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FABLES OF ATTENTION: WONDER IN FEMINIST THEORY AND SCIENTIFIC PRACTICE

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by

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ABSTRACT

"Fables of Attention: Wonder in Feminist Theory and Scientific Practice"

Martha Kenney

Fables of attention are didactic stories about the consequences of how we attend to our world. They act on our sensoria; they teach us how to pay attention. In this dissertation I use the genre of the fable to explore the relationship between attention and storytelling across different ecologies of practice. Specifically, I focus on wonder as a mode of attention in feminist theory and scientific practice. As I read and write fables of attention, wonder does not stay still; it transforms and accrues different meanings as the chapters unfold.

Chapter 1 looks at wonder as epistemological dilation in the scientific writing of American ichthyologist E.W. Gudger (1866–1965), showing how it shaped his scientific objects and guided his passionate empiricism. Chapter 2 tells the story of how STS scholar Helen Verran shifts her mode of attention from wonder to disconcertment as she struggles to remain accountable for the colonial inheritances of her knowledge-making practices. In Chapter 3, I return to wonder, refiguring it for speculative feminist theory. Isabelle Stengers is my guide as I read speculative wonder into the work of iconoclastic evolutionary biologists Joan Roughgarden and Lynn Margulis. Here, wonder helps me to imagine how to tell more responsive and response-able stories about life. The Conclusion is about thinking with aesthetics, the arts of enchantment, and the promise of an illuminated wonder.

Located in the tradition of feminist science studies, each of these chapters is guided by the cosmopolitical question: “What kinds of attention can foster more livable, breathable technoscientific worlds?”

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INTRODUCTION

Fables of Attention

> Fable
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> **2.** A short story devised to convey some useful lesson; *esp.* one in which animals or inanimate things are the speakers or actors; an apologue. (OED)

Fables stir my imagination. They draw together my love of stories, my love of creatures, and my passion for the fantastical. With their animal protagonists and well-crafted morals, fables interest me because they open up questions of agency and responsibility (Keenan 1997). Fables directly address and make demands on their listener. They are social stories that transform and are transformed as they pass from hand to hand. They are playful and artful and serious. The fable is an old genre of storytelling; however, they are largely introduced to us as children, therefore, fables are rarely given their due consideration. Aesop's and La Fontaine's fables are some of the most widely known stories. They are memorable, charismatic, and well travelled. Their power comes not from their realism but from how they stage their concerns and how they enroll their audience.

In this dissertation I offer the term "fables of attention" as a suggestive name for small vignettes about the ways that we pay attention to our world—personal attention and professional attention, highly disciplined attention and "queer forms of inattention" (Butt 2005), attention we're taught in classrooms and attention we learn through experience, attention for pleasure and attention for

survival. As fables, these stories have moral and political force; they show us that how we pay attention—with our ears, our eyes, our hands, our words, our imaginations—matters not just to how we see the world but how we relate "within and as part of the world" (Barad 2007, 37). Importantly, fables of attention are not only stories *about* modes of attention, they *teach us how to pay attention*. They get under our skin and act on our sensoria. They are corporeally didactic.[1]

But exactly what lessons they teach is not always certain. Even La Fontaine's archetypal fables are not unambiguous.[2] Take for example, the fable of the cicada and the ant, where the cicada sings all summer long, neglecting to store up food for the winter; when she asks the ant to share some of hers, the cicada is rebuked. In many of the retellings, the implicit moral is that we should be practical and hardworking like the ant. But reading the original fable, I find it much easier to identify with the joyfully hedonistic cicada than the cruel ant who refuses to share even for fair payment. As translator Stanley Appelbaum notes: "You can imagine La Fontaine siding with both the cicada and the ant" (xv). It is possible to hold two readings, two sympathies, two morals together within the space of this short fable. Which readings make themselves available, which readings resonate, is situated. The moment of pedagogy remains open.

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[1] Often didactic is used as a pejorative to say that a work of literature is one-dimensional or childish—as if only children learned and only children needed stories to furnish their imaginations.

[2] In *Fables of Responsibility*, the book that inspired my dissertation title, Thomas Keenan performs deconstructive readings of classic fables. His most virtuoso reading is the fable of the raven who thinks he is an eagle and tries to snatch a lamb, but his talons become tangled in the lamb's thick wool. The farmer finds him and cuts off his wing, turning him into a plaything for his children. Keenan argues that although the moral of the fable is supposed to be about identity and responsibility, in the story, the raven moves from being a "nameless bird, to a birdless name" (65) skipping the moment where name maps onto being and responsibility could be defined.

Attention at the Lab Bench, Attention in the Field

In Science and Technology Studies (STS), the field in which this dissertation is located, fables of attention proliferate. Fables about the world-making power of scientific attention, yes, but also fables about how we have learned to pay attention as we study technoscientific worlds.

Doing fieldwork in a biochemistry lab, Deborah Heath asked a researcher a series of about the procedure she was doing. Her informant replied: "Just watch. You don't have to understand. You have to be mindless hands before you can be mind and hands" (72). Heath came to understand this response as a fable of attention designed to initiate her into the "body-knowledge of the craft of cell culture" (72), to teach her the modes of attention needed at the lab bench. As she retells this story in her essay "Bodies, Antibodies, and Modest Interventions" (1997), it becomes a fable, not about the procedure that the researcher was doing (she doesn't even tell us what the procedure was), but about the "corporeality of technoscientific knowledge and the ways the mindful body engages the world" (72). She wants the reader to understand that labwork is situated and embodied, even as the "mental" labor of lab leaders is privileged over the "manual" labor of lab technicians and junior researchers.

This is a fable of attention in another way, too. It is also a story about her own ethnographic attention. Importantly, Heath's fieldwork does not simply confirm what she knew already; the interactions she describes affected how she paid attention and what she paid attention to: "I have found my own interpretive and epistemic practices shaped by the encounters with my interlocutors 'in the field'

as we participate in, observe, and critique one another's practices" (81). Attention in this story is intra-active (Barad 2007); it is made through encounters (significant and mundane) where we are asked to pay attention, taught to pay attention, made to pay attention.

The story that Heath's informant uses to teach her the techniques of cell culture, the story Heath tells her reader to illustrate the corporeality of knowledge, the story that stages her ethnographic modes of attention in-the-making—these are not separate. They mutually inform and enliven one another. These layers of attending and storying materially affect, press on, redo one another. Fables of attention connect the modes of attention we study and the modes of attention we practice. Not as reflexive observers, but as participants within "economies of attention" (Daston 2004a) and "ecologies of practice" (Stengers 2005).

Politics of Attention

Attention is always political. Anna Tsing explains that learning to *notice* is to practice the arts of inclusion. In her essay "Arts of Inclusion or How to Love a Mushroom" Tsing teaches us to notice the mycorrhizal webs that sustain forest ecosystems: "Next time you walk through a forest, look down. A city lies under your feet" (191). She alerts our eyes to the fruiting bodies of these fungi, our noses to the decomposition and nutrient exchange in the fungal network, and our imaginations to how the "fungi secrete enzymes into the soil around them"—"like an inside-out stomach" (191), Tsing proposes. She suggests that as we learn to notice mushrooms, to be moved by mushrooms and even to love mushrooms, it

becomes possible to re-imagine not just forest ecosystems, but what counts as the *polis*. It is a cosmopolitical practice. *A city lies under your feet.*

Arts of inclusion, of course, are also arts of exclusion and both can entail harm and destruction, alongside the kind of joy and possibility generated in Anna Tsing's cosmopolitical mushroom hunting. Feminist science studies scholars have always been attentive to both the world-making and world-destroying power of our seeing and knowing practices. S. Leigh Star highlights this commitment as she returns to Bruno Latour's fable of Louis Pasteur (1999), reconsidering its moral. In her telling Pasteur not only successfully "raised the world"; the triumph of germ theory also undermined other ways of knowing: "Pasteur's success meant simultaneously failure for those working in similar areas, and a loss and world-destruction for those outside of germ theory altogether" (1991, 49). Feminist science studies has taught me, again and again, to pay attention to the politics of knowledge, including my own. I have learned that my practices of seeing and knowing are not innocent nor without consequence. Donna Haraway's question—"With whose blood were my eyes crafted?" (1991, 192)—continues to haunt and provoke.

A Brief Itinerary

As I read and write fables of attention through the course of my dissertation, I work within this tradition of feminist science studies, asking who suffers and who flourishes within different economies of attention. I am curious about how we *learn to notice*, especially through didactic stories where narrative and sensorium remake one another.

Each chapter contains "acts of pedagogy" (Loveless 2010)—scenes of teaching and learning. In Chapter 1 ichthyologist E.W. Gudger learns from his mentor W.K. Brooks the virtue of keeping an open mind and the scientific pleasures that follow. In Chapter 2 Helen Verran, working in a classroom in Ile-Ife Nigeria, experiences an attack of visceral laughter that re-does her scholarly modes of attention and her practice of technoscientific storytelling. In Chapter 3 Caroline Walker Bynum teaches her students to encounter the past as unexpected and strange; and T. Hugh Crawford and his students learn about literature, ecology, and carpentry as they timber-frame a Thoreauvian cabin outside of the library at Georgia Tech. In the Conclusion, we visit my own classroom where I am learning to use collective poetry writing as a way into the political aesthetics of evolutionary biology. These acts of pedagogy are not always at the center of each chapter, but form a didactic undercurrent that draws on and informs my guiding question: "What kinds of attention can foster more livable, breathable technoscientific worlds?"

My practices of attending and narrating, like Deborah Heath's, are formed in encounters. The stories I tell are shaped by the texts I read and their authors, by my colleagues and mentors, by my participation in collective practices of living, knowing, and caring. One of the pleasures of being a graduate student—a person who is *supposed to be* learning—is that it is possible to affirm rather than deny the pedagogical influence of my milieu. Looking through the eyes of a student,[3] I

[3] This turn of phrase led me to look up why a student and the opening in the iris are both called a "pupil." *Pupilla* is Latin for little girl, also doll. Apparently the ocular pupil is so called because you can see your tiny reflection in a person's pupil. Both the pupil and the pupil foreshadow the theme of "epistemological dilation" in Chapter 1 and my return to childishness and particularly *girlishness* in the Conclusion.

have discovered that all literature is didactic literature; there are fables everywhere.

In "Fables of Attention," I explore the interrelationship between attention and storytelling across different ecologies of practice through situated readings of texts and encounters. Nearly all of the practitioners I read could be described as either feminists or naturalists (or both!), people who practice passionate cosmopolitical modes of attention—from feminist anthropologist-cum-mycologist Anna Tsing whose *polis* includes unseen networks of mycorrhizae to evolutionary biologist Lynn Margulis whose symbiogenic biosphere is populated by two kinds of organisms: "bacteria and everything else" (Margulis quoted in Teresi 2011).

I track *wonder* as a mode of attention through these worlds, attentive to how it animates feminist theory and scientific practice. However, the wonder I follow is not a singular or settled phenomenon. As it travels from chapter to chapter, wonder begins to accrue meaning; it shifts and mutates as it attaches to different practitioners, moving through ichthyologists, anthropologists, philosophers, teachers, feminists, artists and evolutionary biologists. In the course of this dissertation wonder shapes subjects and objects of knowledge, effects specific inclusions and exclusions. It is sometimes troubling, sometimes promising, always consequential. Each of the texts and moments I have chosen, I have chosen not just because they illustrate something about wonder, but also because they elicit a sense of wonder in me, a sense of wonder I try to covey through my writing. Rather than explain wonder and therefore also run the risk of explaining it away, I participate in these ecologies of practice as a technoscientific fabulist

attuned to the pleasures and dangers of passionate attention. For me, writing feminist theory is not only or always about describing the world as it is, but learning to writes stories to make my reader "think and feel and wonder" (Stengers 2008, 51).

Why Wonder? or "The Long Poem of Walking"[4]

So why wonder and not heartbreak, melancholy, anger, hope, disappointment or any of the other vital passions that surge through our practices of attending and storytelling? Although I fear that it sounds trite, I will take the risk and say that teaching and learning and writing on the UC Santa Cruz campus, wonder found me.

Today, like most days, I am walking home from my office in the Humanities Building down into the redwood forest and reclaimed ranch land, through the residential neighborhoods of Santa Cruz to the apartment where I've lived for the past five years as I've written this dissertation. It's late May—the beginning of the long California summer. The weather is warm; the air is unusually clear. I can see straight across Monterey Bay. Walking down along the broad sloping meadow, my head is still filled with the cares of the day, but I am also beginning to *notice* the liveliness of the landscape. The long-necked heron is gone, but the herd of angus cattle has returned, munching through the grasslands, keeping us safe from wildfires. The thistles, now as tall as my shoulders, are growing with abandon. The grass has turned from green to golden brown seemingly overnight. The mule deer have velvet-covered antlers again; the spotted fawns have emerged

[4] De Certeau 1984, 101

from the forest. Yesterday I saw a three-foot long pale green snake slithering out of the long grass and onto the sidewalk where I am accustomed to watching out for the indifferent little ground beetles who cross my path. Curious and—I must say—a little bit afraid, I stood motionless, watching her undular locomotion. An undergraduate student had been walking behind me and I pointed out the snake to her. When it had passed, we started talking about university and life and television and people. I walked half an hour out of my way to finish the conversation. The snake, long gone on her own path, had stitched us together.

The tempo of the natural world insinuates itself, interrupting the undifferentiated time of deadlines and anxiety, eating away at my cynicism. My thinking and writing have become more open here. More curious, less self-protective. As I wonder at the life that I encounter on my daily walk, the refrain "I wonder, I wonder if..." has taken up residence in my mindful body.

I pass by the park with the duck pond where the acrobatic swallows hunt insects in the evening light. The young woman with the tall boots is walking in the opposite direction with a stately falcon on her gloved forearm. *Everything smells like roses.*

Taking in the landscape, the vista, the summer grass, the antlers, the snake, the unexpected conversation, the woman and her falcon, the roses, it seems to me that the question is not so much, "why wonder?" but "how could it be anything else?"

CHAPTER 1

Wonder: The Ichthyologist and the Rats

"Truth and fable are no more opposed than science and poetry."
-Hayden White

In *Wonders and the Order of Nature: 1150–1750* Lorraine Daston and Katharine Park chronicle the centrality of wonder(s) in six centuries of European intellectual life. Through careful archival research they show that wonder was not always understood to be childlike and opposed to scientific reason; rather, it was long integral to the study of the natural world. They describe how the collecting practices of colonial and mercantile exploration fomented a fury of empirical inquiry that would eventually take the shape of Western science:

> Natural marvels played an important part in the elaboration of forms of natural inquiry based on the study of particulars...The single most important factor was probably the fifteenth and sixteenth century European voyages of exploration, to Africa, to Asia, and ultimately to the 'New World' of America, which yielded wonder on top of wonder. Many of these new marvels had never appeared in ancient or medieval texts; whether reported, depicted, or physically collected, they quickly overflowed the traditional confines of erudition and of medical and pharmacological inquiry to demand empirical study in their own right. (136)

As careful scrutiny of wonders and marvels becomes a mainstay of European intellectual life, 17th century natural philosophers began to understand wonder, curiosity, and attention as closely aligned and mutually defining. For men like Newton, Bacon, Boyle and Hooke, wonder was a passion that could spark

obsessive curiosity and focus keen attention on the object of study. Wonder was "bait and motivation for intense efforts of attention" (311); it caused natural philosophers to stay up all night and to squint their tired eyes for hours at a time, should an object induce their wonder, even to the point of blindness. It was during this time that Descartes famously defined wonder as "a sudden surprise of the soul which makes it consider attentively those objects which seem to it rare and extraordinary" (13). Thomas Hobbes claimed that wonder "excites the appetite of knowing the cause" (311); similarly, Hobbes's intellectual enemy, Robert Boyle had his curiosity spurred by the wonder of glowing phosphors (312). The wonders of these 17th century natural philosophers did not need to come from halfway around the world (though often they did); even the very ordinary could be rendered marvelous: "In order to rivet the attention upon a common fly," for example, "Hooke had to transform it into a marvel by means of the micro-scope" (313). Attention to the marvelous in all its forms (the new, the rare, the unusual, the singular, the exotic, the anomalous, the extraordinary) was an important part of learning about the natural world.

However, as Daston and Park show, this constellation of wonder / curiosity / attention did not last and wonders fell out of favor among Enlightenment naturalists. This shift did *not* happen, they argue, because the wonders were systematically explained and became powerless when their natural causes were named. Rather, "underlying almost all of these [Enlightenment] critiques of wonder and wonders was a new understanding of the pathological imagination as a breeding ground for enthusiasm, superstition and marvels" (339). Enlighten-ment naturalists came to see wonder as vulgar, the product of idle minds. It was

"at once metaphysically implausible, politically suspect, and aesthetically distasteful" (20). Though specialized economies of attention remained important for empirical study, the elites left wonder to the masses. And this is where Daston and Park end their narrative, lumping the present day with anti-marvelous rhetoric of 18th century naturalists in their epilogue. Because of the extreme distaste for wonders in the Enlightenment, they argue, "the odor of the popular" (367) *still* clings to wonder; wonder and wonders have never again possessed the awesome power to "buttress regimes, subvert religions, or reform learning" (367).

In the small but rich literature on the importance of wonder in European culture, almost all authors insist in this absolute *pastness* of wonder. Most often wonder is located in the 15th, 16th, 17th, and 18th centuries, from the voyages of discovery through to the Enlightenment (Evans and Marr, Campbell, Greenblatt, Kenny, Findlen, Biow). However, the history of wonder has been extended back by medievalists (Cohen, Bynum) and forward into the Romantic era (Holmes). In each of these studies wonder is given a historically and culturally specific definition. Wonder in these different accounts is not just one stable phenomenon; it is *thauma*, *admiritio*, *wunder*, *merveille*, *meravilgia*. It is a cognitive passion, an affect, a response, an emotion, an experience, a constellation of words, a rhetoric. Sometimes these words and feelings are overlapping, other times, completely opposing.[1] What is striking in this cluster of studies,[2] however, is that despite the

[1] For example, Steven Greenblatt, in his study of the writings of Early Modern travelers and explorers, draws on Descartes to describe wonder both as an "instinctive recognition of difference" (20) and an integral aspect of the discursive apparatus of conquest (75–76). However, in medieval Europe, Caroline Walker Bynum argues that in theological and philosophical texts, wonder, *admirtio*, is best understood as "cognitive, perspectival, non-appropriative, and deeply respectful of the specificity of the world" (17), as

different definitions, despite wonder actually *being* multiple things, it is rendered a strictly historical object.[3]

Daston and Park are especially insistent that wonder be relegated to the *history* of science. They argue that those who try to recuperate the value of wonder in contemporary life (writers as diverse as Friedrich Schiller, Charles Dickens and Max Weber) employ an anachronistic definition of wonder and belong to a "wistful counter-enlightenment" (360), a desire to return to the childhood of Western science before Reason banished portents, signs, marvels, and wonders from the inner sanctum of science.[4] While it is clear from Daston and Park's research that there was a strong distain for marvels in the Enlightenment, it is only when Western science is told as *bildungsroman* that an interest in wonder must take the shape of anachronistic nostalgia. If the wonders of the medieval scholars, Early Modern explorers, and 17th century natural philosophers are each historically (and linguistically!) specific but potentially interconnected, why is it necessary to leave the study of wonder at the doorstep of the Enlightenment?

Wonder and science are not exactly a strange pairing in the 20th and 21st centuries—how many future scientists were inspired by *Cosmos*, Carl Sagan's

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opposed to "a wondering desire that collects and appropriates what it endeavors to know or projects itself onto an imagined other, a passion that reduces to a startle response at the unfamiliar" (2).

[2] I say cluster of studies because almost all of these books were published in the 1990s and 2000s. Though *Wonders and the Order of Nature* was the inspiration for some of these, other were written prior.

[3] The only completely ahistorical account I read was Fisher (1998). As I explore in Chapter 3, however, some scholars (Irigaray, Bynum, and Stengers) use historical accounts of wonder as a basis for building a contemporary ethics.

[4] See *Wonders and the Order of Nature*, Chapter 9

invitation to wonder at the universe? How many were delighted by the hair-raising power of the science museum's Van de Graaff generator and terrified by the threat of being zapped by artificial lightning, should a sweaty hand lose contact with the smooth metal ball? Daston and Park do not exactly disagree; they argue that before and after the 17th century, "wonder and wonders hovered at the edge of scientific inquiry" (13). It is possible to follow Daston and Park and read the work of Sagan and Van de Graaff as hovering there at the edge, inviting children into careers in science. But, do the grown children really leave wonder(s) behind when they enter the Halls of the Science, giving us another kind of *bildungsroman*? Or is there a way to unhinge this potent conjunction of wonder / curiosity / attention from this 17th century moment and show how it can help us tell stories about the knowledge-making practices of other times and places? Deeply indebted to Daston and Park for their wonderful study, but less than faithful to their historical and spatial boundary-making practices, I offer my own story about wonder and empiricism in the 20th century. Taking a cue from my protagonist, an American ichthyologist who loved natural history lore—fish stories and "fish stories" both—my tale is not intended as a realist history, but an epistemological (beast) fable, what my ichthyologist might have called an "unnatural history."[5]

STS Fables

Writing this fable, I am not only indebted to the canonical allegories of Aesop, La Fontaine, Kipling, and Orwell, but also to the fabulists of Science and Technology

[5] Daston and Park might also call it an unnatural history; though they would likely not mean it kindly.

Studies (STS). Although it has been and continues to be many other things, STS is a culture of fables.

To take a classic example, Ruth Schwartz Cowan's essay "How the Refrigerator got its Hum," with its playful title, draws our attention to the homologies between sociology of technology and Kipling's just-so stories ("How the Camel got its Hump," "How the Leopard got its Spots," &c). The term "just-so story" is often used pejoratively by historians to suggest that the author has written an imaginary tale in place of a complex history. But if we were to take it as a serious literary genre of etiological inquiry, where we examine how a standard (a camel hump or a refrigerator hum) was developed and became fixed, it is quite a fitting description of the sociology of technology.[6] Telling and teaching fables about standards is important for orienting ourselves in the present. Be it bicycles, Bakelite, or bulbs, to tell these techno-origin stories is to participate in the politics of our technological environment.[7]

And there are other kinds of fables that run through the STS literature. Some, like Donna Haraway's "Cyborg Manifesto" announce themselves explicitly as fables,[8] but there are others that are more subtle, taking on their fabulous character through their re-telling. For example, we might think of Sharon

[6] This field of study was actually founded on a fable—Langdon Winner's story of Robert Moses' low bridges. As a brief debate in 1999 brought to light, Winner's story is probably not historically accurate, but rather a "parable" (Joerges) or an "urban legend" (Woolgar and Cooper). "Do Artefacts have Politics?," however, remains an excellent text for enrolling undergraduate students to think about the politics of technology.

[7] This reading of the Sociology of Technology was the basis for my undergraduate class, Techno-Politics: Histories of Everyday Technologies. This class brought together the politics of technology with the politics of storytelling.

[8] Haraway is clear about her motives from the beginning. Here is her first sentence: "This chapter is an effort to build an ironic political myth faithful to feminism, socialism, and materialism." (149). Like Traweek's book, which I will discuss presently, the ironic and the mythic qualities were lost on many readers (despite the explicitness).

Traweek's classic *Beamtimes and Lifetimes* as an anthropological fable, with the laboratory ethnography neatly illustrating its famous epigram[9]—high energy physics is a "culture of no culture, which longs passionately for a world without loose ends, without temperament, gender, nationalism, or other sources of disorder—for a world outside of human space and time" (162). Just like "sour grapes" or "wolf in sheep's clothing," it is the pithy phrase "culture of no culture" that travels, cited again and again in STS literature. This citational practice is explicitly inter-subjective; not because we are invited to identify with the subject of the fable,[10] but because it creates and sustains community.[11] "Culture of no culture" is as much about STS scholars as it is about the specific physicists Traweek follows. Repeating it is an identity statement: We are the people who know that the culture of no culture is *in fact* a culture. It is also an address, a charismatic lure, a clear and clever phrase that invites the listener to learn its lesson and to join the community. Although *Beamtimes and Lifetimes* may also be read as a realist ethnography of science and/or a savvy parody of ethnographic realism,[12] its fabulous community-making inter-subjectivity should not be

[9] As in a conventional fable, this is actually the last sentence of the book.

[10] Horace famously wrote: *mutato nomine te fabula narratur*, change the name and the fable is told about you. This is one of the ways that fables can be thought of as inter-subjective. They address their reader and invite her to identify with the characters.

[11] Similarly, La Fontaine's fables can be thought as generative of "Frenchness," as they have been memorized by centuries of French school children. For two insightful postcolonial commentaries on *The Fables*, see the films *Salut Cousin!* and *Ça Twist a Poponguine*.

[12] Traweek on her narrative strategy: "I wrote my last ethnography as an ironic counterpart to [E. E. Evans-Pritchard's] books, my own ocular story about physicists' desire for panoptic control of nature, an ironic conflation of Nuer cattle and experimentalist detectors" (1992, 436). However, as a quick internet search will tell you, *Beamtimes and Lifetimes* is often taught as an textbook example of realist ethnography in methodology classes at both the undergraduate and graduate level; even after 20 years, readers still miss Traweek's irony and fail to see how she was "playing the genre [of ethnography] for deadpan jokes" (434–435).

overlooked, especially since it is so powerful.

To call something a fable, then, is to foreground its inter-subjectivity, making the apostrophe (the address) more significant than the ontological status of its protagonists. The characters of good fables can be figural (the cyborgs), real (the humming refrigerators), lightly fictionalized (the high energy physicists), and or yet to be determined like the rats you are about to meet. Fables gain their effectiveness not from the authority of realist conventions, but from the elegance and imagination of their construction, as well their ability to address and to unite. Fables are powerful pedagogical vectors; but their power is not dependant on their grip on reality. Put another way, a fable is a case study that asks to be trusted, not believed.[13] Fables are not about ontological claims but practical creativity, their capacity to make new relations. Fables make friends easily; they are charismatic; they surprise and delight. Combining the pedagogical and the charismatic, 18th century literary critic Johann Jakob Breitinger defined the fable as "instructive wonder" (quoted in Rosenberg and Brown 195). And so, a genre that embraces the pleasures as well as the efficacy of wonder is well suited for presenting my case for the persistence of wonder in empirical inquiry.

Webs of Wonder

In an Eternity, what Scenes shall strike?
Adventures thicken? Novelties surprise?
What Webs of wonder shall unravel there?
-Edward Young

[13] In her introduction to the "Case Study" special issues of *Critical Inquiry*, Lauren Berlant writes that the case study is "a genre that organizes singularities into exemplary, intelligible patterns, enmeshing realist claims (x really is exemplary in this way) with analytic aims (if we make a pattern from x set of singularities we can derive y conclusions) and makes claims for why it should be thus" (670).

Although each author is careful to define wonder in historically precise ways, their diverse but interrelated wonders share one important function: they help the historians to *connect*. In his introduction to the edited volume *Curiosity and Wonder from the Renaissance to the Enlightenment*, Alexander Marr writes:

> The lens of curiosity and/or wonder offers a legitimate tool with which to assess the rich interconnections between early modern objects, texts, individuals, and ideas...The study of curiosity and wonder offers, we believe, rewarding ways in which to link the voyages of discovery to medical practices, collecting to the formation of scientific academies, without resorting to anachronistic terms of reference or convenient, but historically inaccurate, conceptual categories. (4)

Here Marr presents wonder as a narrative technology for the careful historian. It offers a way to draw surprising connections between disparate categories of things (objects, texts, individuals, ideas) and different practices (exploration and medicine, collection and science) across continents and centuries. Looking for wonder in the archives, tracing "the web of horror and delight" (Bynum, 4) through the texts, is a powerful method for making historical and topical linkages:

> In order to follow the substantive and chronological contours of the history of wonder and wonders we have integrated both periods and topics usually kept asunder—collecting and romances, travel and court spectacle, medical practice and popular prophecy, natural philosophy and aesthetic theory. (Daston and Park, 18)

Following wonder and wonders through six centuries of archival documents allows Daston and Park to build a strong connective tissue, a "sinuous history" (19), one that challenges some of the most conventional historical plots. If we are

no longer tracking science as vocation but wonder as passion, we can tell different kinds of stories: "The history of science does look different when organized around ontology and affects rather than disciplines and institutions" (18).

Seduced by the connective power of these intricate webs of wonder, I engage my own spinnerets and attempt to extend one gossamer thread into the 20th century. Spider-like, I spin my epistemological fable, making a delicate connection with just one sticky strand. The spider is a good insect to fabulate with (see Hayward 2011). As the pre-eminent reader and writer of fables in the philosophy of science, Michel Serres reminds us that the beast fable tradition is as much about biomimicry as anthropomorphizing. Playing with La Fontaine's name (French for "the fountain"), Serres argues that La Fontaine's (aquatic and bibliographic) sources are, in fact, the animals he writes about:

> Far from representing our human societies, the *Fables* take up and permanently mimic animal groups. These little poems show neither the city nor the Court (*Cour*), but the farmyard (*basse-cour*) or the glade, whose customs and habits are reflected marvelously in the tribunals, the public meetings, the fairs and squares, the salons and the palaces. The application, the reading and the translation do not go from the human collectives towards the animals, but the other way, from the animals to the humans. The source of La Fontaine [/the fountain], but also of Phaedrus, of Aesop and all the fabulists, is here, flowing from the communal water trough of horses and cows, of ducks and dogs, placed right in the middle of the cowshed and the hayloft, in the damp forest where the stags drink, scared by the wolves and the boars. (2001, 116–117, translation mine)

The sources of the STS fabulists have also been animals: scallops (Callon), brittle stars (Barad), Pfiesteria piscicida (Schrader), cloned sheep (Franklin), insects of all kinds (Raffles), and Australian shepherds (Haraway). When Lévi-Strauss's oft-quoted "animal [x] is good to think with" (e.g. Franklin 27) is invoked in the beast

fables of animal studies, it speaks to the methodological debt owed to a companion species. Sarah Franklin describes her method for *Dolly Mixtures* simply as "following sheep around" (9); she takes her lead from both wooly sheep and textual sheep as she writes about biotechnology and the remaking of genealogy.[14] In this tradition I look to the spider, with her strong but delicate silk, to offer an alternative connection practice to Daston and Park's anatomically-inspired method, the "sinuous history."[15]

To do a sinuous history of wonder/curiosity/attention, would be to follow Alexander Marr's appeal to his colleagues for rigorous linear continuity: "Indeed, one of the most pressing challenges currently facing historians of curiosity and wonder is to track the trajectories of these themes through the end of the eighteenth century into the nineteenth and twentieth centuries" (17). An arachnoid fable, on the other hand, is less about generating thick fibrous tissue, than an ephemeral[16] (but relatively strong!) link between different nodes, different times and places.

My silken thread is anchored in Daston and Park's claim that attention to

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[14] This results in the very bad pun "scholar-sheep," which Franklin uses as a verb. The strange and ubiquitous relationship between writing about animals and bad puns is a question for another day. The pull of this tradition, however, is strong; my secret alternative title for this chapter is "Fish Stories and Rat Tales."

[15] Karen Barad warns us that biomimicry re-entrenches the distinction between nature and culture: "With all mirroring practices, biomimcry has a built-in optics based on the geometry of distance from that which is other" (368). However, I read Serres as playfully upsetting assumptions about authorship. In his version, La Fontaine is not author but fountain, the font from which the animals speak. By telling a story that flows in an unfamiliar direction, he increases "the traffic between nature and culture" (Haraway 1989, 15), to use another brilliant phrase from STS commonplace book, in order to denaturalize both.

[16] Indeed, as webs lose their stickiness, most spiders will eat them to recoup the protein. Or as Eva Hayward puts it:"Threads hold together more or less conditionally until they are eaten by the spider who spun them, or swept away in a cleaning frenzy, or reworked after having caught a meal, or simply abandoned for another site" (2010, 246).

marvelous objects (to the new, the rare, the unusual, the singular, the exotic, the anomalous, and the extraordinary) was an important part of pre-Enlightenment knowledge-making practices in Europe. Repelling from this anchor point, I connect to a 20th century natural historian with a passion for marvelous objects, and set out to show how wonder as a mode of attention was integral to his work in ichthyology. In doing so, I am not only interested in historically extending an argument for the persistence of wonder in scientific practice, but also in exploring its specific ontological, epistemological, and ethical contours.

Part II:
The Ichthyologist and the Rats: An Epistemological Fable

The Ichthyologist

Eugene Willis Gudger was born in Waynesville, North Carolina in 1865. His father, a lawyer and later a superior court judge, fought in the Civil War for the Confederate Army; his great grandfather fought in the Revolutionary War. When Eugene was a young boy the Gudgers were visited by Rebecca Harding Davis, a prolific writer and important public advocate for the rights of women, Native Americans, the lower classes, immigrants, and people of color in the United States. Davis encouraged Eugene's curiosity about the natural world, sending him books from a series called "Science for the Young" after her departure. When he graduated with a PhD in Zoology from Johns Hopkins in 1905, Gudger sent her a letter thanking her for the influence she had on his life and inviting

her to the commencement ceremony (Crittenden 1986).[17]

At Johns Hopkins, Gudger studied under W.K. Brooks, a influential man of "quiet, unobtrusive eccentricity" (McCullough, 413), a morphologist and embryologist who mentored many prominent turn-of-century American biologists: William Bateson, Edwin Grant Conklin, Ross Granville Harrison, Edmund Beecher Wilson, and Thomas Hunt Morgan (McCullough 1969, Haraway 1976, Maienschein 1981, Wourms 2007).[18] From Brooks Gudger learned not only the importance of reviewing a wide range of literature as part of the practice of biology (Maienschein, 102), but also the scientific virtue of keeping an open mind. Gudger often repeated the following anecdote (e.g. 1930, 1935, 1946, 1953): As a graduate student he gave a presentation in the Hopkins Biology Journal Club on the sighting of an unknown animal in France, possibly a sea-serpent. After a "deep and painful silence" (1953, 199), another student asked what Brooks thought of the story. Gudger remembers him saying: "It is not safe to say that a thing doesn't exist in nature because you nor any other scientific man has yet seen it" (1935, 424). This moment, this act of pedagogy (Loveless 2010), had a profound effect on his approach to natural history; Brooks had given him the permission to give scientific consideration to all phenomena, including those that had been previously classified as fantastic, supernatural, or fictional, "wild facts"

[17] Before beginning his PhD at Johns Hopkins in 1901 at the age of 36, Gudger taught in public schools and colleges in North Carolina, Tennessee, and Arkansas.

[18] Historian of science Donna Haraway writes, "The nature of Brooks' influence on these extraordinarily creative men deserves serious attention" (1976, 65n1).

that had been recorded but not domesticated by scientific orthodoxy (James 1956).[19]

After completing his PhD, Gudger returned to North Carolina, where he taught at the North Carolina College for Women at Greensborough for the next 15 years, working at the U.S. Bureau of Fishes at Beaufort during the summers, hunting sharks and slicing their bellies to determine what they ate (Figure 1.1). In 1919 he was hired by Bashford Dean to work on the ambitious, three volume, 2100 page, *Bibliography of Fishes.* Gudger compiled and edited the volume on Pre-Linnaean works, which stretched back to the earliest existing accounts of fish (such as Pliny's *Historia Naturalis*) through the tomes of Early Modern naturalists like Conrad Gessner and Ulisse Aldrovani (see Gudger 1936). Upon the completion of the bibliography of fishes, Gudger was given the title of Associate Ichthyologist at the American Museum of Natural History, where he remained until his retirement in 1938 (at age 73). During his time at the AMNH and into his retirement he wrote more the 300 scientific articles and edited the Bashford Dean Memorial Volume, a tribute to his colleague and mentor Bashford Dean (a man who was simultaneously curator of arms and armor at the Metropolitan Museum of Art and curator of fishes at the AMNH with a special interest in armored fishes!).[20]

At the center of Gudger's impressive body of work was his abiding interest in

[19] E.G. Conklin also recalls W.K. Brooks saying: "The term supernatural is due to a misconception of nature; nature is everything that is" (quoted in McCullough 413).

