

## Toxic Century: The Origins of “Environmental Health”

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“Environmental health” describes both a material condition and a cultural perspective. The phrase emerged among public health specialists only in the 1930s, becoming commonplace in the decades after World War II. Of course, the concern with environments and health has a much longer history—whether in the Greek tradition of Hippocrates (*Airs, Waters and Places*), Indian ayurvedic practices, or traditional Chinese medicine. But in these earlier times, the association of health with place was axiomatic; to speak of *environmental* health would have been redundant. The adjective becomes necessary only *after* environments have been intellectually and discursively separated from health. How did that happen, and under what circumstances were environment and health then rejoined? And what social and intellectual implications should we attach to the emergence of a concept of “environmental health” that is presumably distinct from some other kinds of health?

In European societies, scholars have long agreed that a key turning point in the understanding of health and disease occurred sometime in the late nineteenth century. Scholars once pointed to the late nineteenth century as the beginning of a scientific medicine, whereas revisionist historians of the past two decades have brought a more critical perspective to the triumphalist narrative of medical progress. Yet scholars agree that the consolidation of germ theory as the dominant way of understanding disease substantially weakened the intellectual connection between environments and health. Spurred by the discoveries of Louis Pasteur, a new generation of physicians and public health professionals increasingly located the cause of illness not in the broader environment but in specific bacteria, viruses, or parasites. Disease became bounded, and environments far less relevant. Health, in this view, was the corollary of purity: a self-contained body in which the environment was kept at bay.<sup>1</sup>

These intellectual developments were intertwined with unprecedented environmental changes. As European societies utilized first the energy of rivers and then of coal and petroleum, they altered their environments in evermore profound ways, and human bodies—along with understandings of health and disease—would change markedly. The roots of a modern concept of environmental health lie in the late nineteenth century and the rapid environmental, social, and bodily changes brought about by industrialization.

Health in the Industrial Environments: From Purity to Safety

Even before medical professionals had begun to narrow their focus to the human body, industrialization was radically altering existing environments on a global scale, generating new diseases and epidemics in the process. The massive labor requirements of industrialization generated a wholly new kind of environment: the industrial city. Places like Chicago and Manchester grew rapidly into manufacturing centers that were distinguished by their crowded conditions, unprecedented levels of air and water pollution, and the miserable living conditions of their working classes. Infectious diseases raged through the urban centers of Europe and North America, and by the late 19<sup>th</sup> century, responses to these epidemics were underwritten by germ theory. Public health practice de-emphasized the role of the environment in favor of a focus on individual bodies, especially those marked by race: in Europe and North America, ethnic and racial outsiders were frequently targeted as “carriers” of disease into regions otherwise assumed to be healthy.<sup>2</sup>

Horrible levels of urban pollution exacerbated familiar maladies and generated new ones. The dense concentration of humans and domestic animals, combined with wastes generated by industrial processes, changed lakes and rivers into fetid sewers, which transmitted infectious diseases such as typhoid and cholera. The heavy consumption of coal left the air smoke-laden skies and caused epidemics of respiratory disease and childhood rickets. To Progressive-era reformers, the connections between bodies and their environments were clear. They linked poor health to polluted environments and lobbied city governments for action, even as modern medicine narrowed its focus to the body.<sup>3</sup>

To meet their massive demand for resources, the industrializing nations of Europe and North America expanded their control over resource-rich regions, near and far. As new technologies brought unprecedented quantities of coal, oil, and minerals to the surface of the earth, vast numbers of workers were pulled into unlikely locations including the coal seams of North America and Wales, the copper pits of Africa and western North America, the phosphate mines of Polynesia. Factories then concentrated these otherwise familiar elements to an unprecedented degree, while confining workers’ bodies within those spaces for twelve or fourteen hours per day. Among the results of this labor concentration were a growing number of ailments associated with particular trades: “painter’s colic” (lead poisoning), “potter’s rot” (silicosis), “phossy jaw” (phosphorous poisoning). Though many of the diseases associated with particular forms of work had been known for generations, they now appeared much more frequently and affected many more people.

These toxic industrial environments fostered new professions and social movements. Those committed to uncovering the relationship between disease symptoms and industrial work coalesced into a new transnational discipline: industrial hygiene. In both Europe and the United States, Progressive-era reformers visited factories, talked to workers about their illnesses, and tracked the occurrence of symptoms. By the 1880s, the German state was requiring the regular inspection of lead industries, and in 1895 the British government formed the Dangerous Trades Commission to study worker health. Under the direction of physician Thomas Oliver that commission produced a seminal volume on occupational health: *The Dangerous Trades: The Historical, Social, and Legal Aspects of the Industrial Occupations as Affecting Health, by a Number of Experts*. Oliver’s report was exhaustive, but it paid particular attention to dust-producing trades (pottery, tool manufacturing; copper, iron, and zinc production; stone

quarrying; and textile manufacturing) and to those that involved toxic metals: mercury, arsenic, and above-all lead.<sup>4</sup>

In the U.S., the key figure was Alice Hamilton--daughter of an elite mid-Western family, a bacteriologist by training, and a member of the Progressive reform group at Chicago's Hull House. In 1910, Hamilton served on an Illinois state commission charged with studying the health of workers in the "poisonous trades." Her ensuing report documented the massive scope of industrial lead-poisoning and generated some of the first occupational health reforms in the U.S.<sup>5</sup> As Oliver's book and Hamilton's career both suggest, much of the focus of early industrial hygiene was on lead--an old compound long recognized as toxic which had found widespread use at the end of the nineteenth century: in mass-produced ceramics, electrical storage batteries, water pipes, and especially as an ingredient of paint.

