Living in a Nuclear World

The Fukushima disaster invites us to look back and probe how nuclear technology has shaped the world we live in, and how we have come to live with it. Since the first nuclear detonation (Trinity test) and the bombings of Hiroshima and Nagasaki, all in 1945, nuclear technology has profoundly affected world history and geopolitics, as well as our daily life and natural world. It has always been an instrument for national security, a marker of national sovereignty, a site of technological innovation and a promise of energy abundance. It has also introduced permanent pollution and the age of the Anthropocene. This volume presents a new perspective on nuclear history and politics by focusing on four interconnected themes—violence and survival; control and containment; normalizing through denial and presumptions; memories and futures—and exploring their relationships and consequences. It proposes an original reflection on nuclear technology from a long-term, comparative and transnational perspective. It brings together contributions from researchers from different disciplines (anthropology, history, STS) and countries (US, France, Japan) on a variety of local, national and transnational subjects. Finally, this book offers an important and valuable insight into other global and Anthropocene challenges such as climate change.

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Introduction: shaping the nuclear order

Bernadette Bensaude-Vincent, Soraya Boudia, and Kyoko Sato

In March 2020, the Olympic flame traveled from Greece to Japan, destined for the Tokyo Games. For Japanese authorities, the grand start of the Torch Relay symbolised their ability to rebuild following an earthquake, a tsunami and a nuclear accident. Some 20 km from the defunct Fukushima Daiichi nuclear power station, the flame, having made it to Japan, would have begun its journey to Tokyo from J-Village, a luxurious national soccer training center funded by Tokyo Electric Power Co. (TEPCO) and restored with Kuwait's donation. Fukushima Governor Masao Uchibori enthused, "We are happy to send out a message, at home and abroad, that any difficulty can be overcome."[1] Yet, at that time, COVID-19 was reaching pandemic proportions, most of the world was locked down, and several economic sectors were slowing, adding to the region's ongoing problems. According to official figures, 41,000 residents near Fukushima were still displaced nine years after the accident—a number many consider an undercount.

Due to the global pandemic, the "Reconstruction Games," as the Japanese government had dubbed this Olympiad, were postponed until 2021. They coincided with the ten-year anniversary of the Fukushima nuclear disaster, which brought the shock and horror reverberating around the world in 2011. The disaster profoundly changed the lives of tens of thousands of Japanese, turning a vast swath of land with communities, farms and natural areas into a semi-wasteland. As we watched that meltdown take place in a nuclear plant run by a prominent corporation in an advanced industrial nation, we were caught off-guard by the scope of the damage, the uncertainty over residents' health and the future of nuclear technology itself.

One mantra: never again

Today, the Fukushima disaster has become ordinary. It no longer captures the public's attention. Still, its repercussions continue in the everyday struggles of the ongoing evacuation, the uncertainty about the effects of radiation and the lawsuits over accountability and compensation. After the

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2011 disaster, experts were mobilised, risk standards and stress tests were updated and the next wave of nuclear critics voiced their concerns. Yet Fukushima gradually became a thing of the past, a memory. It has been trivialised like the major nuclear disasters that came before—the long list of global nuclear "events" inaugurated by the bombings of Hiroshima and Nagasaki. These events have become so commonplace that their *eventness* is questionable. Their lingering effects are not.

Multiple generations of humans have lived in a nuclearised world. We came close to a full-blown nuclear war during the Cuban Missile Crisis. We[2] have witnessed radioactive contamination from catastrophes like Three Mile Island and Chernobyl. Every accident and fallout incident raises similar questions, such as, *What can we learn from this? How can we ensure it never happens again?* Yet our daily lives are barely shaken by these past and recent events. We feel so at home in this world of risk that few really noticed when scientists nudged the needle of the "Doomsday Clock" up to two minutes before midnight in 2018. Invented by atomic scientists in 1947 to indicate the threat of global annihilation, this portentous clock had been fluctuating within 5–12 minutes before midnight for the last few decades. The jump to a two-minute warning should have been a shocking headline worldwide, but it was not.

About 30 nations including Japan rely on nuclear energy, with dozens of new reactors under construction in the Global South and North. How has such a destructive technology assumed such a central place in our societies over the past 75 years? How is it that, despite major disasters and hollow assertions that they won't happen again, nuclear technology has been so widely adopted and accommodated? How did it become mundane?

This volume is driven by the ambition to better comprehend how nuclear technology has forged this world—and how we have come to live within it. This particular technology offers a case study for understanding how adaptation to disasters and the forgetting of crises can be manufactured. In exploring these questions, the volume's essays build on the contributions of numerous academic works, particularly those that pay attention to technoscience, or the idea that science and technology are more than just tools for fulfilling human needs and desires. In fact, science and technology are *constitutive* of our world. Human artifacts, loaded with economic, social and political values, have lives of their own. They are even constitutive of us as humans, shaping our senses, desires and actions.

