1 Mercury Elementary

People have developed increasingly modern societies in their efforts to improve standards of living. At the same time, they have modified the environment in ways that pose challenges for maintaining and advancing human well-being, today and in the future. In this book, we focus on how people attempt to provide better lives for themselves and their descendants on a finite planet. We draw insights from human interactions with mercury to illustrate how people have made beneficial use of this unique element, how they have been harmed by its toxic properties, and how they have taken actions to protect human health and the environment from its impacts. Analyzing the mercury issue offers an opportunity to trace a millennial-scale history of human interactions with an element whose use has both benefited and harmed human well-being in complex and interacting ways. We develop and apply an analytical framework throughout this book—using the perspective of a human-technical-environmental system—to learn from the long history of human mercury use and exposure, and to inform strategies by which people can effect change toward greater sustainability.

On a sweltering Wednesday afternoon in early October 2013, hundreds of representatives of countries, intergovernmental organizations, and civil society groups from around the world filed into a crowded auditorium in Minamata, Japan, to hear Rimiko Yoshinaga tell a profoundly personal story about the human toll of mercury pollution. She related how fishers and their family members living in small hamlets around Minamata began to suffer devastating health consequences more than half a century ago after a local chemical company, the Chisso Corporation, discharged methylmercury, a particularly toxic form of mercury, into Minamata Bay. Their illness, discovered in the 1950s, resulted from methylmercury exposure, which causes permanent and sometimes fatal damage to the brain and central nervous system, and is now known the world over as Minamata disease.

Rimiko Yoshinaga is one of the storytellers affiliated with the Minamata Disease Municipal Museum, which is dedicated to informing visitors about the disease and its enduring legacy. A quiet and respectful hush quickly descended on the auditorium on that October day as she began to describe her childhood in Minamata and the mysterious illness that began to affect her father, and two years later led to his death, as a result of eating fish from Minamata Bay contaminated with methylmercury. Her mother and two of her grandparents also suffered from Minamata disease. Although many people in Minamata attempted to hide that they were victims of the disease to avoid social stigma and discrimination, a growing number of survivors have spoken out publicly to raise awareness of mercury poisoning, using the Japanese oral tradition of storytelling to share their experiences. Public awareness about Minamata disease also spread around the world through photographs of victims taken by the American photojournalist W. Eugene Smith for *Life* magazine in the early 1970s.

The participants who heard Rimiko Yoshinaga's story were there to attend the ceremonial opening of a conference to adopt the Minamata Convention on Mercury, a new global treaty (H. Selin 2014). They also visited the eco-park that was created on top of contaminated sediments dredged from Minamata Bay during the cleanup project, and ate a lunch of now-safe local fish and vegetables prepared by community members. The next day, October 10, 2013, country representatives formally adopted the final text of the Minamata Convention in the prefectural capital Kumamoto, 90 kilometers north of Minamata. The objective of the Minamata Convention is to protect human health and the environment from anthropogenic emissions and releases of mercury. Its adoption concluded three years of treaty negotiations under the auspices of the United Nations Environment Programme (UNEP). The Preamble of the Minamata Convention recognizes not only "the substantial lessons of Minamata disease, in particular the serious health and environmental effects resulting from the mercury pollution," but also the need to prevent similar events in the future.

Minamata disease remains a politically contentious issue in Japan, as does the government's support for naming the convention after Minamata. Some victims opposed using the name Minamata for the treaty because they believed that the Japanese government had not done enough—either to assess the damage mercury has caused to humans and the environment or to clean up the pollution—and that Chisso has not been sufficiently held accountable. One Japanese activist went so far as to argue that the naming "profanes the honor of the victims" (Kessler 2013). The Minamata victims have nevertheless had an international influence through their storytelling. Shinobu Sakamoto, who contracted Minamata disease in utero, traveled to Stockholm, Sweden, in 1972 (when she was 15 years old) to share her story at the United Nations Conference on the Human Environment, the first global political conference addressing relationships between people and the environment. A major outcome of that conference was the establishment of UNEP. In 2017, UNEP's deputy executive director Ibrahim Thiaw met with Shinobu Sakamoto after she spoke to the delegates at the first Conference of the Parties (COP) to the Minamata Convention. There he delivered a message that, in effect, dedicated the convention to her and all other victims of mercury poisoning.