[20] Bashford Dean believed that the armor collected in the Metropolitan Museum should be worn and presented to the viewers in action. One of the most popular films in the museum collection featured Dean himself inside a suit of armor—"A Visit to the Armor Galleries" (1922). It can be viewed here: http://www.youtube.com/watch?v=NjKbi7YUNaI

the strange and marvelous corners of natural history. His PhD thesis was on the breeding habits and egg segmentation of the pipefish, a species where the "female extrudes the eggs, the male fertilizes them, and they slowly glide into the marsupium on the ventral side of the tale of the male," where they remain until they hatch (1905, 200). His only book-length work investigates accounts of the Candiru, a parasitic catfish that allegedly has "the evil habit of entering the urethra of men and the vulva of women bathers" (1930, vii). He studied fish teratology, cataloguing the abnormal morphology of different species of flat-fish.[21] He chronicled sightings and captures of large and mysterious fish like the whale shark and ocean sunfish. But the most striking category of Gudger's scientific articles were his "unnatural histories," serious investigations of fish raining from the sky, monkeys linking together to make bridges to cross crocodile-infested rivers, jaguars using their tails as fishing lures, and other tales from myth, legend, travelogues, or old natural history books. In these articles he would take up these dubious stories, looking for bibliographic, photographic, and anecdotal evidence to support them. Some, like the rains of fishes, Gudger came to believe were true.[22] Others, like the monkey bridges, he found to be unlikely.

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[21] In an article on the origins of fish teratology in the Early Modern Period (1936) Gudger recounts the origins of his own interest in teratology: As a graduate student Gudger was "considerably disturbed" by the morphology of a skate that did not look like the diagrams in the book (242). As he worked in the lab well after the building was supposed to close, trying to get the "darned thing to agree with the book," his professor stepped in and suggested, "What you have here is an interesting abnormality, a marked departure from the norm" (242). According to Gudger's autobiographical vignette, this initiation into an economy of attention to morphological difference defined his career path: "That settled the question for me, and from that day til this, I've been looking for such departures from the ordinary and it's great sport" (242).

[22] After examining all of the available literature (78 accounts from 300 AD to the present) he concludesdthat rains of fish are real phenomena; what probably happens is that fish are sucked up by giant waterspouts and are deposited on land as the wind velocity decreases (1929, 527). This conclusion caught the ire of Bergen Evans (1904–1978), resident expert on *The $64,000 Question* and professor of English at

Still others, like the story about how rats transport eggs, he left tantalizingly open, neither confirmed nor unconfirmed, ontologically undetermined.

The Rats

We find our protagonist at the American Museum of Natural History in 1935, "bone-tired with working for sixteen months on the problem of abnormalities in flounders" (1935, 153). Taking his mind off of the difficult study of fish morphology, E.W. Gudger sets down his specimens and turns to a remarkable mystery of rodent behavior that had interested him for some time. In the article, "How Rats Transport Eggs," Gudger writes:

> Rats are very fond of eggs and they show great cleverness in stealing them from containers and in carrying them considerable distances and over many obstacles. They will despoil a hen's nest and even steal the eggs from under a sitting hen. Generally these are eaten on the spot, but frequently the rats are desirous of carrying them away. Unlike birds which thrust the beak into the egg and thus transport it, rats find eggs, because of their weight, shape and brittle shells enclosing semi-liquid contents, very difficult objects to handle. However, they are known to transport them without breaking the shell or even leaving a mark on it. How they are alleged to solve the problem will now be set out. (415)

He entertains accounts of how rats have been known to carry eggs upstairs and downstairs, before moving on to his grand finale. In the dramatic conclusion of his article Gudger investigates whether or not rats carry eggs using the following clever technique: one rat lies on her back and clutches the egg in her paws, while another pulls her tail, turning the first rat into what Gudger delightfully dubs an "egg-wagon" (see Figure 1.2 and 1.3). Although there was no scientifically accept-

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Northwestern University, who was critical of Gudger in his book *The Natural History of Nonsense*, one of the first books in the tradition of American skepticism.

ed evidence documenting this practice, Gudger takes the story seriously, tracing it from a 13th century Persian manuscript describing the behaviors of animals to the present day through sources as varied as museum handbooks, histories of human interactions with rats, ethology and natural history texts, travelogues, popular newspaper articles, first hand narratives, French fables, artistic renderings, personal correspondences, and accounts of ethologists, zoologists, and housewives. He quotes the "alleged facts with meticulous care" (424), offering critique and speculation informed by his considerable experience with natural history bibliography. After a careful consideration of the lore, Gudger does not affirm or discredit the story but declares brightly, "Waiting for photographic evidence of a rat-egg-transport, I shall keep an open mind" (424).

This curious article, and particularly its inviting ending, calls to mind medievalist Jeffrey Cohen's impression of wonder as a kind of "epistemological dilation" (228n1). Gudger's open mind, the mind that had let these marvelous rats in to nest in the first place, continues to admit eclectic sources and, even at the end of the article, remains open, ready and waiting to receive the definitive photograph of an egg-wagon. The following sections elaborate and complicate this reading of Cohen with Gudger, staging wonder as a mode of attention that not only guided Gudger's methodology, but also shaped his empirical objects and claims about the natural world. I read a selection of Gudger's many articles, looking for moments in the text where "epistemological dilation" and empirical inquiry go hand-in-hand.

Marvelous Empiricism and Ontological Categories

In some respects Gudger's approach to natural history had more in common with the Early Modern naturalists he read in his exhaustive research for *The Bibliography of Fishes* than his contemporaries. Collected together in my filing cabinet, Gudger's articles resemble 16th century Barber-Surgeon Ambroise Paré's *On Monsters and Marvels*—a book that catalogues a host of marvelous phenomena including conjoined twins, chimeras, sea monsters, and elephants (Figure 1.4). In the history of science told as a *bildungsroman*, coming of age in the Enlightenment, Paré's book would be considered childish natural history, inappropriately mixing real phenomenon like elephants with fantastical ones like sea serpents. However, as Daston and Park describe, these Early Modern treatises were not lacking in scientific rigor. They reflect a struggle with how to grapple with empirical contingency: "Unlike [16th century] natural philosophers, who concentrated for the most part in developing universal causal arguments, men engaged in these enterprises [empirical physicians] had to come to grips with particular natural phenomena in the animal, plant, and mineral worlds" (136). Credited with discovering that boiling oil is not beneficial for treating wounds, Paré had great distain for natural philosophers who overlooked empirical details. Responding to attacks from Etienne Gourmelen, Paré angrily replied: "Now will you dare to say you will teach me to perform the works of Surgery, you who never yet came out of your study" (quoted in Pallister xvii). For Paré, to investigate the sites where ordinary natural laws appeared to be transgressed was to learn to how to be a better surgeon. Considered outside of the history of scientific

progress, Gudger's scientific practice resembled Paré's in the sense that the empirical consideration of marvelous particulars was his entryway into knowledge of natural phenomena.

However, other than his articles on the rains of fishes, Gudger's publications caused no particular controversy among his scientific colleagues. Despite his affinities with Early Modern naturalists, his work in natural history also fit comfortably within the conventions of his day. On the one hand, his position at the American Museum of Natural History, described even now as "a gathering of wonders" (Wallace 2000), made him the inheritor of a tradition a rooted in the collection, careful scrutiny, and public display of marvelous objects. On the other hand, the tropes of the Early Modern period continued to persist in the natural history of the early 20th century, despite the changes in scientific practice. The pages of *The Scientific Monthly* in the 1930s were suffused with what Alexander Marr calls the topoi of wonder— "travel, collecting, natural philosophy, the body" (16). In the very same issue that features "How Rats Transport Eggs," we witness the ongoing entanglement of science, exploration, and travel in the articles like "Admiral Peary: Discoverer of the North Pole" and "Siam in May." [23] Wonder (surprise and delight at exotic specimens and locales) remained a strong affective

[23] Written by Duke University zoologist A.S. Pearse, "Siam in May" is an interesting example of how the travel narrative remains an appropriate genre of writing for a scientific journal into the 20th century. Although there are a few tips for the "orchid hunter" and the naturalist and some basic information about fish that breathe air, the bulk of the article is on subjects like the wonderful art and architecture (406), "the mighty and malodorous durian fruit" (408), and the neighborhood children who looked on amused as he "dashed refreshing water over his soapy body" (413) each morning. Here we have a heightened attention to the exotic in place of and feeding back into scientific marvelous. Concluding his article by addressing his audience with the imperative "Go to Siam!" (414), Pearse conveys his delight with all of the exotic animals, plants, people, buildings, clothing, art, architecture, and landscapes he encountered during his visit, thereby encouraging others to follow in his footsteps. The rhetoric of wonder works to draw other scientists into his work, sustaining and transmitting marvelous economies of attention.

current in scientific museum and print culture; Gudger's interests, in this respect, were not so anachronistic.

Paré and Gudger also deviated in terms of ontological classification. Whereas Paré described congenital birth defects alongside animal/human hybrids as natural phenomena, Gudger drew a distinction between phenomena that were normal, abnormal, or fantastical according to the conventional 20th century scientific metaphysics. Their ontological status, however, did not constrain *what* he wrote about so much as *how* he wrote about it. For abnormal phenomena a like pug-headed brown trout (1929) or albino tarpon (1937)—usually (though not always) categorized as teratological—Gudger details the abnormalities present in his specimen(s), compares them to normal or other abnormal fish of the same species, and sometimes suggested a causal explanation for their abnormalities based on his examination of the specimen and the literature.[24] Fantastic phenomena are accounted for in his articles on the history of natural history. In these articles Gudger takes a fantastical object, describes it, and traces its genealogy from when (if ever) it was believed to be real to the present. When he writes about normal fish, like the whale shark or ocean sunfish, Gudger describes the morphology of rare specimens and the circumstances and location of their discovery (called a "faunal record"). These articles simultaneously constitute natural history, through morphological description, and chronicle the

[24] In the first half of the 20th century when Gudger wrote his articles, genetics became the favored explanation for teratological animals. Although some could be explained with embryological or developmental accounts, unexplained morphological differences became more and more the purview of genetics. Though Gudger often mentioned that he would write an article about the causes of the flatfish abnormalities he tirelessly catalogued, he never did. Though this is just a guess, I wonder if his lack of familiarity with genetics, and its powerful causal stories, stopped him from publishing his findings.

history of natural history as it is happening (see Gudger 1940). By choosing the appropriate genre, any of Gudger's marvelous objects could be easily made into a credible topic for a scientific journal or magazine article.

However, this account about how Gudger tamed his marvelous phenomena with ontological classification is a little bit too tidy. Reading all of his articles together, one gets the sense that there was something more *feral* about his approach to natural history, something obsessive and excessive that transgressed the boundaries of genteel classification. His love of the marvelous, his relentless pursuit of wonder, threatened the integrity of the categories of the normal, the abnormal, and the fantastical even as they authorized his work as properly scientific. In the work of E.W. Gudger the cellular membranes of these categories become more porous, more open to cross-contamination. The normal, the abnormal, and the fantastical do not stay still; they flow in and out of one another, as the pursuit of the marvelous takes over. In the next section, I offer three illustrated fables that stage wonder as a mode of attention that not only guided his scientific practice and shaped his empirical objects, but is replete with categorical surprise. Here I do the history of science as speculative fiction, hoping to create a vivid portrait of the impression that Gudger's passionate writing made on my own readerly imagination.

Fish Stories: Three Fables of Attention

Normal/Abnormal

Eugene Willis Gudger (1866–1956), the subject of these three fables, was a bibliographer, ichthyologist, and lover of natural and unnatural history. He was a teratologist. A monster-hunter. A student of Laws and regularities but hungry for the breech.

Guided by a wonder-struck epistemology, seeking out monsters and marvels wherever he went, Dr. Gudger turned his attention toward the study of flatfishes, Heterosomata, the different-bodied, *the only asymmetrical fish in the seas.*[25] He was drawn in by their strange morphology, captivated by their curious metamorphosis:

> *The flatfishes are the most unusual and anomalous of fishes. In youth they swim and feed in a vertical position as do ordinary fishes; but in adult life they lie on the bottom—not on the belly, but on one side. This side is white and eyeless—its eye having migrated to the upper side which thus possesses two eyes and all of the color. Thus flatfishes are abnormal fishes whose usual abnormalities are entirely normal.*[26]

This is how he wrote about flatfishes. Summer flounder, winter flounder, starry flounder, rusty dabs, lemon sole, he insisted that they were common monsters, *normal abnormal forms.*[27] We must not be tricked by their numbers, he cautioned: *If flatfishes were unusual they would surely be regarded as the most wonderful of all fishes, as the greatest of monstrosities.*[28] In the marvelous hands of E.W. Gudger, a cheap food-fish

[25] 1935, 5
[26] 1941, 30
[27] 1934, 1
[28] 1934, 3

effortlessly became *the great ichthyological enigma.*[29]

Enticed, by not yet sated, he tracked down even stranger specimens:

Flatfishes with patches of color on their usually alabaster bellies.

Flatfishes with little hooks at the tip of their dorsal fins.

Flatfishes on whom the migrating eye stopped short of its final destination, awkwardly trapped on their skinny side of their heads, sandwiched between flat top and flat bottom. Cyclopean, Gudger thought, if you hold them just-so.

Figure 1.5: **CYCLOPEAN FLOUNDER** "Head on view of the totally ambicolorate flounder to show the relative positions of snout, rotated eye and hooked dorsal fin" (1936,7)[30]

He gathered up a modest collection of these fishes from markets, fishermen, and friends,[31] which he examined, photographed, then pickled (often unsuccessfully) in

[29] 1934, 9

[30] The diagram itself also becomes a marvelous artifact. Gudger writes: "This figure is, I believe, the first to show in head-on view the eye and dorsal fin peculiarities of such a flatfish" (1936, 7).

[31] One of these donors was Charles R. Knight, the famous painter of animals and dinosaurs whose work has captured the imagination of illustrious natural historians like Steven Jay Gould. Gudger writes that Knight

glass jars and stored for safe-keeping. As he studied these teratological hetero-somata, these abnormal, normal, abnormal forms he began to discern patterns in their peculiar morphologies. Carefully recording these regular irregularities, he formulated a simple rule:

> *When the whole lower body and approximately one-third of the head is dark, then there will be found an incompletely rotated eye and a hooked dorsal fin.*[32]

Most of his specimens followed the rule: Almost-entirely dark-bellied Cyclopes with hooked fins and patchy fellows whose migrating eyes had safely made the journey to the top of their heads. These were the normal abnormal normal abnormal forms.

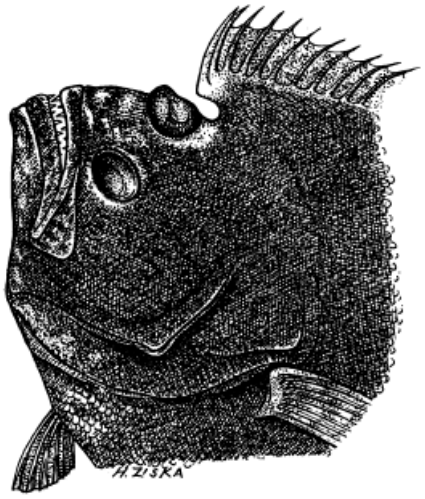

Figure 1.6: **FLOUNDER HEAD ABNORMALITIES** "Upper side of head of a partially ambicolorate southern flounder. Note the eye which is barley over the dorsal crest, and the white patches behind it. Note also the hook of the dorsal white on the point." (1936, 4) [33]

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passed the flounder in a New York City fish market and, "recognizing the interesting abnormality, he purchased the fish, and kindly presented it to the Museum" (1934a).

[32] 1936b, 4

[33] With the desire to make a modest contribution to the history of women in science, I discovered that Helen Ziska was "a delightful scientific artist of German origin" (Colbert, 95). She worked closely with William Gregory King at the comparative anatomy department at the American Museum of Natural History. Her many beautiful illustrations for the AMNH are signed H.Z. or H. Ziska. To my lay eyes, her illustrations for Gudger showcase the head abnormalities he describes much better than the conventional photographs.

But the joy of rules is that they will—*they must*—be broken. The world is too complex and wonderful, in Dr. Gudger's estimation, to let them stand for long.

He kept promising that he would gather all the data, lay out the rules, offer explanations. But he found himself preoccupied by the outliers: A halibut, for example, whose anomalous head was thrown off a Boston pier by an angry fishmonger who wanted more money than Gudger's colleague Firth was willing to pay. This halibut had patches of white and patches of black on its underside (called a "circus halibut" by fishermen). But despite the patches, this fish had, *mirabile dictu*, a hooked fin and cyclopean eye. An abnormal abnormal normal abnormal form!

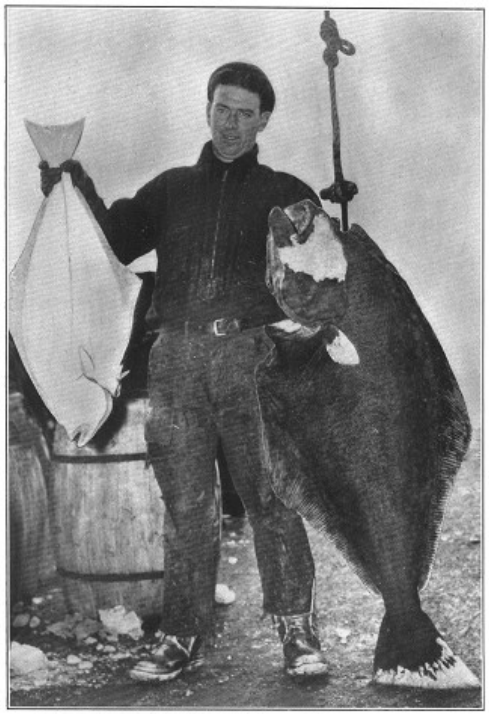

Figure 1.7: **FIRTH WITH HALIBUTS** "Ventral surfaces of two halibuts. The smaller fish has the normal white undersurface. The larger or abnormal fish is nearly complexly dark below, has an incompletely rotated eye and hooked dorsal fin—both of which are absent in the normal fish" (1937, 8).

Unfortunately, Ziska's skills were only enlisted when the specimen was ruined during the preservation process.

So in the end we don't have a classificatory scheme; something perhaps to be expected from an expert on pre-Linnaean natural history. We have instead, E.W. Gudger and his headless halibut, with the categories of normal and abnormal nested like *matryoshka*, evidence of his wonder-lit journey, and an unfulfilled promise to systematize and publish his findings.

Fantastical/Abnormal

As the resident expert on strange creatures of the deep, Dr. Gudger found himself the custodian of many curious artifacts, inheritor to their inviting mysteries. Some, like the photograph of the three-eyed haddock, were not teratological fish at all but clever ruses, monstrous artifacts fabricated by crafty fisherman. But these hoaxes did not irritate Gudger; they enticed him. The haddock, for example, gave him occasion to scour the literature on three-eyed fishes, finding that all known specimens had been embryos, embryos part way to becoming *two- headed monsters.*[34] This bibliographic expedition was not the only source of his ichthyological satisfaction—Gudger came to appreciate the *craftsmanship* of these hand-made creatures. *If this is a "faked" specimen,* he wrote of the haddock, *it must be acknowledged that it is skilfully done.*[35]

[34] 1928, 562. He wrote specifically on two-headed fish in Gudger 1938.

[35] 1928, 570.

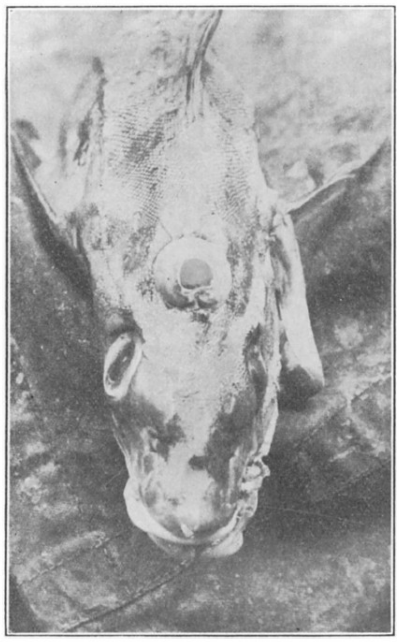

Figure 1.8: **THREE-EYED HADDOCK** "A nearer view of the head of the three-eyed haddock. Note the position of the third eye and its sharp differentiation from the scaly skin" (1928, 561).

Of all the curios entrusted to him, the Jenny Hanivers— sea monsters made from the dried bodies of rays and skates—were, perhaps, his favorite. For his article on the (un)natural history of the Jenny Haniver, he thoroughly examined the specimen that Mr. Altman had kindly left with him, photographing it with Museum equipment, describing it in morphological detail:

> *The head-dress of this Jenny Haniver is made of the rostral cartilage with the flexible membranes partly wrapped about it. The eyes are artificial ones inserted in the nostrils. The flat mouth has been pulled out to give the jaws somewhat the curvature of those in a primate. The tissues on either side of the mouth have been distended into bulging cheeks. The upper parts of the pectoral fins have been folded back behind the head, leaving the remainder of the fins to form wings. The appendages of the pelvic fins of this male fish have been manipulated to form something like legs, and these are supported by wires run through the tissues. Part of the fin membrane is seen on the outside of each 'leg.' At the junction of fins and body are the conjoined enlarged bases of the fins with points*

> *extending upward and outward right and left somewhat resembling the pelvic arch of a primate—of which they are in a certain sense the antecedents.*[36]

Witness the care he took to outline the anatomy of the ray (rostral cartilage, flexible membranes, nostrils, mouth, jaws, tissues, pectoral fins, pelvic fins, fin membranes), the means of manipulation (cutting, wrapping, distending, folding; augmenting wires, and fake eyes), and the human and monstrous structures they resemble (wings, cheeks, jaws, legs, pelvic arches). Gudger attended to the Jenny Haniver *as if* it were a teratological fish whose natural history and morphology must be meticulously recorded for future study.

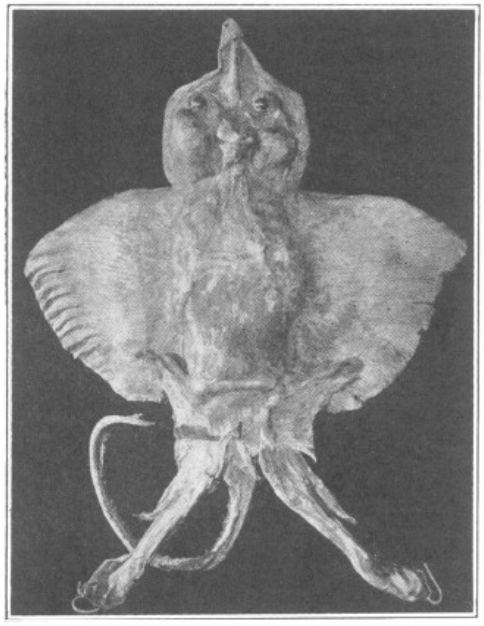

Figure 1.9: **JENNY HANIVER** "A Modern Jenny Haniver: This is made of a skate shaped by hand and dried into the form of a mythological monster" (1935, 512).

To this he added a collection of pre-Linnaean treasures dredged up from his four years of research for the great *Bibliography of Fishes*—the delightful figures of

[36] 1934, 511

monkfish, bishopfish, sea eagles, dragons and basilisks from the pages of Belon, Rondelet, Gessner, and Aldrovandi. *Progenitors of the race of Jenny Hanivers!*[37]

But, he realized, the men who made many of his modern Jenny Hanivers were illiterate fishermen, unfamiliar with these old natural history books. Instead, he surmised that they *discovered a faint human resemblance in the fish and experienced an obscure impulse to accentuate it.*[38] A morphological lure.

An obscure impulse.

Unable to resist, Gudger gave himself over to that same obscure impulse which had possessed the fisherman and began to hunt through the literature for teratological rays, rays that *would easily lend themselves to the making of Jenny Hanivers.*[39] He identified a number of fine candidates, before settling on a figure of an abnormal horned Cyclops ray to serve as the basis for *his own* Jenny Haniver. With its *short horns and sinister single eye,* this ray would make *a most remarkable and weird Jenny Haniver*. An apparition *wherewith to scare children and even grownups.*[40] Not a real monster nor a hoax exactly, because, as Gudger contended, with teratological rays, nature herself makes Jenny Hanivers.

Fantastical. Teratological. Bibliographic. Delightfully horrifying. *A most marvelous Jenny Haniver.*[41]

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[37] 1934, 515

[38] "Animals: Jenny Hanivers," 1

[39] 1934, 522

[40] 1934, 523

[41] 1934, 523

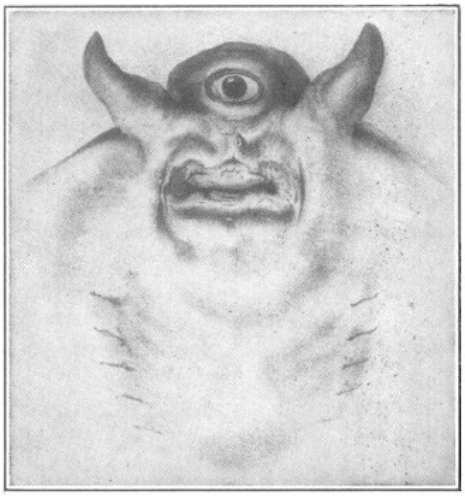

Figure 1.10: **HORNED CYCLOPS RAY** "This would have served as the basis for a most remarkable and weird Jenny Haniver" (1934, 522)

Normal/Fantastical

Gudger had always been fascinated by sharks. They elicited in him a boyish delight, equal parts terror and excitement.

> *If one could see a hammerhead standing vertically in the water and facing one with only the head and mouth out of water, its appearance would certainly justify the epithet 'unearthly.' Many years ago, before I knew anything about hammerhead sharks, I saw such a picture. To me it portrayed a monstrous apparition from the deep, something from a nightmare.*[42]

It was not the hammerhead, however, but the whale shark—*the greatest shark that swims the seas*[43]—that would consume him. In 1913, when Gudger saw the 38 foot long skin of a whale shark, it *tremendously stirred his imagination.*[44] *"What shark was*

[42] 1947, 228

[43] 1941, 81

[44] 1941, 81

this?" he wondered. The question was worth answering. It *had* to be answered.[45]

Thus began his 25 year romance with the whale shark, Rhineodon typus. He was powerless to resist: *It was written in the stars that I had been 'sentenced' to study it 'for the balance of my natural life.'* [46] He wrote more than 47 articles on the whale sharks—those *leviathans of the deep.* And amassed *the greatest collection of whale shark photographs in the world.*[47] He stayed up late into the night watching films of the whale shark, frame by frame on the Museum's Moviola.

Whale sharks were the most noticeably colored shark with the most specialized organs.[48] Clad in well-nigh impervious armor, Gudger wrote, Rhineodon fears not man.[49] Gentle-mannered, it feeds not on large fishes or mammals but on plankton, taking hogsheads of water into its mammoth cave of a mouth.[50]

Three times he missed the chance to dissect a captured specimen. *It nearly broke my heart.*[51]

Finally in 1935 he had his chance to see a whale shark that in the flesh, a whale shark who had *blundered* into a net off of Fire Island, NY. Examining that specimen on the Long Island beach, he was overcome by the same sense of wonder he felt as a young boy looking at the picture of a hammerhead in the book given to him by Mrs. Davis:

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[45] 1940, 229

[46] 1940, 227

[47] 1940, 233

[48] 1941, 81

[49] 1941a, 559

[50] 1940, 227

[51] 1940, 229

> *All other sharks I had handled before were hardly more than minnows compared to this colossus. My excitement was great; I was unable to adjust my mind to how huge it was.*[52]

So great was his excitement he failed to *note accurately the color of that fish*.[53] The head, the heart, and part of the esophagus were brought back to the Museum. The other parts were *too mastodonic*[54] to transport.

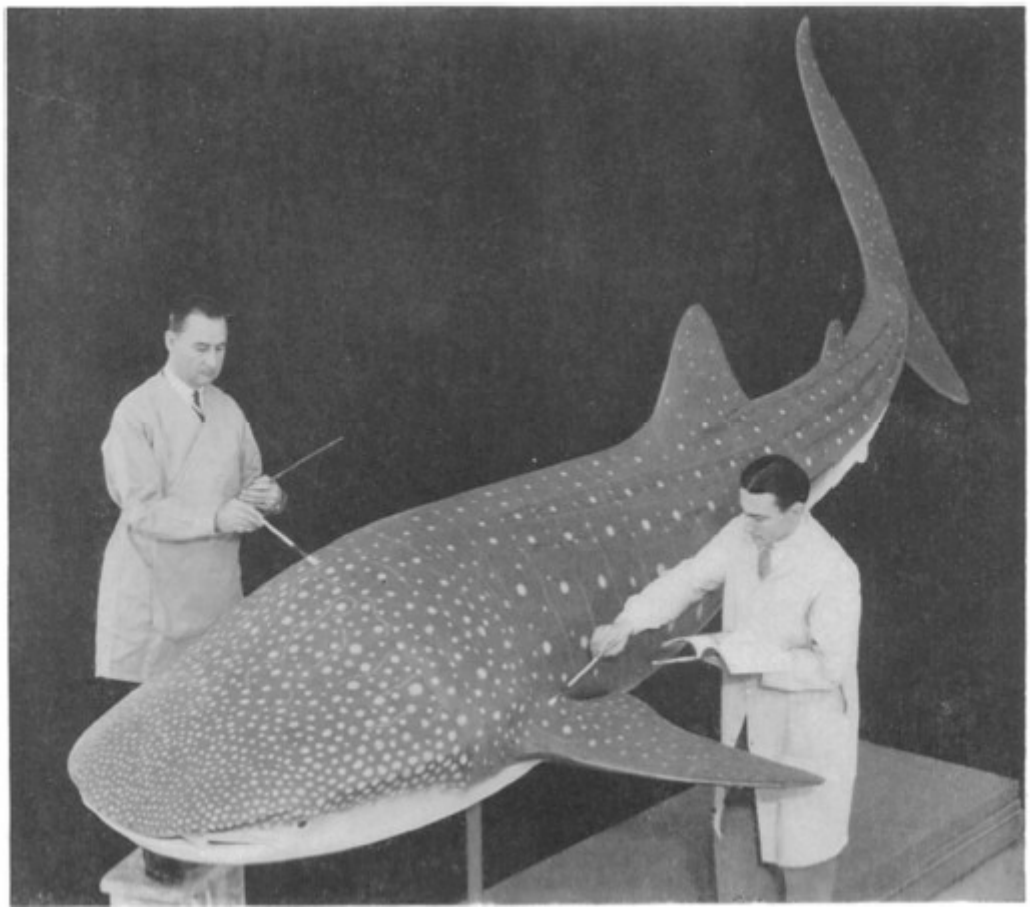

Figure 1.11: **PAINTING THE WHALE SHARK** "The mounted skin of the whale shark in the America Museum. Dr. James L. Clark...and Mr. Ludwig Ferraglio, who mounted the skin, are restoring the markings obliterated when the skin was tanned" (1940, 232).

[52] 1940, 229

[53] 1940, 241

[54] 1941, 90

Just before he examined the Fire Island whale shark, the museum had been gifted a carcass for mounting. Gudger watchfully oversaw the mounting process, fretting over every detail. He even called in the great naturalist William Beebe to confirm that the spots and bars that were to be painted on the shark's skin would be true to life (its skin had faded in the tanning process). When the mounted shark was finally unveiled in 1936, it was a creature of such *grace and beauty*[55] that Gudger felt his life-long quest had at last been *consummated* .[56] It was a *wonderful thing to behold.*[57]

Whale sharks stirred his imagination, excited him, broke his heart, fulfilled him. E.W. Gudger never did marry; he dedicated his life to the study of these gentle-mannered leviathans, colossuses, monstrous apparitions from the deep.

At his request, the word "ichthyologist" was carved on his tombstone.[58]

[55] 1940, 232

[56] 1940, 233

[57] 1940, 228

[58] Crittenden, 382.

Epistemological Dilation and Ontological Suspension

These fables of attention present Gugder's eclectic objects—teratological flounders, Jenny Hanivers, whale sharks—as artifacts belonging to the same practice of marvelous empiricism. The objects were not (only) marvelous in and of themselves, but became so in their encounter with Gudger's passionate attention. Twisting and turning his objects, Gudger always found the most marvelous angle to present—making a flounder into a Cyclops and a hammer-head into a "monstrous apparition from the deep." In an article on a rusty dab with a patchy belly, Gudger wrote: "Whether the scales in this region are albinistic or whether the thin colored epidermis has slipped from the scales I cannot say positively, but I am inclined to think them albinistic" (1935b, 4). Faced with the choice between the marvelous (albino dab!) and the banal (degradation of the specimen), Gudger's inclination, his proclivity, his tendency was almost always towards marvelous, overshadowing the more orderly scientific practices of systemizing and explaining. Gudger was more chronicler than classifier, always on the look-out for new oddities to catalogue and describe. His practices of seeing, investigating, and interpreting were permeated through-and-through by his insatiable wonder-lust; the typically robust categories of the normal, abnormal, and fantastical began to buckle under the pressure.

It was in his articles where he opens up wild facts to scientific inquiry, the genre I am calling his "unnatural histories," that was best suited to this curious mode of attention. Investigating phenomena that were mysterious, dubious, or unconfirmed necessitated an approach that was not mired (at least not initially) in ontological classification. In "How Rats Transport Eggs," Gudger begins with

an agnosticism about whether the egg-wagon phenomenon is normal, abnormal, or fantastical, an agnosticism he maintains even at the end: "Waiting for photographic evidence of the rat-egg-transport, I shall keep an open mind." In the absence of the definitive category, Gudger is free to breathe into the epistemological dilation, to take into evidence, not just scientific accounts, but fables, anecdotes, drawings, and other not so scientific lore. It is this suspension of disbelief (which is also a suspension of belief),[59] the upshot of what he calls "keeping an open mind," that gives him the freedom to fully engage his talents and appetites, to assemble his eclectic bibliography and to approach rats as creatures who could be capable of cooperating with one another to form a living wagon.

Rat Tales: Fables and Natural History

"The fable's anthropomorphism is the same as that of science; just the phyla are different"

-Michel Serres

As he follows the story through history, after the 13th century Persian manuscript, Gudger finds the next instance of the rat-egg-transport in the fables of the Early Modern French poet, Jean de La Fontaine. In a *discours* dedicated to his patroness, Madame de la Sablière, published in 1678, La Fontaine turns the story of the egg-wagon into a fable to refute Descartes' beast-machine hypothesis. Drawing on the empirical philosophy of Pierre Gassendi, La Fontaine derides Descartes for believing an animal to be "like a timepiece that keeps going/ with

[59] At the beginning I said that the power of a fable is not predicated on the ontological status of the characters. By refusing to give the egg-wagon an ontological classification Gudger gives his account a fabulous quality. The difference between La Fontaine's fable and Gudger's unnatural history is that Gudger is driven by the promise of classification.

constant regular motion, blind and devoid of intentions" (147). La Fontaine builds his argument by giving examples of the cunning of animals: a stag who evades hunters by tricking the hounds, a partridge who pretends she is wounded to save her chicks from predation, beavers who build dams and lodges, and foxes who wage elaborate wars against each other. Within the *discours* La Fontaine embeds a delightful apologue to further illustrate his argument. In "The Two Rats, the Fox and the Egg," a pair of rats perform the egg-wagon to escape a hungry fox, thereby demonstrating their capacity for reason. At the end of the fable La Fontaine triumphantly delivers the epigram: "After a story like that, let them come to me and declare/that animals have no intelligence" (155).[60] Fables, with their animal protagonists and rhyming morals are well-suited to challenge Descartes' totalizing "fable of the world" (La Fontaine, quoted in Fumaroli 396).