The concern with factory environments emerged out of Progressive politics and older understandings of health and disease, which linked bodies with their environments. However, in the years after World War I, the study of industrial disease moved into the laboratory. Narrowing their focus to particular chemicals, a new generation of professionals sought to measure health effects quantitatively. This new science of toxicology reduced workplace hazards to specific chemicals which were conceptualized as akin to microbes--as singular agents that were capable of inducing a specific symptom once they entered the body. In the process, toxicology reproduced the exceedingly narrow definition of both causality and disease enshrined in germ theory. What mattered was not the broader environment but the specific chemical exposure.<sup>6</sup>

Furthermore, assumptions about what constituted "disease" within the field were subtly--and sometimes not so subtly--shaped by both the desire to make labor more efficient and the assumption that workers were inherently recalcitrant and dissembling. In the toxicological model, only those conditions that could be linked quantitatively to a measured chemical exposure at and a known physiological effect could constitute chemically induced disease. Conditions of illness that could not be traced to a specific chemical exposure were either dismissed or attributed to other causes. As Christopher Sellers has argued, toxicology served the interests of both new scientific professionals--by granting them the authority of the modern laboratory--and of corporate managers--by helping to normalize chemical exposures in the workplace. Toxicology may be a science, but it was also a political-economic compromise born of the interwar period. The questions that shaped the field revolved less around general ideas of "health" than around questions of labor efficiency and worker productivity.<sup>7</sup>

Assumptions about the body forged in toxicology differed from those common in bacteriology in at least one important respect. Whereas bacteriology assumed that health signified a pure body from which germs had been kept out, toxicology held that health was the result of a stable and balanced body--an understanding taken from the new field of experimental physiology. The new physiologists viewed the human body less as a container subject to contamination than as a self-regulating system that sought, in Harvard professor Walter Cannon's famed term, a condition of "homeostasis." Drawing on the concept of self-regulation, toxicologists introduced the concept of biologic thresholds: the idea that there is always a level of exposure below which the body could absorb and adjust to pollutants without sustaining permanent harm. Derived from laboratory studies of animals that had been dosed with measured

amounts of a single chemical, these biologic thresholds became the basis for “safe concentration levels” within the factory. In this way, modern toxicology normalized the problem of low-level chemical exposures within the factory. Consequently, for these professionals (and their industrial patrons) the concept of environmental and bodily purity had no role: that both environments and bodies absorbed industrial chemicals was not, in itself, a problem.<sup>8</sup> The quest for bodily purity—always unrealistic—was gradually being replaced, both intellectually and practically, by a notion of bodily *safety* in the face of ongoing chemical exposures.

That the hazards of chemicals extended beyond the workplace was already well-known at the beginning of the century. Great Britain had attempted to curb the emissions of chemical factories since the late nineteenth century, recognizing the danger they posed to surrounding communities. By the early 1900s, the public health hazards of lead had been recognized. France banned the interior use of lead paint in 1909, and ten years later the League of Nations pushed for a global ban. Though more than 40 countries would sign the ban, the U.S. was not one—a product of that country’s isolationism, a conservative administration, and the political strength of its lead industry.<sup>9</sup> Consequently, the production and use of lead in American housing and consumer products would proliferate throughout most of the twentieth century.

It was not only paint that posed a significant lead hazard, however. Beginning with the discovery of the insecticidal properties of Paris Green (copper acetoarsenite) in the 1860s, American farmers embraced metallic pesticides to control their mounting insect problems—problems that were largely an outgrowth of farmers’ turn toward specialized cash crops and the spread of monocultures across the North American landscape. It was the particular challenges posed by the gypsy moth—a pest with a high resistance to Paris Green—that encouraged the adoption of a new arsenic-based compound in 1892: lead arsenate. For the next five decades, lead arsenate would be the most widely used insecticide in America (to be surpassed only by DDT). As farmers became increasingly reliant on these pesticides, fresh foods became a potentially significant source of toxic exposure for consumers.<sup>10</sup>

Although the same pesticides were marketed in Europe, farmers there never embraced them on the scale as their American counterparts, and European governments took a more cautious approach. The French banned arsenical insecticides in 1846, and again in 1916, while the British government adopted a strict standard of 0.01 grains of arsenic per pound on foodstuffs in 1903. U.S. regulators were similarly concerned but constrained by their limited authority; the U.S. only adopted a standard for arsenic in 1927, in the wake of a well-publicized poisoning incident and a threatened British embargo of American produce.<sup>11</sup> Lacking the power to ban dangerous insecticides, U.S. regulators turned to the new industrial toxicologists to establish safe concentration levels. But the turn toward toxicology was also an acknowledgement that regulators were not trying to keep poisons out of the body but merely to ensure a minimal level of safety. The logic of the factory, in which some small degree of bodily injury was accepted as “normal,” would now be applied to the public at large.

