Endocrine Disrupting Compounds and Cancer in Wildlife and Humans

Parabens in Personal Care Products

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Abstract: This paper examines the difficulty in proving man-made chemicals in personal care products are contributing to rising cancer rates in humans. Using parabens, a group of Endocrine Disrupting Chemicals, as a case study, I discuss why empirical evidence suggesting implication is sufficient to warrant immediate re-evaluation of chemicals in our environment. Using the theories of resilience and trans-corporeality, I attempt to illuminate the disconnect we have created between humans and nature wherein we fail to recognize early warning signs of danger that manifest as illness in animals and polluted ecosystems.

Image from Mugg Magazine Blog: https://muggmagazine.wordpress.com/fashion/are-your-cosmetics-toxic/

"We have subjected enormous numbers of people to contact with these poisons, without their consent and often without their knowledge."

- Rachel Carson, *Silent Spring*, 1964

This paper examines issues around proving causality of harm from suspected breast cancer-causing endocrine disrupting chemicals, which are widely used in personal care and cosmetic products. The use of these substances surged in production following World War II, and their increased use correlates with escalating breast cancer rates (Colborn, Dumanoski, & Meyers, 1997, p. 137). Environmental carcinogens are continually downplayed, but as their ecological damage is gaining clarity and typically uncommon cancers and health conditions develop in larger portions of human and animal populations, their impact is becoming more difficult ignore. Using Parabens as a case study, I make the argument past and concurrent experiences with similar compounds justify the need for caution and re-evaluation of previously assumed safe chemicals and overlooked sources of exposure. Drawing upon theories of resilience and trans-corporeality, I highlight the observational evidence of harm in wildlife and domestic animal populations caused by human pollution and toxic chemicals to further substantiate the need to restrict the widespread use of petroleum-derived substances.

Cancer is a collection of related genetic diseases resulting from mutations in DNA, which causes old or damaged cells to rapidly divide and spread rampantly into surrounding tissues. It is the result of genetic mutations, which can be inherited (BRCA1&2 in breast cancer) or caused by external or internal influences that damage DNA (National Cancer Institute, 2015). Our knowledge of what causes cancer is still developing, and rising rates in the past century have instigated amply funded and extensive research programs to address causation and find a cure. The most heavily debated area of causality is environmental causes, particularly man-made pollution that can increase the risk of developing cancer (Ness, 2014).

One of the very first instances of cancer being connected to environmental causes was in 1775 in England. Sir Percival Potts noticed rising rates of scrotal cancer in the young men who swept chimneys. He deduced that their cancers were caused by skin contact and inhalation of soot. Similar to many suspected environmental carcinogens today, Potts could not definitively *prove* that exposure to soot was causing cancer (Carson, 1964, p. 196). As society entered the age of industrialization, followed by the age of 'better living through chemistry,'[1] cancers have steadily increased in incidence. Particularly concerning are the rising rates of childhood and young adult cancers. This new age of chemicals was marked by the rapid introduction of synthetic chemicals around the 1940s, the result being "billions of pounds of man-made chemicals poured into the environment, exposing humans, wildlife, and the planetary system to countless compounds never encountered" (Colborn, Dumanoski, & Meyers, 1997, p. 137). Rushed wartime production, false assumptions of human physiology, and a lack of institutional oversight meant scientists and companies never tested substances for their health or environmental impacts. Our current political systems disproportionately favor industry and profits over environmental and human health, such that despite new research showing harmful effects, companies continue to use these substances in products without circumspection.

In conjunction with the increased use of toxic chemicals, rates of breast cancer have been rising since WWII (Malkan, 2007, p. 76). According to NCI's SEER data, breast cancer incidence has risen annually by approximately 2.1% (Breast Cancer Action, 2007). This trend, which increased screening alone cannot explain, is troubling because 50-70% of these cases are absent of any traditional risk factors; these include family/personal history, reproductive history, genetic susceptibility, age of menarche/menopause, diet/exercise, and alcohol consumption

[1] This is a variation of DuPont's slogan "better things for better living…through chemistry." ("Better Living Through Chemistry," 2013).

