Introduction

The Greatness and Misery of Science in a Toxic World

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> Most of the necessary knowledge is now available but we do not use it.
> —Rachel Carson, *Silent Spring*

Twenty-five years after the Chernobyl disaster, the Fukushima catastrophe once again brings into sharp focus the risks imposed on all of humanity by certain technologies. An earthquake, followed by a tsunami, triggered a major international crisis, arousing fears of an unprecedented technological disaster. The nuclear explosion ultimately did not take place, and the worst seems to have been avoided. But significant quantities of radioactive material, iodine 131 and caesium 137 in particular, were released into the atmosphere by three of the six reactors that partially melted. Moreover, large quantities of seawater that had served to cool down the reactors were released into the environment. This event highlights a number of problems linked to the dangers of technoscience. It shows that even in one of the richest and safest countries in the world—and one of the most economically and technologically developed ones—in a high-tech sector that mobilizes a large community of experts and is subject to a whole range of very strict international regulations, and in spite of decades of experience, the management of technoscientific risks—particularly environmental contamination by dangerous chemical substances—is still a major scientific, technological, social, and political problem.

Fukushima is a perfect illustration of the observation that underpins this book and that presents itself as a paradox. Throughout the twentieth century, scientific knowledge and expertise were constantly mobilized to develop public policies designed to prevent or manage the effects of toxic substances on health and the environment. Science has thus served as the guarantor of the effectiveness of systems regulating dangerous chemical substances and physical agents. Yet today, in spite of decades of development in research on toxicants, along with the growing role of scientific expertise in public policy making and

the unprecedented rise in the number of national and international institutions dealing with environmental health issues, problems surrounding contaminants and their effects on health are far from being resolved. Indeed, they are often at the heart of new public crises and advocacy movements denouncing the shortcomings or even failure of policies implemented. These problems therefore remain a major issue for Western societies and international institutions. However, while scientific knowledge has not made it possible to truly protect populations, it has retained a key position within all public debates—particularly because it is still essential in the identification and characterization of toxicants as well as in public legitimization of different policies related to toxicant-related issues. Scientific knowledge and techniques thus have played and continue to play a determining role in rendering the toxic world visible and in making the resulting issues public.

This statement calls for a reconsideration of the roles of scientific knowledge and expertise in the definition and management of toxicant-related health issues. That is the aim of this book, which seeks to shed light on the way environmental health problems posed by toxicants have been conceived and governed since the 1940s. The different chapters analyze the historical, social, and political trajectories that have structured and continue to structure the statuses and functions of scientific knowledge in toxicant-related issues, whether in toxicant regulation regimes or in the different advocacy movements surrounding them.

The analysis in this book is founded upon three methodological choices. First, it encompasses various approaches, both in its questions and methods of investigation, stemming from environmental history, science and technology studies, political science, sociology, and the philosophy of law. By drawing on very different yet complementary perspectives, we can highlight a much broader range of mechanisms, which have governed and organized the production and use of scientific knowledge, expertise, and counter-expertise for the management of problems posed by toxicants. Second, together, the contributions in this book cover a sufficiently long period of time to account for the important transformations of the role of knowledge in the regulation of toxicants, as well as for the diversity of ways in which knowledge has been produced and mobilized in toxicant policies since 1945. Third, the proposed analysis considers several spatial scales, namely, local, national, and transnational, with a diversity of case studies covering different geographic areas.

As a result, this book analyzes the official and alternative statuses and uses of scientific knowledge in the social and political handling of the issue of toxicants at different times from the late 1930s until today, at different levels, from the most local level to international institutions. A significant part of the chapters are focused on the United States, as that is where the design, experimentation, and transformations surrounding the ways toxicants have been governed

historically took place, to then spread to the rest of the world. However, that is not to say that we neglected other parts of the world; we selected case studies through which a much broader host of configurations could be addressed. Thus the Italian case, that of a country that industrialized rapidly in the 1960s and 1970s and witnessed a substantial number of major industrial incidents, the best-known one being Seveso, offers a national configuration very different from that of the U.S. case. The presence at the time of a powerful left wing and trade unions that had found original ways of integrating health and environmental concerns also produced forms of mobilization and counter-expertise worth discussing. Finally, we selected Taiwan in Asia, as it offers yet another configuration, insofar as the contaminated sites result from a long history, related to both colonialism and Western industrial relocations, that further complicates both the production of knowledge on contaminations and advocacy. Through these choices, this book thus offers original perspectives and renewed insights into the issues and processes involved in the management of toxicants.

This book is organized into three parts. Each of them explores a particular aspect of the roles of science in the definition and management of toxicant-related health issues. In this Introduction we discuss each of these main themes. First, we present the various changes in the scientific conceptualization of toxicants since the 1940s, and the ways in which these changes have shaped expertise on and the regulation of toxicants and the problems they pose. We thus show how the production of scientific knowledge and expertise on toxicants and their effects evolved alongside the modes of toxicant regulation. In the second part, we examine the production and uses of scientific knowledge in advocacy movements and in the gradual construction of counter-expertise. We analyze the appearance of counter-expertise in the 1970s and describe the different forms it took on, whether stemming from scientific academia, from the work of scientists working for regulatory agencies, or from lay persons involved in advocacy movements. We identify the diverse roles that the different forms of production of scientific knowledge have played and continue to play in social and political movements surrounding toxicant issues. We emphasize the complex, nonmechanistic relations that subsist between advocacy, nonadvocacy, and knowledge—whether extensive or poor—or ignorance about toxicants. In so doing we highlight that while advocacy movements may involve dynamics of production of knowledge, the existence of significant knowledge on contamination does not necessarily ensure the success of movements, nor even the strengthening of movements.

Finally, in the third part, we consider the role of the social sciences and humanities in the production of knowledge about the ways toxicants have been regulated and as resources for action, whether for regulatory systems or as part of advocacy movements. We first turn back to the main frameworks of

analysis that have been developed, such as the propositions formulated by the social sciences and humanities since the end of the 1960s—when they began to consider ways in which toxicant regulatory systems could be improved. We then present a series of current approaches emanating from the social sciences and humanities after decades of toxicant policies and at a time when regulatory systems in Europe, the United States, and international organizations are being reconfigured. The propositions made seek to define the conditions of production and mobilization of knowledge in regulation, so as to develop systems that can deal more effectively with the public health and environmental problems generated by toxicants.