Although officials focused initially on the hazards of arsenic, the greater danger of lead arsenate lay with the lead. After World War I, environments in the industrialized world were increasingly saturated with lead, especially in the U.S. Lead-based paint was ubiquitous in American life, coating the inside and outside of homes and countless consumer products.

Leaded gasoline was introduced in 1923, despite concerns over its safety for the broader population. The health effects were evident. During the 1920s, pediatricians were aware of “plumbism” among children, and by the late 1930s, they had established the effect of lead exposure on children’s mental functioning. However, the problem was construed largely in class and racial terms—as a disease of children living in poverty who ate the paint that peeled off their walls—which made it easy to ignore calls for strict regulation or radical environmental remediation in favor a narrower focus on vulnerable groups. Moreover, the toxicological insistence on biological thresholds, below which no serious damage was assumed to occur, sustained a decades-long argument over “safe” levels of lead in the environment and in the body.<sup>12</sup>

During World War II and the postwar economic boom, lead production and consumption increased dramatically. The massive numbers of new homes constructed in the postwar decades were filled with lead—in water pipes, in solder for electrical wires, in countless consumer products, and, above all, in paint, ensuring that the public would be continuously exposed to lead for decades to come. Although everyone living in the industrialized world was at risk, exposures were not equal. As a result of limited regulation, Americans had the highest exposures to lead; and within America, it was the poor and non-white who suffered most as they were increasingly confined to the deteriorating housing stock of the inner city. By the early 1950s, an epidemic of lead poisoning existed among poor urban children. However, it was only in response to citizen activism in the 1960s that the first serious measures to control exposure took shape. Even then, the toxicological assumption that there existed a “safe” level of lead exposure stalled efforts at reform. The U.S. would ban lead paint and begin phasing out leaded gasoline only in 1976.<sup>13</sup> Nonetheless, lead still saturates modern environments and bodies, though the geography of poisoning has shifted. The European Union adopted a ban on lead in consumer products in 2006, and lead levels among U.S. residents are declining; however, lead exposure is now far more prevalent in parts of the developing world. Moreover, there is no easy way to dispose of all the lead-laden products that have been brought into existence; they are either placed in landfills or shipped to poorer regions of the globe for recycling, and countries such as China and Uruguay have found themselves with major public health crises. And the modern love affair with lead continues. Today, more lead is mined than ever before.<sup>14</sup>

Lead was an old compound that became much more prevalent in the twentieth-century environment. But industrialization also forged a plethora of new compounds based on the chemical derivatives of coal and petroleum. Driven initially by imperial military demands and--in the U.S. and Germany--patent systems that rewarded individual inventors well, a frenzied search for new synthetic products had begun in the late nineteenth century. Would-be inventors experimented with a variety of materials, but extracts of coal tar--byproducts of the industrial coking process--were key ingredients for many commercially valuable new substances in the late nineteenth century, especially dyes and explosives. Germany--with its ample coal supplies and advanced educational system-- dominated the early manufacture of chemical dyes. Chemical plants sprang up along the Rhine River in the late 1800s, and by 1895 a German physician reported a high incidence of bladder tumors among men employed in one of the dye factories as well as those living directly downstream.<sup>15</sup>

Although coal would remain the major source of chemical feedstocks up until World War II, oil companies began creating useful derivatives from petroleum in the early 1900s. Among the first was petroleum-derived toluol (1903), an ingredient of dynamite. The discovery of the “cracking” process for petroleum (1908)—which broke up large carbon molecules into lighter, more useable fuels—generated new petroleum byproducts and more research. Disruptions in supply networks during World War I spurred the development of synthetic substitutes for critical materials, and by the 1920s, the modern petrochemical industry was launched. Oil companies spawned many useful substances, including synthetic fibers (nylon), synthetic rubber (neoprene), plastics (e.g., Teflon, polyvinyl chloride).<sup>16</sup>

The Second World War created still greater opportunities for the modern chemical industry, particularly in the U.S. where wartime needs encouraged massive federal investments. By the end of the war, domestic manufacturers had begun to replace conventional materials (glass, wood, natural rubber, iron, copper, paper) with synthetics in buildings and consumer products. Houses, once made of wood, glass, metal, plaster, and brick, were now composed plywood, drywall, and plastic. Food underwent a “chemogastric revolution.” Clothes—once made out of cotton or wool—were increasingly made out of nylon and polyester.<sup>17</sup>

The rapid transition from societies based on carbohydrates to those based on the derivatives of coal and petroleum marked a revolution in material life, and we still have not fully reckoned with the implications a century and a half later. Across the twentieth century, the new petrochemical and plastics industries worked successfully to push aside emerging concerns about their products’ effects on health and landscapes, positioning them as culturally “modern” and economically indispensable. “Better things for better living...through chemistry,” as the DuPont Company put it in well-known advertising slogan from 1933.<sup>18</sup>

