1 INTRODUCTION: THE POWER OF NUCLEAR THINGS

In late 2002, US President George W. Bush announced that Iraqi dictator Saddam Hussein had "recently sought significant quantities of uranium from Africa." The implication? Iraq planned to build nuclear weapons, and the world must act.

The scenario seemed plausible. Weapons inspectors had uncovered a clandestine program after the 1991 Persian Gulf War. Surely Saddam would try again. Bush and his advisors had been implying this for months, releasing assorted evidence to make the case. US national security advisor Condoleezza Rice insisted, for example, that Iraq had imported aluminum tubes whose only conceivable use was in a nuclear weapons program.

The administration's display of evidence gained only modest traction in the media. Behind the scenes, many intelligence officials disputed the validity of the claims.[1] With the case for a military intervention foundering, the notion of "uranium from Africa" appeared promising. It could be fleshed out to 500 tons of "yellowcake from Niger," which certainly sounded scarier than "aluminum tubes." Sidelining disputes among intelligence agencies, administration officials declared that the British government had provided corroborating evidence. No need to wait months for UN inspectors to comb the country in search of a smoking gun. After all, as Rice had warned, "we don't want the smoking gun to be a mushroom cloud."

on facing page: (top) The Nagasaki mushroom cloud, 15 minutes after the explosion and 9.4 kilometers from the hypocenter (photograph by Hiromichi Matsuda, courtesy of Nagasaki Atomic Bomb Museum). (middle) Atomic air raid wardens, Bonn, Germany, 1954 (Bettmann/Corbis). (bottom) Miners drilling into rock at Sub Nigel East Gold Mine, 1961 (Ron Stone/Fox Photos/Getty Images).

In early March 2003, experts from the International Atomic Energy Agency obtained the thin folder substantiating the yellowcake claim. It took them only a few hours to determine that the documents were forgeries—and not even good ones. But by then it was too late. In public discourse, "uranium from Africa" had topped the list of evidence pointing to Iraqi weapons of mass destruction. War plans were in motion. On March 19, 2003, a "coalition of the willing" launched an assault on Iraq. A thorough search after the invasion found no evidence that Iraq had restarted its nuclear weapons production or entered into a uranium deal.[2]

Tangled tales of intrigue emerged during the next few years. The forgeries had come to the US through unknown channels from Italian intelligence services, which had obtained them from a former agent named Rocco Martino, who said he got them from a woman employed by the Nigérien embassy in Rome. Martino had been working for French intelligence (perhaps as a double agent) and supposedly tried to sell the documents first. His French handlers had immediately spotted the fakes, doubtless because one signature was purportedly from a Nigérien foreign minister who had left office over a decade before the date of the agreement. These fakes notwithstanding, British Prime Minister Tony Blair insisted that separate evidence revealed Saddam's intentions to get uranium *elsewhere* in Africa, a claim that British intelligence has yet to substantiate.

Had disgruntled CIA agents seeking to trap the Bush administration forged the documents? How about corrupt operatives with business ties to the Iraqi opposition? Conspiracy theories abounded. In the US, the media focused on Joseph Wilson and his wife, Valerie Plame. A former Foreign Service officer who'd begun his diplomatic career in Niger, Wilson had been sent to the capital city of Niamey by the CIA in February 2002 to investigate whether Niger had sold uranium to Iraq. He found no trace of the sale. When Bush claimed the contrary a few months later, Wilson assumed that the president meant some *other* uranium-producing African nation. Upon realizing that Bush meant Niger, Wilson went public. To discredit him, the administration outed Plame as a CIA operative. A truly impressive quantity of ink, pixels, and bytes was devoted to the drama, pitting Bush stalwarts against defenders of Wilson. Bickering over personal credibility drowned out the pivotal issue of whether the president had misled the nation into war.

It also obscured the significance of the Niger episode for global nuclear relations.

Consider the political and technical parameters of the Bush administration's claims. Officials repeatedly stated that Iraq had sought uranium "from Africa." Had Saddam been suspected of approaching Kazakhstan, would they have asserted that he'd sought uranium "from Asia"? In the Western public imagination, Africa remains the "dark continent," mysterious and politically corrupt—the perfect source for black-market nuclear goods. Consider also the assumption that acquisition of uranium constituted prima facie evidence of bomb building. Before uranium attains weapons grade, it must be mined as ore, processed into yellowcake, converted into uranium hexafluoride, enriched, and pressed into bomb fuel. "Uranium" is as underspecified technologically as "Africa" is politically.

The Niger episode reflects the ambiguities of the nuclear state, and the state of being nuclear. What exactly is a "nuclear state"? Does a uranium enrichment program suffice to make one of Iran, as its president Mahmoud Ahmadinejad claimed in early 2010? Or are atomic bomb tests the deciding factor, thereby justifying Israel's insistence that it will not be the first nuclear state in the Middle East? Such ambiguities cannot be dismissed as doublespeak or grandiose rantings. They matter too much to be discounted so easily.

The nuclear status of uranium is an important aspect of these ambiguities. When does uranium count as a nuclear thing? When does it lose that status? And what does Africa have to do with it? This book argues that such issues lie at the heart of today's global nuclear order. Or disorder, as the case may be.

The questions themselves sound deceptively simple. Understanding their significance and scope requires knowing their history. Yellowcake from Niger may not have entered Iraq in 2002, but uranium from Africa was (and remains) a major source of fuel for atomic weapons and power plants throughout the world. Uranium for the Hiroshima bomb came from the Belgian Congo. In any given year of the Cold War, between a fifth and a half of the Western world's uranium came from African places: Congo, Niger, South Africa, Gabon, Madagascar, and Namibia.

This book argues that views from Africa matter not only on their own terms, but also because they transform our perspective on the power of nuclear things. They help us see that *nuclearity*—a term I introduce to
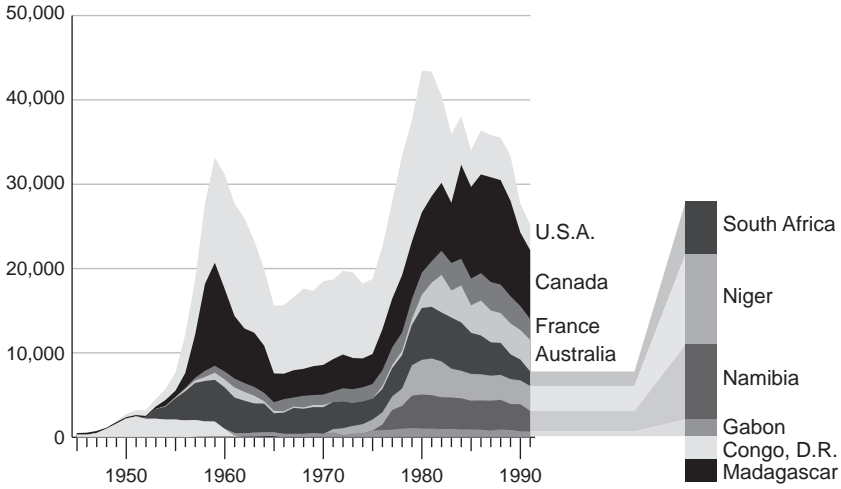
Uranium production (tons per year). (figure prepared by Evan Hensleigh with Dan Hirschman)

signal how places, objects, or hazards get designated as "nuclear"— has often been contentious. Designating something as nuclear—whether in technoscientific, political, or medical terms—carries high stakes. Fully understanding those stakes requires layering stories that are usually kept distinct: atomic narratives and African ones, histories of markets and histories of health. Part I of this book follows the path of uranium out of Africa, tracing some of its historical trajectories through the nuclear world and examining the invention of the global uranium market.

Part II enters these nuclear worlds and excavates their histories, focusing on occupational health among African mine workers. What did nuclear things mean to Fanahia, a Malagasy worker who extracted uranium ore (*vatovy*) from the desert of southern Madagascar in the 1950s and 1960s? Fanahia and his co-workers were taught that if they didn't wear dosimeters they might get fired, but they didn't realize that *vatovy* would end up in French bombs and power plants. How did Marcel Lekonaguia, who mined uranium in eastern Gabon for over three decades, experience nuclear things before he and hundreds of other Gabonese workers learned that radioactive elements had penetrated their bodies, their houses, their water, and their land?

In a very different setting, thousands of migrant workers who toiled in mixed gold-uranium shafts of the South African Witwatersrand never knew about their exposures. Most, like Kokwana Mpandana, believed that gold was the only treasure at their fingertips. Their white supervisors also remained in the dark. Under apartheid, studies documenting high radon levels remained restricted to a handful of scientists and industry officials. After apartheid ended, the mining industry lobbied for exemption from nuclear regulation, insisting that South African mines were *not* nuclear places, radiation notwithstanding. That was a far cry from the experience of workers at Namibia's Rössing uranium mine. Defying their employer and seeking independent expertise on matters radioactive, Namibian labor leaders commissioned a study on the effects of low-level radiation.

I have tried to make this work of scholarship engaging for a non-academic audience. Prologues to the chapters lay out the multiple contexts of this unruly history. This introductory chapter sets the historical stage, explains concepts, and summarizes the book's arguments. Readers interested in how markets get invented, or in matters of political economy more generally, may wish to focus on part I. Those interested in occupational health or labor history will probably prefer to skip to part II. Chapters 2, 6, and 8 cover the production of scientific knowledge and technological infrastructures. Chapters 4 and 7 cover Francophone Africa; chapters 3, 5, 8, and 9 cover Southern Africa. Chapter 10 concludes the book and explores the implications of my analysis for contemporary conundrums. The appendix offers an overview of the sources upon which I based the book.

There are yet more limits to what I could do in a single volume. My discussion of uranium conversion and enrichment is limited to South African efforts. My analysis of labor processes is mostly restricted to worker experiences with radiation and nuclearity. I do not delve deeply into the broader social and economic histories of uranium mines. My examination of radiation exposure is confined to workers; with the exception of one section in chapter 7, I do not discuss environmental contamination produced by mine and mill tailings. There is much to say about all these topics, but I must leave those challenges for later—or to others.

Still, much remains to be done. We require a multitude of starting points. Let's begin with an atomic one.

NUCLEAR EXCEPTIONALISM

The atom bomb has become the ultimate fetish for our times.[3] World order has been created and challenged in its name and for its sake. Salvation and apocalypse, sex and death: the bomb's got it all. In the two decades following World War II, "the bomb" became the ultimate political trump card, first for the superpowers (the US in 1945, the Soviet Union in 1949) then for waning colonial powers (the UK in 1952, France in 1960). Other nations soon followed (China in 1964, Israel in the mid 1960s). Geopolitical status seemed directly proportional to the number of nukes a nation possessed.

