

**CHEMICAL CONTROVERSY: EXPLORING SCIENTIFIC DISAGREEMENT  
AROUND ENDOCRINE DISRUPTING CHEMICALS**

by

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## **Abstract**

Jurisdictions around the world are currently developing regulation to manage endocrine disruptors (EDs)—substances that have the potential to disrupt the hormonal system—but the scientific community is divided over what regulatory approach is best supported by science. Some ED scientists support a hazard-based approach, which restricts substances based on their potential to cause an adverse health effect. Others support a risk-assessment approach, which assesses the likelihood of real-world exposure at a harmful dose.

The typical response to scientific controversy is to call for more research with the aim of clarifying facts and achieving consensus. However, this approach is rarely successful in complex fields surrounded by uncertainties, potentially because it ignores value-related and cultural differences between sides, which commonly underlie controversy in policy-relevant fields. This exploratory thesis aims to describe the modes of thinking characteristic of hazard and risk scientists. To address this, two focus groups were conducted with hazard and risk scientists whose work informs environmental ED regulation. The focus groups were analyzed using an empathetic and symmetrical approach centering around dominant narratives about ED research and regulation.

The analysis found starkly contrasting narratives: the hazard story was about the insurmountable complexity and uncertainty of environmental problems, and industry influence on regulation; the risk story was about barriers to efficient and effective science-policy processes. The narratives were supported by different framings of EDs and different archetypes of science-policy actors. The archetypes from the two sides functioned as tools in a boundary struggle over the definition of good science for use in ED regulation: each story highlights the biases of the disputing side

and asserts their sides' epistemic authority. The dispute has broad ramifications: certain hazard scientists view ED research as an early step in a paradigmatic shift in regulatory toxicology. In line with Knorr-Centina, I conclude that although the hazard and risk approaches are incommensurable; each adds distinct epistemic value to regulatory research on EDs. In concordance with other studies, this conclusion reveals a need to revise science-policy processes so as to leverage a plurality of sciences. Dialogue and increased transparency are suggested as next steps towards this goal.

## **Lay Summary**

Endocrine disrupting chemicals (EDs) pose a wicked dilemma for science and regulation. EDs interact with the endocrine (hormonal) system effecting development and reproduction. They are used in numerous products that promote health, nutrition and beauty; however, EDs also pose a potential threat to the health of people and wildlife. Globally, scientists are divided over how to evaluate ED risk: some advocate for a more precautionary, hazard categorization approach; others, advocate for a more permissive risk assessment approach. Each side accuses the other of being biased and bad scientists. This controversy has exacerbated difficulties in developing ED regulation. I conducted focus groups with scientists supporting a hazard and risk approach. The findings reveal fundamental differences in the story each group tells amongst themselves about ED science and regulation, with starkly different descriptions of the ED problem and of the roles played by different actors involved with researching and regulating EDs.

## **Preface**

This thesis is an original, unpublished work of Bronwyn McIlroy-Young. The approval of UBC Behavioural Research Ethics Board was obtained for the research conducted for this thesis (Certificate Number #H18-00765). With guidance and feedback from my supervisor Dr. Gunilla Öberg and my committee member Annegaike Leopold, I identified the research problem and designed the research program. I moderated one of the focus groups used in the research and observed moderation of the other two focus groups. I analyzed the data with assistance from Dr Öberg and Annegaike Leopold.

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## **List of Abbreviations**

Endocrine disrupting substance (ED)

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I am also grateful for the support of Terre Satterfield, Amanda Giang, as well as members of the EGESTA lab, and the broader IRES community, many of whom provided inspiration, feedback, and companionship along the way. My experience was made richer and my learning enhanced by all of you.

Most importantly, I thank my family and friends, without whom none of this would be possible.

## Chapter 1: Introduction

Endocrine disrupting substances (EDs) pose a formidable challenge for toxicological research and regulation. EDs are substances in the environment, food and consumer products that can impact the hormonal system and lead to adverse effects. Health impacts on wildlife and humans may be tied to exposure to EDs in the environment, which are present in the environment at increasing levels. Addressing EDs is a challenging task and different jurisdictions take different approaches to their evaluation and management. A complicating factor is that consensus is lacking among scientists over how to best evaluate the possible threat posed by EDs: Some support a hazard-based approach, based on a chemical's potential to cause an adverse health effect. Others support a risk-based approach, whereby the likelihood of real-world exposure to a hazardous dose is assessed. Scientists on each side accuse the other of being 'bad scientists' and behaving in a way that is indecorous of a scientist. This controversy has created challenges for the development of ED regulation in Canada, the European Union and other jurisdictions around the world.

It is well documented that scientific controversies in complex policy-relevant are not necessarily resolved by generating more data – in fact the reverse can be so (Halfman, Turnhout, and Tuinstra 2019). Further, while these controversies present themselves as disagreements about facts, there is reason to believe that they often rest on underlying differences between the values and worldviews of the disputing sides (Mason-Renton et al. 2018; Elliott 2017; Douglas 2017; Vázquez Pérez 2019). This exploratory thesis aims to describe the modes of thinking and epistemic cultures characteristic of hazard and risk positions; and, to describe what distinguishes the groups from one another and unifies members of the same group.

To address the research aim, two focus group interviews were conducted with experienced scientists whose work informs environmental regulation on EDs. One group was chosen for its support of a hazard approach and the other for its support of a risk assessment approach. The focus groups were designed to facilitate dialogue about the big picture issues related to ED research and regulation, and about the risk-hazard dispute. Analysis of the focus groups records centered around the dominant narratives about ED research and regulation that emerged from each group discussion. I took an empathetic and symmetrical approach to the two narratives (Fischer 2009; Halfman, Turnhout, and Tuinstra 2019), aiming for a deep and intimate understanding of each group that does not bias one side over the other.

I find that the hazard and risk groups are guided by starkly different narratives about ED research and regulation. The two narratives are compared through an analysis of how each group frames EDs and of the archetypes of different actors invoked in each narrative (regulators, the public, the media, industry, and scientists). I then discuss how the two narratives, viewed in parallel, describe a boundary struggle over the meaning of good science for use in regulation on EDs. My findings reveal a deep divergence between the modes of thinking and cultural worldviews of the hazard and risk groups. I also find that each story was oriented towards a different, fundamental problem facing the science-policy interface for toxicology: the hazard scientists were concerned about the massive difficulty of understanding a highly complex and uncertain environmental problem; the risk scientists focused on barriers to the efficient use of regulatory resources and effective science-policy processes in toxicology. I discuss how the two sides are engaged in a struggle over the meaning of good science for regulation. The archetypes from each story function to highlight biases of the disputing side and assert their own group's epistemic authority to define good science for ED regulation. I conclude that reconciliation of the two sides appears

unlikely, and that consensus in ED science may not be desirable as the perspective brought by each side adds unique value to the science-policy interface. Finally, I suggest that future efforts conduct intergroup dialogue, not aimed towards consensus, but to help to clarify the nature of the disagreement. I also propose fostering transparency about values in the science-policy interface as further steps towards harnessing plurality in science to create more resilient and robust policies.

## **Chapter 2: The endocrine disruption problem**

Synthetic chemicals are an unavoidable element of modern life; they are used in a variety of useful products and processes that we take for granted in our daily lives (Burkhardt-Holm 2010). To keep up with constant technological innovation and the relentless demands of consumer culture, the chemical industry produces tens of thousands of new compounds each year (Wang et al. 2020). However, these new substances are being released to market at a pace that far outstrips science's ability to assess their risks, and government's ability to formulate regulation. As a result, beyond basic screening for well-understood forms of toxicity, many synthetic chemicals have been and continue to be released to market for which their potential risks are largely unknown (Bernhardt, Rosi, and Gessner 2017; Burkhardt-Holm 2010).

Endocrine disruptors (EDs) are a chemical substance-category that has received increasing attention across recent decades. An ED is defined as “an exogenous substance or mixture that alters function(s) of the endocrine system and consequently causes adverse health effects in an intact organism, or its progeny, or (sub)populations” (World Health Organization, International Programme on Chemical Safety (WHO-IPCS) 2002, p1). EDs are capable of mimicking, blocking or otherwise interfering with the production, metabolism and action of hormones in the body (Colborn, vom Saal, and Soto 1993). Endocrine disruption refers to a property of chemicals; unlike most substance-categories, ‘endocrine disruptor’ does not refer to chemicals with a similar structure, use, or set of toxic endpoints. EDs are, instead, highly diverse: “there is no single characteristic or property they all share” (Godfray et al. 2019, p1). They occur naturally but are also produced synthetically on a large scale for use in a variety of products. And they are increasingly present in consumer goods and the environment (Burkhardt-Holm 2010).

The increase in use and presence of EDs correlate with observed increases in a wide range of impacts related to development and reproduction in humans and wildlife (here defined as all non-domesticated animals including fish, amphibians and invertebrates) (Godfray et al. 2019). A large body of research indicates plausible biological mechanisms by which EDs could cause or contribute to many of these observed health impacts (United Nations Environment Programme and World Health Organization 2013); however, the extent to which observed problems with human and wildlife reproduction and development can be attributed to EDs is highly contested (Wilkinson et al. 2016).

## **2.1 Sources and exposure pathways**

EDs are found in a wide range of commonplace items. Bisphenol A, or BPA, is an ED that has been the subject of much public concern in recent years (Brewer and Ley 2011). The human health risk assessment of BPA is also a long-time cause of scientific dispute (Beronius et al. 2010). BPA is commonly used in food and beverage containers, such as plastic water bottles, for its properties as an inexpensive and highly effective plasticizer. EDs are also found in many other plastics, as well as in pesticides, detergents, human and veterinary pharmaceuticals, and personal care products such as makeup (Wilkinson et al. 2016). They are also used as industrial chemicals for various processes (Boxall et al. 2012).

One of the most common sources of ED exposure for humans is pharmaceuticals and personal care products, many of which contain EDs specifically for their endocrine disrupting properties (Boxall et al. 2012). Another common source of human exposure is contact with food packaging and household plastics. EDs that people ingest persist as they pass through our bodies and are eventually excreted in urine and feces. EDs from human egesta as well as EDs from other municipal sources, such as waste from industrial processes, are eventually funneled into

wastewater treatment plants. Inside the treatment plant, some level of treatment typically occurs that may degrade or transform some EDs, but there is still frequently endocrine activity in the effluent that is discharged to the environment (Burkhardt-Holm 2010). Agricultural products with endocrine activity can also enter our waterways, without passing through municipal treatment plants. The extent to which specific EDs appear in humans and the environment varies widely; however, they appear to be ubiquitous in humans as well as in natural water systems: virtually every human and veterinary pharmaceutical has been identified in the aquatic environment (Wilkinson et al. 2016), typically at very low levels. As such, many wildlife are constantly exposed to small amounts of synthetic EDs (Burkhardt-Holm 2010).

## **2.2 Challenges in ED research**

The ubiquity of synthetic EDs in humans and the natural environment is well established, and laboratory studies have demonstrated adverse functional changes in organisms due to endocrine disruption (Burkhardt-Holm 2010). However, we have a very limited understanding of the extent to which ED exposure contributes to the diversity of worrisome trends in the real world health of humans and wildlife populations (Diamanti-Kandarakis et al. 2009).

There are researchers who describe endocrine disruption as different from other, better understood forms of toxicity, claiming that ED risks are uniquely difficult to evaluate. There are several proposed reasons for this. First, ED effects can be subtle: endocrine disruption can occur through a range of modes of biological action, and does not affect a specific biological endpoint (ex. cell death). EDs modify natural bodily processes (Colborn, vom Saal, and Soto 1993). On the level of individual organisms, cancer is clearly deleterious and separate from normal development; however, for ED effects such as entering puberty early, gaining weight easily, or feminization, it can be unclear whether the effect is abnormal, whether it is adverse, and whether

it is caused by endocrine modes of action (United Nations Environment Programme and World Health Organization 2013). Further, some scientists are concerned about identifying endocrine effects because during most life stages our endocrine system is designed to regulate organism development and reproduction, and to maintain homeostasis through constant adaptation in response to changes in our internal and external environment (Birnbaum 2020). Adverse endocrine effects triggered by exogenous synthetic chemicals are not easily discernable in a system that exists in constant flux.

Second, some researchers argue that sensitivity to endocrine disruption varies widely depending on an organism's stage of development. During certain life stages, including fetal development, infancy and puberty, our endocrine system is hypersensitive, meaning that developmental processes may be triggered or impeded by ED interaction with a very small number of receptors (Birnbaum 2020; Demeneix et al. 2020). This area of ED research is highly disputed (Rhomberg and Goodman 2012; Krishnan 2009; Brescia 2020).

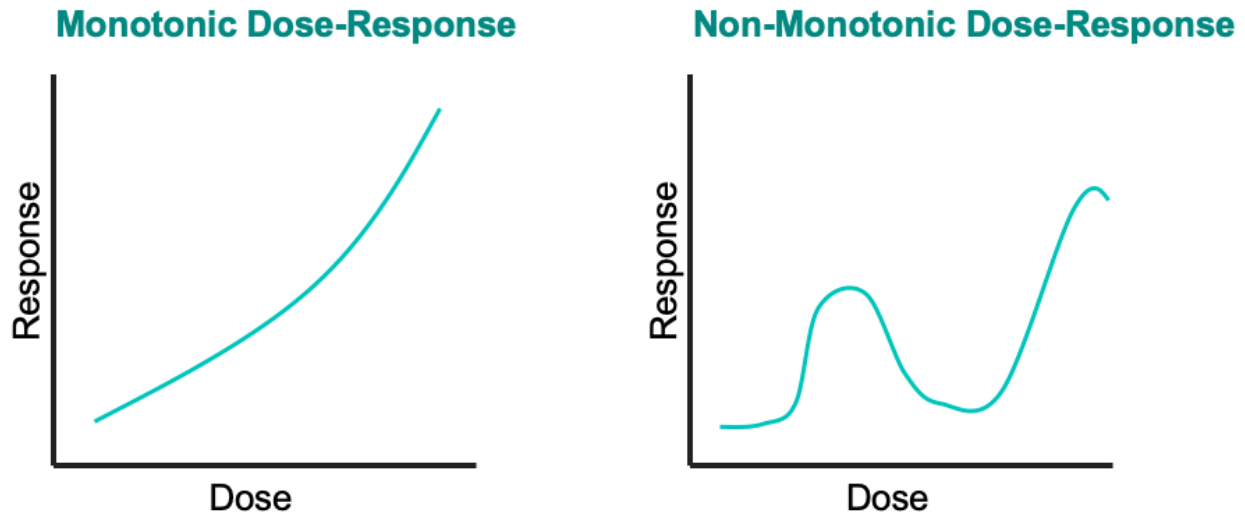
Third, adverse health effects are often latent and can be multigenerational. Infant exposure may affect puberty or adult fertility. Maternal exposure can cause adverse effects in offspring (Parrott et al. 2017; United Nations Environment Programme and World Health Organization 2013).

Some EDs may modify genetic development, changing developmental and reproductive health across two or more generations.

Fourth, some scientists express concern that exposure to a combination of EDs may result in additive or synergistic effects, which are very difficult to assess. The ubiquity of EDs in the environment means that organisms could be exposed to a combination of different toxins, some of which may have endocrine effects. However, risk assessment generally operates on a chemical-by-chemical basis, effectively assuming that organisms will only ever be exposed to

one chemical at a time (Bernhardt, Rosi, and Gessner 2017). From the outcome of this assessment, chemicals are regulated, one-by-one, without consideration for how their interactions with other chemicals might affect the toxicity experienced by organisms. The human, wildlife and ecosystem effects from combined exposure to multiple substances is a growing field of research (More et al. 2019). Depending on the chemicals involved, it could be that the hazardousness of two chemicals cancel each other out, it could be that the effects on the organism are the same as if it were exposed to each chemical individually, or it could be that the two chemicals interact synergistically such that the toxic effect on the organism is greater than the sum of each chemical's individual effect (Bernhardt, Rosi, and Gessner 2017; More et al. 2019). Mixture effects are a great challenge for all of chemical risk assessment and not unique to EDs, but complicate discussion of safe thresholds described below.