Claims for better living aside, the first worker at the DuPont dye works had been diagnosed with bladder cancer six years earlier, and by 1935 dozens of cases had appeared at the factory. Recognizing the company’s potential liability, DuPont funded its own toxicology laboratory in 1934 and hired the German physician Wilhelm Hueper to lead it. Hueper demonstrated that betanaphthylamine—one of the factory’s key products--caused bladder cancer in dogs. However, Hueper’s aggressive investigation of worker risks was not what DuPont had in mind, and Hueper was fired from his position after just three years.<sup>19</sup>

Petrochemicals found some of their most important early applications in packaged and processed foods, but consumers were skeptical. By the turn of the century, growing concern over artificial ingredients in foods had generated calls for reform across much of Europe and the U.S. In 1905, France passed a law on fraud and adulteration in foods; the following year, the U.S. passed the Pure Food and Drug Act, which gave the federal government’s Bureau of Chemistry the authority to seize food that contained ingredients “injurious to health.” The first head of that Bureau, Harvey Wiley, was a staunch Progressive reformer. He was ideologically wedded to the idea of “pure” foods--a view shaped by germ theory and the sanitary revolution of the late nineteenth century which held that healthy bodies were pure bodies while environments were health-neutral except when traversed by dangerous pathogens or poisons.<sup>20</sup>

Wiley and his agency were subsequently charged with determining which specific chemicals were “injurious to health” and thus illegal. That is, the law assumed that good food was basically pure and that the problems stemmed from a few errant chemicals that could be addressed on a case-by-case basis. It was a matter of keeping injurious chemicals out of an otherwise pure body, and those chemicals were assumed to be few and far between. Wiley quickly succeeded in banning the most dangerous preservatives and in limiting the number of food colorants in use. However, court decisions in the U.S. placed the burden of proving harm squarely on the government, and with the rapid expansion of the chemical and processed food industry during the interwar period and beyond, thousands of chemicals would enter the food supply with little or no testing.<sup>21</sup>

### Ecological Bodies and Environmental Health

World War II marked a watershed in the environments of the industrialized world. The war itself generated enormous demands for metals, petroleum, and chemical innovations. Moreover, the discovery of highly effective organic insecticides, the mass production of new petroleum-based consumer products, and the unbridled pursuit of atomic weapons, all ramified in soils, water, and air; that these changes were affecting human bodies quickly became evident. The idea that health was largely independent of environments could not be sustained in the midst of such massive environmental changes.

In the late 1950s, an American marine biologist and science writer sat down to write a popular account of a new class of chemical pesticides and their disturbing effects. Rachel Carson published her landmark book, *Silent Spring*, in 1962 in which she chronicled the environmental and health effects of the new synthetic organic pesticides. DDT and similar organochlorine compounds were highly effective against most insects, while having very low acute toxicity in mammals. The agricultural-industrial complex embraced these new substances as the solution to the health threats posed by metallic pesticides, particularly lead arsenate.

Carson’s book eloquently expressed concerns that had been mounting since the late nineteenth century. Her central argument was that the proliferation of these new substances in the environment would affect human health in unknown and potentially catastrophic ways. To make her case, Carson drew heavily on the evidence of toxicology—including the work of Wilhelm Hueper, the former DuPont physician—as well as on information presented at a lengthy set of U.S. Congressional hearings on pesticide residues and chemical food additives held during 1950-1952 (see box). However, Carson did not view human bodies as bounded entities that were separate from their environments; rather she invoked ecosystem ecology and evolutionary biology to argue that a disruption in the landscape would lead, eventually, to a disruption in the health of those who occupied the landscape. Ecological conditions were inseparable from human health.

Though Carson had focused specifically on agricultural pesticides, the resonance of her book emerged from a growing sense at mid-century that the world was becoming broadly polluted. Suburbanization, rapid industrial expansion—especially the expansion of the chemical

industry--and the increasing use of fossil fuels had made longstanding issues of air and water pollution into an obvious crisis. Smog had become a recurring problem in Los Angeles by the early 1940s. Then, in 1948 an unusually persistent smog killed 19 people and sickened at least one-third of the population of Donora, Pennsylvania. Four years later, the “killer smog” in London sickened 100,000 people and was subsequently determined to have caused 4000 deaths. And although public health experts had been concerned about water pollution since the late nineteenth century, the rapid growth in population combined with a host of new chemical wastes from industry raised the scale and visibility of the issue in the postwar years.