Knowledge, Expertise, and the Transformations in Regulatory Systems

The issues underlying the problems posed by environmental health risks have a long history that has significantly shaped their role in current expert and decision-making communities, as well as in the public sphere. The current ways of managing the environmental health problems posed by toxicants and the roles that scientific and technical knowledge have played in these are the result of an historical accumulation of actions, responses, and institutional configurations and reconfigurations that are rooted in long-term processes about which more needs to be said (Boudia and Jas 2007; Boudia and Jas 2013).

The scientific understanding and study of environmental health problems and the regulatory and public policy systems dealing with them are the product of changes that began back in the nineteenth century and that are closely intertwined with the history of capitalism. Already in the nineteenth century, galloping industrial change profoundly altered the environment, at the cost of chemical pollution, technical accidents, and the poisoning of the bodies of workers, residents, and consumers alike. These multiple effects were not overlooked. They triggered numerous debates and controversies as well as the implementation of a wide range of management mechanisms: expert commissions, especially within academia, court cases, insurance policies, compensation, improvements to technical systems to limit emissions or their effects, the development of sets of regulations to frame the use of toxicants, and new administrations dedicated to the management of potentially dangerous substances (Young 1986; Bernhardt and Massard-Guilbaud 2002; Dessaux 2007; Fressoz 2012; Massard-Guilbaud 2010). Regulation of the activities generating pollution found itself caught up between contradictory logics with, on the one hand, the struggle against visible environmental damage and long-term concerns regarding such damage, and, on the other, the desire to legitimate

sustained industrial growth by states concerned first and foremost with ensuring economic development.

Holding these contradictory logics together has constituted a major issue for the administrations in charge of managing pollutants and the dangers caused by industrial activity. These administrations primarily resorted to science and technology as solutions to hold often contradictory imperatives together: to simultaneously ensure industrial and economic development and manage the concerns and protests that could arise—and to provide forms of health and environmental protection. A doctrine of management of industrial excesses developed in the nineteenth century. It elaborated a logic and rhetoric of intervention that gave scientific knowledge and expertise a central role. Thanks to these, it was possible to regulate the dangers posed by industrial pollutants, by precisely determining danger thresholds and elaborating tools of effective control, management, prevention, remediation, and reparation. As a result, the constant progress of science and technology also allowed for regular improvement of the systems regulating the deleterious effects of industrial activities.

Although laws in this respect were inherited from the early nineteenth century, from 1870 on the implementation of regulatory systems accelerated. This corresponded to a period during which, in general, the state was expanding its ambit and simultaneously changing its methods, notably by developing new administrations in which scientific expertise played an essential part. The last third of the nineteenth century and the early twentieth century was thus a period in which the foundations were laid for many national regulatory systems, namely, with regard to foodstuffs, medicines, professional medicine, toxic substances, and industrial pollution. Science played a crucial role in these changes, in several respects. From the growth of chemical analysis to the rise of the hygienist paradigm, and from the development of toxicology to the increasing normalization and security standards on technological facilities, science and technology, through the knowledge and instruments they produce, contributed to building and ensuring the functioning of systems regulating dangerous activity. But although these regulatory systems became stronger during the interwar period, they failed to prevent sanitary scandals resulting from the development of certain sectors of activity: pollution through industrial accidents and collective poisoning through pesticides, medicines, cosmetics, paintings, foodstuffs, etc. (Kallet and Schlink 1933; Whorton 1974; Sellers 1997). These numerous scandals pointed to regulatory systems' incapacity to prevent the dangers posed by the unfolding Chemical Age. They sometimes brought to light regulatory systems' functioning mechanisms and showed their limits. In most cases the regulatory policies implemented seemed to result from negotiated compromises that were acceptable for industrial actors, not from a desire to encourage the production of scientific expertise on the health and environ-

mental effects of toxicants with the goal of elaborating regulatory measures centered on the protection of public health.

Right at the end of the 1930s, these repeated scandals led to the creation of a movement to amend legislation on toxic substances, which remained active throughout World War II and after it ended. The transformations of regulatory systems that took place between the late 1930s and early 1950s gave an even more explicit role to scientific knowledge and expertise. During this period, the principle of toxicity evaluation prior to issuing a product license, namely, was imposed in a number of countries and for a number of substances (medicine, pesticides, food additives). The aim of these evaluations was to decide whether the substances could be authorized or not, and to set the conditions for their use so that they did not present a danger for public health. The designers and promoters of these new regulations argued that the objective was the complete elimination of "hazards." The Food, Drug, and Cosmetic Act passed by the U.S. Congress in 1938, discussed in the first chapter of this book by Nancy Langston, offers a paradigmatic example of this new approach. Langston shows that this law was based on precaution, but that that was not enough to prevent the dissemination of a substance that is as dangerous as diethylstilbestrol (DES). She analyzes how during the 1940s, three instances of industrial lobbyists' political work achieved the reversal of a decision by the Food and Drug Administration (FDA) that, for precautionary reasons and within the framework of the 1938 Food, Drug, and Cosmetic Act, had demanded that DES be banned.

Among other things, the emblematic case of DES, discussed by Langston, shows that laws on toxicants in the late 1930s, the 1940s, and the 1950s, while theoretically very protective, were not able to deal with the radical change of scale in the problems posed by toxicants from the end of World War II on. First, the numerous biases toward industry did not disappear with these new regulatory systems, and the development of economic activity remained a major concern that justified public health protection systems being virtually systematically bypassed. This was made all the more easy by the rise of potentially dangerous industries like the petrochemistry, synthetic chemistry, and nuclear industries, which stood as emblems of a modernity that promised wealth and a new well-being. These industries developed at such speed that regulatory systems, with far more limited means, could hardly be effective. These industries were socially, economically, and politically far too powerful for public health or environmental protection to have been considered by political authorities as a sufficient reason to restrict their expansion. As a result of the development of these industries, the world witnessed an unprecedented increase in the quantities of chemical substances put into circulation and onto the market, and some of those substances started to be found in the atmosphere, the soil, and water. Although the regulatory systems did rely on scientific expertise,

they did not have the means to carry out in-depth examinations of the numerous new substances brought onto the market (Davis 2001; Ross and Amter 2010; Vogel 2012). In fact, most of them were not evaluated or regulated in any way whatsoever.

This book shows that it is crucial to understand and analyze the changes that took place between the late 1960s and the early 1980s if we are to make sense of the way the regulation of toxicants is structured and functions at present. The most significant change during this period was the unprecedented growth of environmental issues and the long-term inscription of environmental health issues within the different public and professional arenas (Hays 1989; Brooks 2009). At the end of the 1960s, in the wake of the social and political movements of the time, the environment gradually became a major theme of radical criticism. There was a proliferation of environmental health issues making their way onto the political agenda: various types of chemical pollution, air pollution, water contamination, and food contamination were denounced and associated with an unrestrained capitalist economic development.