Nuclear technology is a world-making technology *par excellence*. Since the bombings of Hiroshima and Nagasaki in 1945, this branch of scientific innovation has profoundly changed history, geopolitics, the natural world and everyday human life. The emerging nuclear sector has been hailed as an instrument of national security, a hotbed of technological innovation, and a guarantor of abundant energy (Hecht, 1998;

Jasanoff and Kim, 2013). It has also threatened human health, poisoned water and food supplies, and degraded our environment. Radioactive contamination from atmospheric atomic tests was the first planet-wide environmental issue recognised in the 1950s (Higuchi, 2020). In the current Anthropocene debate, radioactive traces are even taken as the quintessential indicators of humanity's impact on Earth (Masco, 2010).

This volume uses Fukushima as a prism through which we tease out the multifaceted ways in which nuclear technology produced our world. To understand the 2011 disaster, we look back to Hiroshima and reexamine the "balance" of good and evil implicit in this dual-use technology. The analyses presented here are based on newly available historical materials and declassified documents, as well as on field research, Anthropocene studies and a cross-cutting examination of recent international scholarship.[3] They move between past and current events, global and local scales, and various geographical areas, with a particular focus on the United States, France and Japan.

The objective of this volume is not to develop fine-grained historical accounts—it would require several books to do that project justice—but rather to provide an interdisciplinary perspective on the construction of the nuclear order. In this respect, this volume partially overlaps with that of Michael D. Gordin and G. John Ikenberry (2020). Instead of focusing on Hiroshima, however, the works included here highlight the violence of nuclear technology, examine the constitutive roles of nuclear expertise along with institutional and material infrastructure and explore the evolving "nuclear order."

Nuclear order refers to the dimensions of the nuclear domain that constitute and mediate our experience of the world. This use of the term is more encompassing than how it is commonly used in fields like international relations to indicate a global order and the means for preventing warfare through strategic approaches such as deterrence and non-proliferation (Scheinman, 1987; Walker, 2000; Ritchie, 2019). Those analyses tend to focus on nation-states and international organisations instead of survivor bodies, representation, expertise and worldviews. In contrast, the authors in this volume embrace the material and institutional infrastructures of nuclear technology, the cultural categories that structure our experience of space and time, and the symbolic and physical traces that pattern our visions of the world and the future. They approach the nuclear order from multiple perspectives, ranging from discussions of its tangible effects on our lives to abstract changes in culture, knowledge and techno-politics. The authors in this book see the nuclear order both as a product of history and as a constitutive element of the future world.

This book is broken into four sections which represent four entangled dynamics that address two seemingly simple questions: *How has nuclear technology shaped the world we live in? How have we come to live with this technology?* The process of seeking answers sheds light on how we

have learned to live with world-objects, to borrow Michel Serres's term, which maintain a global reach but remain ungovernable and indomitable no matter how much technical work and political regulation is devoted to controlling them (Serres, 2006).

The chapters in the first section, "Managing violence: categories and demarcation," look at how the dangers of nuclear technology have been downplayed within the nuclear order that emerged after the atomic bombings of Japan. The next section, "Pacifying atoms: control and containment," examines how "peaceful" uses of atomic energy have been promoted and regulatory infrastructures established to erase and contain the violence of nuclear technology. The contributions in "Normalising risks: denial and trivialisation" scrutinise the work of institutions and global networks of experts to build life *with* the dangers of nuclear power and radiation. And finally, "Timescaping: memory and future visions" looks both backward and forward, examining how nuclear disasters affect our visions of the past and the future.

Managing violence: categories and demarcation

Why is there such disregard for the evidence of nuclear technology's destructive potential? On the morning of August 6, 1945, people in Hiroshima experienced an extraordinarily powerful blast. The heat melted metal. A highly radioactive "black rain" poured down. An estimated 70,000–140,000 in Hiroshima and 40,000–80,000 in Nagasaki died within months.[4] Tens of thousands more suffered radiation and burns. The United States justified these bombings as necessary to end World War II, deftly evading responsibility for the humanitarian consequences of introducing a weapon of such deadly capability and unpredictable aftermath. The Cold War arms race that followed would be marked by the well-founded fear that the deployment of nuclear weapons could destroy humanity.

The chapters in the first section of this volume explore how a new order emerged out of these early displays of nuclear violence. A key mechanism for establishing this order was the imposition of a clear-cut demarcation between *bombs* and *energy*. Nuclear bombs were presented as destructive, while nuclear energy was promoted for its ability to improve modern life. The former were to be feared and restricted. The latter heralded a bright future. Thus, the reputation for violence was reserved for nuclear munitions, and the risk associated with other applications of nuclear technology was glossed over. Violence became exclusively associated with weapons and war.

Crucial for this decoupling of violence and nuclear technology on the whole was the persistent official downplaying of the slow afflictions caused by radiation. The US Occupation that followed the bombings in Japan characterised the bombs' destructive capacity as instant: a

relatively brief, hot blast. By censoring and controlling the details of *lingering* damage, the Allies purposefully concealed the long-term harm they already had reason to expect among Japanese survivors.