But Carson also invoked a new concern: the danger of radioactive fallout--a product of the atomic bomb and the continuing quest to develop ever more powerful nuclear weapons. Concerns over fallout had emerged immediately after World War II, as the United States committed itself to maintaining nuclear superiority through ongoing atomic testing. Because the nuclear testing program was cloaked in secrecy, substantial information on the dangers of fallout only reached public audiences in the mid-1950s in the wake of serious fallout incidents. In particular, a 1954 test on Bikini Atoll in the southern Pacific Ocean—in which the U.S. exploded the first hydrogen bomb-- generated massive contamination across the eastern Pacific Ocean. Among the victims were the crew of a small Japanese fishing boat. When the sickened fisherman arrived home, a global panic over the possibility of tainted food supplies erupted. More than 30 million Japanese subsequently signed petitions against nuclear weapons testing; the U.S. Congress announced hearings on atomic fallout; and both the U.S. National Academy of Science and the British Medical Research Council launched studies on the health hazards of radioactivity.<sup>22</sup>

The hazards of radiation fundamentally destabilized the notion of bodily safety. Radiation was an unfamiliar and invisible danger capable of traveling long distances and entering unseen into the food supply; even scientists were uncertain about its long-term effects. Moreover, radiation was known to affect not only those exposed but also their unborn children. As a new generation of activist-scientists publicized the dangers of fallout, people across the globe recognized their shared vulnerability to this new and frightening class of contaminants.

These massive material changes helped shift both expert and lay perceptions of health. Based for more than five decades on the modernist conceit of separable and impermeable bodies, dominant ideas of public health had, by 1960, been sorely undercut by the realities of environmental pollution. The re-emergence—or perhaps *persistence* is a better term--of public concerns over environments and their health effects at mid-century would thus again help animate movements for environmental reform and industrial control. In 1960, the U.S. Congress held hearings on “environmental health” which highlighted issues of radioactive wastes, water and air pollution, and chemicals in foods and in the workplace. Two years later, an expert committee appointed to review the issues strongly criticized the institutional separation of environmental from human health programs within the U.S. government and recommended reorganization. By the late 1960s, the modern environmental movement, with its explicit focus on the health effects of pollution, had become a major political force.<sup>23</sup>

*Silent Spring* resonated with publics in Europe, and Japan as well, underscoring the fact that these anxieties were shared across the industrialized world. Among nations, Sweden took



the earliest and most vigorous policy response against pesticides, banning DDT in 1969. However, industry and government representatives in Britain, France, and elsewhere successfully portrayed the pesticide problem as a uniquely American one--pointing to the US's more highly industrialized agricultural sector and their own supposedly more robust regulatory systems.<sup>24</sup>

Although many of these health threats were new in the postwar era, some dated from the moment of the bacteriological revolution, and even before. Arguably, it was the rise of modern medicine with its narrow focus on germs and its assumption of impermeable bodies--and the corresponding disciplinary separation of human health from the environment--that had allowed the unprecedented environmental changes of the twentieth century to take place without any serious consideration of their potential health effects. Nonetheless, experts and lay people alike still adhered to an overarching narrative of medical and scientific progress, maintaining that the recognition of these newer problems stemmed primarily from the "success" achieved in controlling older ones.<sup>25</sup>

By the mid-1960s, public protests were forcing national governments to take action to address environmental pollution. Initially the U.S. government was far more aggressive in regulating pollutants than its European or Japanese counterparts, passing strong regulations to limit air and water pollution and to assess the environmental consequences of government activities. And in their search for regulatory models, American administrators looked to the fields of occupational health and toxicology. In 1970, the U.S. Congress passed the Occupational Health and Safety Act, granting the Department of Labor the authority to set chemical exposure standards in the workplace. A few years later, both the Safe Drinking Water Act (1974) and the Toxic Substances Control Act (1976) gave the U.S. Environmental Protection Agency the authority to set chemical standards for the broader environment.<sup>26</sup> Yet as these laws were being debated and passed, concepts of the body and its relationship to the environment were again shifting.

### From Safety to Risk in a Chemically Laden World

The late twentieth century marked the rise of "risk society" to use Ulrich Beck's term.<sup>27</sup> In Beck's account, the seemingly endless proliferation of material risks to health and environmental integrity is the outcome of capitalist modernization. But without disputing the fact that industrialization has introduced new kinds of health threats, their conceptualization as "risks"--rather than merely as "dangers" or "diseases"--marked a significant discursive and political change. Whereas the ideal of safety had acknowledged that dangerous substances (in the form of chemicals and radionuclides) were bound to enter modern bodies, experts and administrators had also maintained that there were absolute levels below which the body could repair any damage and no harm would occur. The corollary was that regulations needed to ensure that environmental levels never exceeded those bounds of safety. The concept of risk, in contrast, was based on the notion that safety, much like purity before it, was a chimera; it asserted that health risks were inherent and unavoidable in the modern world. From this perspective, health was a relative notion, a state that emerged from the proper balancing of risk against risk and risk against benefit.

“Risk” was a broad cultural discourse; “risk assessment” was a bureaucratic technique that operationalized risk as the basis for environmental policy. Its origins lay in American efforts to regulate the atomic weapons program and carcinogenic food additives. Both radioactivity and chemical carcinogens had defied attempts to designate “safe” levels below which no health effects occurred. Recognizing that assurances of safety in such cases were problematic—yet unwilling to back away from either nuclear weapons production or the use of synthetic chemicals in foods--the U.S. government instead backed away from its commitment to ensuring safety.