Finally, ED dose-response relationships can be non-monotonic. With almost all established forms of toxicity, the magnitude of the toxic effect increases as the exposure dose increases. With EDs, however, in some cases, exposure to a very small amount causes a larger adverse effect than would exposure to a greater amount (Daughton 2004) (Figure 1). Non-monotonic dose-response relationships can occur because of feedbacks or parallel processes within the endocrine system. For example, if 10% of receptors are activated the body will excrete some hormone but activation of 20% of receptors triggers the body to stop excretion. This characteristic of EDs defies the basic principle of toxicology---that "dose makes the poison" (Diamanti-Kandarakis et al. 2009). Chemical risk assessment involves testing chemicals for their toxic effects on an organism at various doses to identify the threshold under which there is no observable adverse effect (Demeneix et al. 2020). EDs complicate this methodology because effects at high doses may not extrapolate to effects at low doses, and vice versa.



**Figure 2.2 Plots illustrating the difference between monotonic dose-response and non-monotonic dose-response**

The potential non-monotonicity of certain ED substances has resulted in a complicated scientific discussion about whether we can assume a threshold under which ED exposure will cause no adverse effects. Some scientists argue that at certain stages in development, certain organisms may be so hypersensitive to endocrine disruption by exogenous chemicals that there is no threshold under which ED exposure can be assumed to be safe (Zoeller and Vandenberg 2015; Dietrich et al. 2013). This group of scientists further asserts that because of the potential non-monotonicity of ED dose-response, there may be adverse effects beneath the lowest observable adverse effect level, which manifests at doses too low to be detected by assessment methodologies. Other scientists support a threshold for ED substances, arguing that the existence of thresholds across toxicants is well established. Further, because empirical science cannot address issues of an infinite number of doses, we rely on theoretical arguments for the existence of a biological true threshold; some scientists assert that it is statistically and biologically improbable that an infinitesimal amount of a substance (ex. one molecule) could trigger an effect

in an organism. These scientists argue that, while low dose effects have been observed for some EDs, this should be assumed to be the exception and not the rule governing ED-dose response relationships. Some researchers propose that endocrine effects are only of regulatory concern if the endocrine-mediated effect is the lead toxic effect, in other words, if it occurs at lower levels than those that cause other types of toxic (Bars et al. 2012). In this view, if a substance is observed to have endocrine effects at a certain dose, but also exhibits other forms of toxicity at a lower dose, it would not be regulated as an ED.

### **2.3 Hazard versus risk: regulatory dilemmas and divided scientists**

EDs pose a formidable challenge for regulators: how do you allow society to enjoy the benefits of these chemicals while protecting vulnerable populations from their risk? Jurisdictions around the world, including Canada and the European Union, are attempting to address this question through supporting the scientific evaluation of EDs (Matthiessen 2013; McKenna and Petitpas Taylor 2018). The results of these assessments can be used to inform regulatory frameworks that balance diverse considerations and stakeholder interests. The design of an ED regulatory framework involves numerous value trade-offs related to protecting the environment, promoting human health, enabling progress and innovation in industry, and using limited government resources effectively.

The question of how best to regulate chemicals has been debated since the formation of regulatory agencies in Europe in the early part of the 1970s (Lofstedt 2011). The most common categorization of chemical regulatory possibilities is hazard classification versus risk assessment. Simply put, “should regulators ban substances that have the intrinsic ability to cause harm, or should they examine whether there is a real probability that these substances will actually cause harm, in part based on exposure?” (Lofstedt 2011, p149). Hazard and risk assessment are not

mutually exclusive; in order to assess risks, one must first classify the hazard posed by a substance. As such, debates center around whether regulation should be based on hazard classification alone, or if risk assessment should also occur. Hazard assessment generally is more independent of the economic consequences of regulation, whereas risk assessment may take those types of impacts into consideration. Hazard classification is also less costly for regulators because it eschews the complex process of risk assessment testing. Over the past decades, approaches have varied across nations, industries and toxicant substance-categories. In the EU, risk assessment is the dominant approach for most substances and industries, but hazard assessment is used for some toxicological effects such as endocrine disruption. (Lofstedt 2011). With ED regulation, decisions around taking a hazard classification versus a risk assessment approach have been fiercely contested amongst the scientists whose research supports ED toxicological regulation; in large part, because of the scientific features of EDs described above. While a diversity of scientific positions within purely academic or exploratory science is often accepted, consensus is expected amongst scientists engaged in research for the purpose of guiding regulation. Consensus in regulatory science, it is argued, is “vital for scientific credibility and the development of regulatory positions that reflect the most appropriate and justified” balancing of protection goals with social and economic considerations (Brescia 2020, p1). Information from key informants and statements published by collections of ED scientists indicate the existence of two polarized camps of scientists within the global ED assessment community: one group who advocates for a hazard assessment approach to assessment and one who advocates for a risk approach (Bergman et al. 2015; Lamb et al. 2014; Dietrich et al. 2013; Gore et al. 2013; Brescia 2020; Demeneix et al. 2020).

For EDs, as with other substances, a hazard approach bases assessment solely on measures of the hazardous properties of a substance. A risk approach considers information about the hazardousness of substances, but also assesses the probability of real-world exposure at a dose that would cause an adverse health effect. Risk assessment is based on the assumption that, although some substances may be highly toxic, we are able to mitigate their risks to populations by managing exposure. By-and-large, regulating on the basis of hazard and not of risk is more precautionary and introduces a greater chance of false positives---banning chemicals without due cause. In contrast, a risk approach is generally more permissive and introduces a greater chance of false negatives---allowing chemicals to go unregulated that do pose a health threat. A major point of contention between the two groups is whether we can assume a threshold under which EDs will not cause an adverse effect. This controversy has played out in academic conferences, peer-reviewed articles and editorials, and meetings to advise ED regulation (Bergman et al. 2015; Lamb et al. 2014; Dietrich et al. 2013; Gore et al. 2013; Brescia 2020; Demeneix et al. 2020).

Disagreement between groups of scientists is not itself a problem: conflict about ideas is an integral part of how science progresses. However, with the case of the ED assessment community, relations between the two sides have deteriorated to a degree that communal knowledge production and science-based policy-formation are inhibited, and major regulatory decisions have been significantly delayed (Scholz and European Parliamentary Research Service 2016; Solecki et al. 2017). The interactions between the two sides are reductive and indecorous, each accusing the other of being biased and bad scientists (Bergman et al. 2015; Lamb et al. 2014; Dietrich et al. 2013; Gore et al. 2013). An additional complication to the hazard-risk controversy is that scientists from each side are further divided into those assessing ED risks to

human health and those assessing their risks to the environment. The human health and ecotoxicology scientists work within distinct disciplinary paradigms and employ different methodologies to address different aspects of ED risk.

## **Chapter 3: The social study of science**

### **3.1 The production of knowledge for regulation**

The typical response for settling scientific controversies is to generate more research. This response is based on the assumption that with enough research, certainty about the facts can eventually be obtained resulting in consensus about the best course of action for regulation (Halffman, Turnhout, and Tuinstra 2019). However, studies of other policy decision-making contexts indicate that this assumption is misguided for cases in which uncertainties are high and scientific consensus is lacking. This is because it fails to recognize that scientific knowledge does not simply translate into action, but requires interpretation, a way of coping with uncertainties, and reconciling competing knowledge claims (Halffman, Turnhout, and Tuinstra 2019). Furthermore, simply gathering more data appears to fall short for cases in which stakes are high and the decisions implicate diverse stakeholder groups, such as EDs, because the controversy is not just about facts; but rather, entwined with contestations over the political, economic and societal implications of those facts (Halffman, Turnhout, and Tuinstra 2019; Funtowicz and Ravetz 1993). In such cases, instead of resolving science controversies, conducting more research can add fuel to the fire and increase polarization between groups. BPA, for example, is both the most researched and the most divisive of all EDs (Beronius et al. 2010; Brewer and Ley 2011). More research is undoubtedly necessary to help guide robust regulatory decision-making, but an approach that strives for scientific consensus through increasing data while ignoring the values and interests embedded in the research context risks causing deeper entrenchment of opposing groups and decision-making stalemate.

In these situations, scientists on all sides typically explain the disagreement by claiming that their own research is objective and data-driven, while the disputing side's research is of poor quality or biased (Douglas 2017; Mason-Renton et al. 2018; Halfman, Turnhout, and Tuinstra 2019; Vázquez Pérez 2019). As such, they propose that an evidence-based decision, one in which regulation follows directly from high quality research, would be guided by research from scientists on their side of the divide and ignore that from scientists with an opposing research perspective. As described above, this is precisely what has been observed within the ED research community.

This is not to say that accusations of poor science are always unfounded. Poor quality research is, unfortunately, commonplace in toxicology as with any other field of science. Biased research, inappropriately influenced by economic or other motives, also exists. Particularly infamous and cases have been documented by Michaels (2008) and Oreskes and Conway (2009), detailing the actions by the tobacco and asbestos manufacturers insisting that science justified the safety of their products long after they were known to pose a serious threat to health (Michaels 2008; Oreskes and Conway 2011). For decades, scientists working for those industries generated research to support statements suggesting a lack of evidence connecting cigarettes and lung cancer.

### **3.2 Science's flawed ideal**

Scholars of science have spent many decades searching for explanations as to why scientists disagree with each other that extend beyond an insufficient amount of data (Longino 1990; Douglas 2017; Halfman, Turnhout, and Tuinstra 2019). This exploration has proven very fruitful: it has helped to shed light on the social forces that shape scientific fields and on the

values that influence the decisions made by individual researchers. Essential to this project is the challenge to the value-free ideal of science, championed by philosophers of science Helen Longino, Heather Douglas and Kevin Elliot. The value-free ideal describes the intuition that “social, ethical and political values should have no influence over the reasoning of scientists, and that scientists should proceed in their work with as little concern as possible for such values” (Douglas 2009, 1; Merton 1979). The common wisdom justifying the value-free ideal is that keeping science far removed from social and political concerns is the best method to ensure its reliability and epistemic authority.

The value-free ideal faces descriptive and normative challenges. Philosophers of science argue that science cannot be value-free because any work undertaken by humans is unavoidably value-laden (Longino 1990; H. Douglas 2009; Elliott 2017). Values originate from our personal identities, upbringing and life experiences, which are bound up with disciplinary standards and methodological commitments from scientific training. Values inform our view about how the world works, and our judgements about how it could be changed for the better. Elliott describes how values influence science throughout the process of doing research, coming into play at any point where a judgement is made---about the framing of inquiry, which questions are asked, how studies are designed, what standard of evidence is chosen for drawing conclusions, and how results are communicated (Elliott 2017). As such, philosophers argue, the value-free ideal is unachievable because values will unavoidably influence the decisions made by scientists, and the ultimate conclusions drawn in scientific research (Longino 1990; H. Douglas 2009; Elliott 2017). Arguments against the value-free ideal have received pushback, particularly from scientists who believe that, despite difficulties, we should continually strive to distance science from values as much as possible (Callow 2019; Betz 2013). However, scholars of science who challenge the

value-free ideal warn that ridding values from science is impossible, and attempts to do so will only serve to obscure their influence (Elliott 2017; Backhaus 2019b; 2019a; Öberg, Elliott, and Leopold 2020). This argument, forwarded by certain philosophers of science, is supported by observations of failed attempts to resolve policy-relevant scientific controversies, described above. Such philosophers argue that scientific disputes in policy-relevant areas are often based in value difference between the disputing sides. When the parties involved in controversy adhere to the value free ideal, the role of values in the dispute goes unacknowledged. So, the only available explanations for the disagreement are that not enough research has been conducted or that one of the disputing sides is doing poor science. Modes of addressing the dispute that involve acknowledgement and discussion of value differences are made unavailable.

### **3.3 The social nature of science**

Other work in the social study of science, predating that described above, offers sociological explanations for how values are shared by communities of scientists and influence their epistemic orientation. Ludwik Fleck was a microbiologist whose early work in philosophy and sociology of science helped to deconstruct the notion that facts are directly observable and can be unambiguously translated into objective conclusions about how the world works. Fleck rejects the notion of an isolated investigator, claiming that human cognition is a collective activity: jointly constructed understandings and experiences form the basis for shared assumptions about reality (Fleck et al. 2008). He uses the term ‘thought collective’ to describe communities of people mutually exchanging ideas or maintaining intellectual interactions. Within thought collectives, members share ways of observing and making sense of the world. As such, we are able to understand members of our own thought collective well but can struggle to understand people from other thought collectives (Fleck et al. 2008).

Thomas Kuhn's work followed from that of Fleck but focused on describing the evolution of science overtime (Kuhn 2012). He articulated the idea of the scientific paradigm: the collection of theories, values, and methodologies shared by a discipline at a given moment in time.

According to Kuhn, paradigms allow for the practice of science by providing a foundation of shared knowledge, tools and assumptions, through which scientists can collaborate and build upon previous research. In this way, the members of thought collectives can be understood as belonging to the same paradigm. Kuhn described a process through which paradigms undergo revision: overtime evidence accumulates that contradicts paradigmatic assumptions, eventually these assumptions are rejected, the paradigm is overturned, and a new paradigm is constructed which better supports the more recent evidence. According to Kuhn, different paradigms are incommensurable, meaning that the members of different paradigms will employ different methods, use different syntax and perceive the world differently from one another. In Kuhn's view, it follows that paradigm shifts must occur because multiple paradigms relating to the same field cannot coexist; there will ultimately be one unified science that dominates a field over a given period of time.

Numerous social scholars of science have built from the work of Fleck and Kuhn, characterizing science as a particular way to organize the social generation of knowledge. In this view, disciplines and subfields emerged to enable specialization and divide knowledge acquisition resources (Krishnan 2009). Karin Knorr Cetina is a sociologist who described how, overtime, disciplines develop unique epistemic cultures. Epistemic cultures are again similar to Fleck's thought community but describes more specifically the common strategies and policies of knowing amongst groups of scientists (Knorr Cetina 1999). To gain expertise as a scientist is to become highly adept at applying the knowledge acquisition tools of their disciplines, and deeply

entrenched in that specific mode of making sense of the world (Fleck et al. 2008; Knorr Cetina 1999). Knorr Cetina's work diverges from that of Kuhn in that she believes that multiple epistemic cultures can and do coexist. According to Knorr Cetina, diverging paradigmatic assumptions do not force a shift, and there is no dominant driver towards a unifying scientific theory. In certain situations, the set of theories held by one epistemic culture may provide the most helpful explanation; in other situations, the set of theories held by a different epistemic culture may prove more useful.

### **3.4 Explaining differences in scientists' values**

There are many proposed explanations as to what causes different groups of scientists to interpret the same set of phenomena differently. The influence of values on experts' policy advice has been studied extensively (Elliott 2017; Spruijt et al. 2014; Pielke 2007; H. Douglas 2000; Barke and Jenkins-Smith 1993; Mason-Renton et al. 2018). Specifically considering perception and assessment of chemical risk, studies indicate that nationality, gender and age are all possible variables that explain differences between scientists (Slovic et al. 1997; Barke and Jenkins-Smith 1993.) Scientists' disciplinary background, institutional affiliation, and cultural worldview have also been shown to affect policy preferences in response to risk---each of these variables has been theorized as a possible explanation for the ED hazard-risk divide.

The hazard-risk controversy is sometimes described as a dispute between toxicologists and endocrinologists. In this view, toxicologists support a risk assessment approach to EDs, claiming that toxicological principles, such as a threshold, also apply to EDs. Endocrinologists, by contrast, believe that the principles governing the endocrine system challenge the basic toxicological principles, which is why they support a hazard approach to ED regulation (Demeneix et al. 2020; Brescia 2020; Gore et al. 2013; Dietrich et al. 2013). The ED dispute is

also framed as a divide between academic and industry-supported science, with academic scientists advocating a hazard approach and industry scientists a risk assessment approach (Bergman et al. 2015).

Sander Clahsen and colleagues conducted an argumentation analysis of two ED articles written by hazard and risk scientists in which they suggest that differences related to cultural worldviews about nature may underlie the hazard-risk divide (Clahsen et al. 2019). The Myths of Nature, derived from cultural theory, describe four specific types of cultural biases about what nature is like, what the world is like, and who is to blame for untoward events (Dake 1992b; M. Douglas and Wildavski 1982; Grendstad and Selle 2000; Dake 1992a; Wildavsky and Dake 1990).

