EDGES OF EXPOSURE

Toxicology and the Problem of Capacity in Postcolonial Senegal

NOÉMI TOUSIGNANT

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To the memory of
Binta "Yaye Sall" Kadame Gueye,
of Mame Khady Gueye and Maya Gueye,
and of Jeannette Baker Tousignant

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Introduction · Poisons and Unprotection in Africa

In early 2008, astonishing levels of lead were detected in the soil and bloodstreams of the community of Ngagne Diaw. Over a prior four-month span, eighteen young children had died there, in a neighborhood of about 950 residents nestled between the coast and the main road leading out of Dakar, the capital city of Senegal in West Africa. Other children suffered convulsions, vomiting, brain inflammation, and loss of concentration and muscle coordination. Some siblings of the deceased children were found to have blood-lead concentrations above the threshold considered to be fatal. Investigations traced this exposure to a recent surge in the price of lead purchased by Indian entrepreneurs. Residents of Ngagne Diaw had long broken and burned used lead-acid car batteries (ULABS) to scrape out lead for fishing weights. In 2005, however, this recuperation activity intensified. Battery debris and lead scraps piled up in and around homes. Toxic lead dust settled on the ground, walls, and floors. It touched skin and was inhaled and ingested.[1]

What can this tragedy tell us about poisons in Africa, and in particular about missing and possible protections? By 2010, when I came to Dakar to study the contemporary history of toxicology, various interpretations were taking shape. One was argued by Adama Fall, a Senegalese lawyer, in

a recent prize-winning plea for this case in an international human rights law competition.[2] Fall set up a striking parallel between the killing of children by lead and the earlier shooting of thirty-eight West African soldiers by the French colonial army in the nearby military camp of Thiaroye in December 1944. This was not simply to point out that the place was prone to tragedy. The massacre of Thiaroye, a topic of well-known films as well as poems, plays, and a novel, has become symbolic of the hypocrisy of late-colonial promises of citizenship.[3] At the very time when France was recognizing its colony's services to the nation and rights to political participation, the African soldiers' demands for decent working conditions and back pay were violently repressed. Seventy years later, a stone's throw from the soldiers' graves, the state had again, Fall implied, betrayed its (potential) citizens. Fall accused the Senegalese state of a series of specific failures: to enforce a long list of national laws and ratified international conventions on worker and environmental protection, and on toxic waste; to effectively regulate and prosecute the guilty transnational firm; and to care for and compensate the poisoned. A proposed plan to relocate Ngagne Diaw's inhabitants had even triggered rumors of a plot by state authorities to grab valuable land in the bottleneck of the densely inhabited Cap-Vert Peninsula. By locating the poisoning in a longer history of state betrayal, Fall echoes readings of other toxic tragedies in Africa, notably the illegal dumping of waste in the city of Abidjan, Côte d'Ivoire, in 2006. These feature a predatory, or at least powerless, state exposing its population to literally poisonous global capital, which inflicts the riskiest forms of extraction and disposal on the cheapest, least-protected lives.[4]

This first interpretation, then, focuses on *exposure*. In the management of the contamination, a second interpretation took form, which instead cast the crisis as a problem of technical capacity. The Blacksmith Institute, a US-based NGO describing itself as "dedicated to solving life-threatening pollution issues in low- and middle-income countries,"[5] was the first institution called in to help in Ngagne Diaw.[6] Although the NGO (since renamed Pure Earth) calls attention to the synergy between toxic risk and economic vulnerability (captured, a few years after the decontamination of Ngagne Diaw, by the expression "the poisoned poor"), its focus is pragmatic. It frames poisoning as a humanitarian crisis, requiring immediate, mobile, and minimal yet lifesaving protections.[7] In Ngagne Diaw, Blacksmith provided expertise and financing for soil removal, house-to-house cleaning, and an awareness-raising campaign on the dangers of lead. It also

provided a portable testing apparatus to measure initial and dropping lead concentrations in soil and blood, thereby obtaining proof of the operation's success in averting the "imminent danger" of epidemic poisoning.[8] Thus Blacksmith presented its intervention as bridging vital gaps in Senegalese state capacity to monitor and eliminate deadly exposures.

Those who carried out the activities supported by Blacksmith and by the World Health Organization (WHO) were experts and technicians working for the Senegalese state. Notably, a small team from the recently established Centre Anti-Poison (Poison Control Center, CAP) was the first to diagnose elevated blood-lead levels. The CAP staff then assisted the Blacksmith and WHO teams in confirming the poisoning and was then put in charge of screening, monitoring, education, and the organization of the drug supply for chelation therapy (to remove lead from the body). Led by toxicologist Amadou Diouf, who was also head of the toxicology department of Dakar's Université Cheikh Anta Diop (UCAD), this team's commitment to detecting and managing poison in Senegal was not limited to the time and place of the crisis of Ngagne Diaw—a "toxic hotspot" in Blacksmith's vocabulary. It was part of a much longer history of efforts to measure and monitor toxic threats in Senegal.

From Diouf and his team's perspective, the horizons of missing and possible protections from poison extended well beyond Ngagne Diaw. Since the 1970s, toxicologists at the university (then named the Université de Dakar) have worked to track down toxic traces in Senegalese bodies and environments, and called for the expansion and routinization of surveys and testing. The head of the university's toxicology unit proposed to create a national poison control center as early as 1973. As money for research and testing came and went, as equipment arrived and broke down, as the plausibility of expansive, regular control faded, toxicologists continued to investigate, even if sometimes on tiny scales, the presence of poisons in Senegal. The very existence of a poison control center, if only as a modest staff and operating budget, at the time the tragedy struck in 2008 owed much to Diouf's tenacious lobbying over the previous years. Diouf's preexisting connections to a private medical laboratory in Dakar, as well as with Blacksmith, also shaped the response to Ngagne Diaw. The private lab helped Diouf get the first tests for lead done on blood drawn from siblings of the deceased children (its staff performed some routine tests on the blood, then shipped samples to France for other tests, all for free). Indeed, Diouf had relied on these connections before to obtain free testing for a study of

exposure to lead in a tiny sample of car mechanics and ULAB recyclers in Dakar—this experience, some colleagues suggested, helped him guess the cause of deaths in Ngagne Diaw. By 2010, the CAP team was working, from a half-finished building and without any laboratory equipment, to take poison control beyond crisis control and into regular, long-term surveillance and response services such as the collection of epidemiological and incident data and a 24-7 poison helpline.

For Senegalese toxicologists and their colleagues,[9] the pasts and futures of Ngagne Diaw are not only of cumulative exposure, as in Fall's plea, or of a static gap in capacity, as Blacksmith sought to bridge. They are of working, succeeding, and failing to gain, keep, and stretch the material and institutional capacity needed to detect and define toxic risks in the country.[10] This history of *struggle for capacity* is what I describe in this book. The rhythms of this struggle have been intermittently set in motion by investments in Senegalese scientific research, in higher education, and, occasionally, in the monitoring of toxic contamination. More often these rhythms have been stilled and interrupted by stagnating budgets, the end of project funding, the breakdown of equipment, and the wait for an overseas trip. Yet pushing into and against broken rhythms of funding, supply, and repair, toxicologists have also fought to extend and hold together fragments of testing capacity and knowledge. They have sought to set the cadence of acts of detection, surveying, and surveillance into more regular, continuous, and cumulative patterns. This struggle is not one of heroic self-sacrifice for the public good; toxicologists in Senegal have, like most scientists anywhere, pursued capacity as a condition of professional survival and success. Still, they have done so as *public* scientists, defined as such by their funding and institutions, and also as practitioners of a set of techniques and expertise that, historically, has become central to how modern industrial societies protect their publics from collective toxic risks.[11] Their pursuit of capacity (and narration of this pursuit) has thus attempted to tie professional ambition to public service and protection.

In this, their success has been partial at best. The majority of their studies have been modest in scope and scale, revealing points of contamination—for example, the presence of pesticides and aflatoxins (the toxic metabolites of some strains of fungus that grow on foodstuffs, particularly under poor storage conditions) in some foods—that have not been linked up to more extensive surveys, regular monitoring, or regulatory action. This work has probably been more effective in obtaining publications and promotions

for toxicologists than any real protections for the Senegalese public. Ultimately, the struggle for toxicological capacity seems largely futile, unable to generate protective knowledge other than as fragments, hopes, and fictions.[12] Still, these fragments count; they map the partial contours of a "landscape of exposure,"[13] pointing not merely to the absence of capacity and protection but to its edges and missed possibilities, where knowable toxicities circulate, uncaptured by analytical equipment, epidemiological surveys, or monitoring routines.

