally, analyses can be greatly simplified because the environmental concentration may be held below a critical level.

Many scientists would agree that some carcinogens are probably safe at an exposure level of a few hundred molecules per rat or per person, but most believe that it would be totally unsafe to be exposed to larger orders of magnitude of a carcinogen.

As new techniques and scientific procedures are developed to measure more accurately the effects of these materials on the human environment, it is probable that other compounds, once thought to be safe, will be shown to be dangerous. Environmental health is a relatively new area for biomedical science, and its knowledge base is relatively undeveloped. We are still learning the basic scientific principles upon which theories of the causes and mechanisms of diseases can be built and tested. For example, the idea that the human body processes, or metabolizes, certain chemical substances into completely different substances which cause tissue and organ damage has been only recently explored, and it is not fully understood. If we are to assess accurately the effects of environmental agents on the human being, we must learn more about these processes.

Over the past two decades we have learned that we may have more to fear from a polluted environment than from acute respiratory disease or gastrointestinal infection. The effect of long-term continuing exposure to small doses of toxic agents of many types—from tobacco smoke to exotic synthetic chemicals—is believed to be more profound than we ever anticipated. As I have indicated, this threat has been

intensified by the rapid development and introduction into our environment of synthetic chemicals over two decades.

Even our most sophisticated techniques and methods are not now sufficient to quickly, inexpensively, and conclusively seek out the chemical "bad actors," predict the effects of various dose levels, and understand their action. As part of this task, we in the Public Health Service anticipate that a continued and concerted effort—the kind of effort that the Public Health Service and its agencies are suited to accomplish—will be necessary before we have a strong enough basis of understanding to act decisively.

Toxic Substances Control Act

It is important that we consider briefly some aspects of the Toxic Substances Control Act, signed into law in October 1976.

The law authorizes the Federal Government through the Environmental Protection Agency to obtain from industry data on production, use, health effects, and other matters concerning chemical substances and mixtures. If warranted, EPA may regulate the manufacture, processing, distribution in commerce, use, and disposal of a chemical substance or mixture. Pesticides, tobacco, nuclear material, firearms and ammunition, food, food additives, drugs and cosmetics are exempted from the act. These products are currently regulated under other laws.

In terms of implementation, the Environmental Protection Agency has the lead role, but several Institutes within the Public Health Service have mandated responsibilities under the Toxic Substances Control Act, as well as the Occupational Safety and Health Act of 1970. The principal highlights of the Toxic Substances Control Act follow.

Testing of chemicals. The EPA Administrator may require manufacturers or processors of potentially harmful chemicals to conduct tests on the chemicals at their expense. Testing may be necessary to evaluate a chemical's health or ecological effects according to specified testing standards. An interagency committee of Government experts will advise the Administrator concerning chemicals to be tested, but his actions are not limited to those recommended by the committee.

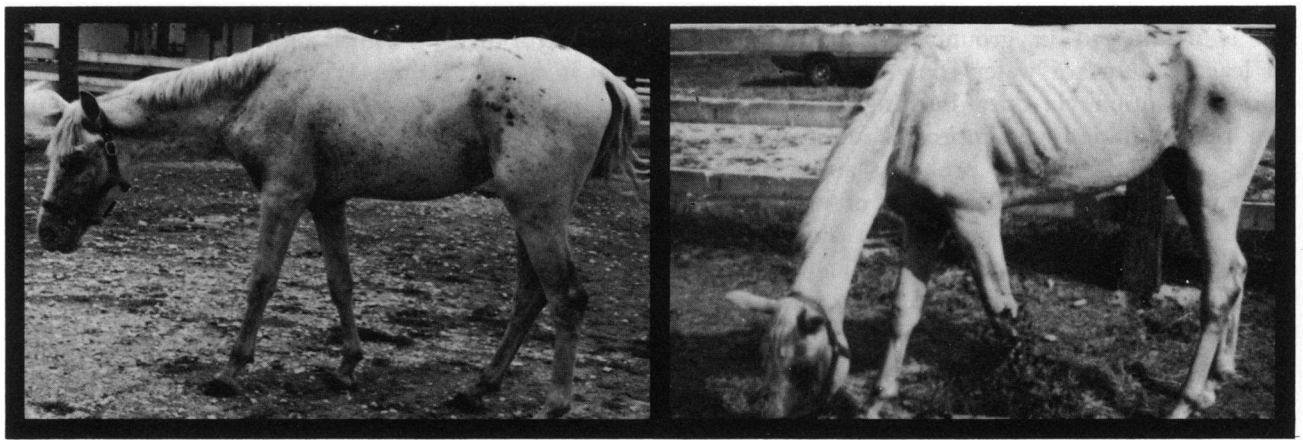
Premarket notification. Manufacturers of new chemical substances must notify the Administrator at least 90 days before the manufacture of the chemicals for commercial purposes. Any chemical not listed on an inventory of existing chemicals published by the Administrator in November 1977 are to be considered "new" for purposes of the premarket notice requirement. The Administrator may designate a use of an existing chemical as a significant new use, based on consideration of the anticipated extent and type of exposure to persons or the environment. Any person who intends to manufacture or process a chemical for such a significant new use must also report this information 90 days in advance of marketing. The Administrator may issue an order and seek a court injunction, if necessary, to ban a new chemical from the market. This action may be taken pending development of test data or completion of rulemaking proceedings to ban or restrict the chemical. Among chemicals which are or may be exempt from premarket reporting are those produced in small quantities solely for research, used for test marketing purposes, or determined not to present an unreasonable risk.