Clahsen proposes that risk scientist's description of the endocrine system aligns with the Myth of Nature that 'nature is tolerant, but within limits'; i.e. the endocrine system is largely capable of absorbing interference from toxicants. From the hazard article he analyzed, Clahsen suggests that those authors' description of the endocrine system is supported by the 'nature ephemeral or fragile' myth of nature (Clahsen et al. 2019). Clahsen's work suggests that hazard and risk scientists may have divergent cultural worldviews about nature; however, due to the complexity of the ED controversy, a wide array of explanatory models are available for unpacking the differences between the two sides. Work by Marco Antonio Vázquez Pérez on science controversy around wastewater treatment also suggests that difference in Myths of Nature underlie scientific dispute around chemical related risk (Vázquez Pérez 2019).

## **Chapter 4: Research approach and methodology**

### **4.1 Research aim**

Social constructivist theories of science have attracted criticism for framing science as entirely relativistic and political. Pushback against social theories of science came to a head in the Science Wars of the 1990s in which scientists accused social scholars of science of anti-intellectualism and of attacking a caricature of science that is a far throw from the reality of scientific practice (Mermin 2008). This critique is supported by instances in which populist and anti-intellectual rhetoric has drawn from arguments forwarded by social constructivists (Collins and Evans, 2020).

I enter this research with an awareness of these challenges to my epistemic orientation. I do not intend for my study to disparage the utility of science, which is undeniably among the most powerful modes of knowing about the world and responsible for much of human progress. I begin from a position of great respect for science and strive to do work that improves its capacity to provide actionable knowledge for policy. Additionally, my work responds to calls for more empirically grounded study of science that better reflects and serves the realities of the issues confronted by scientists in their particular context (Spruijt et al. 2014; Elliott 2017).

In approaching this research, I align myself with scholars who believe that through the integration of a plurality of knowledge perspectives we move closer to an objective understanding of reality (Douglas 2017; Kuhn 2012; Knorr Cetina 1999; Harding 2015). This theory relates to the concept of triangulation, a common marker of objectivity in quantitative research, but assumes that reality is so complex, and possible epistemic perspectives so different that it is often impossible for different groups to draw identical conclusions about the nature of

phenomena (Tracy 2010). To understand this, imagine a crystal with many facets. In the middle of the crystal there is a complicated scene. The glass of the crystal is clouded, but by looking through a facet you can make out a murky image of one of the sides of the scene within. The view from each facet is different and the scene inside is very complicated, such that the images visible from different facets may have little resemblance to one another. My epistemic position is based on the assumption that people will never have direct access to reality: many aspects of the scene within the crystal will always be obscured. However, by viewing the scene through multiple facets of the crystal our perception becomes more complete. The different viewpoints into the crystal represent various epistemic cultures, which, as described, determine an individual's knowledge perspective.

Incorporating a plurality of knowledge perspective contributes to greater objectivity in science, and also to improved regulation: policies that are based on a plurality of scientific perspectives are likely to be more rigorous and resilient than policies that are based on only one scientific perspective (H. Douglas 2017; Elliott 2017; Harding 2015). My Master's thesis research explores the ED hazard-risk controversy as a case of plurality in policy-relevant science. My focus is on scientists whose research supports regulation related to ED impacts on the environment. I consider the groups of hazard and risk scientists as distinct epistemic cultures, each with its own knowledge perspective on ED science and regulation. My aim with this research is to describe the modes of thinking and cultural worldviews characteristic of hazard and risk cultural groups: what distinguishes the groups from one another and what unifies members of the same group. I acknowledge and then temporarily set aside accusations of poor-quality research and bias directed at both sides, hypothesizing that there is value added by both knowledge perspectives,

and additional epistemic value in attempting to hold contrasting perspectives in mind at once as doing so provides a more holistic view of ED research and more sound regulation.

## **4.2 Research Team**

My Master's thesis research was conducted within the EGESTA Lab and is part of a larger research project led by Professor Gunilla Öberg, my thesis supervisor, and Adjunct Professor Annegaike Leopold, one of my committee members. I worked in close collaboration with Öberg and Leopold throughout the course of my Master's research. Their contributions to the project are described here.

- Annegaike Leopold has worked in chemical risk assessment, with a focus on EDs, for 30 years. She was acting as president for the Society of Environmental Chemistry and Toxicology (SETAC) Europe while we conducted this research and is highly connected within the ED research community. Leopold brought the ED controversy to our attention and is the impetus for this research. From the beginning of the project, Leopold has provided detailed background knowledge of ED science and regulation, and of the ED research community and the hazard-risk controversy. Leopold's knowledge and connections enabled us to recruit research participants. She also assisted with interpretation of the results.
- Öberg is the Primary Investigator for the EGESTA Lab. She supervised all aspects of my research and acted as moderator for the two ecotoxicology focus groups.

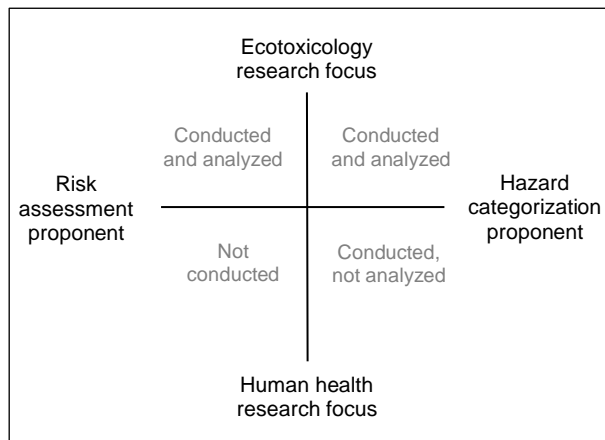
## **4.3 Focus groups**

### **4.3.1 Focus group approach**

The aim of my research is to understand the modes of thinking and cultural worldviews characteristic of hazard and risk scientists. Focus groups are a natural choice of method for research that aims to explore cultural understandings of phenomena because they allow for observation of the social co-construction of knowledge (Belzile and Öberg 2012). In order to achieve my aim of understanding what distinguishes the risk and hazard groups from one another, and what unifies members of the same group, I conducted separate focus groups with hazard and risk scientists.

As described above, research on EDs as with many other toxicants is divided between those who look at effects on wildlife and those who look at effects on human health. In order to generate data on how knowledge is socially constructed within a particular epistemic culture I also designed my study so that the groups were homogeneous in terms of general research focus--- EDs and the environment or EDs and human health. Accordingly, in the original design of this project, I intended to conduct four focus groups: one with scientists who research EDs in the environment and are proponents of a hazard approach to ED evaluation; one with scientists who research EDs in the environment and are proponents of a risk assessment approach to EDs; one with scientists who research EDs and human health and are proponents of a hazard approach to ED evaluation; one with scientists who research EDs and human health and are proponents of a risk assessment approach to EDs (Figure 3.3). Due to time and access restraints, only three of the four focus groups were conducted—ecotoxicology risk, ecotoxicology hazard, and human health hazard—and only the two ecotoxicology groups were analyzed. As such, this research centers around the two ecotoxicology focus groups. In describing my findings from those two focus

groups, I also occasionally supplement with data from the human health hazard focus group, and from other sources of data related to the ED controversy such as publications, presentations, my observations of exchanges at conferences, and my conversations with ED scientists. These other data sources are used to validate, clarify or extend upon findings from the two ecotoxicology focus groups, but none were formally analyzed.



**Figure 4.3.1 Planned and conducted focus groups**

Aligning with this study’s interest in epistemic culture and shared knowledge, we use a social-centric approach to focus groups, as opposed to an individualist approach. Social constructivism and the related dialogic perspective start with the assumption that socially shared knowledge of the human species has a dialogic nature. This means that each individual generates their knowledge as multifaceted and multi-voiced realities situated in culture (Marková et al. 2007). Prioritizing the social over the individual was important for the design and facilitation of the groups in that such an approach enables participants to collectively construct a narrative about a topic (Belzile and Öberg 2012). Focus groups possess a synergy that makes them more productive through pulling more views from participants than would emerge during an interview, which also offered an advantage in this research (Morgan and Scannell 1998; Belzile and Öberg 2012). This synergy is a result of participants ability to challenge and build upon each other’s

ideas and to revisit and re-express their own ideas in response to other participants' comments (Bryman 2015).

According to Catterall and Maclaran, conducting focus groups with an emphasis on interaction can reveal: “the shared language on a topic; what was taken for granted and what was asked for clarification by other participants”; “the beliefs and myths about the topic that are shared, taken for granted, and which ones are challenged”; “the arguments which participants call upon to justify their views and experiences and how others respond to these”; “the arguments, sources and types of information that stimulate changes of opinion or reinterpretation of experiences”; and “the tone of voice, body language, and degree of emotional engagement that is involved when participants talk to each other about the topic” (Catterall and Maclaren 1997, p5). All of this interaction-derived data assisted in addressing my research aims.

The focus groups we conducted had four or five participants. A smaller focus group is preferred when the topics discussed are complex or controversial and participants are likely to have a lot to say (Morgan and Scannell 1998). Through smaller focus groups, it is also easier to establish “communicative common ground”, in which participants co-create a narrative as they go along as opposed to expressing their individual views to the group (Hydén and Bülow 2003; Belzile and Öberg 2012). Additionally, small focus groups tend to be easier to facilitate than large groups (Peek and Fothergill 2009).

The focus groups were conducted in the spring of 2019. Poor participation rates and last-minute dropouts are common barriers to successful focus group interviews (Bryman 2015). This could have been especially problematic for our study for which the participants are distributed across Europe and North America and must travel long distances to participate. In anticipation of this

issue, each focus group took place at the same time and location as international scientific conferences that many members of our target population normally attend.

#### **4.3.2 Sample population**

We used purposive criterion sampling to select participants (Bryman 2015). Identification and recruitment of participants was led by Leopold, guided by her 30 years' experience in the field and extensive network of connections within the population of interest

The general inclusion criteria for the focus groups are as follows:

- Employed as a scientist with evaluation of EDs in the environment as a main research focus, and does research that informs regulation.
- Living in the European Union or North America.
- Appear to have a preference for a hazard identification over a risk assessment approach to ED evaluation, or vice versa. This was determined based on their public statements, publications and Leopold's previous interactions with them. Some participants were clearly strong supporters of hazard or risk, others more moderate or somewhat ambiguous in their preference.
- Attending the conference at which the focus groups were conducted.
- Are mid to late career and relatively respected and influential within their field. This was operationalized through selection of scientists who have a PhD and have been practicing science in the field for over a decade. Leopold used her best judgement as to who is influential. I assumed that mid to late career scientists are more indoctrinated into the social and epistemic culture of their field, which we are interested in learning about than would an early career scientist. I also assumed that speaking to influential scientists

would give our findings greater impact within the community. Additionally, in a more mixed group, early career scientists might be intimidated to voice their opinion in front of the “big names” in their field, so I would be less likely to gather insights from all participants.

There is one exclusion criterion for the focus groups:

- If I believed there is some characteristic of that individual, for example that they have a highly abrasive personality, which will significantly detract from the efficacy of the focus group or the comfort of the other participants. This determination was made based on Leopold’s assessment of potential participants’ personalities from her interactions with or knowledge of the community.

The inclusion criteria outlined deliberately established natural groupings within each focus group (Bryman 2015). Especially as the participants had been in the field for many years, all of them knew or knew of other participants in their group. Moreover, all participants were members of a relatively cohesive professional social-epistemic community, having many similarities with reference to the topic of discussion for the group. This homogeneity within the groups allowed us to observe how the topics of interest are discussed amongst these groups of scientists in real world settings and aided in the co-construction of knowledge within the focus group (Bryman 2015), detailed below.

There are two variables for which we aimed for diversity, and not to homogeneity, within the groups: gender and sector of employment. Each ecotoxicology focus group included participants from at least two different sectors---academia, regulatory and industry. This ensured that these three important perspectives on ED assessment were included in our data. Diverse representation

is also important as hazard proponents commonly perceive risk proponents as being “in the pocket of industry” (Bergman et al. 2015). Likewise, risk proponents accuse hazard proponents of being captured by environmental advocacy groups. This focus group composition helped to capture the varied and nuanced justifications for supporting a risk or hazard approach to evaluation of EDs and, also, to avoid having the perspectives of either side dismissed by certain scientists when our findings are ultimately disseminated to the community.

We aimed to have at least two female participants in each group; however, we were only successful in recruiting one female participant for each of the ecotoxicology groups. Our objective was to avoid potentially strange dynamics as a result of three female researchers interviewing an all-male group. Additionally, because men and women tend to perceive some risks differently (Gustafson 2006), an all-male group would introduce the possibility of a confounding variable in interpreting the results. I acknowledge that having only one female participant in each group placed a higher burden on that participant.

### **4.3.3 Participant recruitment**

Based on the criteria above, we generated a list of 12-20 potential participants for each focus group. The list was ranked according to those we would most like to participate.

Recruitment took place on a rolling basis starting six weeks in advance of the focus groups. For each group, we first sent initial recruitment emails to the top eight candidates (the maximum number we would have participate) on our list of potential participants. Each time a participant responded that they would not be participating, we sent another recruitment email to a participant who was lower down on our ranked list. As we receive participant responses, we reordered the participants on the lists considering the anticipated social dynamics of the group and the diversity

of perspectives we would like represented. For each group, participant recruitment ended when we had at least four confirmed participants and our minimum requirements for gender and sector of employment representation within the group were met.

The initial recruitment email asked whether the potential participant was attending the conference at which the focus group would take place, provided a brief description of the research project and asked whether they would be willing to participate. For those from whom we did not receive a response within one to two weeks, we followed up with a second email repeating our request. For those who responded positively to the initial request email, we sent a second email including the information letter and the consent form for the participant to sign. We again sent a follow-up email if we did not receive a response to our second communication within one to two weeks. We sent a third contact email closer to the date of the focus group reminding them of their participation and providing relevant information about accessing the focus group venue.

The recruitment emails were sent out by Leopold because many of the participants has already met her.

#### **4.3.4 Focus group conduct**

The hazard and risk focus groups with ecotoxicology scientists took place in spring of 2019 and the focus group with human health hazard scientists took place in winter of 2020. The two ecotoxicology focus groups were moderated by Öberg and observed by Leopold and myself. The human health hazard focus group was moderated by me and observed by Leopold. Each focus group took approximately 1.5 hours to conduct, plus 10-20 minutes of introduction and wrap up time. The focus groups took place in a private room at or near the conference venue. The room

contained a table large enough to comfortably accommodate all participants and the moderator, as well as space for the observers.

For all three focus groups, Leopold welcomed the participants and then passed the group over to the moderator. While the focus group facilitation was in progress, the observers watched from the side of the room. Leopold occasionally assisted with the facilitation. As described, only the two ecotoxicology focus groups were analyzed. Having the same facilitation structure for both groups helped control for the influence of facilitation on the focus group discussion.

Each focus group was audio-recorded with three recording devices placed at different locations in the room so as to capture multiple voices from varying distances (Bryman 2015). Field notes were taken by all researchers during the interview to record observations not captured in the audio recording that aided in the interpretation of the data.

Participants were greeted by the researchers as they arrived in the facilitation room. They were provided with tea, coffee and light snacks and given several minutes to get settled in the space and say hello to other participants. Leopold began the focus group by thanking the participants for their attendance and introducing herself to the group. She then asked each of the participants to introduce themselves by stating their names, expertise related to EDs and regulation, and their connection to the other participants. Participants were asked to speak as themselves and not for the organizations they represent. Öberg and I also introduced ourselves to the group.

Leopold then handed over to the moderator who provided an official introduction to the focus group and laid out the ground rules for the discussion. The moderator reminded participants that the discussion was being recorded, checked that everyone had signed the consent form and notified the participants that they could ask for their data to be withdrawn from the study at any point. She then explained what focus groups are and how we intended this focus group to work:

to have the group collectively explore a topic through dialogue, with the moderator asking questions occasionally to ensure that the discussion covered the topics of interest to our study and interjecting if necessary to make sure that all participants were given appropriate time to share their thoughts. The moderator also explained to participants what we intended to do with the data from their discussion.