There was a shift in the way the nature of the issues raised was represented, as evidenced in several chapters of this book. The crisis of the 1970s brought to light the rise of problems whose scale and potential consequences were unprecedented. These new problems were partly defined by the greater scales of space and time within which they existed. Pollution was no longer local but could affect the entire planet. It affected not only health but the entire ecosystem. The consequences were not only immediate; they could be felt decades after exposure or contamination, and over several generations. Due to their unprecedented scale, from the infinitely small to the infinitely big, health and environmental issues raised a host of new questions that experts and institutions had to deal with. Various types of answers were provided. They were both political and administrative, involving regulatory and institutional reconfigurations. At national level, in the United States and certain European countries, this translated into the creation of agencies to manage environmental problems, and/or the reconfiguration of systems regulating toxicants, as symbolized by the creation of the Environmental Protection Agency (EPA) in the United States in 1970 or the development of environmental regulations by the European Economic Community and in European countries from the late 1960s on. At transnational level, new initiatives proliferated. The United Nations Conference on the Human Environment held in Stockholm in 1972, for instance, was organized to discuss the general state of the environment and to identify problems requiring international collaboration. One of the memorable initiatives to come out of this conference was the creation that same year of the United Nations Environment Programme (UNEP).

These different transformations that took place in the late 1960s and early 1970s reflect, and themselves induced, important changes in the role and

place of scientific knowledge in dealing with toxicant issues. In the context of questioning, criticism, and activism, science, along with its actors, products, and methods, came to occupy a central position. The keener attention paid to environmental issues gave a whole new standing to researchers working in the field of environmental health. In the alarms that they sounded these researchers identified the extensive presence of chemical contaminants in the environment as being responsible for the development of new health problems, such as genetic mutations and effects on reproductive problems, which thereby acquired unprecedented public visibility. A large volume of scientific work was produced. After studies on carcinogenesis came those on ecotoxicology and environmental mutagenesis (Frickel 2004). Hence, for a whole host of substances, the lack of greater precautions surrounding their use and regulation in the 1970s could not be explained by uncertainty or a lack of knowledge regarding their pathogenic effects. The absence of significant mitigation of the problems caused by toxicants, following the explosion of knowledge production in the 1970s, began to highlight the fact that, contrary to the public discourse developed for decades, "science alone cannot solve the problems posed by contaminants"—to take Langston's words.

With the proliferation of substances in circulation and the multiplication of denunciations of their effects by activist movements, the screening of dangerous substances and the precise definition of their effects became a core part of the work of researchers, experts, and new institutions in charge of managing contaminants. The U.S. agencies, such as the Environmental Protection Agency and the Food and Drug Administration (FDA), and international organizations like the International Agency for Research on Cancer, created in 1968 under the World Health Organization (WHO), all took on the role of leaders in the field. The multiplication of regulatory and expertise agencies allowed for the growth of research on testing and screening methods. Another feature characterizing the work that developed in the 1970s was the classification of chemical substances' effects. As shown in Angela N.H. Creager's and Jean-Paul Gaudillière's chapters, several research projects and institutional initiatives were dedicated to identifying a relationship between carcinogenicity and mutagenicity or reproductive effects.

Creager's chapter evidences the rise of research focusing on the screening and characterization of chemical substances' toxicity during the 1970s, an explosion that has so far been studied very little. Creager studies the evolution of the work of biochemist Bruce Ames to show the importance given to the development of dangerousness tests, both by industrial actors and by regulatory agencies and environmentalists. In 1973, Ames devised a test to determine the carcinogenicity of chemical substances, which generated strong interest given the possibility of applying it to a host of chemical substances on the market. The test stirred real enthusiasm among environmentalist groups and was rapidly

adopted by industrial actors due to its simplicity and the lower costs involved compared to animal testing. It was based on the assumption that any carcinogen was a mutagen, and that a microorganism was an adequate model for testing mutagenicity as it can develop in human cells. Since the 1970s, the nature and results of this type of test—those by Ames and many others that have been put forward over the years—have played and still do play a crucial role in the definition of regulatory systems. They generate stormy controversies among scientific experts, which are visible to varying degrees in the public sphere. The movement that developed in the 1970s around the Ames test is currently at the heart of proposals to overhaul and elaborate a "new toxicology," formalized in a 2007 report by the U.S. National Research Council (NRC), and seeks to ensure that regulatory toxicology no longer relies essentially on animal testing, but on in vitro tests and computer modeling.

Research on the relationship between carcinogenic effects and toxic effects on reproduction is addressed in Gaudillière's chapter. Since both look at the DES case, comparing Langston's and Gaudillière's contributions sheds light on the nature of the transformations that took place between the 1950s and the 1970s. Gaudillière analyzes the multiple transformations, both legal and scientific, that took place throughout the American court cases on DES in the 1970s. He shows how the confrontation of experts over the course of the court cases led to the production of new knowledge on toxicants. Although this chapter contributes to highlighting an important phenomenon of the transformations that took place starting in the 1970s and that is analyzed in detail in the second part of this book, that of the diversification of the sources and places of production of knowledge on toxicants with the rise of counter-expertise, it also contributes to another very important aspect. It allows us to grasp the crucial issue of the categorization of dangerous substances in regulatory systems. While in the 1950s carcinogenic substances motivated continued investigation and classification work, in the 1970s two other categories of particularly hazardous substances were formalized: mutagens and reproductive toxicants. Later on the CMR category (Carcinogens, Mutagens, Reproductive Toxicants) was developed with a view to adopting a more holistic approach to effects, to establishing links between them, and to classifying chemical substances according to their effects. This classification comprised the substances considered to be the most dangerous, in terms of both their effects and their capacity to have a delayed effect in low doses. It has formed the basis for the development of systems of regulation of toxicants since the 1970s and, in modified versions, is still highly influential in current regulatory systems. Gaudillière's account shows how during a court case, through the confrontation of experts, some of the characteristics of DES which did not fit in with the then prevailing conceptions of toxicants' effects were highlighted. The deleterious effects of DES could be more significant in low doses than in

higher doses, and the timing of exposure could play a crucial role in the type of effects obtained. Gaudillière ultimately shows how instrumental the DES case was in the early 1990s, as during the Wingspread Conference (1991) scientists linked to U.S. health and environmental activism formulated the endocrine disruptors (EDs) hypothesis, and with it a new category of highly hazardous chemicals. Activists currently use EDs characteristics to call for the overhaul of the CMR classification system and for regulatory systems implemented in the 1970s to be scrapped. They consider these both out of date and incapable of protecting populations from the deleterious effects of what they see as the "new toxic substances" (Krimsky 2000; Vogel 2012).