Following toxicologists through their three main institutions in Senegal—a public university laboratory, an ecotoxicological project/center, and a national poison control center—this book weaves together an account of intermittent and insufficient investments in toxicological capacity with fine-grained descriptions of how scientists have kept equipment, labs, projects, and careers going. Its main focus is on what "good science" has meant—in practice, memory, goals, and dreams—to chronically underfunded and ill-equipped scientists. In this, protection from poison figures more as a form of moral imagination (or fiction), which gives value to fragmentary and sought-after capacity, than as a fully articulated vision of how enhanced capacity might initiate and feed into a denser and more effective network of mechanisms of prevention and control. Indeed, neither I, nor toxicologists in Senegal, suggest that better-equipped laboratories and institutions would automatically, or directly, translate into better-protected populations. Avoiding exposure requires many forms of protection, from expanded choices about where to work and live to a variety of types of regulatory investigation and action. Yet the detection of toxicities seems a crucial step in making contamination a topic of public debate and public protection.

It is true that no one is fully free or protected from exposure. Toxicology in Senegal (or other low-resource settings in Africa and the Global South) may not be exceptional in its "powerlessness" to control risk.[14] The world we now live in, some say, is toxic; our bodies are all a bit synthetic.[15] Seeping across social, spatial, and biological lines, omnipresent toxicity is, in Ulrich Beck's "risk society," part and parcel of the inherent risk of late-modern society; its uncontrollability manifests the limits of scientific expertise.[16] Industrial capitalism generates not only risk, David Pellow adds, but also inequality.[17] Economic and environmental vulnerabilities intersect in the uneven distribution—on both national and global scales—of the toxic burdens of progress and growth. Yet whether emphasizing the inevitability of

exposure or its uneven distribution, there is a widespread tendency to take for granted that at least *minimal* acts of toxicological detection and protection are routinely provided to residents of the Global North and are largely absent in the Global South.[18]

To delineate gaps in toxicological capacity is to acknowledge that opportunities to protect from (and to politicize) toxic risk are *withheld*. There is an excellent literature on toxicology in higher-resource settings, especially in the United States, exploring how and why potentially protective knowledge has been obstructed and obfuscated, and how scientists have, in some cases, fought against these limitations.[19] Yet very little scholarly attention is paid to toxicology and toxicologists under more extreme conditions of material scarcity, dependence, and uncertainty. In other words, the overlapping geographies of environmental and scientific dispossession, where "the poisoned poor," in Blacksmith's words, meet, in Africa, what Paulin Hountondji has called "impoverished science,"[20] are largely unexamined. This is the space through which this book moves. It focuses, in its details, on what (un)protection means to scientists' own understandings of capacity, identity, success, and service. On a more general level, however, it is also a plea to invest—for the sake of public health, environmental control, and public debate—in toxicologists' capacity to reveal, measure, map, and keep tabs on the presence of otherwise invisible forms of contamination and exposure in Africa, or elsewhere such capacity is inadequate. I also want to give recognition not only to the futility but also to the persistence, energy, and hopefulness of toxicologists' pursuit, in Senegal, of toxicology as a public and protective science.

AFRICAN MAPS OF EXPOSURE

Poisons in Africa raised scandal before the tragedy in Ngagne Diaw. Three occurrences in particular have prompted commentary on Africans' extreme exposure to the risks generated by a globalizing economy. An early wave of protest arose when, in the late 1980s, the story broke that hazardous industrial waste was being exported from wealthy economies to West Africa.[21] The patterns of environmental racism—siting toxic production and waste near the dispossessed and discriminated—that were under protest in the United States[22] seemed to be going global.[23] A few years earlier, in 1984, a lethal toxic leak at the American-owned pesticide plant in Bhopal, India, was interpreted as a manifestation of the literally poisonous effects

of trade liberalization in an unequal world, facilitated by poverty and unchecked by adequate mechanisms of accountability, regulation, and wealth distribution.[24] Yet waste dumping in Africa, labeled "toxic terrorism,"[25] was also a specific reminder, in the words of journalist Sam Omatseye, "of what Europe has always thought of Africa: A Wasteland. And the people who live there, waste beings."[26]

The second scandal emerged around a leaked memo, signed in 1991 by Lawrence Summers, then chief economist at the World Bank. The memo defended (in jest, Summers claimed) the migration of "dirty industries" to developing countries, citing Africa specifically as "under-polluted" but also as less likely to resist with demands for "a clean environment for aesthetic and health reasons."[27] Scholars seized on the memo as an exceptionally blunt expression of the logic underlying the distribution of toxic risk, and of how this logic exposed Africa in particular. For Rob Nixon, the memo "triply" dismisses Africans: as political agents, as victims of pollution, and as environmentalists.[28] James Ferguson presents it as a "raw form" of the reasoning by which the World Bank justified structural adjustment programs (SAPs) in Africa, suspending "social and moral values" as (potentially protective) buffers of economic rationality.[29] In the introduction to her ethnography of cancer care in Botswana, Julie Livingston cites the memo to illustrate how the prevailing model of epidemiological transition has posited Africans as "biologically simple publics" whose pretransition bodies—afflicted by "infectious disease, fertility and malnutrition"—are unlikely to register toxic effects, especially delayed ones like cancer.[30] Leaked shortly before the implementation of the Basel Convention—an international agreement on the transboundary circulation of hazardous waste adopted in 1989—the memo seemed to warn that regulatory responses would not be enough to stop the powerful forces driving toxic redistribution.[31]

Sure enough, the densification of this international regulatory framework on toxics (the Basel Convention was followed by the Rotterdam and Stockholm Conventions, adopted in 1998 and 2001, respectively)[32] failed to prevent the disposal of dripping drums of toxic caustic sludge around the city of Abidjan, Côte d'Ivoire, in 2006. The official toll was of fifteen to seventeen deaths, and more than 100,000 cases of "nausea, headaches, breathing difficulties, stinging eyes and burning skin."[33] Tracing the sludge to a Dutch commodity-trading company and an Ivoirian company's offer of cheap disposal, an Amnesty International and Greenpeace investiga-

tion casts this exposure as a "story of corporate crime, human rights abuse and governments' failure to protect people and the environment."[34] This failure of protection has been analyzed in explicitly postcolonial terms. The legal scholar Lassana Koné places the illegal dumping—along with the more insidious exports of waste for "recycling," which international mechanisms have struggled to regulate—under the label of "toxic colonialism."[35] As an example of how empire, as a persistent process of ruination, exerts aftereffects, Ann Laura Stoler calls the Abidjan sludge "toxic debris."[36] For Alex Means, the tragedy exemplifies the Ivoirian state's "toxic sovereignty," which, following Michael Hardt and Antonio Negri, is reduced to an "emergency apparatus" that functions only to facilitate the smooth circulation of capital.[37] Set against post-independence expectations in Africa, especially in Côte d'Ivoire, of economic and political emergence and future global convergence,[38] the "stinking toxic waste," writes Sarah Lincoln, materialized "the gap between postcolonial expectation and postmodern disillusionment."[39] Véronique Tadjo, in a collection of texts for the fiftieth anniversary of African independence, aptly expresses the imbrication of contamination with lost hopes of sovereignty and accountability:

> Independence. Liberating ourselves from fatalism and wasted destinies. . . . I haven't even spoken of the toxic waste dump, still alive, still active in the heart of the city. This acrid smell in the air, it is the poison they force us to breathe in. . . . We must refuse, rise up against dereliction. But who are our masters anyhow? Who are they to not pity those they govern. . . . Our greatest struggle, our real independence now is way beyond the squabbling of politicians who wreck our existence. It is what we will leave behind us that matters, what we do of our present that counts.[40]

The framing of poisons in Africa has thus drawn on a strong association between toxicity and *waste*, both as literal waste that is dumped, as an external, material assault on Africans, and as symbolic of the continent's superfluity in the global political-economic order, that is, of Africa *as* waste.[41] This is a useful starting point for thinking about the cumulative and intersecting vulnerabilities—biological, economic, political—through which exposure is amplified. It also links failures of protection both to the political-economic constraints facing African states and to the continent's place in the global imagination: as a dumping ground; as epidemiologically, environmentally, and technologically not yet modern; as cheap and

unregulated; and as in need of rational economic solutions. This framing, however, largely eludes two issues that are of great concern to toxicologists in Africa, and which therefore inform this book.