Although more than 28,000 nuclear warheads now populate the planet, they somehow retain their singularity. We still hear about "the" bomb, as in "When could Iran get the Bomb?"[4] The implication is that nuclear things are unique, different in essence from ordinary things. I call such insistence on an essential nuclear difference—manifested in political claims, technological systems, cultural forms, institutional infrastructures, and scientific knowledge—*nuclear exceptionalism*.

As a recurring theme in public discourse since 1945, nuclear exceptionalism often transcended political divisions, allowing both Cold Warriors and their activist opponents to portray atomic weapons as fundamentally different from any other human creation. The rupture in nature's very building blocks, wrought during fission, propelled claims of a corresponding rupture in historical space and time. "Nuclear" scientists and engineers enjoyed far more prestige, power, and funding than their "conventional" colleagues. Morality-speak inevitably accompanied debates, rendering nuclear things either sacred or profane. Yet whatever the political leaning, exceptionalism expressed the sense that an immutable ontology distinguished the nuclear from the non-nuclear. The difference, or so it seemed, came down to fission and radioactivity.

The technopolitical qualities of being "nuclear" made this form of exceptionalism remarkably robust. Yet nuclear exceptionalism could be made, unmade, and remade. In the early decades, exceptionalism emanated mainly from atomic energy experts and the journalists whose imaginations they captured. The utopian dreams that had accompanied the advent of railways and airplanes found their apotheosis in atomic fantasies. "Our children will enjoy in their homes electrical energy too cheap to meter,"
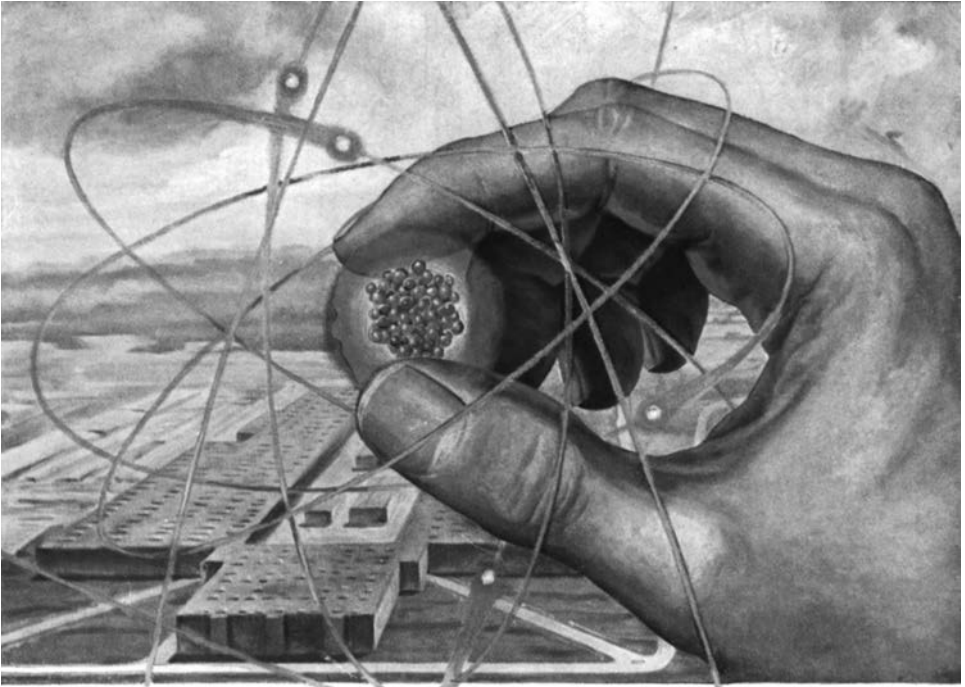
What does Atomic Energy really mean to you?

Dramatic new developments in medicine, agriculture,
and industry promise long-time benefits for us all

A 1952 Union Carbide magazine ad promised a beautiful atomic future.

the chairman of the US Atomic Energy Commission proclaimed in 1954. "It is not too much to expect that our children will know of great periodic regional famines in the world only as matters of history, will travel effortlessly over the seas and under them and through the air with a minimum of danger and at great speeds, and will experience a lifespan far longer than ours, as disease yields and man comes to understand what causes him to age."[5] Shattering the atom had apparently put humanity's ageless dreams within grasp. These were the many promises of nuclear things, and the promise of many nuclear things: limitless electricity, atomic-powered transportation, huge increases in crop yields, cures for disease, and if not eternal life at least one much longer and far more comfortable.

Utopias can be infectious. Atomic fantasies spread quickly on both sides of the Iron Curtain. Nuclear nationalism comforted state leaders anxious about their country status. The French compared reactors to the Arc de Triomphe and the cathedral of Notre Dame. The Russians likened them to samovars. In Communist China, leaders spoke of "the people's bomb"; in India, of the "Smiling Buddha."
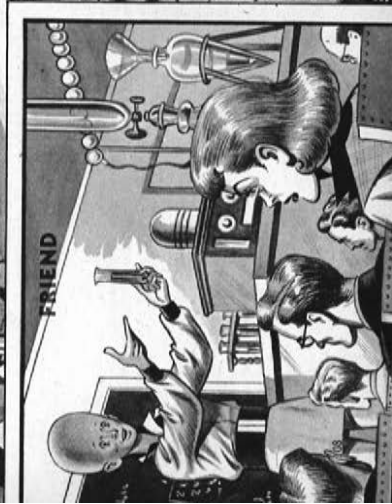
Utopian dreams breed dystopian nightmares, though, and few were more terrifying than nuclear war. Photos of Hiroshima and Nagasaki, censored for two decades, trickled out to haunt the public imagination with spectacles of horrifying burns, peeling skin, and ashy landscapes. Shortly after the atomic arms race began, the superpowers upped the ante on public anxiety by testing vastly more destructive thermonuclear weapons in the waters around the Marshall Islands and on the plains of the Kazakh Soviet Socialist Republic. As geneticists studied chromosomal aberrations caused by radiation, gigantic ants and towering lizards began to wreak havoc, at least in the reels of B movies.

Apocalypse, no longer the preserve of religion, now lay within humanity's technological grasp. Authors and directors spun out scenarios, grim and comic, for reaching the tipping point at which someone, somewhere, pushed the button to end it all. Books and movies imagined the few remaining humans taking refuge in a world sizzling with fallout. Sometimes the two apocalyptic modes merged, famously so in Walter Miller's 1959 novel *A Canticle for Liebowitz*. Set centuries after a devastating nuclear war, the novel opens by depicting a monastic order whose mission is to preserve and illuminate the remnants of scientific texts, including a blueprint signed by a soon-to-be-sainted engineer named Liebowitz. By the end of the book, humanity has reinvented the bomb and again stands poised on the brink of self-destruction.
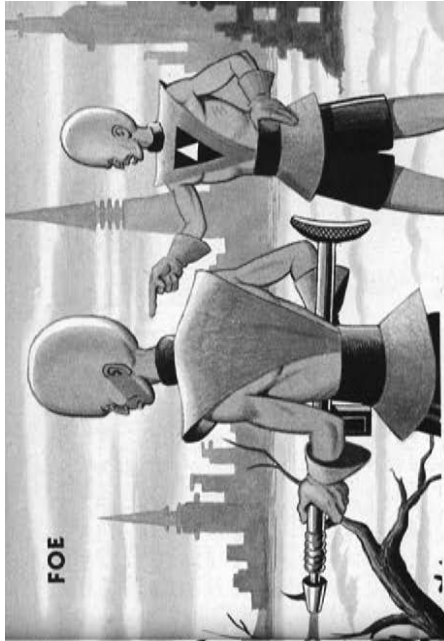
Exuberant or ghastly, nuclear exceptionalism was full of contradictions. For all the efforts at making nuclear things exceptional, there were opposing attempts to render them banal. Government propagandists assured citizens that simple gestures offered protection if the bombs did fall. American schoolchildren could take refuge under their desks, sang Bert the Turtle in the famous "Duck and Cover" ditty. Fallout shelters promised the perpetuation of suburban lifestyles in the event of nuclear war. The hyper-organized Swiss went so far as to pass building codes *requiring* fallout shelters. In the late 1970s, as a teenager, I lived in the suburbs of Zürich.

Far-fetched depictions of how radiation exposure might change the human race expressed the inherent ambiguities in 1950s atomic fantasies. (*Mechanix Illustrated*, December 1953)

My parents ignored the basement shelter, with its massive lead-lined door, leaving it devoid of the canned goods and blankets prescribed for nuclear survival. Secretly I feared the place. How and what would we breathe if the bombs fell?

The spread of commercial nuclear power brought new expressions of exceptionalism and banality, especially in the 1970s. Environmental activists seized on nuclear energy as the symbol of ruthless capitalism and its pollution. They countered the promises of cheap, abundant electricity with the prospects of meltdowns and radioactive leaks. The industry insisted that radioactivity was part of nature, nuclear power just a form of energy like all others. It published reassuring charts that compared the radiation received from the sun, airplane flights, bananas, medical procedures, and reactor proximity. When accidents at Three Mile Island (1979) and Chernobyl (1986) challenged claims to banality, nuclear experts reasserted exceptionalism in the guise of extraordinary safeguards. The nuclear industry spent *more* money than any other on accident prevention and risk mitigation, at least in the West. Chernobyl, they insisted, could be chalked up to Soviet sloppiness.[6]

With the end of the Cold War, nuclear exceptionalism shifted terrain. The "clash of civilizations" replaced the "superpower struggle," and climate change replaced nuclear war as the greatest global fear.[7] In 1989, French public intellectual Régis Debray opined that "broadly speaking, green [meaning Islam] has replaced red as the rising force." This was especially frightening because "the nuclear and rational North deters the nuclear and rational North, not the conventional and mystical South."[8] Anthropologist Hugh Gusterson calls this sort of discourse "nuclear orientalism," arguing that it has crossed left-right political divides to become part of "common sense" in the West.[9] Sure enough, at the dawn of the twenty-first century, George W. Bush's "axis of evil" formulation escalated fears that nuclearity might escape the control of the "rational North."