As well as the transformations in the scale of the problems and in the way toxicants were conceptualized and categorized, this book highlights another type of change in the 1970s. It pertains to the ways in which public policies on contaminants are managed and legitimated, as analyzed by Soraya Boudia in this book. Her chapter shows that the growth of work and the accumulation of data on contaminants and their effects led to the challenging of the threshold paradigm that had structured the perception as well as the regulation of toxicants since the end of the nineteenth century. To fully grasp these changes, it is useful to remember that environmental health problems were approached essentially through the dogma of toxicology, which holds that "the dose makes the poison," in other words, that for each toxicant it is possible to determine a threshold below which no deleterious effect is observed, or below which risks are perfectly negligible. Until the 1970s, all regulations on toxicants were based, officially at least, on this dogma. This meant that from the 1940s on, threshold values were increasingly used, with denominations specific to each domain and the creation of a host of labels, such as tolerable dosage, permissible dosage, Maximum Allowed Concentration (MAC), or Acceptable Daily Intake (ADI). These threshold values made it possible to use substances without their having—at least in theory—too significant or irreversible an effect on health. Nevertheless, from the early 1970s on, suspicion began to grow regarding this approach, through discussions on the effects of low doses of radioactivity and many carcinogens. The accumulation of results concerning the effects of exposure to carcinogens in the workplace or in the environment, along with a number of experimental studies, tended to show that, for numerous substances, nothing permitted the definition of a threshold below which no deleterious effects could be observed.

The question of low doses was a major political issue. It cast doubt on a host of activities that until then had been considered safe or seen as presenting negligible risks. Raising this issue amounted to claiming that innovations could have negative sanitary and environmental effects not only in exceptional situations like accidents, but also in "ordinary" situations, in their normal use. This was inherently a critique of various scientific and industrial domains: without

generating major threats, they contributed to spreading in the air, water, and ground proportions of toxicants considered negligible. The issue of exposure to low doses undermined regulatory systems, for which defining thresholds and threshold values was a major activity. The recognition of the potential problem of exposure to low doses of pollutants de facto generated a contradiction in the practices of regulatory systems. On the one hand, this meant admitting that there is no threshold below which one can assert the innocuousness of a substance; on the other, setting threshold values remained central to regulatory systems (Bächi 2010).

As a result, starting in the 1960s the discourses legitimating regulatory policies began to change noticeably (Jasanoff 1990). To overcome the contradictions generated by the issue of low doses, the procedures used to determine these threshold values were increasingly presented as seeking not to guarantee the absolute innocuousness of the use of certain substances under certain conditions, but to establish "socially acceptable" levels of risk. It was thereby recognized that exposure norms did not result from a scientific decision only, but incorporated economic and political considerations as well. The institutional changes in the 1980s and 1990s fully took into account this new dimension, which was expressed in the desire to separate the "assessment" of substances from their "management." This was formalized in the NRC's Red Book on risk management published in 1983, as Boudia points out in her chapter of this book. The separation between "assessment" and "management" subsequently became widespread; it was adopted in both national and transnational regulatory institutions. A paradoxical situation was thereby officialized in the second half of the twentieth century, in which the way toxicants are governed is still rooted. Regulatory systems recognize that standards of exposure, and more generally, the regulation of toxicants, result from scientific as well as economic and political processes. Yet at the same time, expertise and scientific knowledge are still publicly referred to in order to legitimate decisions on toxicants and their effects.

Activism and Nonactivism: Alternative Uses of Knowledge

The rise of environmental concerns, the unprecedented accumulation of scientific work on the effects of toxicants, and the multiplication of regulatory systems as sophisticated as the ones implemented in the 1970s have not led to the disappearance or significant decline of contaminants' impact on health and the environment. On the contrary, the number and quantities of toxic or potentially toxic chemical substances disseminated since the 1950s has continued to increase, resulting in a proliferation of contaminated sites and the growth of a broad range of deleterious effects on an unprecedented scale.

The lived experience of this materiality, be it in terms of environmental degradation or damage to human health, has played a large part in the transformation of social movements surrounding the issue of toxicants and their effects since World War II. Like environmental health problems, these movements are the outcome of a long history. Industrial pollution and its effects on human health, forests, agriculture, and animal husbandry generated multiple forms of protest throughout the nineteenth century and between the two world wars, ranging from trade union movements to court cases initiated by locals, or press campaigns. In the United States in the 1930s, in the middle of an economic crisis and following numerous scandals triggered by collective toxic contamination, the chemical industry was even accused by the first consumer movements, using a highly successful book, *100,000,000 Guinea Pigs* (Kallet and Schlink 1933). From the mid 1950s on, the idea that human beings had contributed to making their environment toxic consistently gained currency. Following the wave of controversies on the effects of radioactivity, chemical pollution—particularly that linked to pesticides—became a widely debated issue. These concerns originated from certain professional circles, particularly those of cancer specialists, but also from the everyday experiences of the middle classes settling in rapidly expanding suburbs, close to fields where pesticides were used on a large scale. During the 1960s, scientific and civil society actors in the large movements of the time fully embraced the issues underpinning environmental health. The publication in 1962 of *Silent Spring,* which soon became a best seller worldwide, by a marine biologist, Rachel Carson, effectively marked the beginning of a movement that gained importance in the second half of the 1960s (Carson 1962).

The environmentalism that developed from the late 1970s highlighted a number of new questions being raised regarding the place of human beings in the biosphere, the depletion of natural resources, and environmental pollution and its immediate and long-term effect on humankind. These themes were recurrent in a number of actions and movements, led by figures such as Ralph Nader. Health was a pivotal and even structuring dimension of their interventions and a recurrent feature of activism at the time. This movement was supported by activist organizations that later became important, such as the American Environmental Defense Fund, created in 1967 to support anti-DDT movements (Dunlap 1983). These activist organizations did not spring up only in the United States. The numerous preparatory conferences between 1969 and 1972 leading up to the United Nations Conference on the Human Environment held in Stockholm in June 1972 also show the existence of this type of activism in countries of northern Europe. During the 1970s and 1980s, local and national organizations expanded their activities outside their territories of origin, as in the case of Friends of the Earth created by David Brower in the United States, which spread to 76 countries, or Greenpeace, founded in Vancouver, Canada, in 1971 by a small group of anti-nuclear activists.