In this little apologue, La Fontaine adapts natural history into fable. In doing so, the rats themselves are canonized alongside Horace, Aesop, and Phaedrus, as *les sources de La Fontaine*, thus reworking the traditional parameters of the genre. Or, as Michel Serres would have it, drawing our attention to what the fable genre had been doing all along. Instead of employing animals as stand-ins for human morality, La Fontaine presents what he believes to be real rat behavior to reveal the hubris of human exceptionalism. Neither the rats nor the fox speak, setting the style apart from his other fables. Rather than presenting the rats as humans dressed up in the skins of animals, La Fontaine evokes sympathy through descriptions that emphasize the parallels between rat lives and human lives. In

[60] In French, of course, these delightful lines rhyme "Qu'on m'aille soutenir, après un tel récit/ Que les bêtes n'ont point d'espirit" (154)

the hands of La Fontaine the rats become people (*gens*) taking their dinner to their home (*habitation*) while trying to avoid an unfortunate and uncomfortable encounter (*rencontre incommode et fâcheuse*) (154). In this way he asks us to consider the subjectivity of rats, making his readers curious about *how* they think rather than *if* they think. By rearranging the way that fables have traditionally linked up humans and animals, La Fontaine complicates and enriches our understanding of what a fable can do.

As Gudger picks up the fable, the way that he writes about rats echoes La Fontaine: "Living in and around the habitations of men, [rats] have learned most skillfully how to despoil him of his food. Some of these ingenious ways of securing this food almost bear the marks of reasoning" (415). Although his sources include titles such as "Rats and Mice as Enemies of Man" and "The Rat: Its History and Destructive Character," Gudger is taken with their cleverness and curious about what they are capable of.[61] As he introduces La Fontaine into his investigation, Gudger adapts fable as natural history, cultivating a wild fact that had long since gone to seed. To call this an *unnatural history* then does not oppose it to natural history; it cannot be pigeonholed as merely fictional because it takes fables seriously. Remember, La Fontaine based his fable on natural history, on

[61] As Jonathan Burt notes in *Rat* (Reaktion Animal Series), since the 17th century most naturalists displayed a great deal of rat-hate as they studied the morphology and behavior of the rodent. Cuvier, for example, wrote in 1817: "These animals are extremely noxious both due to their fecundity and the voracity with which they gnaw and devour the substances of the whole of nature" (quoted in Burt 43). Rats are overwhelmingly represented as thieves, as dirty, and as possessing boundless appetite and reproductive capabilities (40). Rats as phobic objects and rats as scientific objects were not easily disentangled (47). Gudger's curiosity about rats marks a departure from this tradition. After giving talks on this material, people who "study vermin" have come up to me to say that they were touched by the illustrations of La Fontaine's fables and Gudger's descriptions.

what he believed to be actual animal behavior. Gudger's unnatural history, in the tradition of La Fontaine's rejoinder to Descartes, draws our attention to the intermingling of real and figural animals in science and fable. And because we do not know whether or not the egg-wagon is real or fictional, Gudger's unnatural history stages these rich citational and relational histories, as opposed to the erasure that would occur if it was classified as ahistorical fact or "mere" folklore.

Acknowledging the intermingling does not create an epistemological impasse; rather, this mixture of the real, the figural, science, and fable, is the very condition of possibility for knowledge about animals. Natural history is a science of description and classification and therefore deeply rooted in its print tradition (Nyhart 433). Writing is integral to actually *doing* the science, not just representing it *post facto*. Gudger's compilation of references for Bashford Dean's ambitious *Bibliography of Fishes* was just as important as his contributions to the collection of specimens in The Department of Ichthyology at the AMNH.[62] David Starr Jordan, peace activist, eugenicist, and most famous ichthyologist of his generation ("The Nestor of American Ichthyologists"), wrote of the *Bibliography of Fishes*: "It is majestic, commanding, and above all, insistently useful. No one in the future can attempt research in ichthyology without having these volumes at

[62] In fact, his articles (most of which are preserved perfectly on JSTOR) are far more useful and enduring than his specimens. His fish had the terrible habit of falling apart or disappearing (1935b, 1941). Here is what happened to four different abnormal flounders: "It came up from Norfolk frozen, and unfortunately was not thawed out before being placed in alcohol. And more unfortunately it was not pinned out on a board during the pickling process. As a result it has become badly crumpled and twisted." (1936, 5); "It was received in apparently good condition, but it went to pieces badly when put into alcohol" (1935b, 3); "Gudger (also crowded with work) did not properly defrost the specimen and because of its large size put it in a tank of strong salt solution instead of alcohol. As a result of these two errors, the epidermis began to slip and the fish showed signs of breaking up" (1937, 6–7); "In the process of cleaning the fish for freezing, the head and abdomen had been cut up badly" (1941, 28).

his elbow" (17). Citation of "the literature," relying on descriptions, diagrams and photographs from decades or even centuries ago, is absolutely necessary for studying fish.[63] As Gudger examines La Fontaine's fable he is working inside this literary tradition of ichthyology, a tradition that he is especially familiar with as an expert bibliographer.

Citation is also an important characteristic of fables. Old stories are translated, adapted, repeated, memorized, and their morals circulated in popular speech. In the precursor to "How Rats Transport Eggs," entitled "Animal Carts: How Marmots, Badgers, and Beavers Serve as Sleds or Wagons," Gudger explains how the reports of these mammalian behaviors from Pliny to the 20th century can easily be interpreted as fable rather than natural history: "These accounts from old books may of course be set down as fables, each probably having its origin in its predecessor, the ultimate source being Pliny's story" (156). But, like Michel Serres, he refuses to close off the possibility that the stories an origin in or a relationship to animal behavior. Speaking of Pliny, Gudger writes: "Where *he* got his account, no one can say" (156, italics original). Though the referent is untraceable, Gudger leaves a space of possibility in its absence. To claim that it's *just* a story denies any evidentiary potential it might have, something Gudger was not entirely prepared to discount.

If real rats cannot be definitively and finally separated from fabulous ones, then unnatural history is not simply fictitious (the chaff separated from the

[63] In 2007 J.D. Stevens wrote, "Ironically, both Gudger and [Fay] Wolfson died without ever seeing a live whale shark in the wild" (4). This fact would not seem so ironic if Stevens understood the importance of bibliography in the history of natural history.

wheat in the centuries since Pliny). Using a definition of "unnatural history" that refuses to separate historical fact from fable, we might ask: What kind of ethology is Gudger doing in his unnatural histories? How does his engagement with these eclectic sources enrich our understanding of what it means to do natural history?

Omnivorous Biology, Bibliographic Pleasures

Known in the field of ichthyology as an "indefatigable chronicler" (Wolfson and Notarbartolo-di-Sciara 1980, 1) with a "characteristically encyclopedic approach" (Hubbs 1940, 272), Gudger's research practice involved amassing literature and first-hand accounts, seeking out all possible sources relevant to lay down the matter at hand. Even on subjects that were not germane to his current projects, he was, by all accounts, an insatiable reader. In a letter to *Science* on the controversy over whether the magazine should arrive with its pages trimmed or untrimmed he writes: "I find my weekly copy of *Science* so interesting that I invariably read it clear through, and I do not want to be delayed in getting at its contents by having to cut its pages" (216). It appears that his desire to read the articles inside was so great that he was unwilling to take a moment to locate his scissors and make a quick snip.

Although he kept searching for conclusive evidence,[64] documented methodically by a "scientific man," what enabled his unnatural histories is precisely the absence of this definitive source, the photograph with the promise

[64] Of course the photograph is a historically specific kind of conclusive evidence. In the Photoshop era, it's hard to imagine that a photo would convince naturalists of the existence of this phenomenon.

to release him from the story. In the context of natural history, the impossibility of the perfectly conclusive evidence is clearly a frustration. In fact Gudger critiques Pliny the Elder (!) for being uncritical and including "a great deal of hearsay data" (270), while still admiring his *Historia Naturalis* as the most popular natural history book ever published (a conclusion he reaches by actually counting every edition published since the invention of the printing press).[65] However, the genre of unnatural history showcases just what bibliographic pleasures made themselves available in the absence of conclusive evidence. Reading Gudger's articles one feels the pleasure of unbridled investigation win out over any frustration with uncertainty. Removed from a positivist teleology, his unnatural histories demonstrate the full range of his passionate craft.

Lacking the egg-wagon stable and secure inside a photograph, Gudger voraciously seeks ethological clues from any source he can find. Nothing is off limits. At his most inventive, he lovingly reads the illustrations inspired by La Fontaine's fable for useful details noticing that this "rat has wound his tail around the base of the tail of the other to give him a better purchase" (421), that rat has "his head and neck lifted clear off the ground holding tightly onto the egg" (421), even that one rat has a "happy expression" and a tail with a "cocky attitude" (422).[66] Such a compelling mystery demands an unorthodox and omnivorous approach.

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[65] Interestingly, the authors of the *Whale Shark Bibliography* (1980) charge Gudger with the same oversight: "Most of the 47 entries authored by E.W. Gudger are reiterative, and often careless rehashes of whale shark encounters that were reported to him" (1). They also accuse him of "repetitive narration" and "speculation." It should be noted that some of their least favorite articles are my most favorite (especially Gudger 1940).

[66] These are quotes from his figure captions (reproduced in my Figures 1.2 and 1.3). Look at how, for example, he wants us to "Note the happy expression on the countenance of the second motive-power rat." Here he uses the scientific convention of drawing the reader's eye to one part of the figure in the context of these fable illustrations.

Gudger also includes in his bibliography accounts that he believes to be "dandy stories" (418), "tall tales" (420), and "intended for a hoax" (418). Writing in the genre of unnatural history Gudger finds a place for the history and appreciation of the tall tale within scientific inquiry. As with the Jenny Hanivers that did not prove the existence of humanoid sea monsters, these tall tales cannot be thought of as confirming or refuting the existence of the egg-wagon behavior, but rather, they act as *a different kind of evidence*. They make up the body of lore in which this unnatural history has flourished. Examining these marvelous artifacts gives *him* a better purchase on the phenomenon he seeks to understand.

Gudger not only shows the breadth of sources that might constitute evidence in the egg-wagon case, he also demonstrates the function of imaginative leaps in scientific bibliography. When he encounters a substantial gap in the history of the egg-wagon story between 13th century Persia and 17th France, he engages his imagination: "One questions at once how [the story] got to Western Europe. Could it have been through the Arabs and Moors? This is conjecture only" (420). As Gudger wonders where Ibn Bahktishu, the 13th century Persian scholar, heard about or witnessed the egg-wagon he invites his reader to fabulate with him: "Surely the imagination has free play here" (420), he writes. Like many of the other articles that appeared in that May 1935 issue of *The Scientific Monthly*—those that traffic in tales of discovery, exploration, and travel—Gudger works within the rhetorical tradition of wonder in natural historical writing; he invites the reader to marvel at the wondrous evidence he has gathered and to share in pleasures of compiling a bibliography and provisionally filling in the gaps with

imaginative speculations while still leaving them as gaps, places where the bibliography can grow.

Another kind of bibliographic pleasure is palpable in "Animal Carts" as Gudger reads Edward Topsel's 17th century English translation of Conrad Gesner's 16th century "History of Four-footed Beasts." Here is the quote about the badgers acting as wheelbarrows Gudger takes from Topsel:

> When they dig their den, after they have entered a good depth, for avoiding the earth out, one of them falleth on the back, and the other layeth all the earth on his belly, and so taking his hinder feet in his mouth, draweth the belly-laden Badger out of the cave, which disburdened her carriage, and goeth in more until all be finished and emptied. (155)

Gudger writes: "Note here Topsel's delightful indifference to the sex of the badger wagonette and his quaint spellings- I love his avoiding" (155).[67] Neither the mistakes (switching badger pronouns) nor the old-fashioned language (avoiding instead of voiding) are useful for determining the behavior of the badgers, but the appreciation of these literary quirks can be, nevertheless, a vital part of working with historical texts. And perhaps enjoyment of such savory details (seemingly extraneous to the biological research itself) is part of what makes one person a good bibliographer and not another—it allows him to sustain careful attention.[68] In this example Gudger is looking for specific information on the sex of the animals dragging and being dragged, and is surprised (and then delighted)

[67] To add to the *mise-en-abyme* of bibliographic pleasure, I love that Gudger loves this. I love that he wants to share that he loves it. I want to share that I love it, too.

[68] Daston and Park describe wonder as "bait and motivation for intense efforts of attention" (311). Gudger's delight in working with historical texts was vital to the intensity of his bibliographic practice.

to discover that Topsel didn't really care about this particular detail.[69] Bibliography is partly a practice of active imagination and the enjoyment of the surprises of reading. The genre of unnatural history allows him to indulge in these pleasures that drive his bibliographic practice, but are less visible in his more retrained natural histories.

Empiricism and Enchantment

Even within this playful investigation, it is important to note how Gudger continues to grapple with the question of whether rats actually engage in this curious practice. As in his bibliographic work with natural history, he reads the egg-wagon accounts carefully to see what empirical information he can glean from the details. He dismisses the story of rats acting as a "living egg chute" (418) after a meticulous analysis of the mechanics of the alleged technique. In this story, from the *Saturday Evening Post*, a host of rats climbed a gas meter in a warehouse, jumped onto a platform, and stole dozens of eggs sitting in a crate by forming a chain with their bodies from the platform to the floor and passing the eggs down the chain. Gudger recounts the story complete with the measurements provided by the author: the gas meter is 4–5 feet higher than the platform and 8–10 feet away from it, while the platform is 8 feet above the floor. Before moving onto his analysis Gudger quotes from the newspaper article and embeds question marks to signal which details pique his suspicion:

[69] We can see Gudger trying to infer information about the sex of rats doing the egg-wagon as he recounts a 19th century version of the egg-wagon tale: "Two rats, one large (male?) and one small (female?) were the discovered culprits" (416)

> When they had gained the platform, these rats formed a chain to the floor, forelegs linked to hind legs [like the bridge alleged to be formed by monkeys over the streams in South America]. It was a chain long enough to extend in an easy hollow curve [?] to a point on the floor some distance [?] from the platform, and the last rat lay on his back. When this living egg chute was in place...things began to happen to those eggs. One by one they were lifted [?] from the crate, dropped [?] to animals on the platform, passed safely down the rat chain [in which all paws were occupied in holding fast] and away into the darkness of various rat holes. (J.H. Collins quoted in Gudger 418, comments in square brackets are Gudger's, the ellipsis is mine)

After inscribing his doubts into the original text, he lays[70] into the story with empirical glee:

> To be explained are an 11-foot jump out and away with a 4 or 5 foot drop onto a platform; the lifting of eggs out of a crate presumably 6 or 8 inches deep; the method of the formation of this living chain; the tremendous grip on the edge of the platform exerted by the paws of the topmost rat necessary to support a 9- or 10-foot ("an easy curve") living rope of rats; the passing of 20 or 30 dozen eggs down this "living chute" of rats, each of whom was desperately holding on to the rat above with one set of paws, and the other below with the other set; and finally the method of dissolution of the living chain with safety to its component rats. (418)

Gudger's analysis is systematic and precise. He moves chronologically step-by-step from the beginning of the caper, "the formation of this living chain," to the end, "the dissolution of the living chain with safety to its component rats." He also moves through the story spatially from top to bottom: from just the paws of the topmost rat to the whole rat and then down the rat chain, each holding onto the next first with the forepaws and then the hind ones. Given that the rats have no way to pass the egg down the chain because both sets of paws are occupied, to

[70] Donna Haraway drew my attention to the repeated use of the verb "lay" in Gudger's and my text. With little mention of victims of the egg-wagon (the hens), perhaps what we have is a return of the repressed.

move through every other detail accompanied by exact measurements surely constitutes "empirical overkill," to borrow a turn of phrase from James Clifford (1986, 102). In the end (of course), he concludes that it is a "dandy story," "gorgeous in its ensemble, but faulty in its details" (418). Gudger is unwilling to believe or disbelieve any of these tales without a (ridiculously) minute examination.

When it comes to the central question of his article, do rats, in fact, transport eggs using the wagon technique, Gudger leaves us with this empirical examination:

> It is interesting to note, what many readers have surely already had in mind...the fact that all accounts and figures have the rat-wagon pulled against the lie of the hair. This of course adds greatly to the friction. However, the tail offers a fine holding-on piece, much better than ears and snout. (424)

The excessive friction of the egg-wagon may put the plausibility of the practice into question but this empiricism does not disenchant. Here Gudger's relentless literalism also bestows a fabulous quality to the account. There is the delightful provocation to think of a rat tail, a rat ear, a rat snout, as a potential "holding-on piece." The subject doing the holding is tantalizingly omitted, luring the reader into the scene of the rat-egg-transport. The obsessive empiricist turns out to be the enchanting fabulist. And here, it must be noted, fabulist emphatically does not mean "liar." It is through empirical analysis that Gudger's conjures the fabulous, not in spite of it.

Unnatural History of Science

As they describe the marginalizing of wonder after the Enlightenment, Daston and Park argue that the progressivist history of science tames the pleasure and especially the horror of the marvelous: "Scientists have yet to explain all, perhaps most, wonders, but they subscribe to an ontology guaranteeing that all are in principle explicable" (365). Despite the power this progress narrative has in post-Enlightenment science, wonder interrupts it, if just fleetingly. In the absence of "photographic evidence of a rat-egg-transport," the rats are enriched by speculative possibility; they become transportation technology (i.e. wagons), desiring subjects, characters in fables, historical figures, and objects of empirical investigation. Rapt in the moment, *waiting* for photographic evidence, there is a deferral of the teleological guarantee that the egg-wagon will either be explained or explained away. In the words of Stephen Greenblatt, "wonder continues to remind us that our grasp of the world is incomplete" (24). We see Gudger articulating this same sentiment as he cites Shakespeare in the last line of "How Rats Transport Eggs": "There are more things in heaven and earth than are dreamt of in our philosophy" (424).

The ontological commitment to a "non-human world [that] always expresses more than our understanding provides"[71] give us an unnatural history of science, unnatural because we are so accustomed to the story of linear progress. The future is no longer the only locus of openness and freedom—our pasts and presents are alive with opportunities to know and to relate differently. One of the

[71] I borrowed this turn of phrase from a talk abstract by T. Hugh Crawford. See Chapter 3 for more exploration of this exuberant ontology.

epigrams in the *Bibliography of Fishes* (perhaps chosen by Gudger!) nicely evokes this alternative orientation: "The history of science is the palladium of its freedom; it prevents it from being tyrannized over by narrow bigoted viewpoints." As opposed to Vannevar Bush's conception of science as "endless frontier" (1945) where the past is impoverished and must always be supplemented, for the ichthyologist-bibliographers the past is not only rich with the knowledge of many lifetimes, but can interrupt and humble our present perceptions.

Gudger's unnatural histories allow for the cultivation and care of this alternative historical and epistemological impulse. In an article on Gudger's investigation into rains of fishes in *Popular Science,* the author boldly claims that "modern scientific investigation has solved another of Nature's mysteries" (Martin, 108); however, rains of fishes to this day remain a wild fact.[72] Similarly I have not been able to find any further scientific evidence (photographic or otherwise) for or against the rat-egg-transport since the publication of Gudger's article in 1935. Neither exactly confirmed nor debunked, *mirabile dictu*,[73] Gudger's unnatural histories still resist the ontological guarantee that Daston and Park describe.

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[72] In "Creation Myths and Epistemic Boundaries" Daryn Lehoux argues that the historical "just-so" story about humans moving from supernatural explanations to natural explanations is both false and unproductive. Instead he asks, "Why do we need to see a birth of philosophy or of science as a *way of thinking* rather than a *genre of writing*?" (32). *Popular Science* reads Gudger's article in the historical mode Lehoux critiques. However, this unnatural history (which I suggest is a genre of writing) resists this reading; it uneasily holds together the folkloric history and empirical inquiry.

[73] *Mirabile dictu* (miraculous to say) originally comes from Virgil's *Georgics* and has been used throughout the centuries to transmit wonder from author to reader, fostering an economy of attention (Biow 2–3). For example, I just happened upon a 1938 article by Benjamin Whorf that starts: "Here, wondrous to relate, was an exotic language [Hopi] cut very much on the pattern of Indo-European" (275). Whorf invites us to share in his ethnographic pleasure, his surprise in finding the familiar inside the exotic. Here I invite you to share in my own epistemological dilation.

Wonder and Ethics

E.W. Gudger teaches us to take the wonder that informs his empiricism seriously. A lot has been said about the "waiting for photographic evidence" aspect of scientific practice; Gudger's unnatural histories provoke us to consider the critical possibilities of "keeping an open mind." If we stay with wonder as epistemological dilation, as an openness that disrupts narratives of progress what becomes possible?[74]

In "The Body We Care For: Figures of Anthropo-zoo-genesis" Vinciane Despret explores an ethics of ethology based in openness. She argues for an ethos of experimental design that privileges availability over docility: "An apparatus that does not have a stake in docility is an apparatus that is designed to give the opportunity to the 'subject' of the experiment to show what are the most interesting questions to address to him; what are the questions that make him/her the most articulate?" (124). In Gudger's bibliographic ethology, he is not testing his hypothesis on flesh and fur rats in a cage; he is not an experimentalist.[75] But it could be suggested that the availability Despret is concerned with is still at play. Gudger's ethology, with its evidential eclecticism, is made possible by not taking for granted nor deciding too quickly what is a real and what is a

[74] Since Linnaeus came to mark the beginning of natural history as a proper science ("the international date line of zoology" according to Gudger 1936, 253) Gudger wrote an unnatural history simply by including the work of Gesner and Aldrovandi as part of the living history of ichthyology.

[75] Though experimental and genetic methods are currently privileged in biology (and have been for the last half century), older methods like description and classification continue alongside them, though constantly under threat of losing their status at "science" (Secord 449). To give an idea of the changing topography of what counts as biology, Edmund B. Wilson, a contemporary of Gudger's, divided biology into "bug hunters" (field naturalists), "worm slicers" (morphologists), and "egg shakers" (experimentalists) (Nyhart 440). Despite non-experimental methods being out of fashion, the *Journal of Morphology*, where Gudger published his major flatfish article, is still very much in print today.

fictional rat. Gathering up the textual traces of the egg-wagon behavior and inviting new first-hand accounts, Gudger opens up a question about the abilities of rats that had ceased to be asked seriously long ago. He gives the rats a chance to be articulate.

Here there are some interesting affinities with La Fontaine's egg-wagon fable. Concerned that Descartes' model closed off the world, took away the "colors" of subjective experience, and "had poetry by the throat," La Fontaine used the genre of the fable explicitly to contest Descartes' "fable of the world" (La Fontaine quoted in Fumaroli 398). La Fontaine deploys fable as "instructive wonder" to suggest that rats and other animals are not just objects (beast-machines) but subjects who have the ability to feel and to judge. Gudger's articles, especially the ones he wrote later in life, display a similar sensibility. He wrote articles on "Feline Fishermen," "Fishermen Bats of the Caribbean Region," and "Fishes that 'Play Leapfrog'." Like La Fontaine's gentle anthropomorphizing of the rats taking their dinner to their home, Gudger's descriptions and explanations of marvelous animal behaviors invite a critique of human exceptionalism through sympathy.

In his article "Does the Jaguar Use His Tail as a Lure in Fishing," Gudger assembles accounts from indigenous people and explorers of South American jaguars tapping their tails on the surface of river water to summon frugivorous fish, who mistake the perturbation for falling fruit. Once at the surface, the fish make an easy meal for the jaguar. Providing an explanation for how this behavior evolved, Gudger turns to the house cat. "Cats are intelligent animals" he writes, "that this is true the animal behaviorists have shown with their trapdoors, mazes, and other experimental paraphernalia. Their cats learn by experience"

(44). He notes (delightfully): "The [cat's] twitching tail tells the story of her pleasurable anticipation. The tail is the cat's most emotional member" (44). Putting these observations together he suggests that cats (big and small) might learn to summon the fish by accidentally flicking their tails in the water while watching swimming fish; when the fish come to the surface, they quickly intuit the pattern: "How long would it take this observant and intelligent animal to form such a fishing habit?" (45).

Perhaps unsurprisingly, Gudger attributes this kind of intelligence and emotion not only to mammals like rats and cats but to fish as well: "When one comes to study the habits of fishes—animals at the bottom of the vertebrate tree—the extraordinary things that they do would fill a book" (48). Contrary to the animal psychology of his day, Gudger suggests that fish might experience emotions in his article "Some Instances of Supposed Sympathy among Fishes." Of the leapfrogging fishes Gudger writes: "To me this savors as play as well as possible utility" (1944, 463).[76] In the case of his beloved whale shark "using fishermen's boats as back scratchers" (1941, 567) he writes: "It may be conjectured that this is from playfulness or that it is a manifestation of amiability as is displayed by a friendly housecat" (562). These descriptions of amiability, playfulness, emotion, intelligence, and pleasure would not be out of place in La Fontaine's fables. In sensitive passages like these it is possible to see how wonder as a mode of attention and epistemological dilation fosters a distinctive and

[76] We also see examples of animal agency that blur the line between behavior and choice. Speaking about how many reversed specimens of *Platichthys Stellatus* there are, Gudger writes that he has never encountered "a flatfish so indifferent as to what side it lies upon" (1941 29). He goes on to refer to the whole species as "ambidextrous" (1941, 29). This species-agency he conjures through slight anthropomorphizing is highly suggestive.

sometimes radical curiosity about animals in the writings of a fabulist (who was also a bit of a scientist) and a scientist (who was also a bit of a fabulist).

Wonder and Exoticism

However, as Early Modern historians show, possession and appropriation have accompanied wonder as often as curiosity and respect (Greenblatt, Findlen, Daston and Park). During the same time period exhibitions of human difference functioned quite differently than Gudger's work on fishes. In her chapter "The Culture of American Freak Shows, 1835–1940" Rosemarie Garland-Thomson describes how the freak show became a site where the display of abnormal human bodies presented the public with "the opportunity to formulate the self in terms of what it is not" (59). For Garland-Thomson human freaks functioned as the constitutive exclusion of American identity; freak shows exhibited "America's need to ratify a normative identity by ritually displaying in public those perceived as the embodiment of what the collective America took itself *not* to be" (59). Here wonder (which is paired with delight and revulsion) does not act as "epistemological dilation," making the public curious about the lives of these people. Rather the freaks are reified into symbols of otherness, who are to be gazed at but are not to gaze back, who are to be talked about but are themselves mute. The freak show is an apparatus that has a stake in docility rather than availability. There, the categories of the normal and abnormal, discussed above, take on more of an obvious moral charge, turning them into the normal and the pathological, the deviant, the Other.

And, of course, even when talking about fishes, these categories are never

neutral.[77] In Gudger's scientific rhetoric, we get natural history as monster hunting, and monster hunting as "good sport." At play is a familiar style of boyish masculinity, in which the scientist is figured as explorer, hunter, and detective. For example, the same man who suggests that fish might feel sympathy and enjoy playing leapfrog, also writes, "swordfishing, or more properly, swordfish hunting, is such a romantic undertaking and such good sport" (48). Amplifying the virility of the activity by calling it hunting rather than fishing, we get a sense of Gudger's participation in the culture of the American Museum of Natural History in the early 20th century, what Haraway provocatively calls "Teddy Bear Patriarchy" (1989, 26–58).[78] Although most of Gudger's own specimens were collected by accident, by others fishing for their livelihoods or pleasure, who noticed an abnormality and sent it to him, he could conjure this sense of adventure in even the most mundane places. Gudger chose the title "A Bibliographer Turns Detective" for his article describing how he tracked down a particular reference that he needed for his research. In the article, Gudger captures the romance of swordfish hunting in the practice of bibliographic research (on swordfish hunting). Within this style of natural history, what is at stake is an exotic constitution of reality, where the orders of nature being carved out by spectacular difference and the swashbuckling it takes to capture that difference, in the jungle, under the microscope, or in the archive. Speaking of a two-headed brook trout, Gudger writes: "It was clear that this unusually large monster would be a great prize to a fish teratologist" (1938, 206).

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[77] In his flounder articles Gudger sometimes refers to abnormal specimens as "freak fish," drawing attention to the resonances between the museum and the freak show.

[78] See Figure 1.1 and 1.11.

Although the differences Gudger describes are not as easily mapped onto race, sex, and class as the displays in The African Hall at the AMNH (Haraway 1989), an obsessive lust for cataloguing freakish specimens is a prevalent and disturbing facet of his empirical practice. And although reading Gudger's articles through Daston and Park's grouping of wonder/curiosity/attention is helpful for drawing out the ethical promise of his work, this web of wonder also extends back centuries to colonial collecting practices and across (just a few pages) to the picaresque account of A.S. Pearse's trip to Siam (see footnote 23). In the end, it was probably both his propensity for cultivating wild facts *and* his ability to write in the style of the epistemological adventurer that made him a widely published ichthyologist. In the foreword to the parasitic catfish book, pathologist Aldred Scott Warthin identifies both these qualities of Gudger's work:

> Dr. Gudger has a decided flair for the picturesque in science, as well as for the cold blooded facts [...] With a delightful curiosity concerning the unusual in science, he displays great assiduity and zeal in collecting from the literature all of the facts recorded bearing upon a given case, and assembles these into interesting and entertaining tales that have all the intriguing atmosphere of a detective story. (xiii)

Though my own reading of Gudger has, I hope, upset the opposition between "the picturesque" and "the cold blooded facts," Warthin's endorsement points to the way that his writing successfully mobilized the charismatic scientific narratives of the time, presenting exotic objects for his colleagues to wonder at. And since there is just so much at stake in how we respond to and narrate difference, it is hard for me to claim that wonder as a mode of attention to difference as seen in

the work on E.W. Gudger is somehow an inherently ethical scientific passion.[79] But, the trouble and the delight can be held together within the space of my fable. Gudger, as an abnormal, normal ichthyologist with his normal abnormal normal abnormal flounders, need not be my Francis Bacon, nor my Barbara McClintock (Keller 1995). Like La Fontaine's fable of the ant and the cicada, perhaps the enjoyment of the story does not rest on making a final judgment.

Conclusion: The Power of Fables

Uneasy with the exotic fetishism inherent in this marvelous empiricism, but unwilling to abandon the epistemological and ethical promise of wonder, *I wonder if* the potential is located in the fable itself, in the unnatural history. And in the inter-subjective genre of the fable, its promise is not in its fixity but in its movement: in the citation, adaptation, and dissemination.[80] The egg-wagon story, passed from hand to hand over centuries, is in fact, many stories. A simple tale about two rats carrying an egg home for dinner holds a multiplicity of possible tellings: In La Fontaine's hands it is a scientific fable to oppose the clockwork menagerie of a celebrated philosopher, in Gudger's hands it becomes a bibliographic ethology to reopen an empirical question about the cleverness of rats, and, cupped gently in my own small hands, an epistemological fable about wonder and empiricism in the scientific practice of an imaginative ichthyologist, a way to bring the insights of Early Modern historians to the affects and ontologies of other times and places. With each telling, the fable changes,

[79] In Chapter 3 I open this question up again to investigation.

[80] For a visual example of this citation, see Figures 1.2 and 1.3. These are 19th century illustrations of a 17th century fable, annotated by a 20th century ichthyologist, cited by a 21st century STS scholar.

creating new "attachment sites" (Haraway 2008, 36), different ways of relating to/as subjects and objects.

Inspired by Donna Haraway's invocation to "attend lovingly to stories" (2004, 201) as part of a robust politics of knowledge, I have recently taken some steps to share the egg-wagon story, to facilitate its movement. I sent an e-mail to the producers of Coast to Coast AM, the paranormal radio show of which I have been a long time listener.[81] I asked if I could appear on the show to tell the egg-wagon story and "make an appeal for references to accounts of rats moving eggs and for first-hand information thereon" (Gudger 1935, 423). It's a call-in show with over 11 million listeners each week. I am hoping that the Coast to Coast listeners, these nocturnal caretakers of our unnatural histories, will have some of their own stories to share with me (and maybe even some photographic evidence!). By inviting the listeners to participate in my project, I hope to learn more about rats and rat stories, in order to keep Gudger's empirical question open through the practice of storytelling. Even if I don't get any good calls, I'm sure the audience will love Gudger, his rains of fishes, his Jenny Hanivers. Plus, I have every reason to believe that the egg-wagon, with its nimble charismatic agency, will thrive, mutate, and grow without my help; I like to believe that rats themselves will take care of that, despite the friction of their fur. Their tails and tales are, indeed, good holding-on pieces.

To conclude my own version of the fable, the one about wonder as an empirical passion for and mode of attention to the marvelous, that induces

[81] The e-mails I have sent have so far gone unanswered. I kept this paragraph because this is still something I would like to do. With PhD in hand, I will approach the producers again.

epistemological dilation, that creates ethical availability and determines what counts as evidence, I will turn my essay over to Eugene Willis Gudger and let him deliver the epigram.

In one of his last articles, an article on the unusual fishing techniques of mammals he penned at age 87, under the heading, "Hold in Abeyance Judgment of these Allegations while Awaiting Scientific Evidence" (1953, 199), Gudger concludes by enlisting his readers to share in his project. At the end of his career, which was also the end of his life, Gudger speaks to us with the inter-subjective address of the fable. Drawing on his lifetime of experience as ichthyologist and bibliographer, he shares an epistemological moral—which is simply this: "Let us keep open minds" (200).

FIG. 10. A LARGE TIGER SHARK

THIS SPECIMEN OF *Galeocerdo tigrinus* IS SWUNG BY THE TAIL TO THE CRANE ON THE WHARF AT THE LABORATORY OF THE CARNEGIE INSTITUTION OF WASHINGTON AT LOGGERHEAD KEY IN THE DRY TORTUGAS, FLORIDA. NOTE THE PARTLY EVERTED GULLET DISCHARGING THE FEATHERS OF A WATER BIRD.

Figure 1.1: E.W. GUDGER Gruesome portrait with informative caption by Gudger himself. (Gudger 1932, 414)

FIG. 4. TWO RATS ARE DRAGGING THEIR LADEN FELLOW

NOTE THE HAPPY EXPRESSION ON THE COUNTENANCE OF THE SECOND MOTIVE-POWER RAT AND THE COCKY ATTITUDE OF THE TAILS OF BOTH.—FROM ST. JOHN, 1878.

FIG. 3. GUSTAVE DORE'S DRAWING OF THE RAT-EGG-TRANSPORT

THE MOTIVE-POWER RAT HAS THE TAIL OF THE EGG-WAGON RAT OVER HIS SHOULDER AS A MAN WOULD HAVE A ROPE TO DRAG A HEAVY OBJECT. NOTE THAT THIS RAT HAS WOUND HIS TAIL AROUND THE BASE OF THE TAIL OF THE OTHER TO GIVE HIM A BETTER PURCHASE.
—FROM LA FONTAINE'S FABLES, LONDON, 1878.