Apart from stating the topic of the focus groups, science for policy around endocrine disrupting chemicals, almost no information about the content of the discussion was provided. The project was contextualized as fitting into the researchers' larger research agenda about what to do when you are faced with very large uncertainties in science, but ultimately regulatory decisions still need to be made. The reason for providing minimal information about our research topic to participants is elaborated on below.

#### **4.3.4.1 Stimulus material**

Figure 3. depicts the artwork used as stimulus material for the focus group. Placemats showing the artwork with first question on the interview guide (“What is the question we are trying to answer when faced with an endocrine concern?”) printed above were set on the table in front of each participant. These placemats were referenced, but the artwork itself was not introduced or explained. The stimulus material helped foster a sense of intrigue and to engage the participants in the space and the conversation. The intention of the piece was to encourage reflection about science in society---the context in which it is conducted, the humanity of the people who do science, the social nature of science, its consequences for nature, and for the general public. The meaning of the piece is not immediately apparent: as with most effective stimulus materials it encourages participants to explore a range of perspectives (Wibeck, Dahlgren, and Öberg 2007). The artwork includes various “clues” that suggest we are offering the participants a

representation of the interview context: pollution, debate between scientists, disciplinary norms articulated in textbooks, marketing, etc. It also serves as a microcosm representing science in society against which interviewees can compare their own viewpoint and, for some interviewees, may provoke them to challenge their own ideas (Törrönen 2002).



**Figure 4.3.4.1 Stimulus material for focus groups: artwork commissioned for teaching purposes by Gunilla Öberg, developed in collaboration with the artist Dina Pai.**

#### **4.3.4.2 Moderation and facilitator impartiality**

The discussion began with Öberg posing the first question on our interview guide: “What is the question we are trying to answer when faced with an endocrine concern?” Moderator intervention was kept to a minimum, allowing as much as possible for natural conversation between participants. With some notable exceptions, the conversations in both groups moved to

cover most topics on the interview guide without the moderator needing to explicitly pose the interview questions (Figure 4). Öberg, and occasionally Leopold, intervened throughout to probe participants or follow up on topics of interest that were mentioned but not elaborated on by the group.

One issue we anticipated was that focus group members would get caught up in the technical and scientific details of assessment as opposed to reflecting on wider societal questions. We used a general framing of the interview questions as well as the stimulus material to promote an open, big picture discussion about EDs. Extended discussion about the scientific and technical details of assessment did not become an issue in either group.

Our study considers the hazard and risk scientists as belonging to distinct epistemic cultures. I assume that there are differences in their cultural worldviews and modes of thinking related to EDs and set out to explore what those differences are. To achieve this aim, and validly test the underlying assumption, it was critical that the moderator remained neutral for both groups. As such, we entered the focus groups with an awareness of our preconceptions about how each conversation might go and avoided posing questions in such a way that invoked responses that would match our assumptions (i.e. leading the participants).

We also did not directly refer to the hazard-risk controversy at any point in either session. There are several advantages to this indirect approach. First, our study was initiated under the assumption that the ED assessment community contains two polarized groups; in the case that this assumption is untrue, our study design would still have captured interesting features of how this community thinks about ED risk. Second, if we had informed participants that they had been selected because they support a hazard-based approach to regulation and that our study design contrasted them with risk assessment supporters, they may have modified their behaviour to

align with this framing. Third, our research aim was better served by an indirect approach to discussing the controversy that forced each group to think in new ways about the goals and impacts of their discipline, to “muddle through together”, rather than repeating their old gripes about the opposing side. We believe that the design of the question guide (Figure 4) allowed for conversation about a risk versus hazard approach to emerge naturally, but in a more thoughtful and nuanced way than if they were directly queried about the topic.

We also worked towards moderator neutrality in the technique used to probe participants and guide the discussion in each group. From the first question posed to the groups, the conversations progressed very differently. As such, the moderation was necessarily different between the groups, but not in a way that biased the discussion. The moderator would commonly intervene in the discussion to acknowledge what has been said, summarize their point and encourage reflection from the group (Bryman 2015). In this way, the discussion was guided towards topics relevant to our research without artificially introducing ideas that would not necessarily arise from the group discussion. For example, the hazard group’s response, “What is the question we are trying to answer when faced with an endocrine concern?”, quickly turned into a discussion of the public’s lack of interest in the environmental effects of EDs. To refocus the conversation on the scientific question and associated problems (Questions 1-3, Figure 4), the moderator picked up on a more relevant point that had been mentioned in passing, the ranking of chemicals, and asked the group to elaborate on that (“Tying back to the scientists and you said, I think it was XXX mentioning that the major challenge is how to rank. So, what is the challenge in that?”). For all groups, the participants seemed to resist providing a direct response for certain questions on the interview guide and the question had to be repeated and posed from different angles to elicit a response. This was most apparent for the risk group’s response to Question 4, “Might

there be other scientists who would answer [Question 1] differently? Who would they be?”. This question was approached delicately to maintain neutrality and avoid imposing our assumption of a divided scientific community on the group. For example, when participants in the ecotoxicology risk group responded that regulators would discuss the topic differently, Öberg clarified that we were asking about other scientists; when participants responded that inexperienced scientists would discuss the topic differently, Öberg clarified that we were asking about scientists comparable to those in this room. When the participants eventually mentioned that there was a diversity of opinions around EDs, Öberg asked them to describe that distribution.

The moderator also maintained impartiality through their body language and affect, keeping an engaged but neutral expression, nodding to indicate understanding as appropriate but providing no bodily indications of agreement or disagreement. At the end, the moderator thanked everyone for their participation and explained briefly what would happen with the data they supplied (Bryman 2015).

1. What is the question we are trying to answer when faced with an endocrine concern?
2. How can we answer that question?
3. What are the challenges involved with answering that question?
4. Might there be other scientists who would answer that question differently? Who would they be?
5. Why would others answer that question differently?
6. Why did you answer that question the way that you did?
7. Given that there are different scientists with different answers to that question, what should we do about it?

**Figure 4.3.4.2 Focus group question guide.**

#### 4.4 Transcription

The data from each focus group consisted of three audio files recorded at different locations in the room and two sets of observer notes. I transcribed some sections manually and some using NVivo automated transcription and then reviewing manually. The focus group interviews were transcribed verbatim with annotations indicating laughter and other non-verbal utterances as well as pauses in speech and speaker emphasis. Capturing this richer data in the transcript supported our analysis, which considers both focus group content and participant interaction. I paid specific attention to overlapping and simultaneous speech, such as participants verbally indicating their agreement (ex. “Uh huh, yeah.”) as another participant was speaking. This made visible how participants supported, challenged and built on each other’s ideas. It also enabled us to decipher collective voices—a group process of collaboratively constructing a joint perspective, or argument, which emerges very much as a collective procedures which leads to consensus” (Smithson 2000)—and to distinguish dominant voices (e.g. when one participant is monologuing but not having their opinions supported by the group) from collective voices (Belzile and Öberg 2012).

To increase the accuracy and completeness of the transcripts, the initial transcripts created from listening to one audio recording were reviewed using the other audio recordings of the same focus group to clarify sections where the speech was unclear. The transcripts were also reviewed by Öberg and Leopold. Sections where speech was not decipherable by any researcher in any of the three audio recordings were placed in parenthesis.

Despite best efforts at detailed and accurate transcription, I acknowledge that “the meanings of utterances are profoundly shaped by the way in which something is said” (Bailey 2008). For

these reasons, critical sections of the transcript were listened to as I coded and analyzed to ensure that we are understanding the meaning of the speech. I included frequent timestamps throughout the transcript to make it easier to refer back to sections of the audio.

The final quotations included in this document are edited for readability, including the removal of stutters, repeated words, ‘ums’ and ‘ahs’. One of our participants spoke broken English. For ease of understanding, their quotations are gently rephrased to English syntax and preposition use, based on our knowledge of their native language.

## **Chapter 5: Narrative analysis**

The analysis of the focus groups centers around the dominant narrative about ED research and regulation that emerged from each focus group interview. I found that the hazard and risk groups were guided by starkly different narratives about ED research and regulation. In the following sections, I compare the two narratives through an analysis of how each group framed EDs and of the archetypes of different actors (regulators, the public, the media, industry, scientists) invoked in each narrative. The analysis concludes with a discussion of how the two narratives, viewed collectively, describe a boundary struggle over the meaning of good science for use in regulation on EDs.

### **5.1 Dialogue and the social construction of narrative**

Narrative analysis in the social sciences takes as the object of investigation the story itself (Riessman 1993). Narrative is an essential feature of social life. It is through “the act of storytelling that individuals understand the goals and values of their social groups”, “internalize social conventions” and “understand who they are vis-a-vis other members of groups” (Frank 2002; Fischer 2009, 194). “Storytelling is typically facilitated by the fact that people share a wide range of commonly accepted assumptions” that are rarely questioned (Fischer 2009, p201). These shared assumptions and interpretations of the world are a part of the “background consensus” that enables the social construction of narrative (Habermas, 1973; Fischer 2009, p201). Socially constructed narrative also has a hegemonic function in that assumed common values and beliefs are implicitly asserted during narrative exchange.

Narrative stories impose a coherent interpretation on the barrage of events that confront us in daily life. Narratives are typically structured with a beginning, middle and end: experiences,

observations and actors are threaded together in sequential components with logical connections to one another (Fischer 2009). Narratives deal with what *is*, they describe the world and how it works. This does not make them neutral. Within a narrative, social phenomena are placed inside “larger patterns that attribute social and political meaning to them” (Fischer 2009, p197) In this process, storylines often invite moral conclusions about actors and events. A story of how the world *is* is often accompanied by a suggestion of how the world *ought* to be (Fischer 2009)---and who is responsible for the disparity between *is* and *ought*. Narratives are also constructed in ways that rest upon a particular set of norms, values and arguments, which are often obscured by the ontological presentation of story (Fischer 2009). An idea about how the world *ought* to be precedes any narrative description of how the world *is*. In this way, a focus on narratives can be a powerful way to understand the worldviews, values and arguments supported by groups and individuals.

## **5.2 Narrative in science controversy**

Narrative provides a complement to scientific ways of knowing and describing the world, expanding “epistemology beyond the narrow confines of observational statements and logical proof to a qualitative examination of the ways individuals are embedded in the wider social contexts of situation and society” (Sarbin 1986; Fisher 2009, p196). Narrative analysis of science can reveal how epistemic cultures are unified by a shared understanding of how the world works and what signifies good research; a common cognitive orientation towards the world. Within controversies in policy-relevant science, groups of scientists and regulators can form “discursive coalitions” through adopting a shared narrative about how “the world is to be made a better place, about how their roles complement each other, and about how the world is to be understood” (Halfman 2019, p48). In this context, narrative also functions to integrate what

would appear to be conflicting events into a cohesive and self-validating storyline (Gieryn 1983), for example by conceiving the scientists who produce research that contradicts their own as biased.

The latter half of the 20<sup>th</sup> century saw a turn towards narrative in the social sciences, with increased interest in understanding social life through individual and collective storytelling (Riessman 1993). In this thesis, I apply this analytic lens to controversies in policy-relevant science, which typically present themselves as disputes over details and facts, but in fact turn on differences in the basic story of research, regulation and society (Fischer 2009). A narrative approach to disputes in the science-policy interface points attention to “the role of subjective intentions, motives, opinion, and normative judgments as causal or quasicausal forces that need to be taken into consideration when we move from the technical to the public realm” (Fischer 2009, p195). An analysis via narrative storylines allows us to see roles or archetypes assigned to different actors (e.g. bad scientist, ignorant public, confused regulator). It reveals how agency is framed (e.g. efficacious versus weak actors), responsibilities distributed, as well as the narrator’s perceptions of the cause and effect of events (Halffman 2019a). Narrative analysis can also tell us how an issue is identified (e.g. as an environmental problem or a human health problem) and how an issue is scoped and categorized. The product of this analysis gives insight into how participants comprehend and assess “the direction and purpose of human affairs—who is pushing matters in a particular direction and why?” (Fischer 2009, p195).

### **5.3 Narrative analysis of the hazard and risk focus groups**

Describing narrative from the hazard and risk focus groups involved a lengthy process of analysis. Working with the two transcripts, I conducted multiple rounds of deductive and then thematic coding. The first round of coding was manual and subsequent rounds in NVivo. I

treated the two focus groups separately but worked on them in parallel to facilitate comparison of the two conversations throughout my process of analysis.

Initial coding was informal; intended to increase my familiarity with the data and to see what sections of text stood out or patterns emerged without imposing a particular framework or theoretical lens. I read through each transcript, highlighting and recording analytic notes of my first impressions of the data. This coding process was largely inductive, and the codes applied simply described and summarized sections of data (Sadana, p4).

After completing the first round of coding for both transcripts I reviewed and organized my analytic notes. With support from Öberg, I created a coding scheme based around three general thematic categories: *What is science? How does regulation happen? How are endocrine disruptors framed?* The intention of this round of coding was to deepen my understanding of the data and to begin structuring my analysis to facilitate comparisons across the focus groups.

Working with the transcripts one at a time, I first coded all text segments that related to one of those thematic categories. At this point in the analysis, I began seeing narrative within the data: my subcodes consisted of the framings, characters, and sequences of events that recurred in each focus group interview. I then began to write narrative-style responses to each of the thematic category questions. Both focus group conversations were complex and wide-reaching, and I wrote out two to four different responses to all of the thematic questions for each focus group.

The responses were written in longform, consisting of a detailed summary, exhaustively illustrated with quotations from the transcripts. I worked within the individual narratives before comparing across (Rubin and Rubin, 1995), in alignment with my empathetic and symmetrical approach to analysis described below.

On completing the second round of coding, the codebook was modified and shared with Leopold (Creswell 2013). Leopold independently applied the codebook. The codebook shared was highly open-ended and minimal explanation was provided to Leopold about how to interpret it. I also applied the third version of the codebook to both focus groups. After completing each group, the two different applications of the codebook were shared, and Leopold and I met to compare and contrast our work. The aim of this process was to get new insight into the data, not to cross-check or verify my application.

As described above, the focus group interviews facilitated in this study enabled participants to engage in the social construction of narrative. The participants were selected based on their membership in a presumed common epistemic culture and, therefore, were presumed to hold shared background assumptions about the topic of discussion: ED science and regulation. While both conversations were rich and wide-ranging, my ultimate analysis and discussion center around the dominant narrative from each focus group. This narrative connected across the three thematic categories (*What is science? How does regulation happen? How are endocrine disruptors framed?*) and was supported by contributions from all participants. This narrative emerged as participants challenged and built upon each other's ideas, they revisited and re-expressed their own ideas in response to other participants' comments (Bryman 2015). For example, in this exchange risk group participants muddle through questions around data sufficiency in science versus in regulation:

*Scientist R1: I might have got the number wrong but around, about, how many is that that, just put in the Web of Science the word 'copper' and 'toxicity', those two words and just asked how many references, 1.6 million, there's 1.6 million.*

**Scientist R3:** *It's still an issue though, no?*

**All speaking at once:** *"I feel guilty, I have research though"*

*"Actually, that's one of the ones we should be concerned about--"*

*"Yes, yeah"*

*"We are"*

*"Well with mining"*

**Scientist R1:** *I just sort of feel sorry that we, you know, we spent, you know 1.6 million published studies on something and we still don't know really what we should be doing.*

**Scientist R3:** *We should start regulating, well I think we should have enough information to be able to regulate now.*

**Scientist R2:** *How do we figure that out? How do we know when we have enough data? Is that threshold of data sufficiency the same for all chemicals or can it, can it vary?*

[Pause]

**Scientist R4:** *That's a good question.*

**Scientist R5:** *There's no agreed list of studies that need to be done on a chemical to say this is sufficient. There is in a regulatory sense—*

**Scientist R2:** *But the regulators are---*

**Scientist R5:** *Yes. But not, not from a scientific point of view because you can always ask the next question [...]*

The richness of the exchange between participants made it possible to develop a robust common narrative for each group, constructed through contributions and exchanges between all

participants in each conversation. It is important to note that statements were made in the course of each conversation that qualified, elaborated on, or contrasted with the dominant narrative of the group---this messy exploration of complex topics is a feature of productive dialogue---however, the storylines described below were salient unifying elements of each discussion.