The first is what Rob Nixon calls the "predicaments of apprehension."[42] Not only is waste symbolically charged, but it is also, as in the cases that underpin the analyses cited previously, explicit and perceptible as odor, leaky drums, and fatalities. More often, however, poison is a hidden presence, in traces and residues, while toxicity is sublethal, its effects subtle and delayed. This "slow-motion toxicity," as Nixon calls it, poses the "challenge, at once imaginative and scientific, of giving the unapparent a materiality upon which we can act."[43] Yet, as he points out, the very people and spaces most "exposed to the force field of slow violence are abandoned to sporadic science at best and usually no science at all."[44] As Julie Livingston and Gabrielle Hecht have shown, the conceptual exclusion of Africa from epidemiological and "nuclear" modernity has kept (potential) exposures invisible. That Africans are seen as not yet vulnerable to a disease (cancer) defined as a pathology of "civilization," and African uranium miners seen as not performing "nuclear" work, has justified the absence of research on patterns of cancer causation and prevalence as well as on radiation as an occupational risk.[45] Toxicologists in Senegal, and elsewhere in Africa, have taken up Nixon's challenge and worked against this toxic invisibility to reveal a finer-grained, more varied and complex map of contamination that stretches beyond dumped waste and migrating industries to follow foodstuffs, riverways, and bloodstreams. Yet this map is also marked by the limits of and on toxicologists' capacity; by the constraints posed by the low status of poisoning in national and global health and environmental agendas and by the poor state of their laboratories; and by the restricted size of their sample sets and range of analytical tests and number of studies they can perform. Toxicologists thus highlight both the work it takes to make toxicity visible and the obstacles in their path, hinting—in their partial results, their calls for more testing, their complaints about incapacity and dysfunctional regulation—at the large swathes of invisible toxicity that lie beyond their data and capacity.

By the nature of their expertise, toxicologists are also concerned with a second issue: the (missed) possibility of protection, rather than simply its absence. On the one hand, casting exposure as the product of constitutive global inequality rightly warns against the naivety of simple solutions (regulation, education, even detection) in protecting Africans from toxic

risk. On the other hand, however, this analysis tends to naturalize the absence of protection, dismissing more specific questions about the nature and management of toxic risk. At the opposite end of the spectrum are the Blacksmith Institute's "capacity-bridging" measures of protection for "the poisoned poor": highly effective, even lifesaving, these measures are also necessarily limited in their spatial and temporal reach.[46] Toxicologists aspire to more expansive scales of protective action. Most (if not all) toxicologists in Africa (both locally affiliated and foreign collaborators) have been state employed, and in their research and institution-building efforts they imagine and partially enact more continuous forms of surveillance and control, usually across regional or national territories. In other words, they affirm, even if only indirectly, the possibility of—and the legitimacy of claims to—a protective biopolitics of poison in Africa.

What is on African toxicologists' maps of toxic concerns, and what lies at the edges of and beyond its points of contamination? Over the past decade or two, data on the presence of three categories of toxicants—heavy metals, pesticides, and aflatoxins—in Africa has grown, albeit slowly. Studies have alerted to the risks of heavy-metal exposure associated with, for example:[47] leaded gasoline;[48] oil production and refining (especially in Nigeria);[49] poor disposal, recycling, and burning of waste, including batteries and discarded electronics (e-waste);[50] artisanal and small-scale gold mining (ASGM, which uses mercury and releases lead);[51] industrial mining (especially in South Africa and the Copperbelt);[52] as well as the consumption of contaminated vegetables, fish and seafood, traditional medicines, and cosmetics (notably skin-lighteners containing mercury).[53] As for pesticides, studies have investigated the presence of pesticides (particularly those classified as persistent organic pollutants [POPS] banned since 2004) in breast milk and plant leaves,[54] measured residues on vegetables and in river and drinking water,[55] and examined presumed cases of acute pesticide poisoning.[56] Aflatoxins have been measured in corn/maize, peanut, and cassava products in several African countries, but until very recently both food contamination and human exposure data were very scarce.[57] Data on accidental and voluntary acute poisonings have been compiled from hospital or clinical records, showing the risks posed by pesticides, pharmaceuticals, and, especially for children, paraffin and household cleaning products.[58] With some variations (e.g., in forms and levels of industrial development), this general picture applies to many African countries, including Senegal.

Toxicologists' work multiplies the points of interception of toxic mole-

cules as they are propagated and released by local economic and domestic activity. As with analyses of "dumping," they point to poverty and lack of regulation as major problems: risky, informal occupations such as ASGM as well as ULAB and e-waste recycling occur at the nexus of the dearth of alternative sources of income, the high price offered for metals by foreign buyers, and the lack of oversight over the disposal of batteries and electronics, or over the sale of mercury. Similarly, economic pressures and uncertainty in agricultural production amplify pesticide risks, as do contraband networks, illiteracy and lack of farmer education, as well as the unaffordability of protective equipment and the reuse of scarce plastic containers to store scarce water.[59] Industrial mining and agriculture, powered by foreign capital, are also implicated in environmental contamination; cobalt has been found to travel through the human food chain of the Katanga mining area in the Congo,[60] while there is emerging concern about the presence of pesticides in riverways around irrigated agricultural projects in West Africa.[61] Yet social and economic disadvantage seems to interact in complex ways with access to land, employment, and income in facilitating exposure. In Senegal, for example, toxicologists told me that residents of Ngagne Diaw, as well as communities living around an open-air landfill near Dakar (where they picked and recycled waste) and in villages affected by clusters of (presumed) acute pesticide poisoning, were reluctant to identify toxic exposure and in some cases invoked supernatural causes. Some of the scientists interpreted this as fear of losing homes and livelihoods combined with mistrust of state agents.

Some of these risky substances and activities have attracted international attention. United Nations (UN) agencies, especially the United Nations Environmental Program (UNEP, created in 1972), the WHO, and the Food and Agriculture Organization (FAO), have been concerned with both intergovernmental action and national infrastructures for managing chemical/toxic hazards in the Global South. In addition to coordinating the Basel, Rotterdam, and Stockholm Conventions, UNEP has participated, with the ILO (International Labour Organization) and the WHO, in the International Programme on Chemical Safety, established in 1980, and, with these and other UN agencies, joined by the World Bank and the OECD, the Inter-Organization Programme for the Sound Management of Chemicals (IOMC), created in 1995. Only since the late 1990s have these institutions taken more direct action on the control of toxic hazards in sub-Saharan Africa. These have focused, for example, on fostering national

infrastructure for sound chemical management (including poison control centers, in Ghana and Senegal), eliminating stocks of obsolete pesticides, phasing out leaded gasoline, and responding to acute mass poisonings (in Ngagne Diaw and in Zamfara, Nigeria). The Blacksmith Institute, founded in 1999, began working in Africa around 2001 by assisting selected countries in leaded gasoline phase out. Up to 2010, it was involved in twenty or so projects that included decontamination in Ngagne Diaw and Zamfara (as well as in a lead-mining area in Zambia); a few projects, in Guinea, Mozambique, and Senegal, to reduce mercury emissions in ASGM; and various projects to address industrial and urban pollution.[62] While many of these are modestly funded (10,000 to 45,000 USD or so; figures are not given for all projects), some have obtained or leveraged more significant sums from the World Bank. Following the ratification of the Stockholm Convention in 2004, the WHO and other UN agencies initiated a global survey to screen human breast milk for the presence of POPs that included a capacity-building component.[63]

Toxicologists are thus not alone in raising concerns about toxic risks in Africa. Yet few of these international initiatives—besides being fairly recent and modest in their reach—have directly supported the production of data on pathways, levels, and distributions of exposure. Generally addressing known sources of risk, most did not involve toxicological studies (e.g., ASGM projects promoting safer techniques of mercury use without investigating exposure). In Senegal, they have not brought or left much for toxicologists to work with: an action plan for a poison control center (funded through an IOMC-related project, in the hope that the state would support it, which it has done only slowly and partially), a portable blood-lead testing system (provided by Blacksmith to follow up in Ngagne Diaw, it can only function as long as the NGO provides replacements and supplies of testing kits), and some frozen breast milk samples (a junior lab member drew twice the volume needed for the WHO survey and sent half to a lab in Germany for the WHO study and kept the rest, hoping to one day obtain funding for his own study). Earlier, in the 1980s, a UNEP-WHO-FAO project brought an atomic absorption spectrophotometer, which was only briefly used to fulfill its objectives (to measure heavy-metal traces in fish and seafood to monitor marine pollution in West Africa). An exception is Project Locustox, created by the FAO to measure the environmental impact of locust control operations. Based on the argument that pesticide toxicity had to be evaluated where locust control operations took place, and in the

ecosystems, climate, and spatial scale that it affected, foreign governments, especially of the Netherlands, joined the Senegalese government in building up ecotoxicological research capacity in Senegal for nearly a decade.