Discourse surrounding the "nuclear renaissance" of the early twenty-first century has hewed to the standard industry script by playing down the terrifying longevity of radiation. The prospect of the imminent apocalypse of global warming has allowed nuclear power to reemerge as a commonsense and desperately needed energy source. Predictably, within hours of the 2011 Fukushima reactor disasters, the industry scrambled to maintain a sense of banality. Exceptionalism, nuclear power advocates

Atomic air raid wardens, Bonn, Germany, 1954. (Bettmann/Corbis Images, used with permission)
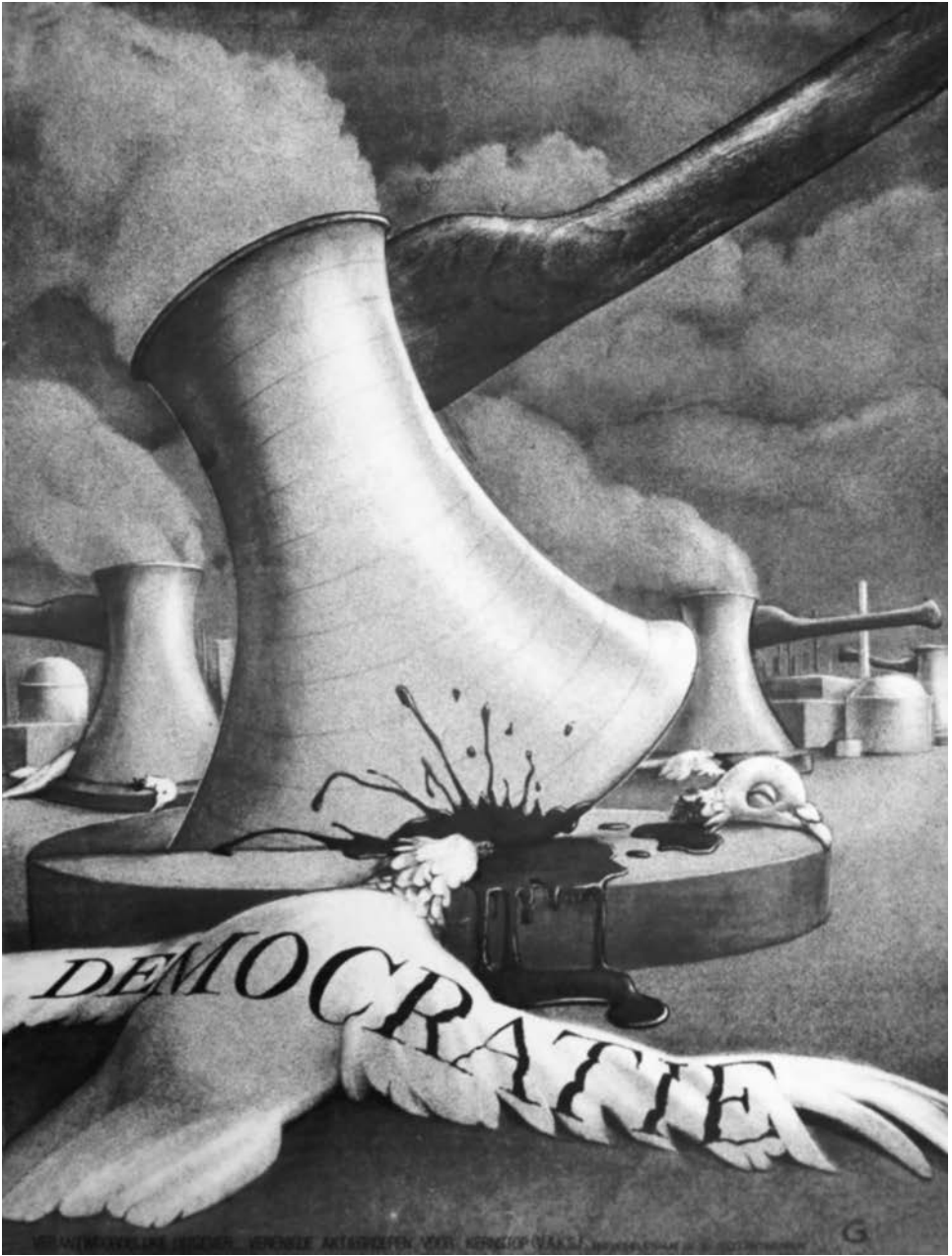
Anti-nuclear poster for Verenigde Aktiegroep Stop Kernenergie, Belgium, ca. 1978–1982. (collection of Laka Foundation; used with permission)

insisted, lay in the earthquake's magnitude and the tsunami that followed—not in the technology.

So much for public discourse. But historians and other scholars have also fetishized "the bomb" and its builders. Witness the obsession with the historical minutiae of "*the* decision to drop *the* bomb," the endless stream of biographies of Manhattan Project scientists, and the insistence on the uniqueness of moral dilemmas posed by atomic activities. Scholars who've managed to move beyond the 1950s remain caught in the trappings of nuclear exceptionalism, concentrating on electricity production and the high-tech systems surrounding weapons. Their work remains geographically centered on the Cold War superpowers and Europe, only occasionally extending to South Asia and Japan. Most treat the "nuclear" as exceptional and self-evident. I include myself among the culprits.

Here's the problem. This unreflective reflex, this certainty about which things do or don't fall into the domain of the "nuclear," simply doesn't correspond to historical realities. That can be difficult to see from the vantage point of a European reactor or a North American weapons lab. Standing in an African uranium mine makes the contingent character of nuclearity much more visible.

Consider: Yellowcake from Niger made Iraq nuclear in 2003. But in 1995 yellowcake didn't make Niger itself nuclear. According to a major US government report on proliferation that year, neither Niger nor Gabon nor Namibia had *any* "nuclear activities." Yet together these nations accounted for more than one-fifth of the uranium that fueled power plants in Europe, the US, and Japan that year.[10] Experts noted decades ago that workers in uranium mines were "exposed to higher amounts of *internal* radiation than . . . workers in any other segment of the nuclear energy industry."[11] But neither workers' radiation exposures nor their role in the global nuclear power industry was enough to render uranium mining in these countries a "nuclear activity."

So what things make a state "nuclear," what makes things "nuclear," and how do we know? Are the criteria for nuclearity scientific? Technical? Political? Systemic?

These questions are matters of ontology, questions about the things and categories of things that exist. Historical actors often deployed an ontology that appeared fixed, incontrovertible, and transparently empirical, in which essential qualities rigidly separated the nuclear from the non-nuclear.

Scholars have generally left this assumption unchallenged. Yet close exami‑
nation shows that the boundary between the nuclear and the non‑nuclear
has been frequently contested. The qualities that make a nation, a program,
a technology, a material, or a workplace count as "nuclear" remain unstable,
even today. There isn't one nuclear ontology; there are many.[12] My term
for this contested terrain of being, this unsettled classificatory scheme, is
nuclearity.

Nuclearity, this book argues, is a contested technopolitical category. It
shifts in time and space. Its parameters depend on history and geography,
science and technology, bodies and politics, radiation and race, states and
capitalism. Nuclearity is not so much an essential property *of* things as it
is a property *distributed among* things.[13] Radiation matters, but its presence
does not suffice to turn mines into nuclear workplaces. After all, as the
nuclear industry is quick to point out, people absorb radiation all the time
by eating bananas, or sunbathing, or flying over the North Pole. For a
workplace to fall under the purview of agencies that monitor and limit
exposure, the radiation must be man‑made rather than "natural." But
is radiation emitted by underground rocks natural (as mine operators
sometimes argued), or man‑made (as occupational health advocates
maintained)?

For mines to be treated as "nuclear" workplaces in any meaningful
scientific, political, or cultural sense, their radiation levels must be detected
and recorded using instruments, laboratories, and comparison data. If these
devices and institutions don't exist, if they break down, if the connections
between them are weak, then the mines devolve into ordinarily dangerous
workplaces rather than specifically nuclear ones. This is one reason why I
argue that history and geography have shaped nuclearity. Mining in Mada‑
gascar began under French colonial rule; uranium in South Africa came
from the gold mines whose labor systems formed the template for apart‑
heid; Namibian uranium became tied up with the struggle for indepen‑
dence from South African occupation. These circumstances all shaped the
institutions and technologies of uranium production. They thus shaped
how a given mine did—or did not—become identified as a nuclear
workplace.

Inherently fractured, nuclearity was achieved by laborious degrees.
Treating mines in France as nuclear didn't automatically confer nuclearity
on French‑run mines in Madagascar. Malagasy ore may have achieved a

geological nuclearity by way of Geiger counters and geologists. But this didn't translate into *medical* nuclearity that Malagasy workers could invoke to make political or economic claims. Colonial rule (and its legacies), grounded in presumptions of racial difference, made that translation particularly difficult to achieve. Making medical nuclearity politically useful would have required that Malagasy radiation exposures become visible through a denser network of instruments, labs, and the like. It would have required state agencies and courts through which claims could be filed. And it would have required that broader manifestations of nuclearity—such as the countless images and scenarios that made "the nuclear age" an "age" in some parts of the world—acquire cultural and political relevance in Madagascar. By shaping the things onto which nuclearity was distributed, time and place shaped nuclearity itself.

Put differently: *Radiation* is a physical phenomenon that exists independently of how it is detected or politicized. *Nuclearity* is a *technopolitical* phenomenon that emerges from political and cultural configurations of technical and scientific things, from the social relations where knowledge is produced. *Nuclearity is not the same everywhere*: it is different in the US and France, in Namibia and Madagascar, in South Africa and Gabon. *Nuclearity is not the same for everyone*: it has different meanings for geologists and physicists, geneticists and epidemiologists, managers and workers, Nigériens and Canadians. *Nuclearity is not the same at all moments in time*: its materialization and distribution in the 1940s and 1990s differed markedly.

To understand nuclearity, we must explore its spatial and temporal variations. Nuclearity took different shapes and had different heft in Gabon, Madagascar, Namibia, Niger, and South Africa. By excavating the historical contingencies, however, I am *not* claiming that bombs and radiation have no specific physical properties. Radiation exposure can cause diseases; atomic bombs could destroy the planet. Such properties matter to the formation of nuclearity, of course, but they do not *by themselves* determine the nature or power of "nuclear" things.

Equally important, my critique of nuclear exceptionalism is *not* an accusation of "atomic alarmism."[14] I do not discount the historical and material significance of nuclear things. Rather, I aim to show the consequences of rendering such things exceptional or dismissing them as banal.

Designating something as "nuclear" is not a straightforward act of classification. Ambivalence and ambiguity, as political scientist Itty Abraham argues, are structural features of nuclear technologies.[15] Agreements and disagreements about *degrees* of nuclearity have significant consequences. They structure global control over the flow of radioactive materials. They constitute the conceptual bedrock of anti-nuclear movements and nuclear power industries. They affect regulatory frameworks for occupational health and compensation for work-related illnesses. And sometimes they send nations off to war.

The ambiguities underlying recent struggles over the nuclear state of the world are too important to be dismissed as mere political wrangling. They are part of the "nuclear age," the claim that nuclear technologies define a phase of human history. Largely because of our mooring in time and space, we haven't known how to view these ambiguities. Our fetishes keep us close to bombs and reactors and far from other places where nuclearity gets made and unmade. We have become complacent and complicit in the equation between nuclearity and "development."

Nuclearity, like many categories, can be deployed as a tool of empowerment or disempowerment. Its significance depends on its technopolitical distribution. Its contingencies are particularly visible in African places . . . provided we don't lump all African places into a single undifferentiated geography. The temptation to do so offers another starting point for our history.