(Breast Cancer Action, 2014). Family history is a factor in approximately 30% of diagnoses, and despite the media hype and exaltation, the heritable BRCA1/2 gene mutations exist in only 5-10% of cases (Breast Cancer Action, n.d.; Silent Spring Institute, n.d.).[2] Some researchers and environmental health justice leaders are looking to environmental carcinogens to explain the trends in breast cancer.

Research into environmental causes of breast cancer is sparse, and proving causality of any specific individual chemical is nearly impossible when people are exposed to numerous carcinogens and potential carcinogens from multiple sources. Recently, use of toxic chemicals in the personal care industry has been getting more attention as a possibly overlooked source of breast cancer causing chemicals. Interest in this area is gaining traction as people have started to realize the cumulative and synergistic impact of toxic chemicals; past studies do not evaluate multiple-product use, but examine individual chemicals. This is not an effective model to understand ecological and biological effects (Colborn, Dumanoski, & Meyers, 1997, p. 196). This complexity makes it difficult to prove a certain chemical directly causes cancer, but researchers are finding definite correlations between toxic substances and cancer cell growth (Ness, 2014). Farther down, I will go into more detail about the debate of environmental toxin causality and correlation with respect to hormone-related cancers.[3]

External substances that can cause, or increase the risk of developing cancer are called *carcinogens* (Physicians for Social Responsibility, n.d.). Well-established carcinogens, like radioactive elements (uranium or plutonium) clearly and directly mutate DNA. Synthetic chemicals that are used in consumer products are harder to identify as carcinogens, but growing

[2] For more statistics, see http://ww5.komen.org/BreastCancer/Statistics.html (Susan G. Komen Foundation, 2015).
[3] Hormonal cancers include those of the thyroid, prostate, testis, ovary, endometrium, and breast (United Nations Environment Programme & World Health Organization, 2013, p. 126).

evidence suggests that many common toxic chemicals found in shampoos, cookware, cosmetics, and clothing could be linked to cancer (Breast Cancer Action, 2014). Carcinogens pertinent to breast cancer can be either mutagenic chemicals, acting on cells directly, or endocrine-disrupting chemicals, which alter normal functions of hormones in the body (Natural Resources Defense Council, n.d.). A wide variety of personal care products and cosmetics contain toxic chemicals linked to breast cancer, and since people use multiple products at once, they are exposed to unpredictable levels of these toxins.

There are approximate 85,000 synthetic chemicals on the market, only about 10% of which have been evaluated for any environmental or human health impacts. Most studies examine substances in isolation, resulting in little data or knowledge about their synergistic effects (Breast Cancer Action, 2014). The lack of testing is often equated to "there is no evidence for harm," which means, because we know nothing about the chemical's safety, it is assumed safe (Steingraber, 1998, p. 102). After almost a century of this attitude, these substances have contaminated our planet so thoroughly that it is impeding our ability to go back and conduct effective tests. Researchers have found high levels of DDT and PCBs in remote areas of the Arctic, far from where these chemicals are manufactured, used, and disposed (Colborn, Dumanoski, & Meyers, 1997, p. 88). These toxic chemicals are an integral part of modern life, and we are seeing their impact at the point of extraction, production, use, and disposal. They are used in furniture, electronics, food, personal care products, and many other consumer goods that we have grown accustomed to having – we have synthetic toxic chemicals to thank for stretchy jeans, iPods, LCD screens, Barbie dolls, neon green hair dye, and unbreakable plastic dishes. However, these innovative new products have come at a cost. Many of these toxic chemicals have been linked with a wide variety of health conditions, primarily stemming from the fact that most are petroleum-based substances. Oil, or petroleum, contains the same building blocks of life as humans and animals: carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur (Morse & Turgeon, n.d.). Therefore, when petrochemicals enter our bodies, they interact actively with our natural chemical and biological systems (Steingraber, 1998, p. 93). Widely used in food, electronics, household items, and personal care products, these chemicals have been linked with allergies, learning disabilities, developmental disorders, reproductive and physical deformities, organ toxicity, endocrine disruption, neurological impairment, and cancer (Robinson, 2015).

