Chemical Agents

The Biopolitical Science of Toxicity

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■ **ABSTRACT:** This article reviews interdisciplinary toxicity literature, building from Gerald E. Markowitz and David Rosner's "deceit and denial" and Phil Brown's "contested illnesses" to argue for a third, more critical analytic that I term "empire and empirics." Deceit and denial pit corporate actors against antitoxins advocates, while contested illnesses highlight social movements. Empire and empirics center the role of imperialism in reproducing today's unevenly distributed toxic exposures. I find this third path the most generative because the products *and* the production of science—toxicants *and* toxicology—are situated in their sociohistorical, politico-economic, ecological, and affective contexts. Revealing the imperialist logics embedded into dominant onto-epistemology also illuminates alternative, liberatory pathways toward more environmentally just futures. I close with examples of "undisciplined" action research, highlighting scholar-practitioners who study toxicity with care and in nonhierarchical collaboration. While undisciplining is challenging, its potential for realizing environmental justice far outweighs the difficulties of doing science differently.

■ **KEYWORDS:** biopolitics, chemical violence, critical feminist science studies, environmental justice, toxicity, uneven exposures

Toxic chemicals leach across landscapes, ooze out of everyday plastics, and persist in prohibited substances. Several generations have thus already, and will continue to, become-with these slippery synthetics, prompting a rethinking of what it means to be human. Given that toxicants are so pervasive and permeable, where, how, or by whom ought the boundaries of "our bodies" be drawn, if at all? This critical feminist review of toxicity literature attempts to address such questions of becoming-with, situating the production of synthetic chemicals in sociohistorical, politico-economic, ecological, affective, and cultural contexts. By "critical feminist," I mean work that conscientiously breaks from the individualistic and racialized capitalist frames characteristic of White liberal feminism, drawing instead from Black, Indigenous, and women of color feminisms, as well as socialist, postcolonial, and queer feminisms. (See Halley 2006 for an overview of feminist genealogies.) I posit that a critical feminist approach to toxicity is necessary if toxicants and the multiple harms they generate are to be meaningfully mitigated.

Even small doses of certain chemicals, known as endocrine-disrupting chemicals (EDCs), can adversely affect developmental and metabolic processes, leading to reproductive problems as well as cancers, stroke, diabetes, and other potentially fatal diseases (Diamanti-Kandarakis et al. 2009). Many ubiquitous toxicants—found in such commonplace items as furniture and food packaging—can also detrimentally alter gene expression (phenotype), without altering genetic code (gen-

otype), in a variety of processes termed “epigenetic.” Because toxic environmental chemicals may or may not catalyze the expression of phenotypes, the negative outcomes of a specific toxicant exposure may not manifest themselves until future generations. Of particular concern to critical feminists, among other scholar-activists, is that places and people who are marginalized on the basis of racial, sexual, and/or economic hierarchies bear disproportionately heavier toxic burdens. Such environmental injustices, entangled with the transgenerational effects of toxic exposures, threaten to turn hegemonic social categories of race and sex back into the purportedly biological categories that social justice advocates have long argued against (Guthman 2014). The following review submits that studies of toxicity, whether grounded in the natural or social sciences, need to incorporate critical theory and historical materialism, modeled after what I call “empire and empirics” scholarship. I further suggest, amplifying critical scholars before me (McKittrick 2015; Roy 2008), that care work and nonhierarchical collaborative study between scientists and cultural scholars, engagements that intentionally center the experiences and knowledges of frontline communities (Sze 2020), offer the surest pathway toward more environmentally just futures.

I will begin with the “deceit and denial” literature, whose name is taken from the title of Gerald E. Markowitz and David Rosner’s (2002) representative book. I will turn to the “contested illnesses” approach, a term borrowed from Phil Brown’s (2007) exemplary monograph, where I also include environmental justice (EJ) research.¹ Third, and most extensively, I will review “empire and empirics” contributions, critiques that underscore the inherently racial, sexual, and imperial biases of toxicant science. In other words, empire and empirics analyses attend not only to who bears the heaviest toxic burdens but also to whose bodies are considered normal and fully human by the hegemonic onto-episteme (Weheliye 2014; Wynter 2003). (“Onto-epistemology” combines ontology—ways of being—with epistemology—ways of knowing, to signify the inseparability of being and knowing. Karen Barad [2007] extends this further with her call for ethico-onto-epistemology, emphasizing the inextricability of ethics, too, from being and knowing.) Today’s hegemonic onto-episteme is the Western European, Liberal, Enlightenment-era type of knowledge production that powerful, global institutions generally consider to be authoritative and truth-generating, inclusive of such concepts as “the” scientific method, rational empiricism, and Cartesian (from French philosopher René Descartes) binaries, which, for example, include such ideas as man is greater than animal and culture is greater than nature (Forbes 2008; Merchant 1989). Engaging critically with the distribution of toxicants as well as with the limits of dominant onto-epistemology, empire and empirics scholarship charts how toxic exposures are unevenly distributed while historicizing the truth-making claims of Western science. Empire and empirics research also grapples with the disturbing ways that chemicals differently co-constitute humans, who remain enmeshed in webs of interdependent relations, inclusive of more-than-human animal and plant life as well as inanimate forms (Povinelli 2016; TallBear 2011). I will close with examples of engaged researchers who build from empire and empirics approaches to generate critical feminist scientific knowledge, highlighting a range of more justice-centered and relational studies of toxicity that explicitly value care work and collaboration.