### **5.3.1 Empathetic and symmetrical approach to analysis**

My initial approach to each group's narrative rests on the interpretive process of *Verstehen*, or empathetic understanding, meaning that we seek to understand events and their meaning from the participant's point of view (Fischer 2009). This approach is supported by our methodological design and by existing literature on studying science controversy (Halffman 2019a). It rests on the assumption that all our participants are credible and spoke authentically in the focus groups. Our methodology justifies this assumption in that through our selection criteria we ensured that the scientists in our focus groups were all accomplished researchers; and, because the focus group meetings were designed to facilitate authentic conversation, any incentives for participants to be dishonest were minimized.

Approaching both groups with empathetic understanding is also supported by literature on science controversy, which emphasizes the importance of treating all sides symmetrically (Halffman 2019a). Throughout this research we have strived to avoid bias towards one side over the other and instead focused on acquiring a deep, nuanced and intimate understanding of the ways of thinking characteristic of both hazard and risk scientists. This decision was guided by research on science controversy indicating that knowledge from opposing groups is often evaluated with remarkable asymmetry: only the side that is assumed to have gotten it wrong is criticized, while the side that is assumed to have gotten it right is believed to have used the appropriate scientific methods and has hence discovered the truth (Halffman 2019a; Elliott

2017). Previous studies on scientific controversies show that it is important not to prematurely assume who is right and who is wrong, and to take seriously the context in which a knowledge controversy plays out and the values embedded within scientific research. This context and these values affect all parties in the debate, not just the ones that might end up on the wrong side of history (Fleck et al. 2008; H. Douglas 2017).

An empathetic approach does not mean that our analysis is uncritical. To the contrary, this approach positions us equally well to learn from the hazard scientist's critiques of risk scientists as from risk scientist's critiques of hazard scientists. Moreover, through taking seriously the claims from each side we are forced to acknowledge the uncomfortable fact that two starkly contrasting perspectives on ED science and regulation co-exist within the same broader research community. This depth of understanding is precluded if we accept the worldview and claims forwarded by one group while hesitating to fully empathize with the other.

#### **5.4 Two stories of ED science and regulation**

Below I summarize the dominant narratives that emerged from the analysis of the two focus groups. Diagrams depicting the two narratives and the relationships between dialogic archetypes are depicted in Figure 5.4.1.1 and Figure 5.4.2.1.

##### **5.4.1 Dominant narrative from risk focus group**

This narrative begins with the media getting hold of some piece of research about endocrine disruptors. The media writes a story that overblows the dangers of the ED. The public reads this story and becomes upset and angry that this dangerous chemical is allowed on the market. The regulators react to the public freak-out by banning the chemical. This regulatory decision is unproportionate to the danger posed by the chemical and not based in science. Endocrine disruptors have become a focal point of media and public attention, but this attention is not

justified scientifically. The majority of scientists condone this overreactive and unscientific approach to regulation, but there is a certain group of scientists with questionable motives who feed into the emotional narrative around EDs.

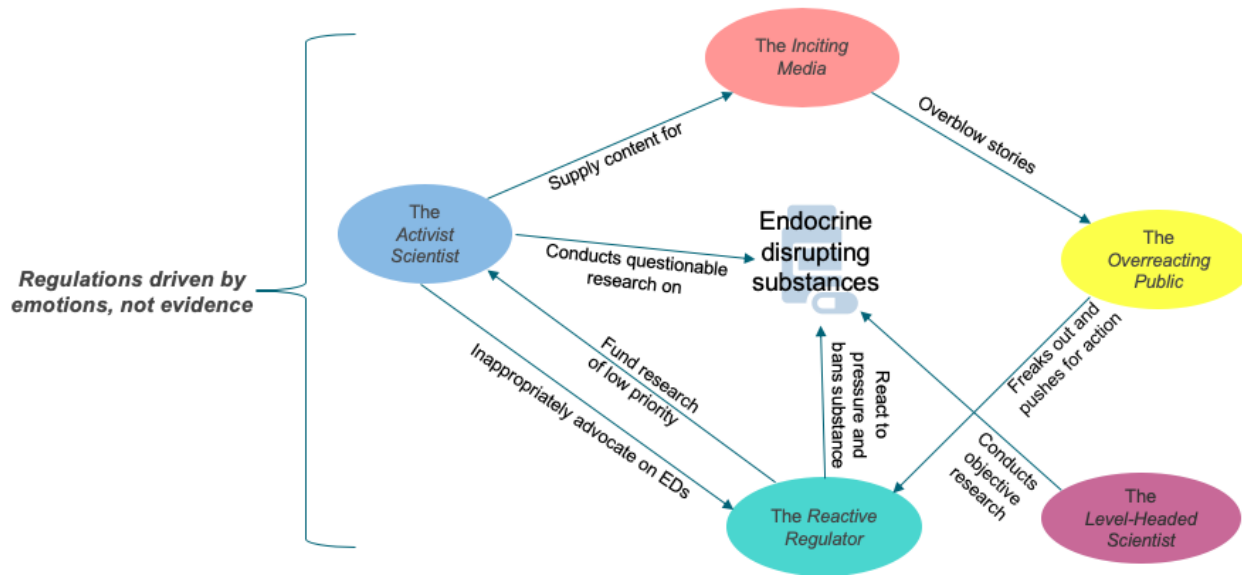
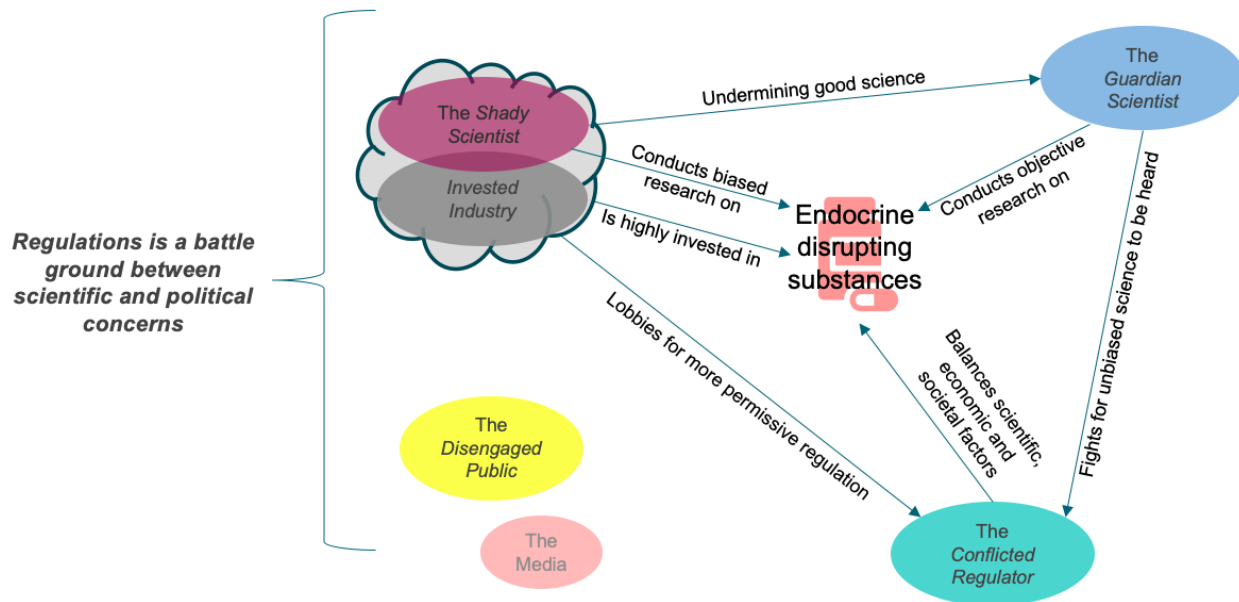


Figure 5.4.1 Diagram of the risk narrative about ED research and regulation depicting the relationships between characters.

### 5.4.2 Dominant narrative from hazard focus group

This narrative begins with the industry’s intense focus on EDs. Because endocrine disruptors are so profitable, industry lobbies extensively to influence their regulation. The scientists are forced to step up, safeguarding unbiased science and presenting it to regulators so as to counterbalance the extensive industry engagement. Regulators are caught in the middle, vulnerable to industry influence, but also striving to balance diverse scientific, societal and economic factors in their decision-making. Industry interest in EDs is so intense that the science itself is threatened by political actors. Certain scientists, with direct or indirect connections to industry, work to manufacture doubt around ED science, attempting to erode the scientific justification for a strong regulatory response to these substances. The public is apathetic and disengaged from the process.



**Figure 5.4.2** Diagram of the hazard narrative about ED research and regulation depicting the relationships between characters.

## 5.5 Framing of endocrine disruptors

Each of the narratives in the two focus groups was accompanied by very different framings of EDs. Differences in framing of environmental issues are known to be major contributors to controversies in the science-policy interface (Elliott 2017; Halfman 2019a). When framing differences are made visible, the nature of disagreement between groups can be clarified. Halfman explains how the framing of an environmental problem can be identified in text and spoken language through looking at how the problem is discussed, including what aspects are included and excluded in the problem description and what metaphors and comparisons are used. Frames can also be identified by analyzing how the problem is described in the context of the broader storyline.

Framing and narrative are closely connected in that both are part of our sense-making through selective editing and interpretation of reality. There is diverse literature on framing from many

disciplines; I employ the definition similar to that of Entmann and other scholars of science: the process of selecting some aspects of reality and highlighting specific relations among those aspects, promoting a particular interpretation of the issue at hand (1993). As with narrative analysis, the concept of framing rests on the basic philosophical assumption that the environment comes to us always already interpreted (Drenthen, 2017). Framing enables us to make sense of the world while also rendering our interpretations limited and subjective by eliminating the possibility of a neutral or pure way to perceive and understand the world; our social context, values and personal history determine the frame by which we describe and make sense of reality (Elliott 2017).

Framing has relevance to the science-policy interface in that the frame we apply implies a particular way of characterizing a problem, message or situation (Biddle, 2018; Elliot, 2017).

Halfman describes two types of framing in the context of conflict management: semiotic, “the process of producing signs” (Halfman 2011, p2); and cognitive, “the process of interpreting signs, actions, other people...” (Halfman 2011, p2). Semiotic framing involves boundary setting, the including and excluding of aspects within a frame (Entmann 1993), and “meaning construction”, assigning meaning to those things within the boundaries. When scientists advise policymakers, they help to set the boundaries of the environmental issue, and it is within those boundaries, or that frame, that decision-makers must make sense of the problem and design solutions. This can be consequential for outcomes of environmental policy as framing effects what we diagnose as the causes of a problem, our moral interpretation of the situation, and ultimately the recommended solutions (Entman, 1993).

Differences in the framing of an environmental issue are common contributors to conflict in the science-policy interface. Mary O’Brian tells a story in her 1999 book “Alternative to Risk

Assessment” that illustrates how different framings of a problem lead to different perceptions of proposed solutions. In the story, a woman stands at the edge of an icy river trying to find a way to get across to the other side. The woman has four risk assessors standing with her on the bank, and each has assessed the risks of her wading through the river to get to the other side. The risk assessors all conclude that the risks of the woman wading across the river are very low. The woman listens to the risk assessors, but then, despite their assurances, she refuses to wade into the river. The risk assessors continue to try to convince the woman, explaining to her again that the risks are very low and there is no good reason why she should not wade across. After some time, the risk assessors become quite frustrated with the woman and ask ‘Why is it that you are refusing to wade into this river? Why don’t you believe our assessments?’ when finally, the woman responds saying ‘No, it’s not that I don’t believe you when you say that it’s safe to wade across here. It’s just that there’s a bridge right over there. So, I’m going to cross the river that way instead.”

In O’Brian’s story, the conflict between the woman and the risk assessors arises out of a difference in problem frame. The risk assessors are answering the question of “Is it safe to wade across to the other side?”. The woman is asking the broader question of “What is the best way to cross this river?”. We see similar disputes in the context of chemical risk assessment, where some scientists believe we should focus less on risk assessment and more on developing less or non-toxic alternatives in the first place so that products and processes we use present no chemical risk (Elliot, 2019). Proponents of exploring alternatives can challenge seemingly comprehensive risk assessments, causing great frustration. Here again, the two groups are framing the problem differently--one asks, “How do we manage the risks of toxicants that are used in products?” and

the other “How can we design products that benefit people without having to use toxic chemicals?”.

### **5.5.1 Risk group framing of EDs**

#### **5.5.1.1 A basket that contains everything**

The risk group framed EDs as a substance-category that is not useful for research and regulation. They often discussed endocrine disruption, the chemical property, but seemed to deliberately avoid talking about EDs as a cohesive substance category, and questioned the utility of the ED categorization. They discussed how ED mechanisms and effects are so diverse that treating them as their own substance-category did not make sense because the boundaries of what chemicals might be classified as an ED are so loose and will continue expanding as more endocrine-related mechanisms and endpoints are discovered.

**Scientist R4:** [I sometimes wonder] *whether absolutely everything won't end up in the endocrine disruption basket.*

**Scientist R5:** [Right now] *we're just looking at a small part of the possible mechanisms on some part of the endocrine system [to determine whether or not a substance is an ED]. So if you expand that, either in vertebrates looking at more endocrine systems or to invertebrates looking at these organisms and I have no doubt that everything will be an endocrine disruptor, and then the scientific definition or the boundaries you set to endocrine disruption are, they're not right.*

#### **5.5.1.2 “Makes everybody go nuts about it”**

EDs were in this group also framed as an overblown threat that receives special treatment without justification. Risk participants claimed that chemicals with endocrine disrupting

properties are not special or unique amongst the full range of environmental toxicants. The group often described how EDs have become the center of a “*perfect storm*” (Scientist R2 and R5): taken up by the media and artificially constructed as a grave threat in the eyes of the public and, subsequently, by regulators. Risk participants expressed exasperation with this entire situation:

**Scientist R3:** *I'm still wondering why is endocrine disruption so much worse than anything else? I don't know. Nobody could explain that to me, but apparently, we all worry about it.*

Scientist R3 refers to the ED phenomena as a typical case of manufacturing hysteria around arbitrary toxicants. They used it as a metaphor to describe other chemicals that have attracted undue attention:

**Scientist R3:** *And this becomes a new endocrine disruptor - I call it - because that's what happened in the 90s because endocrine disruption was this one thing that the public got aware of, lots of money was invested and injected into the research [...]*

The risks group participants also described “endocrine disruption” as a term coined to alarm the public and serve an emotional narrative in order to attract attention to research. This framing of EDs focuses attention on the social construction of concern around an arbitrary set of chemicals with suspected endocrine disrupting properties.

The group also spoke disapprovingly about how EDs have a special status within the EU regulatory framework. Unlike other toxicants, there is a regulatory interest in the ED mechanism. Meaning that EDs may be regulated much more harshly than other toxicants regardless of its actual toxic effect on an organism. The exceptional regulatory treatment of EDs was described as bizarre, unscientific and “*a fascinating construct*” (Scientist R4).