Endocrine-Disrupting Compounds (EDCs) are a group of these toxic substances, which can disrupt the normal activities of hormones or mimic specific hormones, like estrogen. EDCs, especially estrogen-mimickers, are potentially carcinogenic, and many researchers believe using them could be a significant risk in developing breast cancer (Gray, Ph.D., 2010, p. 40). Hormones, and their synthetic counterparts, control gene expression, and can create permanent changes during development. "For all these systems, normal development depends on getting the right hormone messages in the right amount to the right place at the right time" (Colborn, Dumanoski, & Meyers, 1997, p. 46). Thus, timing is instrumental for chemicals that can potentially increase the risk of developing breast cancer. Women have three windows of greatest vulnerability to these EDCs, when cells in breast tissue are undergoing rapid changes. These are during prenatal development, pregnancy, and breastfeeding (Natural Resources Defense Council, n.d.). While chronic exposure can cause health problems, researchers believe that during these windows of susceptibility, especially during in utero development, a single instance of exposure can have profound and permanent impacts (Colborn, vom Saal, & Soto, 1993, p. 381).

The female body actually processes synthetic estrogen and natural estrogen differently, strengthening the case for caution using EDCs. When women are pregnant, a specific protein in the blood will bind to excess hormones, protecting the developing fetus from over-exposure to estrogen. This protein does not bind with synthetic estrogen, which means that the fetus is not being protected through the mother's natural defense systems. The vulnerable fetus is exposed to an excess of estrogen, potentially causing birth defects or increased risk of cancer later in life (Colborn, Dumanoski, & Meyers, 1997, pg. 140). As research advances, we are only learning more about the damaging effects of EDCs, strengthening the argument to eliminate their use.

Prior to industrialization, in earlier civilizations, humans took clues and warning signs from the health of the ecosystem and the species surrounding them (Smith & Lourie, 2009, p. 207). Sudden changes in migratory patterns or the presence of a species could signal a potential threat to humans as well. In the modernized industrialized world, industries work hard to disconnect humans from these warning signs in nature (Smith & Lourie, 2009, p. 207). However, in the last two decades there has been an upsurge of concern over environmental pollution and the possible impact of those toxic chemicals upon humans. Animals are exposed to the toxic chemicals we have created through pesticide use, mining and resource extraction operations, manufacturing waste, agricultural and industrial run-off, urban pollution, and disposal of our contaminated products. The role of synthetic estrogens has been of particular concern, for their wide range of impacts from reproductive deformities to cancer, and their ability to undermine the fundamental ability of species to populate and survive. Rachel Carson was the first to highlight the disastrous effects of pesticide use on wildlife populations, and helped to develop a public dialogue around these issues, which have only amplified since the publishing of *Silent Spring* in the 1960s. After decades of toxic chemical use, polluting every corner of the world, the impact on wildlife has become more subtle, but no less serious than when Carson was writing. As Colborn and Dumanoski frame it, "It was hard to miss the masses of dead birds that littered suburban backyards after aerial spraying in the 1950s […] Abnormal parental behavior or poor survival of young, on the other hand, are less immediately apparent but perhaps no less important in the long run for a species' survival…" (Colborn, Dumanoski, & Meyers, 1997, p.15). It is easy to forget, but animals end up interacting biologically with the same chemicals as humans, and often, in the same ways. A reminder of this lies close to home; researchers have found that disease patterns among domesticated dogs can be an early warning sign of potentially health threats to humans.