Regulation of hazardous chemical substances and mixtures. The Administrator may prohibit or limit the manufacture, processing, distribution in commerce, use, or disposal of a chemical substance or mixture if he finds that these activities present an unreasonable risk to health or the environment. Labeling may be required for a chemical or any article containing the chemical.

When regulatory actions are proposed, there must be an opportunity for comments by interested parties, including an oral hearing, and in certain instances, cross-examination. For imminent hazards, the Administrator may ask a court to require whatever action may be necessary to protect against the risk.

Exports and imports. The Administrator may regulate a chemical intended for export only if it presents an unreasonable risk to health or the environment of the United States. If necessary to determine whether there is such a risk, testing may be required. The Administrator is responsible for notifying the governments of importing countries of any regulatory restrictions or test data submitted for export chemicals. With respect to imports into the United States, no chemical substance, mixture, or article containing a chemical substance or mixture will be allowed into this country if it fails to comply with any rule or is otherwise in violation of the act.

Other provisions. The law also provides authority to require reporting and recordkeeping by manufac-



Left: Fairly normal horse. *Right:* Same horse after exposure for a few weeks to a riding arena contaminated with TCDD.

turers and processors of chemicals, to expand research activities, to address the relationship of this law to other laws, and to provide for civil actions and petitions by citizens. In addition, the law requires EPA to take action to regulate polychlorinated biphenyls. The act prohibits all production of PCBs after January 1979 and all distribution of PCBs in commerce after July 1979.

DHEW's role. Under the Toxic Substances Control Act, the Department of Health, Education, and Welfare's role encompasses three major areas:

1. Advice and consultation to EPA on the setting of standards or guidelines for test development, selection of substances to be tested, determination of the extent of human exposure, development of EPA research programs and project priorities, and interpreting the health significance of industrial studies required under the act.
2. Collection, exchange, retrieval, and dissemination of data on toxic substances.
3. The conduct of research studies.

These activities seem fairly straightforward, but when the number of DHEW organizations involved is considered, the act has really opened a host of agency interactions. The agencies involved include the National Institute of Occupational Safety and Health, the National Institute of Environmental Health Sciences, the National Library of Medicine, the National Institute of General Medical Sciences, the National Heart, Lung, and Blood Institute, the National Cancer Institute, and several support divisions of the National Institutes of Health.

This act provides a much needed capacity to move forward in establishing mechanisms for assessing new toxic products of industry and those in our environment.

Resource Conservation and Recovery Act

A great deal of attention has been given to the Toxic Substances Control Act, but another important statute on the environment has been enacted by Congress. Entitled the Resource Conservation and Recovery Act of 1976 (Public Law 94–580), this act governs hazardous waste management.

As administered by EPA, the act defines "hazardous waste" as any solid waste, or combination of solid wastes, which because of its quantity, concentration, or physical, chemical, or infectious characteristics poses a substantial present or potential hazard to human health or to the environment as associated with the method of disposal. This definition covers a lot of ground. Generally, we are talking about toxic chemicals, flammable materials, radioactive materials, explosives, and biologicals. Other hazardous wastes include wastes generated by hospitals, laboratories, academic institutions, and Federal institutions.