## 5.5.2 Hazard group framing of EDs

### 5.5.2.1 A complex challenge for research and regulation

Participants in the hazard group framed EDs as a complex and difficult issue which society has limited ability to understand and control. EDs were described as a big unknown in scientific research: the fundamental question of whether and to what extent EDs are harming sensitive wildlife species and humans is unanswered and, perhaps, unanswerable in the foreseeable future. Participants in this group framed EDs as a complex problem with many facets, for example, requiring consideration of both human and wildlife exposure. They also described how EDs originate from a range of sources, some of which are difficult to measure or control and may not be fully accounted for in current management approaches. Additionally, participants discussed how exposure to an ED chemical does not occur in isolation:

*Scientist H2: [...] everything is multifactorial [...] it's not just this chemical, it's millions of chemicals.*

The complexity-framing of EDs was also constructed through their discussion of how the impacts of EDs, and synthetic chemicals generally, on wildlife health cannot be isolated from other anthropogenic impacts on the environment such as climate change:

*Scientist H2: It's not even just this problem [with] chemicals [impacting wildlife] there's all of the other [type of anthropogenic impacts] when you go into a wild. There's habitat destruction, there's climate changes, there's changes in water use, [...] if you're working in an aquatic system there's water abstraction, there's*

*you know everything. So it's so hard to say this chemical A is  
[effecting] species B.*

### **5.5.2.2 An underacknowledged threat**

Participants in the hazard focus group also framed EDs as an unorthodox challenge for toxicological risk assessment, compounding the uncertainties described above. They described how endocrine endpoints have not even been tested for until recently, suggesting that ED issues have gone undetected for a long time. Moreover, the group expressed how endocrine disruption as a mode of biological interaction defies traditional assumptions in toxicological research and chemical risk assessment (i.e. “the dose makes the poison” and safe thresholds). As such, tried-and-true testing methodologies are insensitive to or inadequate for EDs:

***Scientist H3:** [...] some of the more [...] old fashioned classical toxicologists [...] they think they can solve everything by the test methods [...] showing a threshold values and dose response relationships and it's very clearly showed that [...] this does not necessarily give you the full picture [when it comes to EDs]*

Their comments implied concern that previous or current test methods fail to reveal the full extent of endocrine disruption risk, therefore potentially exposing species to serious harm. The group framed EDs as a murky and deeply worrisome threat. One scientist in the hazard group compared EDs to smoking: both being massive threats to public health which society moved slowly to understand and respond to. EDs differ from smoking, they explained, in that “*they are much more complicated*”; and therefore, it will take much longer for us to know and appropriately respond to their risk:

*Scientist H3: The main question is: does these endocrine disrupting chemicals actually affect humans in any serious way? and I think there's a lot of data and knowledge accumulating and it's going faster now than it has [ever before]. But there's a long way. You don't have any smoking gun [showing the extent of ED impacts on human and wildlife health] and you probably won't have that for a relatively long time to come.*

## **5.6 Dialogic archetypes**

The term archetype is used in several disciplinary domains. Archetypes may refer to the Platonic philosophical idea of pure forms embodying the fundamental attributes of a thing, or to the Jungian concept of ideas and images shared universally through humanity's collective conscious (Edinger 2017). Archetypes in literary analysis and in comparative anthropology describe recurring symbols and motifs in art, stories, and other cultural manifestations. Of these related conceptualizations of archetypes, my application here is closest to that used in literary analysis and anthropology. I build on the work of Doug Cloud who discusses rhetorical archetypes, "recurring [representations] of an identity category that, crucially, gets used instrumentally", in rhetoric about corrupted climate scientists (Cloud 2020, p2). Cloud describes rhetorical archetypes as "stock characters" of discourse, "recognizable figures that appear again and again such that they are familiar enough to support arguments" (Cloud 2020, p2). Rhetorical archetypes serve as a cultural shorthand, their reference to someone of the same cultural group can convey great meaning (Cloud 2020).

My application of archetypes diverges slightly from that of Cloud in that I do not seek to analyze the persuasive function of archetypes in rhetoric. Rather, I analyze the co-constructed archetypes that emerge from the dominant narratives from each focus group conversation. I will refer to

these as dialogic archetypes, or as characters to emphasize my analytic interest in the role they play in the dominant narrative (Halffman 2019a). My analysis of dialogic archetypes does not shed light on arguments (the extent to which participants were attempting to persuade with their focus group contributions is debatable) so much as it assists in unpacking shared narratives and moving us closer to understanding the worldviews and ways of thinking common to each epistemic culture. Further, because hazard and risk scientists are each actors in the other's story, the dialogic archetype analysis helps us to see how these incongruous narratives map onto the same reality.

As with rhetorical archetypes, dialogic archetypes are made up of motives, actions and attributes that tie together into coherent characters. The relationship “between motives, actions and attributes is circular. Actions and attributes suggest motives; motives help explain those actions and attributes” (Cloud 2020, p4). Archetypes do not exist naturally or emerge unambiguously from discourse; identifying and describing archetypes requires interpretation on the part of the researcher (Cloud 2020, p3). In the following section, I identify and describe the dialogic archetypes from the dominant narratives of each focus group, breaking down their motives, attributes and actions as directly stated or implied in the conversation, and compare their presentation between the two groups. I also consider how they delineate one group of actors from another, how responsibilities are distributed across the characters in each narrative, and which characters are described as having agency (Halffman 2019a). The dialogic archetypes I discuss are those used in reference to regulators, risk scientists, hazard scientists, industry, the public, and the media.

As mentioned previously, both conversations were complex and many of these actors were discussed in multiple different ways over the course of each focus group. Certain aspects of the

archetypes from the risk group appear in the hazard group's description of that same actor, and vice versa. However, the character played by each actor in the dominant storyline of each group is different. Since the focus of my analysis is on dialogic archetypes emerging from co-constructed narrative, each archetype below is described only as it exists in the hazard or risk focus group.

### **5.6.1 Regulatory decision-makers**

Regulatory decision-makers were frequently mentioned in both focus group discussions. Several of our participants have worked directly with or for regulators and recounted stories from those interactions. Regulators were discussed in varied and complex ways, but, in each group, a particular description of regulators recurred many times throughout the conversation. This specific character or archetype of regulators emerged through contributions from all participants. The regulator archetype in the hazard group was very different from the regulator archetype in the risk group, but each played a major role in that group's dominant narrative about EDs. In the following, I call these two archetypes the *reactive regulator* in the risk narrative, and the *conflicted regulator* in the hazard narrative.

#### **5.6.1.1 The *reactive regulator* in the risk group narrative**

The *reactive regulator* responds reflexively to public outcry and is motivated by a need to appease the public and gain political popularity. This archetype appeared consistently in the risk group but was absent in the hazard group. All participants in the risk group invoked this character at one time or another during the focus group interview, often in disparaging terms and tone of voice, collectively constructing a clear and cohesive archetype. The motives of the *reactive regulator* were often described explicitly:

**Scientist R5:** *[...] the people behind the minister say, [...] ‘regulate this and this group of chemicals more, it seems to be that public opinion is in favour of that.’*

The *reactive regulator* was commonly discussed in terms of its close relationship with the public:

**Scientist R2:** *[...] the best tool we have to do it that’s most dramatic and perhaps gives the public the strongest perception of safe heroic politicians is to come and ban these dangerous chemicals.*

Participants in the risk group stated, again and again, that regulatory decision-making around EDs is not driven by scientific factors because regulators respond to the public’s anxiety, which is not reflective of actual scientific priority concerns for chemical regulation. This is very clearly articulated by Scientist R3 who described Canada’s decision to ban BPA as follows:

**Scientist R3:** *Canada banned bisphenol A. If you get the media attention around it. If you look at it much more deeply, it was a pure policy decision. Had nothing to do with data. There was not a single data point that would have supported that decision. And they only banned it in certain products to come out from a government perspective on top and as saying ‘well, babies are protected now’. But this was a super [...] disconnected from the science [...] But it was all to do with public perception.*

These explicit descriptions were often accompanied by damning assessments of the decision consequences:

**Scientist R5:** *[...] the politician can feel ‘I’m a hero, I’m protecting you and I’m regulating this and this’ but he’s not solving a problem. So, then money is not good invested and that should worry the public. [...] I think that is a*

*major concern, not only for scientists but it should be a concern for any taxpayer.*

### **5.6.1.2 The *conflicted regulator* from the hazard group narrative**

The *conflicted regulator* strives to balance diverse scientific, economic and societal considerations. It was the only regulator archetype that was consistently invoked in the hazard group. The *conflicted regulator* was also present in the risk group but was discussed much less frequently than the *reactive regulator*. All participants in the hazard group described regulation of EDs as a highly complex process that involves weighing diverse issues and interests:

**Scientist H2:** *[...] for the policy really was this idea that there are [...] different types of issues [related to ED regulation]. There's issues relating to people being out to keep businesses going, there's issues with different chemicals having different impacts, you're saying if we have to have this chemical that actually could be impacting loss of the species compared to a more targeted group of animals or plants or whatever. And, how do you decide what's worse?*

**Scientist H1:** *[...] if I'm having my regulatory hat on [...] is it really a problem just having it flagged as an endocrine substance, or is it really concern the population we want to save [...] And then going a step further, if we are thinking of banning [the ED substance] and then it would be somehow [...] need to be replaced because it's necessary [...] the replacement is that really better? although its perhaps not an endocrine concern [...] is endocrine concern per se a problem or is it just something we should be aware of, and dealing within the overall solution?*

The hazard group often described the *conflicted regulator* as being in the unenviable position of making very difficult decisions, decisions that fell largely beyond their own responsibility as scientists.

**Scientist H4:** *And then when you talk about prioritizing [with reference to regulation][...] I don't think it's my job [as a scientist] to know about the use patterns for different types of chemicals and how that---now we go to risk assessment---how the exposures in areas are for every different compartment of human health and the environment that is not a part of my main job at least as a researcher on EDs. It's a little bit more complicated thinking in this ranking of what is important*

The *conflicted regulator* is often torn between making scientifically guided decisions and caving to industry pressures. Industry's attempt to influence regulators to make more lenient decisions about ED regulation was brought up many times in the hazard group.

**Scientist H2:** *[...] there's so much lobbying by industry and by other areas that also want the government's attention [...]*

**Scientist H1:** *[...] then realizing that there's an enormous commercial and then economic pressure [around EDs]*

They sometimes described instances in which the *conflicted regulator* had caved to industry pressure:

**Scientist H1:** *[...] So it's absolutely clear [that this ED substance used in pig farming was having] effects in fish even in the very low picogram range. And then, the EMA [European Medicines Agency] decided we can't ban it because it would affect the whole pig industry in Europe.*

## 5.6.2 The public archetypes

The topic of the focus group conversations was ED science and regulation; but both groups discussed the public at several points throughout the meetings. In both group conversations, the public was often described negatively, beyond this similarity, their portrayals of the public contrasted starkly. The risk group's descriptions of the public were more consistent, and the *overreacting public* archetype played a major role in the dominant group narrative about ED research and regulation. Hazard participants described the public in different ways over the course of the meeting. The archetype of the *disengaged public* was invoked more frequently than others, but not consistently or strongly supported through contributions from all participants. The *overreacting public* and *disengaged public* archetypes are described below.

### 5.6.2.1 The *overreacting public* from the risk group narrative

The *overreacting public* is driven by their emotions and is irrationally concerned about the threat posed by EDs, with a disturbing amount of influence over regulatory decision-making. The *overreacting public* responds to media stories about EDs and exerts pressure on regulators to ban substances they wrongly believe to be dangerous. This archetype was frequently referenced in the risk group but absent from the hazard group.

*Scientist R2: [...] you've got some stories [that are not scientifically grounded] that have been put into the public domain that say that create a sense of fear. And then the public turns to governments and say 'you've got to protect us from this fear'*

The *overreacting public* was described by risk participants as irrational, dimwitted and not understanding important scientific concepts, such as hazard and risk. The participants often contrasted attributes of the public with attributes of scientists:

**Scientist R2:** [...] it's about 'precision of terms' and I think as scientists maybe we're more familiar with trying to be precise with our terminology, but I don't think the public appreciate the distinction of some of these terms. And again, this distinction for me between endocrine disruption and then endocrine activity, I don't think the public care. [...] in other terminology that I think is relevant to this debate, that again I think public misunderstanding, is the difference between hazard and risk.

Participants frequently discussed how the public buys into evocative narratives peddled by the media that exaggerate or misrepresent chemical risk. The public responds to emotional triggers in media stories rather than critically considering the scientific evidence that supports those claims.

**Scientist R5:** You need these images, and that reaches the public, [...] it's not the data, it's the emotions that reach them.

**Scientist R3:** [Specific substances] make it into the media and all of the sudden this becomes the issue. [...] [a substance] that was presented in a way that the public will say, 'okay we care about this'.

As described above, the dominant risk narrative rests on a close relationship between the *overreacting public* and the *reactive regulator*, one in which public anxiety is the primary influence on regulatory decision-making. The risk participants made many statements that condemned the extent of public sway over ED regulatory decisions:

**Scientist R3:** And if you look at other chemicals, I think there are way worse chemicals that we ought to regulate if you think about it, but the regulation was just

*made based on public outcry or on the societal drivers, not a scientific driver.*

### **5.6.2.2 The *disengaged public* from hazard group narrative**

The *disengaged public* has little knowledge of or interest in chemical effects on the environment; their only engagement with EDs is concern about impacts on human health or on charismatic wildlife species. This archetype was frequently invoked in the hazard group but entirely absent from the risk group: while the *overreacting public* is the driving force behind chemical regulation, the *disengaged public* is uninvolved.

**Scientist H2:** *[...] whether you're a lay person who just want to have a safe environment and they want to not have to think about what chemicals they are using and not have to think about anything in their environment they just expect it all to be OK for them to be using and they wouldn't expect issues with you know if there's pesticides on their fruit or if there's herbicides and things [...]*

Hazard participants frequently expressed their frustration over the lack of public interest in their field of research. They implied that the public is lazy and self-interested with regard to chemical risk; expecting to not have to think about chemicals in their products at all and only caring about EDs when learning that they may negatively impact their own health.

**Scientist H2:** *The general people haven't got a clue [about EDs in the environment]*

**Scientist H4:** *They just go, 'that's weird.'*

**Scientist H2:** *Yeah. They would. And then they'd kind of say 'oh is it in the drinking water is it going to affect me?'*

The participants discussed exceptions to public apathy about chemical pollution in the environment, such as effects on charismatic species, interest in BPA because it has been popularized by celebrities, and how specific groups like recreational fishers care about species that are relevant to their interests.

***Scientist H1:** [If you take] some kind of fashionable species [for example] related to birds [...] [then] it's a completely different matter, I fear, [than] if you have some kind of a fish [...]*

***Scientist H2:** And also, there's that's kind of charismatic, if it's a frog. People love frogs. [...] Whereas, having worked with molluscs, people don't care.*

One possible reason to the difference between these two public archetypes is that hazard participants might have been describing the public's attitudes and behaviours only with regard to EDs and wildlife; whereas, the risk participants might have been describing the public's attitudes and behaviours towards EDs and wildlife as well as EDs and human health. While our selection criteria ensured that all participants researched ED effects on wildlife, participants in both groups sometimes discussed EDs with reference to human health, or ED impacts generally without distinguishing between human and wildlife exposure. This is significant for the interpretation of the public archetypes because, as stated many times in the hazard group, the public is much more interested in potential effects on human health than wildlife health. The fact that the risk participant who spoke most often about the public's overreaction to EDs, Scientist R2, had previously researched EDs and human health provides support for this interpretation.

### 5.6.3 The media archetype

#### 5.6.3.1 The *inciting media* from the risk group narrative

The media was absent from the hazard group narrative; but, the *inciting media* character played a significant role in the risk group narrative. The *inciting media* is motivated by a desire to attract a larger audience. It instigates the public freak out and subsequent regulatory misfiring on EDs by publishing evocative stories, with little regard for accurate or responsible science communication.

**Scientist R5:** *[...] with endocrine disruptors of course [the media uses] pictures of pregnant women, babies, and the falling sperm count ... You need these, these images that reaches the public, it's the emotions, it's not the data. [...] Then you need to coin it a term so 'endocrine disruption', 'gender benders'*

Risk participants discussed the media in negative terms and with a tone of voice that indicated they strongly disapproved of its actions. They appeared to blame the media, to a large extent, for the way in which the ED topic has gone off the rails.

**Scientist R2:** *I'm just wondering if there's a sort of a perfect storm here with the endocrine topic. Where you've got some stories that have been put into the public domain that say that create a sense of fear.*

**Scientist R3:** *There will be, always, [scientific research] reported in a way that somebody can manipulate it.*

The *inciting media* takes scientific findings and spins them into evocative stories that magnify or misrepresent the risk posed by EDs. Their stories use images, terms and narratives that play on the emotions of the public to get them to care about the issue. The media stories about EDs

succeed in invoking a strong response from the public, who becomes fearful and enraged to learn about these allegedly dangerous chemicals. Ultimately, the stories put out by the inciting media result in public demand for regulatory action on EDs.