Through their storytelling, Minamata disease victims tell of their own and their families' exposure to methylmercury, and the ostracism they faced after being afflicted with the disease. The Minamata stories, however, reflect much more than the human health effects from a local case of methylmercury poisoning: they address broader issues of human dignity, the importance of family and local community, responsibilities of governments and the private sector to address dangerous pollution, people's relationship with the environment, implications of modernity and industrialization, and the role of individual and collective efforts to move forward toward a better and safer future for all of humanity. In these respects, the Minamata stories are not just mercury stories: they are sustainability stories. They are tales of human struggles to live and thrive on a shared and finite planet that has been fundamentally transformed by humanity's interactions with the environmental processes essential for human survival and prosperity.

Stories like those told by the Minamata victims exemplify the ways in which people listen to, and learn from, the past. Oral and written storytelling can effectively raise public awareness and advocate for change. Rachel Carson (1962) caught the world's attention when she wrote *Silent Spring*, the story of the harmful effects of dichlorodiphenyltrichloroethane (DDT) and other similar pesticides, and linked their agricultural use to a decline in bird populations. Her widely read story contributed to the launch of the modern environmental movement in the United States and elsewhere.

Stories remain pervasive in much contemporary discourse around environmentalism (Harré et al. 1999). The telling of stories can also be critical to help envision, support, and guide transitions toward greater sustainability (Chabay 2015; Veland et al. 2018; Kuenkel 2019). In this respect, storytelling not only provides historical information and context, but also informs thinking about what a more equitable and sustainable world may look like.

The courage of the Minamata storytellers, and other victims of mercury pollution who have struggled to be heard and recognized, has inspired this book. The Minamata stories connect to a broader set of mercury stories across the world and through time. Coal burning and industrial manufacturing emits mercury while producing energy and goods. Millions of gold miners in Africa, Asia, and Latin America use mercury to earn an income, but it also threatens their health and the environment. Mercury from these and other sources travels worldwide through the atmosphere, land, and oceans. Pilot whales in the Atlantic accumulate methylmercury; some of this ends up in children in the Faroe Islands who suffer developmental delays from their mothers' consumption of whale meat and blubber during pregnancy. Many people in other regions of the world, including high-income urban residents as well as subsistence fishers, are also exposed to methylmercury from eating seafood. An estimated 200,000 children were born in 2010 in the United States alone to mothers whose methylmercury levels put these newborns at risk of neurological damages (Driscoll et al. 2018; US Environmental Protection Agency 2013).

Aim of the Book

We intend this book for readers with different backgrounds who share an interest in how an interdisciplinary perspective can inform understanding and action on mercury and other sustainability issues. For social scientists whose specialty is in political science, sociology, geography, history, economics, and other subjects, we illustrate how environmental processes and technologies affect social dynamics and change. For natural scientists studying the environment, we show how technological change and social institutions modify physical, chemical, and biological interactions. For engineers who study technical processes or seek to enhance technological performance, we underscore the need to account for environmental processes and governance arrangements in design and evaluation. For practitioners in the area of sustainability, we show how examining issues from a systems perspective can inform their efforts. For all audiences, we demonstrate the utility of a structured analytical framework by which perspectives and information from different fields can be brought together to better analyze and advance sustainability.

Global political attention to sustainable development can be traced back to discussions that informed the 1972 United Nations Conference on the Human Environment in Stockholm (Linnér and Selin 2005). An oft-quoted definition of sustainable development was set out by the United Nations World Commission on Environment and Development (also known as the Brundtland Commission) in their 1987 report *Our Common Future*: development that “meets the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development 1987, 8). The current global political approach to sustainable development is embedded in the 17 Sustainable Development Goals (SDGs) intended to address economic, social, and environmental issues in an integrated and holistic way until 2030 (Kanie and Biermann 2017; Kamau et al. 2018). We use the term “sustainability” in this book to refer to a societal goal, and the term “sustainable development” as the process by which societies progress toward greater sustainability.

Academics have defined and analyzed sustainability in different ways (Bettencourt and Kaur 2011). Definitions and measures of sustainable development vary in specifying what should be developed and what should be sustained (Parris and Kates 2003). In this book, we apply an anthropocentric perspective and focus on human well-being, now and in the future, as a central challenge of sustainability. Ensuring that Earth’s life support systems remain healthy, while maintaining and improving human livelihoods for both current and future generations, is one of the most critical challenges to ever face humanity. Although a broad array of research from multiple disciplines focuses on mobilizing knowledge to inform societal efforts to promote sustainability, additional in-depth empirical research is necessary—not only to further develop and test theories of how people interact with Earth’s life support systems but also to generate knowledge that can inform sustainability transitions (Clark 2015).