We know today that radiation from bombs, tests and accidents causes various diseases and disabilities as well as fear about social stigma and future health. Downplaying this intrinsic violence has been necessary for expanding nuclear energy programs. Although nuclear weapons continued to proliferate and inspire fear about human extinction, civilian programs, starting with the US Atoms for Peace campaign in 1953, flourished without causing similar alarm. But as disasters like Three Mile Island, Chernobyl and Fukushima reveal, nuclear violence is not bound to formal hostilities. The potential for devastation is embedded within the reactor, in its capacity for producing massive amounts of invisible radiation. The process is not constrained by the intended outcome.

Much of our understanding of the health effects of ionising radiation owes to the *hibakusha*, the survivors of the 1945 bombings. Kyoko Sato's chapter shows how international and national standards that rely significantly on such knowledge have been used to distinguish who is—and is not—worthy of medical and financial support as officially certified *hibakusha*. Survivors and their supporters have challenged the Japanese government's classificatory approaches by providing testimonials about their bodies and experiences and counter-expertise that problematises the authoritative knowledge's limitations. Although this has helped to expand *hibakusha* status gradually, numerous exclusions of aging survivors have added symbolic violence to their physical, psychological and social struggles. Sato argues that the negotiations over *hibakusha* status served as an arena in which the consequences of the bomb and radiation exposure were defined and redefined. These deliberations involved much wrangling over thresholds between high and supposedly safe doses based mostly on each survivor's proximity to ground zero, while devaluing each survivor's lived, bodily experience and evolving knowledge on multiple pathways of radiation exposure and their effects.

Politics around categories and demarcation have shadowed the handling of many instances of risk and damage. Because ionising radiation is invisible, nuclear technology has required practices for delineating the spatial boundaries between contaminated and habitable zones. The booming field of nuclear geography focuses on the human and social aspects of designing, mapping and enforcing exclusion zones in everyday life as well as in disaster areas (Davies, 2013; Alexis-Martin and Davies, 2017). These zoning and compensation practices usually result from tangled compromises involving standardised measurements and negotiations between authorities and citizens.

In contrast to the slow creep of radiation, the violence of nuclear tests is spectacular and swift. On July 16, 1945, scientists viewing the Trinity test at the Alamogordo Range in New Mexico were flooded with feelings

of awe and beauty (as well as the fear of a looming Doomsday) that words could not describe. Only witnesses, it seemed, could realise the "nuclear sublime" (Wilson, 1994) in this striking demonstration of force that became so instrumental in shaping a new vision of the world. Following this first live viewing of an atomic blast, film and photographic representations served to reinforce the inescapable impression of violence in the nuclear sublime as the province of weapons alone.

In the 1950s, Kodak and a few other contractors recorded nuclear tests in the Pacific, capturing them visually with cutting-edge imaging technology and registering the effects of radiation using film badges affixed to their workers' uniforms. Joseph Masco's chapter examines the technopolitics of these recordings and dosimeter badges, showing how menacing images of explosions were linked to a slow violence on bodies as well as to the contamination of the global environment. While the curated representations of atomic mushroom clouds became deeply engraved in the popular imaginary, records of radiation exposure, duly recorded and dully considered within safety thresholds, quietly allowed those tests to continue. Masco argues that technical innovations designed to record these nuclear tests have not only influenced our use of images and our understanding of nuclear dangers, but have also created an archive of US nuclear nationalism. These detailed records of both extreme and slow violence may hold immense implications for nuclear accountability.

The selective set of unclassified images that were displayed in museums, films and on TV became iconic of the nuclear era. Together with the pro- and anti-nuclear propaganda of the Cold War, propaganda and government-controlled images helped to frame nuclear issues as matters of survival at a time when the United States and the Soviet Union were frantically building up their nuclear capacities, developing rocket technologies and engaging in espionage. Following Sputnik in 1957, the American series of Apollo space missions captured images of Earth as a "Blue Marble," indirectly molding a global view and contributing to the study of environmental changes on a planetary scale. Inspiring both wonder and trepidation, these images facilitated what Sheila Jasanoff (2015) calls "sociotechnical imaginaries," or the visions of social orders and desirable futures that could be achieved through technoscientific advances.

Boundaries are prominent in nuclear imaginaries—not only geographic boundaries but the boundaries between military and civilian applications, between worthy and unworthy uses of nuclear technology. In the hazy rhetoric of fear and security, destructive pursuits come from "bad guys" while "good guys"—identified as Western, White and male—work with non-destructive atoms. Only the "other" needs policing, screening and improvement.

John Krige's chapter describes this rhetorical effort via boundary work, in which tropes of gender, race, and pathology were mobilised to create a "nuclear apartheid" that denied "others" access to nuclear

weapons. In other words, dual-use was established according to externalised malice (Rabinow and Bennet, 2012: 123) against internalised good intentions to support the illusion that "we" are entitled to split atoms. From the dawn of the nuclear age, Krige argues, US leaders have framed nuclear weapons as an existential issue and American leadership as key to controlling proliferation and maintaining a stable world order. Colonialist and imperialist worldviews are so deeply embedded as to be virtually indistinguishable from the entire endeavor (Churchill and LaDuke, 1992; Hecht, 2012).

