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# Toxics Trouble: Feminism and the Subversion of Science

*Toxic chemicals trouble bodies and ecosystems, politics and culture. This essay points to the matrix of factors constitutive of what can be termed "industrial culture" as the backdrop, then moves on to describe displacements and shifts that have made toxics increasingly legible. New ways of connecting and visualizing information, enabled by digital infrastructure, have been critical, mobilizing knowledge practices and formations inflected by what can be thought of as a semiotic theory of meaning. Poststructural, postcolonial and feminist theorization of ways meaning and authority is made, and foreclosed, enable a reading of the historical shift and politics at hand. The problem, and possibility, is in what Homi Bhaba called "Articulating the Archaic," permitting what was once culturally unassimilable to refigure how we think about relatedness, knowledge, reasonableness, and care.*

A dream of toxicologists at the turn of the 21st century was to build a database to house and connect a vast set of data and studies relevant to environmental health science. The proposed size of the database was impressive, but most critical was the connections it would allow. New findings from gene expressions studies would be linked to established findings in histology, clinical chemistry and pathology. The database would be designed to permit data integration across studies to enable new kinds of meta analysis. Data could be archived so that it could be reanalyzed as new data analysis software became available.

These toxicologists were at the U.S. National Institute of Environmental Health Science (NIEHS), in the newly established National Center for Toxicogenomics. Their mission was to turn toxicology on its head, upending the slow, one-chemical-at-a-time, rodent-based approach that had become toxicology's signature. They were proud of what the older approach had achieved, and of the carefulness of the methods upon which findings were based. But they knew that the established approach was no match for the vast number of chemicals in use, and about which there was increasing concern (Fortun/ Fortun 2005).

The goal was to cultivate "the emergence of toxicology as an information science that will enable thorough analysis, iterative modeling, and discovery across biological species and chemical classes" (Waters et al. 2003: 17). Raymond Tennant, Director of the National Center for Toxicogenomics (NCT), described the overall goal as "systems toxicology." Toxicology, he argued, "will progressively develop from predominantly individual chemical studies into a knowledge-based science in which experimental data are compiled and computational and informatics tools will play a significant role in deriving a new understanding of toxicant-related disease" (Tennant 2002: A8).

Rather than focusing on "apical endpoints" (tumors, for example), the effort was "to define pathways and gene interactions through which chemical or environmental stressor effects are mediated," recognizing that "there are a plethora of environmental factors and stressors, such as ultraviolent and ionizing radiation, biological agents and dietary and lifestyle components" (Tennant 2002: A8). The human body was conceived as porous, and situated in socially, biologically and chemically dense space; the body's interior was also conceived as complex, and difficult to represent in conventional terms.

To develop systems toxicology, it was argued, interpretive challenges at multiple levels of biological organization had to be addressed. But capacity for this was limited: "The lower levels of complexity (genes, gene groups, functional pathways) reflect our current levels of understanding and our ability to describe and package that knowledge using what might be termed 'linear bioinformatics,'" NCT researchers explained. They also recognized that linearity was what risk assessors wanted. Risk assessors, NCT researchers knew, sought to define a sequence of key events and common (linear) modes of action for environmental chemicals and drugs. Yet "systems biology reality" was more complex, involving constant, global change in cells in response to ongoing environmental stimuli. Such a reality is "only dealt with superficially" at present, they wrote (Waters et al. 2003).

With this NIEHS effort, knowledge, too, was conceived as emergent from complex interactions, between varied data sets, studies and researchers. And knowledge, too, was situated in socially complex space, a space laced with thousands of chemicals that had not yet been studied, a space in which prevailing modes of risk assessment demanded linear constructions of toxicity even as toxicologists recognized more complex biological realities.

The "Chemical Effects in Biological Systems" (CEBS) database has not developed as quickly and dramatically as its founders hoped it would.[1] But the momentum to develop new strategies for toxicology for the 21$^{st}$ century has continued (NRC 2007). The challenges ahead are considerable, and daunting.

1 See http://www.niehs.nih.gov/research/resources/databases/cebs/index.cfm

A massive increase in funding for environmental heath research will be required. The techniques of toxicology will need to be revised and accelerated. Young scientists need to be drawn into a field that doesn't (yet) enjoy high fashion status. Toxicologists, as one older scientist told me, have long been thought of as the sewer-diggers of science. Revising this will require no less than a cultural shift. Ramping up toxicology will mean that industrial culture writ large has to be powered down.

Such a shift is already underway. In what follows, I will briefly describe what I think of as industrial culture, and how the logics of industrial culture foreclose engagement with toxics.[2] I'll then describe recent developments in toxicology and the environmental health sciences more generally that have made toxics more meaningful. New ways of connecting and visualizing information, enabled by digital infrastructure, have been critical, mobilizing knowledge practices and formations inflected by what can be thought of as a semiotic theory of meaning. Poststructural and feminist theorization of ways meaning and authority is made, and foreclosed, enable a reading of the historical shift and politics at hand.