AFRICA AND TECHNOLOGY

"Africa" has also been a fetish in Western imaginations, and for far longer than the atom bomb. Savage and starving, inferior and infantile, superstitious and corrupt—the list of pejoratives goes on and on. The image of Africans as irrational took root in the Enlightenment and took off during the imperialism that followed. Europeans built political philosophies premised on the radical Otherness of Africans.[16] Armed with Maxim guns and industrial goods, they saw artisanally produced African technologies as proof of a primitive existence.[17] "Africa" became seen as a place without "technology." Colonialism, the conquerors were convinced, would transform the continent through European science, technology, and medicine.[18] During the decades of decolonization and Cold War, modernization

theorists followed suit, updating the language and tools of the colonial "civilizing mission" but sticking to its core vision: humanity perched along a ladder of development, with well-meaning Westerners at the top and Africans at the bottom.[19]

Such perceptions infused Cold War pop culture, which sometimes placed its atomic fixations and "savage Africa" in the same narrative frame. Uranium mines provided the most legitimate reason for setting atomic stories in Africa. In the 1953 film *Beat the Devil*, Humphrey Bogart and Gina Lollobrigida set off with a band of rogues to stake a uranium claim in British East Africa. An episode of the campy 1950s television series *Sheena: Queen of the Jungle*, set in Kenya, has the buxom heroine protecting "her natives" and a white-owned uranium mine from a nefarious prospector and his African sidekick, Leopard Man.

African jungles and feuding superpowers pervaded comic books too, merging again in stories about uranium mines found amid ignorant "natives" in loincloths. My favorite example comes from a 1954 *Jungle Action* comic featuring Lo-Zar, a blond, muscle-packed Tarzan clone. The lord of a remote African jungle inhabited by pygmies, Lo-Zar learns that "human beings from a red power" have invaded his "sanctuary." "Behold, little men of the Matubi tribe," he says after capturing a map from a red agent, "plans for the location of a new material for which rats like these invade our jungle and kill, scheme, and rob . . . Uranium!" Lo-Zar immediately knows what "uranium" means, even though the Matubi find the word "strange." "In the world," he intones, "there are two types of men . . . those on the side of democracies who would use it to protect their rights . . . and creatures called reds who seek destruction and terror with it!" Upon which he grabs a vine and swings off to defeat the Reds, along the way battling dinosaurs, "sentries from prehistoric ages" that signal the primitiveness of the place.[20]

Black Africans had no agency in these narratives. Their homes were sites of Cold War struggle; white heroes protected them and their resources from falling into the wrong hands.[21] Black superheroes didn't achieve distinction until the *Black Panther* series in the 1970s, over a decade into decolonization. This time uranium was rendered as "vibranium," which could "change the body structure of humans and transform them into living horrors." The African kingdom of Wakanda guarded the mysterious metal. "Wakanda history is the history of vibranium," explained T'Challa,

Lo-Zar in *Jungle Action*, 1954 (copyright Marvel Entertainment, LLC; used with permission)

the Black Panther's alter ego. Wakandans "survive and prosper because they've never been abused." Absent the depredations of colonial rule, they became a technologically advanced society dedicated to protecting the human race from vibranium's harmful effects. Their goal was financed by the sale of the metal "to research laboratories for astronomical prices."[22] In this fantasy, Africans profited technologically and financially from their resource.

Americans might have been ready to imagine Africans as technological agents in the 1970s, but apartheid South Africa marched to a different historical rhythm. "Bantu education" sought to exclude black Africans from scientific and technological knowledge. Apartheid elites viewed their nation as the product of a dialectic: nature and geography made it African, industrialization made it part of Western civilization.[23] Purple prose from the 1979 official history of the South African Atomic Energy Board, *Chain Reaction*, bore an eerie resemblance to comic book text—though the South African author was deadly serious:

In terms of human social advancement, much of the vast African continent is poor; the civilisation of today has not even reached the more remote areas and a subsistence existence is still the lot of millions of its inhabitants. But beneath the dripping jungles and the searing desert sands, in the hills and mountains and the far-reaching grassland and scrubland lie rich mineral deposits which are the envy of many nations—oil, coal, gold, uranium, diamonds, copper, chrome, cobalt and a myriad of other base, precious, and exotic minerals. . . . [T]he Republic of South Africa, with its advanced technology, is far ahead of the rest of the Continent in cataloguing and exploiting its mineral resources. . . . Although coal is believed to have been used by the Zulus several centuries ago when they exploited outcrops of it to replace charcoal for smelting iron ore, the mining of minerals really dates only from the last century; small-scale coal recovery started in the early 1800s, copper in the mid-century, diamonds nearly twenty years later and then, in 1886 came the opening up of the Witwatersrand gold fields.[24]

After gold came uranium. In this rendition, precolonial Africa was a place without technology. Even Zulu coal use seemed a matter of conjecture, not "really" a part of the continent's history. Only Europeans could fully appreciate the vast potential of African minerals. Mining, with its ability to generate wealth, thus figured as Africa's historical destiny.

Scholars have fought vigorously against the fetishizing singularity of "Africa." As historian Lynn Thomas observes, the academic field of African

history "partly came into being [at the height of the Cold War] by challenging racist, teleological, and condescending presumptions embedded in . . . conceptions of the modern."[25] Countering stereotypes of Africa as static and tradition-bound, historians demonstrated the dynamism and diversity of precolonial polities.[26] In the 1970s, scholars inspired by dependency theory argued that Europeans and Americans had achieved their supposedly exemplary industrialization thanks to slavery and imperialism. This exploitation, rather than any innate inferiority, explained the "lack" of technological development in Africa.[27]

Other writers challenged conceptions of African manufacturing and agriculture as inefficient. Both before and after the arrival of Europeans, Africans made technological choices well adapted to their social and environmental contexts. West African textile industries may not have been mechanized, for example, but thanks to their materials and skills they matched or exceeded European cloth in quality.[28] Evidence concerning early smelting and metalworking techniques demonstrates the sophistication of precolonial African innovations.[29] Social scientists have recently begun to examine technological creativity in colonial and postcolonial times, portraying Africans as skilled in designing and re-purposing a full range of technological objects and systems, from guns to electricity meters.[30]

Many of these insights have particular salience for the history of mining in Africa. Mineral extraction and metallurgy predated the arrival of Europeans by centuries, archeologists have shown, with gold, copper, and iron integral to political dynamics in many parts of precolonial Africa.[31] Beginning in the late nineteenth century, however, Europeans dramatically increased the scale of mining, fundamentally transforming many African societies and landscapes. By the early twentieth century, some 200,000 men migrated annually to work in South African gold mines. Colonial states obligingly imposed taxes to facilitate recruitment, pushing millions of Africans into wage labor.[32] Roads, railways, and ports served as symbols of the breadth of colonialism's "civilizing mission," but these sociotechnical systems were often designed to meet the narrow needs of mining and other colonial industries. The political, economic, and technological legacies of these infrastructures outlasted colonial rule.

The exploitation and violence accompanying these transformations are an inescapable part of Africa's past and, all too often, its present. But

Africans weren't passive victims of mining capital. However constrained by colonial or postcolonial conditions, miners brought their own notions of collectivity and identity to their workplaces, making choices and fashioning their own lifestyles. The economic and cultural effervescence of life in the compounds enabled miners to escape total control by management, even under the repressive conditions of apartheid South Africa. Mineworkers generated new forms of gender and ethnic expression, new modes (and expectations) of modernity. In some places, the universalizing promise of "modernization" and "development" that accompanied the start of decolonization gave labor unions means of claiming political rights.[33] All these forms of ferment varied by time and place, group and circumstance.

Demonstrating African historical, political, and technological dynamism is important for combating stereotypes about "Africa." Yet, as anthropologist James Ferguson argues, the *idea* of "Africa" as a singular place persists, replete with pessimism about its technological future. Most writers on globalization omit or dismiss African places in constructing their theories of global connectivity, describing the continent as the "black hole" of the information age.[34] Journalists follow suit, as do policy makers, financial investors, and others.

Responding to this relentless marginalization, Africanists have demonstrated how diverse places on the continent have long been connected to other parts of the world. Making such connections visible disrupts the illusion of smooth, flowing networks invoked by contemporary usage of the word "global."[35] Political scientist Jean-François Bayart uses the term "extraversion" to describe how Africans strategically seek international connections and resources in waging battles for sovereignty and survival. Historian Frederick Cooper cautions that appeals to "universal" values and supranational authority, though often powerful, also expose "the limits of the connecting mechanisms" and the "lumpiness" of power.[36]

Fruitful as this scholarship has been, it has largely left unexplored the technological systems that are so often invoked by globalization theorists as the material channels for global power in the contemporary world. So while Africanists have examined technological creativity, mining's complex history, the power of universals, and the continent's uneven connections with the rest of the world, they have yet to put all these elements together.

Technology's absence from analyses of African political agency, though doubtless not deliberate, makes it appear exogenous—a global force that

buffets ordinary Africans and turns them into victims. Such a view makes it difficult to grasp how technological entanglements permeate industrial labor in postcolonial Africa, how these entanglements both open and close political possibilities, and how their contradictions sometimes serve as sources of hope. By exploring the political, technological, and medical life of nuclearity in Africa, this book offers purchase on such questions.

Along the way, we must also remember that discourse portraying "Africa" as a place without "technology"—a trope that says as much about perceptions of what counts as "technology"[37] as it does about perceptions of "Africa"—has real political and economic effects. Although the continent contains more than fifty countries, "Africa" (like "the bomb") retains its rhetorical singularity. However misleading it may be, this perception of singularity has concrete consequences for foreign investment, for diplomatic decisions, for how many Africans see themselves, and for a wide range of other things.[38] Including some nuclear ones.

IN A (POST)COLONIAL REGISTER

In one form or another, empire has long been central to nuclear geographies. Congolese ore exploding over Hiroshima was only the beginning. Britain's weapons program exploited imperial ties to uranium-rich regions in Africa.[39] Uranium reserves gave apartheid South Africa a material role in the "defense of the West." France's nuclear program depended on ore from its African colonies. Australia, Canada, and the US found uranium in Aboriginal, First Nation, and Navajo lands. Soviet bombs used uranium produced by prison labor in East Germany or dug from mountains in Uzbekistan and Kyrgyzstan. The list goes on.

As empires crumbled, the rhythm and rhetoric of decolonization affected the power of nuclear things. Less than three months after the US bombed Hiroshima, the United Nations charter proclaimed "the principle of equal rights and self-determination of peoples." In principle if not in practice, a new world order would be built upon a foundation of equality. Independence would free Africans and Asians from the shackles of white rule. Formerly colonized people could choose their leaders, pursue economic prosperity, educate their children, and join the global community as peers. New nation-states would serve the interests of their people, who

for the first time would be citizens rather than subjects. The 1948 Universal Declaration of Human Rights was hailed as a leap forward for humankind, a moral-historical rupture, just like atomic power.