Neo-colonialist visions were manifested in the ways the United States unflinchingly changed the legal status of Micronesia and created a flexible nuclear network for weapons testing in the Marshall Islands. The territorial grab would spare the US homeland the risks of nuclear testing while dooming to harm the indigenous islanders and unanticipated others (including the Lucky Dragon No. 5's Japanese fishing crew, operating in the area of the Bravo tests). Describing the emergence of this unique arrangement from the perspectives of both the islanders and the US authorities, Mary X. Mitchell's chapter exemplifies the complex entanglements of nuclear technology and imperialism that reinforced the post-war, neo-colonial world order of White and non-White countries.

The externalisation of malice initiated during the height of atmospheric nuclear bomb testing in the 1950s still fuels fears of "Islamic bombs," "rogue states" and "nuclear orientalism" (Gusterson, 1999). To cope with the violence of detonation and radiation, a tentative nuclear order has been established according to demarcation strategies between good and bad, safe and dangerous, contaminated and habitable. Despite the emphasis on what is good and safe, radioactive fallout from bombs, tests and reactors has lasting and possibly immeasurable effects on humans and their environments.

Pacifying atoms: control and containment

The violence inherent in splitting atoms had to be domesticated to secure the technology's acceptance. It took considerable work to pacify global concerns about the access to nuclear arms and build a convincing system for preventing their use. The attention to atomic bombs generated by the Cold War arms race proved foundational for instituting containment and deterrence efforts. Shortly after the detonation of the first nuclear bombs, a world peace movement took on this global threat (Wittner, 1993; 1997), with scientists and intellectuals calling for the creation of international nuclear governance.

A complementary logic of pacification was at work in the promotion of nuclear applications in medicine and energy. Shoring up the boundary between military and civilian atoms, this strategy used intense publicity efforts to create a positive image of civilian nuclear applications. Scholars

have described the huge investments made in promoting non-military nuclear technology on the political stage and in the public arena, beginning with speeches on the greatness of a nation (Hecht, 1998) and followed by the Atoms for Peace campaign in the 1950s (Krige, 2006). During the 1970s oil crisis, nuclear reactors promised abundant energy. Today, amid concerns about climate change, nuclear energy has been rebranded as a green technology that does not emit planet-warming gases.[5]

Scientific expertise has played a key role in producing the pacified atom. The Manhattan Project, for instance, resulted in an unprecedented concentration and coordination of expertise and investment to master a complex and uncertain technology for producing bombs, reactors, and radioisotopes (Hughes, 2002; Oreskes and Krige, 2014). Cold War efforts to discern the terrestrial, atmospheric and oceanographic conditions in which nuclear bombs could be used, along with the race to understand the effects of radiation, contributed to the creation or profound transformation of entire scientific fields such as environmental sciences and climate research (Doel, 2003; Turchetti and Roberts, 2014). Nuclear knowledge has also served as a tool for foreign policy, notably in the late 1940s and into the 1950s, when the United States shared knowledge and isotopes to help improve relationships with other nations, foster European integration and entice nations to the American side of Cold War geopolitics (Creager, 2015; Krige, 2016).

In this second section of the volume, path-breaking scholars scrutinise how pacification efforts were embedded in the distribution of knowledge about nuclear technology, the creation of infrastructures and instruments for radiation and risk measurement and the global standards proposed and adopted during the postwar years. It emphasises how this advancement of knowledge and control paradoxically *also* produced ignorance and blind spots. Based on fear initially, the postwar nuclear order was rebuilt on "rational foundations" by scientists, engineers and experts who framed a regime of global surveillance, oversight and regulation that legitimised nuclear activities in the public eye. Certain of these scientists rose to prominence within global networks while serving national interests and mediating between nuclear institutions and political authorities regarding the dangers of fallout.

One key actor in this work, as Angela N.H. Creager and Maria Rentetzi's chapter shows, was the International Atomic Energy Agency (IAEA). Founded in 1957 with the stated aim of promoting the "peaceful" uses of nuclear technologies while preventing the diversion of these resources to military uses, the agency has twin divergent goals. That the IAEA simultaneously promotes and seeks to control these technologies has never been reconciled or even officially acknowledged. By promoting, advocating and monitoring the development of atomic energy in its member states, the IAEA embodies a new regulatory presence that decisively directs the dissemination of technologies, materials, laboratory

designs and safety practices (though it once lacked the explicit authority to enforce its recommendations). Yet, although the promotion of civilian nuclear technologies resembles other postwar programs for economic development in the Global South, the dual uses of atomic energy necessitate a different regime of geopolitical control.

Networks for monitoring radioisotopes and radioactive contamination are another mechanism in building the image of mastery over nuclear technologies. Nestor Herran's chapter considers the role of these networks in the emergence of the nuclear order and the specific regimes of global surveillance. He shows how the development of radiation monitoring was initially motivated by military concerns—specifically, whether the enemy had developed its own atomic weapons. Later, this activity coalesced with 1950s-era concerns about tracking radioactive fallout because of controversy over the health risks of nuclear tests. The expansion of nuclear power stations in the 1960s was accompanied by early efforts at international coordination on monitoring radiation. The Chernobyl accident accelerated these efforts and saw the emergence of citizens' counter-expertise platforms that shaped new forms of communication within the state-controlled apparatuses (Topçu, 2013).