Toxics can be said to be subaltern within industrial culture. Like the subaltern figures analyzed by Gayatri Spivak (1988), toxics can't speak within established order. But space can be cleared for the emergence of new orders of meaning – that deal differently with difference, relationality, and what counts as reasonable,[3]

2 My focus is the United States, where industrial culture is particularly entrenched and protected by law. Countervailing thinking about the risks of industrial chemicals has nonetheless developed, animated by events such as the 1962 publication of Rachel Carson's *Silent Spring*, late 1970s coverage of the health threats of buried industrial chemicals in Love Canal, New York, and the 1984 Bhopal disaster (which mobilized many "fenceline" communities in the United States). The primary legislative response to the Bhopal disaster in the United States granted the public (and particularly at-risk communities) the "right-to-know" about industrial risk, both catastrophic (as happened in Bhopal) and routine. This legislation led to the creation of pollution inventories and other environmental information resources that have driven the concerns described here. Nonetheless, momentum to revise the 1976 Toxics Substances and Control Act (TSCA) has been repeatedly undercut. Throughout 2009 and into 2010, for example, U.S. Congressional hearings were held to "revisit" TSCA, and many scientists testified in support of reform. While industry representatives first agreed that TSCA needed to be "modernized," they later withdrew support for proposed bills. By late 2010, advocates described TSCA reform efforts as dead.

3 There is now a wealth of scholarship that critically assesses conventional, "Enlightenment" constructs of Reason, the best noting how alternatives are both coded by and

cognizant of intersectionality[4], aware that something and someone always gets left out. Environmental health scientists today are doing this kind of work – producing new forms of scientific practice, infrastructure and knowledge, mobilizing a cultural shift with profound political implications.

## The Matrix of Industrial Culture

Subalternity is not, it must be emphasized, about lack on the side of the signifier. It is not that the subaltern cannot speak. The problem is that she can't be heard. The problem of and for the subaltern is that dominant language (and theories of language) shut her out. As natives are shut out by imperial culture, toxics are shut out by industrial culture. They are ubiquitous, but disavowed, ignored while depended on.[5] How is this so? What matrix of factors constitute "industrial culture," cumulatively foreclosing toxics?

First, many toxins are pharmakons in the most literal sense. They are medicines, remedies, solutions, but also poisons. In many uses, they are efficacious *because* they are poisonous. Toxics thus resist explanation though binary opposition, explanation that insists that one is male or female, good or bad, safe or dangerous, promise or poison. Industrial culture has been built on such binaries.

Toxics also change, refusing stable identity. Each chemical has a structure, attached to other structures in a chemical product such as a pesticide. Many of

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must be worked out within governing norms and discourses. Jacques Derrida, for example, explains that "(s)ince the revolution against reason, from the moment it is articulated, can operate only within reason, it always has the limited scope of what is called, precisely in the language of a department of internal affairs, a disturbance" (1978: 36). For overtly feminist critiques of conventional constructs of Reason (and objectivity), see Donna Haraway's "Situated Knowledge: The Science Question in Feminism and the Privilege of Partial Perspective" (1988), Evelyn Fox Keller's "Dynamic Objectivity: Love, Power and Knowledge" (1985:115-126) and Gayatri Spivak's essays in Other Worlds; Essays in Cultural Politics (1987b).

4 In the early 1990s, feminist and critical race theorist Kimberlé Crenshaw criticized identity politics for ignoring intersectionality - asking people to be either raced, woman or queer, and for ignoring intragroup differences. This makes it difficult to deal with domestic violence in black communities, for example, and limits the standing women, in particular, have before the law. An intersectional sensibility involves recognition of multiplicity: the simultaneous examination of race, ethnicity, sex, class, national origin, sexual orientation, etc.

5 Homi Bhaba describes subaltern groups as "oppressed, minority groups whose presence was crucial to the self-definition of the majority group" (1996: 191).

these structures aren't stable. They change as conditions change, often creating byproducts through interaction with elements in new contexts. Their "fate," as exposure scientists refer to it, is hardly straightforward. This is a problem; industrial culture insists on more stability. Stable identity across time is the making of both ethical and epistemological integrity. We know a good man through his consistency; we know good science through duplicated results; we know a hazard as a hazard only if it can be clearly and straightforwardly linked to an origin. Straight reproduction is all that is recognized. No dissemination allowed.

Then there is host susceptibly. Humans – and other creatures – do not all react in the same way to toxic exposure. Age and sex play a role. Genetics likely plays a role. A study in Mexico City (known for exceptionally poor air quality and particularly ground-level ozone levels), for example, showed that interindividual variation in ozone response can be connected to variation in common polymorphisms in two genes involved in response to oxidative stress – not just in the general population, but *among* children with asthma. The study concluded that children with two particular genotypes appear more susceptible to developing respiratory symptoms related to ozone exposure (Ramirez-Aguilar et al. 2006). Ozone thus is, and is not, a specifiable agent of disease. Industrial culture does not like this kind of play.

Nor can industrial culture deal with intersectionality. As Kimberlé Crenshaw demonstrated many years ago, dominant discourses and institutions don't allow for there being a lot going on (Crenshaw 1989; 1991). If one is black and a woman, and maybe even queer, the system doesn't know what to do with you. You have especially limited standing before the law. Toxicologists would call this "cumulative effect," and recognize that it is difficult to deal with in science, law and regulation. If you smoke and have occupational exposure to welding fumes, for example, it is difficult to discern how your occupational exposure makes a difference to your health. Industrial culture tends to end the story there. The difficulty of intersectionality just isn't taken on; things that are difficult, things comprised of complex and shifting relationships, are rendered meaningless. As philosopher Daniel Price argues in *Touching Difficulty* (2009), we deal today with a deep cultural bias against things that we can't know in advance, that we can't grasp from known subject positions, and articulate with clarity. Difficult knowledge thus isn't apprehended. Price suggests that we could learn to reach for it, to touch difficulty. But this would require new ways of ordering meaning.