The growth of these large activist organizations in the 1970s and 1980s went hand in hand with the rise of other types of organizations for which issues of environmental contamination were a major concern. Older organizations that previously focused on nature conservation reoriented their activities. In North America at least, movements for women's health engaged with the issue of the effects of toxic substances on health, initially with the question of synthetic hormones. Local victims' associations were created in long-term struggles against industrial actors responsible for the contamination of certain sites (Brown and Mikkelsen 1990; Kroll-Smith et al. 2000; Allen 2003; Brown 2007). Certain scientists involved in the production of official expertise, outraged by certain practices, founded independent research and expertise institutions, as in the case of the toxicologists and epidemiologists who founded the Italian Foundation, the Instituto Ramazzini. With a view to forming alliances, pooling their resources and increasing their capacity for action, some national organizations also federated and developed large transnational networks. Thus, over the last four decades, extremely complex webs of activist organizations have formed, including small and large organizations wielding varying degrees of power, with varied and sometimes contradictory objectives. All agree, however, on the existence of unacceptable threats to health and the environment caused by the uncontrolled excesses of the chemical era (Pellow 2007).

Scientific knowledge has played a growing role in the actions of the different advocacy movements (Ottinger and Cohen 2011). With industrial actors and political and administrative authorities denying the existence of problems related to toxicants, it became necessary to provide scientific proof of the existence of dangerous effects and to assess the extent of environmental pollution. Alternative production of scientific knowledge and counter-expertise therefore began to grow in the second half of the 1960s. The aim of such production was and still is not only to prove the existence of contaminations and deleterious effects, but also to reveal them and make them visible. It was expected that this would trigger or strengthen mobilization, thus prompting industrial actors and government authorities to deal with the problems at hand. This alternative production of scientific knowledge and counter-expertise unfolded in three interdependent processes.

The first was the involvement of established scientists—some of whom were renowned—in environmental causes in the name of science. Based on the results of research that they or others had carried out, several scientists became whistle-blowers. They decided to make facts and concerns public and to call for the implementation of prevention and remediation policies. During the 1960s and especially the 1970s, the number of renowned and less-known scientists adopting this kind of attitude multiplied. Apart from emblematic figures such as Rachel Carson (Lear 1997) or Barry Commoner (Egan 2007), many scientists, presented in a number of chapters in this book, embraced the issue of the effects of toxicants. The generalized contamination of the environment, the

fauna, and human beings by PCBs (Polychlorinated Biphenyls) was revealed for instance through the relentless work of a Swedish researcher, Soren Jensen, between 1966 and 1968. His work was rapidly circulated within international arenas and contributed to launching an important movement, particularly in the United States, to reveal numerous contaminations from these substances. Despite massive lobbying by the company producing them, Monsanto, and those that used them, such as General Electric (McGurty 2009), this movement achieved a total ban on PCBs in 1979 in the United States, and in the mid 1980s in most European countries—but the ban did not resolve the problems caused by these very persistent substances.

This unprecedented involvement of scientists, whether they were well-known or not, was accompanied by a move toward the redefinition or even the creation of new disciplines to address the wide range of questions raised by the breadth and complexity of contaminations. From the 1970s, the rise of new fields such as "chemical mutagenesis," "environmental hormones," and ecotoxicology reflected the desire to articulate the promotion of new research subjects and approaches not yet recognized in the academic world, with the need to bring to light and study the problems generated by the massive circulation of potentially toxic chemical substances. This involvement motivated by professional concerns may have been complemented by a more political type of involvement. Laura Conti's scientific work in Italy in the 1970s, discussed in Stefania Barca's chapter in this book, is a particularly interesting illustration of the different types of scientific and political activism. A doctor by training and a communist, Conti developed a form of environmentalism that placed toxicants and human beings at its center. This environmentalism insisted on the multiple and complex relationships between the living and the nonliving, and showed the irreversible effects of the constant release of petrochemical waste into nature, which could not be controlled by simply resorting to thresholds on toxic concentration. Conti's scientific work was therefore nurtured by her political commitment, just as her political involvement was deeply influenced by her scientific work.

Other forms of knowledge production emerged in addition to the production of new knowledge on toxicants by academic researchers or researchers working for activist movements. Local action surrounding contaminated sites, studied in this book by Paul Jobin and Yu-Hwei Tseng as well as by Barbara L. Allen, increased exponentially starting in the second half of the 1960s, first in the United States and then in other parts of the world. The administrative and legal proceedings that took place as part of these mobilizations, providing scientific evidence of contaminations and their deleterious effects, proved to be a significant factor of success. Calling on academic researchers—even specialists able to demonstrate the existence of deleterious effects—has not always proved easy or effective. Some scientists, such as the Taiwanese epidemiologist Lee

Ching-Chang, described by Jobin and Tseung, refused to reveal their results beyond narrow academic circles. Others, such as the epidemiologist Patricia Williams, a chemical contamination specialist discussed by Allen, were first and foremost concerned with conforming to the scientism criteria of their professional community. Yet the time frame of academic research that eliminates any possible bias and the time frame of protest mobilization do not always coincide, and results can be made available too late to support the cause of activists. Moreover, the expectations inherent in academic research do not always correspond to activists' expectations, as each world has its own motivations.

Due to the inappropriateness or shortcomings of academic research in producing sufficiently conclusive scientific evidence, activist or victims' groups began developing other types of knowledge production, sometimes turning to actors other than established academic researchers. The victims themselves, relatives, and doctors or scientists who were not too concerned about their careers were able to organize themselves, identify patients, and gather data on exposure to finally show correlations between local exposure and the abnormal increase of certain serious pathologies. Patients' organizations and the cartographic work carried out at many contaminated sites gave rise in the 1980s to what Phil Brown calls popular epidemiology (Brown 2007). This is based on the elaboration and implementation of techniques that differed from those used by government authorities and regulatory bodies. It has allowed scientists allegedly less specialized in a certain subject, doctors without a research activity, retired engineers, laborers, office workers, mothers, etc., not only to produce data, but also to become experts on certain health and environmental problems. In this perspective, Allen discusses the case of Gabriele Bortollozzo, a worker from 1956 to 1990 at the highly contaminated site of Montedison in Italy, while Jobin and Tseng consider that of former workers from the Taiwanese factories of Radio Corporation of America. Both cases are highly representative of this bottom-up knowledge production by the victims themselves or their relatives—with the support, over time and depending on the locations, of activist organizations and committed scientists.