As we contend with 75 years of nuclear waste and fallout, containment is a crucial part of civilising nuclear development. The IAEA and other experts funded by nuclear advocates invest heavily in the production of concepts and doctrines concerning risks and how they should be managed (Boudia, 2014). In this vast market, serious accidents akin to the explosion of a bomb are a central theme.

Thus, in his chapter, Maël Goumri demonstrates how, when faced with a body of studies, nuclear engineers and other experts can go from denial of the reality that an accident could occur to patiently developing the concept of "hypothetical accidents" to make major risks conceivable yet manageable. Using cases from the United States and France from the 1950s to the 1980s, Goumri shows how these experts framed severe accidents as improbable and "theoretical," relegating the possibilities of accidents to a "residual" domain instead of tackling them head-on or learning from actual experiments. Goumri argues that these strategies depended on technical and social work that embedded them within the material and institutional infrastructures of nuclear governance.

Containment strategies are central to Tania Navarro's chapter on the transnational governance of nuclear waste. Documenting past and present decisions regarding radioactive waste management, Navarro reveals how French experts and decision-makers saw a partnership between nature and technology as a way to solve disposal problems. She argues that the conceptual shift from waste *disposal* to waste *storage,* and the correlated change in action from dilution to containment, which took place globally, came directly out of the scientific and social concern that increased right alongside the increasing volume of radioactive waste.

Surveillance of installations, regulation of risk and the monitoring of radiation are indispensable companions in the nuclearised world. Nuclear physicist Alvin R. Weinberg observed that the "military priesthood" set up to control the proliferation of atomic weapons had to be extended to other uses of radioactive materials (Weinberg, 1972). The "Faustian bargain" between nuclear professionals and society offered cheap and clean energy, but required that society ensure the longevity of expert institutions and buy into a defanged acknowledgement of risk.

Normalising risk: denial and trivialisation

The quest to control and contain radioactivity, reactor products and waste is fundamental to nuclear technology. However, accidents and the production of counter-expertise undermine this "containment doctrine." After 75 years, the cumulative damage caused by nuclear technology is considerable. The chapters in the third section consider how nuclear institutions and their advocates (including national governments) have worked to minimise these nuclear hazards and their aftermaths, developing new ways of governing the consequences of living amid toxic ruins.

There are several mechanisms of secrecy that intentionally render nuclear activities and their effects invisible. From the beginning of the nuclear age, practices of secrecy were constructed around the technical details of weapons and reactors (Galison, 2010; Wellerstein, 2021) as well as the effects of radiation at Hiroshima and Nagasaki—details that were not fully disclosed for decades (Lindee, 1994). Far from exceptions, these patterns of retention and dissimulation of information are distinctive features of the nuclear milieu.

Hiroko Takahashi's chapter focuses on an episode that took place in 1954, when politics and diplomacy dictated the terms of scientific debate over the effects of radiation and thereby terminated diagnostic testing and the collection of empirical data. After a Japanese fishing boat was exposed to fallout from a US thermonuclear test in the Marshall Islands, the Japanese government responded to public fear and anti-nuclear mobilisation by initiating a short-lived program to inspect tuna catches for radiation. Those fish sufficiently contaminated were destroyed. Takahashi argues that the so-called full settlement that resulted from this case was crucial for the United States and its continued nuclear testing program. The agreement was bolstered by Japanese and American scientists who downplayed the health consequences of radiation during a Tokyo conference.

The multiple logics and methods that contribute to dissimulation and invisibilisation have been articulated by historians. Censorship and press codes restricted early discussions of the bomb (Braw, 1991; Takahashi, 2012), but for decades, scholars have interviewed the inhabitants of Bikini Atoll and the Marshall Islands (Johnston and Barker, 2008; Takemine, 2015), veterans of atomic tests, African uranium miners (Hecht, 2012),

and nuclear plant workers (Jobin, 2017) to backfill crucial data. Practices of disqualification and denial have, in turn, been maintained through psychological and physical violence, as illustrated in communities around Chernobyl (Kuchinskaya, 2014; Brown, 2019). Tactics include refuting the suffering of victims, denigrating opponents, and sometimes engaging in threats, surveillance, imprisonment or death sentences (perhaps its own sort of nuclear waste containment and disposal—simply applied to the human evidence of ongoing risk).

Kate Brown's chapter brings us to Chernobyl, where the politics of medical knowledge and the legacy of the Cold War are borne out among parents who failed to mobilise and bring foreign attention to their children's illnesses. Because of the influx of Western medical experts following the accident, Brown reasons, Soviet medicine's focus on environmental causes of disease gave way to individualist approaches that attributed cancer and other maladies to behaviors, psychological states or genetic coding. The "experts" working for UN and national nuclear agencies built these Western assumptions into their reviews and presentations, dismissing the effects of fallout and even blaming Soviet citizens for their "addiction" to state welfare.