**Scientist R3:** *[...] the few [scientific studies or communications] that percolate to the top are like key words that are somewhere passed to the public and they make it into the media and all of the sudden this becomes the issue.*

## **5.6.4 The industry archetype**

### **5.6.4.1 The *Invested industry* from the hazard group narrative**

Industry was only discussed a couple of times in passing in the risk group conversation but played a major character in the hazard group narrative. Hazard participants characterized industry in a few different ways over the course of the discussion, often drawing on their personal experiences collaborating directly or indirectly with industry scientists to support the development of ED regulation. Although their depictions of industry were complex, over the course of the meeting, the group invoked a specific archetype many times over, which I will refer to as *invested industry*.

*Invested industry* makes a lot of money off of ED products and will go to great lengths to ensure that these chemicals are allowed on the market.

**Scientist H2:** *...there's so much lobbying by industry [on EDs] ... I think it's quite different [than] in some other areas of toxicology.*

Many times throughout the focus group, the scientists discussed how EDs are constitutive of highly lucrative products and processes for industry.

Participants claimed that more rigorous and precautionary approaches to ED testing and management would be very costly for industry. As such, *invested industry* has focused an

inordinate amount of attention on influencing research and regulation of endocrine disruptors as compared to other types of chemicals. Hazard group scientists discussed how the *invested industry* attempts to influence how regulatory decisions are made from research on specific substances. This included lobbying on how substances are ranked or prioritized, deciding which studies to include in a chemical assessment, and conducting weight of evidence evaluations so as to have chemicals be regulated more leniently. Here, a scientist describes how industry-results on BPA differ systematically from results produced by non-industry affiliated scientists:

*Scientist H1: [...] if you're just divided the result by the affiliation of the authors, it's quite, very, very clear that all these authors with industry affiliation, finding no conclusion about the endocrine effect of BPA, but all the academics and regulator or other, I think that's 95 percent of them, finding an endocrine effect of BPA.*

### **5.6.5 The scientist archetypes**

This research project was built on the assumption that the community of scientists who do research that guides regulation on EDs is polarized, with influential and highly vocal scientists supporting a hazard categorization and a risk assessment approach. The focus groups were designed so as to facilitate conversation about this divide. However, neither conversation, considered individually, paints a clear image of a fractured researcher community. Scientists in the risk group framed themselves as part of a secure majority, inhabited by all reasonable scientists in the ED field; scientists from hazard group spoke as if there was approximate scientific consensus about EDs. Both groups also described the opposition to the majority or consensus understanding of ED science as originating from a relatively small group of biased, misguided or inept researchers. In this way, both hazard and risk scientists denied scientific

legitimacy to the opposing group by presenting them as “others” rather than credible scientific peers.

In the following section, I describe the hazard and risk group’s archetypical descriptions of themselves and their perceived scientific peers, and the archetype they invoked of “the other”, i.e. dissenters of their perceived scientific consensus or majority view. Through this, I compare how each group characterized themselves with how they are characterized by the other group in their narrative about EDs. I refer to the risk group participants’ archetypical description of themselves as the *level-headed scientist*, and their archetypical description of the “other” scientists as the *activist scientist*. I refer to the hazard group participants’ archetypical description of themselves as *guardian scientists*, and their archetypical description of the “other” scientists as *shady scientists*.

The risk group does not distinguish between industry employed scientists and scientists employed in other sectors; some of the risk group participants in fact work for industry themselves. This is a notable difference from how characters are delineated in the dominant hazard group narrative, where the different motives, attributes and actions of industry and non-industry connected scientists is of great importance.

#### **5.6.5.1 The *level-headed scientist*: self-archetype from the risk group narrative**

The *level-headed scientist* archetype refers to the character that risk group scientists and their peers play in their group’s dominant narrative. *Level-headed scientists* are motivated to produce high quality research that effectively serves overarching regulatory protection goals.

**Scientist R2:** *I think as scientists [...] we try to make these informed decisions that are very rational, rather than these very emotive discussions [...]*

**Scientist R5:** *I try to be as scientific as I can about the subject, and data based.*

The *level-headed scientist* is rational and data driven. Unlike other characters in the risk narrative, the *level-headed scientist* has retained a sense of perspective, was described as capable of taking all of the uncertainties into account and understanding the bigger picture on EDs. Risk participants commonly described the character of the *level-headed scientist* through contrasting their own motives, attributes and actions with those of the *overreacting public*, who was described as emotionally driven and irrational.

Risk group participants also constructed the *level-headed scientist* archetype through emphasizing their focus on data quality, and discussing the importance of considers the larger story told by the totality of research on EDs, rather than reacting to single studies or non-replicable observations:

**Scientist R5:** *And I look also for quality in data was something that [other scientist in the risk focus group] and I have in common [...] and things we emphasize is weight of evidence. So, if you have a data mountain, don't go cherry-picking but really look at the overall picture and usually if you take a lot of data together and a clear image emerges than if you go for single observations.*

Scientists in the risk group also suggest that they belong to a group that possesses wisdom and has a sense of perspective about the bigger picture of chemical research and risk assessment:

**Scientist R4:** *In this room you've got people who probably can take a step back and say 'in the grand scheme of things there are always uncertainties in science and risk assessment'*

**Scientist R1:** *[...] in this room I think you have got more than 100 years of experience [...] you got people who have [...] thought about this a lot.*

Another attribute of the *level-headed scientist* is their focus on how toxicological research can serve broad regulatory protection goals. Many times throughout the discussion, participants in the risk group expressed frustration about scientists who pursue purely scientific goals without awareness or concern as to how their work connects to regulatory frameworks. Risk participants also condemn toxicological research that is of too poor quality to inform chemical risk assessment.

**Scientist R1:** *I've become very concerned in probably 5 the last 5 to 10 years on the quality of published science and [...] partly how useless much of it is for regulation. So, I've got really quite interested in how could we try and improve the quality of science so we have better science that we can regulate more wisely on.*

**Scientist R4:** *[...] the amount of papers you get to review and [that] say 'oh this is the worst thing in the world, you're going to kill the [wildlife species]'. So, I know the regulatory data point's lower than that, and this really was a non-issue. I think if people were more aware of what is done and what isn't done then they could do their research more appropriately in areas of probable interest [...]*

#### **5.6.5.2 The activist scientist: “the Other” scientist archetype from the risk group narrative**

In the dominant narrative from the risk group, they describe “the other” as scientists who engage in shady behaviours with ulterior motives; who are archetyped as *activist scientists*. The *activist scientist* inappropriately advocates the severity of the ED problem, contributing to the perfect

storm around EDs. The *activist scientist* holds an extreme position, that is not well-justified by science, and sometimes derails productive scientific dialogue with their emotional rhetoric about EDs.

**Scientist R3:** *[...] it's a very civil dialogue and then you have the odd things that perk out and become advocacy and then they get a little ugly [chuckling]. And you've gotta be careful. Where I think it's more an emotional agenda that's pushing the issue than a scientific dialogue [...]*

The risk participants accuse *activist scientists* of pushing an emotional narrative to forward their agenda and insinuate that they may have an economic or political motive for these actions.

**Scientist R4:** *I'm not sure it's only emotional, I think there are other motivations pushing some of those things, it leads to emotion. I think there are financial interests [...] and [these EDs are] money-makers not just for the companies, they're money-makers for the NGOs as well.*

*Activist scientists* believed that low dose effects for EDs are common and are very vocal about that belief. Risk participants discussed how certain regulation was based on research from activist scientists. They suggested that this research is of poor quality and ED regulation that assumes low dose effects are widespread is unjustified. For example, Scientist R1 and Scientist R3 discuss how research of questionably quality was used to support the banning of BPA in Canada:

**Scientist R1:** *I think that the quality of the science suggesting that BPA causes reproductive effects at very low concentrations is poor science and not reproducible. That's a personal opinion ...*

**Scientist R3:** *Which, I would personally agree with.*

*Activist scientists* are alarmist and outspoken in a manner that is extreme and unbecoming of a scientist. They feed into the damaging cycle of public reaction and regulatory response to EDs for personal gain.

**Scientist R1:** *But if you had Fred vom Saal here or Theo Colborn or any of them [...] so many meetings I've heard them say 'this a really serious concern.'*  
*Absolutely believe in non-monotonic dose response curves, bisphenol A definitely should be banned, Fred vom Saal would get up at conferences and say that, they argue internationally about it [...] They're very entertaining! They do it publicly!*

**Scientist R5:** *But you need these images [related to EDs], and that reaches the public, it's the emotions, it's not the data [about EDs], it's the emotions that reach them. So, if you are smart, maybe you could come from an advertisement agency and you help that scientist getting his issue pushes.*

### **5.6.5.3 The guardian scientist: self-archetype from hazard group narrative**

The *guardian scientist* archetype is invoked by hazard participants in describing themselves and their scientist peers. This scientist archetype is similar to the *level-headed scientist* in that both are guided by the objective pursuit of knowledge. The *guardian scientist* safeguards uncorrupted scientific knowledge against political forces and advocates good science for use in ED regulation.

**Scientist H3:** *[...] I felt that was a really hard fight to keep science in place. So, this definition of what is an endocrine disrupting chemical was not a political definition but a purely scientific.*

The hazard group participants described that the guardian role arises from the intense involvement of political actors in ED science and regulation, which is unlike that directed at other types of toxicants.

**Scientist H2:** *[Scientist] can't simply get away with delivering information [about EDs] anymore. [...] Everybody is expected to understand, to a certain extent now, the lay of the political landscape, the lay of the economic landscape because there's so much lobbying by industry and by other areas that also want the government's attention.*

The *guardian scientist* has various roles and responsibilities beyond simple data generation and delivery to regulators. Hazard scientists discussed how they need to do a better job of communicating their research so that it is more usable for regulators. They also described how scientists influence regulation through choosing to enlighten regulators on certain topics, by way of researching them and not others, and would often like for their results to be taken further.

**Scientist H4:** *[...] you need to change the way you deliver your research data. So it's more useful or usable for regulators. [...] At least in [the ED field], I think it's quite different in some other areas of toxicology.*

Because of industry's intensive involvement in research and regulation in their field, ED regulation is vulnerable to capture by industry interests. *Guardian scientists* are engaged in a continuous uphill battle to counterbalance industry influence on regulation, and safeguard objective science and regulation of EDs.

**Scientist H1:** *All this ranking [of which substances to prioritize for regulation] is quite political. [...] we need some kind of input from people who actually do what they want [...] without being biased.*

#### 5.6.5.4 The *shady scientist*: “the other” scientist archetype from the hazard group narrative

In the dominant narrative from the hazard group, the participants describe “the other” as scientists who play an antagonistic role in their story. I refer to this scientist archetype as the *shady scientist*. The *shady scientist* researches EDs but has an explicit or insinuated connection to industry, which corrupts their research. Hazard participants described the *shady scientist* as manufacturing doubt around ED science to achieve political or economic aims.

*Scientist H3: [...] because there was no definition, there was no criteria for what, what do we all agree is an endocrine disrupting chemical. [...] so what some people in the industry tried to do, not only the industry. But was sort of to dilute the definition for what, what is an endocrine disrupting chemical.*

Hazard scientists repeatedly describe the motives and actions of *shady scientists* as “political”. “Political” is a devil term in the hazard group discussion (Cloud 2020): its use was accusatory and potent but similarly vague. Hazard participants contrast the “political” with the scientific, the former referring to economic drivers of behaviour and the later to the objective conduct of science. Much of the discussion in the latter half of the hazard focus group is about *shady scientists* and their attempts to blur the line between “political” and scientific, which was harshly condemned by hazard participants.

*Scientist H3: Sometimes that [Scientist H3 laughs shortly], you know, the differentiation between what is political and what is science may also be quite blurred.*

The hazard group described many of the *shady scientists*’ political actions surrounding the European Commission mandate to define of criteria for identifying EDs following the 2009 decision that ED pesticides should be banned based on hazard assessment. This was primarily

recounted by Scientist H3: because of this regulation, industry and *shady scientists* pushed for fewer chemicals to be defined as an ED so that they would not be pulled off of the market. Hazard participants described *shady scientists* engaging in various questionable behaviours, including challenging the tests and criteria for identifying EDs (i.e. sex ratio change), claiming that endocrine effects are actually just toxic effects, claiming that certain species are too sensitive to be tested on for ED effects, and claiming that proposed ED effects are not population relevant.

**Scientist H3:** [...] *The argument that 'You should not use zebra fish because they are too sensitive' this is to me purely a political argument.*

**Scientist H4:** *Yeah. That had nothing to do with science.*

**Scientist H1:** *Change and sex ratio is one of the big [indicators] that this [bio-ecological effect] some kind to do with endocrine system and if you challenge this you need a good proof. And if you just state it in this kind of discussion, it's not science.*

**Scientist H4:** *And the reason for the statement is quite sure it's because in Europe it's mostly it hazard driven, the endocrine regulation.*

Each of these actions is described as or implied to be politically motivated and not purely scientific:

**Scientist H2:** *Do you think they were doing it to muddy the waters for political ends rather than scientific?*

**Scientist H3:** *Yeah, yeah.*

Scientist H3 described how *shady scientists* had also manufactured doubt around aspects of the ED problem by publishing an open letter with harsh critiques of a report proposing criteria for the identification of EDs. The report was released soon before the European Commission met to

define the criteria and had an impact on that discussion. The group compares this methodology to that of the tobacco industry covering up the health effects of smoking and to those who promote skepticism around climate change for political ends (Michaels, 2008; Oreskes and Conway, 2010). Scientist H3 continues to describe how these scientist's motivations were shown to be purely political and not scientific by describing how they abandoned their argument the moment they were forced to defend it scientifically.

### **5.7 Thinking beyond narrative**

The empathetic and symmetric approach to narrative analysis provided a deep and multi-dimensional understanding of the hazard-risk controversy. The hazard and risk conversations were each united by a single narrative, jointly constructed by all participants in that group.

Within the hazard and risk narratives, participants casted themselves as protagonists in stories with great challenges and high stakes. The narrative archetypes provided motives behind the various actors involved with ED research and regulation, which explained their actions as they played out in the context of the broader story.

The differences between the two stories are jarring. At first glance, they appear to be describing an entirely different substance-category and set of circumstances surrounding its research and regulation. However, upon closer examination of the two narratives, it's possible to decipher how each represents a different perspective on the same scene, views of the same reality from different facets of the crystal. Each group's descriptions of "the other" reflects the behaviour and statements made by scientists in the opposite group. The actions of the *shady scientist* from the hazard group narrative and the actions of the *level-headed scientist* from the risk group narrative are in fact very similar; as are the actions of the *activist scientist* and the *guardian scientist*. Both the *shady scientist* and the *level-headed scientist* question the definition and criteria for EDs. For

the *level-headed scientist*, this action is described as being motivated by politics and dismissed as an attempt to manufacture doubt around EDs to serve political ends; whereas, in the risk group the *level-headed scientist* challenges the definition of an ED because they believe that chemicals with endocrine disrupting properties should not receive special scientific attention or regulatory treatment as such. Similarly, the *activist scientist* and the *guardian scientist* both step beyond the traditional scientist role of data provider to advocate to regulators the seriousness of the ED problem. In the risk group, this action by the *activist scientist* is described as using inappropriate, emotional methods, insinuating an ulterior motive. Conversely, the hazard group participants present themselves and their fellow *guardian scientists* as forced to defend and advocate for objective science on EDs so as to counterbalance industry influence, employing a broader range of methods that are not necessary for communication with regulators around other substances. In each case, the described action is the same, but the assumed motive behind it is different. Therefore, I assume that the actual actor is the same, but the character they play in each story is different. In this way, by looking at the same actor in the context of both stories allows us to see how hazard and risk scientists feel fully justified in actions that are condemned by the opposite group. The different assumed motives and narrative context of the action results in an opposite normative evaluation.

Returning to the work of Fleck and Knorr Cetina, the analysis of the narratives provides a perspective from which to view the hazard and risk groups as two distinct epistemic cultures existing inharmoniously within the same research field. Based on this theoretical work and my own research, I hypothesize that support for one or the other of these narratives is a defining feature of the hazard and risk epistemic cultures in the ED controversy: belief in the dominant hazard or risk narratives unifies those cultural groups and distinguishes them from one another.