Figure 1.2 and Figure 1.3: **EGG-WAGON ILLUSTRATIONS** Two 19th Century Illustrations of La Fontaine's "The Two Rats, The Fox and The Egg." Captions by E.W. Gudger. (1935, 422 and 421)

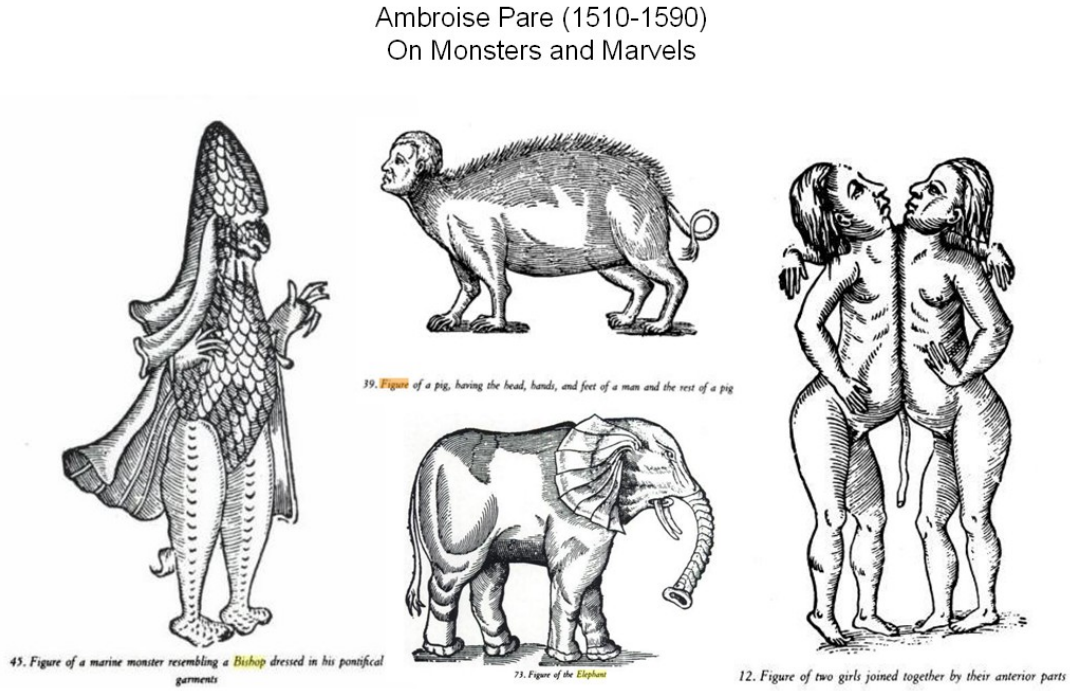

Figure 1.4: **PARÉ'S MONSTERS AND MARVELS**

CHAPTER 2

Disconcertment: Helen Verran's Relational Empiricism

"Theory can be a dew that rises from the earth and collects in the rain cloud and returns to earth over and over. But if it doesn't smell of the earth, it isn't good for the earth"
-Adrienne Rich

Modes of attention are practices of sensing, detecting, seeing, and knowing; they are also practices of **worlding** (Haraway 2008, Tsing 2010, Stewart 2011). The modes of attention we adopt as scholars are not only ways of perceiving and making sense of the world; they are part of the collective process of world-making. They are arts of inclusion and exclusion that give form to the subjects, objects, categories, narratives, entities, and forces that furnish our imaginations and populate our lives (Tsing 2011). Scholarly attention is by no means the most important activity in the sometimes beautiful, sometimes deadly "ontological choreography" that pulls worlds together and rends them apart (Thompson 2005); it is mundane and consequential, part of the ongoing dance of everyday life.

Helen Verran, the central figure in this chapter, is an STS scholar who has become keenly attuned to technoscientific worlding—not just the worlding of the communities she studies, but also how her own modes of attention contribute to making and un-making worlds. This is not (only) an empirical matter, but carries with it the ethico-political question: "Who or what is able to flourish in the worlds we are composing together?" As someone who has worked in places where epistemological flourishing had been troubled by longstanding colonial relations,

Verran found that she could not ignore how her own empirical and analytic practices were contributing in small ways to reinforcing or resisting these historical legacies. In her book *Science and an African Logic* (2001), which details her work with Yoruba and English counting in Nigeria, and her journal articles about Yolngu and Euro-American knowledge practices in Australia, Verran performs a **relational empiricism** (Verran 2007b, 179), where the "analyst [herself] is configured as an emergent part of the collective" (Verran forthcoming, 5)—a participant in the cosmopolitical activities of worlding (Stengers 2010, Stengers 2012).

Verran's relational empiricism grows out of an ontological proposition that has been generative in feminist science studies over the last decades: relational materiality (Law 1999, 4).[1] Working and playing with the empirical, theoretical, and narrative possibilities of this proposition, feminist science studies scholars have presented an inspiring array of technoscientific objects as materialized relations.[2] To conjure a world where *beings* emerge from *doings*, Donna Haraway writes that technoscientific bodies are "nodes that **congeal** from interactions" (1997, 142); Karen Barad tells us, "reality is **sedimented** out of particular practices" (2007, 390); Helen Verran explains that "what's real emerges in gradually **clotting** and eventually routinized collective acting, and not only human acting"

[1] This is how Verran accounts for the lineage of the term: "Relational empiricism is my name for a family of analytic framings that began to emerge in science studies and anthropology in the late 1980s: actor-network theory, sociology of translation; modest witnessing; Melanesian eversion; material semiotics; a postcolonial imaginary of emergence; baroque analysis, are some of the particular named versions that can be found in the literature" (Verran forthcoming, 4).

[2] e.g. Donna Haraway's genes (1997), Annemarie Mol's arteriolosclerosis (2002), John Law's TSR2 aircraft (2002), Karen Barad's quantum phenomena (2005), and Lucy Suchman's humanlike machines (2007).

(2001, 37).[3] Using metaphors that evoke the hardening of fat, grit, and blood, Haraway, Barad, and Verran offer us a repertoire of visceral tropes for conceiving objects and subjects, bodies and matter as outcomes, not essences. Relational empiricism is an analytic indigenous to this dynamic world; it asks us to confront the proposition of relational materiality in the context of our own research practices and to grapple with the politics of knowledge-making as world-making.

Accountability

Karen Barad's notion of **accountability** is helpful for imaging worldly research practices, research practices that are simultaneously empirical and ethical, that are about knowing *and* relating. For Barad accountability requires that we **provide accounts** of the material-discursive apparatuses that materialize our empirical objects (2007, 224). Like an expanded and complicated version of the "equipment list" or "materials and methods" section of a scientific paper, the idea is to track the material, historical, economic, social, political (etc.) relations that produce knowledge (including our own practices). The purpose of this extended equipment list is not just to provide accurate representations of how objects congeal, sediment or clot from relations, but to learn how to **remain accountable** for "what matters and what is excluded from mattering" (220) within the research apparatus. In other words, accountability demands that we consider the politics of our research practices, which includes critical attention to who lives and who dies, who suffers and who flourishes in the worlds we are making.

[3] Another trope: What Deleuze and Guatarri describe (sublimely) as intensification, Verran domesticates as felting, "the (largely irreversible) matting together of wool fibres" (2009, 171).

In Verran's decades working with Yoruba and Yolngu communities whose knowledge traditions have been and continue to be threatened by the epistemological standards of Western Science, we see accountability emerge in her work as a necessary condition for epistemological flourishing. For Verran epistemological flourishing is not about preserving indigenous knowledge in a pure or unchanging state, protected from Western science. Instead, it is about finding ways of "going-on together" (2002, 742),[4] even and especially in the wake of violent histories where communities have long been cut off from what sustains them. Deborah Bird Rose, who also works inside the legacies of Australian settler colonialism, thinks about this in terms of **resilience**:

> The term 'resilience' is used in a technical way by ecologists. It refers to relationships within ecosystems and is attuned to the instability of living systems...In human terms, resilience has a similar meaning, referring to the capacity of groups to sustain themselves in flourishing relationships with their environments, to cope with catastrophe, and to find ways to continue. (6–7)

Resilience is about adaptation and creativity, the ability to respond to change and to conserve the "relational order(s) through within and through which [collectives] have a life" (Verran forthcoming, 5). Central to Verran's work is her belief that knowledge-making practices are integral to how people sustain themselves in flourishing relationships with their environments, cope with

[4] Verran's term "going-on together" emphasizes both ongoingness and collectivity, where what counts as the collective is open and contingent. It is an explicitly political activity: "Choosing to arrange things for a going-on together, or a going-on only in *this* way, is a politics. It is a politics built either on trust and commitment to community here and now, or a politics of imposition, a commitment to a knowledge community that is not here and now. This later strategy amounts to an intimate form of colonizing" (118).

catastrophe, and find ways to continue. She is committed to participating in projects that strengthen resilience and make it possible to go-on together.[5]

This chapter follows Helen Verran as she struggles to remain accountable for the colonial inheritances of her empirical practices, in particular her modes of attention. It follows Verran as she narrates her shift from wonder as a mode of attention to an emergent mode of attention she calls **disconcertment**. As she shifts her attention, different objects, different stories, and different practices follow—objects, stories, and practices that are more promising for "going-on together" in the face of colonial histories. Through the course of this chapter, Verran provides us with an example of Karen Barad's accountability *and* enriches our ability to imagine what empirical accountability might look like. She shows how us STS research can participate in composing livable technoscientific worlds, offering up pieces of choreography that might help us to move a little more gracefully within own worlding practices.

Accounting for Counting: *Science and an African Logic*

From 1979–1986, Helen Verran lived and worked in Ile-Ife, Nigeria. She taught science teachers at the Obafemi Awolowo University and supervised them in primary school classrooms teaching the lessons that they developed together. Although the official language of instruction was English, the school children were able to speak and count in both English and Yoruba. Counting in Yoruba is different than counting in English. For example, Yoruba numbers are not based on a system of base-10 graphics, rather "the Yoruba series of number names

[5] As Deborah Bird Rose writes, "resilience works with connectivity and commitment" (49).

generates primarily around a base of twenty. Utilizing a secondary base of ten, and then a further subsidiary base of five, integers emerge" (55). Verran discovered this intricate system of numbers active in Yoruba life, yet, by government mandate, it was not taught in the classroom. Less than two decades after Nigeria's independence from the British Empire, advocating for local knowledge traditions felt timely and important. So Verran set out to argue for the importance of teaching Yoruba numbers alongside English numbers in primary school curricula.

Science and an African Logic (2001), published 15 years after Verran left Nigeria, is the result of this original desire to do postcolonial politics with numbers. The structure of the book stages Verran's long and difficult writing process, presenting her insights not ex nihilo but as emerging tentatively from ongoing engagement. It contains segments from an earlier manuscript called, "Numbers and Things," where Verran employed a cultural relativist argument in order to combat the colonial assumption that The Yoruba Number System was a primitive version of The English Number System. She argued that English and Yoruba number systems offer equally good ways of numerating. In her manuscript she argued that the difference between number systems was not hierarchical, as in 19th century colonial accounts, but based in different cultural histories of quantifying.

Despite her confidence that her work was politically important in that it showed the epistemological value of Yoruba numbers, Verran was unable to finish the first manuscript, feeling it "failed to deliver a useful critique" (20). *Science and an African Logic* both incorporates and comes to terms with the

failure of her first effort, in order to offer new possibilities for thinking of the lives of numbers in postcolonial times and places. We can see Verran working towards this explicitly in the sequence of its chapters. After introducing the challenges she faced writing *Science and an African Logic* and how she came to her current methodology, the book is divided into three sections. Each section consists of three chapters—the first is a chapter from her earlier manuscript, the second chapter decomposes the argument (as well as the objects) of the first by critiquing her unstated assumptions, and the third chapter develops an alternative account that does not rely on the same assumptions (Figure 2.1). Verran is clear that "the sequence of chapters in each section does not constitute a redemption narrative"; she "struggles to keep the tensions" (20).

These sequences of three chapters also explicitly stage Verran's accounting process, as she presents nuanced empirical and theoretical arguments about English and Yoruba counting. Although the arguments Verran makes could very well stand alone as a philosophical and anthropological contribution to the literature on numbers and mathematics, the recursive chapter structure emphasizes how Verran's distinctive *process* of theorizing is the vital force of *Science and an African Logic* and, as I will illustrate, becomes a distinguishing feature in her subsequent writing. In this chapter, I characterize this recursive methodology in terms of Karen Barad's notion of accountability in order to emphasize the relationship between empirical objects, modes of attention, and social theory in Verran's scholarship. In *Science and an African Logic* we can see her accounting practice at work in the way she uses the middle chapters in each section to trace the significant relations that materialized the empirical objects of

her original manuscript. As she makes her "equipment list," her objects are decomposed and then recomposed, demonstrating accounting not just as critique but as a re-signification and re-materialization practice.

From Wonder to Disconcertment: Decomposing The Yoruba Number System

In the first set of chapters (3, 4, and 5), Verran accounts for some of the relations that materialized the most prominent object in her original study, "The Yoruba Number System." In Chapter 3 Verran describes The Yoruba Number System: it is a multi-base system; it had been a strictly oral system until the 19th century; it is made up of words that generate numerals rather than graphics that represent them; vowel harmony and elision are important for numeral generating; small numerals are expressed using standard words, but there are multiple possibilities for naming larger numerals; some of the possible names for large numerals are considered more elegant than others; there are several distinct sets of numbers in The Yoruba Number System, two that are akin to English cardinal and ordinal number, and another that is used only for currency; there is no "zero" in any of these sets of Yoruba numbers. Verran also provides a chart where she gives English numerals, their corresponding Yoruba names, and how each name is generated through addition, subtraction, and multiplication (Figure 2.2).

Reified by a standard organizing technology (a chart) and a description of its inherent properties, The Yoruba Number System can be compared to other objects in the same family, like our own base-ten English Number System. Verran locates the differences between these Systems in separate cultural histories: English speakers inherit a numbering tradition based on counting on fingers

(base-10), while Yoruba speakers inherit a numbering tradition based on counting on fingers and toes (base-twenty, ten, and five). Here, cultural relativism provides a causal story for the intuitive perception that The Yoruba Number System is different than The English Number System.

In Chapter 3 Verran presents two similar objects, two Number Systems, with an essential difference: their distinct cultural histories. Observing and describing these two objects entailed a particular mode of attention to difference, one guided by a pleasure in the discovery and careful study of strange and marvelous objects. I am inspired by Lorraine Daston and Katharine Park to call this mode of attention "wonder." Although their detailed historical study *Wonders and the Order of Nature 1150–1750* addresses a different historical context, the empirical practice they describe echoes forward in Verran's description of her response to Yoruba numbers: "I was quite enchanted by Yoruba numbers and turned my delight to painstaking work" (52). This painstaking work described/manifested a marvelous object deserving of her readers' wonder too: "How can we appreciate the complex architecture of this system?" (56), she asks, teaching us to see and to admire the elegance of this exotic artifact.

In Chapter 4, the decomposing chapter, Verran explains how the wonder that informed Chapter 3 did not simply draw her to her object; it actually contributed to the shape and character of The Yoruba Number System in her original manuscript. Objects constituted by wonder and as "wonders" travel in specific ways. By outlining The Yoruba Number System in an academic article for non-Yoruba speakers to admire, it needed to be translated into base-ten. This translation, Verran argues, "can be understood as a form of standardizing, as finding a form

to bring the Yoruba numeral system "home" to display its beauty and unusual features to my colleagues" (74).

She builds this argument by drawing a troubling comparison between her own relativist project and Adolphus Mann's universalist project for the Royal Anthropological Institute of Great Britain and Ireland. In 1886, Mann describes The Yoruba Number System as part of his "objective scale of civilization" (78), where he compared civilizations in order to scientifically explain the cultural superiority of white Europeans. Mann, too, was delighted with Yoruba numbers, and turned his delight into painstaking work. Despite their different historical context and opposing political aims, Verran argues that they experienced, collected and displayed their object in a similar fashion:

> We have disentangled the Yoruba numeral system from its embedded and literally embodied way of contributing to the ongoing life of Yoruba trading and reentangled it in the pages of books and journals. By getting it onto pages and into books in reembodying it, we have literally objectified it; we have rendered it as an object—the Yoruba numeration system—whereas before our interventions there was not an object at all. (75)

Verran adds a second historical comparison, which lends more concreteness to this concept of disentangling/reentangling. Drawing from the colonial history of her home country, Australia, she compares herself collecting The Yoruba Number System to Captain Cook collecting "spears, axes, carrying baskets, flutes, fans, and hats" (74) from the Pacific islands for display in European museums. Although Cook, Mann, and Verran presented their objects as found, Verran comes to argue that the collecting process (including wonder as mode of attention) defined the contours of the objects (number systems or carrying baskets).

I want to briefly pause here to suggest that although this analogy is effective for staging her dilemma, it does not, I believe, speak to the underlying truth of Verran's first manuscript (i.e. that it *was* colonialist), but works as a kind of "speculative comparison" that motivates her to develop a different set of empirical practices, which can effect a shift between scholarly writing as a representation of natural objects to scholarly writing as a form of participation and a practice of worlding. The Yoruba Number System as an object was more suited to participating in academic lectures "back home"; it was not a promising object for collectively addressing the epistemological challenges of everyday life in a bilingual community with a situated colonial history. In the decomposing chapter, Verran *accounts* for how The Yoruba Number System had been constituted by her own wonder, together with the translation and standardi-zation required to take her object home. Verran's accounting is not a rejection or disavowal of her painstaking work on The Yoruba Number System; rather, accounting for the object decomposes the object, allowing to her to name and practice a different mode of attention. She calls this nascent mode of attention **disconcertment**.

Science and an African Logic begins with a story of Verran sitting in the classroom of one of her students, Mr. Ojo, as he showed the children how to measure the length of their bodies. Verran was expecting him to teach the lesson as they had planned: each child is given a length of string to measure his/her height from the top of their head down to the bottom of their feet, the string is then placed on the floor and its ends marked with chalk, finally, a meter stick is used to measure the space between the chalk marks. This is not the lesson Mr. Ojo

taught. Instead he gave each child a string and a 10 cm long piece of cardboard with 1 cm divisions marked. He instructed the children to use the string to represent their heights, wind the string around the card, count the number of full times the string was wound around the card, multiply that number by ten and add the remaining centimeters of string to the product. The children were delighted; Verran was "scandalized" (3). She experienced the new lesson as both exactly the same and completely different than the one they prepared; caught by the whiplash between difference and sameness, she laughs. Visceral laughter, as Verran tells it, is an embodied response to the difference between the two lessons: the difference between a length of string paired with chalk and a meter stick, and a length of string paired with a 10 cm long piece of cardboard; the difference between length as singular extension (stretch of string) and length as a plurality (bundle of strands).

Verran describes her new method as "staying true to laughter," starting from the moment of puzzlement and confusion—the moment of disconcertment. Disconcertment is a way of paying attention to specific differences that are often forgotten or explained away: "It is easy to ignore and pass by these moments—part of the problem is their fleeting subtlety—yet it is possible to become acutely sensitized to them. Interruptions, small and large, are what we, as theorists must learn to value and use" (5). Here, we are no longer being asked to appreciate the complex architecture of The Yoruba Number System; we are invited to join Verran in laughter.

And, in this peal of collective laughter, The Yoruba and English Number Systems fade away; now there are just children, cards, string, little pieces of

cardboard, moving about the classroom, succeeding (or failing) at doing length, making an anthropologist nervous. Quantifying—in this case, measuring—is one of the products of all this activity (a messy classroom might be another). When learning how to measure, Verran argues, students are not learning how to correctly apply abstract entities (numbers) to nature, they are learning the rituals and routines necessary to enact quantification: "Certainty of numbers is an outcome of the routines by which they are constituted in collective acting, not in their unique capacity to truly represent a foundation in a system of symbols" (Verran 1999, 150).

We can characterize this movement from wonder to disconcertment as "postcolonial" in two related ways. First, *Science and an African Logic* is based in a "critical practice that addresses the significance of colonialism in the formation and practice of social theory" (Mitchell 2002, 7). Comparing her methods to those of colonial science, Verran changes the way that she images and responds to difference, which remakes her empirical objects. Wonder gave her essential numbers with inherent properties that could be collected and transported back home; disconcertment gives her numbering and children (objects and subjects) as outcomes of collective acting.

This process of decomposing and recomposing her empirical objects contributes to the thicker definition of the postcolonial offered by Verran in *Science and an African Logic*: "the ambiguous struggling through and with colonial pasts in making different futures" (Verran 2001, 38). Postcolonial projects, in this sense, involve learning to craft knowledge and collective practices that can contribute to the epistemological flourishing of historically

subjugated people. For Verran, this is not simply about protecting or valuing indigenous knowledge, but about finding ways of respecting and working with differences in situated technoscientific practice. When colonial relations have largely defined what knowledge practices are considered legitimate, creating conditions for epistemological flourishing requires ongoing attention to what enables and forecloses the recognition of differences and the ability to stay with differences as they emerge in practice. The differences between Mr. Ojo's lesson and the planned lesson are important to examine because Mr. Ojo's lesson succeeded at teaching the children to measure their height, whereas others attempt to teach quantification "by the book" were less successful (10–11). Teaching and learning creatively are an important part of crafting different futures. However, what counts as creative teaching or collective flourishing cannot be known in advance, but is a matter of attentive participation; this is why Verran calls the struggle of postcolonial projects "ambiguous."

How does *Science and an African Logic* as an academic book contribute to this postcolonial project? Verran's first manuscript had a straightforward political aim; she conceived of it as a text that could both give an accurate account of Yoruba numbers and inform progressive policy decisions. The political project of *Science and an African Logic* is less clear-cut. It is a difficult and at times awkward book (even for an STS audience) that will likely not be read by Yoruba math teachers or policy makers. However, if we think of writing a book as one participatory practice among many others (e.g. teaching, talking, counting, laughing, etc.), we do not need to locate its politics in its accessibility (nor locate all of Verran's political practices in her writing). An academic book can instead

be seen as a site where Verran formulates concepts and narratives that re-orient her within her own research practices, helping her learn how she might contribute meaningfully to collective flourishing. At the same time she offers her readers approaches for recognizing and respecting differences that could be useful within their own projects (postcolonial or otherwise). One key practice that Verran offers in her ambiguous struggling though and with colonial histories of empiricism in Nigeria and Australia is what I am calling here accountability.

Into the Compost Heap: Decomposing, Composting, and Composing

There is a danger in using the word "accountability" to describe what Verran is doing. It can quickly call to mind the audit regimes of contemporary neo-liberal bureaucracies (Strathern, 2000; Power, 2007;Woolgar and Neyland). Institutional accountability involves procedures of assessment that are designed to bring business practices to light to evaluate efficiency and fiscal responsibility. If we embrace the metaphor and apply it too quickly to empirical STS research, we run the risk of encouraging the kind of social theory that places its faith in exposure (Sedgwick 2003; Latour 2004). The "protocols of unveiling" (Sedgwick 2003, 143) that have dominated the tradition of critical theory, like the audit, work by revealing the hidden workings of power. We can also see this at work in the more empirical strands of STS that aimed to open the black boxes of science to describe their hidden machinations. "Accountability" could further strengthen the academic culture that privileges critique and revelation over other, more subtle and creative, approaches. However, in *Science and an African Logic* Verran severs

the association between critique and exposure, rerouting the associative pathways of accountability.

In her decomposing chapters, Verran exposes the hidden assumptions that informed her original analysis. However, transparent and certain knowledge is not her ultimate goal. Instead, the moment of exposure acts like a railroad switch; it allows the analysis to change track, to tell different stories, to articulate different objects. Being accountable for colonial histories does not guarantee the truth of her explanations. Verran writes, "I do not claim this new account should be accepted because it tells the way generalizing 'really' is" (2001, 158). She does not move from how the world "seems" to how the world is. The action is not one of unveiling. Verran performs what she calls a "generative critique," a critique that enables something new to happen: "A generative critique offers the possibility of innovation, a way that things might be done differently to effect futures different from pasts" (20). Of course critique and revelation have often served this purpose—opening black boxes, for example, allows us learn about scientific practice in a way that can give us purchase to think about how it might be done *otherwise*. With her term "generative critique" Verran amplifies this sometimes quiet potentiality, making it harder to think of critique as an end in itself and instead as part of an "ecology of practices" (Stengers 2010). When Verran suggests that generative critique can help us "do things differently" I believe her meaning to be quite literal; it is about enacting objects in unfamiliar ways (236). As The Yoruba Number System is decomposed, a new way of figuring numbers emerges. Thinking with Verran, I want to develop a sense of accounting that is

about **remaking objects rather than just laying bare the relations that produce them**.

Verran borrows the term "decomposing" from Marilyn Strathern. Strathern describes it as a kind of analysis used by people in New Guinea, a way of taking things apart. In an essay about how the Hagen people came to recognize white Australians as human through the trading of shells and pigs, Strathern explains how she understands decomposing: "'Things' are forms in which relations appear. The premise is an aesthetic one. Forms appear out of other forms, that is, they are contained by them: the container is decomposed, everted, to reveal what is inside" (249). In her reading of Strathern, Verran adopts decomposition not as "an exotic form of indigenous analysis" (42) to serve as an antidote to colonial knowledge, but as a methodological provocation for postcolonial theory: "the resonance interests and inspires me, helping me name what I do in this book" (43).

Inspired by this game of cat's cradle already in progress (Haraway 1994), I feel encouraged to participate in the fun by introducing a trope to the exchange. Verran's decomposition suggests to me the organic biodegradation that happens in a backyard compost heap. Composting is both an empirical and political practice, as Maria Puig de la Bellacasa explains: "The techniques of composting are an important part of earth activist trainings. Not only how to keep a good compost going, but also how to become knowledgeable regarding the liveliness, and needs of, a pile of compost" (2010, 160). In opposition to metaphors of bringing stuff to light, the compost heap draws us into the (sometimes smelly) darkness where recognizable forms are broken down by hungry critters. Following a mantra I learned from Donna Haraway—"I am a creature of the mud" (2008,

1) —this decomposition engenders a kind of analysis that demands we get epistemologically dirty. Armed sometimes with just a pitchfork, the composter must learn to replace the question "how can we be sure?" with "how to live with doubt?" (Mol 2002, 165). Thinking with compost is more about aerating than illuminating,[6] opening up material and epistemological spaces without the presumption of sight.

In *Science and an African Logic* Helen Verran adds some tasty clippings to her heap, chapters carefully written for an abandoned book. Deep in the warmth of compost, the decomposer communities of STS and postcolonial theory digest the objects from her unpublished manuscript. As these objects are decomposed, Verran's generative critique produces nutrient rich soil from what was previously refuse. Thinking decomposing with composting helps us to grasp what Isabelle Stengers means when she writes, "critique must present itself as an ingredient of the assemblage, not as critically examining/dismembering the assemblage itself" (2008, 44). Decomposing is not valuable on its own or as such, but is an important element of a healthy ecosystem and a necessary condition of life on Earth.

The term "generative critique" invites curiosity: "what is this critique generative *of*?" In the simplest sense we might think of Verran's composting process as generative of writing and writing as a kind of worlding. As Donna Haraway writes, describing Isabelle Stengers' engagement with Whitehead: "Abstractions, which require our best calculations, mathematics, reasons, are built in order to break down, so that richer and more responsive invention,

[6] I return to the question of illuminating in the Conclusion, opening it up like I do here with accountability.

speculation and proposing—worlding—can take place" (Haraway 2008, 93). In *Science and an African Logic*, the decomposing of old stories about numbers enables new stories about numbers, new stories that are nourished by the passions and energies that animated the old. In *The Gender of the Gift* Strathern draws our attention to this work of composition in decomposition:

> Anthropological exegesis must be taken for what it is: an effort to create a world parallel to the perceived world in an expressive medium (writing) that sets down its own conditions of intelligibility. The creativity of the written language is both resource and limitation. By language, I include here the arts of narration, the structuring of texts and plots, and the manner in which what is thus expressed always arrives...already a composition of sorts. Decomposing these forms can only be done through deploying different forms, other compositions. (17–18)

Decomposing is, thus, both a form of critique and of storytelling. When micro-organisms and insects have broken down the available organic matter, we are not left with nothing, but with humus, an earthy substance that enables and nurtures new life. The stories that emerge from Verran's decomposition offer new kinds of companion narratives (Frank 2010, 42–43) that orient her within postcolonial projects, informing richer and more responsive participation.[7]

In *Science and an African Logic* decomposing is integral to Verran's accounting practice. In the process of accounting for how wonder constituted The Yoruba Number System as her original object, decomposing allows Verran to pay attention differently, giving her different objects. If, following Strathern, decomposing is always also composing (and composition is sometimes writing), then our nutrient-rich accountability needs to attend to the arts of narration and

[7] See "Clunky Minimalism" below for a concrete example from Verran's work in Australia.

the structuring of plots. Accounting, in this sense, refers not only to "rendering a reckoning" but to the creative practice of "narration and relation" (OED). Giving an account does not have to look like performing an audit, but can also look like telling a story. Storytelling is a practice of relating, of forging connections with words. These relations are not just between actors and events within the story, but between those who listen, repeat, and adapt it.

If we look at storytelling as a relational as much as a representational practice, it becomes possible to resist the cartoon version of empirical research as opening black boxes and revealing their contents. It becomes easier to see what *else* is going on. Even in a theoretically playful field like STS, the conventions and codes of academic realism have the potential to hide the creative work of composing and naturalize the subjects/objects in the account. Verran, however, helps us see ethnographic writing conventions as generative, not of true representations (tracings of real relations), but of **promising fictions**, echoing Strathern's definition of ethnography as an "effort to create a world parallel to the perceived world." She explains that the stories that begin her book are imaginative reconstructions:

> Mr. Ojo and the other teachers I tell of are fictional characters. I have abided by the conventions of changing details in telling of them and their pupils. In some cases, the episodes I tell of are composites of several incidents; in others, they allude to a specific occasion. (2001, 239n3)

Here, the ordinary ethnographic convention of changing a subject's name to preserve anonymity is deployed explicitly as an element of story-crafting. The story of Mr. Ojo and the other classroom vignettes are best read not as realist

ethnography but **fables of attention.** Fables, like those of Aesop or La Fontaine, are social stories that orient their readers around moral questions. Verran's fables present an empirical orientation that offers a different mode of attention to other practitioners reading her book. As the people (including the ethnographer herself) are fictionalized, disconcertment, an otherwise cumbersome and unfamiliar signifier, is brought to life and imbued with meaning. Verran's fables of attention are about narration and relation. Through these charismatic narratives that are fun to re-tell (I often do!), Verran names and fosters an alternative way of figuring and paying attention to differences that may enable different forms of response and participation. Verran and other scholars she has inspired with her stories, continue to use disconcertment to orient themselves in projects where how to go-on together is uncertain and very much at stake (e.g. Verran 2002, 730; Verran 2007, 114; Law and Lin 2011; Postma and Postma 2011). They act as powerful relays for ethnographic "economies of attention" in the making (Daston 2004, 443).

And, it is important to emphasize, fables do not just *illustrate* social theory; social theory is a storytelling practice (Verran 2001, 119). In the next section we will see Verran tell another kind of theoretical story to explain her disconcertment. In this second framing, Mr. Ojo's lesson disconcerted Verran by creating palpable tensions between two different practices of measuring length, which she comes to describe as "competing ways of ritualizing in quantifying microworlds" (172). Despite being introduced in a realist academic style, Verran's microworlds and the tensions they produce are also inventive stories. In this part, Verran's simple and elegantly wrought fables are joined by different **aesthetic**

strategies that employ more troubled language—clunky translations, awkward terminology (e.g. quantifying microworlds), and "redundant detail" (100). In places Verran's theoretical descriptions test the limits of intelligibility, not as avant-garde or experimental writing, but in the strange banality of describing familiar things in unfamiliar ways (243). Shuttling between writing styles and accounting strategies, between laughter, disconcertment, and competing ways of ritualizing microworlds, Verran draws our attention towards all of the coordinating work involved in narrating and relating.

Praxiography

The predominant narrative style that Verran employs in *Science and an African Logic* is **praxiography**. Praxiography is Annemarie Mol's rather unwieldy signifier for a simple concept. A praxiography is "a story about practices" (Mol 2002, 31). It is a genre of writing that complements an STS mode of attention to practices and processes in technoscientific worlds. By foregrounding relations, it becomes "possible to say that in practices objects are *enacted*" (33). In this kind of account objects cease to be abstract, singular, and absolute. They become material, multiple, and mutable. Praxiography is a genre of storytelling that is skilled at expressing worlds relationally and, as Verran shows, it can be a useful narrative style for practicing relational empiricism.

In the second set of chapters (6, 7, 8), Verran shifts from **describing objects** to **narrating routines** as she recounts an experiment she conducted with Yoruba and Australian children. In this experiment she passed a substance (Coke,

peanuts, or water) from one large container to two small containers. She then asked the children if the total amount of the substance was the same or different than before. Recording and analyzing their answers, Verran discovered how children successfully or unsuccessfully solved problems by quantifying.

In Chapter 6 (one of the chapters from her original manuscript) Verran focuses on her findings. The experiment showed that young English-speaking children, older English-speaking children, and Yoruba-speaking children utilize different concepts when they quantify substances. Verran called these three different concepts "thingness," "volume," and "unicy," respectively. She argues that each of these concepts provides children equally good, logical, and abstract ways of quantifying. Verran uses these findings as the basis for a policy recommendation: "Modern Yoruba education should be bilingual and as part of that program, alternative forms of quantifying should be separately taught and learned in school" (142).

Revisiting the experiment in Chapter 7, the decomposing chapter, she focuses not on the results, but on accounting for her own experimental practice. Verran's methodology required intricate choreography: "I messed around with children, words, water, Coke, peanuts, bottles, bowls, beam balances, tape recorders, translators, transcriptions, index cards, tabulations of numbers, and so on, ordering them all into an almost smooth operation" (146). However, all of these elements were missing from her original chapter: "Telling of my experiment as searching for already existing entities—the abstract objects of quantifying—hides a vast amount of laborious but creative work" (146). By creating an equipment list and narrating her experiment as praxiography, Verran decom-

poses her found objects. In this account, the coordination of children, words, water, Coke, peanuts, etc. *materialize* thingness, volume and unicy. They are not simply found; they are made through collective action, which includes (but is not limited to) the actions of the anthropologist. Here we have a kind of accounting guided by the phrase scrawled in red ink in the margins of algebra tests- "show your work!".

However, Verran's task is not finished when she writes herself in the scene. This is not the kind of self-reflexivity that prescribes "self-vision as a cure for self-invisibility" (Haraway 1997, 33). It is a relational empiricism based on accounting for how she participates in shaping her objects of knowledge. Like in the first set of chapters, this accounting practice is a form of generative critique that remakes Verran's empirical objects. As thingness, volume, and unicy are thrown onto the heap and begin to decompose, she describes how children who can successfully quantify have learned to perform specific routines. They are able to track the peanuts, as they move between containers, while keeping their eyes fixed on boundary-making (169). The three groups of children employ three different practices of attending to boundary-making, which they learn through participating in different (though not fixed nor mutually exclusive) microworlds.

The term "microworld" comes from Joseph Rouse who developed it to describe the laboratory as a space where protocols and equipment are standardized to facilitate the emergence and stabilization of new objects. As Verran takes it up she expands its definition, using microworld to refer not only to the laboratory but other "banal and ordinary sites of getting on in collective life" (257n2). For Verran, marketplaces, classrooms, and laboratories are all examples

of quantifying microworlds where enumerating activities happen and cohere into reliable routines of quantification.

The difference between these microworlds, in Verran's account, is not one of kind but one of power. Taking a lesson from Latour's iconic story of Louis Pasteur, Verran writes: "If science's explanations are to be made as general claims, its microworlds must be infinitely extended" (210). Pasteur, as the fable goes, extends the microworld inside his swan-neck flask, remaking the world through germ theory. While Latour focuses on explaining the success of Western science, Verran is concerned with the imperialism implicit in this infinite extension. Because Yoruba quantifying is vulnerable in the face of the English standard, Verran finds it difficult to side with the epistemologically powerful. As S. Leigh Star writes, offering a feminist reading of Latour's story: "By experience and by affinity, some of us begin not with Pasteur, but with the monster, the outcast" (1991, 29). Similar to Verran's comparison of her first manuscript with the collecting practice of Captain Cook, Star uses a canonical STS figure (Latour's Pasteur) to propose an alternative set of empirical and narrative practices for situated worldings and re-worldings. These practices are proposed not as a general theory or as a policy to be applied uniformly, but as a part of a relational empiricism where what counts as a good social and epistemological story is always contextual and at stake.