Deceit and Denial: Clean Science, Dirty Scoundrels

Several scholars have documented the multitude of corrupt acts by petrochemical corporations, including attempts to suppress findings that would reduce profits and to strong-arm regulators into rule-making decisions that favor the firm (Krimsky and Gillam 2018; Markowitz and Rosner 2002; Proctor 1995). Following the imprints of imperialism, though these historical legacies are not a focus of the deceit and denial literature, petrochemical corporations tend to be

based in the United States and Western Europe. Their toxic fallout, meanwhile, disproportionately permeates “the periphery,” including marginalized communities within the United States and Western Europe, and across the Global South (Agyeman et al. 2003; Fortun 2001; Pellow 2007). Deceit and denial research frames toxic exposure as a problem stemming from unethical industry employees (inclusive of so-called “sell-out” scientists who leave academia to work for industry) and corrupt government bureaucrats, while the Western sciences that create, define, and measure toxicity remain beyond reproach. Books like *Doubt Is Their Product* (Michaels 2008), *The Polluters* (Ross and Amter 2010), and *Merchants of Doubt* (Oreskes and Conway 2010) deliberately distinguish between “sound science” and “sounds like science,” to use David Michaels’s (2008) turn of phrase. Their authors meticulously detail how petrochemical industries not only suppress in-house scientific findings, protected by intellectual property law, but also hire public relations scientists—highly credentialed experts who assure regulators, judges, and juries, as well as the general public, that safety concerns are mere lay misunderstandings. Sheldon Krinsky (2000) takes a slightly different approach, critically analyzing the scientists and regulators who diligently measure toxicants’ harmful effects, including especially the low-dose toxicity of EDCs. In Krinsky’s (2018) more recent work, however, readers still encounter a scenario in which “sound science” (read: disinterested) is pitted against “sounds like science” (read: interested). To be sure, archival and juridical records amply evidence how petrochemical industries justify delays in regulatory action by insisting upon the need for more conclusive scientific data. (EJ activists refer to this hampering strategy as “paralysis by analysis.”) And yet Krinsky’s (2018) call “to protect the scientific enterprise, one of the core pillars of a modern democratic society, against the forces that would turn it into the handmaiden of industry or politics,” a sentiment shared by other deceit and denial scholars, merits greater scrutiny.

While carefully researched and engagingly written, deceit and denial accounts tend to be US-centric, overlooking the coloniality of science and the liberal nation-state alike (Lowe 2015; Petitjean et al. 1992). For instance, Frederick R. Davis’s (2014) history of toxicology, which focuses on the carcinogenic and endocrine-disrupting pesticide DDT, only mentions in passing the US congressional decision to ban DDT domestically and yet still allow US-based chemical corporations to deploy this toxicant across the Global South. Focusing on the United States is not without good reason, as several major petrochemical firms originated in the United States and continue to exert tremendous power given the sheer volume of poisons they distribute worldwide (Clapp 2017). Yet this US-centric angle carries significant limitations. As empire and empirics work shows, which is discussed further below, contemporary disparities in toxic exposure emerge from imperialist legacies, both in terms of who becomes more poisoned and how science claims to “know” poisons. Future accounts of petrochemical scientists’ deceit and denial ought to situate their narratives within (settler) colonial states’ own legacies of deceit and denial. Ann Laura Stoler’s (2008) concepts of “imperial debris” and “imperial formations” provide a particularly helpful analytic. Stoler’s framing compels scholars to re-view today’s chemo-environmental injustices as ongoing reverberations of (settler) colonialism, rather than as discrete, finite occurrences of the recent past or disconnected present. The next review category, contested illnesses, comes closer to understanding toxic exposures as inextricable from historical-material power asymmetries.

Contested Illnesses: Environmental Injustices and Embodied Health Movements

Contested illnesses analyses tend to amplify inequitable sociostructural relations more than those of deceit and denial. Indeed, illnesses often become contested by and through the pro-

cesses of deceit and denial, as petrochemical industries routinely deny claims that their toxic products cause disease. However, contested illnesses work generally separates science from culture in ways that curtail these otherwise compelling projects. Contested illnesses scholars might question the bounds of an epidemiological study design, for example, but not go so far as to socio-historically locate the science of epidemiology all together. Nevertheless, their scholarly-activist approaches offer crucial contributions by documenting marginalized communities' differential exposures to toxicants, underscoring how physical and environmental disparities in toxic burdens are thoroughly social.

Laura Pulido's (1996) chronicle of the California-based United Farm Workers Organizing Committee shows how these predominantly Chicano/a and Hispanic worker-activists saw pesticides as both a demand and a tool of their 1960s struggle. Farmworker-organizers understood that their greater exposure to pesticides and vulnerability to health risks was precisely because of their disempowerment, and that they would not experience reduced exposures unless they gained greater social power vis-à-vis their bosses. Brian Williams (2018) also historicizes the racialization of pesticide exposure in the United States, documenting how White supremacist plantation owners of the southern states responded to Black resistance to Jim Crow-era oppression by increasing their reliance on pesticides. Rather than pay living wages to "uppity" Black farmworkers, White plantation owners adopted more mechanistic, and more poisonous, farming methods. Julie Guthman and Sandy Brown (2016), among others (Arnold 2016; Barba 2020; Harrison 2006; Shattuck 2019), show how the racialization of pesticide exposure persists into the present. Newly regulated soil fumigant "buffer zones" around schools and residences in California, for instance, render invisible the toxic burdens borne by racialized farmworkers well within the toxic zone, workers who can presumably harvest more produce faster after the soil has been fumigated. As Guthman shows in her newest book, *Wilted* (2019), both exploitative labor practices and land values, whether residential or agricultural, depend upon the maintenance of this toxic geography.