We wrote this book with the goal of advancing the knowledge and theory of sustainability through an empirically grounded study of the mercury issue. To this end, we aim to draw lessons relevant to other contemporary sustainability challenges in ways that inform practice and policy-making. The analytical framework that we introduce and deploy in this book centers on the concept of a human-technical-environmental (HTE) system that is embedded in the context of institutions and knowledge. We apply our framework, which we call the HTE framework, to the mercury issue, but, as we discuss further in chapter 8, it can also be used to study other sustainability issues. The HTE framework uses a matrix-based approach to examine interactions in systems and interventions aimed at enhancing sustainability. We introduce the framework in further detail, including the components of the human-technical-environmental system and the matrix-based approach, in chapter 2. In the book as a whole, we pose and address four research questions:

1. What are the main components of systems relevant to sustainability?
2. In what ways do components of these systems interact?
3. How can actors intervene in these systems to effect change?
4. What insights can be drawn from analyzing these systems?

Addressing these four questions requires drawing on approaches and insights from literatures across the natural sciences, the social sciences, and engineering. For too long, disciplinary training and boundaries have prevented integrated studies of complex systems. Yet, such systems can only be fully characterized, examined, and understood through an interdisciplinary approach that bridges spatial and temporal scales. Our own scholarly backgrounds are different but overlapping: Henrik specializes in understanding governance processes that deal with chemical pollution and other environmental issues, whereas Noelle examines the transport and fate of mercury in the atmosphere. Both of us have interdisciplinary academic training, and we frequently apply perspectives from multiple fields to advance understanding of the human influence on the environment. In addition, we share an interest in policy-relevant questions of how to promote and govern sustainability transitions.

The analytical and empirical focus of this book connects with the field of sustainability science (Kates et al. 2001; Komiyama and Takeuchi 2006; Kates 2011; Spangenberg 2011; de Vries 2012; König and Ravetz 2017). This rapidly growing and increasingly diverse set of scholarship is defined by the empirical problems it analyzes, where research is motivated by the need for informing action (Clark 2007). Knowledge of how complex systems function is necessary, but not sufficient, for such action. As succinctly argued by Pamela Matson and colleagues (2016, 12): "It is also necessary to understand how people, as active, committed agents of change, can intervene in those systems to make them work differently. Almost always, such interventions require collaboration to be effective." Choices about such interventions are often contested, and must often be made in the face of incomplete scientific information, diverging political and economic interests, diverse social conditions and cultural traditions, and different levels of access to financial and technical resources.

Mercury Stories as Sustainability Stories

Stories involving mercury—an element that humans have mobilized and used for at least 8,000 years—provide a wealth of empirical material through which to analyze sustainability. We tell the mercury stories in this book and analyze them from a systems perspective—examining system components, interactions, and interventions—as a way to help scholars interested in sustainability better understand how human actions have engaged with physical quantities of matter in ways that simultaneously support and are harmful to human well-being over generations. Many cases previously analyzed in the sustainability science literature involve human use of ecosystem resources, such as water and forests (e.g., Carpenter et al. 2009; Gleick 2018; Young et al. 2018). We add to this literature by looking at mercury as a commercial product and a pollutant. This dual focus brings into play characteristics of sustainability issues that are different from those addressed in many previously studied cases.

Humans have known about several of mercury's unique and useful properties since antiquity (Goldwater 1972). Mercury, a naturally occurring element in the Earth's crust, gets its name from the Roman god who was known as a winged messenger. The connection to a messenger god makes mercury a particularly appropriate focus for telling stories relevant to sustainability. Newspapers and magazines in several languages, including English, French, German, Italian, and Spanish, have the word "mercury" in their titles as a nod to the winged messenger. Mercury was also the god of merchants, travelers, and tricksters. The word "mercurial," relating to sudden and unpredictable changes in people's moods and behavior, refers to this deity. The British Broadcasting Corporation (BBC), building off this meaning, referred to mercury in 2013 as "the quixotic bad boy of the periodic table" (Rowlatt 2013). This is a suitable moniker for a substance that is attractive, volatile, and dangerous.