Political leaders blended nuclear and postcolonial discourses about rupture and morality in various ways. Postwar French and British leaders not only hoped that the atom bomb would substitute for colonialism as an instrument of global power, but also saw in it a means of preventing their own colonization by the superpowers. In 1951, Winston Churchill's chief scientific advisor, Lord Cherwell, said: "If we have to rely entirely on the United States army for this vital weapon, we shall sink to the rank of a second-class nation, only permitted to supply auxiliary troops, like the native levies who were allowed small arms but no artillery." Across the Channel that same year, French parliamentary deputy Félix Gaillard chimed in: "Those nations which [do] not follow a clear path of atomic development [will] be, 25 years hence, as backward relative to the nuclear nations of that time as the primitive peoples of Africa [are] to the industrialized nations of today."[40] In claims such as these, nuclearity signified power, its absence signified colonial subjugation, and the undifferentiated mass of Africa remained the metonym for backwardness.

For Europeans, such acts of technopolitical mapping had deep roots, extending the assumptions and practices of the "new imperialism" to the nuclear state and the state of being nuclear. Colonial warfare rested on the assumption that different moral structures underlay the rules for conflict with "civilized" nations and with "savages." Aerial bombing followed the machine gun as a tool of extermination, claiming its first victims in oases outside Tripoli (1911) and villages in Morocco (1913). Even as ecstatic prophets in Europe and America proclaimed the airplane's ability to ensure world peace, the RAF experimented with strategic bombing in Baghdad (1923) and the French bombarded Damascus (1925).[41]

For prescient science fiction writers, it was only a matter of time before atomic weaponry followed suit. In a Pacific war with virulent racial overtones, several hundred thousand Japanese became the first victims of the "white race's superweapon."[42] As the Atomic Bomb Casualty Commission industriously erected colonial scientific structures to study the explosions' aftermath,[43] the US and Britain had already begun to scour African colonies in a desperate bid to monopolize the magic new stuff of geopolitical power: uranium.

The equation of nuclearity, nationhood, and geopolitical power also drove atomic ambitions in new countries eager to recover from empire—especially India, as Itty Abraham has forcefully argued. India's first Atomic Energy Act was passed on 15 August 1948, a year to the day after independence. It received eloquent support from Prime Minister Jawaharlal Nehru, who declared humanity "on the verge . . . of a tremendous development." He continued:

Consider the past few hundred years of human history: the world developed a new source of power, that is steam—the steam engine and the like—and the industrial age came in. India with all her many virtues did not develop that source of power. It became a backward country because of that. The steam age and the industrial age were followed by the electrical age which gradually crept in, and most of us were hardly aware of the change. But enormous new power came in. Now we are facing the atomic age; we are on the verge of it. And this is something infinitely more powerful than either steam or electricity.[44]

In Nehru's rendition, Abraham points out, "India became colonized because of its lack of technological sophistication."[45] Indian scientists subsequently saturated their atomic energy program with postcolonial significance, proclaiming it (and themselves) engines of modern statehood. The desirability of Indian nuclear things wasn't in doubt. For the next two decades, debates focused instead on whether India should build a bomb or pursue a distinctively Gandhian—that is, peaceful—nuclearity.

Meanwhile, US President Dwight Eisenhower's 1953 "Atoms for Peace" speech to the United Nations acclaimed the emergence of atomic power plants and medical radioisotopes that served "the peaceful pursuits of mankind." The centerpiece of the initiative would be an agency that would run a fuel bank supplied principally by the existing stockpiles of "normal uranium and fissionable materials" held by governments in both East and West. "Experts would be mobilized to apply atomic energy to the needs of agriculture, medicine, and other peaceful activities," Eisenhower proclaimed, adding that "a special purpose would be to provide abundant electrical energy in the power-starved areas of the world."[46] "First World" nuclearity would thus solve "Third World" problems.

Although the fuel bank proved unfeasible, other elements of Eisenhower's proposal morphed into the International Atomic Energy Agency. Discussions about the agency's membership structure began in 1954. For Western leaders, maintaining political credibility amid rising Cold War

Eisenhower's 1953 Atoms for Peace speech to the United Nations was carefully staged as a major world event. (UN photo by MB)

tensions required the IAEA's Board of Governors to have adequate representation from both East and West. Achieving technical credibility meant that atomic expertise had to play an important role in the selection of board members. Postcolonial nations, however, challenged this nuclear geography.

Indian delegates warned that if atomic governance relied solely on technical achievement and a Cold War, East–West balance, the agency would reproduce the global imbalances perpetrated by colonialism and

industrialization.[47] The warning had become a leitmotif for Indian inter-
ventions in international forums. A year before Eisenhower's famous
speech, India had spearheaded the creation of the UN's Disarmament
Sub-Committee, calling for "the prohibition of atomic weapons and the
use of atomic energy for peaceful purposes only."[48]

Nehru had brought a similar message to the 1955 Afro-Asian Confer-
ence in Bandung, Indonesia, an event credited as the birthplace of the
Non-Aligned Movement's search for a third way in the bipolar Cold War.
Bandung's Final Communiqué specifically "urged the speedy establishment
of the International Atomic Energy Agency, which should provide for
adequate representation of the Asian-African countries on the executive
authority of the Agency."[49] During the long process of IAEA statute nego-
tiations, India followed through on its message with a proposal that quali-
fication for a seat on the Board of Governors should combine nuclear
"advancement" with regional distribution.

The sentiments from Bandung reverberated well beyond the IAEA
negotiations. The Final Communiqué had also called for peaceful uses of
atomic energy and made numerous references to nuclear weapons, assert-
ing that "the nations of Asia and Africa . . . have a duty towards humanity
and civilization to proclaim their support for disarmament and for prohibi-
tion of these weapons." The conference condemned racial discrimination,
especially in apartheid South Africa, and called for a worldwide study of
"the way radioactivity from tests of nuclear and thermonuclear weapons
spreads through the atmosphere and in the waters of the ocean."[50] Facing
the threat of fallout from French atomic tests in Algeria a few years later,
Ghanaian Prime Minister Kwame Nkrumah, internationalist activist
Bayard Rustin, and other Pan-Africanists built on the Bandung declaration,
denouncing the "desecrat[ion of] the soil of Africa in the interests of a
new "nuclear imperialism."[51]

Finalized in 1957, the IAEA's founding statute reflected India's influence
by allocating five permanent board seats to member states deemed the
"most advanced in the technology of atomic energy including the produc-
tion of source materials." Five seats were distributed according to geo-
graphical region.[52] Uranium producers in Eastern-bloc and Western-bloc
nations would rotate through another two seats, and "suppliers of technical
assistance" would rotate through one seat. The ten final spots would be
distributed among the eight IAEA regions by election.

Protest in Accra against French nuclear testing in Algeria, September 1960. (Bettmann/Corbis Images; used with permission)

The emphasis on "advancement" transformed the Cold War obsession with technological rankings into a structural feature of the IAEA. Yet geography and national history also mattered. The regional framework accommodated—even encouraged—postcolonial fantasies of nuclear nationalism. So what would make a nation count as "most advanced in the technology of atomic energy including the production of source materials"? What were "source materials," and how significant a manifestation of nuclearity were they? In the 50 years since these phrases laid the foundation for the global nuclear order, their meanings have been negotiated and renegotiated in treaties, contracts, and practices. A few examples suffice to illustrate the high stakes of nuclear exceptionalism.

Consider the role of apartheid South Africa, whose delegate was responsible for including "source materials" in the IAEA statute as an indicator

of technological "advancement." By 1956, contracts with the US and Britain had made uranium production vital to South Africa's economy.[53] Anticipating that the IAEA would play a central role in shaping the future uranium market, South Africans were determined to obtain a statutory seat on its board. But the apartheid state represented the antithesis of the postcolonial settlement pursued by India. Only by presenting a depoliticized, technical vision of nuclearity could South Africa hope to secure its seat.

When IAEA statute discussions took place in 1954-56, South African nuclearity was limited to uranium production underwritten by a small research program. This was an increasingly tenuous basis for a claim to superior "advancement," especially since uranium's nuclearity was in flux in the mid 1950s. Before that period, the uranium narrative went something like this:

• Uranium was the only naturally occurring radioactive material that could fuel atomic bombs. These, in turn, were weapons of a fundamentally new kind, capable of rupturing not only global order but the globe itself.
• Uranium ore was rare. If the West could monopolize its supply, it could keep the Communists at bay and make the world safe for democracy. The West therefore had to secure all sources of uranium around the world. Nothing mattered more.
• Uranium's significance made it imperative to proceed as secretly as feasible. Geological surveys, actual and potential reserves, means of production, and terms of sales contracts were state secrets one and all.

If uranium's nuclearity imposed secrecy, that secrecy in turn reinforced the ore's nuclearity. Uranium thus became the only ore subject to legislation specifically targeted at ensuring the secrecy of its conditions of production. By the mid 1950s, however, it had become clear that, although high-grade pitchblende was rare, lower grades of ore were everywhere. The Soviets had found their own sources, making a Western monopoly on "source material" impossible. The real challenge lay not in *finding* ore but in *processing* it to weapons-grade quality.

In IAEA statute discussions, one sign that the nuclearity of uranium ore had eroded was that nations whose primary claim to nuclearity lay in uranium production would have to rotate seats on the IAEA board. Indeed,

India had tried to relegate South Africa and Australia to mere "producers" rather than "most advanced" in their regions. Prevailing on their powerful American and British customers, South African delegates succeeded in having "source materials" count as an indicator of "advancement," even though South Africa was no more technologically "advanced" in 1957 than, say, Portugal, which also mined uranium.[54] Their difference lay in technopolitical geography. Portugal was in Western Europe, a region at the pinnacle of nuclear "advancement." South Africa was in the IAEA's Africa/Middle East region, where its competitors for nuclearity—Israel and Egypt—carried political baggage even heavier than its own.

In a time and place where the Cold War trumped racial injustice, South African "source materials" made the country nuclear enough to drown out the increasingly vocal opposition of postcolonial nations to the apartheid state. For the purposes of IAEA board membership, South Africa's uranium production served as the pinnacle of African nuclearity. That status did not falter in 1958 when the Belgians, under the auspices of the US Atoms for Peace program, built a research reactor on what is now the campus of the University of Kinshasa. Congo was then still under colonial control, and only nation-states could achieve representation on the IAEA board. Yet South African prominence did not diminish in 1960 after the Republic of the Congo achieved independence. Apartheid South Africa would not get ejected from the IAEA's Board of Governors until 1977, when pressure from the international anti-apartheid movement proved too strong to resist.