Following Pulido, scholars like Sylvia Tesh (2000) and Scott Frickel (2004) amplify social movements, documenting how EJ activists and advocates struggle to gain scientific "proof" for the injustices of toxic exposure, demanding in some cases the "undone science" (Frickel et al. 2010) that would corroborate their lived experiences. Synthetic chemicals and their manufacturers are especially hard to indict, given the messy complexity of multiple chemical interactions, long latency periods between exposure and ill health, and toxicology's inherently limited understanding of toxicants themselves (as elaborated at the end of this section). Phil Brown (2007) emphasizes the embodied experiences of toxic exposure, noting how EJ activism informs health-focused social movements. People suffering from contested illnesses, so named because their etiologies are in dispute, politicize their toxic exposures to gain publicly funded research and public health-centered regulation. Engaging in "citizen science," or what Phil Brown and Edwin Mikkelsen (1990) call "popular epidemiology," environmental health activists take biomedical matters into their own hands, conducting their own health surveys and measuring their own exposures and body burdens so that public officials will take notice of community-generated scientific evidence that more conventional, top-down measures might not have captured (see also Steingraber 2010). Embodied health social movements show particularly well how contested illnesses extend the work of deceit and denial, as popular epidemiologists leverage the language of science to counter chemical manufacturers' claims that their industrial toxicants are not to blame for exposed communities' innumerable cancers, reproductive dysfunctions, asthma, metabolic disease, and so on (Shostak 2004).

Lindsey Dillon's (2014) ethnographic work in Hunter's Point, a historically Black and economically and environmentally marginalized neighborhood in San Francisco, California, em-

phasizes how government-led attempts to repair toxic damages are a far cry from reparations. The ongoing legacies of a highly toxic Navy base, alongside city government's chronic disinvestment in Hunter's Point, co-produce this neighborhood's enduring, racialized underemployment and chemical contamination. Chloe Ahmann (2018) chronicles a similar case of a profoundly polluted, marginalized neighborhood within Baltimore, Maryland. Attending to her interlocutors' struggles against the "slow violence" (Nixon 2013) so characteristic of toxic exposure, Ahmann conceptualizes "moral punctuation," wherein EJ activists rework time as a political maneuver. Moral punctuation "condenses protracted suffering and demands an ethical response, eschewing the delays of political caution and the painstaking work of ensuring scientific certainty" (Ahmann 2018: 144). Javier Auyero and Debra Swistun (2008, 2009) attend to the suffering of slow violence in an Argentinian shantytown. Chemical latency not only makes it difficult for exposed communities to demand justice but also confuses people into underestimating dangers and becoming apathetic. While acknowledging the extreme duress of structural poverty, Auyero and Swistun caution that disenfranchised residents can be easily manipulated by "socially consequential institutions" (2008: 358), namely Shell Corporation, government officials, and local physicians, who differently wield toxic uncertainty to the detriment of individual and environmental health.

Science remains the voice of authority in contested illnesses scholarship, but is leveraged differently than in deceit and denial literature. Whereas in the latter industry-friendly scientists wield "sounds like science" (Michaels 2008) to delay and dilute regulations, contested illnesses activists reclaim "sound science" and demand "undone science" in order to receive long-overdue medical care and other public entitlements. Aya Hirata Kimura (2016) takes this conversation further, noting how citizen science itself is not immune to the ills of social hierarchies. Working alongside "radiation brain moms" in Fukushima, Japan, Kimura, in her ethnography, shows how mothers who mistrust Japanese state/scientific authorities' assurances—that food grown in the fallout of the 2011 nuclear disaster is safe for their children to consume—are dismissed and derided as antiscientific, irrational, and "rumor-spreading" because of their inferior social status as women. Kimura also notes how this particular citizen science effort adopted characteristics of Western science rather than local activism. Mothers testing their families' food (for radiation levels) presented themselves and their efforts more like bench scientists than organizers. Their community-based testing sites were laboratory-like—clean, quiet, controlled—rather than the teeming, righteous activist spaces one might imagine. This subdued reaction was not a product of mothers' lack of genuine anger, but was instead due to a trifecta of silencing forces: neoliberalism, scientism, and postfeminism. Kimura's work raises important questions about the future of citizen science efforts, or "the scientization of activism" (2016: 20), given the constrained role of the citizen-subject under neoliberal governance.