Beyond these intermittent (and one exceptional) provisions of equipment, funding, and research/regulatory objectives, Senegalese toxicologists have asked their own questions, and, with the state paying salaries but giving little toward research, they have mobilized their "own" resources, such as leftover capacity from earlier projects, contacts with foreign scientists, and gifts of free testing or access to lab facilities. What we know about levels of contamination and indicators of exposure in Senegal—and likely in other African settings—owes much to improvisations of capacity that are sometimes productive but often also modest and fragile.[64]

LOSING AFRICAN SCIENCE

Toxicology is certainly not the only science in Africa that has struggled to survive as a publicly funded activity. Nor is the regulation of toxic risk the only state function that has struggled to remain (or become) a source of public protection. The trajectory of toxicology and that of other sciences in Africa follow a broadly shared sequence: from a brief period of growing—but largely promissory—investment in science as an African(ized), national, collective, and development-oriented enterprise (circa 1940s–1970s), followed by a generalized drop in public (both national and international) funding for science in Africa from the 1980s, leading to the stagnation of scientific activity and/or to new "entrepreneurial" strategies for capturing foreign, nongovernmental, or private resources.[65]

There are, of course, variations in this general trajectory, with some sciences in some places and times being the target of more intensive national or transnational investment, especially with the recent rise in transnational funding for global health research.[66] Toxicology, however, has not been a significant or sustained target of attention for the Senegalese state or, as seen earlier, for intergovernmental or nongovernmental organizations. Toxicologists themselves have largely defined their field by deploying and prolonging capacity that was either only briefly or not specifically—and nearly always insufficiently—funded *as* capacity to detect and monitor toxic risks. The state has provided the biggest and steadiest source of money through salaries; indeed, a large proportion of African scientists have been employed by the public sector. In Senegal, however, state sal-

aries seem to have been paid more regularly and at higher levels than in other African countries. Yet national public budgets have rarely paid for laboratory equipment, fieldwork, or other research-related expenses. The main duties of the small number of toxicologists employed by the university have been to train pharmacy students and to take up additional functions (e.g., in education planning, a hospital pharmacy, or the drug control lab). From at least the 1980s, their regular budget could not support research, while their proposal for a national poison control center was put on ice for the next two decades. Research—needed to advance careers and supervise students (the pharmacy degree in Senegal includes a thesis requirement)—came to depend on brief, uncertain sources of support such as international projects, "favors" from sympathetic collaborators, and paid analytical contracts (with the exception, again, of Project Locustox). With the specter of inactivation constantly looming, toxicologists sometimes resourcefully stretched and stitched together remnants of capacity, and sometimes simply waited for the next project or overseas trip. A few gave up on public employment and set up pharmacies or consultancies; others gave up on lab work, investing themselves in teaching or in their additional appointments.

This book, then, tells a familiar story: that of the "abandonment" of public science (and health) in Africa by the state, as it experienced economic crisis from the late 1970s, and, from the 1980s, implemented SAPs (of cuts in state spending and liberalization reforms designed to make African economies more competitive), and, more recently, has been only selectively invested in by newly generous global health donors.[67] This is a story of scientists' experiences of loss, and, for some, of new strategies of survival and success. Loss illuminates change; what was, even if only as possibility or memory, but is no longer. It also illuminates value; what is missed. Following lines of loss can thus help us to understand what scientific capacity, both narrowly and broadly defined, means in settings of (threatened) peripheralization, scarcity, dependence, and stagnation. Capacity is equipment and supplies that were or might have been, the skills to use them, the actions they allowed. But there is also, as Wenzel Geissler has vividly described, the sense of movement and directionality that was activated by functional materials and the qualities of the knowledge it could produce.[68] For the government parasitologists Geissler studied, this was a shared velocity with a collective destination: toward a better future, in which the progressive principle of science fused with individual career ambitions and

societal projects of development. As others have pointed out, the sense of movement that animated post-independence African science was also a *synchronous* one, an ability to "keep up" (whether on a distinctive parallel pathway or a converging one) with science elsewhere, that was also underpinned by aspirations to *equivalence* or equity in material capacity and epistemological quality.[69] Such forward-moving, synchronous, equivalent capacity has never been more than a promise. But it is a promise that has grown increasingly elusive, as dependence on projects, collaboration, and contracts has either slowed down or broken up the rhythms of scientific activity and careers.[70] An equivalent toxicology has been associated, in Senegal, not only with innovation or the cutting edge (e.g., the development of new analytical methods) but also with capacity for detection and regulation, that is, the possibility of doing and repeating routine tests to identify and monitor environmental and public health risks. Senegalese toxicology as an active, state-funded science, plugged into functional state mechanisms of food, drug, environmental, and poison control, appeared as a plausible proposition in the 1970s, when the toxicologist Georges Gras proposed a poison control center and set out to measure mercury levels in hair and fish. It is the loss of plausibility of toxicology as equivalent both in its capacity to advance, or keep up, and in its capacity to *protect* that I explore in this book.

Loss of capacity to protect is a central thread in studies of health care and public health in Africa. In their review of the anthropology of structural adjustment and health, for example, James Pfeiffer and Rachel Chapman describe the stripping back of public protections, impeding access to both care and to protective goods such as water, food, and employment.[71] The ethnography of health workers in the public sector has described their reactions, from the 1980s, to a "withdrawal" of the state (manifesting as the drying up of supplies, deteriorating of facilities, and sometimes shrinking or delay of salary payment), and to their own diminished capacity to serve the public. In some cases, workers "abandoned" public service, privatizing care by charging (often illegally) for services and medicines, trading in privileges and favors, or seeking additional or alternative revenue from NGOs.[72] But they have also suffered a sense of moral loss ("demoralization") and sought to improvise care and protection in the face of scarcity, poor working conditions, and the inadequacy or nonaffordability of what they had to offer.[73] Though the term *unprotection* has not, as far as I know, been specifically used in this literature, it is from the sense of loss that it

suggests—experienced by those who, "abandoned" by the state, feel they can no longer do their job to care and to protect, as well as by a population that is not or no longer served or protected by a deteriorating public health system—that I define its relevance for describing a tenacious yet largely futile struggle for toxicological capacity. Not in any official dictionary, *unprotection* is defined in a Wiktionary entry as: "removal of protection from something; act of unprotecting."[74] These are exactly the dimensions I seek to underline: a loss of what once was and/or is acknowledged to be possible, and an ongoing, active process that fails to protect, even though it may not aim to expose.

UNPROTECTIVE TOXICOLOGIES

Longings for an African toxicology that once was, might have been, or might yet be equivalently protective raise a question: just how protective would an equivalent toxicology be? Is the better-funded, better-equipped toxicology of better-regulated settings, which Senegalese toxicologists often refer to vaguely as existing out there (France is their main point of comparison), *really* protective? Toxicology is a field defined by a general object—poison and its effects—rather than by its methods or applications; it is a branch of many sciences and disciplines, from chemistry and pharmacology to forensics, occupational health, and environmental sciences. It has many histories, dating back to "the earliest humans," but is generally agreed to have gained in importance and coherence in the twentieth century as a result of two factors. The first is the synthesis of new compounds, from the late nineteenth century and accelerating from the mid-twentieth, and their propagation (as with older poisons such as lead) due to technological progress paired with the intensification of industrial manufacturing, agriculture, extraction, and consumption. The second is the proliferation of regulatory institutions and laws concerned with controlling toxins in foods and drugs and other commodities, in workplaces, and in the environment, which also accelerated after World War II. Though toxicology can be a science of innovation, helping to calibrate novel poisons to kill selectively (pests, parasites, and pathogens but not hosts or bystanders), and a forensic science (cause of death, doping control, etc.), it has come, in the postwar era, to play an important societal role as a science of regulation.[75]