Dogs, like cats, rodents, birds, and other short-living animals, are useful predictors of disease risk because illnesses appear faster than in humans, and they are often more sensitive to environmental contaminants (Reif, 2011, p. 51). Disease patterns in pets and wildlife, especially rising rates of identifiable health conditions, are also a sobering reminder of the extent humans have altered the environment in which animals must exist; in our anthropocentric worldview, they are subject to our decisions and have no voice as to the actions to take in altering their ecosystems. Studies confirm a link between pesticides and cancer in domestic dogs, finding an increased risk in malignant lymphoma, testicular cancer, and bladder cancer. Canine Malignant Lymphoma (CML) is similar to non-Hodgkin's Lymphoma (NHL) in humans, a cancer of which farmers in the United States and New Zealand have increased rates (Reif, 2011, p. 53). Studies of dogs with owners who used the pesticide 2,4-D (2,4-dichlorophenoxyacetic acid), revealed that these dogs had a 30% higher chance of developing CML (Reif, 2011, p. 53). Additionally, this risk had a positive correlation with the frequency of applications in a given year.

Larger animals with lifespans similar to humans are important indicators that corroborate human statistics and laboratory results. They may not be predictors, but they strengthen the case that human created pollution does have a significant impact on biological life. Marine mammals are particularly sensitive to environmental contaminants as they are high on the food chain and their fat content means they retain high levels of damaging lipophilic chemicals (Reif, 2011, p. 54). In the St. Lawrence River Estuary off the coast of Quebec, the Beluga whale population has continued to shrink even after commercial whaling was halted in the 1950s. Autopsies performed since the 1980s indicates that man-made chemical pollution is to blame for the dying whales. Bladder cancer was first discovered in one Beluga in 1985, which was coincidently the most common form of cancer among the workers of the nearby aluminum smelter (Steingraber, 1998, p. 133-134). More autopsies would reveal a wide array of chronic illness, including high incidences of bladder, stomach, breast, and ovarian cancers. Researchers commonly found whales with missing teeth, mouth, stomach, and esophagus ulcers, bacterial infections, skeletal and reproductive deformities, and tumors both benign and malignant (Colborn, Dumanoski, & Meyers, 1997, p. 144; Steingraber, 1998, p. 135). In 2002, 27% of the Belugas found dead had some form of cancer, which mirror the rate of cancer in the surrounding human population (Steingraber, 1998, p. 135). Researchers found high levels of PBCs, DDT, and other pesticides and endocrine disrupting chemicals. Many of the very sick whales were actually born after the pollution levels in the river were highest and had started declining. This indicated that the calves were receiving high concentrations of these toxins from the mother in utero and during breastfeeding (Colborn, Dumanoski, & Meyers, 1997, p. 145). Like whales, humans also store toxins and can pass those toxins along to offspring; this phenomenon adds a layer of complexity to the influence of toxic chemicals, because the effects of toxins can be vastly different for adults compared to developing fetuses. Whales are also a good indicator species, because they are in greater contact with toxic chemicals in their environment. The pollution caused by the manufacture, use, and disposal of consumer products inevitably seeps into lakes, rivers, oceans, and other bodies of water.

Personal care products today are saturated with toxic chemicals that are mostly untested and unregulated; overlooked for too long, toxic exposure from beauty products is finally gaining attention among consumers and the media in the past several years. Women use on average twelve different personal care items daily, many of which share common toxic ingredients (Fox, 2010). Approximately 60% of topically applied substances are absorbed into the skin, and with chemical penetration enhancers, this figure may be higher (Gabriel, 2008). Like other sources of toxic chemicals, it is difficult to prove harm from specific ingredients and to regulate their use. Additionally, without proper regulation or warnings on products, we have pregnant women and young teenagers using these endocrine-disrupting products without knowledge of their potential harm. Manufactures claim levels of chemicals in products are within a safe dosage range, but researchers are building a strong case showing otherwise, pointing out that companies neglect the unusual behavior of xenoestrogens and combined exposure from food, household products, and personal care products (Darbre & Charles, 2010). While there are many chemicals of concern in personal care products, parabens in particular are under revived scrutiny after a study published earlier this year, raised questions about the chemical's potency and ability to increase the risk of breast cancer.