Mercury's ubiquity has made it part of popular culture. Farrokh Bulsara, the dynamic lead singer for the band Queen in the 1970s and 1980s, went by the name Freddie Mercury, a fitting choice for his charismatic and fluid persona. A 1981 recording with Freddie Mercury and David Bowie performing Queen's "Under Pressure"—a song about high-stakes stresses in today's world and hopes for a better future—was played during the Minamata Convention negotiations as delegates broke into smaller groups to address contentious issues. When the negotiations concluded at 6:59 a.m. on Saturday, January 19, 2013, in the Geneva International Conference Center, the organizers instead played another Queen song, "We Are the Champions." The song delivered a congratulatory message to the delegates as well as an exhortation to be the Minamata Convention's chief champions going forward. At the start of the first Minamata Convention COP, "We Are the Champions" played again in the same room, beginning the formal treaty implementation process; the soundtrack quickly switched back to "Under Pressure" as the discussions turned to more politically sensitive issues. Given Queen's "presence" at these events, it seems appropriate that the stylized fish logo for the Minamata Convention is affectionately nicknamed Freddie.

Mercury is mobilized from the Earth's crust by natural processes and by human activities. These natural processes include volcanic eruptions and the weathering of rocks. People have moved large quantities of mercury from geological storage into the atmosphere, land, and oceans during both preindustrial and industrial eras. This human influence has enhanced the amount of mercury cycling through the environment several-fold (Selin 2009; Amos et al. 2013). Consistent with the Minamata Convention, we use the term "emissions" in this book to refer to mercury entering the atmosphere, and the term "releases" to refer to mercury entering land and water. The term "discharges" covers both emissions and releases. Today, every ecosystem on the planet, no matter how remote, contains mercury discharged by humans. Additional mercury is in stockpiles, contaminated sites, and landfills. Current discharges of mercury add to this burden every day, and because of mercury's slippery tendency, it cycles back and forth through the land, atmosphere, and oceans for centuries (Selin 2009). Some mercury that deposits to ecosystems is converted into methylmercury, which then increases in concentration as it moves up food webs.

Mercury is sometimes referred to as quicksilver in English and several other languages because of its slippery and changeable nature. It is the only metal in the periodic table that is liquid at room temperature. But elemental mercury (the silvery liquid form) and methylmercury (the particularly toxic form that caused Minamata disease) are only two of the element's several forms. There are also many other types of mercury compounds. People have used different forms of mercury in a variety of products for thousands of years. Some of mercury's earliest uses were in religious ceremonies, traditional medicines, and paints. Miners used mercury to extract gold and silver from ore for centuries, in a simple amalgamation process that workers in artisanal and small-scale gold mining (ASGM) in many developing countries continue to use to this day. More recently, mercury has been used in a wide variety of products, including dental fillings, pesticides, batteries, light bulbs, and electrical equipment, and as a key element in industrial processes to produce a variety of chemicals and plastics.

Exposure to different forms of mercury can cause serious health problems. Inhaling high concentrations of elemental mercury vapor may lead to severe impacts, especially in occupational settings. Ingesting high doses of methylmercury can be lethal, as seen in Minamata. Lower doses can cause decreases in IQ and other neurological damage in children exposed in utero, and result in cardiovascular and other health problems in adults (Eagles-Smith et al. 2018). Because mercury is long-lived and ubiquitous in the environment, a piece of tuna on a dinner plate anywhere in the world contains methylmercury that may have come from mercury emitted by a currently operating coal-fired power plant and from mercury mined in the 1500s. Multiple factors influence how people are exposed to and affected by methylmercury, whether through individual food consumption patterns and genetics, or broader issues, such as land use change, that affect how much methylmercury is formed in ecosystems. Scientists increasingly realize that examining mercury's effects requires understanding not only its behavior in the environment, but also the influence of societal factors and human-induced changes to ecosystems and the climate (Obrist et al. 2018).

Many societies initially saw mercury as a valuable resource. Over time, with improved scientific knowledge of its environmental and human health impacts, mercury came to be perceived as a dangerous pollutant, a concept that echoes prior descriptions of pollution as "matter out of place" (Douglas 1966). The societal movement of mercury and many other materials that created pollution problems was initially intentional. Metals including lead and cadmium as well as organic chemicals such as the pesticide DDT, the industrial chemicals polychlorinated biphenyls (PCBs), and the stratospheric ozone-depleting chlorofluorocarbons (CFCs) were distributed in commerce before it was discovered that their use and dispersal posed dangers to the environment and human health. Unintentional emission of large amounts of mercury from combustion of coal also links it to other air pollutants, such as sulfur dioxide and carbon dioxide. Technology and engineering play a prominent role in the use of mercury and in mitigation of its harms, drawing attention to the role of industrial processes as they interact with ecosystems and environmental phenomena.