It doesn't help that there is a quite remarkable paucity of scientific research on chemical toxicity to build from. In part, this is because of vested interests and related lack of funding. It also is due to the structure of law. In the United States, for example, the Toxics Substances Control Act (TSCA) is structured such that assessment of toxicity does not have to occur unless there is reason to believe that toxicity is a problem. So there is a funny looping. One does not have to inquire about problems unless one already knows there are problems. In the worst cases, often corporate, there can be an egregious will *not* to know, an imperative not to ask questions. Since TSCA was enacted over thirty years ago only a handful of substances have been banned under its authority (Schierow 2007; U.S. E.P.A. 2007). Such is the logic of law.

The law also privileges property over trespass, production over distribution, trade secrets over the right-to-know. What migrates beyond a plant's fenceline, or out of the plastics and textiles of consumer products, are always posterior in industrial culture, trumped by what is inside, essential, valued.

And then there are the logics of science. There are over 85,000 chemicals registered for commercial use in the United States. The U.S. National Toxicology Program (NTP), since its establishment in 1978, has only tested a few hundred chemicals. In part, this is because rodent studies are slow and very expensive. In part, this is because of what has counted as good science. As historian of science Evelyn Keller argued in the 1980s, science in the past tended to attract obsessive-compulsive personalities – personalities who tend to focus so intently on the object of their concern that context falls away. Their desire is to name, specify and control the objects of their study. Drawing on Shapiro's *Autonomy and Rigid Character* (1981) and *Neurotic Styles* (1965), Keller explains that "(t)he central concern of the obsessive-compulsive is control, not so much of others as of oneself... Under this harsh regime, attention is subject to the same kind of control as is the rest of behavior, leading to a focus so intensely sharp and restricted that it precludes peripheral vision, the fleeting impression, the hunch, the over-all feeling of an object.... And what does not fit is not acknowledged: The rigid or dogmatic compulsive person simply ignores the unusual; he narrowly follows his own line of thought and goes right by anything out of the way" (1985: 121-122). Toxics are difficult if not impossible to attend to in this kind of regime.

The last factor in the matrix of industrial culture that I'll point to here – the list does go on – is also a matter of bias, in this case explicit, against computational ways of knowing. The work of Peter Huber, infamous advocate of the free market, tort reform and "sound science," is illustrative. According to Sourcewatch, Huber made his name working for the (U.S.) Chemical Manufacturers Association in the 1980s, discrediting concerns about industrial products such as Agent Orange (infamous toxic defoliant used by the United States in the Vietnam War). His apparent task was to support corporate legal arguments that there was "no proven harm" from these products. This was accomplished by blocking or discounting critical evidence, creating a space in which chemical manufacturers' own evidence was accepted in court proceedings. Anything else came to be called "junk science," a term coined in Huber's 1993 book *Galileo's Revenge: Junk Science in the Courtroom*. As legal and social movements addressing toxics became increasingly visible in this period, the concept of "junk science" became part of Huber's effort to "save the environment from the environmentalists" (Cheseboro 1993). Huber's argument was simple:

> "To believe wholeheartedly in micro-environmentalism [concern about toxics], one must be either a savant or put a great deal of trust in savants. In particular, one must put one's trust in computer models. The model is everything. Only the model can say where the dioxin came from, or how it may affect our cellular protein. Only the model will tell us whether our backyard barbeques (collectively, of course) are going to alter rainfall in Rwanda. Only the model can explain why relentless pursuit of the invisible – halogenated hydrocarbons, heavy metals or pesticides – will save birds or cut cancer rates. The cry of the loon is replaced by the hum of the computer. T.R. [Theodore Roosevelt] trades in his double-barreled shotgun for a spectrometer." (Huber 1998: 1)

By this logic, anything that we cannot see "with our own eyes," is by definition, not a risk. Prosthetics of seeing are disdained. If things are difficult, they (simply) must be discounted.

This bias against difficulty, so central to industrial culture, has been resurgent in the United States of late, with conservatives and broadcasters making their mark by denying climate change, climate science (and its computer models) and the difficulties these pose. Clearly, there is cultural and political work to be done in response, and it is more than a problem of failed communication conventionally conceived.

The problem is in what counts as causation, evidence and science, and in how people think about the ways meaning and significance is produced. What is contested is what could be called language ideology. Those who argue that there is "no evidence" of climate change or hazards from environmental chemicals work with an essentialist theory of language that depends on objects having inherent and stable meaning. The way meaning can emerge from semiosis, from the play of prior signification, is discounted. The need to invent new ways of seeing is disdained. Environmental health scientists are taking a different tack.