As a science able to call into question the safety of lucrative molecules and of their profitable uses, perhaps even shake the very foundations of

industrial society, toxicology was, as Nathalie Jas has suggested, "potentially subversive."[76] Yet as she, Soraya Boudia, and others have concluded, this potential was straitjacketed by a compromise: between protection and production.[77] This compromise, as Christopher Sellers has shown, penetrated toxicology's very methods, which were centered on the mechanistic determination of safe thresholds (on the basis of animal dose-response tests) of toxic concentration, that is, "the dose makes the poison."[78] Developed during a time when research on toxic hazards was largely funded by industry (in its own laboratories or via university departments),[79] this threshold-based toxicology was reassuring: exposure was measurable and therefore could be controlled.[80] After World War II, toxicology's methods were enshrined in new or expanding national regulatory institutions (in the United States [where toxicology has generated the most social scholarship], the principal ones are the Food and Drug Administration [FDA], the Occupational Health and Safety Administration [OSHA], and the Environmental Protection Agency [EPA]), as well as international standards for food, drug, environmental, and occupational safety.[81] These methods were slow to catch up with the new risks posed by the exponential increase in new chemicals and their pervasive presence in open, dynamic environments, lending, as Michelle Murphy puts it, "a narrow shape to what counted as a significant chemical exposure" and thus producing a "domain of imperceptibility."[82] Toxicology's methods were unable to define or control the toxicity of postwar pesticide-saturated agricultural landscapes,[83] of the late twentieth-century synthetic office building,[84] or of the endocrine-disrupting effects of low-level exposures to plastics.[85] Toxic ignorance is also produced by what goes untested: the EPA and FDA, for example, have been criticized for testing only a tiny fraction of chemicals in circulation and of produce for pesticide residue monitoring, and for inadequately sampling in hazard assessments.[86] If science has also, at times, been clearly and scandalously manipulated by industrial interests,[87] its "powerlessness" to generate protective knowledge is, for Boudia and Jas, "systemic," built into "the very functioning of [regulatory] systems." They conclude, "Despite the immensity of the activity they have generated, these systems have not allowed for the production and accumulation of real knowledge on toxic substances."[88]

My aim here is not to set up a detailed comparison between Senegalese toxicology and its better-equipped counterparts. It is to ask the question: If toxicology everywhere is unprotective, then what, if anything, is distinc-

tive about toxicology in Senegal? To some extent, "African" toxicology is simply an extreme point on a spectrum of unprotectiveness in the exposure sciences, that is, one instance of a science that has generally failed to keep up with the proliferation and complexity of toxic risk (an "archaic" science, as Murphy has said of mainstream, regulatory toxicology).[89] Yet the protection/production compromise that has held toxicology *back* has also been held *up*, in wealthier economies, by a degree of minimal protection. Even an "archaic" toxicology can, for example, identify groups of children who are at risk of lead poisoning, measure pesticide residues in food, or detect the enzyme-inhibiting effects of exposure to some types of pesticides in blood. In Senegal, the capacity to perform and repeat even such basic tests, using standard analytical methods, in order to detect substances and measure concentrations that can then be compared to accepted safety standards, has often been missing or partial. It has never been taken for granted. While toxicologists have, at times, managed to do this on tiny scales (thus pointing, for example, to the contamination of artisanal peanut oil and paste with aflatoxin, or of tomatoes and citrus by heptachlorine residues),[90] their calls for "regular monitoring" have marked off a wide expanse of missing knowledge—the results of repeated tests that neither they nor another laboratory were likely to perform—from the fractional coverage of their improvised capacity. Their dependence on external support (and the limits this has imposed on their capacity), the "fictional" nature of the "regular monitoring" for which they often call (yet which gives meaning to their small-scale work), and their sense of failing to measure up not only to the nature of toxic risk in Senegal but also to a better, more equipped toxicology in the Global North: all this adds a specific (postcolonial) quality to the quantitative "end of the spectrum" position of Senegalese toxicology.

Whether varying in degree or in kind, the unprotectiveness of toxicology has not been accepted passively by all of its practitioners. As Kim and Mike Fortun, Scott Frickel, and Michelle Murphy have shown, some groups have defended toxicology's professional ethos as a public-service science, or as a "civic science,"[91] by protesting and pushing against the limits placed on their ability to know and to protect. The Fortuns describe a "sense of the civic" among American toxicologists that is anchored in a narrative of postwar regulatory expansion that underpins toxicologists' "commitment to practical knowledge."[92] In the pursuit of this ethos of regulatory application, limits to knowledge, or "not-knowing," provokes, they observe,

ethical anxiety.[93] Historically, the kind of not-knowing toxicologists have worried about is the biased or misguided manipulation of their methods or results. Murphy provides a good example. In the 1980s, a large group of EPA employees formed a union, Local 2050, to claim their right to a "neutral" workplace against the threat—to the institution's founding ethos of state protection—of the pro-industry, antiregulation influences allowed in by the Reagan administration.[94]

The fight against not-knowing has also taken the route of promoting methodological innovation. From the late 1960s, scientists engaged in what Frickel has described as a "modest . . . reform movement" to institutionalize genetic toxicology (the study of toxic effects, notably of mutation, in genes). These "scientist-activists," as he calls them, sought to overcome the not-knowing imposed by old disciplinary boundaries and regulatory structures, thus laying the foundations for a "new public-service genetics."[95] In the case of toxicogenomics, the study of responses of the entire genome to toxic exposure, too much information can also, as the Fortuns observe, become a form of not-knowing, in the sense that complexity and uncertainty can obscure pathways to regulatory applications. They describe how "caring for data" in order to inform regulatory practice even in the absence of certainty was thus imbued with ethical significance: "a sense of the civic that depends on and mandates information infrastructure."[96]

I would not go as far as to call Senegalese toxicologists *activists*, even in the modest sense proposed by Frickel, for they could have taken a much more public role in diagnosing and denouncing the conditions that generate exposure (e.g., by working more closely with the Pesticides Action Network) as well as the inaction and inefficacy of the state, or in putting poisoning on national and global health agendas (as Blacksmith has been doing recently, and, to some extent, the staff of the CAP). Yet in their very struggle to survive and succeed as scientists, and to create or maintain the three toxicological institutions that I studied, they have improvised and imagined a more capacious and protective toxicology, thereby "refusing" the forms of not-knowing that threatened the "civicness" of their practice (as in the cases described previously). Improvising with scarce resources, as Julie Livingston and Claire Wendland have suggested for nurses and medical students, can activate a collective ethos of care and responsibility, one that has, historically, been defined as civic and national. To some extent, then, improvisation stretches the limits of capacity toward imaginations of good medicine and nursing that are defined not only by technical

but also by moral criteria of efficacy and value. Still, if capacity stretching can be seen as a form of protest against the unprotectiveness of poorly equipped medicine or science, it can lead not only to moral imaginations of responsibility and commitment but also to moral illusions of protection, tied, for example, to regulatory futures (of "regular monitoring") that may never come. The challenge, then, is to discern, in improvisation, a will to protect while recognizing its fragilities and futilities.

STUDYING THE RHYTHMS OF CAPACITY

Lost capacity, improvised capacity, missing and future capacity; these, my informants (people who have worked in the three sites I studied) differentiated, as Geissler's parasitologists did, in terms of temporal qualities of rhythm and direction. They referred to past times when scientific activity moved faster, kept pace, and filled up time, when it could be synchronous, continuous, and cumulative. They described the slowing, intermittence, and waiting that resulted from sporadic and uncertain funding, broken-down equipment, and trips overseas. At the poison control center, hoped-for futures were of durable routine surveillance and response, while at Project Locustox, the prolonged time of cumulative ecological observation was argued to be crucial for building an ecotoxicological regulatory infrastructure.

This book is cadenced by these rhythms. It seeks to decipher their meanings as expressions of value, that is, of the goods associated with active, well-equipped science; of the material but also moral threats of inactivity/inactivation; and of how scientists would like to see themselves as committed public scientists, as resourceful African scientists, and as equivalent global scientists. In other words, I follow the contours of scientists' own narration of their history and explore how its rhythmic qualities (sometimes explicit, sometimes as I interpret them) define capacity and its corollaries: scientific virtue, the advancement of knowledge and of careers, public service and protection. Thus, the "rhythms of capacity" delineate the loss and pursuit of "good" science in times of shifting hopes and uncertain, often scarce resources.