Nancy Langston (2010) underscores gendered inequities as well, focusing on inadequate and unjust regulatory and medical institutions in her history of the DES disaster in the United States (see also Sze 2006). DES is a synthetic estrogen that was (over-)prescribed to millions of women in the 1950s. This toxicant caused reproductive cancers and other serious health issues for future children and grandchildren of the women who ingested it. Langston argues that manufacturers, regulators, and physicians continued to market, approve, and prescribe DES, despite known (and unknown) health risks, because these patriarchal institutions dismissed women's self-identified health needs while perpetuating gendered myths about miscarriage and menopause. Maintaining the critical gaze on the regulator, Jill Harrison (2011) describes US environmental and agriculture agency responses, or lack thereof, to citizen science and activist actions around pesticide drift. Harrison found not only that power asymmetries persist between farmworkers of color and predominantly White chemical regulators, but also that scientific practices

themselves render certain exposures—and bodies and systems—invisible. The devices used to measure toxicity levels are not designed to capture where and how pesticides drift from their targets of application, for example.

Harrison hints at the science studies critique that scholars like Michelle Murphy (2006) take as their starting point. Official pollution measurements are not simply flawed because of where monitoring devices are placed (i.e., deliberately far from affected areas), but also because such measurements make authoritative claims about toxicants that are predictive at best. While all scientific inquiry is predictive, toxicology's predictions are particularly dangerous. Toxicology's necessarily uncertain findings are interpreted to be "certain enough" for the purposes of chemical regulation and deployment (Boudia 2014; Nash 2008; Packer 2020). As Sara Shostak notes: "[The] gold standard of toxicological testing relies on the thirteen-week and two-year rodent bioassays" (2013: 20). Even the best toxicology studies necessitate a great deal of extrapolation (from rodent to human, high dose to low dose, short-term to long-term), and rarely analyze more than one chemical at a time. Arguably, then, given this inherently uncertain science, we come to know toxicants not through the toxicology, but through violence done to other/ed bodies. In the cases of DES, discussed above, or thalidomide (Dally 1998; Winerip 2013), it is pregnant women and their children and grandchildren who bear the (body) burdens of uncertain toxicological predictions. (See also Mansfield 2012; and Lappé et al. 2019.) DES and thalidomide are but two of a plethora of public health disasters that revealed the real dangers of toxicants—chemical violence that toxicology's controlled laboratory conditions cannot predict, never mind prevent. Empire and empirics scholarship, reviewed next, confronts these limits of dominant toxicant science.

Empire and Empirics: Decentering Dominant Onto-Epistemology

I characterize studies of toxicity as critical feminist if they offer intersectional (Crenshaw 1989) analyses that understand chemical deployment and its ill-health effects as always already racialized and sexualized (Voyles 2021). This third approach, grouped here under the heading "empire and empirics," refuses Eurocentric e/valuations of human mattering and unsettles Western knowledge claims, while simultaneously insisting that specific people and places bear disproportionate toxic burdens and that these unevenly distributed harms must cease.

Soraya Boudia and colleagues (2018) call for a scholar-activist shift to toxic "residues," as opposed to isolating a specific chemical, country, or community, in an effort to unsettle dominant science and states' arbitrary yet authoritative demarcations of regulation and nation. Toxicants do not adhere to Western liberal regulatory or classificatory systems, and critical research on toxicants should likewise complicate its conceptual tools. As Boudia and colleagues phrase it: "Residues are transgressive. They disobey boundaries, appear where they shouldn't appear, alter environments, and enter communities and bodies without permission. Following them around, rooting them out, holding them up to the light, allows a different world to come into view, a world we cannot see so clearly if we begin our exploration with the economics of chemical production or the legal studies of chemical regulation or the chemical politics of sick communities" (2018: 167). Natalia Duong's (2018) creative consideration of "the agency of Agent Orange" allows such a different world to come into view. Duong's analysis of conjoined, and later surgically separated, twins Việt and Đức—born conjoined because of the toxic effects of dioxin, a lingering metabolite of the chemical weapon Agent Orange—follows the residues of this US-made and deployed poison across Southeast Asia through the babies' bodies, the Vietnamese hospital, Japanese charitable contributions for the surgical procedure, and the postwar Vietnamese state,

among other actors and spaces. In so doing, Duong deftly decenters the US state-subject and dominant scientific approaches, refuses to stigmatize disability, and demands accountability.²

Kristina Lyons (2018) disentangles an analogous form of chemical warfare: the aerial spraying of US-made pesticides, mainly the carcinogenic glyphosate, for the “war on drugs” in Colombia. These aerial deployments destroy farmer livelihoods as they poison interdependent, more-than-human ecologies. Lyons’s feminist ethnography offers “evidentiary ecologies as an alternative form of evidence-making under conditions of military duress” (2018: 416). Colombians’ lived experiences of aerial deployments of toxicants, to which they respond with socio-ecological reparative practices, call for accountability above and beyond the imposed limits of “official state compensatory processes” (2018: 416). While not exclusive to toxicants, Hannah Landecker’s (2015) “biology of history” concept also traces the bio-chemical-material residues of warfare, bringing power asymmetries into stark relief. One especially virulent strain of antibiotic-resistant bacteria named “Iraqibacter” (*Acinetobacter baumannii*) was not merely generated by bacterial movements alone, but rather was co-produced by US and other imperialist incursions into Iraq (Dewachi 2019). The 1990s Gulf War blocked Iraqis’ access to the variety of medicines necessary for thwarting antibiotic resistance; having to adapt itself to only three different antibiotics, *A. baumannii* quickly mutated and is now resistant to all known antibiotics.