From the early 1990s and with varying time frames in different countries, a third form of change occurred through which the development of counter-expertise within local movements and national and transnational organizations, by scientists and nonscientists, took on a new dimension. From the early 1980s, the supposedly profound transformation of systems regulating toxicants that took place at national and international level during the 1970s following environmentalist activism proved to have been a failure. During the 1990s, the multiplication of highly visible issues and scandals surrounding the deleterious effects of technoscience stressed the fact that science was not in a position to provide clear answers and precise information on the dangers incurred. Yet in situations of uncertainty, decisions concerning the regula-

tion of technoscientific practices had been taken behind closed doors by small groups of experts. Strong mobilization, defiance of certain innovations, and the discrediting of certain administrative and statal systems led policy makers to develop new modes of government, underpinned by new systems under the banners of "participation" and "transparency" (Pestre 2008). In this new context, activist organizations and committed scientists were encouraged to participate as "stakeholders," or even as experts on certain committees in order to represent "citizens'" point of view. While the shortcomings of participatory systems had become fully visible by the late 2000s (Irwin 2006; Pestre 2008), the presence of civil society representatives and alternative scientists as "experts" or "stakeholders" in current official expertise processes seems to be a given in many national and international contexts. This is closely monitored and activist organizations' representatives have a say in decision making, or have means similar to those of other interest groups—particularly industrial lobbies. But, apart from the context of the 1990s, which opened a window of opportunity for counter-expertise to get closer to official expertise processes, what made activist organizations legitimate experts within these committees was their grasp of the cases and scientific competences that they had developed in various ways, over the previous two or three decades.

While the resulting production of alternative knowledge in various contexts played a significant part in shaping the development of movements around toxicants over the last four decades, many difficulties were encountered. Providing evidence that meets scientism criteria of damage or potential damage, even serious damage, has often not been enough to obtain the compensation, remediation, or prevention demanded by activist movements or victims' organizations. The chapters in this book offer more nuanced positions regarding the role of scientific knowledge and counter-expertise in mobilizations surrounding problems related to toxicants. Numerous cases show that balancing health-related and environmental risks with the disappearance of economic activities that are essential to certain regions presents an important dilemma that even the production of irrefutable scientific knowledge cannot resolve (Auyero and Swistun 2009). In other situations, legal and administrative systems function in such a way that the production of knowledge on contaminations is far from sufficient to produce a decision in the victims' favor, or the decision provides far less than the victims had expected. Laura Centemeri's analysis of the inhabitants of the Seveso site that was contaminated by dioxins following a major industrial accident in 1976 highlights how knowledge is not sufficient motivation for taking a stand. Even though this site attracted much attention in the study of the effects of dioxins on human health, and the research results tended to show the extent of the damage caused, these data did not spur the inhabitants of this Seveso region into action. Centemeri identifies many factors to explain this paradox, including the inhabitants' attachment to

the territory in which they live and their refusal to see it stigmatized by activists and scientists highlighting major pollution. The overall context made it impossible for the necessary alliances to form in Seveso to mobilize the most affected people. Thus, certain movements have failed in spite of undeniable proof of the contaminations and their effects, while others that rested on far more tenuous and debatable causality links have succeeded. This points to the fact that the success of activist movements is contingent upon their capacity to build effective alliances and apply political pressure. From this perspective, alternative scientific knowledge and counter-expertise are indeed essential but certainly not sufficient; sometimes they are not even indispensable to the success of a social movement against toxicants.

Ultimately, the important movements that have developed since the 1960s have certainly not managed to reverse the trend that began in the late eighteenth and early nineteenth centuries, which saw Western societies choosing a capitalist model of development relying on ever-increasing industrialization at the expense of the environment and human health. At the local level, however, they have managed to win trials, to prevent the creation of a rubbish dump or a waste management center, to close a factory, to clean up contaminated sites, or to compensate victims. At national and international level, they have obtained lower standards of exposure, bans on polluting substances and technologies, amendments of laws, and overhauls of regulatory systems. They have even managed to highlight unanticipated toxic effects and to introduce new issues within scientific and public arenas. The alternative production of scientific knowledge and expertise may have been essential to these achievements, but it has never been the only determining factor. The effective use of this production was possible only because it was embedded within political strategies that, for various reasons, have allowed "subrogate interests" to, at least temporarily, override "dominant interests" (Bosso 1990).

Putting Knowledge, Ignorance, and Regulation into Perspective

The multiple health and environmental problems posed by toxicants are not behind us—far from it. The number of chemical substances in circulation continues to grow. To the toxic legacy of banned or regulated substances like DTT and PCBs as well as the many unregulated ones, new substances whose effects are still relatively unknown, such as nanocarbons, are being added. Faced with this situation, many actors are currently calling for a profound reform of expertise systems and modes of regulation surrounding toxicants. Many social scientists, without all sharing the same point of view, are directing severe criticism toward existing expertise and regulatory systems, some adding their voices to different nongovernmental organizations to demand an overhaul of

these systems. This attitude is not new. Since the 1970s, when many social movements highlighted the significance and the extent of contaminations that existed since the end of World War II, certain fields within the humanities and social sciences, namely, law, sociology, political science, history, anthropology, and psychology, have taken an interest in the functioning of scientific expertise and systems regulating toxicants and the technosciences and, since then, have been offering different types of analyses that have sometimes led to normative positions proposing given types of change.

Certain cross-country comparative studies have sought to bring to light the social, institutional, and cultural factors explaining the nature of the expertise produced and the way regulatory systems are organized (Brickman et al. 1985; Vogel 1986). In doing so their aim has been to define norms and strategies to improve the functioning of these systems. Extensive work in the humanities and social sciences has called for greater transparency in the procedures underpinning scientific expertise and decision making. One of the concepts that has stemmed from this work and has been taken up in the different public policies is "sound science." Such analyses, produced mainly in the 1980s, were based on the more or less explicit assumption that science is able to effectively inform public decision making, provided that systems of expertise offer experts the means to draw on "state-of-the-art science" and to make the different points of view public.

Starting in the 1980s this approach was heavily criticized by other researchers whose work insisted on two interdependent issues. First, there are many moments of significant scientific uncertainty in processes of expertise, for which no "sound science" is available. Second, drawing on several case studies, these researchers stressed that in these situations of uncertainty, experts tend to make decisions that are rather in favor of industrial actors, at the expense of consumers, citizens, or patients (Hood and Rothstein 2001; Abraham and Reed 2002). In other words, a bias in favor of industrial actors and economic imperatives exists in expertise and regulatory systems. These authors argued that reforms of systems of expertise were needed, not to guarantee the use of a "sound science," which did not necessarily exist, but to reduce the bias in favor of industrial actors and to ensure that the interests of consumers, citizens, and patients are taken into account.