Denials of nuclear danger take many forms and different degrees of sophistication depending on the political context in which they are issued. In his chapter, Harry Bernas argues that the 2011 Fukushima disaster resulted from a long social, economic and political process. That is, it was a "normal accident," according to Charles Perrow (1984), rather than an "unforeseeable" event caused by natural disaster, as Japanese authorities claimed. Bernas shows how power utilities, ministries and safety overseers largely ignored or denied the possibility of major accidents despite considerable knowledge that a major earthquake and tsunami along the Fukushima coastline were, seismologically speaking, overdue. It seems the drive to accrue profits and power, as well as bureaucratic inertia, allowed authorities to underestimate risks, tolerating or even encouraging uncertainty and criminal malpractice in the approval and siting of nuclear facilities along Japan's fault-ridden coastlines.

The mechanisms for minimising hazards and their consequences often fall under what Gabrielle Hecht calls nuclear exceptionalism (2012). Hecht uses several studies to show that exceptionalism consists of singularising each case, justifying it according to local and contextual circumstances, and mobilising cultural explanations for local outcomes that are often tainted by stereotypes. In the exceptionalist view, the Chernobyl accident could be dismissed as the consequence of using an old Soviet-era reactor, inferior to those at work in Europe, while Fukushima can be dismissed as an outcome of extraordinary circumstances—of an earthquake, a tidal wave and a cascade of technical failures exacerbated by a culture of obedience in which people did not feel empowered to improvise and take initiative to counteract a new and unusual threat.

The flip side of exceptionalism is the simultaneous normalisation and trivialisation explored throughout this volume. Making nuclear technology non-problematic despite its many uncertainties requires political maintenance work, a whole host of techno-political initiatives that make nuclear institutions resistant to challenge and criticism. By constantly readjusting their technologies within shifting economic and political contexts, nuclear actors labor to convince the world that nuclear technology is indispensable. The maintenance work that keeps nuclear industries running occurs through different mechanisms, including the production of knowledge and technical innovation, the implementation of safety and security, the presentation of public expertise, the construction of categories and the development of governance technologies.

Soraya Boudia's chapter takes a historical perspective on global nuclear governance, which has long been a political proving ground for designing and testing ways of managing hazards. Nuclear governance, this chapter argues, is characterised by a succession of three intermingled paradigms—containment, risk assessment and adaptation—forged and promoted through transnational expertise and regulatory institutions such as the IAEA, International Commission for Radiation Protection (ICRP) and United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). Focusing on the adaptation paradigm, Boudia shows how Chernobyl and Fukushima prompted a series of social experiments endorsing the continuation of daily life in "sustainably contaminated" areas, as well as how these political devices are being applied in other areas.

A vast array of instruments and practices have gone into the repertoire of initiatives developed by nuclear institutions to overcome crises and criticisms during the past 75 years. The approaches and tools used to characterise, delimit and manage risks have accumulated their own intrinsic contradictions and tensions, becoming a source for new risks and undermining the legitimacy of institutional models without hampering the ability to pursue nuclear development despite the exorbitant economic and environmental costs.

Timescaping: memory and future visions

The violence of nuclear technology and the efforts to tame it have deeply affected humans' experience of space. The fear of destruction has led institutions such as the IAEA to create a global system of surveillance that collapses national borders and allows scientists and politicians to transcend the confines of earth. The iconic image of the Blue Marble afforded humans their first view of Earth from the outside—a view from nowhere (Grevsmühl, 2014) that turned our relationship to the planet inside-out. It facilitated "the withdrawal from terrestrial proximity" that

Hannah Arendt describes as "earth alienation" and which is considered the hallmark of modern science (Arendt, 1958: 264–265).[6]

If the nuclear age reshaped our experience of space through a dual process of globalisation and abstraction, has it also affected our experience of time? Jeremy Rifkin observed, "Time is our window onto the world. With time we create order and shape the kind of world we live in" (Rifkin, 1987: 7). The questions addressed in the fourth section of this volume are inspired by the notion of the order of time and its relationship to the nuclear order of the postwar age.

A number of European historians have tried to characterise the categories that frame ways of dealing with the past, present, and future. Because we take time for granted, we are usually unaware of these categories and their performativity. Observing the changes in the experience of time prompted by modernity's promise of emancipation and progress, Reinhart Kosseleck introduced the concept of the "horizon of expectation" (2004). François Hartog (2015) coined the phrase "regime of historicity" to describe the connecting of past, present, and future in a way that is specific to a given period. The modern future-oriented regime of historicity has such a coercive power that it constitutes an "order of time."