Alongside Lyons’s (2018) critique of Colombia’s official compensatory regimes, Fabiana Li (2009), Daniel Renfrew (2013, 2017, 2018), Peter C. Little (2019), and Angeliki Balayannis (2020) document how top-down and technocratic processes of accountability both fail to curb petrochemical corporate power and allow government actors to shirk responsibility, all the while maintaining an illusion of action. As Li writes of Environmental Impact Assessments: “Couched in a language of transparency, environmental management, and democratic participation, these practices are both pervasive and difficult to criticize” (2009: 219). Renfrew (2013, 2017) cautions against the pragmatism of public health campaigns, drawing from his anthropological work on Uruguay’s unequal lead exposures, which tend to individualize environmental health crises and blame the racialized victim. Because preventing toxic exposure requires dethroning deeply invested and well-resourced petrochemical corporations, “[the] harm reduction approach is then portrayed as the only viable option; a more financially feasible and politically expedient ‘pragmatic’ response” (Renfrew 2018: 3). Balayannis (2020) follows chemical residues via the mental and physical labor behind the so-called “removal” of hazardous waste. Her multisited ethnography shows how the “bureaucratic spectacles” of remediation cleanly omit toxic residues that are irremediable, for instance the contaminated soil beneath an abandoned pesticide shed. Such bureaucratic spectacles cannot contain the slippages of substances, as when hazardous material suits tear, or sacks containing pesticides split, excessively contaminating the Tanzanian laborers, in Balayannis’s study, who carry out the toxic work of removing banned and expired chemicals produced elsewhere. On another side of the African continent, Little (2019) conceptualizes “toxic postcolonial corporality” as a means of refusing the technocratic, pragmatic, and ultimately inadequate government responses to racialized environmental injustices. Ghanaian electronic waste “recyclers” are structurally positioned to take on this extremely toxic work as a cumulative result of colonial exploitation and extraction, inclusive of the uneven global movements of electronic commodities (Akeso and Little 2018; Little 2019). Little suggests that centering workers’ embodied struggles, including such visceral evidence as the burn scars on their skin, refuses the depoliticized distancing and victim-blaming of public officials (e.g., extolling workers to wear face masks correctly), while simultaneously constituting undeniable, powerful testimony against the insults and injuries of greenwashed technofixes.

Gabrielle Hecht (2012) similarly traces toxic residues across sociospatial boundaries without letting perpetrators off the hook. Her analysis of radioactive materials firmly centers imperial-

ism both because “empire has long been central to nuclear geographies” (2012: 22) and because of which people and places are considered nuclear.³ For example, in 1995, US authorities labeled Niger, Gabon, and Namibia, which together “accounted for more than one-fifth of the uranium that fueled power plants in Europe, the US, and Japan” (2012: 13), as bereft of nuclear activity, simultaneously erasing these African uranium miners’ exposures as well as their crucial, if not sacrificial, role in the global nuclear industry. What makes something or someone nuclear is not simply the presence or absence of radiation, but the presence or absence of radiation measurements and measurers (on the problems of postcolonial scientific capacity, see Tousignant 2018). As Hecht writes: “Colonial rule (and its legacies), grounded in presumptions of racial difference, [makes] that translation particularly difficult to achieve” (2012: 15). Presumptions of racial difference paired with “chemicals’ sneaky and undetectable characteristics” (Nunn 2018: 1333) also make for particularly pernicious “toxic encounters” (2018: 1330). Alongside other authors in this section, Neil Nunn (2018) insists on placing “toxic geographies” in their “longstanding histories, ideologies and systems of control” (2018: 1332)—specifically settler colonial space, in his work (see also Romero et al. 2017 on “chemical geographies”). Arguing that Canada’s contemporary governance strategies obscure the connections between settler colonialism and ongoing racialized disparities in toxic exposures, Nunn urges anticolonial EJ struggles to resist settler culture’s tendency to compartmentalize “toxic encounters and [frame] these incidents as distinct and unrelated” (2018: 1332). Instead, an Indigenous EJ thinks of “toxicity as a form of affective relationality between people and other subjects, material, immaterial and animate, inanimate” (2018: 1333).

Vanessa Agard-Jones (2013, 2014, 2015), Adriana Petryna (2013), and Michelle Murphy (2006, 2013, 2017) narrate various entwinements of imperialism and toxicants wherein racialized and sexualized hierarchies become embodied in unprecedented forms. In Agard-Jones’s (2013, 2014) case, Afro-Caribbeans in the Antilles, colonized by France, remain exposed to and still suffer from chlordécone long after direct colonial rule. (Known as kepone in English, this endocrine-disrupting pesticide was manufactured by the US-based Allied Chemical Co.) Notably, chlordécone was banned in the United States and France nearly two decades before it was banned in Martinique and Guadeloupe. Agard-Jones’s (2015) analysis shows that in addition to colonial toxic products, the Antilles also remains burdened by colonial toxic masculinity, as local media derogatively suggest that chlordécone exposures have produced homosexuality among men. Narrating a different space and time of imperialism, Petryna (2013) listens to lower-classed Ukrainians recall how they were forced to “remove” nuclear waste from the Chernobyl catastrophe (beginning in 1986) after robots disposed to complete the same task could not operate because of such extraordinarily high levels of radioactivity. This uneven proximity to nuclear fallout has produced new forms and practices of what Petryna calls “biological citizenship,” whereby those seeking public entitlements must demonstrate and document a state-sanctioned degree of deformation and disability.