Outline of the Book

In this book, we relate intersecting stories about mercury at different times and in different places. We divide the book into three parts.

In part I, "A Framework for Sustainability Analysis," we devote a single chapter (chapter 2, "Analyzing Human-Technical-Environmental Systems") to presenting our systems-oriented HTE framework, together with the matrix-based approach. We explain how this framework is tied to the four research questions that we listed above by a four-step process that involves (1) identifying and classifying system components, (2) identifying and selecting several system interactions, and tracing the pathways of other interactions that affect them, (3) identifying actors and exploring interventions in the system, and (4) synthesizing insights from the previous three steps. Those insights relate to three thematic areas that shape our discussions and are integral to the structure of this book: systems analysis for sustainability, sustainability definitions and transitions, and sustainability governance.

Part II, "Sustainability Stories about Mercury," comprises chapters 3 through 7. Each of these five chapters focuses on an individual topical mercury system that illustrates major issues and themes in mercury science and governance. We begin each chapter with a short italicized paragraph that describes how the mercury system relates to broader issues of sustainability. We then relate a brief story about mercury to help communicate the complexity of the specific mercury system to readers who approach the book with different backgrounds and interests. Following this introduction, we structure the five chapters identically, based on the four-step process outlined in part I, to make it easier for readers to track and compare system components, interactions, interventions, and insights across the mercury systems. We end each chapter with another italicized paragraph that summarizes its conclusions.

In chapter 3, "Global Human-Technical-Environmental Cycling: Chasing Quicksilver," we address mercury as a pollution and management issue by examining the global cycling of mercury through the atmosphere, land, and oceans, as well as through society. We discuss the increasing analytical and practical difficulties of drawing a clear distinction between natural and anthropogenic sources of the mercury that travels through the environment, in part as a result of the growing influence of human-induced land use and climate changes on the cycling of mercury. We argue that fully evaluating global scale flows of mercury requires that knowledge about mercury's biogeochemical cycling in the environment be better integrated with data on its societal use and transport. This is particularly important when looking at the global mercury cycling system from a sustainability perspective. In addition, we detail the design and content of the Minamata Convention as a primary global-scale intervention to address the full lifecycle of the mercury problem, thus affecting both the environmental and societal cycling of mercury.

In chapter 4, "Human Health: Mercury's Caduceus," we explore the human health system for mercury, examining how people have been affected by mercury through occupational exposure, the use of mercury in medical treatments, and the presence of methylmercury in food. Mercury was extensively used in workplaces and in medicines for centuries after negative effects on humans were documented. Efforts to mitigate health damages from mercury relied on incomplete and varying scientific and medical knowledge of its hazards—many people who suffered from mercury poisoning did not know what caused their symptoms. We show that many early strategies to alleviate human health problems from mercury in workplaces and medical treatments relied on minimizing risk, and that more comprehensive efforts to phase out mercury use did not start until the twentieth century. Although some remaining mercury uses in dental amalgam and vaccines are still judged to have net positive consequences for human well-being, methylmercury exposure from food continues to harm human health worldwide in the twenty-first century, and its risks will continue for generations.

We focus in chapter 5, “Energy, Industry, and Pollution: Mercury, Winged Messenger,” on the atmospheric system for mercury, particularly on the origins and consequences of atmospheric mercury emissions from large industrial sources. Mercury emissions from point sources, especially those that burn coal, have added a large amount of mercury to the atmosphere since the start of the Industrial Revolution. Efforts to address mercury emissions from point sources have largely consisted of end-of-pipe controls, and a growing number of countries are adopting technology-based regulations. We show that the incremental application of pollution-abatement technology had substantial positive impacts on reducing mercury emissions in North America and Europe. However, emissions remain high, and in some cases are increasing, in Asia and other regions. Although countries have shown limited willingness to address some of the underlying activities that lead to mercury emissions (including coal burning), incremental actions to control pollution can also affect fossil fuel use and thus the global challenge of climate change.