Praxiography is one technique for resisting, what we could call (with tongue firmly planted in cheek), the Verranization of Nigeria. Rather than insisting on the solidity of her found objects (thingness, volume, and unicy) and fixing them in educational policy, Verran "[tells] stories about the lives of objects and how

these lives proceed in reliably managed microworlds" (2001, 210). Telling about her own practices helps account for her role in materializing her empirical objects. In doing so her objects are re-materialized. They are now outcomes of collective practices: "An object clots when the repetitions and routines of its generating microworld become a ritual" (62). In this way Verran is participating in the microworlds she describes, performing a relational empiricism that is attentive to the labor required to stabilize objects.[8]

Although her new account can no longer rely on the stability and authority of found objects to argue for the value of Yoruba quantifying, she is still able to do important empirical and political work on "power objects" like numbers. De-composing thingness, volume, and unicy, by telling about her own coordination work allows Verran to develop an alternative knowledge-making practice that is more mindful of the Empire working inside of empiricism. This does not make Verran's work innocent. As Donna Haraway soberly reminds us "feminist inquiry is no more innocent, no more free of the inevitable wounding that all questioning brings, than any other knowledge project" (1997, 191). However, it does make possible a different way of doing politics.

Ontological Politics or Narrating as Aerating

As Verran's objects decompose, a politics of administering discrete objects—*do* teach *this* number system, *don't* teach *that* number system—is no longer suitable

[8] This is an important difference between Verran's accountability and the notion of accountability that comes out of enthnomethodology (e.g. Garfinkle 1967). While enthnomethodological accountability is concerned with the everyday routines and interactions in different communities of practice, it does not place the ethnographer's own practices in the same sphere of activity.

for her relational world. Moving away from the found objects of her original account (The Yoruba Number System, The English Number System, thingness, volume and unicy), she begins to find herself drawn to Annemarie Mol's concept of "ontological politics." Mol argues that if we understand objects not as discovered but as enacted, we can formulate a different political question: which version of an object should be performed? She suggests that we (people who inhabit, attend to, and narrate worlds) move away from the representational question—"is this knowledge true to its object?" towards the ethical and practical question—"is the practice good for the subjects (human or otherwise) involved in it?" (2002, 165). The ontological politics Mol describes requires attentiveness to the different ways an object is/can be performed at different places and times; and what these performances enable and foreclose.

In *Science and an African Logic*, Verran does ontological politics by narrating her encounters with numbers in specific and deliberate ways:

> By telling stories of Yoruba and English numbers as I have here, I have linked them in a way that is quite different from the links in practice that I have been narrating. Linking through telling stories effects an explicitness that enables another sort of politics. Such explicit storytelling effects a politics centered on the choice about *how* to go-on; the question can be discussed. (2001,118)

Verran writes herself into her book, not as participant-observer, but as **participant-storyteller**, coordinating disparate parts into a narrative designed to foster new kinds of discussions around teaching numbers in Yoruba classrooms.[9] In this shift from participant-observer to participant-storyteller, the activity of

[9] The Yolngu community that Verran currently works with call her their "consultant philosopher" (Verran 1998: 258); this title also draws attention to theorizing/storytelling as participating.

participation is reconfigured. The participant-observer participates in order to observe. The participant-storyteller "tells stories as part of her participation" (Verran 1999, 151). Her stories are crafted to make a difference in the worlds she inhabits. They are worlding stories.

Verran re-composes her narrative in order to shift the locus of decision. In her original account the differences she describes between the two discrete number systems are not open to management by those who are most directly affected (20). As she revisits her account, the relevant actors change from government policy makers to the people who work with numbers and students in their everyday lives: "These are empirical and contingent matters. They need to be worked out with teachers and their curriculum advisers, and discussed in schools' communities" (119). Verran's stories about quantifying open up a space for more people to share in Mol's question: "is the practice good for the subjects involved in it?" There are more choices about which versions of numbering to enact.

Choice, at first, is a strange word to use in an account where we are asked to think of subjects and objects as materialized relations. It has a way of naturalizing the human subject as a privileged actor who can make rational decisions. This seems opposed to the kind of subject that is enacted in a dance of relating (Mol 1999, 87, see also Thompson 2007). However, if we decouple agency from intentionality, as Karen Barad does in her own ontological storytelling, the problem begins to feel less intractable. In *Meeting the Universe Halfway*, Barad calls for "a new sense of aliveness" (177) where all matter is understood as dynamic, not immutable or passive (155). Agency within this dynamic universe is

a doing, not a property of the human or of a discrete individual; there are always a multitude of agencies unfolding as the world is continuously reconfigured through ongoing intra-action. Within this dynamic world it is impossible to imagine that one single story or one narrative style cannot capture all of the liveliness and exuberance; we need to deploy multiple stories about agency. Some meticulously empirical, some imaginative. Some on the quantum scale, some on the people scale. Different agential narratives enable different ways of responding and relating.

Writing in the genre of praxiography about how numbering is enacted in microworlds opens up a space for discussion among the people who teach and learn mathematics. Though this kind of storytelling can be powerful, ontological politics might be too grandiose a name for Verran's more down-to-earth practice. To return to the smelly trope of the compost heap, perhaps it is better to think of **narrating as aerating**, and the ontological storyteller as a worm, a Red Wriggler tunneling through the compost, creating pockets of air, spaces of agency—spaces to move and spaces to breathe. The worms eat as they burrow, excreting casts that enrich the humus; thus worms are both contributing to and facilitating the labor of the bacteria, fungi, nematodes, mites, snails, and slugs in breaking down organic matter (Puig de la Bellacasa 2010, 160). Some of the agencies that narrating/aerating facilitates may be called "choice" or "management"; some might be called "bacterial growth" or "aerobic decomposition"; others have names that we, unaccustomed to the lively diction of naturecultures,[10] are still

[10] Naturecultures is Donna Haraway's neologism for fighting the persistence of the nature/culture dichotomy in thinking and in speaking. By jamming together the rhyming verbs narrating and aerating, I follow Haraway's lead in order to locate human choice and bacterial digestion in the same sphere of agency.

struggling to articulate with clumsy tongues. Thinking of the participant-storyteller as a sticky red worm wriggling through the compost, nourishing and nourished by the heap, might help us better imagine academic storytelling (theorizing) as one of the many "material practices of intra-acting within and as part of the world" (Barad 2007, 90).

One important tactic in Verran's aeration work is paying attention to what usually is explained away. "Explaining away" happens when significant differences are elided rather than attended to, when bumpiness is smoothed, when multiple objects are collapsed into one. In the first part of this chapter I wrote about how staying true to laughter and starting from disconcertment helps Verran focus on and narrate the differences she had first explained away. Disconcertment as a mode of attention allows her original objects to decompose, which, in turn, enables her to compose new stories, stories that make the differences in numbering practices open to management (rather than erasing them or treating them as essential).

Creating openings for management, which I've been calling aerating, is a useful practice in situations where microworlds collide on uneven footing. Some of these collisions can lead to what Verran calls "postcolonial moments":

> Postcolonial moments are made where disparate knowledge traditions abut and abrade, enmeshed, indeed often stuck fast, in power relations characteristic of colonizing, where sciences usually line up on the side of the rich and powerful. Postcolonial moments interrupt those power relations, redistributing authority in the hope of transformed contexts for the exercise of power. A postcolonial moment is not about retrieving lost purity by overthrowing and uprooting an alien knowledge tradition. Rather, it might effect an **opening up and loosening**. Increasing possibilities for cooperation while respecting difference, postcolonial

> moments can lead to amends for past injustice. (Verran 2002, 730, emphasis mine)

For the participant-storyteller, these postcolonial moments are "occasions for theorizing, for telling differences and samenesses in new ways" (729). Post-colonial theory, in this formulation, is a kind of writing we do when the accustomed stories about sameness and difference are contributing to ongoing practices of subjugation and getting in the way of going-on together.

In the next section I will explore how Verran's **translations** are sites where sameness/difference is continuously being managed, and indeed, could always be managed otherwise. Using disconcertment as her guide, a mode of attention to the unsettling differences that are often explained away, Verran's aerating work includes crafting translations with ontological traction, building empirical tools that make their translation-work visible, and identifying powerful translations that go unnoticed. Each of Verran's engagements with translation works to reconfigure sameness and difference, to effect an opening up and loosening, to create spaces to move and spaces to breathe.

Clunky Minimalism: An Aesthetic for Postcolonial Moments

Beginning with Verran's original manuscript, her method includes a careful attention to the practice of translation. In Chapter 9, the culmination of her first study, Verran highlights the importance of staying with linguistic difference as a way of investigating the ontological commitments embedded in language. Ontological in this sense is about worlding—about how language participates in shaping our lived worlds in some ways and not others. Verran explains that we

are unaccustomed to paying attention to how language contributes to shaping ontologies: “It is not common for speakers of a language to examine what types of material objects their language commits them to. Rather, the difference will be noticed as a difficulty in translation” (2001, 187). Instead of smoothing over the difficulty in translation, Verran accentuates it. She translates a Yoruba phrase that would normally be understood as the equivalent of the English phrase “He saw three dogs” as “He saw dogmatter in the mode of a group in the mode of three” and the even clunkier alternative: “He saw matter with the characteristics of dogness manifesting here/now as a collection divided to the extent of three” (194–195). Verran brings out these linguistic differences in order to argue that Yoruba and English have two different ways of arranging space, time and matter when speaking a sentence. She argues that each language figures space, time, and matter into different kinds of objects—”spatiotemporal particulars with various qualities” (English) and “sortal particulars in various modes” (Yoruba) (50).

In Chapter 10, Verran then decomposes “spatiotemporal particulars” and “sortal particulars” by pushing the methodology of Chapter 9 further, by lingering in the space of difficult translation. According to Verran, her first attempt resolved the translation difficulty by making recourse to a world of common referents (space, time, and matter) that are simply arranged differently in Yoruba and English. In her second attempt, however, she does not maintain there is an essential sameness underlying the different grammars; she shifts to praxiography to narrate how differences and samenesses are generated through practice. In Chapter 11 the nouns of the English language (which were previously

spatio-temporal particulars) are narrated as outcomes of specific relational rituals. The three different outcomes that Verran describes are extensions, durations, and resistances (232).

This new story does not require us to replace one foundation (objects) with another (interactions, practices, or collective acting). While praxiography threatens to enforce the understanding that actions are foundational or pre-linguistic, my reading of Verran's theoretical move is that she is building a metaphysical translation tool for taking *serious* ontological differences *seriously* when shuttling between two worlding practices. Durations, extensions, and resistances are not saddled with the history of Western metaphysics and do not require that common ground be located only in Western territory. Therefore they offer more promise for cross-cultural translation than the more conceptually nimble space, time, and matter. Newborn and awkward to our ears, these strange terms announce themselves as translation tools.

As she continues to follow this line of analysis, Verran jokes: "It is difficult to say this without sounding quite daffy" (232). Trying to talk about the ontological assumptions embedded in the English language is difficult to do while writing in the English language. In response to Thomas Kuhn's notion of incommensur-ability, Helen Longino argued that objectivity requires a robust practice of articu-lating and discussing the background beliefs with which we assess evidence and make sense of the world (1979, 54). Verran shows us the kind of uncomfortable linguistic pretzeling that it takes to stammer about even some of our most basic assumptions. For example, in Chapter 11 familiar entities like English nouns become "space-time bits" or "duration-extensions" (2001, 232). The compounding

awkwardness of these words allow ontological commitments of the English language to take on sharper contours. They can be discussed. Alternatives (Yoruba ontologies, for example) can be considered more seriously. One more daffy translation has "freed us from the modern myth that space, time, and matter are given and must be represented" (233). This is a big claim. But the way she gets there is unassuming. Verran stubbornly picks at seams of her translations. The method is simple but not tidy. I imagine her ripping at seams, pulling out invisible threads with fingers and teeth, surrounded by scraps of fabric, like Catullus's Parcae, with bits of thread clinging to her lips (Catullus 64, line 316).

Without someone to pick at the seams, bad translations can sabotage opportunities for learning; post-colonial moments can be missed. In her article, "A Postcolonial Moment in Science Studies," Verran describes a workshop in Australia where environmental scientists had the opportunity to observe and learn about w*orrk*, an Aboriginal practice of using fire for land management. The scientists, though eager to learn from Yolngu landowners, were frustrated and perplexed (disconcerted) by what they saw during the workshop, especially by the unfamiliar practice of gathering clams and yams at each of the firing sites. Disconcertment quickly yielded to bad translation: "It seemed [to the scientists] that a *worrk* was to some extent 'just a ritual' of lighting fire as accompaniment to a 'foraging' expedition" (743). Verran, as aerator-narrator, travels back into the fertile site of disconcertment and begins to craft ontologically-thick translations that better express the metaphysical commitments of both the scientists and the

Yolngu landowners.[11] She narrates resonances and dissonances between these two firing regimes differently in order to facilitate better understanding between them. Talking about these traditions together requires ongoing translation that enables partial connections but refuses to ignore the ontological friction: "Reconciliation must allow for metaphysical difference to be respected, while shared embodied and embedded concerns [can act as] grounds for respectfully going on together" (754).

While she is telling new stories about the practices of scientists and Yolngu landowners, Verran does not occupy some ontological no-man's-land outside of these two microworlds: "[My] frame is no more free of metaphysics than any other, but it is both minimalist...and explicit about the framing" (754). Verran's theoretical rigging[12] is slight—she pays attention to moments of disconcertment and takes them to signify a clash of microworlds—but it announces itself loudly. The stories generated by staying with disconcertment present themselves as provisional constructions: "Being messy and seamy, [they] acknowledge the actualities of other times and places, and make the generalizer's accumulation of power more evident—and, for that reason, less certain" (757). Her rig does not hide its presence nor do the stories let you forget about their role as an aerating

[11] For example, Verran gives us two different translations for the Yolngu *wänga*, which usually gets tritely translated as "sacred sites." She uses "clan lands" to evoke the sense of belonging in *wänga* ; she uses "people-places" to evoke an inherent relationality. Giving two translations, both unfamiliar to Anglophones, makes it more difficult to ignore the ontological commitments that *wänga* carries.

[12] Here I use rigging instead of framework. Although they have similar meanings, "framework" has become a sleeping metaphor in scholarly writing. Along with the nautical meaning of "rigging" I want to add a second association, inspired by the television show *MythBusters*; on *MythBusters* the hosts build elaborate and clever technological rigs to test modern myths. Each rig is a provisional construction, set up for a specific myth, and dismantled after they finish the episode. Sometimes bits of old rigs are reused or repurposed for new rigs.

technology. Donna Haraway captures this feminist resistance to seamlessness nicely when she writes, "I try to make words—like all meaning-making tools—to stumble, to make a lot of racket, to generally resist naturalization" (1997, 306n36). Verran's clunky minimalism is an aesthetic that helps resist peaceful naturalization.

This aesthetic does not only apply to meaning-making tools like words and theoretical rigging, but also to digital technologies like software. From 2003–2006 Helen Verran worked as part of a team of researchers called the Indigenous Knowledge Resource Management in Northern Australia (IKRMNA). One of their primary projects, TAMI (Text, Audio, Music, Image), was a computer program intended to facilitate Aboriginal collective memory projects. In the process of developing TAMI, they tried to avoid encoding Euro-American epistemic categories into software meant for organizing indigenous knowledge. Verran's explanation of the TAMI project shows the same aesthetic sensibility as her stories about the firing regimes:

> TAMI is designed as a clunky piece of software. All its 'mechanical' processes lie on the surface. It is a learning/teaching surface designed to recognise and manage ontic incoherence, interference, and interruption, and to make that managing obvious and explicit. Consequently TAMI will never be a very comfortable experience either for teachers or learners. Users would be constantly aware that representations stored in TAMI, and the various configurations in which they might be arrayed, are mutable. (2007, 122)

Uncomfortable software seems counter-intuitive. Especially since one of their primary goals was to allow people with little print or computer literacy to learn how to use TAMI. However, TAMI's awkwardness was conceived to protect some of

the ontological concerns of her Yolngu collaborators. The danger in using software to archive indigenous knowledge is that it would act not as a lively collective memory tool, but as a museum or graveyard. Computer software that is slick and seamless runs the risk of making the digital media appear as self-sufficient representations, cut from their living context, archived and frozen in time. TAMI, however, was designed to make it difficult to understand the text, audio, music, and images as standing alone. Here Verran brings the clunky minimalist style she developed in her theoretical writing to bear on her participation in this collaborative project. Although the project did not receive enough funding to reach completion, it constitutes, I believe, an important attempt to address the question of how digitized indigenous knowledge can resist appropriation and translation into an idiom that will not sustain its metaphysics. Despite the fact that TAMI never became a stable artifact, Verran's descriptions of the collaboration offer her readers the practical tactic of building intentionally creaky technologies as one way to do ontological politics in a postcolonial context, where one way of doing worlds is in danger of being obliterated by another.

Critical Accounting: Making Numbers Clatter

This brings me back to numbers. Numbers are a particularly smooth and manipulable meaning-making tools. They hide their seams well. They are slick and trustworthy (Porter 1995). Unlike words, which can be slippery and polysemic, numbers are taken to be self-evident. This apparent self-evidence makes it hard to see the powerful relational work that numbers perform. Despite their predilection for smoothness, Verran makes her numbers stumble and clatter, drawing attention to their status as quantifying technology. Building on

her work from *Science and an African Logic,* Verran continues to pay attention to where numbers hiccup.

In "Numbers as an Inventive Frontier in Knowing and Working Australia's Water Resources," she notices that the water quality data gathered by thousands of volunteers for Waterwatch Victoria, an environmental NGO, has not been added to the "official data" at the Victorian Water Resources Data Warehouse, the official government registry of water quality in Victoria. Since Waterwatch collects their data in order to "fill in spatial and temporal monitoring gaps" (175) in the official collection, it is disconcerting that the two sets of data have not been consolidated. Verran uses this disconcertment, this glitch in data aggregation, as a way to interrupt the otherwise smooth elision of two separate numerical functions. She argues that numbers that comprise the water quality data can be used to manage a one/many relationship; they can also manage a part/whole relationship. The Waterwatch numbers and the official numbers create a one/many relation by collecting various sample sites (ones) together into an aggregate of sites (many) to assess the health of Australia's freshwater. The official numbers, however, can also have another function: they can transform each site (part) into a commercial entity called "The Australian Water Market" (whole). However, the Waterwatch data is not considered reliable enough to perform this second function. Verran uses this as a "peep-hole," an opening into the political work of numbers, which is often missed as numbers travel and are enrolled for different purposes:

> If not for the glitch...the conflation of a project whose explicit purpose is public good: to get a better picture of the rapidly deteriorating state of the waters of Australia's rivers and creeks, swamps and lakes, with a project

> whose stated purpose is to trade those waters and enable a few to reap private capital gain from that trade would be more seamless. (178)

Drawing our attention to where the translation fails for the Waterwatch numbers, Verran highlights where it has been successful for the official numbers. Although "highlight" could easily be understood as a metaphor of disembodied vision, I imagine it as part of a material reading practice, like the one I often perform with my fluorescent Sharpie. Highlighting in this sense is not about making things clear but about scribbling as a mode of attention—more *Harold and the Purple Crayon* than Descartes' "natural light of reason."

The way the data in the Victorian Water Resources Data Warehouse slips from one numerical function to another is disturbing because the political work they do is completely opposed. By articulating this contradiction, Verran emphasizes and troubles the translation. Not just to expose the translations as translations but to demonstrate how numbers are "materialized relations" (171) and to make their relations explicit.

Here is accountability at work: tracing social connections, making the equipment list, narrating the relations. Numbers are forgetful. When they are deemed reliable and certain enough to be included in the official database, the Waterwatch data are just as capable of forgetting their histories as the official data. All of the earnest volunteers committed to environmental sampling as a means to healthier ecosystems will fade as the numbers begin to constitute The Australian Water Market. Here Verran's accounting is a kind memory work. Giving the numbers a history makes them less agile (178), less prone to wander unaccountably. Accounting is not just about counting up the numbers but also

about writing a story of the relations that they materialize; and doing the political work of stabilizing some of these relations and not others. Highlighting the silent translation with her purple Sharpie, Verran makes the movement of these numbers fluoresce.

Conclusion: Counting, Accounting, and Accountability

To work against the bureaucratic and economic associations of accountability, I have been emphasizing its narrative valences. I have drawn attention to accounting as telling stories, as coordination work, as making relations, as the laborious but mundane practice of writing an academic book. Here, however, Verran reminds me why it is important not to lose the quantitative sense of "accountability." Working with numbers as materialized relations requires the skills of a talented accountant, someone who is as familiar with mathematics as she is with storytelling, someone who can follow numbers as they "continually evert themselves, flipping imperceptibly from their one-many manifestation to the whole-parts form of working, shifting between signing as symbols and signing as icons" (Verran 2010, 178). Just as effective composting requires serious microbiological and agricultural savvy, not just tossing things randomly onto the heap, effective accounting requires precise mathematical techniques and a feeling for the liveliness of numbers.

Accounting in this sense is a critical counting practice that recognizes that numbers do important relational work but do not stand alone. In this view, quantitative methods lose their authority and self-assuredness (though not their creative ability, nor even their precision). Verran reminds us that counting is

never certain and always political. This is not a dismissive critique of quantification, but an important reminder that we need to conjure our own lively numbers to count with and count on. Alongside our commitments to critical social theory, which Verran has taught me to understand as participatory storytelling, we can also imagine other forms of academic participation that engage with the kind of worlding that numbers do. Feminist quantitative methods, postcolonial statistics, and queer accounting come to my mind as playful names that might whet our political and epistemological appetites as we learn from Verran's work with numbers.

Together with a renewed appreciation for counting, Helen Verran also gives us an important lesson in accounting and accountability. Accounting figured as writing the equipment list may too easily be interpreted as an exercise in representation and reproduction or in critique and audit. Verran gives us a way of understanding accounting that is not about faithful representation or bringing hidden relations to light, but descending into the darkness of the compost heap. The accounting that she practices does not present itself as unveiling but as storytelling, as decomposing, as highlighting, as aerating, as stitch-ripping. In her books and articles, Helen Verran demonstrates a kind of accounting where "show your work!" acts as a reminder to resist naturalization and the will to infinite extension (the Pasteurization of France, the Verranization of Nigeria), where critique is only important as an "ingredient of the assemblage" and decomposing is also about composing—composing new stories specifically designed to facilitate understanding between different knowledge traditions. This is a kind of accounting that encourages theoretical rigging to be clunky and

minimal, and all meaning-making technologies to show their seams, while straining to carry their equipment lists with them, creaking and groaning under the weight. This rich set of accounting practices helps us to envision what accountability could mean for a robust relational empiricism.

By working the triads "counting/accounting/accountability" and "decomposing/composing/composting" through Verran's writing, this chapter has been an exercise in turning over the compost pile again, keeping her objects, concepts, and insights in a state of generative transformation. As we struggle to remain accountable to the worlds we participate in creating, revisiting and revising our own work and the work of those who inspire us can be important and useful practices for doing intellectually and politically engaged work on and in technoscience. Ongoing untidy recursive theory, theory that is looping and tangled, full of uneasy returns, disconcerting encounters, and decomposing compositions, could be our best bet for doing STS explicitly as a worlding practice, for crafting accountable stories, for living well in technoscientific worlds.

Coda: Re-enchantment and Laughter

There are two claims in the previous chapter that continue to provoke me, claims that open wider questions about what it means to be a participant storyteller in technoscientific worlds. The first provocation is that the process of decomposition stimulates new compositions. In Chapter 2 I followed the decomposition and re-composition of a book: *Science and an African Logic* is composed from the decomposed arguments in "Numbers and Things."[13] Verran calls this process generative critique. It is more difficult, however, to see how the composting process of generative critique is also at work in her empiricism. As Verran begins to pay attention to practices, "The Yoruba Number System" is decomposed. But what new empirical objects are composed? What happened to the numbers when there is no longer a "Yoruba Number System"? This brings me to the second, and related claim. When Verran tells stories about numbers as a product of collective acting, she explains: "I do not claim this new account should be accepted because it tells the way generalizing 'really' is. It is another description generated in an interpretive cosmology alternative to foundationism" (158). In other words, Verran does not suggest that we replace one foundation (objects) with another (interactions, practices, or collective acting). They represent different storytelling practices that contribute to different kinds of worldings. Storytelling practices that are ongoing and dynamic. They stimulate more compositions and decompositions—stories that narrate different beings and different doings, none of which can claim final ontological authority, but that each do different work (including ontic work). In this coda I return to the question of re-composed

[13] I return to the question of an academic book as an object in the Conclusion.

objects and refused foundations, as a way into the dense relays between worlds and stories. Here I locate *Science and an African Logic* as one moment (one set of stories) in Verran's larger project of staying true to the laugher that came over her in that Nigerian classroom. I begin with the question: What happened to the numbers?

In the compost heap of *Science and an African Logic* we witness numbers as abstract objects fall away, yielding to numbering as embodied practice; things decompose into doings. Like Borges' imaginary Tlön language, the grammar of praxiography seems all verbs and no nouns.[14] But objects are persistent (and useful!) conceptual categories and English continues to thirst for her nouns, her subjects and objects, her duration-extensions.[15] And so, the numbers, having eroded into a silt of practices, come to settle and sediment again. In Verran's later writing, the entities called numbers return—but differently. They are no longer abstract and eternal, but relational and agentive. Here Verran explains how she has come to see these lively numbers, beckoning with her lyrical description:

> To understand numbers' agency in this ontic sense we can imagine them, like all agential entities, as inhabiting the spaces or intervals between collective enactments. Numbers seem to lie there mostly just out of focus in collective life, always ready to actively re-exist when we do the right actions and say the right words. I imagine numbers pulsating and quivering there in these intervals, always in potential, apart from their brilliant,

[14] An example of Tlön: "There is no word corresponding to the word 'moon,' but there is a verb which in English would be 'to moon' or 'to moonate.' 'The moon rose above the river' is *hlor u fang axaxaxas mlo*, or literally: 'upward behind the onstreaming it mooned.'" (8) Like Verran, Borges' narrator extenuates the ontological differences in his translation.

[15] An insightful quotation from Benjamin Whorf, who would have loved Tlön: "We are constantly reading into nature fictional acting entities, simply because our verbs must have substantives in front of them" (65).

> ephemeral realization or clotting in enactment, time and time again. (2007, 112)

These numbers are organic, fleshy, and a bit grotesque, bringing us back to the David Cronenberg imagery of practices congealing (Haraway) or clotting (Verran) into objects. The science fiction atmosphere of this passage, I believe, is not incidental. The task of envisioning *other* forms of life or envisioning familiar forms of life *otherwise* has often been the purview of "the inflamed imaginations of SF filmmakers and biologists" (Haraway 1992, 324). Re-presenting objects as sticky agential conglomerations[16] is indeed an sf genre, one that is indebted to but distinct from praxiography (Mol) or accounting for an apparatus (Barad). Switching genres, we can see that verbs are not inherently more real or more politically advantageous than nouns, practices are not more real or more politically advantageous than objects.[17] Here Verran narrates numbers as things again, but locates their thingy-ness, their materiality, their substance, in an ordinary elsewhere, a space of potential just out of sync with our lived worlds. These numbers are inter-dimensional creatures, manifesting in the here-and-now as luminous and incorporeal when summoned by ritualized gestures of quantification.

This movement from number as a stable object, to numbering as practices, to sf numbers quivering in the intervals stages what Lucy Suchman calls (after Taussig) "the demystification and re-enchantment of lively things" (2007, 243).

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[16] I chose this word thinking of how David Tennant pronounced it on *Doctor Who*, savoring each of the syllables: "con-**GLOM**-ER-A-tion." A wonderfully sf articulation.

[17] This particular point is meant to speak against the trend towards a growing practice of process-based foundationalism that I've noticed in STS and philosophy. Realist readings of Deleuze and Whitehead (see for example Brian Massumi and Steven Shaviro) often underpin this process-based ontology.

Demystification is a familiar practice in critical academic circles, including those of Feminist Science Studies. If technoscientific objects (e.g. human-like machines in Suchman 2007), like Marx's commodities, derive their power, in part, by "masking the labours of production" (244), then drawing attention to these hidden or disavowed relations constitutes a compelling form of critique.[18] However, paired with re-enchantment, demystification need not be figured as true unveiling, but a genre of (potentially) efficacious narrative, a counter-spell to a prevailing "capitalist sorcery" (Stengers and Pignarre 2011). Or, in Suchman's case, a counter-spell to a dominant humanism where the human is figured as a rational, autonomous agent. Like Verran's concept of the "generative critique" and Haraway's "materializing refigurations" (1994, 62), Suchman's "demystification *and* re-enchantment" stands as a reminder that critical narratives that account for the production of powerful technoscientific objects are only one storytelling practice among many in composing and decomposing matters of care (Puig de la Bellacasa), an "ingredient of the assemblage" (Stengers).[19]

So what is this "re-enchantment" that stands in relation to a critical or empirical demystification? In *Human-Machine Reconfigurations* Suchman associates it with the long-standing feminist project of returning agency to an objectified nature (Merchant 1980, Haraway 1991, Barad 2007, Puig de la Bellacasa 2010, Latour 2010, etc). Her own practices of demystification point to a

[18] See Haraway's account of gene fetishism in *Modest_Witness* for her implosion of Marxist commodity fetishism and powerful technoscientific objects.

[19] Talking back to Latour, Maria Puig de la Bellacasa emphasizes the need for critique as part of care: "To promote care in our world we cannot throw out critical standpoints with the bathwater of corrosive critique" (2011, 91).

troubling paradox at the heart of 21st century robotics: "Contrary to the apparent enlivening of objects promised by the sciences of the artificial, I want to propose that an investment in obscuring the performative foundations of persons and things works to deaden the resulting artifacts" (256). Frustrated by the trail of dead objects left in the wake of AI hype, Suchman goes in search of viable "techno-poetic objects," calling on the power of re-enchantment. Here, re-enchantment, like demystification above, is also about casting a spell, a spell of *re-animation with a difference*.

To illustrate: a small vignette from the Seminar in Experimental Critical Theory (SECT VII) I attended in Honolulu in the Summer of 2011. In the kind of luminous cat's cradle (Haraway 1994) moment that sometimes happens when passionate people have the opportunity to think with one another, Lucy Suchman returned to a youtube video that Media Artist/Scholar Sha Xin Wei had shown earlier in the week.[20] The video was of a performance piece called the Sultan's Elephant, during which a giant girl puppet showered in the water spraying from the trunk of a giant elephant puppet and then wandered off into the street. The size and realistic movements of both puppets was impressive: The elephant alone, which was over 20 feet in height and weighed as much as a live African elephant, took 22 people to operate. Performing her own reading on the video, Suchman juxtaposed two stills: one of the girl at her most life-like, making eye contact with the camera and a second of one of the "manipulators" dressed resplendently in red and gold holding one of the cables that animated the puppet. Suchman was not as impressed by the effect of autonomy (represented by the first still) as she

[20] http://www.youtube.com/watch?v=qBXr15K2uSc

was by the elaborate rigging and distributed agencies that created this effect (represented by the second still). But her preference for the second was not in order demystify the performance. There wasn't really anything to demystify: Unlike many of the human-like machines Suchman writes about, the elephant and the girl wore their rigging on the outside. The enchantment of the Sultan's Elephant, Suchman argued, was generated in the oscillation between remembering and forgetting, of seeing the puppet as a whole girl and then as an extraordinary choreography of people and of parts.

I must admit, that one year later I can't quite hold onto Suchman's enchanted reading of the Sultan's Elephant. It was situated and ephemeral. Lucy Suchman, with her intimate knowledge of human-like machines, was the only one at the seminar who could have produced *this* particular reading of the video. Which brings me back to Verran's numbers. Verran's re-enchanted numbers are also situated re-imaginings. They are the product of her lengthy and rigorous engagement with numbering. They do not run the risk of being taken as things-in-themselves; these numbers, like Suchman's reading, are also difficult to hold on to, they carry the contingency of Verran's situated knowledge, of her decompositions and recompositions. And in this way they challenge us to *imagine with* Verran. They beckon.

And for the sf reader, a feeling of wonder rises up to meet them. This wonder is not wonder in the presence of essential difference, but the wonder of seeing a familiar object carefully and beautifully re-imagined and re-materialized. This is a wonder that lures us to participate in Verran's sf worlding; it is an invitation "to speculate, imagine, feel, build something better" (Haraway 2008, 92). Along with

that "sudden surprise of the soul" aroused by these agential numbers as we see them pulsating and quivering in the intervals, there is speculative wonder, pregnant with curiosity and doubt, as in "I wonder, I wonder if…" Verran's description implores me to wonder: I wonder if we can learn to count with her numbers. I wonder if we can learn to keep up with their agility. Not the powerful and invisible agility of the Waterwatch Victoria data, but a relational agility, like the kind that's practiced by Donna Haraway and her spirited Aussie, Miss Cayenne Pepper (2008). As our eyes, hands, and imaginations become more accustomed to tracing and joining with the agencies of numbers, new possibilities for quantitative worldings are activated.

Wonder, re-enchantment, sf worlding are the terms I want to carry forward into the next chapter. They have different sets of associations and possibilities for thinking and relating than the clusters of words that organized the preceding chapter: composing, decomposing, composting and counting, accounting, accountability. Accounting and composing are active verbs that are easy to imagine as clear-headed professional practices. Going back to wonder as "epistemological dilation" here reminds us that knowledge-making can also be about more passive and passionate practices, the ways that we honor how we are troubled, enchanted, haunted, delighted, possessed or inspired.[21] To stay with these sometimes fleeting, sometimes persistent visitations requires bravery and creativity. Helen Verran stayed true to her laughter, decomposed her numbers, and recomposed them again, calling upon the arts of language to stabilize these

[21] I'm thinking here of the conclusion to one of my favorite passages from *Modest_Witness*. Donna Haraway writes: "I think I am on the side of the vampires, or at least some of them. But, then, since when does one get to choose which vampires will trouble ones dreams?" (265).

charismatic creatures long enough to connect and cathect.[22] Possessed by visceral and inarticulate laughter, she refused to temper it; instead she trusted it as a guide for (re)writing a book on the serious topics of postcolonial politics and the philosophy of numbers. The personal and embodied—the gut feelings and belly laughs—are not just politically important, but, as Verran shows, can also be scholarly, a guide for doing empirical inquiry that is sensitive to research as encounter. In the final section of the coda, I return to laughter as method, drawing attention to its political and epistemological possibilities.

Staying True to Laughter

Laughter is an exuberant outburst. A response to encounter.

Science and an African Logic is not the only important book that begins with a laugh. According to Michel de Certeau, Michel Foucault's work was fueled by an "exceptional exercise of astonishment" that was born from the laughter that bore witness to the tiny ruptures in the everyday: "Something that exceeds the thinkable and opens the possibility of 'thinking otherwise' bursts in through comical, incongruous, or paradoxical half-openings of discourse" (194). Foucault famously explained how the astonishment of Borges' Chinese encyclopedia led to him writing *The Order of Things*: "This book first arose out of a passage in Borges, out of the laughter that shattered, as I read the passage, all the familiar landmarks of my thought" (xv). de Certeau takes this laughter, which is at once

[22] Borrowing the name of an ongoing poetry reading series in Toronto, we might call this "lexiconjury."

wonder at the sensation of alterity[23] and a disconcertment that destabilizes the familiar, to be central to Foucault's art of thinking. He argues that Foucault practiced a mode of attention, "exact and vigilant attention," to the "marks of otherness" that are hidden in plain sight, "readable but unread because they take the expected and the codified by surprise" (194). "When he discovered them," de Certeau imagines, "he would roll with laughter" (194).