## Movements and Differences

> Change often involves a pivotal event that builds on previous history and opens the door to a new era. Pivotal events in science include the discovery of penicillin, the elucidation of the DNA double helix, and the development of computers. All were marked by inauspicious beginnings followed by unheralded advances over a period of years but ultimately resulted in a pharmacopoeia of life-saving drugs, a map of the human genome, and a personal computer on almost every desk in today's workplace. Toxicity testing is approaching such a scientific pivot point.
>
> *National Research Council,*
> *U.S. National Academies, 2007*

As told in my opening story, toxicologists at the turn of the millennium dreamed of working within dense grids of data and findings, grids that would operate discursively, letting researchers wander through data, building insight through comparison. They wanted new forms of collectivity, new ways of relating data, and new ways of producing scientific knowledge. The call for new kinds of environmental health practice and knowledge has been sustained, and key players – the U.S. National Academies, the U.S. Environmental Protection Agency, and the U.S. National Institute of Environmental Health Sciences – have provided leadership.

The National Research Council hosted a series of workshops in the early 2000s that resulted in a 2007 publication that quickly became an important reference and guide, *Toxicity Testing in the 21st Century: A Vision and a Strategy.* The report is unabashed in asserting that a new era of environmental health sciences is upon us, comparing recent and expected advances to the discovery of penicillin, the elucidation of the DNA double helix, and the development of computers. Key to the shift was movement away from a system based on whole animal testing and apical end points, to a system based in in-vitro methods that evaluate biological perturbations using cells and cellular components, of mostly human origin. The report is clear that mere changes to the established system will not be sufficient. A "transformative paradigm shift" is required.

The NRC report identified many problems with the established paradigm. Extrapolating from animals to humans, and from high dose lab controlled exposures to low-dose actual exposures, which occur in mixtures; the time and expense of established methods. Referencing a report from the U.S. General Accounting Office, the NRC report emphasizes that in 1979 there were 62,000 chemicals in commerce; today there are 82,000, and about 700 are introduced each year. Basic toxicity data is lacking on many of these chemicals, and new nanomaterials create new evaluation challenges. The report is clear that a "critical feature of the new vision is consideration of the risk context (the decision making context that creates a need for toxicity-testing information) at each step and the ability to exit the strategy at any point when sufficient data have been generated for decision-making" (2007: 4).

By 2008, the Tox 21 partnership was forged to realize the vision for toxicity testing laid out in the NAS report published the year before. The partnership included the U.S. National Toxicology Program, the U.S. EPA, and the U.S. National Institutes of Health Chemical Genomics Center (NCGC). The U.S. Food and Drug Administration joined the partnership in summer 2010.

Prioritization is central to the EPA's work that contributes to Tox21. The EPA's National Center for Computational Toxicology, formed in 2005, is now oriented by a 2009 Strategic Plan for Evaluating the Toxicity of Chemicals. Key components include digitizing legacy toxicity testing information, building a database network to make models and underlying data publically available, and building virtual liver and embryo (v-liver and v-embryo) models. The latter projects (the v-liver and v-embryo projects) are a response to concern that taking testing out of whole animals could miss metabolic and other downstream effects of chemicals, acknowledging that toxicity is not always caused by the "parent" compound – the actual chemical to which an animal is exposed – but sometimes by a metabolite of that compound – by unexpected offspring, so to speak, what could be called bastard effects.

Other aspects of EPA's initiative also attend to things industrial culture tends to ignore or disavow. Bodies, for example, are not conceived as enclosed properties. Bodies are recognized as subject to trespass, as open systems. Toxicity testing thus must include exposure science. Efforts by EPA and associated researchers to describe human exposures and exposure science draw an impressive array of things into the picture: exposures in the workplace, through product use, through air, water, and food. They also draw out the many kinds of science – on chemical structure, fate and biotransformation, on host susceptibility and population dynamics – that needs to be part of toxicity testing. The goal is to build systems perspective at all levels of biological organization.

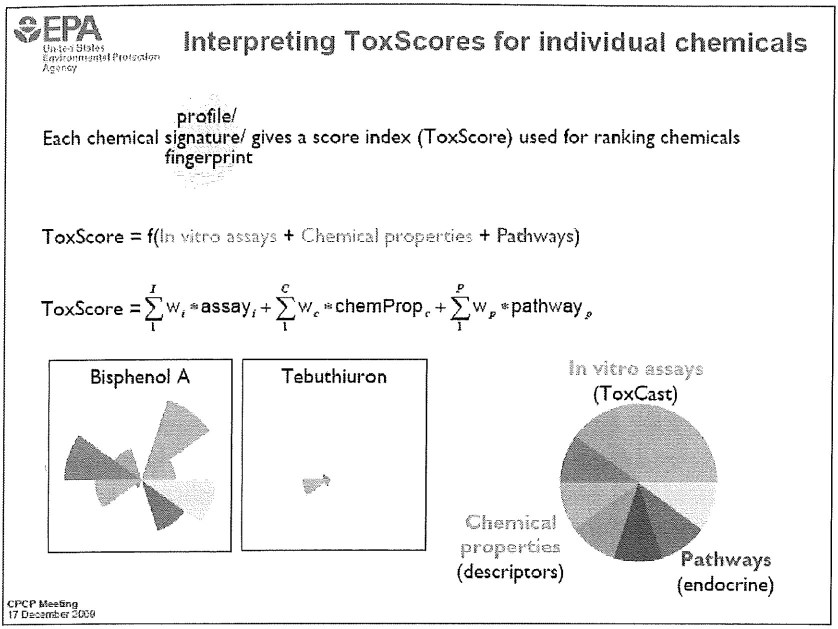
Linking different kinds of data and research is critical to the new approach. Rather than trying to understand whether a particular chemical is a hazard or not, through isolated studies, the effort is overtly intertextual, oriented toward "requisite precision." Requisite precision itself, though, is a challenge to generate. Prioritization of research and regulation makes it more possible, and is advanced by EPA's ToxPi effort – the Toxicological Priority Index – which provides a "new weight of evidence framework" (Linnenbrink 2010, Reif et al. 2010).[6] The ToxPi initiative is aggressively cumulative, building on many kinds of data and signification to create a new mode of signification expressive of toxicity. The key is discursive density that enables comparison. The system generates rather than represents meaning.