This hypothesis is supported by the strength and coherence of two narratives, and the unanimity with which they were communicated in the hazard and risk groups. Further, as discussed above, the hazard and risk scientists' self-descriptions compliment the way in which "the other" scientists were described in the other groups' narrative. This provides further support for the hypothesis that the narratives which emerged from the focus groups are features of the larger epistemic cultures of risk and hazard scientists. Further, I found external validation for this hypothesis from my observations of hazard and risk scientists at conferences, and through their published writing. Their behaviour and comments in these contexts align with the narratives about ED research and regulation recounted in each group.

Narrative is built from and asserts a particular set of norms, values and arguments (Halfman 2019a). As such, my analysis of the dominant hazard and risk narratives moves us closer to understanding the location of the fundamental divergence in the values and scientific logics of the hazard and risk cultures. The two stories are about different problems with ED research and regulation. The risk narrative is about barriers to the efficient use of regulatory resources and effective science-policy processes in toxicology. The hazard narrative is about the massive difficulty of understanding a highly complex and uncertain environmental problem, and about safeguarding science and regulation from industry influence. The focus on these different problems suggest that the two cultures have different views of nature and humankind's ability to understand and manage it. Risk scientists believe that it is possible to use present knowledge and tools to predict risk; and therefore, that it is possible to gain knowledge that allows us to understand nature. Hazard scientists believe nature is unpredictable and that our present knowledge and explanatory models do not allow for us to form a reliable understanding of potential harm. This finding compliments Clahsen's observation that the way in which hazard

and risk scientists describe the endocrine system is supported by different Myths of Nature from cultural theory (Clahsen et al. 2019). This also aligns with the findings of Vázquez Pérez who discussed how scientists on either side of a controversy related to chemical risk appear to support different Myths of Nature (Vázquez Pérez 2019).

These two views of nature, and our ability to comprehend and control it, are summarized in a statement by Scientist R4 from the risk group who describes how certain scientists and regulators “*see those uncertainties as being insurmountable*”, whereas they and their peers acknowledge that “*there are always uncertainties in science in risk assessment*” but those uncertainties “*we can generally deal with in one way or another.*” Scientist H3 from the hazard group articulates the sentiment that the uncertainties surrounding EDs are vast and our ability to reduce those uncertainties is very limited:

*[...] this issue with endocrine disrupting chemicals is much more complicated. So, there's not an easy way [...] And I think there's a lot of data and knowledge accumulating and it's going faster now than it has been done. But there's a long way. You don't have any smoking gun and you probably won't have that for a relatively long time to come.*

## **Chapter 6: A fight over the meaning of good science for regulation**

### **6.1 Boundary disputes in policy-relevant science**

The symmetric analysis of hazard and risk narratives allows for us to take a broad view that encompasses many dimensions of the ED controversy. From this vantage point, drawing on the theory about boundary work by sociologists Thomas Gieryn and Aaron Panofsky, I view the hazard-risk controversy as a boundary struggle over the definition of good science for use in policy on EDs. The scientist archetypes described in each groups' central narrative function to draw a boundary that supports the in-group's science and discredits science produced by the disputing side.

Epistemic cultures are actively maintained and transformed overtime (Knorr Cetina 1999).

Within the social structures of a scientific field, these cultural dynamics arise in part out of competition between scientists for funding and influence. Science controversies are a part of the cultural dynamics within a field. Gieryn and Panofsky describe controversies within science as a cultural struggle over the meaning of good science. Defining science is a long-standing theoretical issue in sociology of science. But distinguishing science from non-science, or identifying the attributes that make up good science, is also a very practical issue for scientists, who's daily work and interactions attribute some characteristic as science so as to construct a boundary that distinguishes science from non-science (Gieryn 1983). Gieryn refers to these actions as boundary work. Panofsky expands from Gieryn's concept of boundary work, describing a two-fold struggle enacted by individual scientists within the social structure of their field: to demonstrate that they are doing good science and to define good science in a way that benefits them (Panofsky 2014). Depending on the state of the field and a scientists' location

within it, the focus of a scientists' efforts may be on reinforcing the prevailing definitions of good science or on overthrowing the prevailing definitions to assert a new meaning of good science that aligns with their scientific practice. The groups who succeed in establishing or maintaining a definitional boundary which locates their own work on the side of good science and opposing groups' work on the side non- or bad science enjoy greater funding and influence. According to Panofsky, the outcomes of these struggles "transform or conserve the field of forces that govern the subsequent struggles" over the conduct and meaning of good science (Panofsky 2014, p4).

With the case of the ED controversy, the significance of the definitional boundary and the reward for delineating it extend beyond the academic sphere. The outcomes of boundary disputes in policy-relevant fields have direct political, economic, environmental and societal consequences for the regulation guided by that science. This is especially so in highly technical fields, such as chemical risk evaluation, for which science is put in a central position for environmental decision-making (Halffman 2019b). As such, the focus of the dispute is not necessarily over what science is good, but what science is good for use in regulation. In the hazard-risk controversy, the issue of epistemic authority to guide regulatory decision-making is at center stage.

The relevance of knowledge for policy changes the stage on which the dispute is enacted and the cast of characters who play a role. Panofsky describes how a scientists' peers are the actors to which individual researchers must demonstrate their performance of good science and argue their definition of good science. For EDs and other policy-relevant areas, the scientific community does not independently define good science for use in regulation. This struggle over definitional boundaries plays out by-and-large in the messy grey zone of the science-policy interface. It could

be argued that regulators have the ultimate arbitration power in such disputes as a boundary is explicitly affirmed through developing the tools and processes by which the decisions are made about what science will guide regulation. My analysis of the ED case indicates that in such situations the tools and processes by which regulators decide which science is included and how it is evaluated for use in regulation also become a site of conflict.

## **6.2 Paradigmatic change in ED science**

Scientists engaged in the ED controversy are well aware of the ramifications of the boundary dispute. The side whose science is leant greater epistemic authority has greater influence over ED regulation. My participants discussed multiple scales on which the knowledge dispute plays out: deciding the overarching regulatory approach to EDs, defining criteria for identifying an ED, and determining whether or not individual chemicals are categorized as an ED. On each level, risk scientists work to reinforce prevailing definitions of good science for regulatory chemical assessment, and to posit that the meaning and practice of good science is the same for EDs as for other toxicants. Hazard scientists assert that the prevailing definition of good regulatory science does not apply to EDs and fight for a new canon of research principles and methodologies for that substance-category. Each side's definition of good science classifies their science as good and the other side's as bad.

Panofsky describes how the struggles over the definition of good science have broad ramifications: the prevailing side can choose to transform or conserve the forces that constitute the epistemic culture of the field, and to influence the rules by which future boundary struggles play out (Panofsky 2014). In some milieus of the ED controversy, scientists imply or discuss explicitly how decisions made about EDs have the potential to transform the future norms for toxicological research and regulation. This was not discussed directly in either of our main focus

groups but is a part of the discourse in some academic meetings, and is referenced in certain scientific articles and reports (Barouki 2017; EURION Cluster 2020). It was also discussed at length in our focus group with scientists who research EDs and human health and are proponents of a hazard classification approach to ED regulation. Hazard scientists argue that EDs are not as anomalous as they are sometimes conveyed to be, but rather the first paradigm-defying data points that are beginning to unravel the flawed dogma that governs the field as a whole and inspire new modes of understanding toxicological risk. Hazard scientists express optimism that ED research will challenge institutionalized assumptions such as monotonic dose-response and the narrow focus on conventional toxicity endpoints (Barouki 2017; EURION Cluster 2020). In this view, EDs herald a new paradigm of toxicological research and regulation, one that is structured to account for mixture effects of chemicals, interactions with other stressors, windows of developmental vulnerability, and considers diverse mechanisms of physiological disruption as well as epidemiological and multi-disciplinary methodologies. This argument is supported by the worldview underlying the hazard narrative: anxiety around the inadequacy of our current tools and models for providing knowledge of chemical risk. In contrast, risk scientists express that our current methods and assumptions—weight of evidence assessments, NOAEL, risk assessment—while imperfect, are adequate; and the only viable alternative to an ‘anything goes’ approach to decision-making about toxicants. They warn that special regulatory treatment of EDs sets a “dangerous precedent” (Dietrich et al. 2013), hinting at the possible unraveling of the well-established tools and processes that exist to protect human and environmental health to the best of our ability.

### 6.3 Archetypes as boundary tools

Scientists involved in a boundary struggle employ various strategies to delineate their preferred definition of good science. In the ED hazard-risk controversy, archetypes from the dominant narratives are a central medium for boundary drawing. For each story, “the other” archetype serves to undermine the epistemic authority of the disputing side, while “the self” archetype positions in-group scientists as defenders of objectivity and other epistemic virtues in regulatory science. A common observation from previous controversies is that those directly involved evaluate the disputing sides asymmetrically with regard to illegitimate influences on the science they advocate (H. Douglas 2017; Mason-Renton et al. 2018; Halfman, Turnhout, and Tuinstra 2019). “The other-” and “self-” archetypes from each group support this asymmetric evaluation: the *guardian scientist* and the *level-headed scientist* (“self”) are motivated by the objective pursuit of knowledge and service of regulatory protection goals; the *shady scientist* and the *activist scientist*, by contrast, are motivated by non-epistemic (political, personal, financial or emotional) factors (“the other”). In this way, the scientist archetypes direct attention towards the illegitimate value influences on the science of the disputing side, and away from the potentially undesirable value influences on the work of in-group scientists.

The motives assigned to these archetypes colour interpretation of their actions as described in each group’s narrative. The research produced by *shady scientists* is corrupted by their connections to industry, and their questioning of the ED definition and criteria is an attempt to manufacture doubt in service of political goals. “Manufacturing doubt” is a loaded term in the context of science controversies, used by Michaels (2008) to describe the tobacco and fossil fuel companies’ efforts to spread doubt and confusion around scientific consensus. Risk scientists were explicitly accused of manufacturing doubt by scientists in our hazard group as well as in

editorials written by other hazard scientists (Bergman et al. 2015). Hazard scientists' boundary struggle is also served by the blurry boundaries of the *shady scientist* archetype. Some shady scientists are described as being directly employed by industry, but often their connection to industry is insinuated but never made explicit. As such, any scientist whose research approach contradicts that of the hazard scientists can be cast as a shady scientist, and their work subsequently discredited.

The *activist scientist* in the dominant risk narrative is characterized by their methodologically questionable research as well as their potentially ulterior motives. Their epistemic authority of the *activist scientist* is undermined by risk scientists by repeatedly being described as emotional in their motivation and communications. The *activist scientist* is implicitly contrasted with the *level-headed scientist* who is data driven and has maintained a sense of perspective on the ED topic.

The archetypes from the hazard and risk narratives also serve their boundary delineation in the way that the different characters involved with ED research and regulation are parsed. In the hazard narrative, industry connected scientists and non-industry connected scientists play different roles. This differentiation has a critical narrative function: the central struggle of the hazard story is between political and scientific forces involved with ED research and regulation. In the risk narrative, industry connected scientists and non-industry connected scientists are not differentiated, implicitly communicating that differences between those groups are irrelevant to ED research and regulation. Additionally, both hazard and risk groups describe their self-archetype as representative of the consensus or secure majority position supported by ED researchers. "The other" archetypes are framed as a small group dissenting the widely held scientific position (de Melo-Martín and Intemann 2018). This further discredits the position of

“the other” while bolstering the epistemic authority of the in-group scientists; thereby, the archetypes of other and self are utilized to assert a definitional boundary that supports the legitimacy of the in-group’s science for use in regulation.

#### **6.4 Making plurality in science work**

This research has started to lay bare the deep roots of the ED hazard-risk controversy. The narratives that define and divide the hazard and risk cultures are powerful: they communicate and enforce the goals and values of the epistemic community, while providing a meaningful identity for individuals. The narratives are resilient and help to reinforce the divide. They allow for both sides to feel secure and validated about behaviours that the other side condemns. These narratives also function to integrate events that have the potential to challenge the assumptions of scientists on each side: problematic actors are assigned motives that discredit their claims or are drawn out of the story entirely. Our findings and studies of other science controversies, indicate that consensus on the ED issue may not be possible in the foreseeable future (Halfman, Turnhout, and Tuinstra 2019; Funtowicz and Ravetz 1993; Mason-Renton et al. 2018; Elliott 2017): ED research will continue to be evaluated asymmetrically, so as to either provide support for one’s own position, or be demonstrative of poor quality and biased science on EDs.

This may seem a disheartening conclusion. However, while our research demonstrates the resilience of the hazard and risk modes of thinking, and the resulting dispute, it simultaneously reveals the unique value that both perspectives add to research and regulation. Each narrative is oriented around a different critical issue facing toxicology, for EDs and all substances. We confront the spectacular complexity of the natural world with a meager collection of tools; we are insufficiently capable to comprehend, let alone quantify, the damage that we ourselves have inflicted on nature. However, our epistemic limitations do not diminish our responsibility to

divide regulatory resources efficiently and to ensure that the policy response to environmental risk is fair and proportionate. Our research reveals a deep tension between these two challenges. But, we will surely do better in addressing them both if we lean into this tension; and here we see the value in our attempt to emphasize equally with conflicting narratives on science and regulation. This is supported by numerous other studies that arguing that consensus in science may not be desirable because policies that are based on a plurality of scientific perspectives are likely to be more rigorous and resilient than policies that are based on only one scientific perspective (H. Douglas 2017; Kuhn 2012; Knorr Cetina 1999; Jasanoff 2005; Harding 2015). The aim of our broader research agenda is to help enable the productive and responsible integration of diverse scientific perspectives into policy making. Understanding the inalienability and unique value of the contrasting scientific perspectives in the case of the ED controversy is a first step, but much more work is required from here.

My two main hypotheses from this research have implications for future research and application in the ED science policy interface. First, that the dominant narratives from the two focus groups are foundational to the hazard and risk epistemic cultures. And, second, that these narratives are supported by different Myths of Nature from Cultural Theory. These hypotheses relate to broader theory about values in science. My findings suggest that each epistemic culture is united by shared values, which influence the scientific judgments they make in the process of doing research. A valuable extension from my research would be to better understand the differences in values between the hazard and risk groups. This could be accomplished through facilitating dialogue between the hazard and risk scientists. As described previously, the dialogue methodology is valuable for constructing intragroup knowledge; however, dialogue is more commonly associated with discussion across groups. In this case, the dialogue would not be

intended to reconcile hazard and risk groups, but to "...isolate and help to clarify the nature and scope of disagreements and differences of perspective and values among involved parties" (Parsons and Lavery 2012, p2). Dialogue can also "illuminate pathways to potentially effective solutions or resolutions to issues for which there is entrenched disagreement among interested parties" (Parsons and Lavery 2012, p2). Perhaps indicating a way forward that addresses the fundamental science-policy issues of focus for both groups.

My research indicates that value differences potentially play a very significant role in the hazard-risk controversy. In the chemical risk management field, the values that influence expert judgment throughout the scientific and regulatory process are obscured by the focus on decision-making that is science-based. The technical framing of these problems also casts the public as ineligible to engage in the decision-making process and underqualified to criticize the decision outcomes. Building from this study, I suggest fostering transparency about the role of values in the ED science-policy interface as a next step. The virtues of transparency in science are widely acknowledged, within and beyond scientific communities. But, efforts to increase transparency generally focus only on making data and methods available for the benefit of knowledge production. Transparency about values also aids with knowledge production, but additionally can contribute to more democratic and robust decision-making. Value transparency brings hidden values into the light allowing for public engagement about the norms and assumptions that underpin research and regulation. Based on my research, value transparency for the case of ED regulation may involve a reflection about how the scientists whose work supports regulation view nature, uncertainty and the limits of human control. For example, is the regulatory approach more supported by the assumption that nature is vulnerable or by the assumption that nature is robust.

Through continued research and the development of processes to foster value transparency we aim to have plurality of scientific perspectives be an asset for science and regulatory decision-making.

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