Although the archival and analytic practices that Foucault displays in the dense chapters of *The Order of Things* are more measured and historically rigorous, they nonetheless failed to stifle the laughter:

> Try as he may, the care he puts into controlling, classifying, distinguishing, and comparing his readerly finds is incapable of stilling the tremble of awakening that betrays in his texts his manner of discovery. His works, then, combine the laugh of invention with the concern for exactitude, and even if, over the years, the exactitude gradually wins out over the laugh. (195)

The classificatory and optical[24] style of Foucault's argumentation was not hypocritical, according to de Certeau, but was evidence of his subversive positioning and furtive movement.[25] To shine a light on and articulate the non-verbal practices that make up his "microphysics of power," Foucault must be

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[23] Although, not the kind that turns into fetishizing exotic Otherness. That Borges' encyclopedia is fictional means that the Other cannot be an empirical object for Foucault; instead, this passage is able to shatter the binary and "disturb and threaten our age-old distinction between the Same and the Other" (xv).

[24] According to de Certeau *Discipline and Punish* is argued through three optical figures: "representational tableaux (exemplary narratives), analytic tableaux (lists of ideological 'rules' or 'principles' relating to a single phenomenon), and figurative tableaux (seventeenth-nineteenth century engravings and photographs)" (191). This optical style of theorizing, he argues, "is a subversive operation, hidden by and within a limpid discourse, a Trojan Horse, a panoptical fiction, using clarity for introducing an otherness into our episteme" (191).

[25] In Chapter 3 I discuss Joan Roughgarden's work as being "improper" in de Certeau's sense (not having "its own place"). De Certeau also describes Foucault in these terms: "This way of thinking cannot have a discourse of its own, because it amounts essentially to a practice of non-locus" (192).

located somewhere *else*, lurking off in the shadows. de Certeau begins his essay "The Laugh of Michel Foucault" by quoting from *The Archeology of Knowledge*: "No, no, I'm not where you are lying in wait for me, but over here, laughing at you." (193). This "art of thinking" (191) that is always in the shadows and on the move is belied by the respectable lucidity of Foucault's theoretical enterprise. In de Certeau's reading, he was "a ballet dancer disguised as a librarian" (192). Or in another speculative comparison, inspired by Anna Tsing, Foucault was a mushroom with only the fruiting body above ground with networks of mycelia branching in unknown directions beneath the ground. It is only mushroom-naïve who take the cap for the whole organism—a mistaken metonymy. Chthonic and loamy, Foucault's thinking both nourished and exceeded the spectacular fruiting body of his writing.

Already in 1969 de Certeau felt that people were enamored with Foucault for the wrong reasons.[26] Because of the enduring centrality of Foucault's work to the critical humanities and social sciences over 40 years later, de Certeau's uneasiness is worth returning to in a contemporary academic context. Isabelle Stengers has recently argued that Foucault is often mobilized in the name of an intellectual exceptionalism that claims, "we know how the world really is," while everyone else "just believes":

> We have become used to Michel Foucault's 'shocking' ways of questioning our modern pride in matters such as psychiatry or penal practices. But the shock now may well be addressed even to academic followers of Foucault, those who have turned his production of destabilizing, and even

[26] De Certeau's work is often appreciated for the wrong reasons, too. Many graduate students, for example, can describe his concept of tactics vs. strategies, but cannot say much about his "art of thinking" and the politics of his reading practices.

> frightening, demands for lucidity into a 'we know better' industry. (2008, 49)

Although this formulation is not entirely fair to the diverse scholars who have been inspired by Foucault, it provides an occasion to reflect on the reasons that his scholarship has remained so popular. For example, why was he the most cited author in cultural anthropology journals from 2005 to 2010, despite not having been an ethnographer?[27] Leaving aside historical reasons, such as the prominence of Paul Rabinow as a translational figure, I feel that the mixture of "shock" and "exactitude" that de Certeau identifies remains at play, with the shock contributing to the charisma of his oeuvre and the exactitude to the ongoing profusion of citations. But while citing Foucault can conjure epistemic authority, this is not, according to de Certeau, the source of Foucault's power: "His immense erudition is not the principle reason for his effectiveness, but rather this art of speaking which is also an art of thinking" (191). Here de Certeau reminds us that as we reverentially and often humorlessly apply concepts like "biopolitics" or "governmentality," Foucault is likely elsewhere, having the last laugh.[28]

de Certeau's generous and mischievous reading of Foucault is important not just because it wrests him away from the "we know better" industry (which might be a bit of a straw man anyway), but because it offers us an alternative way of

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[27] http://www.gjotsuki.net/Anthropology%20Citation%20Ranking.html

[28] A quick note on academic seriousness: Rane Willerslev author of *Soul Hunters*: *Hunting, Animism, and Personhood among the Siberian Yukaghirs*, recently re-evaluated his approach to animism by returning to stories he left out of his book where Yukaghir hunters joke about the spirits. He concludes: "If the indigenous animists are not supposed to take their own animist rhetoric too seriously, perhaps anthropologists should follow their lead" (2012). However, though the article argues this point nicely, it fails to demonstrate what this might look like, revealing the poverty of self-serious academic realism as the dominant genre of scholarly writing.

imagining and relating to his writing practice. Like Helen Verran, we can think of Foucault's immense theoretical project in terms of "staying true to laughter." Laughter is an effect of encounter. Specificity matters. We know this from the arts of comedy, where the subtleties of timing and delivery make the difference between polite and uproarious laughter. But we laugh not only because something is funny; we laugh because something is surprising, because something is *not* funny or because something is true. We laugh with surprise or relief. We laugh at or with or just 'cause. There is awkward laugher, knowing laugher, generous laughter, cruel laughter, nervous laughter. Unhinged laughter—maniacal, mischievous, or mad. Unexpected laughter that makes tea shoot out your nose. Inappropriate laughter that cuts through the thick seriousness of the lecture hall. Stifled laughter and forced laughter. Laughter that is shy, warm, good-natured, bitter, or painful. Laughter as giggle, as snort, as chuckle, as snigger, as snicker, as guffaw. Through laughter we relate. We laugh to connect, to flirt, to charm, to disconcert, to detach, to belong. It is inarticulate and exuberant and most often pleasurable.

There are many ways of "staying true to laughter," only some of which appear erudite. Because laughter is so very inarticulate it invites language. And because if language was good enough to begin with we wouldn't have responded with laugher, there are always multiple crisscrossing ways to account for it. Of course there are other embodied responses generated through intra-action with the world (crying, trembling, sweating, sighing); "staying true to laughter" is one example, one refrain that might be useful for scholarship that is more faithful to the encounters that occur in life's contact zones. (It is *always* surprising to me

that few scholars write about teaching—the central contact zone of many of our professional lives[29]). And the joyfulness of laughter may also hold a particular political charge at this moment in the university, where "academic organizations increasingly come to adopt practices...that were formerly specific to the corporate domain" (Kleinman and Vallas 2001, 453).[30]

These concerns about the knowledge industry or "scientific factory" were also at the forefront of de Certeau's thinking. His anti-capitalist politics were not limited to analyzing the labor of others, but addressed how academic labor was implicated in capitalist systems and contemporary forms of knowledge/power. In his essay "Popular Cultures: Ordinary Language" he describes *la perruque* ("the ruse") as a set of small, mostly unconscious tactics by which workers resist capitalist systems. His famous examples include the secretary who writes a love letter on company time and a factory worker who takes a scrap of fabric home for his child to play with. Less well-remembered is the end of his essay (a passage that always brings tears to my eyes), where he turns this question back to scholars and universities: "Let us try to make a *perruque* in the economic system whose rules and hierarchies are repeated, as always, in scientific institutions" (27). de Certeau imagines how scholars can subvert the laws of the "scientific factory" through gift giving, solidarity, and free exchange even when bosses and colleagues will not turn a blind eye (28). He writes: "I know of investigators experienced in this art of diversion, which is a return of the ethical, and of pleasure and of invention within the scientific institution" (28). The return of

[29] There is, of course, a large literature specifically on pedagogy, but teaching stories rarely make it into works not specifically about teaching. Excepting, of course, *Science and an African Logic*.

[30] See also Bousquet 2008.

laughter is also a return of pleasure. And the making of what my colleague, Nicole Archer, calls a "critical hedonism."[31] In a climate of austerity in academic institutions, austerity that disproportionately affects the arts, humanities, and interdisciplinary studies, extravagance, joy, and generosity have political implications.[32] They can be refusal of the "embodied anxiety" (Sigl 2012) that many academics face in building their careers.

Although it has been central to a recent "turn" in the social sciences and humanities, affect is most often figured as the topic of study or the thing to be theorized rather than as an invitation to ask what "affective economies" (Ahmed 2004) animate our own bodies as scholars and as people.[33] For example, Lisa Sigl's dissertation (cited above), which investigates embodied anxiety as a product of the institutional constraints faced by life scientists in Austrian universities, makes no mention of her own embodied anxiety, as a PhD student working in the very same academic system. The irony of this particular example draws our attention to the way that the writing conventions of sociology can conspire with institutional pressures to keep personal struggles and pleasures outside of proper academic knowledge.[34]

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[31] Archer's critical hedonism is a little bit darker, I think, than what I'm proposing here. All Marquis de Sade and Georges Bataille. She hasn't published on this concept yet, but her graduate syllabus can be found here: http://people.ucsc.edu/~naarcher/CriticalHedonismSyllabusREVISED.pdf

[32] Meditating on the radical power of laughter in the face of science that claims universal power on behalf of the prevailing social order, Isabelle Stengers writes: "The laughter of someone supposed to be impressed always complicates the life of power" (2000, 44).

[33] Queer and feminist work on affect, of course, often draws explicitly on the author's own feelings. In this context, Ann Cvetkovich's *Depression: A Public Feeling* offers an interesting counter-point to Sigl because it starts from personal academic anxiety and works to collectivize and politicize these feelings.

[34] In the two creative writing workshops I have hosted for STS scholars, I have noticed that almost all of the social scientists write first-person journal-type pieces about their personal feelings about their research.

In this context "staying true to laughter" has important and overlapping personal, political, and epistemic connotations. It is about embodied attention, situated knowledge, writing that is faithful to encounter, critical hedonism, and reparative scholarship. Eve Sedgwick, whose work on affect was always openly animated by her own feelings, fiercely defended the reparative against a prevailing paranoid sophistication:

> Reparative motives, once they become explicit, are inadmissible in paranoid theory both because they are about pleasure ('merely aesthetic') and because they are frankly ameliorative ('merely reformist'). What makes pleasure and amelioration so mere? (144)

Reading Sedgwick together with Verran and de Certeau, we learn to ask: What feelings inform our work? What surprises do we find ourselves beholden to? Who do these feelings connect us with? What affective economies are we living inside and through? Which pathways of exploration and expression give form to these vital obligations and imbrications?

In a recent article on the popularity of "Dance Your PhD" contests for young scientists, Natasha Myers argues:

> The enthusiasm with which scientists have embraced the Dance Your PhD contests suggests that they are on the look-out for ways to resist discursive conventions that limit what is possible for them to see, to say, to imagine and to feel. Perhaps it is through the medium of dance that they are best able to avow, rather than continue to disavow, their richly embodied kinesthetic knowledge and the affective entanglements that inflect their inquiry. (178)

Although there are traditions of social science inquiry that do take seriously the researchers' feelings, it seems to me that it remains outside of mainstream literature and training.

Following Myers' analysis of the dancing scientists and her own practice of dancing as "a means of *cultivating new dexterities* for sensing, recording and propagating movements and affects,"[35] I would like to conclude by asking what forms of expression might change what it is possible for *us* to see, to say, to imagine and to feel; how can we avow rather than disavow our richly embodied knowledge; how can these forms of expression help us to resist the comfortable authority of the "we know better industry" and the embodied anxiety of the "scientific factory"? As Emma Goldman famously said,[36] in a quote that is, fittingly, the epigraph to Archer's "Critical Hedonism" syllabus: "If I can't dance, I don't want to be part of your revolution." If, in this spirit, we were to take Charis Thompson's "ontological choreography" quite literally, passionate academic expression—writing, speaking, knowing as dancers *and* as librarians—becomes a practice of sf worlding, a choreography that generates ontologies, that brings worlds into being by "cultivating new dexterities." Ecstatic, worldly, and affectively-charged, moving like Denis Levant to David Bowie in *Mauvais Sang*,[37] we can activate different possibilities for living, knowing, and feeling. These forms of expression are communal and reparative; they demonstrate "the inextricability of aesthetics and survival" (Tsing 2005, 167).

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[35] http://adanceaday.wordpress.com/. Natasha Myers describes this research practice in the endnotes to "Dance Your PhD: Embodied Animations, Body Experiments, and the Affective Entanglements of Life Science Research" (184–185n33)

[36] Or didn't say. According to multiple sources, it seems that Goldman probably never said this. But I do love the genre of the fabulous quotation, so I'm keeping it.

[37] http://www.youtube.com/watch?v=gt2KlkBUgXA Denis Lavant is, for me, one of our pre-eminent sf actors/dancers, not only in *Mauvais Sang*, but also in *Beau Travail* (http://www.youtube.com/watch?v=Q7Yag9t_HkY) and in *Toyko!* where he crawls out of the sewer and lumbers down the Tokyo streets (to the Godzilla soundtrack) stealing and consuming cigarettes, cash, and chrysanthemums, before returning again to the sewers: http://www.youtube.com/watch?v=BMVbd1Fodvc

The next chapter and the conclusion, which re-animate wonder for feminist inquiry, explore the aesthetic and reparative in scientific knowledge-making and storytelling; I argue that a serious engagement with what might at first seem like the "merely aesthetic" (poetry, laughter, art, and dance) is crucial for enabling response-ability in technoscientific worlds.

Figure 2.1: ***SCIENCE AND AN AFRICAN LOGIC*** **TABLE OF CONTENTS**

Table 3.1. Yoruba Language Cardinal Numerals, Showing Their Derivation

Modern Graphic Numeral	Yoruba Cardinal Name	Derivation Implied in the Name
1	kan	1
2	méjì	2
3	mẹ́ta	3
4	mẹ́rin	4
5	márùún	5
6	mẹ́fà	6
7	méje	7
8	mẹ́jọ	8
9	mẹ́sán	9
10	mẹ́wá	10
11	mọ́kọ̀nlàá	(+1 + 10)
12	méjìlàá	(+2 + 10)
13	mẹ́tàlàá	(+3 + 10)
14	mẹ́rìnlàá	(+4 + 10)
15	mẹ́ẹ́ẹ́dogún	(−5 + 20)
16	mẹ́rìndínlógún	(−4 + 20)
17	mẹ́tàdínlógún	(−3 + 20)
18	méjìdínlógún	(−2 + 20)
19	mọ́kọ̀ndínlógún	(−1 + 20)
20	ogún	(20)
21	mọ́kọ̀nlélógún	(+1 + 20)
22	méjìlélógún	(+2 + 20)
23	mẹ́tàlélógún	(+3 + 20)
24	mẹ́rìnlélógún	(+4 + 20)
25	mẹẹ́dógbọ̀n	(−5 + 30)
26	mẹ́rìndínlọ́gbọ̀n	(−4 + 30)
27	mẹ́tàdínlọ́gbọ̀n	(−3 + 30)
28	méjìdínlọ́gbọ̀n	(−2 + 30)
29	mọ́kọ̀ndínlọ́gbọ̀n	(−1 + 30)
30	ọgbọ̀n	(30)
31	mọ́kọ̀nlélọ́gbọ̀n	(+1 + 30)
32	méjìlélọ́gbọ̀n	(+2 + 30)
33	mẹ́tàlélọ́gbọ̀n	(+3 + 30)
34	mẹ́rìnlélọ́gbọ̀n	(+4 + 30)
35	marùúdínlógójì	(−5 + (20 × 2))
36	mẹ́rìndínlógójì	(−4 + (20 × 2))
37	mẹ́tàdínlógójì	(−3 + (20 × 2))
38	méjìdínlógójì	(−2 + (20 × 2))
39	mọ́kọ̀ndínlógójì	(−1 + (20 × 2))
40	ogójì	(20 × 2)
41	mọ́kọ̀nlógójì	(+1 + (20 × 2))
42	méjìlógójì	(+2 + (20 × 2))
43	mẹ́tàlógójì	(+3 + (20 × 2))
44	mẹ́rìnlógójì	(+4 + (20 × 2))
45	márùúndínlàádọ́ta	(−5 − 10 + (20 × 3))
46	mẹ́rìndínlàádọ́ta	(−4 − 10 + (20 × 3))
47	mẹ́tàdínlàádọ́ta	(−3 − 10 + (20 × 3))
48	méjìdínlàádọ́ta	(−2 − 10 + (20 × 3))
49	mọ́kọ̀ndínlàádọ́ta	(−1 − 10 + (20 × 3))
50	àádọ́ta	(−10 + (20 × 3))

Figure 2.2: **TABLE OF YORUBA CARDINAL NUMBER NAMES** (Verran 2001, 56)

INTERLUDE

On Worlds and Worlding

"There is no self without a world"
-Anne Carson

I keep getting pulled into worlds. Drawn in by their gravities, my lungs acclimate to their atmospheres. I breath them in. I am worlded.

Figure 3.1: MAMMALS OF THE EOCENE (Matternes, 1964)

As early as I can remember, I have been captured by gravity wells and "rogue force fields" (Stewart 446) pulling me elsewhere. I remember watching LeVar Burton on *Reading Rainbow* (1983) and *Star Trek: The Next Generation* (1989), both sf programs in their own right, luring me into other worlds, book worlds and future worlds. In *The Thread of Life* (1982), a coffee table book about evolution I took from the basket in the living room, I studied landscapes from the Oligocene,

Pliocene, and Miocene Epochs overstuffed with long extinct mammals—*uintatherium*, a six-horned saber-toothed plant eater, *synthetoceras*, a snout-horned even-toed hoofed ungulate, and *megalonyx*, a giant ground sloth.[1] As a teenager, growing up with the internet, I lurked[2] in chat rooms and on message boards, in communities that were resolutely not "mine," some salacious, some mundane. Not as a voyeur or anthropologist, but to breathe in the density and composition of their atmospheres. Working at cinemas and science museums, I ushered patrons into other worlds, I popped the corn, I watched the shows for free. I hungrily read J.G. Ballard, Thomas Pynchon, William Gibson and Don Delillo, writers who made fictional worlds by amplifying peculiar affects and intensities of contemporary life. "I believe in my own obsessions" Ballard wrote (1984, 176); I basked in the obsessions of others. In college I fell in love with the elsewheres of feminist theory, with the project of building more livable worlds in the here-and-now by collectively crafting critiques, commitments, stories, and actions. I spent many sleepless grad school nights in the radio world of Coast to Coast AM, listening to other people's stories about UFOs, shadow people, secret governments, numerology, chupacabras, chem trails, and CIA mind control experiments.
I immerse myself, feeling out their "rhythms, valences, moods, sensations, tempos" (Stewart 445) and the categories that spawn and mutate as these worlds expand and contract. Real and virtual worlds, future and past worlds, fictional and theoretical worlds, always happening and happening and happening:

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[1] These are reproductions of murals by Jay H. Matternes that can be seen in the Smithsonian's Hall of Mammals.

[2] Lurk: "To move about in a secret and furtive manner" (OED). The internet-specific meaning was added to the OED in 2001.

worlding, sf worlding, other worlding, "autre-mondialisation" (Haraway 2008, 3). I am worlded.

SF Worlding: Big Man Japan

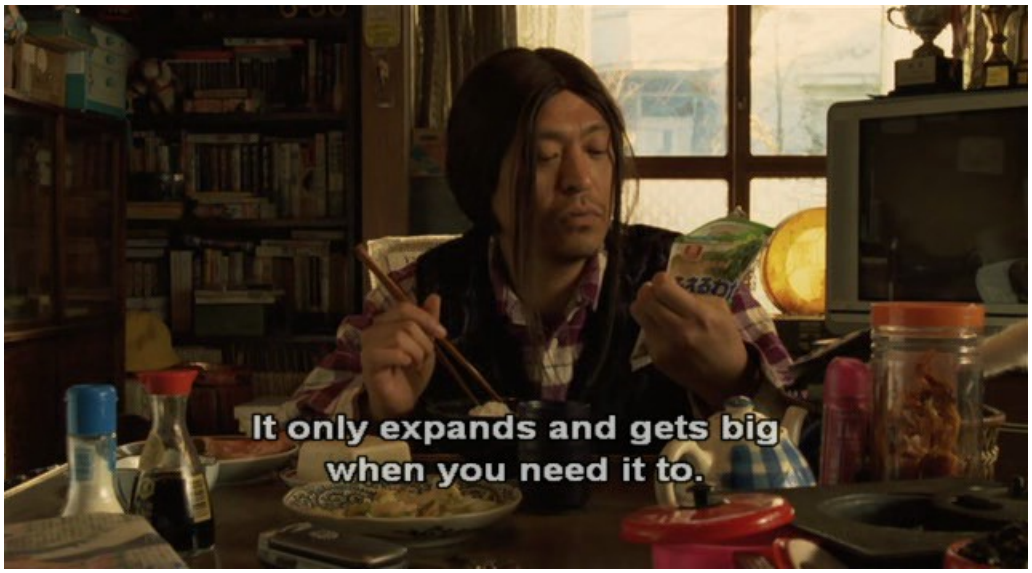

Figure 3.2: SATO AND HIS SEAWEED IN *BIG MAN JAPAN*

Big Man Japan (2010) is a Japanese mockumentary about a man with a unique job: he waits until a giant monster attacks Tokyo, travels to the nearest power plant where, via some outrageous electrical procedure, he becomes huge and lumbers off to fight the monster. Upon defeating the monster he shrinks again and awaits the next attack. Although his father and his grandfather, who had previously served as Big Man Japan, were revered by the citizens of Tokyo, he is seen as a throwback and a liability, a disgraced hero who does more harm than good. His wife and daughter left him years ago. He has the flat affect of someone who lives with perpetual disappointment. Early in the film, the "director" asks him why he always carries a collapsible umbrella and, later, why he keeps a

package of dried seaweed on his kitchen table. His answer is the same: "Because they only get big when you need them to." In the absence of public support or any close human relationships, he has formed "inanimate affections" (Chen 2011), attachments to these everyday objects that share his capacity for timely expansion. For me it isn't the obvious science fiction premise of a man who becomes big to fight monsters that gives the film its sf pull. It is in the category—"things that only get big when you need them to"—that the world of the film begins to cohere, to become atmospheric. I am pulled from my orbit and down into the film. [3]

STS Worlding: Overpasses, Underpasses, and Fishways

Figure 3.3: **FISH LADDER SIGN** Photo by Wildcat Dunny.

STS writing is, of course, replete with technoscientific worlds that sprout, blossom, and burst with lively categories. In "Intimate Bureaucracies: Roadkill,

[3] One reason I never liked the *Star Wars* films, I think, is that for all their nomenclature there are no *categories*.

Policy, and Fieldwork on the Shoulder" Sandra Koelle takes her reader through animal over- and underpass worlds, populated by passionate researchers trying to reduce road-kill by rerouting biological corridors. She tells us about the sand track-beds that researchers use to determine which animals are passing under the underpasses and over the overpasses. In the winter they sometimes freeze, making it difficult to record the passages of "soft padded animals," such as bear, canine, and feline species. The technology of the sand-track beds catalyzes a taxonomic "cut" (Barad 2007) between animals with hooves and animals with soft pads. As these categories are cleaved from one another we learn not just about the anatomy of animals but the apparatuses that track them, about how sand behaves as it freezes and how feet interact with the frozen sand. And in dammed rivers we witness the emergence of another peculiar and alluring category: the fish ladder (which sounds like the set up to a silly joke).[4] The techno-poetic constraints (dams blocking the flow of the river) and possibilities (jumping salmon!) give shape to the technological and economic compromise of the fish ladder. Fish ladders and soft padded animals—these categories beckon, provoking curiosity about the sets of practices, technologies, and investments in which are germinate. Sparkling lures for the techno-politically attuned.

[4] I learned about the fish ladders in the Science and Justice event "Enacting Multiple Salmon: Collaboration across Multiple Practices," October 25th, 2012. Here is a nice video of a fish ladder in use: http://www.youtube.com/watch?v=uqR2g8darqs

Academic Worlding: Teaching and Learning

Figure 3.4: **THE HISTORIAN BREAKS FREE** of his shackles from *That Mitchell and Webb Look*

People are also worlds; they have their own atmospheres. One ongoing pleasure of academic life is the process of acclimating oneself to the intellectual and affective atmospheres of professors and colleagues, to feel what questions, passions, modes of attention animate one another, to find yourself moved by their concerns. Thinking about Natasha Myers' work on protein crystallographers, I was wondering what we, in the humanities and social sciences, articulate with our bodies. What do our gestures *mean*? What do our gestures *express*? What do they *activate*? Surely they do not enact a precise language, but a kind of "tentacularity" (Hayward 2010, 593)—gestures as organs for "feeding, feeling, and grasping" (Wikipedia). In a sketch from the British comedy show *That Mitchell and Webb Look*, an expressive historian is being filmed for a BBC documentary about WWII.[5] When asked by the director to tone down his hand

[5] http://www.youtube.com/watch?v=6Hpd5M8Vfdg

motions, his gestures (comically) become more and more exaggerated. The crew even resorts to tying his hands together with rope. But as soon as he begins to speak again, his arms exuberantly break free of their shackles and gloriously begin to flail about again.

I think there's something smart about this parody. The more I teach, the more I gesture—trying to feel out concepts, to grasp the passions of students, to feed on the energy of the room, drawing everyone into collective task of worlding the classroom. I pace, I gesticulate, I flail about, in a (sometimes mad) attempt to generate enough atmosphere to make soft padded animals and collapsible umbrellas and my other eclectic cares—things I have pocked from the worlds I have visited—cohere and enroll. I am worlding.

Worlding

How wonderful that scholars like Kathleen Stewart, Anna Tsing, and Donna Haraway have adopted the term "worlding," to draw attention to the ways that worlds come together through collective action and how they attract, repel, enroll, animate, and incite us. In this theoretical milieu worlds are "lived [compositions] with tempos, sensory knowledge, orientations, transmutations, habits, rogue force fields" (Stewart 446). In her article "Atmospheric Attunements"—the article that inspired this brief interlude—Kathleen Stewart offers vignettes from her fieldwork and from her life, moments of "sensing out and living through worlds" (450). She writes about her daughter's "pink phase" and her stepson's homelessness, the trajectories, moods, and intensities that people get caught up in, attach to, inhabit. Worlds as "scenes and pulsations" (449). Stewart is

interested in "theory" not as a genre for representing or explaining worlds, but as a mode of writing that can "create new spaces for thinking about and imagining what might be going on" (445). Stewart's project is a kind of sf anthropology, an attempt to develop "forms of writing and critique that detour into descriptive eddies and attach to trajectories" (452). It is about pulling "academic attunements into tricky alignment with the amazing, sometimes eventual, sometimes buoyant, sometimes endured, sometimes so sad, always commonplace labor of becoming sentient to a world's work" (445). [6]

Kathleen Stewart's atmospheric attunement and Helen Verran's generative critique are useful names for doing writing explicitly as worlding. Another comes from Isabelle Stengers and her constructivist approach to philosophy. Stengers explains, "I consider that my job, as a philosopher, is to activate the possible, and not to describe the probable" (2011). Like Whitehead, she is constructing and taking care of categories, abstractions, refrains, and other magic words pragmatically crafted to betray the Modern categories that poison our thinking and choke our worlds (2008, 50–51). They are "sheer fabrications" (51)—another sf to add to Donna Haraway's science fiction, scientific fact, speculative feminism, string figures, so far (2011)—for sf worlding. The point is not whether they are true or real but whether and how these fabrications move through worlds and how they make us "think and feel and wonder" (51). Like Stengers, Verran, Haraway, and Stewart, I am interested in what theoretical and philosophical storytelling makes possible, as one consequential practice among

[6] Stewart's "atmospheric attunements" has something in common with Trinh Minh-Ha's concept of "speaking nearby," which is not a technique or method but "a way of positioning oneself in relation to the world" (Chen 1992, 86).

many in the collective task of building and sustaining livable worlds. My approach in this next chapter is less anthropological than Stewart's, less philosophical than Stengers', and more bookish in spirit—taking texts as worlds, performing readings as worldings. An approach with obligations to Michel de Certeau (1984), Eve Sedgwick (2003), and, of course, LeVar Burton. I still feel the pull of *Reading Rainbow* and *Star Trek: The Next Generation*.

CHAPTER 3

Wonder: A Feminist Adventure

The subjects are cyborg, nature is coyote, and the geography is elsewhere
-Donna Haraway

PART I: Wonder

This chapter is a return to wonder. A return to wonder with a difference. In Chapter 1 I detailed E.W. Gudger's passionate empiricism, showing how wonder as epistemological dilation opened his scientific practice to the world in ethically promising ways, but also how it ultimately figured difference as essential and exotic and gave us ichthyology as monster-hunting. An ambivalent, historically-situated wonder. In Chapter 2 I described how Verran began her study with wonder, but shifted to disconcertment, feeling that wonder was not the right mode of attention for the postcolonial worlding she was struggling to do. Wonder as a colonial mode of attention. In the Coda of Chapter 2 I detailed my own sense of wonder at Verran's sf numbers, which was not wonder at an essential difference, but a speculative wonder: "I wonder if." This chapter deploys wonder as a mode of attention for sf worlding by latching on to its speculative valences and seeing what kinds of sensitivities and response-abilities are activated.

Daston and Park argue that wonder is no longer an integral part of scientific knowledge: "To be a member of the modern elite is to regard wonder and wonders with studied indifference. Enlightenment is still in part defined as the anti-

marvelous" (368). I wrote Chapter 1 because I simply didn't believe this to be true—I can still *feel* the force of wonder in scientific inquiry. Taking a 20th century example, American ichthyologist E.W. Gudger, I told a historical fable that placed wonder at the center of Gudger's scientific practice, showing how it helped to constitute his empirical objects in some ways and not others. In this chapter, I continue to move farther from Daston and Park's periodization by introducing and performing more speculative intertextual readings of wonder. The wonder(s) in this chapter are not ahistorical or general, but historically *unmoored.* The chapter opens with a discussion of Luce Irigaray, Caroline Walker Bynum, and Isabelle Stengers. Beginning with a specific historical text or moment in European intellectual history, these scholars each tease out the epistemological and ethical potentially of wonder through creative re-readings, following the hunch that wonder might be a helpful figure in the process of articulating a specific knowledge-politics. Drawing together insights from these scholars' situated engagements with wonder, the chapter thickens their refigurations by discussing the practices of evolutionary biologists Joan Roughgarden and Lynn Margulis, and feminist science studies scholars Carla Hustak, Natasha Myers, Mel Chen, and Eva Hayward as they seek to craft more responsive and responsible stories about life. Speculative feminist theory, in particular Donna Haraway's concept of sf worlding, guide this project of reimagining wonder and foreground the themes of storytelling and response-ability: "How to be response-able is the consequential question in sf worlding" (Haraway 2011, 15).

In what follows, wonder acts as a point of contact, a lightening rod, for a set of epistemological and ethical sensibilities that are indigenous to multiple worlds, including feminist science studies, evolutionary biology, and speculative fiction. Drawing these together within the space of this chapter is its own kind of sf worlding, a practice of cultivating sensitivities for an "imagined elsewhere" (Haraway 1992, 295) that Sandra Harding once called (immodestly and oppositionally) a "successor science" (1986). A project driven not by the frontier logic that sacrifices the present in the name of a utopian future, but by the refrain: "Another world is possible! Another world is here!" (Puig de la Bellacasa forthcoming, 3). This political slogan calls for a practice of caring for the future by caring in the present, of gardening rather than terraforming or geo-engineering,[1] a practice of "sowing worlds" (Haraway forthcoming). By collecting these wonder-seeds from multiple texts, my hope is to facilitate growth, propagation, and cross-pollination for more promising knowledge ecologies. Worlding as gardening.[2] The wonder that takes root in this chapter is about cultivating openness, learning to live with uncertainty, practicing the speculative arts, making the ordinary strange through techniques and technologies of attention, trust in the liveliness of the world, and telling stories that strengthen response-ability.

[1] This was a point that Margaret Fitzsimmons made at the "Emerging Terraformations: Geoengineering and Science Fiction" Conference at UCSC in 2010. She and I were the only two women to speak and we both brought seed metaphors with us. I quoted from LeGuin's "Carrier Bag of Fiction," which Donna Haraway (who originally put that essay in my hand) works with in her short essay "Sowing Worlds." Definitely a moment where I felt that another world is here.

[2] Closer to Anna Tsing sensuous description of the exuberant and weedy swidden agriculture of the Meratus Dyak than the French formal gardens which were designed to impose order onto nature.

Addressing Wonder or Writing Under the Influence

In the following section I begin my practice of re-signification by returning to three previous feminist mediations on wonder: French philosopher Luce Irigaray's "Wonder," American medievalist Caroline Walker Bynum's "Wonder," and Belgian philosopher and chemist Isabelle Stengers' "Diderot's Egg." I trace the contours of each of their concepts of wonder, paying careful attention to how each they mobilize wonder within their larger epistemic and political projects. The ways that each scholar defines and animates wonder differ, but they also have important resonances—especially around questions of attention, storytelling, relating, and difference.

Perhaps the most striking similarity, though, is that these pieces were all originally written as oral addresses. Irigaray's chapter was part of series of lectures she gave at Erasmus University in Rotterdam in 1982, Bynum's article is the text of her 1997 presidential address to the American Historical Association, and Stengers' article is a revised version of a paper presented at the Radical Philosophy conference *Materials and Materialism* in London in 2007. Importantly, these are not just talks or lectures, they are specifically *addresses*. Like fables,[3] they directly *address* their listeners. These pieces were crafted to *influence*, to flow into (*in-fluere*), their audience, to move them. The history of the word influence, the OED reminds us, is heavy with astral and occult significance; influence is the "flowing or streaming from the stars or heavens of an etherial fluid acting upon the character and destiny of men" and also "the inflowing,

[3] "A fable is an address or call to the other" (Keenan 56).

immission, or infusion (*into* a person or thing) of any kind of divine, spiritual, moral, immaterial, or secret power or principle." Influence is about astral transmissions and secret powers. It's therefore not surprising that these feminist scholars chose wonder, which also retains a certain aura of the mystical, as the vital force, for this, the spoken medium.

Although I did not attend any of these events, in the following sections I read their written texts, trying to feel the consequences of their addresses, to let their propositions flow through me. It is a practice of *writing under the influence.* In contradistinction to Harold Bloom's anxiety of influence, where Oedipal poets must reckon with their forefathers in order to produce original work,[4] writing under the influence is a feminist reading practice that honors the writers who have made it possible for me to write. Rather than distancing myself (through critique or through historical separation[5]), writing under the influence is about exposing myself to the immanence of reading. In each of the sections that make up the three parts of this chapter, I focus on the work of one scholar, feeling how her address transforms my approach to thinking and writing with wonder. Of course these texts are also transformed by my own concerns, just as alcohol (and perhaps astral transmissions) are metabolized by the cells of a body. In other words, I do not passively reflect these thinkers but *in-corporate* and *metabolize* them in order to animate wonder as a concept for my feminist knowledge-politics.

[4] Bloom denies that this a is a good reading of his argument (xxii). However, influence for Bloom is always an anathema to original poetry: "Influence is *Influenza*–an astral disease." (95)

[5] I am thinking here of the harm in telling feminism as a linear history, a frontier epistemology of successive "waves" and "turns" (see Hemmings 2012 and Purcell 2012). You can see in my discussion of Irigaray my struggle not to relegate Irigaray to "the second wave" and to show that I "know better" than her when it comes to questions of sexual difference (while still differentiating my own position). I think these easy knee-jerk readings often inure us to the effects of texts from other time and places.