The ToxPi numerically integrates multiple chemical and biological knowledge sources. This numeric summation is displayed graphically – as a circle, with component slices of the circle representing information about chemical properties (in orange), from different types of in vitro assays (in green) and from pathway effects indicated by the assay results (in blue). The bigger the slice the greater the potency. The now infamous Bisphenol A (BPA), commonly used in plastics, can be compared to the herbicide Tebuthiuron (also suspected to cause endocrine disruption), for example. The slice representing estrogen receptor assays extends farther from the center for BPA when compared to Tebuthiuron, indicating that BPA is more potent across estrogen receptor assays. BPA also ranks above Tebuthiuron in all other ToxPi slices.

This numeration and visualization allows chemicals to be sorted, ordered, and prioritized. The many chemicals covered by the EPA's Endocrine Disruption Screening Program can thus be prioritized for further study. All ToxCast chemicals can also be sorted by endocrine score, allowing researchers to evaluate what the Endocrine Disruption Screening Program has left out. And new data can be layered in, and comparisons generated. One can compare endocrine scores with and without exposure data, for example. The sign of toxicity can be continually toggled and refigured as new data becomes available or comes to seem relevant.

These developments don't prove that toxics, at last, can speak. But they are being expressed in new ways. Truth, or at least knowledge, is being made differently, though comparative, juxtapositional, aggregative moves that provide angles on

6 "Weight of evidence" frameworks have been at the center of disputes over which and whose science will be used in toxics regulation in the United States. See Sara Vogel's excellent article "The Politics of Plastics: The Making and Unmaking of Bisphenol A 'Safety'" (2009). Brendan Borrell's "The Big Test for Bisphenol A" (2010) also describes controversies around the science of Bisphenol A, hinting at the incredible weight of industrial culture in the United States.




Both images from David Reif, Matt Martin, ShirleeTan, Keith Houck, Richard Judson, Ann Richard, Thomas Knudsen, David Dix, Robert Kavlock. "Endocrine Profiling and Prioritization of Environmental Chemicals Using ToxCast" Presented 17 Dec 2009, CPCP Meeting. National Center for Computational Toxicology, Office of Research and Development and Office of Science Coordination and Policy Office of Pollution Prevention, Pesticides and Toxic Substances.
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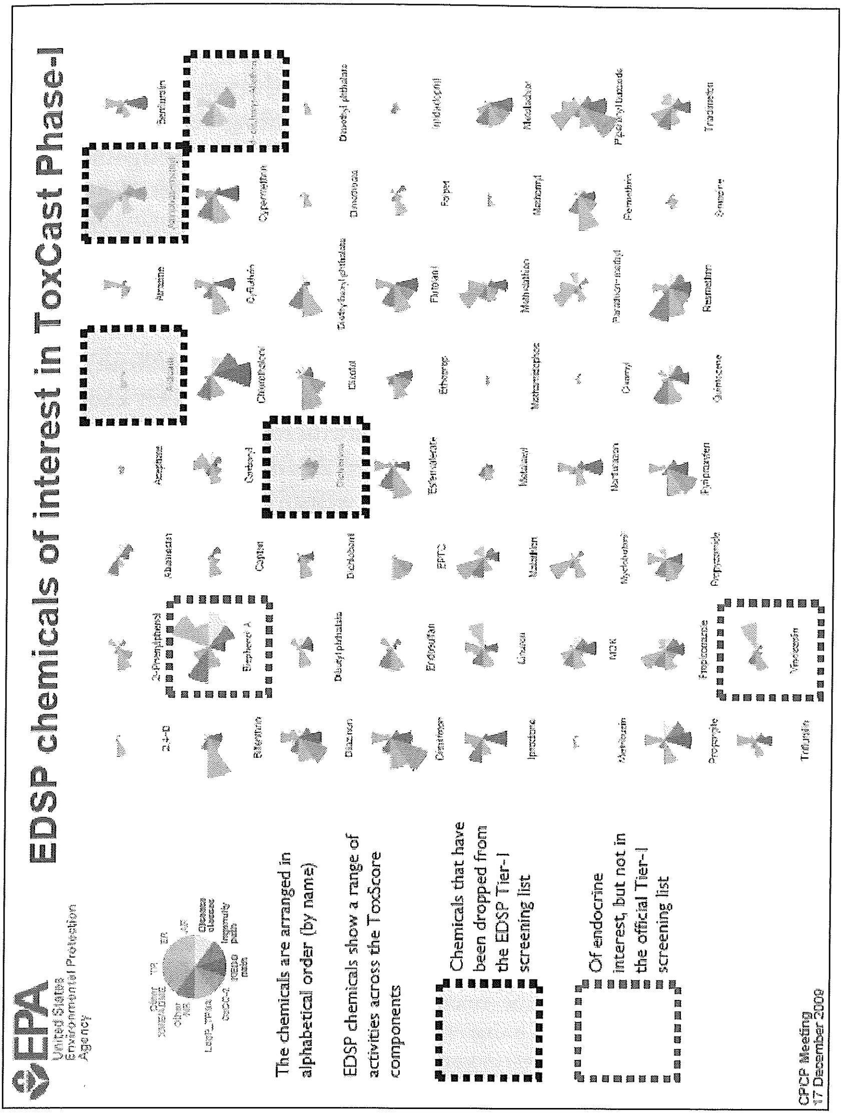
EPA
United States
Environmental Protection
Agency
EDSP chemicals of interest in ToxCast Phase-I
The chemicals are arranged in alphabetical order (by name)
EDSP chemicals show a range of activities across the ToxScore components
Chemicals that have been dropped from the EDSP Tier-I screening list
Of endocrine interest, but not in the official Tier-I screening list
CPCP Meeting
17 December 2009