In chapter 6, “Assets and Liabilities: Mercury, God of Commerce,” we discuss the products and processes system for mercury. The use of mercury extends across a broad array of commercial products—including thermometers and other measuring instruments, pesticides, paints, light bulbs, and batteries—as well as in industrial processes, including chemicals manufacturing. We explore how commercial mercury uses had many societal benefits, even though the mercury in these products and processes also harmed human health and the environment. Technology developments in the private sector sparked many early applications as well as later phaseouts of mercury use in consumer goods and manufacturing processes. In contrast, concerns about mercury’s environmental and human health dangers influenced the adoption of only some of the technology that made mercury phaseouts possible. Since the late 1900s, when governmental and public pressures on industry to stop using mercury increased, the commercial demand for mercury has declined substantially. Damages from past uses continue to pose challenges because mercury remains in wastes, in contaminated sites, and in the environment worldwide.

We devote chapter 7, “Mining and Sustainable Livelihoods: Mercury, God of Finance,” to the ASGM and mercury system. Mercury use in ASGM is a leading global source of mercury discharges to the environment and of mercury exposure for people. We discuss how ASGM miners in developing countries use large quantities of mercury to separate gold from ore. Many ASGM miners depend on mining and mercury use as a source of basic income, but not without cost: their use of mercury harms their health and the local environment and adds to the amount of mercury that cycles through the environment globally. ASGM is influenced by local conditions, but is also linked to global-scale mercury and gold supply chains. Mining often takes place without official permits, affecting efforts to address mercury use and a wide range of other environmental and social problems associated with ASGM. We explore how initiatives targeting mercury use in ASGM involve efforts to reduce mercury use, exposure, and discharges, with a simultaneous goal of phasing out mercury use altogether in gold mining.

Part III, "Lessons for Sustainability," contains the final three chapters of the book. These chapters build on the analysis of empirical material from the second part of the book to synthesize findings related to our four research questions. In these chapters we also propose ways to apply our analytical framework to other sustainability issues, and discuss lessons for further action on the mercury issue targeted toward different audiences.

In chapter 8, "Sustainability Systems: Seeing the Matrix," we look across the systems-oriented analyses of the mercury systems by returning to our first three research questions on system components, interactions, and interventions. We discuss how a limited number of human, technical, environmental, institutional, and knowledge components can be used to describe and analyze the mercury systems, and how some of these components may also be relevant to other sustainability issues. We then illustrate how shorter and longer pathways involving interactions across human, technical, and environmental components coexist, with many interaction pathways crossing spatial and temporal scales. A broad range of actors with different levels of power and influence initiated interventions to change interactions among system components; these interventions had different goals, influenced systems across space and time, and targeted various leverage points. The chapter ends with a discussion of ways that the HTE framework can be further developed and applied to study other sustainability issues.

We come back to Queen and Freddie Mercury as the inspiration for the title of chapter 9, "Sustainability Insights: Earth 'Under Pressure.'" In this chapter, we integrate the major insights from the mercury systems as they connect to the three thematic areas of systems analysis for sustainability, sustainability definitions and transitions, and sustainability governance. First, we discuss the need to account for human, technical, environmental, institutional, and knowledge components together in sustainability analyses. We highlight how the ability of the mercury systems to adapt has affected human well-being both positively and negatively, and stress the importance of looking across temporal and spatial scales when examining systems of relevance to sustainability. Next, concerning sustainability transitions, we argue that variations in values attributed to the benefits and risks of mercury make it difficult to define sustainability, and to evaluate changes to human well-being across populations and over time. We also detail how incremental transitions were important to human well-being. We then turn to sustainability governance, and the importance of ensuring that institutions fit the physical problem they are set up to influence. We discuss how institutional design can help address multiple sustainability issues simultaneously, and argue that environmental and societal factors should both be considered when evaluating whether institutions such as the Minamata Convention are effective.

For the subtitle of chapter 10, "Sustainability Champions: 'We'll Keep on Fighting … ,'" we quote a line from the Queen song "We Are the Champions." We conclude the book by drawing practical lessons for "champions" who are researchers, policy-makers, and thoughtful citizens by reflecting on ways to move forward in the face of challenges posed by mercury pollution, from local to global scales. We call on mercury researchers to consider mercury in a larger context of other sustainability issues, to expand their work across disciplinary boundaries, and to develop and communicate useable knowledge in collaboration with stakeholders. For decision-makers addressing mercury-related challenges, we suggest looking for different kinds of interventions across multiple geographical scales, focusing attention on high-impact actions, and considering long-term impacts of different intervention strategies. In the final section, we urge thoughtful citizens who are concerned about mercury use and exposure to consider the implications of their consumption choices, to work together to push for efforts to further address mercury related risks and problems, and to share their and others' sustainability stories.

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Mercury Stories

Understanding Sustainability through a Volatile Element

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