Work stemming from a different perspective has also sought to promote lay or alternative knowledge as opposed to expert knowledge. It emphasizes that "lay people" have knowledge, interests, and concerns other than those of "scientific experts" regarding important issues about technoscience and its sanitary, environmental, and social impacts (Irwin and Wynne 1996; Wynne 1996; Pestre 2008). Their knowledge, interests, and concerns are no less valid; they stem from different perspectives that deserve to be taken into account in the production of expertise and in public policy making. If science, especially

in situations of uncertainty, is not able to provide sure answers to the problems raised by technoscience, then it is important for public decision making to rely not only on expert claims, but to fully integrate the knowledge, concerns, and interests of "lay people." To promote a more democratic management of technoscience and the problems it poses, these researchers have often been involved in the development of participatory procedures encouraging the growth of counter-expertise and its integration into regulatory systems.

These various sets of works have gradually shown the limits of scientific knowledge in resolving the issues raised by toxicants and the often political nature of decisions regarding these substances. These two features have been emphasized in four types of work. First, certain studies, namely, in environmental history or the history of environmental health, have emphasized the materiality of the problems of environmental degradation and pathologies (Markowitz and Rosner 2002; Blum 2008). In doing so, they have highlighted the numerous instances of reductionism and downplaying in official expertise. Indeed, a deep rift exists between the materiality of damage and the existence of exposure norms, between the reality of chemical cocktails to which certain populations are exposed and substance-based approaches, between the years of illness, the individual, family or collective tragedies, and the slow pace of court cases and regulatory processes, and between situations of potential or immediate danger and the time needed to validate scientific knowledge. These studies have also shown how different social movements—economic and/or political interest groups—have sought to mend or maintain this rift, triggering numerous confrontations. A second type of work in the fields of law and political science has paid attention the construction of systems to regulate toxicants as a whole (Bosso 1990; Cranor 1997). By showing both the complexity of these systems and the extent to which they are shaped by political choices, this type of work has helped bring to light how little weight science and expertise may have in decision making—even though more often than not these systems claim to be "science-based." Such work, which often has normative objectives, has contributed to many analyses since the 1970s, analyses that have a view to inventing other, more effective, regulatory systems and that have also involved rethinking the place and role of science and expertise in systems of expertise. A third type of work, stemming from sociology and political science, stresses the impossibility of building consensus and public policies based on scientific knowledge alone. These works consider that in most risk situations, technical uncertainty is too great for robust social consensus to be built. They therefore call for new modes of discussion, decision making, and policy making to be imagined and implemented, based on the aim of building consensus between the different actors concerned. These works, looking at consensus conferences, participatory democracy, or hybrid forums, have been very successful with policy makers, namely, in Europe (Callon, Lascoumes, and Barthe 2009).

Many sociologists and political scientists thus play an important role in advising and defining regulatory policies. Developing compromise among different actors is central to this literature, which praises the many benefits of participatory systems, including overcoming profound social asymmetries through debate. A fourth and last type of work, "environmental justice studies," is particularly developed in the United States. Openly contributing to research for action, it seeks to highlight that the burden of toxic contamination is primarily borne by certain social groups that are particularly poor and discriminated against: black minorities, Mexican migrant workers, "native" populations. In so doing, this type of work associates social inequality—based on race, class, gender—with greater toxic contaminations, and the struggle against these contaminations is presented as a source of empowerment and as attempting to implement a failing social justice. To do so, it seeks to identify the most effective advocacy strategies and ensure the success of movements. In this context, particular attention is paid to the production of knowledge, whether that production is academic, stems from regulatory systems, or comes from grassroots movements ("street science"). One of the important objectives is to counter efforts that official systems may pursue to make contaminations and their effects invisible and to identify ways of transforming these systems so that they may contribute to making toxicants and their consequences more visible.

Thus for several decades now, the humanities and social sciences have not been working from an exclusively analytical perspective, but one that is also normative and aiming at transforming regulatory and expertise systems surrounding toxicants. Following several reconfigurations and attempts at transforming these systems, certain analysts are currently shifting their positions, sometimes significantly, from what their colleagues or they themselves may have proposed in the past. Carl F. Cranor's chapter offers a perfect illustration of this shift. From a philosophy of law perspective, Cranor has contributed to a lot of reflection on the use of scientific evidence in legal decisions and how society might approach the regulation of toxicants. Through his chapter in this book, Cranor's approach clearly seeks to influence public decision making in the context of the current U.S. reform of the Toxic Substances Control Act (TSCA). He tries to explore not what science is unable to know or do, but what law and regulatory systems have been or are unable to achieve. More importantly, Cranor looks at science and what it is able to show, to emphasize the ineffectiveness of law and to shed light on how inhabitants of the United States are "legally poisoned." Cranor's work shows the shift of position that some of its representatives have made. While the objective of these studies is always to think about and propose a legal framework and regulatory system with the aim of protecting human health and the environment, an explicitly activist dimension is emphasized.

The idea that the strengthening of expertise and regulatory systems does lead to greater protection can be questioned from several perspectives. One of these could point, as researchers studying the tobacco industry have done,

to the importance of the economic interests at stake, and to the significant political and public work that contributes to invisibilizing or minimizing the ensuing problems. Several strategies have been studied from this perspective, from lobbying to instilling public doubt. The weight of economic interests is of course a crucial parameter in issues of expertise and regulation. And this weight is what leads certain actors to call for greater regulation. However, more regulation does not necessarily mean that toxicant problems will be resolved. The major problem is a systemic one, which lies in the very functioning of these systems. Through the long-term analysis offered in this book on the role of science in expertise and regulation, one aspect stands out: despite the immensity of the activity they have generated, these systems have not allowed for the production and accumulation of real knowledge on toxic substances, as, on the contrary, through their very functioning they have contributed to producing and disseminating ignorance. Producing ignorance does not just involve hiding certain knowledge, ignoring certain questions, minimizing certain effects, or deliberately producing public uncertainty (Proctor 1995; Oreskes and Conway 2010), even when knowledge is available to form a verdict. It is another type of production of ignorance that some of the authors of this book are concerned with. In their chapter, Scott Frickel and Michelle Edwards, through a detailed analysis of the risk assessment process for soil contamination in New Orleans after Hurricane Katrina, reflect on expertise in terms of its ability to produce not knowledge but ignorance. They also show that this ignorance then circulates and not only forms the basis of certain political decisions but is also integrated into other types of expertise. The two authors thus offer a new perspective on expertise and regulatory systems that invalidates the idea of an optimization of knowledge production in current settings. The significance of this perspective reversal is twofold. First, it is embedded in and contributes to an important theoretical shift in science studies, known as the New Political Sociology of Science, to which Frickel is an active contributor and which seeks to reposition the political at the heart of the analyses produced by science studies (Frickel and Moore 2005). Second, this reversal allows for new perspectives to shed light on processes that have not been noticed or studied much until now, and through which science-based regulatory systems are not able to protect public health and the environment.