things – toxics, in particular – that were difficult to articulate previously. It is a kind of truth and knowledge that will be difficult to translate into policy and law. I can imagine the difficulties ahead, and many hours of debate over what is, and isn't "junk science." But the grounds of the debate are shifting. There is, now, social, technical and cultural infrastructure that changes what can be signified, and made significant. Methodological acumen will always be called for. What could be called a semiotic, feminist theory of meaning and language will be critical.

## Toxics Trouble

Consider, for example, arguments made by (the notoriously difficult) Judith Butler.[7] Her now classic *Gender Trouble* begins by undermining a key assumption and fantasy of feminist theory: that women need to be represented in language and politics. Butler's argument is not that women are, already, adequately represented, nor is she against recognition of and respect for women by dominant institutions. Butler emphatically recognizes women as a problem, and clearly calls for a different order of things. But the way there, she insists, is not through discovery of the reality and significance of women, which heretofore has been ignored. Instead, women – and gender, and even (biological) sex -- needs to be recognized as made in its enactment, within specific semiologies. Only then will there be freedom to recognize new kinds of subjects, and new kinds of relationships (Butler 1990).

Butler argues that women are not born but made, that gender is performative rather than expressive, made in the acts that constitute it. Gender is thus always a matter of context, and is always open to resignification. This does not make it unreal or insignificant. Indeed, it is the open-endedness of gender that makes

7 Consider, also, the knowledge practices and feminist semiotics encouraged by Teresa de Lauretis, emphasizing the need to understand both what systems say, and what they do not and cannot say. Understanding the gender effects of a social system, de Lauretis argues, demands "a movement back and forth between the representation of gender (in its male-centered frame of reference) and what that representation leaves out or, more pointedly, makes unrepresentable" (1987: 25). The analyst must find or invent a way to move "between the (represented) discursive space of the positions made available by hegemonic discourses and the space-off, the elsewhere, of those discourses: those other spaces both discursive and social that exist, since feminist practices have (re-)constructed them, in the margins (or 'between the lines,' or 'against the grain') of hegemonic discourses and the interstices of institutions, in counterpractices, and in new forms of community." (1987: 25) Toxics will require this kind of movement, continually attentive to what resists representation, and to what can be heard within different orderings of meaning.

space for a positive politics – a space in which what counts as reasonable, related, normal and pathological can be remade. These arguments have inspired a wealth of scholarship in feminist and queer studies, in literature, anthropology and beyond. Relating them to feminist science studies is also vitalizing, changing how one thinks about the practice and purchase of science. This is especially important in dealings with toxics.[8]

Environmental health science, conventionally conceived, is expected to demonstrate the health hazards of environmental exposures by demonstrating that a particular exposure causes a particular disease endpoint. This task is quickly overwhelmed by the complex of factors in play in the making of health and disease. Effort to delineate *the* endpoint usually encounters so many detours and switchbacks that causation is all but impossible to establish. Toxicity resists representation.

Herein lies the problem. Toxicologists, and other environmental health scientists, are cast as sewer diggers, responsible for unearthing and representing toxic effects in a body assumed to operate like a pipeline. What goes in the pipe is expected to come out at the other end, recognizable as such, its identity intact.[9] The process is linear, straightforward. Toxicologists are supposed to dig it up.

What if, instead, causation was understood as an effect of signification, rather than as something that exists as prior, discoverable and then requiring representation? What if causation were treated as made rather than found, performative rather than expressive? What if the environmental health sciences were understood as operating in ways described by poststructural theories of language and identity?

Constructs of causation – in different historical periods, in different scientific fields, in different philosophical traditions – have been extensively queried. This scholarship needs to make its way into the imagination of and about the environmental health sciences. Even more fundamental, though, is the need for a theory of language that doesn't assume and depend on significance preceding signification. What would be the effect?

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8 It is worth recalling here the thrashing Judith Butler received for being difficult to read. Here, again, industrial culture's bias against difficulty is evident. Also recall that Butler is difficult to read partly because of the intense intertextuality of the way she theorizes and writes. Environmental health scientists today, aiming to animate and leverage intertexuality through efforts like Tox Pi, may be accused of similar folly.