Parabens are a group of petroleum-derived chemicals widely used as antimicrobial preservatives in shampoos, body lotions, facewash, cosmetics, and other personal care items. These chemicals have been in use since the 1920s and were among the chemicals grandfathered in under TSCA (Toxic Chemical Substances Act) in 1976, which means they were exempt from additional testing and safety regulations (EWG, 2008). Products usually contain multiple parabens, with the prefixes of methyl-, ethyl-, propyl-, isopropyl-, and butyl-, the most commonly found being methylparaben (EWG, 2008). Parabens are endocrine disruptors, which activate the same estrogen receptor as estradiol, a naturally occurring hormone (Silent Spring Institute, 2015). Their endocrine-disrupting abilities were discovered in 1998, over fifteen years ago (Darbre et al., 2004, p. 6). Absorbed through the skin, with the help of penetration enhancers also found in products, parabens are generally metabolized and eliminated from the body in a short time. Industry argues that rapid metabolism and low dosage make the chemical safe to use in a wide variety of products. However, recent studies indicate that parabens may actually bioaccumulate like other EDCs and when products contain a mixture of paraben compounds, or are combined with other EDCs and cancer growth promoters, they are a potentially significant risk factor for breast cancer (Darbre et al., 2004; Darbre & Charles, 2010; Pan et al., 2015).

Past studies of paraben safety and interaction with human cells are criticized for inaccuracy and study of effects in isolation from other contributing factors. Molecular biologist at UC Berkley, Dale Leitman, comments that while many believe they are too weak to have any effect on humans, “this might not be true when parabens are combined with other agents that regulate cell growth” (Sanders, 2015). Additionally, as other studies of EDCs have shown, these chemicals do not behave normally like other mutagenic toxic chemicals, and do not follow a linear pattern of dosage and health risk. For example, while animal studies in laboratories showed that parabens are metabolized quickly; researchers assumed this meant they would have no impact and would not accumulate in the human body. Mice and rats have much shorter lifespans than humans do, and thus, these tests do not accurately reflect potential health concerns from fifty or more years of chronic exposure.

The Breast Cancer Fund's 2012 document State of the Evidence: The Connection Between Breast Cancer and the Environment, stated,

> Measurable concentrations of six different parabens have been identified in biopsy samples from breast tumors. The particular parabens were found in relative concentrations that closely parallel their use in the synthesis of cosmetic products (Gray, Ph.D., 2010, p. 44).

This indicates the use of parabens in personal care products could have a significant role as the source of exposure to parabens. In 2004, a controversial study was published in the UK, which discovered intact paraben compounds present in twenty breast cancer tumors; methylparaben was the most common one found (Darbre et al., 2004, p. 11). The authors noted that we should now add parabens to the list of breast cancer inducing chemicals that bioaccumulate in breast tissue, alongside organochlorine pesticides (DDT) and PCBs (Darbre et al., 2004, p. 8). Darbre et al. (2004) highlight past studies showing that parabens can cause chromosome abnormalities and interfere with enzyme function at the cellular level (Darbre et al., 2004, p. 6). Within a sample population of twenty breast cancer tumors, researchers discovered four contained double the average amount of parabens; building upon their earlier studies, the authors believe these levels have potential to alter estrogen levels in breast epithelial cells (Darbre et al., 2004, p. 11). The authors note how intact parabens in breast cancer tissue, "demonstrates that at least a proportion of the parabens present in cosmetic, food and pharmaceutical products can be absorbed and retained in human body" (Darbre et al., 2004, p. 9). Darbre and Charles (2010) reassert their argument in a more recent study examining the involvement of low-dose environmental xenoestogens in consumer products (Darbre & Charles, 2010). Their findings indicated that low-dose xenoestrogens (parabens noted) accumulate in certain areas of the breast, suggesting importance of dermal exposure, and work together to produce harmful levels (Darbre & Charles, 2010). Most recently, a study published by Pan et al (2015), examined the response of breast cancer cells to parabens in the presence of a naturally occurring growth factor. They concluded, "Parabens might be active at exposure levels not previously considered toxicologically relevant from studies testing their effects in isolation" (Pan et al., 2015, p. 2). HER2-positive[4] is one subtype of breast cancer, involving expression of a specific estrogen receptor; two-thirds of breast cancers are estrogen receptor positive (Pan et al., 2015, p. 3). This study showed HER's presence in breast tissue can amplify the effects of butylparaben, which binds to the estrogen receptor, and stimulates cancer cell proliferation (Pan et al., 2015). The authors criticize previous studies of parabens, because they have no taken into account the effects of these chemicals when other physiological elements are involved, such as growth factors, which could alter the potency or mechanism of the substance (Pan et al., 2015, p. 14). The studies described above all point towards the same basic conclusion: previous studies of parabens in isolation are not accurate; parabens accumulate in breast tissue; parabens as levels believed safe could be more potent. Essentially, we have exposed people and animals to these chemicals, and have used them widely based upon no factual evidence or guarantee that they are safe.