This temporal vocabulary picks up on aforementioned work on memories and histories of postcolonial African science. It also takes inspiration from a broader set of anthropological studies that have described experiences of material decline and reversal in Africa in terms of shrunken, in-

terrupted, fragmented, and "leaping" temporal horizons: what Jane Guyer has called "the temporality of lived economies."[97] In a landmark 1995 article, Janet Roitman and Achille Mbembe vividly describe the nostalgia, incomprehension, and uncertainty with which Cameroonians responded to a sudden 50 percent currency devaluation (in 1994, as a measure of structural adjustment aiming to reduce the price of exports). The economy, which had only recently seemed to be "on a continuous and irreversible path of progress," now manifested as unfinished buildings, decaying urban infrastructure, and unpredictable, shrinking salary payments.[98] In the Zambian Copperbelt, James Ferguson contrasts "expectations of modernity" of the post-independence decades—the progressive temporalities of economic and political emergence that promised a "joining up with the world"—with, in the 1990s, a feeling of loss and of "abjection," of being "thrown aside, expelled" from membership in global society.[99] Economic decline and reform also weakened the hold of African states over collective experiences of time. Shared memories, histories, and anticipated futures were central to the ambitions of African postcolonial nation-building. These were orchestrated through economic planning, commemoration, monuments, public employment and services, patronage of the arts, and infrastructural investments.[100] From the 1980s, the actions of the post-developmental state became increasingly episodic, delayed, or unpredictable, while the "event-based" presence and narratives of the churches and NGOs took over many of its functions. In Togo, writes Charles Piot in 2010, "the linear time of the dictatorship . . . and the continuous time of the ancestors is being replaced by a noncontinuous temporality, one that is 'punctuated' (Guyer, 2007) and event-driven, and one that anticipates a future while closing its eyes to the past."[101] Others have described new temporalities of "projectification" generated by NGO and transnational interventions, or the "syncopation" of day-to-day survival.[102] Science, with its heavy reliance on public funding and its strong associations with development and progress,[103] in combination with worldwide trends in the cost and technical sophistication of scientific research, has been particularly vulnerable, in Africa, to such temporal interruption and fragmentation.[104]

At the same time, as I point out, scientists themselves also, in their improvisations as well as in their memories and aspirations, seek to set the tempo of their own work—or at least their narratives and fantasies of this work—thus actively pursuing what Adeline Masquelier has called "meaningful temporalities."[105] In the case of toxicology, a science whose identity

is, in Senegal as elsewhere, strongly linked to its regulatory applications, meaningful rhythms are not just those of advancement (of innovation, progress, development, success, etc.). They are also those of continuous activity, of the regularly repeated analyses of surveys and monitoring, and of incremental accumulations of data. The value of such routine and regulatory rhythms of scientific activity has received little attention in African, or other, settings, especially other than as a form of "time-discipline" (as in E. P. Thompson's seminal essay on the inculcation of new modes of industrial production)[106] or beyond Weberian associations of routinization with rationalization, bleakness, and disenchantment.[107] Where continuous and incremental time is fragile, where work and lives are constantly disrupted, the promise of routine temporalities might be invested with both practical and moral value as a source of order, security, and protection.

Deploying and attending to "rhythmic" descriptions of succession, intersection, and discrepancy between pasts and presents, this book is both historical and ethnographic. The majority of its sources are historical in that they are "from" the past: laboratory spaces and equipment that have remained; documents that have been archived, left, or put away; and stories told about what was (only the last chapter is based more substantially on ethnographic observation). In addition, my narration is historical, in that I refer to the past as being *in* the past, which I order chronologically and periodize. I describe change and package sequences into times of greater or lesser resources, capacity, and activity. And yet, this book is mostly about the present. Relying to a large extent on oral history to guide my overarching narrative, and to interpret a very fragmentary textual and material record of past activity, I listened to stories and looked at objects as they existed in the present.[108] I made an effort to get to know this present; I paid attention to the sites where I found documents (most were not formally archived but kept or left in situ) and where I conducted interviews, and spent additional time interacting with these spaces and their occupants informally (though more so at the poison control center and the university laboratory than at "Locustox"). It was through my encounters with people, spaces, documents, and equipment in this present that I glimpsed what lost, gained, elusive, illusory, and hoped-for capacity might mean to toxicologists (then but especially now). This present was experienced by my informants and materialized in laboratories or their absence, as one of incapacity, or, more specifically, of diminished (no longer) and anticipated (not yet) capacity. I do not fully share the sense of nostalgia and optimism

they often projected and instead underscore past constraints on their capacity to detect and to protect as well as its future uncertainty. Yet I also take seriously memories and hopes of "better times" as indices of "better toxicology." If this book is also about toxicology in the past (I do attend to sources as *both* records and remains), it is mostly about the meaning this past acquires from and gives to the present, during the time I spent studying it, over a period of about eight months between January 2010 and March 2011.

TEMPOS: STRUCTURE OF THE BOOK

The chapters in this book are ordered chronologically and framed according to the tempos that my informants remembered or described for distinct periods. An exception to this structure is chapter 1, which is polyrhythmic and enters the laboratory of toxicology and analytical chemistry at the UCAD in Dakar during a present time of inactivity (at the time of my fieldwork in 2010). In this chapter, I describe the challenges and reflect on the stakes—for defining how capacity is made and kept—of recovering the rhythms that once animated its equipment. While primarily a reflection on what to make of a stilled but once active material record of scientific activity, this chapter also provides an overview of the lab's history that serves as a map for the periods described in chapters 2, 3, and 5.

Chapter 2 follows the history of the university lab from the early 1960s to the early 1980s. The post-independence decades were the time of *la coopération* (overseas cooperation), that is, of French technical assistance to its former African colonies. French nationals still occupied most senior positions at the university, including in toxicology and analytical chemistry. Yet technical assistance promised the mutual advancement of both expat and African scientific careers, as well as of science itself and of African development. Focusing on the aspirations to *advancement* expressed by different members of the lab—a former colonial pharmacist, a French academic toxicologist, and a Senegalese technician—this chapter illuminates tensions between, and contradictions within, distinctive visions for the Africanized toxicology that might emerge in Dakar.

Chapter 3 examines the pursuit and value of *routine rhythms* of scientific work in the university lab from the early 1980s. At this time, the first Senegalese PhDs in toxicology and analytical chemistry returned from France to replace the French *coopérants* (technical assistants) in the lab.

Cuts in both French assistance and Senegalese state funding threatened to break up the tempos of scientific work in the university laboratory at the time when its leadership was being Africanized (or "Senegalized"). International investments in the lab's equipment provided opportunities to stretch and project analytical capacity toward the regular monitoring of toxicity in Senegalese environments. While exploring the civic value invested in regular rhythms and routine science, this chapter also presents the memory and ideal of protective toxicology during this period as a *fiction*.

Chapter 4 is about the prolongation of a transnational collaboration that aimed initially to evaluate the environmental effects of chemical locust control, and then to develop a "Sahelian" ecotoxicology for assessing pesticide toxicity. Focusing on the arguments put forward for continuing to invest in Sahelian ecotoxicological research, this chapter examines *prolongation* as both an epistemological and political project to link the "Sahelization" of ecotoxicology's methods to its durable relocation in Sahelian institutions. Those who made these arguments understood infrastructure and resultant capacity as an accumulation of connections between ecosystems, institutions, scientists, data, equipment, and methods. The fragile success of the transition from collaborative project to permanent local institution raises questions about the kinds of support, and the kind of scientific work, needed to make an environmental science responsive to national imperatives of regulation and protection.

Chapter 5 is about poison control in the making during a time of renewed state provision. In 2010, I observed the CAP's director and staff seeking to initiate, as soon as possible, regular and continuous rhythms of surveillance and response. This "hasty routinization" was set against the prior temporalities of delay and crisis attending to the center's creation, and sought to evoke new opportunities for an expanded biopolitics of poisoning. Yet as they moved toward bureaucratic routines of government, center staff also distanced their project from the Senegalese state as an uncertain and partial provider while working out how to complete the construction—both literal and metaphorical—of their institution.

NOTES

INTRODUCTION

1 WHO, "Intoxication au plomb à Thiaroye sur mer, Sénégal"; Wilson, "Technical Expert Mission"; Blacksmith Institute, "Project Completion Report"; Haefliger et al., "Mass Lead Intoxication from Informal Used Lead-Acid Battery Recycling in Dakar, Senegal."

2 The competition is held annually by the Caen Memorial Centre for History and Peace. Fall's plea, "Ngagne Diaw ou le dernier mohican de Thiaroye," which won first prize in 2010, can be found on the institution's website: http://www.memorial-caen.fr (accessed August 11, 2015). Winning pleas in other years have addressed topics such as the death penalty, euthanasia, and women's rights.

3 Mourre, *Thiaroye 1944*.

4 Means, "Toxic Sovereignty."

5 The Blacksmith Institute is presented on its website, which was still live in October 2016. In 2015, it changed its name to Pure Earth but continues to define itself as "an international non-profit organization dedicated to solving pollution problems in low- and middle-income countries, where human health is at risk"; see http://www.pureearth.org/what-we-do/, accessed August 12, 2015.

6 Blacksmith received support from the Green Cross Switzerland and Terragraphics Environmental Engineering for this intervention.

7 See, for example, Blacksmith Institute and Global Alliance on Health and Pollution, "The Poisoned Poor."

8 Blacksmith Institute, "Project Completion Report."

9 The actors I followed in this study are those who have worked in or with three toxicological institutions and include individuals who were not trained as toxicologists (e.g., statisticians, managers, and entomologists, as well as the analytical chemists who work alongside toxicologists at the university) as well as scientists who are not Senegalese nationals (French technical assistants in the 1970s to early 1980s and Dutch ecotoxicological scientists who worked at Project Locustox in the 1990s). Yet all have worked toward making, keeping, and mobilizing scientific and regulatory capacity to monitor toxic risk in Senegal. The general term *toxicologists*, then, covers this group as a whole.