9 This construct of how things work is not unlike conventional constructs of how communication works. Derrida offers a different reading, emphasizing how every mark is iterable, and prone to (productive) dissemination and polysemia.

The environmental health sciences would continue to ask if toxic effects are real, but their orientation would be different. Rather than trying to establish proof through single, definitive studies, research would always be situated within a dense semiology, with both a surplus of meaning, and acknowledged discursive gaps. It would be recognized that what should count as evidence, and as a finding, has to emerge from within this semiology. The goal would be akin to what anthropologists call "thick description," rather than proof. There wouldn't be deference to constructs of causality imported from physics and mechanics. Yet research would be animated by ideas from adjacent fields. "Stream science," one toxicologist told me, "provides models for us to think with."

As I have described, many environmental health scientists are working in this manner today, highly reflective about the practice and politics of "sound science."[10] In so doing, environmental health scientists are leading an epochal shift in the way science is configured. Most basically, science is pluralized.[11] It is recognized that the identity of "sound science" depends on the specific semiologies in which it works: what is sound depends on context. For the environmental health sciences, the huge and growing number of substances of concern is an overt driver

10 Calls for "sound science" are not straightforward. Writing about tobacco science, Ong and Glantz explain that "[p]ublic health professionals need to be aware that the 'sound science' movement is not an indigenous effort from within the profession to improve the quality of scientific discourse, but reflects sophisticated public relations campaigns controlled by industry executives and lawyers whose aim is to manipulate the standards of scientific proof to serve the corporate interests of their clients." (2001: 1749) Also see David Michael's "Doubt is their Product: How Industry's Assault on Science Threatens Your Health" (2008).

11 The particular challenge of validating field science (as opposed to laboratory science) is explicated by Robert Kohler in *Landscapes and Labscapes: Exploring the Lab-Field Border in Biology* (2002). Kohler describes how the "new natural history" first attempted to orient and validate itself by incorporating laboratory techniques into their routine practice. This approach resulted in important theoretical advances, and a number of practitioners were wedded to it. Ultimately, however, according to Kohler, treating the field like a laboratory failed, and the most exciting advances occurred once this was acknowledged. Between the 1930s and the 1950s, as naturalists took on the challenge of developing techniques particularly suited to the field context in which they worked, ecology and evolutionary taxonomy built identities of their own as respectable scientific disciplines. Chris Sellers (1997) tells a different kind of story in his account of the consolidation of occupational health as a field, describing how the field consolidated and built legitimacy by adopting laboratory approaches and standards, despite the field conditions in which they worked (in the early twentieth century).

of practice, as is the need to speak about toxics within risk assessment domains unaccustomed to what "biological reality" has become. Science is legitimated in context, not in isolation.[12]

Bodies and biology, too, are coming to be understood as open signaling systems, situated in spaces laced with social, biological, and chemical stressors, made up of intersecting pathways subject to perturbation even when exposures are too low to measure. Results can be multiple, and a matter of pathway directionality and momentum. Health and disease are not only endpoints, but processes.

Knowledge production also becomes more complexly conceived. The reality and complexity of the biological drives and haunts the knowledge systems being built in the environmental health sciences. But it is also acknowledged that the complexity is such that one doesn't just discover and represent it. Comparison and multiplication of viewpoint is critical. Signification depends on signification. As Butler (1990) taught, practices of signification are productive, evidence is made through repetition.

The scientific figure here is not the obsessive compulsive described by Evelyn Keller, nor the careful man of mechanical objectivity described by Lorraine Daston and Peter Galison (2007). The obsessive compulsive makes knowledge by excluding what seems irrelevant. Mechanical objectivity makes knowledge through careful representation of an object assumed to have inherent qualities and meaning. Comparison is not required to make sense of it. The object does not need to be situated within a system to be comprehensible. Indeed, systems building is discouraged. What is happening today in toxicology and other environmental health sciences is very different. "Informated objectivity" may work as a descriptor.

## The Stakes

What are the stakes? How do constructs of causation, evidence and science matter? Let's look at recent news coverage of Bisphenol A: "Is BPA Safe? Europe Also Seeks Assurances." This is the title of a September 2010 post in the *New York Times Green Blog*, following up on a longer article on Bisphenol A earlier in the week. The post has a central point: "Animal studies have suggested that the substance can cause health problems by mimicking the hormone estrogen, but there is no evidence of harm to people." The post goes on to say that the European Union has declared BPA safe at the levels to which most people are exposed, but

12 For historical perspective, see Robert Proctor's *Value-Free Science? Purity and Power in Modern Knowledge* (1991) and Thomas Nagel's *The View from Nowhere* (1986).

that France and Denmark have nonetheless banned BPA from baby bottles and food packaging for children. The post also notes that the federal and many state governments in the United States are re-evaluating BPA, by analyzing data from more than 800 studies. The photo that opens the post is telling, showing one-day-old mouse pups injected with BPA so that scientists can research its effects on their prostate cells (Grady 2010b).

This articulation of concern about environmental health indexes the discursive contradictions and shifts that I aim to draw out here. How, it must be asked, can there be "no evidence of harm" to people, yet more than 800 studies worthy of further analysis? What constructs of biology, causation, evidence, knowledge and science are assumed and called for here?