TRADING NUCLEAR THINGS

Today's media see the IAEA primarily as the UN's "nuclear watchdog," conducting inspections to certify that civilian installations haven't been diverted to military ends. But this function emerged over time. The IAEA was originally formed to *facilitate* the circulation of certain nuclear things.[55]

The South Africans craved a seat on the IAEA board because they wanted to sell uranium and shape its market. Their seat secured, they lost no time exploring these commercial possibilities. Donald Sole, the South African delegate for over a decade, used his IAEA contacts to deepen relationships with potential uranium customers. In 1959, Sole escorted two representatives of the South African Atomic Energy Board (AEB) all over

Western Europe. This "sales survey team" sought to forecast supply and demand for the upcoming decade, guess at the probable price structure of commercial contracts, and assess how safeguards might constrain the sale of uranium.[56] The tour proved so fruitful that the AEB's sales committee repeated it regularly, building on Sole's expanding network of contacts.[57]

South Africans were by no means alone in using the IAEA in this way. From its inception, the agency served as a forum (in the Roman sense of marketplace) for its members to learn about competing technologies and materials, make commercial contacts, and offer or apply for technical assistance. It was *as part of all this*, I argue, that IAEA members began discussing international rules for regulating the flow of atomic knowledge and things. I'll get to those discussions shortly, but first let's take a quick look at some of nuclear trade deals concluded inside and outside the halls of the IAEA.

In 1955, even before the IAEA got underway, the gigantic Atoms for Peace conference in Geneva was part international scientific conference, part trade show, and part intelligence-gathering operation.[58] The US had long been selling radioisotopes for medical use.[59] After Eisenhower's 1953 speech, it began exporting research reactors too, selling 25 by 1965.[60] Westinghouse and General Electric, as vendors of commercial reactors, competed fiercely for domestic and foreign customers beginning in the 1960s. The Soviets worried that Atoms for Peace deals would lead to weapons proliferation, but they worried even more about American hegemony. They began their own reactor sales to Eastern Europe in the mid 1950s, using a fuel take-back system to prevent the production of weapons-grade material. These exports, ideologically construed as instruments of modernization, served as flagships for a Soviet-style "civilizing mission" in Eastern Europe.[61]

Other countries also used nuclear exports to expand their technopolitical reach. Some of those transactions justified the Soviet fears about the proliferation risks of exporting dual-use technologies. The French began to export nuclear technology in the mid 1950s, starting with the sale of a reactor to Israel. Emulating French design, the reactor was ostensibly geared toward electricity generation but was in reality optimized for the production of weapons-grade plutonium.[62] Israeli scientists, like their French colleagues before them, promptly began churning out plutonium

for a secret bomb program.[63] In the next two decades, customers for French reactors and other nuclear systems included Spain, South Africa, Iraq, and Iran.

Canada had also developed a reactor design, and in the mid 1950s it sold a research reactor to India. Expecting to supply the fuel, the Canadians were surprised when the Indians manufactured their own fuel rods, which entitled them to keep the spent fuel. From this, the Indian scientists secretly extracted weapons-grade plutonium for use in their "peaceful nuclear explosion" of May 1974. The test was widely interpreted as part of a weapons program, rather than as an emulation of the superpowers' programs to use nuclear explosives in large-scale construction projects.[64] It outraged and embarrassed Canada, which promptly implemented a strict safeguards policy. But by then it was too late.

SAFEGUARDING THE NUCLEAR ORDER

The problem with the trade in nuclear things was the exceptionalism of things nuclear. How to buy and sell technologies that carried such heavy moral baggage and destructive potential? States not only had to agree on *how* to regulate trade, they also had to agree on *whom* and *what* to regulate. Who could be trusted with which systems? Which materials, knowledges, and systems were unique to atomic weapons? Which served civilian systems? Which were dual-use? How did technologies that served both nuclear and non-nuclear systems fit in? It seemed understood that strongly nuclear materials should be subject to stricter controls than weakly nuclear ones. Banalizing certain things promised to ease some of the tensions between promotion and proliferation. But what would banalization mean in practice?

It was clear that "fissionable materials" should be controlled, but where in its multiple stages of processing did the "source material" of uranium ore become "fissionable material"? The distinction mattered enormously because the two categories were subject to different controls. In the words of one South African scientist who participated in the IAEA statute discussions, "the definitions would have to be essentially practical, rather than 'textbook' in nature, . . . legally watertight, and must take account of certain political implications."[65] In 1957, the IAEA abandoned the more ambiguous term "fissionable material" (preferred by the Indian delegates)

in favor of three other categories: "source materials," "special fissionable materials," and "uranium enriched in the isotope 235 or 233."[66]

The new definitions alone didn't determine methods of control. The US promoted a pledge system in which purchasers agreed not to pursue military ends and agreed to accept international inspections to verify compliance. While most other nations *selling* nuclear systems paid lip service to such a scheme, buyers rejected the prospect of controls. Arguments on both ends obscured mundane political and commercial issues. The US, the UK, and the Soviet Union simply refused to accept inspections on their soil. Western European designers of nuclear systems, fearing that inspections would open the door to commercial spying, accused the US and the UK of seeking competitive advantage. They argued that Western Europe should also benefit from inspection exemption, and that Euratom, the recently created European nuclear agency, could offer sufficiently strong safeguards.

South Africa wanted to avoid any commercial disadvantage caused by mandatory controls on uranium end-use. They suspected that the Israelis, enticed by a French offer to sell them uranium with no strings attached, had broken off negotiations to buy South African uranium in 1962 because of safeguards meant to placate the US and the UK.[67] Within India, experts disagreed over whether to build a bomb at all, but at the IAEA they tried to keep their options open by arguing that regulations would perpetuate colonial inequalities and undermine national sovereignty. Overall, "Third World" nations deemed such regulatory proposals straightforward moves by the North to dominate the global South by writing the rule book in its own favor.[68]

The 1968 Treaty on the Non-Proliferation of Nuclear Weapons (usually referred to as the Non-Proliferation Treaty, or NPT) expressed all these tensions.[69] Under the NPT, "nuclear weapons states" pledged not to transfer atomic weapons or explosive devices to "non-nuclear weapons states." The latter, in turn, renounced atomic weapons and agreed to accept IAEA safeguards and compliance measures. Strikingly, the NPT invoked human rights language and the rhetoric of development:

1. Nothing in this Treaty shall be interpreted as affecting the *inalienable right* of all the Parties to the Treaty to develop research, production and use of nuclear energy for peaceful purposes. . . .

2. All the Parties to the Treaty undertake to facilitate, and *have the right to participate in*, the fullest possible exchange of equipment, materials and scientific and technological information for the peaceful uses of nuclear energy. Parties to the Treaty in a position to do so shall also cooperate in contributing alone or together with other States or international organizations to the further development of the applications of nuclear energy for peaceful purposes, especially in the territories of non–nuclear-weapon States Party to the Treaty, *with due consideration for the needs of the developing areas of the world*.[70]

In an effort to accommodate postcolonial morality and palliate the ascendancy of the Cold War paradigm, the NPT essentially declared that nuclearity of the "peaceful" persuasion was a fundamental right. As far as I can tell, no other international treaty has ever referred to a scientific or technological activity as an "*inalienable* right" of special importance to "the developing areas of the world."[71]

    The NPT codified global nuclearity but left the IAEA to implement the vision. The agency launched a major "technical assistance" program aimed at developing nations. It tried to design a safeguards system but had trouble determining which things to include. South Africa pushed to exclude mines and ore processing plants from official definitions so as to minimize external oversight of its industry. The IAEA's 1968 safeguards document *specifically excluded* uranium mines and mills from the classification of "principal nuclear facility," which were seen as "a reactor, a plant for processing nuclear material irradiated in a reactor, a plant for separating the isotopes of a nuclear material, a plant for processing or fabricating nuclear material (excepting a mine or ore-processing plant)."[72] The 1972 safeguards document further excluded uranium ore from the category of "source material," thereby exempting its production from the ritual of inspections.[73] International authorities thus didn't consider uranium "nuclear" until it underwent the conversion processes that turned it into feed for enrichment plants or fuel for reactors. By the 1970s, in other words, the nuclearity of uranium ore and yellowcake had plummeted.

    Inspections and safeguards offered mechanisms to balance the spread and containment of nuclear things. But how would exporters know what they could sell? In 1971, a group of NPT signatory states appointed

representatives to the newly formed Zangger committee, tasked with draft-ing lists of things nuclear enough to trigger safeguards.[74] The first "trigger list," which appeared in September 1974, included reactors, fuel fabrication and reprocessing plants, and enrichment plant equipment. India's "peaceful nuclear explosion," though, rendered the list obsolete four months before it was published. In the wake of the Indian test, the Nuclear Suppliers Group (which included non-NPT states like France) formed to establish more complex lists and practices.[75] Yet NSG compliance remained volun-tary even as its lists grew longer and more detailed.[76]

Much remained unresolved or underspecified. Did uranium ore count as "source material" or not? It depended on which IAEA document one looked at. Did yellowcake count as "natural uranium" for export purposes? Also unclear. These fine-grained and ever-shifting distinctions framed global trade by separating the things that could be sold from those that could not. In and of themselves, uranium ore and yellowcake were deemed sufficiently banal to be bought and sold without exceptional inspections. Even NPT signatories could export yellowcake without IAEA intervention. Safeguards on uranium sales, if they existed, consisted only of contractual promises not to use ore for military ends, an accommoda-tion between the exceptionalism of nuclearity and the banality of commerce.

This accommodation, in turn, laid down the technopolitical conditions under which "the uranium market" could exist. In the 1940s and 1950s, the US and the UK had strongly resisted the notion of a "market value" for uranium.[77] Invoking the specter of Soviet supremacy, they'd strong-armed suppliers into cost-plus pricing arrangements and kept contract terms secret. Cold War ideology had thus placed uranium beyond "the market."[78] Only after safeguards on uranium ore became defined as end-use pledges written into sales contracts did the "uranium market" emerge as an object and a practice of political economy.

That's where part I of this book begins.

PROLIFERATING MARKETS: ARGUMENTS AND THEMES OF PART I

Social scientists and humanists writing about the nuclear age have spent little time on markets. We might think of this absence as the scholarly fallout of nuclear exceptionalism. Markets, commerce, commodities, and

prices seem like ordinary topics, banal in comparison to the threat of apocalypse, the thrill of "electricity too cheap to meter," the weirdness of "atomic cocktails," the fearsome threat of radiation.