Scientists had known since the mid-1920s that radiation exposure caused genetic effects across generations with no identifiable threshold, or safe, level; the genetic effects of radiation are neither visible nor measurable at the scale of the individual. A key feature of genetic effects is that they can only be observed statistically: as an overall increase in the number of mutations in a population. Because some mutations occur naturally, it was, and is, impossible to say whether a particular individual mutation is due to radiation (or chemical) exposure or whether it would have occurred anyway. Moreover, risks that are substantial across a population may be slight for an individual. This paradox made it possible for nuclear experts to downplay the threats of exposure by focusing on only the relatively small risks that any individual might encounter, while glossing the statistical likelihood of tens of thousands of mutations across the population. It also made it possible to compare, at least rhetorically, the hazards of radiation to an individual with those posed by natural background radiation, other workplace hazards, or even the risks of driving an automobile. Moreover, in the context of the Cold War, the U.S. Atomic Energy Committee (AEC) repeatedly emphasized the enormous security threat posed by the Soviet Union. Implicitly, the AEC and its supporters were offering a cost-benefit analysis (though never publicly phrased as such) in which the health costs of radiation exposure to Americans were more than balanced by the supposedly overwhelming benefits of U.S. nuclear superiority.<sup>28</sup>

This way of framing health concerns—as necessary risks taken to ensure greater benefits—served to normalize some level of radiation health effects. Acknowledging that there was no safe dose of radioactivity, the main standard-setting body in the US, the National Committee on Radiation Protection had quietly renamed the standards in 1948 without, however, changing the allowable exposure: in the case of radiation, “tolerance dose” became “maximum permissible dose.”<sup>29</sup> By definition, risks were never zero.

Contemporaneous with the fallout crisis in the mid-1950s, the U.S. FDA had been struggling internally with how to regulate the explosion of chemicals in foods, several of which were suspected carcinogens. In 1958, the U.S. Congress acceded to mounting concerns that there was no identifiably “safe” level of exposure to a carcinogen. The so-called Delaney Amendment of the Food Additives Act embraced an older philosophy of purity as it banned the use of potential carcinogens in processed foods. The law aimed for pragmatism, however, by exempting from scrutiny many additives already in widespread use. At the time, the U.S. was the only country to take such a precautionary approach; guidelines adopted just a few years later at the international level articulated the cost-benefit approach favored by industry.<sup>30</sup>

But the difficulties of legislating purity in the face of an already chemically suffused food supply became quickly apparent, and over the next two decades the FDA moved quietly away from its no-carcinogen policy. In the 1970s, with the articulation of its proposed “sensitivity of method” policy (see box), the FDA embraced the concept of risk as the basis for regulation. That shift culminated in 1979, when the FDA proposed a numerical standard for “acceptable risk” for carcinogens in the food supply (1 in 1,000,000). Quantitative risk assessment had moved into the consumer realm.

The principle of quantitative risk assessment was embraced by industry representatives and conservative political leaders in their effort to rein in the new environmental regulations of the late 1960s and early 1970s; these groups saw risk assessment as a means of interjecting cost-benefit analyses into environmental and health regulations, despite the public’s deep resistance to evaluating human health in economic terms. Both conservative courts and presidential administrations seeking to roll back the power of regulatory agencies advocated risk assessment as a more “scientific” approach to managing environmental health.

At the same time, public concerns over toxicity were exploding globally, abetted by a series of large-scale disasters. In 1976, an explosion at the ICMESA chemical plant in Seveso, Italy released dioxin, immediately killing more than 3000 farm animals. In 1978, the story of the chemically contaminated community at Love Canal, New York became a national story, prompting recognition of thousands of toxic waste sites across the country. A year later, the Three Mile Island nuclear plant in Pennsylvania underwent a partial meltdown, forcing the evacuation of 140,000 people. And in 1982, the Union Carbide Plant in Bhopal, India exploded releasing a brew of toxic gases; more than three thousand people were killed and half a million injured in what remains the world’s worst industrial accident.

As public fears over toxins rose, quantitative risk assessment attained new visibility. In 1983, the U.S. National Research Council endorsed risk assessment as a broad regulatory strategy to assess hazards and establish priorities across multiple domains. Leading figures in the administration of President Ronald Reagan publicly embraced risk assessment as a means of prioritizing--and limiting--what they viewed as excessive environmental and health regulations of the preceding decade.

By the 1990s, the framework of risk had largely replaced the notion of safety in American regulatory policy. Though advocates argued that risk assessment made environmental policy more scientific and less overtly political, critics claimed the process merely recast political and social judgments as technical decisions in order to limit public input. What was rarely articulated was that the ascent of risk assessment marked the triumph of a market logic applied to health and the body. And although risk assessment gained hold first in the US, its incorporation into international trade agreements ensured its spread to America’s trading partners. Yet this was a political and professional shift that had never been widely endorsed or even debated by the public. Most people—in the U.S. and elsewhere in the industrialized world--still expected governments to ensure their *safety* of the face of environmental contamination. These diverging perspectives were increasingly manifest in numerous toxic controversies that pitted regulators and scientists who asserted the negligible “risk” of contamination against local communities clamoring for greater levels of safety and precaution.