Despite growing observational and epidemiological evidence among wildlife populations and humans, and supporting laboratory studies, little has changed over the past few decades in terms of research and regulating toxic chemicals. As we examined in the discussion above, the evidence for proving irrefutable causality is weak, and the chemical industry uses this flaw as an advantage to stymie chemical bans and regulations. This indicates an inherent flaw in our acceptance of health risks from toxic chemicals, and our history of dismissing potential environmental and health impacts of introducing little-understood substances into common use. Additionally, Ness (2014) notes, "Since the spatial movement of toxicity is nearly imperceptible

[4] HER refers to Human Epidermal Growth Factor Receptor, a naturally occurring substance that promotes cell growth (Pan et al., 2015, p. 2).

and its temporal movement occurs over decades, proving causation is very difficult." This sentiment is shared among past and contemporary colleagues including Carson (1964), Steingraber (1998), Darbre and Charles (2010), and Colborn, Dumanoski, and Meyers (1997).

The spatial movement of toxic chemicals is unpredictable and uncontrollable, because these, mostly unnoticeable chemicals, follow ecological systems of wind and water migration (Ness, 2014). Federally unregulated under the Safe Drinking Water Act, toxic chemicals from pharmaceuticals and personal care products are frequently found in drinking water; at least 20 unregulated chemicals found in water are linked to breast cancer (Steingraber, 1997, p.193). Additionally, studies of trees and forest groundcover in remote locations have confirmed the global dispersion of chemicals such as DDT and PCBs, even long after these chemicals were banned. In 1993, high levels of these chemicals were found in soil and leaves of upper New Hampshire's White Mountains, far from any place these chemicals were produced or used (Steingraber, 1997, p.173). These industrial pollutants, pesticides, and personal care toxins end up in our air, our soil, and our drinking water, with no way of knowing their origin, where they will go, or how much will disperse (Steingraber, 1997, p. 5). While there is great dispersion of toxins, there is a strong correlation between proximity to certain toxic activities and high rates of diseases. For example, the risk of breast cancer development for women living close to dumpsites is 6.5 times greater than average (Ness, 2014). Rates of cancers are similarly higher for women working in toxic industries like salons and laundry mats. Thus, low-income women, often of childbearing age, face the highest risk of cancers from environmental contaminants.

The second issue with establishing any causality is temporal distance from exposure to development of cancers. As discussed earlier, women have windows of increased vulnerability to EDCs, and developing fetuses, going through rapid growth or overall at an increased level of vulnerability from toxic chemicals. The DES Daughters in the 1970s, on the heels of the thalidomide catastrophe in the 1960s[5], opened up a dialogue about possibility of long-term delayed health impacts from pre-natal exposure to synthetic chemicals (Malkan, 2007, p. 9; Colborn, Dumanoski, and Meyers, 1997, p. 49). DES (diethylstilbestrol), banned in 1971, was a synthetic estrogen drug given to women during the 1940s and 1950s to prevent miscarriages (Colborn, Dumanoski, and Meyers, 1997, p. 48). The effects of DES were realized after doctors in Boston saw a startling increase in young women with an extremely rare form of vaginal cancer (Colborn, Dumanoski, and Meyers, 1997, p. 55). The mothers of these young women had all taken DES while pregnant. Most of the health impacts of DES were not present at birth, but began to appear as the women reached puberty, childbearing age, and mid-life. DES Daughters are twice as likely to develop breast cancer, and face high rates of other ovarian and vaginal cancers, infertility, and reproductive organ deformities (Malkan, 2007, p. 9). The DES story serves an important lesson concerning the way toxins can affect our health in unpredictable, non-linear, and indirect ways. Without exercising caution in using these chemicals, the health impacts take decades and generations to become evident, at which point, thousands or millions of people have been exposed.