Michelle Murphy and Reena Shadaan (Murphy 2013, 2017; Shadaan and Murphy 2020) stress the racialized, “transgenerational chemical violence” of EDCs in particular. In the Anishinaabe and Haudenosaunee territories (known, for now, as the Great Lakes area of the United States and Canada), toxicants long since prohibited continuously permeate resident relations. “Forever chemicals” like polychlorinated biphenyls (PCBs) persist in the air, water, and soil, and bioaccumulate in fish and human breastmilk while their harmful effects may be passed on epigenetically (see also Liboiron 2021). Kim Fortun (2001) similarly emphasizes the complexities of “continuing liability,” drawing from the 1984 Bhopal disaster—still ongoing—wherein a pesticide factory exploded, having been poorly maintained by the US corporation Union Carbide. This sudden and enormous release of highly toxic gases gruesomely murdered an estimated

15,000 impoverished, rural Indians and gravely injured and impaired at least 600,000 more. In such toxic disasters, EJ advocates must struggle against the inequities of “First World” transnational corporations situating their high-risk sites in “Third World” locales while avoiding any sort of transnational liability. Meanwhile, EJ activists must also struggle against the “rigorously unlinear, unpredictable, cumulative effects” of the toxicants themselves (Fortun 2001: xvi), movements and inter/re/actions for which Western science fails, or refuses, to fully account.

Mel Chen (2011, 2012) extends such historically contextualized analyses of disproportionate chemical harm, examining in the case of lead exposure how toxically induced difference itself becomes a site of continued discrimination. Urban-residing, African American boys, who are already racially stereotyped as “at-risk,” or volatile, unintelligent, and impure, are further stigmatized once lead-poisoned, and are presumed to be necessarily more “delayed.” Chen calls for an antiracist, queer, “crip” (Kafer 2013) politics that holds perpetrators accountable without succumbing to White supremacist, heteronormative, and ableist assumptions about race, sexuality, and cognition (see Barba 2020 and Clare 2017). Chen’s methods—unabashedly sensual and nonlinear—productively destabilize Western onto-epistemology in and of themselves. Nicholas Shapiro (2015) offers a complementary contribution in his concepts of the “chemical sublime” and “chemo-ethnography,” the latter along with Eben Kirksey (Shapiro and Kirksey 2017). Within the chemical sublime, “indistinct and distributed harms [of toxic exposures] are sublimated into an embodied apprehension of human vulnerability to and entanglements with ordinary toxicity, provoking reflection, disquiet, and contestation” (Shapiro 2015: 369). Chemo-ethnography is how Shapiro and Kirksey characterize recent anthropological approaches, such as Chen’s, to better understanding chemicals in and as relations. “Chemo-ethnographers . . . conduct research on economic, personal, political, and sentimental relationships that have emerged with modern chemistry . . . [considering] chemical relations in more-than-human realms” (Shapiro and Kirksey 2017: 482). Similarly, other scholars (Ahmann and Kenner 2020; Auyero and Swistun 2009; Spackman and Burlingame 2018) document forms of what Elizabeth Roberts and Camilo Sanz (2018) call “bioethnography,” tracing the complex entanglements of biological, ecological, chemical, and social co-constitution.

Western-trained scientists began sounding alarms over toxicants’ interference with hormones as early as the 1960s (Carson 1962; Davis 2014; Krimsky 2000). By the 1990s, this mounting concern over the adverse effects of EDCs had reached a crescendo in what Giovanna Di Chiro (2010) calls a “heteronormative sex panic.” Public health advocates expressed grave concerns over “feminized frogs,” “demasculinized alligators,” and “plummeting sperm counts” (Colborn and Clement 1992; Guillette et al. 1996; Hayes et al. 2002; Swan 2021), while media outlets suggested that female–female couplings in seagulls could only be “abnormalities” produced by EDC exposure (see critiques in Ah-King and Hayward 2013; Pollock 2016; and Lambert and Packer 2019). Like Agard-Jones (2015), discussed above, Anne Pollock (2016) and Alexis Shotwell (2016) challenge these heteronormative stereotypes without losing sight of the structural inequities that overexpose specific communities. Paraphrasing Pollock, even if it were true that hormone-interfering chemicals “make animals gay,” why should this outcome be understood as harmful? While “queering endocrine disruption” (Pollock 2016) does important work to shift scientific cultures, including pointing interrogations toward the polluters, such critiques must take care not to undermine marginalized communities’ intergenerational claims of unjust exposures and related pursuit of reparations. It is worth noting here as well that Syngenta Corporation has viciously attacked biologist Tyrone Hayes for his research on the endocrine-disrupting effects of their toxicant atrazine, one of the world’s most prevalent pesticides. Syngenta’s campaign against Hayes seems to have been especially hostile because Hayes is African American (Aviv 2014).