Irigaray: Wonder for an Ethics of Sexual Difference(s)

In her short essay "Wonder," Luce Irigaray performs a poetic feminist reading of René Descartes' *The Passions of the Soul.* A reading that is much more faithful to Descartes' physiology than to his metaphysics. *The Passions of the Soul* was Descartes' final book, published in 1649—a treatise on emotions, perceptions, and sensations. Irigaray's exploration is not trapped within Descartes' body/soul divide; instead she is drawn up into the current as the passions move *between* body and soul. She follows closely how wonder, spurred by the sensuous perception of a rare and extraordinary object, creates an impression in the brain, which dispatches the spirits to hold fast to that impression, employing the muscles to sustain its memory within the senses. Irigaray probes tissues aroused by wonder, the untouched place in the brain "which is tender and not yet hardened by past impressions" (77). She follows the path of spirits, the medium that causes human and animal bodies to move, as they rush to the brain to preserve and fortify the image of the wondrous object. In this way, Irigaray dwells within the strangeness of Descartes physiology, a strangeness that is often forgotten or explained away as his philosophy is abstracted into "ideas"—an ironic Cartesian dualism of philosophical history (historical thoughts severed from historical bodies). Irigaray's feminist refiguration begins with a return to Descartes' passionate body and extends outward—down into the earth and up towards the sky—creating delicate poetic channels between the "vegetal and earthy" and the "ideal and heavenly" (72)

Irigaray begins by naming wonder as the passion that attracts us to difference, and thus, is the "motivation behind all mobility" (73). Wonder is the "moment of illumination" (77) between the self and the world. Not the self and the world as separate, but becoming together through curious encounter: "*Who art thou*? I *am* and I *become* thanks to this question" (74, italics original). The question of how to respond to difference is also a question of becoming-with: "Wonder is a mourning for the self as an autarchic entity; whether this mourning is triumphant or melancholy. Wonder must be the advent or the event of the other" (75). Because, for her, wonder marks the space of becoming in the encounter with difference Irigaray writes: "This passion is indispensable not only to life but also or still to the creation of an ethics" (74).

The ethics Irigaray develops through her feminist readings of canonical Western philosophers (Plato, Aristotle, Descartes, Spinoza, Merleau-Ponty, Levinas) is an ethics of sexual difference. She seeks a way to stimulate more salubrious encounters between men and women, the masculine and the feminine: "We need to change the relations between form, matter, interval, and limit, an issue that has never been considered in a way that allows for a relationship between two loving subjects of different sexes" (12). To think sexual difference with Descartes' physiology of wonder, she locates the extraordinary within the ordinary: "This would only be possible when we are faithful to the perpetual newness of the self, the other, the world" (82). Being faithful to the perpetual newness of the familiar requires specific technologies and techniques of attention and a sensitivity to mundane but possibly consequential differences.

Sexual difference is not extraordinary in and of itself but becomes so through creative perception.[6]

In my estimation, however, Irigaray's engagement with wonder goes beyond "the question of sexual difference." To read Irigaray like Irigaray reads Descartes—reading as passionate betrayal—this address presents differences that are not already pre-figured as *sexual* difference. Wonder, as Irigaray defines it, is an "attraction to that which is not yet (en)coded" (75). Differences that are palpable but not yet named, or not fully namable: "Before and after appropriation, there is wonder" (74).[7] This essay, more than the others collected in the book, reaches beyond the foundational masculine/feminine binary that grounds Irigaray's project,[8] and can even be coaxed into affiliation with more multivalent contemporary engagements with difference, even those that contain an explicit critique of her concept of sexual difference. For example, Eva Hayward, who I will discuss in more detail later, is clearly in critical conversation with Irigaray when she writes: "Sexual differences (not sexual difference) remain unfinished; sexual ontologies stay active, ongoing, differentiating. If sexual differences and sexuality are exuberances, contingencies, then sex is profusive, a superabundant

[6] Sara Ahmed also focuses on rendering the ordinary extraordinary in her discussion of wonder (2004). Her emphasis, informed by a Marxist feminist perspective, however, is on wonder as an opening for engaging with the surprising historicity of ordinary things: "I would suggest that wonder allows us to see the surfaces of the world *as made*...Historicity is what is concealed by the transformation of the world into 'the ordinary,' into something that is already familiar and recognizable" (179–180).

[7] I see this statement as a poetic challenge issued from her engagement with Descartes physiology, rather than a given. Irigaray's wonder is mythic. It oscillates between the historical and an ethics to come.

[8] For an excellent discussion of Irigaray's sexual difference see Cheah and Grosz 1998. This interview between Judith Butler, Drusilla Cornell, Elizabeth Grosz, and Pheng Cheah offers both generous and critical readings of sexual difference. I share Butler's frustration with making masculine/feminine the "paradigmatic interval of difference" and the heterosexist assumptions that underpin her ethical imagination. But am also taken with Irigaray's fierce feminist readings and poetic ethics. I don't want to rehash the critiques here; instead I use Irigaray's wonder to push against Irigaray's sexual difference.

happening" (2010, 235). However, Hayward's evocative description of an ongoing and active sexual differentiating can be nicely harmonized with Irigaray's challenge to be "faithful to the perpetual newness, of the self, the other, the world." And Hayward's description is, in turn, enriched, as Irigaray reminds us that profusive, superabundant happenings may at first seem perfectly ordinary—they are made wondrous through acts of poetic attention. That this kind of cross-generational reading suggests itself in the context of wonder, I feel, is not by chance. Here, thinking-with-wonder induces a constellation of openings and a proliferation of latent possibilities that have affinities with other possible worlds: the could-have-beens, the almost-weres, and the yet-to-comes.

What I find most nourishing about Irigaray's wonder is that it brings together practices that are usually kept apart. Wonder is "the passion that inaugurates love and art. And thought." (82). Through wonder, love, art, and thought become kin. They are surges of passionate unfurling, dividing momentarily only to coalesce again. Irigaray begins her essay by mourning the fact that philosophers are no longer physicists and that by splitting science from thought, we are "splitting our life, our bodies, our language, our breath into several worlds" (72). Wonder helps her to reclaim the ability to say love, art, thought, and science in the same breath. This is a reparative gesture that is well suited to the worlds of feminist science studies, worlds that feminist-philosopher-physicists like Evelyn Fox Keller, Astrid Schrader and Karen Barad call home. Writing her way out of these toxic divisions, Irigaray challenges us to see our intellectual curiosity as part of the vital movement and exotropic desire that animates our flesh and seeks

out new impressions for the "excitable tissue" (Myers 2012) deep within the slick, pink folds of our Cartesian brains.

Bynum: Wonder for a Historian's Ethics

In her 1997 Presidential Address to the American Historical Association, Caroline Walker Bynum traces the contours of medieval wonder—*admiratio*—as she had come to know it in working with 11th–14th century European manuscripts. She defines *admiratio* with historical specificity presenting it as qualitatively different from Early Modern or Cartesian wonder; *admiratio* is "cognitive, perspectival, non-appropriative, and deeply respectful of the specificity of the world" (24). She illustrates each of these adjectives with rich examples from her archival research. For instance, she shows *admiratio* as perspectival rather than an essential property of objects with this vivid quote from 13th century theologian James of Vitry: "Perhaps it is the Cyclopes, who all have one eye, marvel as much at those who have two eyes as we marvel at them" (14). Her purpose, however, is not simply to provide an historical account of medieval wonder, but to mobilize a specific "set of ideas and reactions" (3), bringing them to bear on her task as President of the AHA.

Before she historically situates wonder, she situates herself as an historically situated historian. She describes herself as an idealist, a "product of the 1960s," with a poster from Paris 1968 hanging on her office wall that states: "*Toute vue des choses qui n'est pas étrange est fausse*" (every view of things that is not strange is false) (1). She reads this slogan diffractively through *admiratio*, as she

articulates her approach to doing history and, more importantly, to *teaching* history.

In the context of this address, wonder is a professional mode of attention and part of an ethics of writing history:

> It seemed to me...that I was trying, both as a scholar and as a teacher, to jolt my listeners and readers into encounter with a past that is unexpected and strange, a past whose lineaments are not what we at first assume, whose traces in our sources answer questions we haven't asked and deliver only silence to our initial, self-referential queries. (1)

For Bynum, what it means to be an historian is to take the alterity of the past seriously and to be moved by textual encounter. Although an unmediated encounter with history is not possible—the questions and practices of the present will always be a part of historical interpretation—Bynum argues for a patient and listening history that is not immediately subsumed by the sameness of the here-and-now. Wonder, in this sense, is about careful attention to differences in the practice of writing history as worlding the past. A vocational sensitivity. A historically-situated vocational sensitivity, indebted to the global decolonization and liberation movements of the 1960s, which made the question of how to study and narrate otherness an insistent concern of scholars in the humanities and social sciences (Godzich 1986, x–xii). The epistemological and political concerns that gave rise to Women's Studies and Ethnic Studies departments at that time are palpable in Bynum's approach to history. And like Irigaray, she is centrally concerned with the question of appropriation and the collapsing of difference into sameness:

> Our research is better when we move only cautiously to understanding, when fear that we may appropriate the 'other' leads us not so much to writing about ourselves and our fears as to crafting our stories with attentive, wondering care. (25)

Wonder here is an invitation to develop modes of attention to differences as part of learning to tell better stories about the past.

Bynum is advocating for the kind of slow history, thick with "what ifs" and "maybe nots," that comes out of a close reading practice that is ongoing and tentative. When she explains how she identifies the wonder that medieval scholars might have *felt*, she explains that she does not just look for "emotion terms" in the text, spurning the kind of keyword search privileged by our increasingly digital reading practices (15).[9] Instead, she reads for the reactions of an implicit reader, the way the author's descriptions have been staged to provoke an emotional response. Reading for these more subtle and uncertain cues is more difficult than a keyword search. It requires a specialized mode of attention; one that must be learned from experienced practitioners and through diligent practice. It is not surprising, then, that Bynum concludes her talk with a turn to pedagogy:

> We must rear a new generation of students who will gaze in wonder at texts and artifacts, quick to puzzle over a translation, slow to project or to appropriate, quick to assume there is a significance, slow to generalize about it. Not only as scholars, then, but also as teachers, we must astonish and be astonished. For the flat, generalizing, presentist view of the past encapsulates it and makes it boring, whereas amazement yearns toward

[9] The keyword is, of course, also an analogue reading strategy as is evidenced by the convention of an index at the back of the book. However, digital search technology, such as those available in digital collections, Google books, and even Amazon.com, further reinforce keyword searches a default mode of reading to such a degree that to *not* have a digital copy of a book hampers one's ability to read it. "The Digital Humanities" gives further institutional authority to digital reading practices like data mining.

> an understanding, a significance, that is always just a little beyond both our theories and our fears. (26)

In this rich passage, Bynum gives us a sense of how she understands her duty as the president of the AHA. Reading this keynote address it is clear that she feels not only responsible to the AHA as a professional association but to history as a knowledge tradition. History, in this view, is more than the study of the past; it is a culture of practitioners with multiple (sometimes contradictory) methods and orientations, which give us some histories and not others. Here Bynum is mindful of teaching as a process of transmitting and transmuting an ethics of attention.[10] Thinking about teaching, rather than "scholarship" or "knowledge," orients us differently. The questions that arise from a pedagogical orientation are questions of generations: "What kinds of knowledge practices have we inherited, what kinds commitments and practices have we developed, and which should we endeavor to pass on?"[11] Teaching, like parenting and gardening, can be a form of "caring for generations" (Haraway 2007, after Deborah Bird Rose) and "sowing worlds" (Haraway forthcoming).

Wonder is the name Bynum gives to the mode of attention she is most invested in passing on. Bynum's wonder draws together care for generations, the ethics of vocational practices, crafting stories slowly and carefully, respecting and responding to difference, and above all a commitment to the sf worlding we

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[10] Sara Ahmed suggests that cultivating the capacity for wonder is integral to feminist pedagogy: "The politics of teaching Women's Studies, in which feminist pedagogy becomes a form of activism as a way of 'being moved,' is bound up with wonder, with engendering a sense of surprise about how it is that the world has come to take the shape it has. Feminist teaching…begins with this opening, this pause or hesitation, which refuses to allow the taken-for-granted to be granted" (182).

[11] Feminist pedagogy has a long tradition of figuring teaching as a kind of sf worlding: "Feminist educators have a passion for their teaching, and are driven by a vision of 'a world which is not yet.'" (Manicom 365)

call education. As she draws her address to a close, she re-writes the slogan from her poster, gathering together the epistemological, ethical, and ontological dimensions of her proposition: "Every view of things that is not wonderful is false" (26).

Stengers: Wonder for a Materialism without Elimativism

In "Diderot's Egg: Divorcing Materialism from Elimativism"[12] Isabelle Stengers takes up the question of materialism, channeling wonder as an affective force for opening up how we define and encounter matter. She introducing her own concept of wonder using the kind of historical tableaux that she characteristically employs to stage her provocations: In Diderot's imagined dialogue with D'Alembert, he turns to his colleague and says: "Do you see this egg? With this you can overthrow all the schools of theology, all the churches of the earth" (9). Stengers reminds us that D'Alembert was a physicist, not a theologian; Diderot's charge was not against powerful religious stories but against D'Alembert's "closed definition of a rational science" (10).

Wonder is what Stengers calls the response that Diderot attempted to provoke by holding up the egg. Stengers' wonder means both "to be surprised" and "to entertain questions" (10). It about openness and speculation and trusting in the astonishing capacities of matter. In this context, scientific practices do not lead to universal knowledge, but relevant knowledge(s):

> The power of wonder with which Diderot tired to infect D'Alembert was not intended to inspire a common conception of matter, but to have

[12] Another version of this essay is entitled "Wondering about Materialism."

> D'Alembert accept that his conception of matter was not the 'rational' one, *but the one his practice produced as relevant.* (10, emphasis mine)

Like Irigaray and Bynum, Stengers focuses on the practices (including techniques and technologies of attention) that produce relevant knowledge. Avoiding both universalist and relativist positions, Stengers advocates for a pragmatic approach grounded in the history and materiality of scientific practices:

> Nature is neither knowable..nor unknowable...Nature is that about which *relevant knowledge* may be produced. If we pay due attention to it, we can learn, discern relations, and multiply entities and ratios. (2011b, 106, emphasis mine)

She suggests that we understand the natural sciences as an "ecology of practices" (2005, 2008, 2010), which requires that we acknowledge the "the plurality and diverging character of practices" (9, emphasis original) without pronouncing them equal or equivalent.

Returning to Diderot's egg, wonder is that which pushes against elimativism—the belief that one story or one set of practices (usually called rational or scientific) can explain nature. In fact, for Stengers, the study of matter must explicitly be protected *against* reason and scientific authority:

> If there must be a materialist understanding of how, with matter, we get sensitivity, life, memory, consciousness, passions and thought, such an understanding demands an interpretive adventure that must be defended against the authority of whoever claims to stop it in the name of reason. (10)

Matter that can produce a fuzzy, yellow chick from inside the smooth, white egg, matter that can give us memory, consciousness, passions, and thoughts is neither

inert nor mechanistic.[13] The kind of materialism that Stengers presents here has roots in feminist science studies accounts of agential matter. In "Situated Knowledges," for example, Donna Haraway asks us to think of nature as Coyote, the trickster figure in Native storytelling traditions of the American Southwest. This metaphor stages nature as "witty agent and actor" (201) and leaves room for "surprises and irony at the heart of all knowledge production" (199).

Whereas the rats were the tricksters of Gudger's story and the egg was the passive victim of their rodent ingenuity, the egg is the trickster in Stengers' fable. But an egg is a funny protagonist; from the outside it doesn't seem to be *doing* anything (before the moment when—all of a sudden—a chick might chip through the shell with its sharp little beak). Diderot and Stengers take advantage of this apparent passivity. If the egg will not actively challenge us (it will just sit there being an egg), we need learn how to relate differently to it; they suggest that we "*give* to the egg *the power* to challenge [our] well-defined categories" (10, emphasis original). Giving matter the power to challenge our epistemological certainties is not exactly an ontological proposition (matter *is* x), but a "speculative commitment" to narrating and relating to what matter might be if it is capable of x (Puig de la Bellacasa 2011, 96).

Like Bynum, who teaches her students to "craft [their] stories with attentive, wondering care," Stengers' wonder is a wonder that incites storytelling: "I am

[13] This is not a critique of reductionism in the sciences. As Latour writes (and I think Stengers would agree): "reductionism offer an enormously useful *handle* to allow scientists to insert their instrumentarium, their paradigms and produce a long series of practical effects" (2010, 483, emphasis orginal). But there is a difference between "efficient handles and the staging of nature" (484). Diderot's egg is about the staging of nature.

convinced that we need *other kinds of narratives*, narratives that populate our worlds and imaginations in different ways" (9, emphasis mine). Here Stengers not only affirms the importance of narratives in our knowledge-making practices, but expresses her desire for politically robust narratives that world us differently. Although Stengers argues that in an ecology of practices "practices do not contradict each other" (14), narratives can and do; they can also hold contradictions uneasily within the space of the text, maintaining the tensions by staging them. Thinking with another trickster story, the story of Raven stealing the light, medical sociologist Arthur W. Frank writes that "stories enable humans to live with…paradox" (64). If divergent practices produce different sets of relevant knowledge, we must learn to tell trickster stories or else we will end up settling for "a rather vague version of what physicists claim to be reality," i.e. a generalized (and therefore ir-relevant) version of a specific form of authoritative knowledge.[14]

This conceptualization of materialism enables a specific kind of knowledge politics. Different from Annemarie Mol's "ontological politics," where we ask "what version of an object should be performed," Stengers' knowledge politics is about connecting matter to political struggle. The materialism of Diderot's egg is a materialism where Karen Barad's question of accountability— "what matters and what is excluded from mattering?" (220)— is always on the table: "This is a materialism of another kind, a kind that may be connected with the many

[14] In Chapter 7 of *Cosmopolitcs I* Stengers illustrates how physics becomes generalized by describing how neuroscientists (mistakenly) appropriate the concept of a "state" from physics to give neuroscience the "power to explain" (94) the brain, and therefore also the mind. See also Latour's discussion of continuity of space and time in Latour 2010.

struggles that are necessary against what simplifies away our world in terms of idealist judgments about what would ultimately matter and what does not" (9).[15] A common conception of matter (the generalized physics reality) means that the same things are always excluded from mattering. Relevant knowledges about a Coyote nature offer up different possibilities for mattering that can challenge (rather than just confirm and uphold) the established order.

In this way Diderot's egg asks us to "give up mastery but keep searching for fidelity" (Haraway 1991, 199). It prompts us to consider what kind of practices, what kinds of stories can rise to meet this challenge. What kinds of interpretative adventures and relevant knowledges are possible? What happens when we give the egg "the power to cause us to think, feel, and wonder, the power to have us wondering how practically to relate to it, how to pose relevant questions about it" (10)? How can we be response-able to the egg? These are questions that require practical experimentation (and not necessarily scientific experimentation—this is, after all, an article that defends Mesmerism against the debunking operations of Modern Science). Responding to these questions might draw on the kinds of visual intimacies practiced in the field of embryology that have accompanied

[15] This insistence on connecting materialism to struggle separates Stengers from certain tendencies within new philosophical movements of "Speculative Realism" and "New Materialism." In the book *New Materialism: Interviews and Cartographies* that contains extended interviews with de Landa, Barad, Braidotti, and Meillassoux, the editors note: "Whereas Barad and Braidotti work towards a new materialism that is immediately ontological, epistemological, and ethical, DeLanda and Meillassoux seem to be more interested in the ontological." If the feminist thinkers represented do not feel that the ontological can be addressed without the ethical and the other authors do, the *matter* of new materialism simply does not cohere. The category of new materialism therefore can be misleading and claims about matter from thinkers like Barad and Stengers can be appropriated for those who are not at all concerned with the ethical or political commitments of their materialisms.

techniques like candling and windowing,[16] techniques that allow the embryologist to observe the development of the chicken embryo *in ovo*. Or it could be about holding the egg in your hands and trying to feel it as if for the first time. How can we relate to the egg without breaking it? As Pignarre and Stengers remind us this is a pragmatic question: "Pragmatism is an art of consequences, an art of paying attention [*faire attention*], as opposed to the philosophy of the omelet justifying the cracked eggs" (17).

The sense of wonder induced contemplating, *really contemplating*, the egg, is one that opens up rather than closes down epistemological possibilities. But also remains inextricably connected to political (what worlds are created, upheld, made possible, or destroyed?) and ethical (how to relate?) questions.

Demanding Wonder

These three addresses challenge their audience not just to pay attention but to *faire attention*, to *make* or *do* attention is a specific way. Irigaray challenges us to be "faithful to the perpetual newness, of the self, the other, the world." Stengers asks us to "*give* to the egg *the power* to challenge [our] well-defined categories." Bynum suggests that we teach our students to "gaze in wonder at texts and artifacts, [to be] quick to puzzle over a translation, slow to project or to appropriate, quick to assume there is a significance, slow to generalize about it." Wonder,

[16] Both candling and windowing are low-tech embryology techniques with long histories. Candling refers to the practice of observing the embryo by holding the egg up to a light (previously a candle now an LED). Windowing involves cutting a small hole in the shell and then sealing the hole (previously with another piece of egg shell, now with scotch tape). While candling is non-lethal for the embryo, eggs that are windowed using a standard technique only have an 8.2% chance of hatching. Using a modified technique, this can improve to 63% (Andacht et al 2004).

in each of their refigurations, is not an automatic response to perceiving an exotic object, but a mode of attention that must be crafted, taught, adopted, lived through practice, adapted, and, potentially, savored.[17] These are pragmatic and ethical propositions: Together let us cultivate the capacity for wonder in our knowledge-making and living practices (which we should not think of as separate, Irigaray reminds us).

To use a word that I learned from Stengers, these refigurations of wonder are *demanding* (2007 10). Not officially or authoritatively demanding, but demanding like a cat walking on your laptop keyboard, interrupting your work, asking you to relate differently to the world around you ("pay attention to me!!"). In the feminist tradition of collectively composing and decomposing objects, categories, stories, and concepts, of writing under the influence, this kind of feline wonder might be a good companion for sf worlding. It challenges us to relate differently in our research and writing practices or help us name what we are doing in new and useful ways (Verran 2001, 237). As Sara Ahmed, another student of wonder, writes: "[My relation to feminism] has felt like something more creative, something that responds to the world through joy and care, as well as an attention to details that are surprising" (179). Wonder might strengthen creativity, joy, care, and attention in life sustaining ways. Not just in feminist theory, but also in scientific practice. In this spirit, the following section explores the potentialities

[17] The modes of attention described by Irigaray, Stengers, and Bynum are not without their pleasures. For example Bynum's wonder involves a practice of reading and re-reading, the frustrations of finding your initial questions were irrelevant are rewarded with hard-won pleasures of gaining a feeling for the text and learning to pose better questions.

of this demanding wonder in evolutionary biology and the possibilities for telling responsive and response-able stories about life.

PART II: Speculation

The universe is not only queerer than we suppose, but queerer than we can suppose.
-J.B.S. Haldane (quoted in Heinrich 2012)[18]

Although few scholars have explicitly responded to Irigaray's, Bynum's, and Stengers' addresses, one notable exception that helps set the stage for this next section is T. Hugh Crawford's "The Power of Wonder: Stengers, Bennett, Whitehead and Heinrich." I had the pleasure of hearing this paper as part of a series of panels on Isabelle Stengers' *Cosmopolitics* at the 2011 SLSA conference, where Stengers herself acted as respondent. Crawford, who gave his paper in absentia,[19] took the opportunity to put Stengers' work into conversation with a problem that emerged from an undergraduate class he taught called "The Natural History of Wood":

> A theme that recurred throughout our deliberations was the problem of 'wonder.' I call it a problem because it is fairly easy to understand and at times slips into a form of child-like wonder, deploying the term and the attitude for some sort of neo-primitivist thrill. Instead, we wondered about a non-naïve wondering—one that is productive and can be set up against modern forces of disenchantment. (1)

This non-naïve wonder that Crawford and his students began to theorize together

[18] In his TED talk "Queerer than we can suppose," Richard Dawkins rather unfortunately interprets this quote to mean that science tells us truths that are counter-intuitive to our commonsense experience of the world. Heinrich interprets the quote to be about scientific humbleness in the face of the richness and complexity of nature.

[19] Thanks to T. Hugh Crawford for sharing a written version of his paper with me.

(in passionate conversation with philosophical and scientific interlocutors) is part of a pragmatic project to fabricate "a different kind of knowledge assemblage" (1).[20] Along with Stengers, he envisions more curious forms of scientific practice that are less compatible with the 21st century logics of capitalism (Crawford 2) and actively resist the "toxic categories" of modernity (Stengers 2008, 55).

Crawford is no stranger to practical experiments in alternative knowledge assemblages. In 2009 his honors American literature class on Henry David Thoreau was transformed into "Thoreau Housing Collective Inc." With Hugh Crawford as their CEO, their central aim was to build a faithful reproduction of the cabin that Thoreau himself built by hand, where he spent almost two years writing *Walden*. Following the clues left by Thoreau[21] and books about 19th century carpentry, Crawford and his students chopped down Southern Yellow Pines, rough hewed beams, cut joints and mortises, and raised the timber frame of the cabin (all without the use of electricity or modern tools); they read Thoreau, William James, John Dewey, Bruno Latour, and Michael Pollan; they interviewed experts in woodworking, psychology, Thoreau's literature, and someone who built his own house.[22] They also learned the modes of attention that come with using unfamiliar tools and suffered the consequences of inattention ("We paid for

[20] I adopt the capacious sense of "fabrication" that Stengers develops to include philosophical concepts (2008).

[21] In an earlier class Crawford and his students made an annotated edition of *Walden* with notes on the material culture and practices of Thoreau's milieu: https://docs.google.com/a/ucsc.edu/viewer?url=http://lcc.gatech.edu/~crawford/Walden/Walden_Text.pdf&chrome=true

[22] Further information about this class is available at www.thoreauhouse.org.

stitches after discovering our lack of fluency with an adze and a broadaxe"[23]). Pedagogy, in the context of this curious course, involves taking seriously what emerges as collective matters of care in the classroom[24] while constructing, composing and timber-framing together.

Returning to the SLSA talk, T. Hugh Crawford illustrated his non-naïve wonder by turning to Bernd Heinrich, who he described as "an emeritus professor of zoology at the University of Vermont, former holder of the record in the 100k [...], and the author of numerous scientific studies and half dozen quirky books that dance delicately between memoir and science" (8). In Heinrich's book *The Trees in My Forest*, Crawford found knowledge grounded in careful and passionate attention to the ecological happenings in one 300-acre plot of Vermont forest. He argued that Heinrich's writing articulates "wonder at the complexity of the world he is discovering" (8), a kind of complexity that makes him stop and listen to "the voices (personal, private, mute, ignored) usually silenced by mainstream science" (8). Crawford employed a particularly vivid example from *The Trees in My Forest* to conclude his talk:

> [Heinrich noticed] the pines of the same species in slightly different locations produce or do not produce an abundance of cones in a particularly season. He first details his own flawed observations, then works through a range of possible explanations, finally setting on some form of tree communication. He then offers up a comment that will warm the heart of every good cosmopolitician: "we do not know, because we have not listened closely enough to the language of trees." (9)

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[23] Quote from student Victor Lesniewski: https://docs.google.com/a/ucsc.edu/viewer?url=http://lcc.gatech.edu/~crawford/Research/What_would_Thoreau_do.pdf&chrome=true

[24] Broadly construed to include coniferous forests on the campus and the building site for a Thoreavian cabin.

The wonder Crawford gleaned from the pages of Heinrich's book is a wonder characterized by vigilant attention and ongoing speculation, "I wonder *if*." The cosmopolitical force of Crawford's reading lies in the provocation behind the statement "we do not know, because we have not listened closely enough to the language of trees." Like Diderot's egg, the cones, when given due attention, have "the power to cause us to think, feel, and wonder, the power to have us wondering how practically to relate to [them], how to pose relevant questions about [them]" (Stengers 2007, 10). Heinrich's coniferous speculations open up rather than close down possibilities for knowing and relating to pines; they stimulate pragmatic questions about how to craft relevant knowledge.

Following Hugh Crawford's cosmopolitical reading of Berndt Heinrich, this section continues to theorize the work of the speculative—"I wonder if"—in biological explanations. And while (of course) wondering about the world has been at the heart of scientific inquiry of all kinds, this discussion runs with Isabelle Stengers' radical definition of the speculative,[25] a definition that denounces the opposition of "scientific fact" to "speculative fiction" and "resists the lure of serving truth against illusion" (Stengers 2008, 40). I am interested here in claims that teeter between fact and fiction, truth and illusion, as a way into the scientific and political possibilities of speculative inquiry. This is not capitalist speculation of "one must speculate to accumulate" but one grounded in

[25] Although "Diderot's Egg" is part of the edited volume *The Speculative Turn: Continental Materialism and Realism*, the definition of the speculative deployed by the editors in the introduction is not nearly as rich as Stengers approach: "The works collected here are a speculative wager on the possible returns from a renewed attention to reality itself" (3). Stengers sense of the speculative is about activating possibilities for thinking, feeling, and knowing within a coyote nature (not a closed conception of "reality itself").

a feminist knowledge-politics: "we must speculate to relate and narrate."[26] Thinking scientific speculation with venture capital gives us a high-risk science with dramatic boom and bust cycles, where investment in wild speculations might lead to big epistemic/financial pay-offs or costly dead ends. The risk in Stengers' notion of the speculative is about *being at risk with ones claims* without relying on received notions of authority or rationality as justification (see also Haraway 2011). This is the risk you might find yourself exposed to when following a personal, political, or epistemic intuition that runs counter to the dominant scientific discourse. A risk that is often rewarded with ridicule.

In this section I look at wonder and speculation in the work of Lynn Margulis and Joan Roughgarden, two evolutionary biologists who have put themselves at risk as they critiqued central tenets of Neo-Darwinism (natural selection and sexual selection, respectively). I explore how the speculative charge of their evolutionary theories has generated both charisma and controversy in biological and feminist worlds. My readings of Roughgarden and Margulis are *influenced* by the concerns of Irigaray, Bynum, and Stengers,[27] particularly by Stengers' challenge to divorce materialism from elimativism to connect with struggle. Conversely, the scientific and political contexts of Roughgarden's and Margulis' work also helps bring specificity and imaginative traction to Stengers' abstract challenge. Using 21st century cases that are still ongoing sources of political and

[26] Reclaiming and re-signifying words like accountability and speculation from capitalist occupation is central to my theoretical project.

[27] This reading practice is influenced by the many feminist engagements with scientists, especially Evelyn Fox Keller's writing about Barbara McClintock (another insider/outsider), which is simultaneously a faithful account of McClintock's scientific practice and an expressive reading inflected by Fox Keller's own political and theoretical commitments.

epistemic controversy, I aim to foreground the urgent stakes in learning to wonder about matter.

Joan Roughgarden: How many Plots can the Data Hold?

Joan Roughgarden's (b. 1946) 2004 book *Evolution's Rainbow: Diversity, Gender, and Sexuality in Nature and People* is one of the few books that can and should be shelved in both the evolutionary biology and LGBT section of the bookstore. In it she narrates the sheer diversity of sex, gender, and sexuality among animals (including humans), revealing that a heteronormative view of nature cannot possibility account for the amazing range of beings and doings in animal worlds. Diversity, Roughgarden argues, is the rule, not the exception ("Nature abhors a category," she quips).[28] Even though Roughgarden takes all of her examples from the existing peer-reviewed literature, this insight is not reflected in the tenets of sexual selection as a general theory. She believes that the universal male and female templates offered by sexual selection theory are "inadequate to address the diversity of bodies, behaviors, and life histories that actually exists" (169); she therefore proposes (but does not yet elaborate) an alternative theory to better account for sexual diversity in the context of evolution. After the publication of *Evolution's Rainbow*, Roughgarden set out to construct her alternative theory and to devise methods for testing and revising it in her lab using mathematical models. This research program led to the controversial article in *Science*, "Reproductive Social Behavior: Cooperative Games to Replace Sexual Selection" (Roughgarden, Oishi, and Akçay 2006) and to her popular book, *The Genial Gene:*

[28] Roughgarden 2004, 14.

Deconstructing Darwinian Selfishness (2009). In *The Genial Gene*—its title a risky refiguration of Richard Dawkins' *The Selfish Gene*[29]—Roughgarden argues that competition at the level of the gene, the level of the gamete, or the level of the whole organism is not sufficient to explain evolutionary success. She begins to construct a model that posits cooperation through teamwork as an important social dynamic between individuals of the same species. Starting from cooperation rather than competition, Roughgarden returns to the questions of sexual diversity from *Evolution's Rainbow*, offering different explanations for the social behaviors and physical traits she catalogued.

Central to this project is Roughgarden's bold proposition to replace sexual selection with a new theory that she calls "social selection." Sexual selection theory posits that within a given species certain physical traits (feathers, antlers, etc.) provide males with a reproductive advantage. The females choose the males with the best example of this trait[30] and thus it is selected for within the population at large: feathers get brighter, antlers get bigger. These stories, whose stock characters are the promiscuous male and the coy female, are about the reproductive success of individuals and about how "good genes" out compete "bad genes." They often feature male/male competition and female choice, center around

[29] Roughgarden is less interested in critiquing the arguments in *The Selfish Gene* than with the dominant philosophy of selfishness that has followed the metaphor. In fact, she agrees with Dawkins' critique of group selection and his emphasis on individual selection. However, Roughgarden disagrees that there is a stable definition of a biological individual. Organisms like "popular trees, strawberries, and beach grass" (8), for example, have one genome that results in multiple bodies and others like endosymbiotic corals and lichens have multiple genomes in the same body. She wonders what individualism could possibly mean in the context of such organisms.

[30] In the most gene-centrist version of female choice in sexual selection, females chose males only for the quality of their genes, so that they can pass those genes on to their offspring. This is, off-puttingly, called the "Sexy Son Hypothesis."

reproductive sex, and assume sexual conflict rather than cooperation. In order to challenge these conventional narratives that reduce all the rich empirical observations of animal sociality to the zero sum game of competition, Roughgarden suggests that biologists should focus less narrowly on mating, and instead, investigate which physical and behavioral traits[31] ensure that the most offspring make it into the next generation (her definition of evolutionary success). Social selection is defined as "selection for, and in the context of, the social infrastructure of a species within which offspring are produced and reared" (2007, 24). If evolutionary biologists abandoned sexual selection as the master narrative, Roughgarden argues, they would be able to tell more adequate evolutionary stories that figure behaviors like co-parenting, animal friendships, same-sex sex, non-reproductive sex, and other "reproductive *social* behaviors" (2006) as evolutionarily significant. Roughgarden's theory of social selection is not a supplement to sexual selection theory; it was explicitly designed to replace the central narratives of sexual selection widely accepted by contemporary evolutionary biologists.

Among her scientific peers, the reaction to this argument and to Roughgarden's research since *Evolution's Rainbow* has been overwhelmingly negative (usually in the register of dismissive, confused, annoyed, or angry).[32] In response

[31] These are not necessarily separate categories in Roughgarden's work because physical traits have social functions. For example in many species she argues that markings and colors constitute a kind of "body English" or physio-semiotics (to use a more convoluted but less Anglo-centric term) that communicate to other members of the social group.