The statement that there is "no evidence" of harm to people from BPA recuperates an essentialist, representative theory of meaning. Within a given study, BPA is identified as causally connected to a particular disease outcome, or not, and thus as a hazard or safe. Simple binaries organize significance. If an apical end point can't be identified, there is no finding. Findings that point to non-linear effects across body systems, appearing at different moments in development, can't count as meaningful. The possibility that some toxins – like BPA – operate at very low levels (overturning long standing assumptions that the dose makes the poison) can't register. Perturbations that clearly disturb usual processes but without a recognizable end point don't count.

Differences between studies – some done with animals, some in vitro, using different methods and doses of exposure, measuring results as varied as body weight or gene expression in the brain – are treated as a liability. Disciplinary differences are also said to be a problem, as are differences between science in universities and in regulatory agencies. The huge amount of toxicology research done in corporate labs isn't mentioned in the article.

Different results from supposedly identical experiments have made things even worse. The article reports on one meeting where such results were presented. Scientists in the audience reportedly said that they didn't "want to hear you two speak until you work this out." Discordance is censored rather than a call to careful comparisons and collective deliberation.

Differences in the way BPA has been handled in different countries, and in different U.S. states, is presented as confusion at best, and at worst a function of green marketing and consumer fear. Carefulness within regulatory agencies is all but derided. The U.S. FDA, for example, is reported to have taken "a potentially paradoxical position, on the one hand saying there is no evidence of harm to humans, and on the other supporting industry actions to get BPA out of baby bottles and feeding cups, and to find alternative liners for food and formula cans." (Grady 2010b) The possibility that the U.S. FDA, too, is figuring out new ways of thinking about toxics, toxics knowledge, and science writ large isn't noted.

The title of the longer New York Times article discussed here is evocative: "In Feast of Data on BPA Plastic, No Final Answer." (Grady 2010a) Its conclusion is also somber: "Over the next few years, researchers hope to bring coherence to this confused and troubled field." My reading is much more positive, though my evidence similar. Toxic science today may be troubled, but it is also troubling, questioning and displacing what has long counted as biological causation, evidence and "good science."

Indecision about a substance like BPA is partly a consequence of industrious, industrial effort to produce doubt and inconclusion, legitimated by an essentialist, representative theory of meaning. Indecision about BPA is also, however, about ambitious but tentative effort to work within new orders of meaning, produced and made sensible by what can be thought of as semiotic, performative theory of meaning.

New work in the environmental health sciences reads the body as a complex and open signaling system, displacing readings that imagine the body as functioning like a pipeline: what goes in on one end is supposed to come out the other with its identity intact.[13] In the new way of reading, hazard is less specifiable, indicated by perturbations that redirect where an already signaling system goes. Health effects are not only a matter of visibly dirty discharge at the end of the pipe. Knowledge, too, is treated differently in the new model. Instead of seeing definitive results in a single, duplicated study, "results" are understood as emergent from comparison and aggregation of diverse, partial findings. Knowledge, like environmental health, is understood to be a cumulative effect.

Science, too, becomes a different enterprise. Its legitimacy no longer comes from its distance from the socio-political sphere, but from its responsiveness to this sphere. Good science is that which acknowledges that decisions have to be made about thousands of potentially toxic substances, with hundreds more being added to the list each year, including nanomaterials, which excite precisely becomes they have infinitely more modes and surfaces of action than conventional substances.

Feminist and postcolonial theory enables a reading of this shift. Following Gramsci, on through the work of feminist and postcolonial scholars, we know that politics happen through articulation, that sense and sensibility are actively produced, in struggle, through modes of combination. Sense, reason, and culture

13 Think, instead, of Derrida's *The Postcard* (1979).

are thus made through the way things are connected, or not, seen as related and as patterned.

The problem, and possibility, is in what Homi Bhaba (1994) called "Articulating the Archaic," permitting what was once culturally unassimilable to refigure how we think about bodies and knowledge, reasonableness and right action.[14] Toxics have the potential to mobilize and signify this shift. The challenge is not in assimilation – making things make sense within hegemonic orders – but in permitting what can't be assimilated, finding ways to address people, chemicals and health hazards in their alterity. It is a feminist project, a project that must attend to that which resists representation, narration and generalization, while acknowledging the need for programmatic statements and action. A project that will require continual attention to oddity and queer ways of relating, to ways meaning and marginality are coproduced. Science must be upheld by subverting it, developing forms of collectivity, deliberation, law and culture that recognize that truth is not what it used to be, that toxics are, indeed, trouble.

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14 Speaking about "Articulating the Archaic" with W. J. T. Mitchell, Bhaba explains: "There, I was attempting to describe the way in which the articulation of cultural differences has to deal with what can't be translated; what may be incommensurable in the moment of cultural difference emerges in language as an evacuation of the very signifying and symbolic register that is required, in another moment, for its representation. It is a kind of enunciative disturbance that throws the process of interpretation or identification into flux – which for that very reason makes the need to identify, to interpret, to historicize, all the more intense." (http://prelectur.stanford.edu/lecturers/bhabha/interview.html)

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Elvira Scheich / Karen Wagels (Hrsg.)

# Körper Raum Transformation

## *gender*-Dimensionen von Natur und Materie

WESTFÄLISCHES DAMPFBOOT

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