Elizabeth Hoover (2017) and Elizabeth F. S. Roberts (2017) wrestle more directly with these “violent entanglements” (Roberts 2017), while also making the authority of dominant science work for different sovereign subjects. Roberts’s economically, socially, and geographically marginalized Mexican interlocutors perceive the police as more of a threat to their well-being than the toxic sewage permeating their neighborhood, the stench of which keeps the police away. Moving as an intermediary, Roberts works closely with the residents of Colonia Periférico to shift the ways her epidemiologist colleagues conceive, conduct, and conclude their scientific studies. Hoover’s (2017) work underscores the settler colonial undertones (and overtones) of such concepts as “toxic trespass” while also highlighting Mohawk nations’ “survivance” (Vizenor 2008) strategies against the ongoing occupation of their territories. The rivers, livelihoods, and landscapes of the Akwesasne community with which Hoover engages have been polluted by settler colonial incursions for hundreds of years. For Akwesasne, more recent (1980s) episodes of methyl mercury and PCB pollution, among other toxicants, interrupting their fishing, eating, and breastfeeding are only the latest in a series of bodily, sensory, and material violations (also see Spice 2018). Toxic exposures from the 1980s and beyond, compounded by toxic exposures—broadly defined—from the 1880s if not earlier, will persist in Akwesasne spaces and bodies into the foreseeable future. As the title of Hoover’s book simply yet profoundly puts it, *The River Is In Us*. Importantly, this Akwesasne community “reshaped how science is conducted and created a third space [of sovereignty] where the subjects and community are also part of the research process. . . . They did not reject the institutions of science altogether, recognizing the need for this type of knowledge, but neither did they agree to a conventional research study” (Hoover 2017: 261–262). Here, we see how empire and empirics scholarship reclaims the “sound science” of deceit and denial analyses by insisting upon nonhierarchical collaborations and explicitly valuing care work.

Elizabeth A. Povinelli (2015, 2016) engages with Indigenous cosmologies of “kincentric ecology” (Salmón 2000) as well in her immersive scholarship and art practice with the Aboriginal Belyuen community of Northern Australia, people who likewise bear disproportionate toxic burdens in the fallout of settler colonialism and its extractive industries. In a sick sort of solidarity with the residents of the poisoned Mexico City neighborhood in Roberts’s (2017) work, Povinelli codirects an “improvisational realism” film, wherein four Indigenous men in Darwin, Australia, successfully avoid police capture (having been falsely accused of theft) by hiding in a radioactive disposal zone, which itself was erected near a sacred site: “Don’t worry . . . [the police] won’t come in here. We’re safe, too much radiation here; we’re safe” (Povinelli 2015). The Belyuen cosmology that Povinelli learns from offers a kind of resignation to the present world’s toxicity, suggesting that the Earth’s inhabitants have no choice now but to turn to different forms. Many non-European onto-epistemologies have long understood that “the body” neither begins nor ends at the skin (Cajete 2000; Kimmerer 2020). Recent findings in epigenetics and the nonlinear movements of EDCs are also upending dominant interpretations of heredity as well as of the toxicology tenet that “the dose makes the poison” (Vogel 2008). Counterintuitively, perhaps, EDCs can be more harmful at lower doses than at higher doses, demonstrating that toxicity also depends upon the timing of exposure, rather than simply on the quantity. Indeed, all manner of environmental traumas, from famine to dispossession to working the third shift, can detrimentally interfere with our metabolic systems and catalyze inheritable, epigenetic changes that lead to ill health (Brave Heart 2000; Thayer and Kuzawa 2011; Rothstein et al. 2009). As the limits of Western onto-epistemology become clearer to conventional practitioners themselves, I suggest that humble engagement with Indigenous, Black feminist, queer, and other anticolonial conceptions of interdependence holds great deconstructive and regenerative potential.

Conclusion

Critical historians and practitioners are increasingly unsettling Western onto-epistemology (including the natural and social sciences), situating the development of this worldview in legacies of imperialism and its attendant schemes of racialization and sexualization.⁴ Historicizing the scientific enterprise in this way compels re-analysis of knowledge producers as well as knowledge produced. Phenomena such as “the” body or chemical are inextricable from the social relations that conceive them (Barad 2007). Toxicants are thus better understood as “imperial formations” (Stoler 2008) than as preextant or discrete entities, for it was racialized and sexualized projects of empire (Anderson 2006; Lugones 2007; Markowitz 2001) that seeded what is now widely referred to as “Science,” inclusive of its material and semiotic objects. This historical emergence means that, in addition to toxic exposures, the toxicant too is racialized and sexualized. How might critical thinkers and EJ activists proceed from this “permanently polluted” place (Liboiron et al. 2018)?

Indigenous and postcolonial scholars rightfully insist that research methods be as committed to decentering Euro-Americanness as research topics (Lyons et al. 2017; Tuck and Yang 2012). In response to these calls, a growing community of engaged researchers are building from empire and empirics critiques to productively dismantle disciplinary boundaries. Scholar-activists such as Kim Fortun (2014), Nicholas Shapiro and colleagues (2017), Katherine McKittrick (2015, 2021), and Julie Sze (2020) are among those who insist on repoliticizing the depoliticized quantifications of dominant science by way of nonhierarchical collaboration between physical scientists, social scientists, humanists, artists, activists, and other “creatives” (Prescod-Weinstein and McKittrick 2021). Empire and empirics analyses further reveal that “living in a toxic world” (Nading 2020) includes radical forms of care work. Caitlynn Beckett and Arn Keeling (2019) rethink the kinds of toxin removal projects critically analyzed by Balayannis (2020), for example, by insisting on new forms of remediation that are “ongoing, creative [processes] of community healing” (2019: 216). Reframing remediation processes as ongoing, rather than as finite events delimited by the bureaucratic technics of toxic cleanup, centers public participation and the affected public’s EJ demands. Nerea Calvillo’s (2018) ethnographic work in Madrid, Spain, likewise calls attention to different ways of attuning to toxicity. In response to government officials moving air pollution monitors so that less was officially tallied, Madrid residents acted in collective ways to “shift the focus from asking ‘what is toxic?’ to asking ‘what do we need to know about the toxic to act?’” (Calvillo 2018: 374). Resonant with Lyons (2018), Manuel Tironi (2018) highlights “intimate” forms of activism, documenting the small yet powerful acts of care-work-as-resistance that marginalized Chilean residents engage in, such as cleaning chemical residues off their tenderly cultivated gardens or healing their loved ones’ toxicant-induced ailments. Tironi urges EJ advocates to acknowledge these “hypo-interventions” and “intimate activism” as care-full forms of everyday resistance to the unavoidable, unending crises of permanent pollution.