Part I of this book challenges the absence of political economy from most scholarship on nuclear topics. Specifically, it explores the place of African ores in the global uranium trade. Chapter 2 examines efforts to commodify uranium through the invention of "the uranium market," taking note of how the design of market-making tools excluded black Africans from data production and decision making. Chapters 3–5 delve into the transnational technopolitics of uranium from Africa. Chapter 3 focuses on South Africa, Britain, and Namibia. Chapter 4 looks at Gabon, Niger, and France. Chapter 5 turns to Namibia, Europe, and the US. Together, the four chapters in part I develop the following arguments:

• Uranium was re-invented as a banal commodity. Beginning in the 1960s, mining companies, brokerage firms, geologists, economists, national institutions, and international agencies all sought to facilitate the sale and purchase of yellowcake by turning uranium ore into a commodity governed by economic mechanisms instead of political ones. They created what Michel Callon and other sociologists have called market devices—technologies that generate knowledge and practices which create markets and define their means of commercial exchange. These devices served as tools for de-nuclearizing yellowcake, turning it into a banal commodity subject to the "laws of the market."[79]

• De-nuclearizing uranium offered a way to assert power over the terms of its trade. Despite claims to the contrary, politics and economics remained tightly bound in uranium's market devices. Invoking the "free market" validated a political geography in which imperial powers could continue to dominate former colonies after independence. In Britain and South Africa, the "free market" took on a valence of moral rectitude in assertions that anti-apartheid and anti-colonial sentiments should not affect the uranium trade. France invoked the "free market" to maintain its privileged access to African uranium when postcolonial Gabonese and Nigérien governments tried to assert sovereignty over natural resources.

• For African uranium producers, the shifting boundary between exceptionalism and banality was deeply entangled with the technopolitics of

state sovereignty. Precisely because it was profoundly political, the denuclearization of uranium was heavily contested. The international antiapartheid movement and the Namibian liberation struggle invoked the politics and nuclearity of uranium in seeking sanctions against South Africa. In the wake of the 1973 oil crisis, both Niger and Gabon protested French neo-colonial pricing practices that undermined their sovereignty and undervalued their ores. They diverged in their responses, though. Niger emphasized the political value of uranium for French atomic programs to ask for price increases. Gabon pursued mechanisms of banalization that would give it more control over uranium sales.

• Transnational entanglements between licit and illicit transactions suffused the technopolitics of African uranium. In the mid 1970s, Niger sold yellowcake to Libya and Pakistan, and Gabon tried to sell some to Iran. These were legitimate transactions by some lights, but not by others. Around the same time, the UN declared Namibian uranium illicit because of South Africa's continued colonial occupation. To get around accusations of illegitimate commerce, uranium hexafluoride conversion plants in Europe and the US used "certificates of origin" as market devices. These certificates erased the Namibian origin of Rössing yellowcake. The converted product thereby traversed the unstable boundary from illicit to licit thanks to a new nationality that enabled its commercial circulation.

That's only half of my story, though. The history of uranium is not just about the political economy of yellowcake. It's also about the people who dug out the rocks. It's about their labor, their bodies, and the radon they didn't know existed. To see all this, we need to shift scales and find a new entry point.

THE (NON)NUCLEAR LIVES OF MINES

Uranium ore may be high or low grade. Its host rock can be hard or soft, can contain other valuable elements (thorium, radium, copper, gold) or nothing else worth extracting. Shallow deposits are mined in open pits, whereas deep deposits require tunnels and underground shafts. Some mines extract uranium exclusively; others produce it as a by-product. Many operations include mills that crush the ore and perform the first phase of extraction using various technologies and solvents, depending on the rock,

the materials available locally, and the metallurgical expertise of plant designers. The mines then either ship the ore out for further processing or take the next step themselves and produce yellowcake.

The bottom line: uranium mines, in all their diversity, looked a lot like other mines. Underground operations were dangerous, dark, and dusty. French supervisors at the Mounana mine may have scoffed at Gabonese workers reluctant to work underground for fear of evil spirits. But regardless of whether or not spirits lurked, the work was terrifying, with its constant danger of shafts collapsing or methane exploding. A 1970 flood at Mounana trapped five miners in a cul-de-sac. The spectacle of their bloated bodies, retrieved after six excruciating days of searching, remained seared in Gabonese memories for decades.[80] And other insidious hazards lurked: if the host rock had a high silica content, for example, miners could contract silicosis.

Open pits also carried dangers, including rock falls, heat exhaustion, and ever-present dust. For miners in Madagascar (and elsewhere), the most memorable moments were the narrow escapes, like this one recounted by Jeremy Fano:

I was in the quarry, it was eight o'clock in the evening. . . . They put the dynamite in place and lit it, and it exploded. A bit of rock flew off and fell on my foot. . . . A few toes were left, and I tore them off. . . . There was blood everywhere. . . . Rebem went to go see the boss to say that I badly hurt. He arrived and said don't touch it, we'll take you to the hospital and the doctor will do it. . . . But I said no, it's too far, these toes are just here, better rip them off now. . . . Then they could bandage me in the truck on the way to the hospital. . . . They gave me ten shots in the hospital, that's when I knew I was alive again. . . . I had fainted.[81]

Three decades later, when Fano heard that a foreigner was asking questions about the *vatovy* years, he walked 10 kilometers from his home to the town where I was staying. His one concession to the old injury: unlike most other inhabitants of the region, he wore shoes.

Scary. Arduous. Painful. Dangerous. Debilitating. But nuclear? Even in places where uranium epitomized nuclearity, the association did not necessarily extend to the mines themselves.

Some experts thought it should, even as early as the 1940s. In a 1942 medical textbook, Dr. Wilhelm Hueper of the US National Cancer Institute wrote that "the oldest known source of occupational pulmonary

Workers in a uranothorianite mine in the Androy, Madagascar, 1950s. CEA vet-
erans liked the exotic look of this image. (courtesy of Cogéma)

malignancy resulting from the exposure to radioactive ores is represented
by the cobalt mines . . . in Saxony, Germany." The Renaissance physician
Paracelsus had noticed the ailment in the sixteenth century, but "it was
not until 1879 that this occupational illness was diagnosed properly as a
malignant tumor."[82] Duncan Holaday, an epidemiologist with the US
Public Health Service who struggled to introduce radon monitoring into
American uranium mines (starting in the 1950s), liked to say that "the
effects of exposure to excessive amounts of radon and its daughters were
observed and studied long before the fission of uranium was discovered."
Holaday often reminded his colleagues that uranium miners were "exposed
to higher amounts of internal radiation than . . . workers in any other
segment of the nuclear energy industry."[83] After a visit to uranothorianite
mines in Madagascar in 1960, a metallurgist for the French atomic energy
commission ruefully described an example of such exposures: "The con-
centrates are spread out in the sun on large sheets of metal and are turned
over periodically by a worker armed with a trowel or a rake. This

procedure is clearly archaic, long, and above all dangerous because the worker is exposed to dust and radiation."[84]

In 1976, the first *Manual on Radiological Safety in Uranium and Thorium Mines and Mills*, a joint effort of the IAEA and the International Labour Organization, went even further than Holaday, declaring that "uranium mining is unique in the nuclear industry in that it is the only component of the nuclear production cycle that has associated with it a significant incidence of occupational illness"—an assertion that workers who'd been sickened at Rocky Flats and other weapons production sites could easily dispute. Nonetheless, the manual went on to state that although uranium mills were much safer, they shared at least one thing in common with mines: "both are more nearly descendants of earlier technologies than part of the modern 'nuclear industry' and its recognized innovations."[85]

The implications of this otherwise irrelevant observation were clear. The dangers of uranium mines were linked to their historical roots rather than their modern nuclearity. Two decades later, the South African Chamber of Mines pursued another line of reasoning in its official comments on a post-apartheid proposal to give nuclear regulators jurisdiction over uranium mining. The Chamber insisted that "radiation protection is essentially a health issue and not a nuclear energy issue, and therefore does not belong within the Nuclear Energy Act."[86] This meant, of course, that mines should not fall under the jurisdiction of nuclear regulators.

Even the strongest advocate for nuclear regulation of South African uranium mines didn't think that high radon levels necessarily mandated mine closures. "It's no use regulating and then saying well, sorry chaps, but we're going to make ten thousand of you redundant because the levels are too high," health physicist Shaun Guy told me in 2004. Guy had spent years uncovering radon levels that the South African mining industry had tried to hide, fighting hard to obtain regulation. But, he said, "I don't agree that you close down mines because the levels are too high—that's my personal opinion. . . . A lot of people lose their jobs. . . . [With a] First World industry in a Third World country like South Africa the impact can be enormous, whereas in America and the UK the government just says close it down and that's it, there's no argument about it because there are various safety nets. . . . But there's no safety net here."[87] South African

economic conditions, Guy felt, required a different approach to risk management.

Placing a "First World" industry in a "Third World" environment required accepting higher exposure, sometimes by invoking fantasies about the efficacy of "First World" safety nets. Sometimes it meant denying the danger outright. In chapter 7, I tell the story of Dominique Oyingha and his brother, who extracted uranium for three decades at the French-run mine in Gabon. When Oyingha confronted the mine doctor regarding his sick brother in the 1960s, the doctor responded, "Are you crazy? . . . Who told you that uranium made people sick?"[88]

So knowledge about the health effects of working in a uranium mine existed "long before" the discovery of fission, at least as early as 1879. Yet throughout the twentieth century, experts had to assert and reassert the existence of radiation hazards, as though they'd been newly discovered. A cognitive dissonance emerged from inversions of historical time, from the presumed rupture between the modern and the traditional, from the presumably related gap between the First and Third Worlds. How could the *least modern* part of the nuclear industry carry the greatest danger of internal exposure to the *most modern* of hazards?

As part of the *nuclear* industry, uranium mining seemed oddly out of place in Africa. But as part of the *mining* industry, it seemed right at home. The ongoing need to reassert the unique dangers of uranium mining also reflected constant contests over those dangers. Perhaps managing radiation exposures in mines wasn't "a nuclear energy issue" at all? Perhaps those lung cancers and other ailments had as much to do with arsenic, or smoking, or dust? Was the mere *potential* of contracting lung cancer worth an economic sacrifice for everyone?

THE NUCLEAR LIFE OF RADON

Much of the wrangling concerned a seemingly straightforward question: Does radon exposure cause cancer? Uranium atoms decay into radon, which then decays into other elements that, when inhaled, lodge in the lungs and bombard soft tissue with alpha particles. Determining if a particular lung cancer was triggered by radon exposure gets complicated, though. Let's break the question down into its three constituent parts: radon exposure, cause, and cancer.

First, radon exposure. How much radiation *from radon* did mineworkers absorb? Before the 1980s, personal dosimetry captured only external exposure from gamma rays, the type of radiation that penetrates clothes and skin, causing burns and internal cellular damage at high doses. Unlike gamma levels, which are easy to predict from the ore grade and can be detected using a simple piece of film, alpha levels are inherently unpredictable and vary throughout the mine with the type of rock, the mining activity, and the ventilation system. At first, only heavier instruments stationed throughout mining areas could capture radon readings. Most mines chose to average these results, which undervalued the dangers of "hot spots" far from the air vents, where reduced ventilation meant elevated radon daughter levels and higher temperatures—the kind of place where (for example) white foremen stationed black workers in South African mines. As we'll see in greater detail throughout part II, measuring radon exposure presented significant technopolitical complications.