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“Environmental health” is a term born of the twentieth century as it unfolded in the industrialized world. It acknowledges both the intellectual separation and the inescapable links between bodies and their ecologies. But how exactly those links should be understood remains strongly contested. The regulatory system put into place in the early twentieth century was predicated on the twin ideas that bodies were relatively impermeable and that environmental health threats were discrete and limited in number. Once it became clear that hundreds of pollutants were entering bodies and tens of thousands were present in the environment, regulators faced an impossible task. While the public expected safety, industry representatives and their supporters argued that only the most dangerous chemicals required direct regulation, and only if present at very high levels. Yet the accumulating scientific knowledge has undercut the bases for such an assumption: very low-dose exposures may generate substantial effects; chemical effects may be synergistic and cumulative over a lifetime; and the number and amount of exposures are far higher in many cases than anyone anticipated.

In response, those most vested in the growth of the chemical and nuclear industries have sought to shift regulatory strategies towards those more commensurate with inherently dangerous and environmentally destructive technologies—that is, toward a system that weighs costs (or risks) against purported benefits, and in which the risks of pollution can be weighed against any number of other health threats. The “risk society” in which we currently find ourselves is not simply a world full of hazards generated by industrial capitalism, but a world in which most of us have come increasingly to understand our own health—and that of our children—in terms of (economic) tradeoffs.

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<sup>1</sup> George Rosen, *A History of Public Health*. (New York: MD Publications, 1958); Nancy Tomes, *The Gospel of Germs: Men, Women, and the Microbe in American Life* (Cambridge, Mass.: Harvard University Press, 1998); Linda Nash, *Inescapable Ecologies: A History of Environment, Disease, and Knowledge* (Berkeley: University of California Press, 2006).

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<sup>6</sup> Sellers, *Hazards of the Job*, 141-86; Linda Nash, "Purity and Danger: Historical Reflections on the Regulation of Environmental Pollutants," *Environmental History* 13, no. 4 (October 2008): 651-58.

<sup>7</sup> Sellers, *Hazards of the Job*, 159-69.

<sup>8</sup> Nash, "Purity and Danger"; Sellers, *Hazards of the Job*, 175-83; Steve Sturdy, "Biology as Social Theory: John Scott Haldane and Physiological Regulation," *British Journal of the History of Science* 21 (1988): 315-40.

<sup>9</sup> E. C. Halliday, "A Historical Review of Atmospheric Pollution," *Monograph Series. World Health Organization* 46 (1961): 9-37; Christian Warren, *Brush with Death: A Social History of Lead Poisoning* (Baltimore, MD: Johns Hopkins University Press, 2000), 57, 62.

<sup>10</sup> James C. Whorton, *Before Silent Spring: Pesticides and Public Health in Pre-DDT America* (Princeton, N.J.: Princeton University Press, 1975).

<sup>11</sup> The American arsenic standard of 1927 would be relaxed in 1940 in response to the powerful opposition of American fruit growers and their political allies. Whorton, *Before Silent Spring*, 68-92, 133-75.

<sup>12</sup> Warren, *Brush with Death*. The lead standard was also delayed by the absence of a rapid method for detecting lead; improvements in analytical methods allowed the U.S. to adopt a standard for lead on foodstuffs in 1933. Whorton, *Before Silent Spring*, 220-21; Sellers, *Hazards of the Job*, 200-209.

<sup>13</sup> According to Warren, consumption of lead in the U.S. rose by 70% between 1939 and 1944. Warren, *Brush with Death*, 134-77 (statistic on 173). Until the late 1960s, American public health officials maintained that a blood lead level of 60 ug/l was acceptable. That standard has been progressively lowered, most recently in 2012, to 5 ug/l. Most researchers today have concluded that blood lead levels should be at or very near 0. Rosner and Markowitz, *Lead Wars*, 18 (on safe levels); J. L. Pirkle et al., "The Decline in Blood Lead Levels in the United States. the National Health and Nutrition Examination Surveys (NHANES)," *JAMA: The Journal of the American Medical Association* 272, no. 4 (July 27, 1994): 284-291.

<sup>14</sup> "Lead Poisoning in China: The Hidden Scourge," *The New York Times*, 5 June 2011; Daniel E. Renfrew, "New Hazards and Old Disease: Lead Contamination and the Uruguayan Battery Industry," in *Dangerous Trade: Histories of Industrial Hazard Across a Globalizing World*, ed. Christopher Sellers and Joseph Melling (Philadelphia: Temple University Press, 2012), 99-112. Annual global production of lead has increased by 38% since 1970 to 4.7 million metric tons. U.S. Geological Survey, "Historical Statistics for Mineral and Material Commodities in the U.S.," Data Series 140, <http://minerals.usgs.gov/ds/2005/140/#data> (accessed 2 December 2013). In 2006, the European Union initiated a ban the use of lead in nearly all consumer products; other countries have not followed suit.