> No one doubts that an order of time exists—or rather, that orders of time exist which vary with time and place. These orders are, in any event, so imperious and apparently so self-evident that we bow to them without even realizing it, without meaning to or wanting to, and whether we are aware of it or not. All resistance is in vain. For a society's relations to time hardly seem open to discussion or negotiation. The term "order" implies at once succession and command: the times (in the plural) dictate or defy, time avenges wrongs, it restores order following a disruption, or sees justice done.
>
> (Hartog, 2015: 1)

Of particular interest for this book, however, is Barbara Adam's concept of a timescape. The timescape view emphasises the coexistence of multiple forms of time within a temporal regime. Adam attends closely to the entanglement of physical and cultural temporalities that generate multidimensional and complex timescapes, asserting that humans cannot embrace time without simultaneously encompassing space and matter—that is, without embodying it in a specific and unique context (Adam, 2010: 1).

Science fiction in literature and film strongly links technology with visions of the future, a relationship explored by decades of science and technology studies. In particular, "desirable futures" are central to Jasanoff's "sociotechnical imaginaries," defined as "collectively held, institutionally stabilised and publicly performed visions of desirable

futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology" (2015: 4). The role of media such as radio and television in disseminating far-ranging visions of scientists, engineers and science policymakers is also well established (Nieto-Galàn, 2016). But so far, visions of the future have been the only expression of the technological footprint on the cultural frameworks of time.

This section's chapters broaden this scope in two respects. First, they demonstrate the intimate ties between visions of a nuclear future and visions of the past and the present, without separating questions raised by the nuclear order of time from questions about space. They next discuss questions such as the extent to which Hiroshima and Nagasaki reconfigured the modern regime of historicity, with its promises of a better future. In order to tackle such issues without reifying the nuclear order (Hughes, 2002), this section focuses on the particular cases of the world's three leading nuclear countries: the United States, France and Japan.

Because nuclear technology was first used in a global war, it could be considered simply another form of mass bombing that targets cities and kills civilians. The conventional practice of airborne attacks did not raise moral issues in 1945, and no serious objections were prompted by the shift from German to Japanese targets that was the impetus for launching the Manhattan Project (Bernstein, 1995). Does this mean that the first atomic bombs were perceived as just local operations meant to impact a global conflict, or did they generate a deep, unsettling fear of the future?

In the aftermath of Hiroshima and Nagasaki, it is obvious that nuclear technology reconfigured our sense of place and the world around us. The bombings were epoch-making events. The actors and witnesses who commented on Hiroshima and Nagasaki were quick to realise that these local bombings would reconfigure the future. They talked about the "dawn of a new era" that became known as the "nuclear age," thus conveying the image of a global transformation.

The authors in this book emphasise the striking contrast between the locality of the bombings and their global impact. Hiroshima and Nagasaki raised awareness that the human species had the power to destroy itself, to bring biblical warnings of apocalypse to fruition. In her chapter, though, Bernadette Bensaude-Vincent argues that the emergence of catastrophic visions by no means eroded the promise of a better tomorrow. Nuclear technology nurtured both catastrophic and optimistic visions of what was to come. A strikingly ambivalent order of time emerged to allow the promise of a "bright future" atop the ruins of atomic bombings.

Ran Zwigenberg (2014) has described the unabated desire for Hiroshima to be born anew, a dream the city's mayor articulated on the first anniversary of the 1945 bombing. In his chapter here, Zwingenberg tackles the critical issue of understanding why Japan, a victim of atomic bombing, came to embrace nuclear power. Atoms for Peace played a

crucial role in combining a culture of memory with plans for modernisation. Many in Hiroshima and the anti-nuclear weapons movement who supported nuclear power were motivated by a strong desire for modern life and its comforts. Japan embraced nuclear power enthusiastically in the decades following the bombing while transforming Hiroshima into a symbolic sanctuary dedicated to world peace.

Scott Gabriel Knowles closes the volume with a look at the cultural practices of memorialising nuclear catastrophes in a broader perspective. Memorial practices often center on "events," but nuclear disasters, as you will read in every chapter of this book, span multiple timescales. To emphasise the difficulties in memorialising these tragedies, Knowles introduces the notion of a "slow disaster" in which risks and fears are known long before and long after any single "event." Museums, filmmakers, artists and citizens in Japan and across the world have worked to bring dignity to victims and survivors of Fukushima and knowledge to the public. They do so in a fog of uncertainty, a fog that clouds the fate of many displaced people and raises questions about the future of life on earth.

What now? Open questions for further research

Is it possible to predict the end of the nuclear age? Nuclear technology has profoundly shaped our societies, influenced political and economic trajectories and colonised swaths of our lives. With the exception of radionuclides used in medicine, nuclear technologies have been controversial since the dawn of the "atomic age." Arms protesters have never weakened their stances, regularly assembling in Hiroshima and playing strategic roles in non-proliferation negotiations around the world. At the same time, rising environmental movements have also tempered their opposition to civilian nuclear power since the 1990s when zero-carbon energy policies started to favor nuclear power plants over more traditional mining and refining efforts. It is an uneasy moral balance when the slow disaster of nuclear fallout and the slow disaster of climate change compete in public discourse.