Critical scholars more identified with the natural sciences are also studying toxicity differently. For example, Max Liboiron’s Civic Laboratory for Environmental Action Research (CLEAR) practices generative methods of toxicant research that are at once feminist, queer, anticolonial, and firmly grounded in the material realities of unjust exposures (CLEAR 2017a). CLEAR studies do not simply measure the quantity of plastics polluting a given fish system, for instance, but also intentionally include the colonial legacies that produce these ongoing toxic relations, and meaningfully involve local residents, embracing their different sets of expertise (Liboiron 2020b). Sara Wylie’s (2018) Public Laboratory for Open Technology and Science (Public Lab) engages in community-based, participatory scientific knowledge production as

well, using “low cost, do-it-yourself environmental monitoring tools.” Cleo Woelfle-Erskine’s (2020) Feminist Research in Eco-Social-Hydrologies (FRESH) lab conscientiously experiments in ways that make Black, Indigenous, queer, and trans liberation movements central to urban ecological restoration, or what they term “science for the riparian dispossessed.” Whether through “improvisational realism” filmmaking (Povinelli 2015), Tribal protocol (as opposed to colonial/university-defined Institutional Review Boards; Hoover 2017), intersectional feminist lab meetings (CLEAR 2017b; Woelfle-Erskine 2020), or DIY environmental-monitoring tools (Wylie 2018), undisciplined, engaged scholarship refuses—and prefigures alternatives to—the technocratic abstractions and obfuscations generated by official risk assessment, remediation, or accountability regimes (see Mansfield 2021). In sum, approaches like bioethnography (Roberts and Sanz 2018) and chemo-ethnography (Shapiro and Kirksey 2017), or the participatory practices of CLEAR and Public Lab, produce scientific knowledge with intention, rejecting the dominant view of science as disinterested and acultural. Expanding early feminist analyses of the situatedness of all knowledge (Haraway 1988), even that which makes claims to objectivity (Harding 1995), today’s critical feminist studies of toxicity embrace care and collaboration out of their recognition that (embodied) experiences, practices, and knowledges are always incommensurable and nevertheless valid.

Such transdisciplinary efforts are not without their challenges, from unsupportive academic departments to funding scarcities to government-led attempts to “cancel” critical race theory (Goldberg 2021). Moreover, given that tens of thousands of toxicants are currently circulating (Birnbaum 2013), many of which will never disappear even once production ends, vital questions endure: who is to be held accountable and how do “we” (Liboiron 2020a) move on when toxic effects are forever? Empire and empirics analyses help reveal care work and collaboration as liberatory pathways through today’s bio-chemical-political predicaments. In the poetic phrasing of Black feminist theorist Saidiya Hartman: “[Care] is the antidote to violence” (Kaba 2017). Toxicants cannot be put back in their bottles, but cultural-scientific spaces can center the embodied experiences of frontline communities and relational onto-epistemologies of other/ed cosmogonies. Clearly, the dominant Western approach to toxicants has not adequately protected environmental health. I encourage conventionally trained scientists to more care-fully and collaboratively confront the biochemical *and* the biopolitical of toxicity. We may all learn from cultural scholars, artists, and EJ activists to better understand toxicants’ imperial formations and unruly residues, and rise to the challenges that such creative, undisciplined studies demand. Only through truly decolonizing actions will we co-create more pleasurable, livable lives on a swiftly turning planet.

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■ NOTES

1. The environmental justice (EJ) literature is vast and beyond the scope of this review on toxicity. See Kojola and Pellow (2020) for a recent review of EJ scholarship.
2. A full account of the toxic residues of Agent Orange would require its own article. For more on the “contested illnesses” wrought by this particular chemical weapon, see Tine Gammeltoft’s (2014) ethnography of Vietnamese parents struggling with the stigma of Agent Orange exposure, as materialized by their babies’ potential health issues. Children of Vietnam veterans in the United States have also experienced exposure-related complications, which likewise remain contested by chemical manufacturers Dow and Monsanto (now Bayer). See Hertz-Picciotto et al. (2018).
3. A rich body of literature exists on the chemo-cultural toxicity of nuclear radiation specifically, too numerous to fit in this review, including for example the work of Traci Brynne Voyles (2015) and Joseph P. Masco (2004, 2015).
4. In this “antiscience” historical moment, I wish to emphasize that such critiques of science are not refusals of reality (Weigel 2019), nor openings for climate denial, but rather more explicit acknowledgments of reality and the exigency of action.

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