Hazardous waste generation is growing at a rate of 5 to 10 percent annually as a result of a number of factors, including increasing production and consumption rates and bans and cancellations of toxic substances and energy requirements. Land disposal of hazardous waste is increasing as a result of the implementation of the Clean Air Act (as amended), the Federal Water Pollution Control Act (as amended), the Marine Protection, Research and Sanctuaries Act, and the denial of previously accepted methods of disposal such as ocean dumping.

The key problem in hazardous waste management is the adverse impact on public health and the

environment resulting from land disposal. This problem is manifested in groundwater contamination via leaching, surface water contamination via runoff, air pollution via open burning, sublimation—food contamination via improper storage and disposal, and direct contact problems and explosions which may result from the mixing of wastes.

Under the Resource Conservation and Recovery Act of 1976, open dumping of all solid wastes must be ended by 1983. EPA is required to identify and publish a list of hazardous wastes within 18 months and to set standards for the handling, transportation, and ultimate disposal of those wastes. Under guidelines to be developed by EPA, States are to establish regulatory programs; if States fail to do so, EPA regulations will apply. Civil and criminal penalties are established for violation, up to $25,000 per day for noncompliance, a year in prison, or both.

Other major provisions of the new legislation include:

1. A requirement that all Federal procurement agencies buy items *composed* of the maximum allowable percentage of recycled materials.
2. A requirement that public participation must be promoted in the development of all Federal and State regulations, guidelines, information, and programs under the act.
3. Permission for citizens to bring suits to obtain compliance with the law.
4. Requirement of a number of special studies in certain areas such as sewage sludge management, low-technology means of resource recovery, measures to reduce the generation of waste, waste collection practices, management of mining and agricultural wastes, and economic incentives to promote recycling and waste reduction.

The immediate need is a broader understanding of the act and support at all levels—by the public, industry, and government.

The effect on our program lies with some of the research, demonstrations, and studies that will be conducted in areas such as sewage sludge management and the management of agricultural wastes that impose residual health effects via the food chain.

Implementation of the Acts

Implementation of the Resource Conservation and Recovery Act and the Toxic Substances Control Act is a difficult challenge. We have not been fully aware of the subtle but deadly effects of chemicals for decades. Now we must establish and extend basic knowledge and establish new frontiers of science and technology to determine the real risks and find ways to control them. We must act with speed and focus—not in haste or panic. We must recognize that minimal risks are inescapable, and that our society must take precautions to prevent the occurrence of silent epidemics of illness and death.

Our priority efforts are focused on:

1. Working closely with EPA in implementing the Toxic Substances Control Act and the other relevant acts.
2. Reestablishing strong State and local technical capacity within health and environmental protection agencies through technical assistance programs.
3. Strengthening occupational health programs to decrease exposure of workers to unhealthy and unsafe working conditions, including increased research in teratogenesis, mutagenesis, and carcinogenesis to protect the health of women in the workplace, and development of control measures in existing plants to include retrofit technology and modification of industrial process.
4. Applying increased emphasis on research, epidemiology, statistical efforts, data systems, and basic studies on toxicology.
5. Intensifying efforts to identify and disseminate toxicological information on chemicals in the environment, both purposeful and inadvertent, to which people are exposed.

In each of these efforts our fund of knowledge, although by no means complete or satisfactory, is sufficient to permit significant progress. How to mount effective programs and how to assign responsibilities among public and private interests are knotty problems, to say the least. Even more difficult is figuring out what kinds of efforts are feasible and who should pay for them. But there can be little argument with the fundamental premise that prevention must occupy a much larger place in any national health strategy for the years to come.

At the Federal level, we can initiate, support, and catalyze certain program efforts. We may even conduct some small portion of these programs. It is to the State and community health levels, in cooperation with the academic and industrial sectors, that we will have to look to a major extent for the identification of hazards through epidemiologic surveillance and monitoring. The States and local communities can best directly assess the environmental hazard, be it naturally occurring or the result of an industrial process. The elimination of the health hazard depends on all of us—the Federal-State partnership, industry, and the public.