Next, cause. According to standard scientific practice, determining causality requires isolating the effects of a contaminant. Did illness in uranium miners come only from radon exposure, or did other contaminants (such as tobacco) contribute or even serve as the primary trigger? Researchers proceeded in two ways. The epidemiological approach favored by the US Public Health Service involved calculating exposures, tracking individual histories, recording physiological characteristics, and statistically analyzing data for meaningful correlations. Collecting data presented endless challenges. Even if scientists reached consensus on their choices, doubts about the conclusiveness of the analyses persisted among mine operators, atomic energy agencies, and experts from other fields. Statistics offered correlation, not certainty about cause.

By contrast, animal experimentation, such as that favored by French atomic energy scientists, *was* equipped for causal determination. It seemed simple: Expose rats to radon and see if they got cancer. They did. Did tobacco smoke make it worse? Yes. Case closed? Not quite. People aren't rats. Just because rats got cancer didn't mean that people would. Lung size, air intake rate, and bronchial mucosa all mattered for *how* and *how much* radon caused cancer. Therein lay the vulnerability of animal experimentation. More research, please! For both the epidemiological and experimental approaches, conclusive causality proved endlessly elusive.

We'll explore the problems of establishing causality in more detail in chapter 6. It's worth noting that similar issues have long plagued studies of other occupational and environmental contaminants. The effects of asbestos, lead, silica, vinyl chloride, and pesticides have all been thrown into doubt by corporations pitting epidemiology against experimentation and invoking the specter of uncertainty. Tobacco industry officials cynically boasted that "doubt is our product."[89] Doubt produces delays in setting standards, in creating regulations, in testing, and in enforcement. It lowers operating costs and raises profits. Contaminants may be recognized and regulated in one place but not another; many industries distribute their hazards across international borders for precisely that reason. So radon and radiation were by no means unique, although they were paradigmatic—at least in the US, where cultural anxiety about radiation during the Cold War alerted labor leaders and the public to the possibility that invisible dangers lurked in industrial activities.[90]

At last we come to cancer itself, which is difficult to see and treat, especially in Africa. First there's the problem of time. Radon exposure takes 10 to 30 years to instigate disease. That's a long time to track people in a scientific study. It's also enough of a lag to generate doubt about the link between exposure and illness. In France, Gabon, and Namibia, miners often worked for the same company for decades. In the US, Madagascar, and Australia, mine operations typically lasted less than 10 or 15 years, making it difficult to find out whether workers subsequently contracted cancer.

Next comes the problem of detection. Even a mining site that has dedicated doctors and clinics can't detect cancer without the right diagnostic tools. Mine clinics are rarely outfitted with the proper tools, often because officials aren't interested in finding cancer. So argues Jacqueline Gaudet, from whom we'll hear more in chapter 7. Both of Gaudet's parents contracted cancer while working at a mine in Gabon. Misdiagnosis by mine clinicians meant that effective treatment was too late by the time the family returned to France. The lack of diagnostic tools at the mine, Gaudet insists, enabled operators to claim that there were never any cancers at all. When even French citizens lacked access to life-saving diagnosis and treatment, what hope was there for African workers?

Finally, as historian Julie Livingston argues, the global health community has until recently treated cancer like a "First World" disease. Many researchers have assumed that Africans simply don't live long enough to contract

most types of cancer. Oncology got a promising start in post–independence Uganda, but by the 1970s it had withered under the effects of political violence and structural adjustment. Since then, oncological research and development has been geared toward patients in rich countries with extensive medical infrastructures, an approach that has favored expensive treatment plans.

In contrast, public health in most African countries has been influenced by colonialism, missionary work, mineral extraction, and other external interests. Its focus on infectious disease, malnutrition, and fertility has shaped statistical collection and policy planning in ways that make it difficult to introduce new dimensions.[91] Among other repercussions, this has led to a near-total absence of national cancer and tumor registries. As we'll see in chapter 9, when Namibian labor leaders began to worry about cancer and called for research into the health effects of local uranium mining, the lack of a Namibian registry posed an insurmountable stumbling block. How could anyone know whether uranium had caused *excess* cancer without a baseline against which to measure the surplus?

The question of causality—"Does radon cause cancer?"— has always been a historical and geographical question. It has no single, abstract answer above and beyond the politics of expert controversy, labor organization, capitalist production, or colonial difference and history. That answers depend on the friction between these, however, is most clearly visible at the margins of nuclearity.

NUCLEAR WORK: ARGUMENTS AND THEMES OF PART II

Uranium mines—especially in Africa—were at the margins of an industry driven by claims to exceptionalism. Compared to reactors and bombs, they appeared banal and peripheral, more closely allied (technologically, politically, and geographically) to other forms of mining than to other nuclear things. Indeed, many aspects of the stories I tell about African uranium miners resemble the histories of labor and occupational disease in asbestos or gold mining.[92] That's part of my point. The nuclearity of uranium mines was not self-evident. It was not handed down from on high. Nor was it their only significant characteristic. The real, material similarities with other mining workplaces often made nuclearity *more* difficult and laborious to produce.

Part II of this book examines the considerable work required to make African uranium mines nuclear. Chapter 6 presents a history of "global" data and standards for radon and radiation exposure, paying attention to the invisibility of African uranium miners in this process for over five decades. Chapters 7–9 explore how and why miners in Madagascar, Gabon, South Africa, and Namibia did or did not construe their labor in nuclear terms. Together, the four chapters in part II develop the following related arguments:

• Standards for radon exposure were fundamentally technopolitical. Radon exposure standards reflected the tensions in reconciling scientific research results, technological systems for measuring and containing radiation, national imperatives, corporate profit, international organizations' quests for global authority, and shifting power relations between experts, corporations, and labor. Since the 1970s, the International Commission for Radiological Protection (ICRP) has promoted the exposure philosophy of ALARA: As Low As Reasonably Achievable. "As low as" reflects the rough consensus that all radiation exposure has some health effect; "reasonably achievable" represents a concession to economic and political imperatives (and power). Buried deep in the ICRP's philosophy is the assumption that human lives have different values in different places. As we'll see, this philosophy has been interpreted as legitimation for spending less to protect workers in poor nations who have remained invisible to experts.
• Invisibility was systemic but not always deliberate. Invisibility resulted from what historian Michelle Murphy calls regimes of perceptibility—that is, assemblages of social and technical things that make some hazards and health effects visible but leave others invisible.[93] Such regimes had local, national, and global dimensions that included dosimeters and protective equipment, laboratories for analyzing exposure results, mechanisms for communicating those results, national regulatory systems, manuals, guidelines, and conferences. We'll see, for example, that radiation experts in apartheid South Africa deliberately avoided studying radon exposures of black miners. In Europe and North America, experts accepted the South African rationales for excluding black workers because these rationales matched standard epidemiological criteria for selecting study populations.
• The stakes of inclusion or exclusion were scientific, political, and corporeal. For varying reasons, radon exposures endured by miners in South

Africa, Madagascar, and Gabon never became scientific data. This absence
shaped biomedical knowledge, allowed for greater exposure, and permitted
the absence of occupational health regulation. For example, radiation
levels in South African mines remained unregulated for decades, with
untold results for miners. Where regulatory principles did exist, actual
practices diverged significantly. The standards and rules at Mounana, for
instance, weren't necessarily tied to state supervision and weren't always
implemented.

• Some African miners eventually developed politically usable forms of
nuclearity; others didn't. In none of the countries I examine did uranium
miners achieve "biological citizenship," a term that anthropologist Adriana
Petryna uses to describe how Chernobyl victims used their radiation
exposures to fashion new identities and lay claim to health care, welfare,
and other resources.[94] Some miners, though, came closer than others to
making their exposures politically, socially, and medically meaningful.
Because uranium production in southern Madagascar ended long before
workers could file claims in transnational arenas, it never achieved a nucle-
arity that allowed Malagasy exposures to serve as a resource for postcolo-
nial claims making. Although Gabonese workers remained largely unaware
of their specific exposures, they eventually developed their own sources
and contexts of knowledge about radiation, which enabled them to seek
compensation and remediation after the mines closed. For their part,
Namibian uranium workers used political alliances formed during the
liberation struggle to develop a sophisticated sense of nuclear exceptional-
ism and its political possibilities.

AFRICA AND THE NUCLEAR WORLD

This book argues that nuclearity has never been defined by purely techni-
cal parameters. Like other master categories that claim global or universal
purview, the "nuclear" both inscribes and enacts politics of inclusion and
exclusion. Neither technical function nor radiation sufficed to make
African nations and their mines nuclear. Part I argues that the nuclearity
of African uranium—along with the banalization of uranium ore more
generally—was closely tied to the political economy of the nuclear indus-
try. This had consequences for the legal and illegal circulation of uranium
and for the global institutions and treaties governing nuclear systems. Part
II argues that the historical and geographical contingencies shaping the

"nuclear" as a category also had profound consequences for the lives and health of mineworkers.

In no way can we point to neat divisions between "global" processes and "local" examples. Institutions and agreements that claimed "global" purview, like the IAEA, the ICRP, and the NPT, were themselves "local" by virtue of their inclusions and exclusions, by the ways they circumscribed knowledge, defined expert communities, and conducted debate. The concepts, standards, and practices they produced changed *every time* they were implemented, either on the ground or underground.

Anthropologist Anna Tsing uses the notion of *friction* as a metaphor for the creative and destructive power generated by "universal" concepts and practices when they travel.[95] This friction calls attention to the unevenness with which knowledge travels, the inequalities that shape its motion, the always-local circumstances that change its content along the way, and the material consequences of its motion. The production and dissolution of nuclear things in African places, I argue, occurred in the friction between transnational politics and (post)colonial power, between abstract prescriptions and embodied, instrumentalized practices.

Along the way, I demonstrate not just the uneven spatial distribution of nuclearity, but also its uneven temporalities. There was no moment in global time when the nuclearity of uranium mines became forever settled everywhere. Variations depended in part on clashes between different historical rhythms: decolonization and Cold War; knowledge production and capital flows; mine openings and closures; apartheid, transnational activism, and postcolonial politics.

The stakes of Africa's absences from the nuclear world continue to accumulate. In the uranium boom currently in progress across the African continent, mine operators and state officials—invoking the need for "social judgments" advocated by the ICRP and other international sources of authority—pit the immediate urgency of "development" against the long-term uncertainties of exposure. This book documents the historical and ongoing struggle to see Africa in the nuclear world, and the nuclear world in Africa.