10 For a description and examples of Africanist, historical, and ethnographic approaches to scientific and health capacity, see Geissler and Tousignant, eds., *Special Issue: Capacity as History and Horizon*.

11 See, for example, Fortun and Fortun, "Scientific Imaginaries and Ethical Plateaus," and Boudia and Jas, eds., *Toxicants, Health and Regulation*.

12 In *Speculative Markets*, Kristen Peterson argues, somewhat similarly, that the regulation of fake drugs in Nigeria is largely futile despite significant institutional and technical regulatory capacity due to the structure of both national and international pharmaceutical markets, as well as the adjustment of African economies and the multiple economic and political pressures on local regulatory action. Her focus, however, is on the speculative practices that have created a vigorous and ultimately unregulatable pharmaceutical market, while I focus more narrowly on the specific limits placed on potentially protective toxicologically testing and research.

13 The term is from Mitman, Murphy, and Sellers, *Landscapes of Exposure*.

14 Boudia and Jas, eds., *Powerless Science?*

15 Roberts and Langston, eds., "Toxic Bodies/Toxic Environments"; see especially Daemmrich on biomonitoring, 684–693.

16 Beck, in *Risk Society*, characterizes late modernity as generative of pervasive, incalculable risk (including the production and release of hazardous chemicals) and as cognizant of the limits of scientific control. Boudia and Jas, *Toxicants, Health and Regulation*, 2, describe a late twentieth-century shift in the politics of contaminant regulation from the objective of mastering to that of coping with generalized contamination, a condition that results from the failure of regulation. They follow up on the failure of regulation as the result of its contradictory logics (to legitimate production and protect populations) in *Powerless Science?* The best overview of how different theories of modernization address the issues of unequal exposure to and protection from toxic risk is Pellow, *Resisting Global Toxics*, 18–24.

17 Pellow, *Resisting Global Toxics*; see also, on the relationship between industrial hazard and globalization, Sellers and Melling, eds., *Dangerous Trade*, and Sellers, "Cross-Nationalizing the History of Industrial Hazard."

18 Pellow, in *Resisting Global Toxics*, insists on the potential of activism to temper the maldistribution of risk and to reinforce protection (against theories of modernization that posit risk as inevitable) but pays little attention to the scientific study of sources, patterns, and consequences of contamination and exposure.

19 See, for example, Markowitz and Rosner, *Deceit and Denial*; Sellers, *Hazards of the Job*; Murphy, *Sick Building Syndrome*; the essays in Roberts and Langston, eds., "Toxic Bodies/Toxic Environments"; Frickel, *Chemical Consequences*; and Fortun and Fortun, "Scientific Imaginaries and Ethical Plateaus."

20 Hountondji, "Scientific Dependence in Africa Today," 9.

21 Brooke, "Waste Dumpers Turning to West Africa."

22 Robert Bullard's work on the contamination of black communities in the southern United States popularized this term; see his now-classic *Dumping in Dixie*.

23 Marbury, "Hazardous Waste Exportation."

24 Fortun, *Advocacy after Bhopal*.

25 O'Keefe, "Toxic Terrorism." See also Third World Network's collection of essays, *Toxic Terror*.

26 Cited in O'Keefe, "Toxic Terrorism," 87. Brooke, "Waste Dumpers Turning to West Africa," reports that an editorial in *West Africa* described the content of "dozens of letters from angry readers" and summarized the "traumas cited" as slavery, colonialism, and unpayable foreign debt.

27 A copy of the leaked memo, "Whistle Blower's Corner/Lawrence Summer's 1991 World Bank Memo," is available on the website of the Basel Action Network at http://ban.org/whistle/summers.html, accessed August 12, 2015.

28 Nixon, *Slow Violence*, 2.

29 Ferguson, *Global Shadows*, 71–78.

30 Livingston, *Improvising Medicine*, 30–31.

31 Clapp, *Toxic Exports*, 2–3, asks why, despite the outrage the memo provoked, international regulation has failed to control the circulation of hazardous waste and points to loopholes in this and later conventions—which she describes as a "leaky dike." One such loophole concerns waste labeled "for recycling" rather than disposal. While an amendment to the Basel Convention was proposed in 1995 to explicitly ban the export of waste for recycling from OECD to non-OECD countries, it had not yet been ratified or implemented by many countries.

32 The Rotterdam Convention concerns prior informed consent (specifying the criteria for a country to make an informed decision about allowing the entry of "certain hazardous chemicals and pesticides"), while the Stockholm Convention aims to restrict or eliminate the production and use of certain substances classified as persistent organic pollutants (POPs), such as DDT and PCBs, which remain in environments and bodies for very long periods of time. See UNEP, "The Hazardous Chemicals and Wastes Conventions," September 2003, http://www.pops.int/documents/background/hcwc.pdf.

33 Amnesty International and Greenpeace Netherlands, *The Toxic Truth*, 2.

34 Amnesty International and Greenpeace Netherlands, *The Toxic Truth*, 2.

35 Koné, "Pollution in Africa."

36 Stoler, "Imperial Debris," 197 and 204.

37 Means, "Toxic Sovereignty."

38 On African expectations of "convergence," that is, of full global economic and political membership in the future of development, see Ferguson, "Decomposing Modernity."

39 Lincoln, "Expensive Shit," 3–4.

40 Tadjo, "Dessine-moi (écris-moi) une independence . . . ," 66–67. Unless otherwise noted, all translations are my own.

41 On people, likewise, as waste of the economy, see Bauman, *Wasted Lives*.
42 Nixon, *Slow Violence*, 4.
43 Nixon, *Slow Violence*, 3 and 15.
44 Nixon, *Slow Violence*, 16.
45 Livingston, *Improvising Medicine*, especially 29–51; Hecht, *Being Nuclear*, especially 183–212 and 259–286.
46 It should be noted, however, that the Blacksmith Institute's activities in Africa are not limited to emergency remediation operations but also include education initiatives to make risky activities safer or provide individuals with alternative revenue-generating possibilities (e.g., this was the case in Ngagne Diaw) and, more recently, a toxic sites identification program to screen potentially contaminated areas for health exposure risks (thereby beginning to expand the map of known or partly known risks). Yet it remains focused on well-delimited "toxic hotspots" and emphasizes the need for urgent action in "the world's most polluted places." See the Pure Earth website and Pure Earth and the Global Alliance on Health and Pollution "The Poisoned Poor."
47 Overviews of sources of heavy metal pollution in Africa are given by Nriagu, "Toxic Metal Pollution in Africa," and by Yabe, Ishizuka, and Umemura, "Current Levels of Heavy Metal Pollution in Africa." A comparison of these reviews, published in 1992 and 2010, shows an increase in concern with, and studies of, metal contamination on the continent. The earlier report also shows that, despite the scarcity of data available at that time, this was already identified as a serious and worsening problem, especially for children in urban settings, although it should also be noted that this was prior to the phasing out of leaded gasoline.
48 See, for example, Diouf et al., "Environmental Lead Exposure: A Pilot Study"; Diouf et al., "Environmental Lead Exposure: A Cross-Sectional Study"; and Tuakuila et al., "Blood Lead Levels in Children."
49 See, for example, Chindah et al., "Distribution of Hydrocarbons and Heavy Metals," and Emoyan et al., "Evaluation of Heavy Metals."
50 See, for example, UNEP and Kimani, "Environmental Pollution and Impacts on Public Health." Cabral et al., "Low-level Environmental Exposure," is one of the rare studies in an African setting that tests for markers of exposure and its effects on the body rather than merely measuring levels of contamination. Asante et al., "Multi-trace Element Levels," presents itself as the first study of human exposure to e-waste recycling. See also Cabral et al., "Impact du recyclage des batteries."
51 See, for example, Lo et al., "Childhood Lead Poisoning"; Ikingura and Akagi, "Monitoring of Fish and Human Exposure"; and Van Straaten, "Mercury Contamination."
52 See, for example, Banza et al., "High Human Exposure," and Ikenaka et al., "Heavy Metal Contamination."
53 See, for example, Sobukola et al., "Heavy Metal Levels"; Gras and Mondain,

"Problème posé par l'utilisation des cosmétiques mercuriels"; and Obi et al., "Heavy Metal Hazards."

54 Kinyamu et al., "Levels of Organochlorine Pesticides Residues"; Diouf et al., "Utilisation des feuilles de manguier comme bioindicateur."