These distant temporal and spatial feedback loops make study of causation tedious, and indicate a definite need for a different model of safety evaluation that looks at correlation and broad epidemiological patterns. For example, with the Beluga whales, it was evident that high levels of toxic chemicals from nearby industrial activity was impacting their health, similarly to

[5] Thalidomide was an anti-nausea and sedative prescribed to pregnant women in the late 1950s. This drug, prescribed to thousands of women, was deadly to some babies, and in thousands others, caused severe birth defects like missing arms and legs, deafness, blindness, and cleft palates (“Thalidomide: The Canadian Tragedy,” n.d.).

the local residents, but this conclusion was made based upon a correlation of rampant disease among whales and people, and the high level of toxins present in the environment.

Rachel Carson was the first individual who illuminated the issues around our widespread use of toxic chemicals. Through scientific data and descriptive stories, she shed light on the ecological damage, and public health consequences, of flooding the environment with unstudied synthetic petrochemicals. Carson (1964) writes,

> [T]he central problem of our age has therefore become the contamination of man's total environment with such substances of incredible potential for harm–substances that accumulate in the tissues of plants and animals and even penetrate the germ cells to shatter or alter the very material of heredity upon which the shape of the future depends (p. 18).

There are two important elements embedded within this statement. First, she is addressing the idea of trans-corporeality, in which humans are inseparable from the natural environment we have polluted. Secondly, she is underscoring the theory of resilience, which toxic chemicals weaken by destroying the very basis for life.

Stacy Alaimo (2010) uses the theory of trans-corporeality to address environmental and biological contamination by underscoring the historical, economic, and political forces that divide humans from the natural world. Trans-corporeality attempts to reframe human physical existence as "always intermeshed with the more-than-human world" and "ultimately inseparable from 'the environment'" (Alaimo, 2010, p. 2). This theory aims to examine issues across physical bodies, drawing the environment close to humans and conceptualizing the environment as more than resources for human exploitation. Through the focus on bodily natures, and movement across physical existence, this theory illuminates the connection between toxic chemicals in the environment and toxic chemicals in human bodies and biological organisms. Thus, scholars employing trans-corporeality seek to make visible the invisible toxic substances by validating personal and community experiences of toxic exposure, and articulating the importance of ecological health that the powerful actors in market capitalism deny.

Walker and Salt (2006) define resilience as “the ability of a system to absorb disturbance and still retain its basic function and structure” (p. 1). Three key concepts fundamental to resilience thinking, relevant to toxic contamination, are the loss of biodiversity, threshold limits, and feedback loops. Broadly, the use of toxic chemicals reduces resilience of communities, animal population, and ecosystems by causing irreversible contamination, damaging reproductive health in animals and humans, and increasing the vulnerability of disease and collapse. Resilience thinking, like trans-corporeality, builds upon the premise that humans, whether apparent or not, are inherently connected to the ecosystems around us, and that we are all connected in a complex, biological, and continually changing system (Walker & Walt, 2006). Our current framework is antithetical to the nature of ecological systems, by ignoring the importance of distant feedback loops; we look at landscapes, regions, and ecosystems as isolated from each other (Walker & Salt, 2006, p. 33). Studies of toxic chemical distribution as discussed above show the danger in this approach; our use of toxins in the United States has subjected native communities to horrendous levels of carcinogens in the artic regions. Cancer has particularly distant feedback loops, as exposure to environmental contaminants can contribute to the development of cancer decades later.