This book therefore points toward a conclusion with important consequences: not so much a call to strengthen expertise and regulation but a call to profoundly overhaul the world of knowledge production in these systems. For such an overhaul to take place, particular attention should be placed on a careful and multidisciplinary examination of the instruments and modes of production of knowledge and rules. Yet this does not mean that scientific knowledge should form the core basis of decision making. This raises the question of knowing what should be at the heart of these systems. This book explores several possibilities that seek to subvert the very logic of these sys-

tems. Thus Sheldon Krimsky's chapter suggests the importance of working in a precautionary framework. The chapter's starting point is the study of scientific production through an analysis of the way the effects of low doses of endocrine disruptors are scientifically studied. He identifies many factors, ranging from the complexity of the issue to the actions of industrial actors, which cause a number of questions to remain without a stable answer. While the argument that science's incapacity to produce the expected knowledge has already been widely discussed, Krimsky's analysis makes two different contributions. First, as other works have done, this study shows the value of delving into the production of scientific knowledge and analyzing both the potential and the limits of such production. Second, this analysis leads to a valuable consideration, both in heuristic and political terms: if science is not able to provide the expected answers, how can we make sense of its role and of the constant rise of "science-based" regulatory systems? Krimsky's answer is unequivocal: if science cannot provide all the answers expected from it, then it should no longer be the only central frame of reference of regulatory systems; these systems must also rely on other approaches. The shift he calls for is one that grants less importance to scientific knowledge and expertise and more to other approaches, such as precaution. It is central to a current broader movement involving both scholars and activists.

What thus becomes apparent is that reinforcing expertise and regulation, without calling for a profound overhaul of all the foundations of expertise, is necessarily bound to fail. However, it is no easy task to simply enumerate what should be done. This is the difficult exercise Jody A. Roberts tackles in his chapter. His contribution is an analysis of what could be an effective regulation of the chemicals that he qualifies as "unruly technologies." Roberts first looks back on half a century of chemical regulation and reviews the reasons why these regulations never really worked. From the materiality of chemicals that never behave as anticipated, to the practices of industrial actors, through the limits of science and technology: a host of combined factors has ultimately led to the recurrent failure of regulatory systems. Roberts then discusses what could be an effective regulation of chemicals: for him, the answer lies in the diversity and multiplication of approaches. He thus explores solutions such as encouraging economical consumption, substituting, and developing green chemistry, while also recognizing their limits. Like all the other authors in this section, Roberts insists on the need to shift the center of gravity of regulatory systems. He suggests placing justice, not science, at the heart of regulatory systems as a means of guaranteeing their effectiveness in terms of health and environmental protection. In doing so he draws on and points to the value of work studying environmental justice movements. As well as opening this new perspective, Roberts's contribution reminds us just how important it is to integrate a historical dimension into any reflection on the future of the regulation of toxicants.

By showing that expertise within current regulatory frameworks rests more on ignorance than on knowledge, by offering to place precaution and social and environmental justice at the heart of policies on the management of toxicants, these chapters both reject the centrality publicly granted to science in regulatory systems and call for a reconsideration of the past and current implications of upholding this centrality. This type of approach does not discredit science in any way. On the contrary, it seeks to give it its rightful place in our societies. Above all, it seeks to remind us that while the toxicants and environmental contaminations that a society produces do constitute scientific and environmental issues, they are first and foremost political issues, involving economic and societal choices.

Conclusion

The problems caused by environmental contaminations and their effects on health are currently a major concern for many actors: scientists, activist organizations, policy makers, regulatory agencies, and industrial actors. They all stress how important these questions have become for research as much as for public policy and for the way industrial activity is performed. Reforms and new public policies like Registration, Evaluation, Authorisation and Restriction of Chemical substance (REACH) in Europe, the TSCA in the United States, or the creation of a Global Chemicals Regime, as well as industrial actors' growing references to sustainable and responsible development and to ethics, all provide an indication of unprecedented awareness and a collective desire to finally break away from past practices (Sachs 2009; Selin 2010). However, analysis of the production and use of scientific knowledge in the regulation of toxic issues as well as in advocacy movements paint a much more contrasted picture, which departs from the sometimes naive optimism demonstrated by certain social scientists. On the contrary, they call for a review and in-depth examination of past and current policies and movements and of their contributions and impasses.

The conclusion reached in this book is very dire: while science plays a determining role in defining dangerous health and environmental effects and making them visible, and while it has sometimes provided resources for advocacy movements and contributed to the adoption of new regulatory systems offering greater protection, it has also largely contributed to developing situations of invisibilization and accommodation. It has done so by conferring upon these the seal of objectivity, by producing and putting forward certain results at the expense of others and by giving the policies adopted the air of choice when in fact renouncement was primarily at stake. As result, science contributes to the development of regulatory systems producing and spreading ignorance and scientizing and legitimizing public policies that naturalized

the asymmetries between those affected by the contaminations and those benefiting from them—whether financially or in terms of comfort of living.

This conclusion does not discredit science in any way. On the contrary, it seeks to give it its rightful place in our societies. Above all, it seeks to remind us that while the toxicants and environmental contaminations that a society produces do constitute scientific issues, they are first and foremost political issues, involving economic and societal choices. The new wave of regulatory reforms currently taking place makes this observation all the more important. These reforms—from REACH in Europe to the reform of TSCA in the United States—are taking place during a period of intensification of a global economic crisis, which can only make the economic dimension of the governance regarding toxic issues more significant—a dimension that played a structuring role throughout the twentieth century. Just like the climate change policies that led the way, health-environmental policies must also deal with dilemmas that are difficult to resolve. In a society where asymmetries of power and of situations are strong and play a structuring role, science is also caught up in these asymmetries it is not able to overcome—and which in many cases render it powerless. However, recognizing these difficulties, attempting to identify and enumerate them, does not mean refraining from criticizing the choices made, and certainly not giving up on the long-term transformation of a society slowly poisoning itself.

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