Nuclear technology is, in fact, aging, and its future is open to debate. The first generation of nuclear reactors is being decommissioned, while a new generation of EPR reactors comes online and other "advanced" reactors are being designed. Even in countries that have opted out of nuclear activities and claim to be "atom-free," reactor decommissioning will take decades and there will still be a demand for radionuclides for therapeutic and research purposes. Moreover, nuclear waste has a lifetime far exceeding that of political regimes.

Nuclear technologies are here—not forever, but for a duration that exceeds our power of anticipation. The world cannot be denuclearised by political decisions alone, so it seems that *there is no end of the nuclear age* in sight. Future generations must coexist with material artifacts and

contamination from this technology. The question, then, is how to adjust social and political timeframes around the inexorable lifetimes of radioactive materials. The easy solutions of storing waste aboveground or burying it underground are made complex because of the toxicity of radioactive matter. Isolating the technosphere from the biosphere is utopian thinking, since many organisms can flourish in extreme milieus and new life forms will undoubtedly make harmonious arrangements with manmade radionuclides, as is already visible in the thriving wildlife populations surrounding Chernobyl. Separation is not an option, and so adaptation becomes the only possibility.

Again, our nuclearised timescape defies the naïve hope of a foreseeable end to the nuclear age, save a Doomsday scenario. The abolition of nuclear weapons is a globally divisive issue. On the one hand, the historic Treaty on the Prohibition of Nuclear Weapons was passed by the UN in July 2017, with 122 countries voting in favor, and entered into effect in January 2021. ICAN, the International Campaign to Abolish Nuclear Weapons, received the 2017 Nobel Peace Prize for its work in helping to secure the treaty. The organisation has been working closely with survivors of Hiroshima and Nagasaki. On the other hand, not a single nuclear-weapons state supports the treaty. Not even Japan, the only country to have endured atomic bombings, supports it.[7] Furthermore, the treaty bans only the military use of nuclear weapons and does not address civilian nuclear technology.

This limited, variegated success is a call to consider the place of nuclear technologies in the global environmental crisis and to probe the connections between the nuclear order and the Anthropocene. After much debate, a working group of geologists in charge of classifying geological periods settled on nuclear technology as the best marker for the beginning of the Anthropocene; the plutonium released by nuclear tests in the mid-twentieth century fulfills the three criteria for marking a new period: it is man made, operates on a planetary scale, and lasts long enough to be relevant on the geological timescale.

We are living in an age marked by nuclear technologies so powerful that they affect Earth systemically. Not only a nuclear apocalypse threatens our lives and our safety but also the slow disaster of the technology's ongoing, mundane uses. The disturbing possibilities of a world shaped by the nuclear alert us to the emerging character of the adaptive Anthropocene—the complex relationships between planetary warming, global health issues, ecological crises, and the nuclear order.

Notes

1 M. Ishigami, Japan's Post-Disaster Reconstruction Symbol Re-Opens with Kuwait's Help, *Arab Times*, April 21, 2019, p. 3. Available at: http://www.arabtimesonline.com/wp-content/uploads/pdf/2019/apr/21/03.pdf [Accessed June 9, 2021].

2 "We" refers to humans in general rather than people whose lives have been severely disturbed, affected, or broken by the impacts of nuclear explosions or radiation. It does not mean the abstract Anthropos, the generic notion used in the term "Anthropocene." A lesson learned from Fukushima is that "we" members of the human species are bound to Earth, dependent on the drift of continents, the occasional earthquake, storms, tsunamis, winds, land, and fish.
3 These perspectives benefit from two workshops that brought together historians, anthropologists, STS scholars, and philosophers to discuss key moments in the nuclear world.
4 Wellerstein, A. (2020). Counting the Dead at Hiroshima and Nagasaki. Bulletin of the Atomic Scientists, August 4. Available at: https://thebulletin.org/2020/08/counting-the-dead-at-hiroshima-and-nagasaki/ [Accessed July 4, 2021].
5 For instance, American business magnate and philanthropist Bill Gates has been an active supporter of increasing nuclear power production to cut emission. Clifford, C. (2021). Bill Gates: Stop Shutting Down Nuclear Reactors and Build New Nuclear Power Plants to Fight Climate Change. CNBC, June 11. Available at: https://www.cnbc.com/2021/06/11/bill-gates-bullish-on-using-nuclear-power-to-fight-climate-change.html. [Accessed July 4, 2021]. Conca, J. (2021). Wyoming to Lead the Coal-to-Nuclear Transition, With New Reactor Planned by Bill Gates-Backed TerraPower. *Forbes*, June 5. Available at: https://www.forbes.com/sites/jamesconca/2021/06/05/wyoming-to-lead-the-coal-to-nuclear-transition/?sh=7090a8e56de1 [Accessed July 4, 2021].
6 This ambition to overcome our earth-bound condition seems to be the opposite of the movement, prompted by the Anthropocene, from the "infinite universe to the closed world." The planetary view of the world from the outside gives way to a view from the inside. To emphasise this radical change, Bruno Latour contrasts the condition of "Modern Humans" with that of "earthlings," humans belonging to the small fringe of the planet between the atmosphere and the soil (Latour, 2018).
7 As of June 2021, 54 states have ratified the treaty.

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