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- <sup>15</sup> Mark Cioc, *The Rhine: An Eco-Biography, 1815-2000* (Seattle: University of Washington Press, 2002), 112-130.
- <sup>16</sup> Peter H. Spitz, *Petrochemicals: The Rise of an Industry* (New York: Wiley, 1988); Fred Aftalion, *A History of the International Chemical Industry* (Philadelphia: University of Pennsylvania Press, 1991).
- <sup>17</sup> U.S. Department of Health, Education and Welfare, Public Health Service, *Report of the Committee on Environmental Health Problems* (Washington DC: U.S. GPO, 1962), 21; Suzanne Rebecca White, "Chemistry and Controversy: Regulating the Use of Chemicals in Foods, 1883-1959" (Ph.D., Emory University, 1994), 211-36.
- <sup>18</sup> David J Morris and Irshad Ahmed, *The Carbohydrate Economy: Making Chemicals and Industrial Materials from Plant Matter* (Washington, D.C.: Institute for Local Self-Reliance, 1992); Jeffrey L Meikle, *American Plastic: A Cultural History* (New Brunswick, N.J.: Rutgers University Press, 1995)..
- <sup>19</sup> Wilhelm C. Hueper, "Cancer of the Urinary Bladder in Workers of Chemical Dye Factories and Dyeing Establishments," *Journal of Industrial Hygiene* 16:4 (1938): 255; Christopher Sellers, "Discovering Environmental Cancer: Wilhelm Hueper, Post-World War II Epidemiology, and the Vanishing Clinician's Eye," *American Journal of Public Health* 87, no. November 1997 (1997): 1824-35. DuPont's medical director would later fabricate charges that Hueper was a Nazi and then a Communist. Robert Proctor, *Cancer Wars: How Politics Shapes What We Know and Don't Know About Cancer* (New York: Basic Books, 1995), 39-40, 43.
- <sup>20</sup> Pierre-Antoine Dessaux, "Chemical Expertise and Food Market Regulation in Belle-Epoque France," *History & Technology* 23:4 (December 2007): 351-368; Suzanne White Junod, "Food Standards in the United States: The Case of the Peanut Butter and Jelly Sandwich," in *Food, Science, Policy, and Regulation in The Twentieth Century: International and Comparative Perspectives*, ed. David F. Smith and Jim Phillips (New York: Routledge, 2000), 167-188.
- <sup>21</sup> White, "Chemistry and Controversy," 1-161. Britain followed suit, banning formaldehyde, salicylic acid and boric acid in 1925. Michael French and Jim Phillips, *Cheated Not Poisoned?: Food Regulation in the United Kingdom, 1875-1938* (Manchester: Manchester University Press, 2000). Among Wiley's most significant failures was his attempt to ban saccharin. Junod, "Peanut Butter and Jelly Sandwich."
- <sup>22</sup> Rachel Carson, *Silent Spring* (Boston: Houghton Mifflin, 1962); Gilbert Franklin Whittemore, "The National Committee on Radiation Protection, 1928-1960: From Professional Guidelines to Government Regulation" (Ph.D., Harvard University, 1987), 505-49; Soraya Boudia, "Global Regulation: Controlling and Accepting Radioactivity Risks," *History & Technology* 23, no. 4 (December 2007): 389-406.
- <sup>23</sup> U.S. Public Health Service, *Report on Environmental Health*; Samuel P. Hays, *Beauty, Health, and Permanence: Environmental Politics in the United States, 1955-1985* (New York: Cambridge University Press, 1987).
- <sup>24</sup> Mark Stoll, "Rachel Carson's *Silent Spring*: A Book that Changed the World," 2012, website, <http://www.environmentandsociety.org/exhibitions/silent-spring/overview>.
- <sup>25</sup> See for example, U.S. Public Health Service, *Report on Environmental Health*; Hays, *Beauty, Health, and Permanence*.
- <sup>26</sup> Richard N. L. Andrews, *Managing the Environment, Managing Ourselves: A History of American Environmental Policy* (New Haven: Yale University Press, 1999).
- <sup>27</sup> Ulrich Beck, *Risk Society: Towards a New Modernity* (London: Sage Publications, 1992).

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<sup>28</sup> Whittemore, “National Committee on Radiation Protection,” 135-217; J. Samuel Walker, *Permissible Dose: A History of Radiation Protection in the Twentieth Century* (Berkeley: University of California Press, 2000); Joseph B. Boland, “The Cold War Legacy of Regulatory Risk Analysis: The Atomic Energy Commission and Radiation Safety,” (Ph.D., University of Oregon, 2002), 496-617.

<sup>29</sup> Whittemore, “National Committee on Radiation Protection,” 322–23.

<sup>30</sup> Sarah A. Vogel, *Is It Safe?: BPA and the Struggle to Define the Safety of Chemicals* (Berkeley: University of California Press, 2013), 34-38; .FAO/WHO Expert Committee on Food Additives, *Evaluation of the Carcinogenic Hazards of Food Additives*, Report of the Joint FAO/WHO Expert Committee on Food Additives (Geneva: World Health Organization, 1961), <http://apps.who.int/iris/handle/10665/40493>.