55 See, for example, Diouf et al., "Étude du niveau de pollution de l'eau de puit"; Pazou et al., Organochlorine and Organophosphorous Pesticide Residues"; Bempah, Kofi, and Donkor, "Pesticide Residues in Fruits"; and Anderson et al., "Passive Sampling Devices." While a few thesis research projects in Senegal (in both the toxicology lab and the plant biology department of the Faculty of Sciences) had, earlier, tested vegetable, fish, and water samples for pesticide residues, the first larger-scale, published study of pesticide levels in vegetable crops, confirming impressions that contamination levels exceeded accepted safety standards, only came out in 2016; see Diop et al., "Monitoring Survey of the Use Patterns and Pesticide Residues."

56 See, for example, Touré et al., "Investigation of Death Cases."

57 Williams et al., "Human Aflatoxicosis in Developing Countries."

58 Tagwireyi, Ball, and Nhachi, "Poisoning in Zimbabwe."

59 Amadou Diouf, oral presentation on pesticides, World Social Forum, Dakar, February 2011.

60 Banza et al., "High Human Exposure."

61 Anderson et al., "Passive Sampling Devices."

62 See "Completed Projects," Pure Earth website, http://www.pureearth.org/projects/completed-projects/, accessed October 17, 2017.

63 See "Global Monitoring Plan," Stockholm Convention website, http://chm.pops.int, accessed October 17, 2017.

64 Even a quick review of recent publications on toxic contamination and exposure in Africa shows that most rely on collaboration with foreign labs, where much of the testing is probably done (which means freezing and shipping small batches of samples); many are "pilot" or "exploratory" and comment on the scarcity of available data (especially on human markers of exposure).

65 For a good overview, see Gaillard, Hassan, and Waast, "Africa." The best overview for health is Prince, "Situating Health and the Public."

66 For example, medicinal plant science was funded as a matter of national pride and self-sufficiency in Ghana in the postindependence decades; see Droney, "Ironies of Laboratory Work," and Osseo-Asare, *Bitter Roots.* Gilbert, "Re-visioning Local Biologies," describes a productive HIV research collaboration between Senegalese and American scientists from the mid-1980s, but the exponential rise in HIV/AIDS research funding redirected efforts elsewhere; see also Crane, *Scrambling for Africa.* On the uneven landscapes created by "enclaves" of well-resourced global health research within deteriorating national scientific and health care infrastructures, see Geissler, "Archipelago of Public Health."

67 Indeed, toxicologists have suggested their work has been "doubly abandoned" by the state and by "global health." Anthropologists have similarly

observed the effects on some areas of health care and research (cancer, diabetes, hypertension, sickle-cell anemia) of neglect relative to investment in high-priority areas of global health investment such as HIV/AIDS. See Livingston, *Improvising Medicine*; Fullwiley, *The Enculturated Gene*; Mulemi, "Technologies of Hope"; Whyte, "Publics of the New Public Health"; and Whyte, "Knowing Hypertension and Diabetes."

68 Geissler, "Parasite Lost."

69 Arnaut and Blommaert, "Chthonic Science"; Tousignant, "Broken Tempos"; Osseo-Asare, "Scientific Equity"; Droney, "Ironies of Laboratory Work."

70 Waast, "L'état des sciences en Afrique"; Geissler et al., "Sustaining the Life of the Polis"; Tousignant, "Broken Tempos."

71 Pfeiffer and Chapman, "Anthropological Perspectives."

72 Ridde, "Per Diems Undermine Health"; Loewenson, "Structural Adjustment and Health"; Prince, "Situating Health and the Public"; Pfeiffer, "International NGOs"; Turshen, *Privatizing Health Services*; Masquelier, "Dispensary's Prosperous Façade"; Jaffré and Olivier de Sardan, eds., *Une médecine inhospitalière*; Whyte, "Pharmaceuticals as Folk Medicine."

73 Foley, *Your Pocket*; Livingston, *Improvising Medicine*; Wendland, *A Heart for the Journey*.

74 See "Unprotection," on the Wiktionary website, https://en.wiktionary.org/wiki/unprotection, accessed October 17, 2017.

75 See, for example, Monosson, "Chemical Mixtures."

76 Jas, "Public Health and Pesticide Regulation."

77 Boudia and Jas, "Risk and Risk Society"; Boudia and Jas, *Toxicants, Health and Regulation*; and Boudia and Jas, *Powerless Science?* This echoes the modernization theory of "treadmill of production," which, as described by Pellow, explains capitalism's continuous production of social and environmental harm in part by the state's contradictory roles "to both facilitate capital growth and provide for social welfare and environmental protection": *Resisting Global Toxics*, 21.

78 Sellers, *Hazards of the Job*, especially 139–184, describes the development of occupational hygiene science in the 1920s in university laboratories, notably at Harvard, that sought to neutralize the political tenor of prior Progressive Era assessments of workplace hazards and legitimate corporate funding for their activities. See also Vogel, "From 'The Dose' to 'The Timing.'"

79 Markowitz and Rosner, *Deceit and Denial*, 5.

80 Sellers, *Hazards of the Job*, 183. For France, Nathalie Jas describes, in "Public Health and Pesticide Regulation," a more autonomous, cautious, and critical stance on the part of academic toxicologists. Yet their involvement in regulatory activities, where they came up against those who sought to promote the use of toxic substances such as pesticides in economically productive activities, similarly resulted in the legitimization of both pesticide use and of a regulatory system they knew to be insufficiently stringent.

81 Boudia and Jas, *Toxicants Health and Regulation*; Murphy, *Sick Building Syndrome*, 88.

82 Murphy, *Sick Building Syndrome*, 91.
83 Nash, *Inescapable Ecologies*, chapter 4.
84 Murphy, *Sick Building Syndrome*.
85 Vogel, *Is It Safe?*; Langston, *Toxic Bodies*.
86 Pellow, *Resisting Global Toxics*, 29–30; Environmental Defense Fund, *Toxic Ignorance*; Elderkin, Wiles, and Campbell, *Forbidden Fruit*; Frickel and Vincent, "Hurricane Katrina."
87 Markowitz and Rosner, *Deceit and Denial*.
88 Boudia and Jas, *Powerless Science?*, 21.
89 Discussion, "Workshop on Infrastructures of Exposure: Toxicity, Temporality and Political Economies in Africa," Cambridge, UK, March 14, 2014.
90 Diop et al., "Contamination par les aflataxies"; Diop et al., "Bioaccumulation des pesticides."
91 Fortun and Fortun, "Scientific Imaginaries and Ethical Plateaus," 44.
92 Fortun and Fortun, "Scientific Imaginaries and Ethical Plateaus," 48.
93 Fortun and Fortun, "Scientific Imaginaries and Ethical Plateaus," 49.
94 Murphy, *Sick Building Syndrome*, 119–121.
95 Frickel, *Chemical Consequences*, 141.
96 Fortun and Fortun, "Scientific Imaginaries and Ethical Plateaus," 49.
97 Guyer, "Prophecy and the Near Future," 411.
98 Mbembe and Roitman, "Figures of the Subject."
99 Ferguson, *Expectations of Modernity*, 236.
100 Cooper, "Africa's Pasts"; Diouf, "Urban Youth and Senegalese Politics"; Werbner, *Memory and the Postcolony*; De Jorio, "Introduction to Special Issue"; De Jong and Rowlands, *Reclaiming Heritage*.
101 Piot, *Nostalgia for the Future*, 163–164. The reference is to Guyer, "Prophecy and the Near Future."
102 On how health care seekers navigate the fragmentation of "projectified" HIV/AIDS care, see, for example, Whyte et al., "Therapeutic Clientship." On the temporal effects of urban poverty and infrastructural absence, see De Boeck, "'Divining' the City."
103 Clarke, "A Technocratic Imperial State?"; Kusiak, "Instrumentalized Rationality"; Kusiak, "'Tubab' Technologies"; Droney, "Ironies of Laboratory Work"; Osseo-Asare, *Bitter Roots*.
104 Geissler, "Parasite Lost"; Okeke, "African Biomedical Scientists."
105 Masquelier, "Teatime."
106 Thompson, "Time." An innovative application of this idea to scientific work is Charles Thorpe's analysis of the social organization of time in atomic bomb research at the Los Alamos Laboratory during the war. Thorpe argues in "Against Time" that scheduling regulated daily work and became an end in itself, a work ethic that cut scientists off from the larger moral and social implications of bomb research.
107 Lee, "Weber, Re-enchantment and Social Futures."
108 Geissler et al., eds., *Traces of the Future*.