Environmental contaminant puts pressure on the threshold limits of ecosystems, and eventually, they will reach a tipping point, shifting to a new state of being; our use of toxins pushes our ecosystems closer to a state that is unable to support biological life. Salt and Walker (2006) state, “a system’s resilience can be measured by its distance from these thresholds. The closer you are to a threshold, the less it takes to be pushed over” (p. 63). Thus, we are reducing resilience by pushing ecosystems closer towards their thresholds. In humans, exposure to toxic chemicals is pushing us closer to sterility with every generation. Studies are showing a direct correlation between date of birth and sperm health in human males; Danish researchers discovered that between 1940 and 1990, semen count had dropped by 45% on average (Colborn, Dumanoski, and Meyers, 1997, p. 173). Similar trends are apparent in wildlife populations.

The use of toxic chemicals reduces diversity, and most importantly, it reduces functional diversity, which is crucial to a system's reliance and ability to maintain threshold distances. Functional diversity refers to the range of species or elements in system that each performs necessary jobs to keep the system healthy, and by reducing these elements, the system is more vulnerable to catastrophes. Toxic chemicals have devastating impacts on ecosystems in various ways; nitrogen fertilizers change water chemistry, EDCs hinder reproductive health, and various pesticides and other industrial pollutants poison and kill off entire populations of species. Carson (1964) wrote about the death DDT, and other pesticides, caused in wildlife from repeated spraying to eliminate insects that developed resistance to the substances after just three or four applications. Furthermore, the loss of diversity caused by toxic chemicals has a profound effect upon all aspects of a system, including humans. Eliminating the vast range of natural defenses for agriculture reinforces our need for toxic chemicals, making our food systems vulnerable to disease and infestation should those chemicals cease to provide adequate protection (Dyer, 2014). Species loss along the food chain increases food insecurity for animals, including humans, higher along the food chain. This is particularly relevant to subsistence-based communities, who may rely upon fish or wild animals as a primary food source. Loss of genetic diversity in plants and animals leaves populations susceptible to complete annihilation from a single epidemic (Walker & Salt, 2006, p. 142).

The various impacts of toxic chemicals upon the resilience of a system make it clear that these substances are greatly weakening our resilience as a society, dependent upon a health ecosystem to survive. The impact of these toxins weakens our resilience in terms of physical health. DES is a good example of how exposure to a drug during fetal development can have long lasting impacts upon an individual's immune system, lowering their resilience to environmental carcinogens and undermining their ability to withstand developing cancer.

These toxic chemicals pollute not just our bodies, but also the bodies of our potential offspring, and of the broader ecosystems in which we live. Using resilience thinking and the theory of trans-corporeality, we can better understand the serious impacts of these substances upon our ecosystems and ourselves. The lessons we can learn from wildlife indicates a serious need to change current industrial practices and establish higher expectations of safety for chemicals before they are widely used on the market. The lesson to be learned from examining past EDCs, like DES, DDT, PCBs, and others, is that the importance of caution should not be trivialized. The unknowns and uncertainty around impacts of toxins should not malign the efforts of those advocating for strong regulations, if anything, it should cast doubt upon assumed safety and demonstrate a need for closer examination of the substances we put into our environment. The argument I make here is that parabens, while potentially very harmful, are still widely used due to our traditional models for understanding causality, correlation, and risk of developing breast cancer; using the precautionary principle would have eliminated the existence of these chemicals in the consumer market. The other point that I make in examining the generally loose evidence for parabens in personal care products affecting breast cancer development, is that we cannot look at elements of this system in isolation; we need to examine breast cancer causes from a whole systems perspective. Whether or not personal care products are a main source of exposure, or if parabens in those products contribute significantly, the fact remains that breast cancer is a widespread epidemic and women are exposed to EDCs. The logic is simple, as Steingraber states, “If you have carcinogens in the water, someone is bound to get cancer” (Chevannes, 2010). The same is true of every other aspect of our environments.

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