[32] There are only a few scientists who have cited her work on social selection to frame their research. MacFarlane et al argue that in birds "MM sexual interactions may occur to facilitate social alliances and inclusion, allowing resource exchange required for reproduction" (30). Nalepa and Grayson use the

to her 2006 article, *Science* published ten letters signed by forty biologists who collectively argued that not only does sexual selection not need replacing but Roughgarden and her co-authors were profoundly misguided in their claims and approaches. At the very best, they argued, Roughgarden's claims are "entirely consistent with current sexual selection theory"[33] (Pizzari), at the very worst they are just plain wrong. The problem, it seemed, was not simply her commitment to recognizing a greater diversity of sexual and social behaviors. But rather it was her attack on the central narrative of sexual selection that provoked 40 evolutionary biologists to respond as if to a threat—as if, like Indiana Jones, she was trying to replace their Golden Idol with a bag of sand.[34] Roughgarden incisively observes: "It would be okay to add a little fluff to sexual selection to account for gay and gender-bending animals, so long as I do not touch the central narrative" (2007, 36). In the intervening years Roughgarden's research has been largely ignored by evolutionary biologists and when it is cited, it is routinely characterized as "idiosyncratic" (Nesse 2007, 144; Oshaka et al 2010, 158), "unusual" (Clutton-Brock 2007, 1882), "unorthodox" (Oshaka et al 2010, 260), and representing only a "fringe viewpoint" (Rubenstein 2012, 22).

Despite the iconoclasm of her opening salvo, however, Roughgarden's rhetoric is unfailingly inviting. She does not claim that social selection is a fully developed theory or that all of the tenets she formulated will hold, but instead

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term "socially monogamous" to describe "social living arrangements" of cockroaches "without inferring any sexual or reproductive patterns" (364).

[33] Even for those who accept many of Roughgarden's claims miss the scientific import of her iconoclasm, believing it to be "an important extension to existing thought, and not a revolutionary departure from it" (Holmes 2009)

[34] Thanks to my former student Jose Guerrero for this image.

that evolutionary biology would benefit from calling into question the adequacy of explanations grounded in sexual selection in light of the fact that many thousands of species do not conform to Darwin's male and female templates. At the end of *The Genial Gene* she writes, "Time will tell whether social selection is indeed correct or whether some substantial modification or third approach is needed...There is still much to be done in the basic science of biology...the welcoming door is open. Come on in" (248).

In interviews, talks, and popular articles Roughgarden has responded to criticism, not by entrenching further but by inviting more evolutionary inquiry. This strategy can be seen, for example, in an online video interview with science journalist Robert Wright.[35] Wright, who is clearly skeptical of Roughgarden's claims, presses her about her critiques of evolutionary psychology studies that are based in sexual selection theory. Wright cites a well-known study by Martin Daly and Margo Wilson (1982) that claims that in humans, men are more jealous about the sexual infidelity of their partners, whereas women are more jealous of emotional infidelity. Their theory, based on a sexual conflict model, is that this is an evolutionary adaptation that helps males ensure that they raise their own offspring and helps females ensure that the males will stick around to provide for their children.[36] Wright is convinced that this theory makes excellent intuitive sense and is also borne out by the "raw data".

What is interesting to me here is not Wright's position, but Roughgarden's

[35] http://bloggingheads.tv/videos/2063

[36] In *The Genial Gene* Roughgarden is critical of sexual selection explanations of Extra-Pair Parentage (EPP). In her own stories she takes trickery and jealousy out of the equation altogether (especially in non-humans).

response to Wright. She does not point out the gender stereotypes and hetero-normative assumptions embedded in Daly and Wilson's jealousy story.[37] Instead she asks Wright "whether there was an alternative hypothesis that was on the table which they could have confirmed, instead of the one they claimed to have confirmed." *Is there another story*? This strikes me as a smart and potentially disarming response to Wright's line of questioning. It is simultaneously respectable within conventional scientific discourse and gestures towards something more radical. Roughgarden suggests that Daly and Wilson's study, or at least the way Wright remembers it, might be "bad science." Although she makes it clear that she is, in fact, a proponent of evolutionary psychology as a field, she is concerned about the prevalence of studies where the "data are mined to effect an appearance of the confirmation of [a single] hypothesis." In her response to Wright, Roughgarden demands a more rigorous relationship between narrative and evidence. She insists that evolutionary psychologists test more hypotheses.

This attitude is representative of Roughgarden's *modus operandi* more broadly. In her laboratory at Stanford, she returns to the most potent fables of sexual selection and re-tells them, trying on different hypotheses. In Rough-garden's work, the peacock's feathers, the primary trope of sexual selection theory since Darwin, no longer seduce peahens, but are used instead to gain acceptance from other peacocks. She argues that flashy plumage acts as "admission tickets to power-holding cliques that control the resources for

[37] Roughgarden is careful to keep the debate at the level of scientific evidence rather than narrative construction. Although she insists that her primary goal is "replacing the central narrative" of sexual selection, the reasons she cites are usually in the register of the empirical rather than the social or political.

successful rearing of offspring" (2006, 29). Bright feathers are part of a set of "social inclusionary traits" that consist not only of physical characteristics but social behaviors like grooming.[38] In their *Science* article, Roughgarden and her co-authors use cooperative game theory to illustrate the viability of this alternative hypotheses. The hypothetical questions becomes empirical: *Is there evidence to support a different story?*

Testing hypotheses is well within the traditional scope of both popular and scientific understandings of how scientific knowledge is made. Given the uncontroversial framing of her method, what could account for the controversy surrounding her approach? The question Roughgarden posed to Wright—*is there another story?*—harbors within it the suggestion that multiple evolutionary stories are possible. This is a speculative question as much as it is a hypothetical or empirical question: *I wonder if* there is another story? Although Roughgarden's approach gracefully holds together hypothesis and speculation, speculation is a more feral practice. Speculation runs the risk of escaping the enclosure of respectable science into a wilderness where fact and fiction are not cleanly and properly demarcated. It presents itself as a threat to "proper science," where proper science is defined as the rational production of universal knowledge. Thus, we might say that one resistance biologists have to Roughgarden's theories is about not allowing *wild speculation* into the hallowed grounds of accepted facts.

[38] She is also interested in the story a team of Japanese biologist tell: both the peacock and the peahen started out with brightly-colored plumage, but the peahen evolved more camouflaged feathers to avoid predation during nesting.

Speculation, it seems, is always improper. It does not have its own place (*lieu propre*).[39] Speculation is improper, first, because it is "not in accordance with truth, fact, reason, or rule" (OED).[40] It is not about what there *is* but what there *might be*. Speculation is on the side of the possible, not the probable (see Stengers 2010, Chapter 1). Its allegiances are elsewhere. Because speculative operations quietly (and sometimes not so quietly) insist that "another world is possible, another world is here," they are always interrupting the smooth operation of business-as-usual. Thus, speculation is also improper because it is "not in accordance with good manners, modesty, or decorum; unbecoming, unseemly; indecorous, indecent" (OED). Roughgarden's scientific speculation can be taken as a double transgression: factual and moral. Always out of place, often unwelcome.

Roughgarden does, however, carve out a space to nurture her hypotheses. She is nest-building, like the Eurasian Oystercatchers that she writes about her *Science* article, who sometimes rear their young in cooperative or competitive threesomes. These black and white wading birds with striking red eyes make shallow nests called scrapes by digging out a bit of earth on the ground near the shore. As Roughgarden and her lab mates[41] practice their science, they bring bits of data back, like pebbles, to line the scrape. They use co-operative game theory

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[39] See de Certeau 1984.

[40] Although Roughgarden's theories draw on the existing peer-reviewed literature. Her theories are not in accordance with—that is, not in harmony or out of synch with—the explanatory narratives these are often embedded in. Therefore, she is attacked as being "scientifically improbable" (Pizzari et al 2006), "a misrepresentation of the facts" (Dall et all 2006), or just "plain wrong" (Dall et al 2006).

[41] In *The Genial Gene*, Roughgarden is always careful to write about how her graduate students and postdocs contributed to the project. She narrates science as social knowledge as much as she narrates evolution as social selection.

as an empirical strategy, drawing payoff matrixes to show how individuals might bargain with each other to maximize "team fitness." Since it was introduced to evolutionary biology in the 1980s by John Maynard Smith, game theory has become an accepted mathematical strategy for modeling evolutionary theory; so, with payoff matrixes in hand, Roughgarden's team make their own place.[42] It is not just wild speculation, but a speculative empiricism—a practice that is explicitly both scientific and narrative.

However, since Roughgarden challenges the central narrative of sexual selection, her carefully assembled data are, more often than not, rebuked—her theory of social selection remains improper. You can feel the anger rise up in response Roughgarden's impropriety. In the letters published in *Science*, Roughgarden's work is characterized as an "attack on Darwin" and an affront to scientific progress ("it threatens to set the clock back 30 years"). The letter writers argue that she "fails to understand the scientific method."[43] They claim her story is improper because it challenges Darwin's story (or a Neo-Darwinian interpretation of Darwin's story). And since the principles of sexual selection underpin scientific facts about evolution writ large, it is "not in accordance with truth, fact, reason, or rule." It is improper because it is untrue and by being untrue it is received as an attack on The Truth and science-in-general.

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[42] The way Roughgarden et al use game theory has also come under attack. Dall et al argue that they "misrepresent the philosophical basis of cooperative game theory" and that "cooperative game theory [is] irrelevant to evolutionary biology." British mathematician Kenneth Binmore has been particularly hostile towards Roughgarden's use of game theory. See Binmore 2010 and Roughgarden 2012 for her rebuttal. I say hostile rather than critical due to the condescending language Binmore uses and his inability to keep Roughgarden's pronouns straight (though the *Journal of Evolutionary Biology* should be held accountable for this too).

[43] The first quote is from Dall et al 2006. The second two from Pizzari et al 2006.

In *Science* the letters only obliquely criticize for Roughgarden for introducing an inappropriate "socio-political perspective" into what should be objective science (Dall et al). However, in *The Scientist* mathematical biologist Troy Day was more forthcoming about the reason for the outpouring of critical letters: "Many people felt that this was completely shoddy science and poor scholarship, all motivated by a personal agenda" (quoted in Akinson 2006). Here we have the same old story where scientific objectivity is only accessible to some subject positions and everyone else's claims are considered to be "just politics." "Personal agenda" is a barely disguised euphemism for Roughgarden's identity as a transgendered woman, and more broadly the politics of the LGBT community, which she dared to write openly about *Evolution's Rainbow*. Because Roughgarden is forthcoming about her personal and political perspective, this is given as the reason for her lack of objectivity and her "shoddy science." As Donna Haraway writes in her chapter on Adrienne Zilhman: "woman the scientist becomes the trope figuring bias" (1989, 346).[44] And here, for "trans woman the scientist" this is doubly so, as evidenced by the heartbreaking transphobia in some biologists' responses to *Evolution's Rainbow*.[45] As a feminist and a science studies scholar, I find this response to be sadly unsurprising; however, rather than detailing the injustice here, what I would like to emphasize is how the seemingly offensive aspect of Roughgarden's work is her impropriety.[46] She not

[44] "Zilhman's science cannot be allowed to cohabit with her feminism, which has turned an already marked gender into politics, which is quintessentially marked 'other' to unmarked science. Either feminism or science must be evicted" (Haraway 1989, 345).

[45] See Roughgarden 2007, 33–35 for examples. I do not want reproduce these hateful comments here.

[46] On inappropriateness see also Donna Haraway's "The Promises of Monsters: A Regenerative Politics for Inappropriate/d Others."

only goes against the official story, but by insisting on being heard in a scientific context, she is stubbornly "not in accordance with good manners, modesty, or decorum; unbecoming, unseemly; indecorous, indecent." Put more simply: *How dare you.*

Hypothesis and speculation are both at play in discussions around Roughgarden's work. She argues that she is testing hypotheses; her detractors argue that she is speculating wildly. However, if we do not insist on a clean break between the two, we can imagine a practice of evolutionary biology that is more open to narrative possibility. As Roughgarden herself points out, there are plenty of opportunities for spinning narratives from evidence and building narratives to guide scientific modes of attention. Here, we can use Roughgarden's daring work to formulate a refrain that is at once speculative and scientific: "*how many plots can the data hold?*" This is not a relativist question. It is pragmatic. The answer is not infinite. To borrow a phrase from Marilyn Strathern, it is more than one but less than many. We can only know if we try.

If we return to the central theme of Stengers' meditation on wonder—connecting materialism with struggle—Roughgarden's predicament is less intractable. The tensions that Roughgarden negotiates in her written work could be eased. We can see these tensions in *The Genial Gene* where personal, political, and scientific commitments sit uncomfortably side-by-side, pulling and pushing against one another. Writing about the dominance of sexual conflict narratives in evolutionary biology that make males and females into enemies and reproduction into warfare, Roughgarden writes:

> Yet again, the issue before us is not whether one finds these thinly disguised rape narratives appealing or repugnant. The issue is whether a kind of rape actually does underlie all male and female relationships throughout nature. Sexual-conflict advocates do not acknowledge even the possibility of alternative hypotheses springing from a different point of view. Nonetheless, the scientific method requires alternative hypotheses. (205)

It is clear from her use of the description "thinly disguised rape narratives" that Roughgarden does find these stories repugnant and this repugnance motivates her desire to search for evidence to furnish other narratives. As she distances herself from her own motivations in this passage ("the issue is not whether we find these narratives appealing or repugnant"), I can't help but wonder if it is possible to affirm these personal, political, and scientific desires at the same time. So that we can avoid "splitting our life, our bodies, our language, our breath into several worlds" (Irigaray 72).

In *Evolution's Rainbow* and *The Genial Gene* Roughgarden expresses her sadness that same-sex mating, co-parenting, and friendship among animals (including humans) are viewed as not evolutionarily significant at best, and an evolutionary disadvantage at worst.[47] Her contention is that, contrary to the dominant story, these reproductive social behaviors do matter. Not to not just "add a little fluff to sexual selection"; they make real species-shaping difference by contributing to the social infrastructure within which offspring are produced and reared. This is a political as well as an empirical struggle. It calls on

[47] A recent article in *The Quarterly Review of Biology* on an epigenetic theory of homosexuality illustrates how this logic is mobilized in scientific studies: "The common occurrence of homosexuality is perplexing from an evolutionary perspective. Simple logic suggests that a fitness-reducing phenotype should be selected against, but homosexuality is nonetheless surprisingly common in human populations" (Rice et al 2012, 344).

evolutionary biology to contest rather than confirm an established order. And to recognize that what one finds personally and politically repugnant can be an invitation for speculative thinking and for creating scientific "narratives that populate our worlds and imaginations in different ways" (Stengers 2007, 9). Thinking of evolutionary biology this way requires us not to cleave hypothesis from (wild) speculation and not to invest in only settled theories—the bio-political stakes simply are too high. The negative reception of Joan Roughgarden's recent work demonstrates the need not only for feminists to critique sexism, homophobia, and transphobia in scientific discourses and communities, but also to help develop pragmatic approaches to speculative inquiry. I offer "how many plots does the data hold?" as one refrain that might stimulate a speculative empiricism for composing more livable worlds (storied biospheres), where the questions of "what matters and what is excluded from mattering?" (Barad) is always open and never settled once and for all.

Lynn Margulis: To Savor a Speculation

Lynn Margulis (1938–2011) was one of the most heralded and controversial biologists of the 20th century. She became a household name for developing the theory of endosymbiosis—the theory that eukaryotic cells evolved by incorporating free-swimming bacteria, which later became organelles such as plastids and mitochondria. Her paper, "On the Origins of Mitosing Cells" was rejected by 15 journals before it was finally published in *The Journal of Theoretical Biology* in 1967. Throughout her career, Margulis opposed models of evolution centered around individual organisms, emphasizing instead the importance of symbiotic

relationships in evolutionary change. She conducted and inspired research on evolutionary and developmental processes in organisms with persistent symbionts like "solar-powered sea slugs" (Rumpho et al 2000) who derive their energy from the photosynthesis performed by the algal chloroplasts they harbor inside their digestive cells and Hawaiian bobtail squids who are host to bio-luminescent vibrio bacteria who protect them from predation (McFall-Ngai et al 2012). Although the theory of endosymbiosis is strongly supported by genetic evidence and has now become a textbook biological fact, many of Margulis' theories remain contentious. She argued that evolution and speciation are driven not by random genetic mutation and natural selection, but by symbiogensis, "the generation of evolutionary novelty though symbiosis" (Rice 388) via mechanisms like horizontal gene transfer. Like Roughgarden's theory of social selection, symbiogensis cannot simply be added to the Modern Synthesis as a symbiotic corollary to the central mutation narrative; it offers a direct challenge to Neo-Darwinian narratives of evolutionary change.

However it is important to note that although both Margulis and Roughgarden have challenged dominant Neo-Darwinian assumptions and although both scientists' work have been enthusiastically received by feminist science studies scholars (e.g. Myra Hird 2009 and Stacy Alaimo 2010), their evolutionary theories are not readily compatible.[48] Margulis, for example, was critical of evolutionary biologists like Roughgarden who propose evolutionary

[48] Which is not to say that there couldn't be interesting questions at the intersection of Margulis and Roughgarden. Rather, what I'm suggesting is that we shouldn't automatically construct a Posthumanist Synthesis by combining these two singular (in Stengers' sense) theories.

theories that pertain to all organisms, but study animals almost exclusively.[49]

Attention to bacteria rather than attention to animals led Margulis into different research questions, different theories and metaphors, different empirical objects, and different instincts about what matters in evolution and what does not. When you begin with bacteria, for instance, life takes on a different shape: "Evolutionary biologists believe the evolutionary pattern is a tree. It's not. The evolutionary pattern is a web—the branches fuse, like when algae and slugs come together and stay together" (Margulis in Teresi 2011). Although the politics of Margulis' work are not as immediately obvious as in Roughgarden's, she fought relentlessly against a pervading elimativism in molecular biology and refused to be silenced by settled facts. She also dared to write poetically and speculatively about life. She wove her passions into the tissue of her language. "Symbiogenesis," she wrote, "was the moon that pulled the tide of life from its oceanic depths to dry land and up into the air" (1998, 111).

The poetic and speculative qualities of her thinking and writing drew and continue to draw others into the world of her evolutionary ideas. Reading Stanley A. Rice's *Encyclopedia of Evolution,* I noticed that the entry on symbiogenesis contains not one, but three exclamation points! Surprised by such enthusiasm in the usually restrained genre of the encyclopedia, my curiosity was piqued.[50] Turning to the introduction, I quickly discovered the reason for the exuberant punctuation. Rice writes:

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[49] Margulis referred to these scientists disparagingly as "anthropocentric zoologists" (Margulis in Teresi 2011).

[50] The Wikipedia style guide, for example, polices the use of exclamation marks: "Use the exclamation mark with restraint. It is an expression of surprise or emotion that is generally unsuited to a scholarly or encyclopedic register." The exclamation mark, it seems, is also improper.

> My entry into the world of science might have been in 1976. A sophomore biology major at the University of California Santa Barbara, I was a creationist. To me, there were only two ways of looking at the world. There was only one kind of creationism, and one kind of evolution, and I had chosen the former. The first scientific seminar I attended was a presentation by Lynn Margulis…As I watched Margulis's films of spirochete bacteria embedded in the membrane of a protist, waving exactly like cilia, a light went on in my head. I realized that there were more than two ways of looking at the world, and more than one way of looking at evolution. I realized that evolution was not a doctrine chiseled in stone to which all scholars had to give religious assent. I saw that evolution was an exciting field of exploration in which not only many discoveries of fact but perhaps whole new concepts awaited scientific researchers. (xv)

Rice was enchanted, not by a fully accepted theory like the endosymbiotic origins of mitochondria, but by one of Margulis' more controversial theories: that motile spirochetes infected protists to become the undulipodia[51] (cilia and flagella) that we see in eukaryotic cells (see for example, Margulis and Sagan 1990, 144).[52] He wasn't drawn to this idea because it represented an exciting new scientific fact but because it presented science as an "interpretative adventure" (Stengers) rather than the arbiter of a universal truth. Through this encounter with Margulis in a UCSB classroom, Rice was able to re-imagine evolutionary biology not as a field characterized by established dogma and new frontiers, but by the activation of new possibilities (whole new concepts!) within worlds we thought we already knew. An sf worlding (speculative fact) with the gravitational field to

[51] Undulipodia (Latin for little waving feet) is a term Margulis rescued from the history of biology to refer to both cilia and eukaryotic flagella (Margulis 1980).

[52] Although this theory has still not been proven conclusively (Margulis 2005), there is good evidence to support it. Electron microscopy shows that all undulipodia have the same structure of microtubules, indicating a common ancestor. Furthermore protists such as Mixotricha "the beast with five genomes" paradoxa, found in the gut of a termite, have symbiotic spirochetes attached to the surface that confer motility (Margulis 2005).

pull in not only posthumanists like Myra Hird but also (former) creationists like Stanley Rice.[53]

The theory that undulipodia evolved from motile spirochetes is one of Margulis's most deliciously sf concepts; it gives us an alternative genealogy of the eukaryotic cell but also insight into "the history of consciousness" (as it were): "When I describe the origin of the eukaryotic cell via bacterial cell merger, I emphasize that the components that fused in symbiogenesis are already 'conscious' entities" (Margulis 2001). Cilia play an important role in this origin story because the sensory cells of animals all have cilia with the exact same physical structure. Margulis argues that these undulipodia evolved from free-swimming spirochetes who were already able to sense light and motion. Therefore our own "sensitivities to wafting plant scents, tasty salted mixtures, police cruiser sirens, loving touches and star light" (Margulis 2005) were all made possible through our endosymbiotic histories. The implication is that not only do we have a bacterial sensorium, but free-swimming spirochetes also have a "microbial consciousness" (2001, 55). This is a demanding hypothesis, bristling with possibilities for re-thinking a wide range of phenomena from evolution and symbiosis to consciousness and sensory experience. It worlds us otherwise.

However, the same speculative force that makes Margulis' theories so alluring to some has also created controversy and drawn ridicule from others. Her involvement with the Gaia Hypothesis, her popular books, many of which she wrote with her son Dorion Sagan, her adherence to and support of unpopular

[53] For a taste of Rice's passion for biology, see his YouTube channel that has videos of him playing Charles Darwin (or at least wearing his hat) explaining evolutionary concepts: http://www.youtube.com/watch?v=FQo63lz6R8U&list=UUH_oDic96cAwMwP_AIeTXCw&index=2

theories and scientists, these all became fodder for an ugly and oft-repeated story: Lynn Margulis was a brilliant pioneering biologist who boldly went against established wisdom to champion the theory of endosymbiosis, but then became kooky and recalcitrant, an embarrassment to not only herself but also to evolutionary biology. You can read this mixture of admiration and embarrassment, for example, in Richard Dawkins' review of Margulis and Sagan's *Mystery Dance: On the Evolution of Human Sexual* in *Nature* (1991). He begins by praising Margulis as a "courageous outsider" (442), but quickly makes it clear that he is disgusted by the popular genre,[54] philosophical "pretention" (442), scientific speculations with their "cavalier lack of evidence" (442), and most of all the descriptions of human sexuality.[55] Although it is certainly not the consensus, there has been a steady contingent of scientists who believe more or less: "It's unfortunate that she has veered into some weird second stage." (Francisco Varela in Brockman 1996).[56] What remains surprising to me is that those who repeat this narrative cannot see (or refuse to allow) any connection between the kind of speculative inquiry that leads to a surprising scientific discovery and the kind of speculative inquiry that feels unseemly (overzealous, vulgar, embarrassing, strange).

One way to combat this kind of narrative is to show how many of Margulis'

[54] Many scientific reviews of Margulis's popular books express a distain for their genre. A particularly angry critique of *Acquiring Genomes* characterizes it as being "chattily written in the fashionable mode of pop-science journalism" (Cavalier-Smith 1010). However, this isn't always the case. Stanley Shostak wrote in a mixed, but generally good review: "Margulis and Sagan's style alone turns vice into virtue" (1124).

[55] After one direct quote he writes simply: "Yuck!" (442).

[56] This rhetoric of the "weird second stage" is not confined to biology. In a recent review of Myra Hird's book, sociologist Marion Blute writes: "This unfortunately strikes me as more or less true to the spirit of [Margulis'] more recent work, her great accomplishment notwithstanding"(1163).

strange ideas are increasingly supported by research done with the latest generation of genomic sequencing and high-throughput RNA techniques (Gilbert, Sapp, and Tauber 2012). This is an important story to tell, but it rests too easily on a clean hierarchical split between truth and illusion—Margulis' speculations were not unseemly because they were right. Here we lose our grip on Stengers' challenge to connect materialism and struggle by appealing to the truth. The story I would like to propose instead is that Margulis' speculations were not unseemly because they *mattered*, they *worlded*, they *gathered*.

To venture more deeply into the territory of the unseemly (rather than shying away), I turn to look briefly at the controversy around the 2009 publication of Donald Williamson's article "Caterpillars evolved from onychophorans by hybridogenesis," in *Proceedings of the National Academy of Sciences (PNAS)*, an article that Margulis brought to the attention of the journal and sent out for peer review. Williamson, like Margulis, is interested in "the importance of saltational and sporadic evolutionary processes" rather than looking for the gradual accumulation of mutations (2009a, E132). In this paper Williamson argues that larvae and adult insects of the same species do not have a common ancestor; instead, they have two different ancestors whose genomes merged via hybridization. He posits that onychophorans (velvet worms) are the ancestors of caterpillars, grubs, and maggots; their genomes were acquired by butterflies and moths through sexual hybridization. The larval transfer hypothesis, he argues, is testable and he encourages genomicists to investigate it by comparing the genomes of animals with larvae, related animals without larvae, and relatives of the possible sources of the larval genomes.

Williamson's article created controversy first within the *PNAS* editorial board and later in the wider scientific media. Although *PNAS* did end up publishing the article, they published a companion article entitled simply "Caterpillars did *not* evolve from onychophorans by hybridogenesis" (emphasis mine), in which the authors use pre-existing genomic data to contest Williamson's hypothesis (Hart and Grosberg 2009).[57] *Nature*, *Scientific American*, and other scientific journals and magazines published pieces condemning the article (e.g. Borell 2009, Corbyn 2009, Dolgin 2009). Margulis was accused of nepotism,[58] Williamson of "phylogenetic speculation" (Giribet 2009, E131). Though less vitriolic than the reaction to Roughgarden's *Science* article, the scientific debate was palpably colored by personal attacks, revealing there to be more at stake than simply the publication of a weak hypothesis in a prestigious journal. The articles routinely painted Lynn Margulis as a zealot who used her influence to get a dubious article into print simply because it supported her pet theory and Donald Williamson as a doddering old man and scientific outsider—"a wheelchair-bound 87-year-old [retired] zoologist" (Borell 2009).

But even in these dismissive articles there were other, more muted voices of biologists who were interested in entertaining or at least not silencing Williamson's hypothesis. Insect paleontologist Conrad Labandeira was quoted in

[57] They argue: "Hybridogenesis between distantly related animals does not explain patterns of morphological and life-history evolution in general, and the genes and genomes of animals provide strong evidence against hybridization or larval transfer between a velvet worm and an insect in particular" (1).

[58] The controversy was further exacerbated when *PNAS* retired the form of peer-review (called Track I) that allowed members of the NAS to bring papers by non-members to the journal's attention and choose the reviewers. Apparently the timing was an unfortunate coincidence (Dolgin 2009), but it gave the appearance that there was something out of the ordinary or suspect about the review process.

Scientific American as saying: "If I was reviewing [this paper] I would probably opt to reject it...but I'm not saying it's a bad thing that this is published. What it may do is broaden the discussion on how metamorphosis works and...[on]...the origin of these very radical life cycles" (Borell 2009). While unconvinced by Williamson's claims, Labandeira, who describes his own scientific practice as motivated by "sheer abject curiosity,"[59] remains interested in how his article might activate different possibilities for investigating and narrating radical life cycles. This isn't so much about entertaining a hypothesis, as it is about *savoring a speculation*. Williamson's article (if we let it) can take us back to our childhood curiosity about the life cycles of butterflies and moths. How did they evolve the capacity for such drastic morphological change? What would it be like to emerge as a moth with a new body, a new sensorium, with your caterpillar-self only a genomic memory?

It is not surprising that Bernd Heinrich, Hugh Crawford's "wonderful, wild idiot," who is learning to listen to the language of trees, was one of the few who was willing to savor Williamson's phylogenic speculation. In his popular book *Life Everlasting: The Animal Way of Death* he meditates on a "hummingbird sphinx moth" (!) that he caught in a cherry tree in his yard in Maine. Drawing on Williamson's article he muses that the transformation of the caterpillar to the butterfly constitutes "a reincarnation not just from one individual to another, but the equivalent of a reincarnation from one species to another" (183). Although his description of the metamorphosis of the caterpillar doesn't hinge on the truth

[59] http://www.youtube.com/watch?v=iTt12UxnUvY&feature=player_embedded

of Williamson's speculation (caterpillars evolved from onychophorans by hybridogenesis), his narration is animated by the possibilities for thinking of life and death activated by Williamson's article:

> When my hummingbird sphinx month caterpillar had grown to its full size, it left the cherry tree where it had fed all its life to wander about on the ground and then burrow into the soil. There it created a crypt for itself; lying there motionless in the dark, it eventually shrank, shed its dead skin, and turned into a mummylike shape with a hard covering. As its organs dissolved, its insides turned to mush, and most of its cells died. However, some groups of cells, named 'imaginal disks' [sic] (from 'imago'), remained. These, like the buds on a plant that can grow into a twig and the twig into an entirely new plant, are like seeds or eggs generating new organs.[60] During this apparent 'resting' or pupal stage, the disks secreted enzymes that destroyed the larval cells and incorporated the proteins and other nutrients from those cells into themselves. Eventually all of the larval cells were replaced, and the new cells assembled in an orderly way to produce the moth. As with most of life, this process followed specific instructions encoded on genes that directly affect physiology. (183–184)

This passage, studded with seductive metaphors and imagery, gives to this hummingbird sphinx moth the power to challenge our anthropocentric ideas about life and death and to see reincarnation not (only) as a spiritual concept but a material phenomenon as well. In Heinrich's account we see the cherry-tree munching caterpillar create a cocoon and slowly become a pupal "soup" (Williamson 2009, 19903), preparing for the time when imaginal discs—like buds, like seeds, like eggs, like Diderot's egg—will bring the hummingbird sphinx (back) to life, this time as a moth.

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[60] The role of imaginal discs may be overstated here. Petr Svatcha argues: "Only one copy of each organ or region is produced during ontogeny of an individual, and no cellular 'replacement' of larval parts by adult ones takes place. Strict homology is always maintained and only those organs which are externally completely undeveloped in the larval stage (in Lepidopetera the wings and genitalia) can be wholly represented by permanently internal imaginal discs" (1992, 112). However, much of this research has been done on *Drosophila* and it is unknown how much of the hummingbird sphinx moth, for example, is regenerated inside the cocoon.

Reading Heinrich's seductive prose, I feel that evolutionary biology needs fewer "just so" stories and more "what if" stories, fewer facts to live with and more speculations to savor.[61] One of the lasting legacies of Margulis's life and career has been what her theories have been able to sustain both in terms of scientific research and in terms of the possibilities for thinking life. Thomas Kuhn called these kinds of atmospheric Class M stories, "paradigms." And indeed Gilbert, Sapp, and Tauber suggest that the symbiotic view of life presents a "new paradigm for biology" (336).[62] Paradigms, according to Kuhn are "incommensurable ways of seeing the world and of practicing science in it" (16). In more evocative terms, they are seeds for sowing worlds (Haraway forthcoming), imaginal discs for scientific tissues to come.

In the symbiotic view of life the biosphere is no longer populated by individual organisms, but holobionts—"multicellular eukaryotes plus their colonies of persistent symbionts" (Gilbert, Sapp, and Tauber 326). Holobionts become the selectable entity in evolutionary processes. The immune system, for example, is re-cast not as "defensive weaponry" (330) but as a "socializing and unifying force" (332) that is created and supported in part by the microbiome. Which brings us to an sf phrase that nicely captures the otherworldliness of this symbiotic paradigm: "To obey the immune system is to become a citizen of the holobiont" (332).

Whether or not Roughgarden's and Margulis' theories of social selection and

[61] Maybe not always from the same people. I'm imagining something like a "Bureau of What-if Stories"

[62] Indeed, their approach is Kuhnian throughout: "We perceive only that part of nature that our technologies permit and, so too, our theories about nature are highly constrained by what our technologies enable us to observe. But theory and technology act on each other reciprocally: we construct those technologies that we think are important for examining a particular perspective of nature." (326)

symbiogenesis become new paradigms for "normal science" in evolutionary biology still remains to be seen. But, normal science or idiosyncratic science, they still have the ability to excite the tissues of the untouched place in our brains "which is tender and not yet hardened by past impressions" (Irigaray 77). They make us wonder. And indeed, they are already generating many marvelous facts. What could be more wondrous than a shadowless squid hunting in the moonlight, her light organ filled with luminescent bacteria who share with their host "a 'secret' language of mutualistic symbiosis" (McFall-Ngai et al 2012, 8)?

PART III: Response-ability

Wonder must be the advent or the event of the other. The beginning of a new story?
-Luce Irigaray

The above sections highlight how different modes of attention (attention to bacteria rather than animals, attention to reproductive social behavior rather than sexual reproduction) led two biologists to tell different stories about evolution, which engendered different intuitions about biological agency and possibility. They help us to imagine what Isabelle Stengers means when she challenges us to divorce materialism from elimativism to connect with struggle. In the work of Joan Roughgarden and Lynn Margulis we see powerful relays between attention, evidence, and narrative, relays that world us differently. "How many plots can the data hold?" and "Savor that speculation!" are two of many possible refrains that might help us navigate between these categories in the "interpretive adventure" called evolutionary biology (Stengers 2007, 10).

Although storytelling is one scientific practice among many, narratives develop our sense of what is meaningful, what matters, and who acts in the world (Martin 1991, Haraway 1989).

Arts and humanities people have their own practices of agential storytelling that share many political, material, and intellectual stakes with biologists, but are based in other scholarly crafts, with divergent lines of accountability associated with specific disciplinary, interdisciplinary and sometimes undisciplined traditions. Although some of these practices can be called empirical (for example the archival research done by historians), it is the aesthetic quality of these scholarly activities that I want to highlight here. Aesthetics, in the sense I deploy, is about how elements are arranged together, how they are composed, how they are brought into relation in the space of a text (Latour 2004, Puig de la Bellacasa 2010, Stengers 2010).

Aesthetics are political because they do consequential relational work. As Ursula K. LeGuin writes: "A novel is a medicine bundle, holding things in a particular, powerful relation to one another and to us" (153). As Ruth Ozeki said at a recent Science and Justice Working Group event: "Fiction is performative. It can model an attitude or way of holding things...You have to teach readers how to step into your fictional world and by doing so you've invited readers into a performance that you are actually doing together with or via the body of the text."[63] Novels, poetry, feminist theory, speculative fiction—these genres of composition gather together and stage their "matters of care" (Puig de la Bellacasa 2011) in ways that perform relations between things and teach their

[63] "Too Many Ps?: Personal, Political, Publics, and Potatoes." UC Santa Cruz. 5 April 2012.

readers to inhabit sometimes unfamiliar, agential worlds. They are practices of sf worlding.

In his article "An Attempt at a Compositionist Manifesto," Bruno Latour foregrounds the work of agential storytelling as a response to catastrophic environmental change, as he argues for the importance of composing rather than critique. Writing in the (feminist) science studies tradition that sets out to betray the anthropocentric binary between active humans and passive nature, he suggests that we, as scholars, must "tackle the tricky question of animism anew" (481). Following a similar hunch to Irigaray, Bynum, and Stengers, Latour is drawn to the description of the 16th century cosmos presented in Daston and Park's *Wonders and the Order of Nature*. Like our other authors he refigures wonder for the task at hand, arguing that "our age has become the age of wonder at the *disorder* of nature" (481, italics original). In this new age of wonder, the central concern is not about rationality or matters of fact, but how to tell faithful and fantastic stories that make us better companion species within a Coyote nature.[64]

Latour believes that this is not only a scientific matter, but also a literary one. The question of animism, he writes, is one that "humanist and literary studies are actually better equipped than most social sciences to deal with, thanks to their attention to the complex semiosis of human and nonhuman fictional characters...The redistribution of agency is the right purview of literary studies"

[64] To put Latour in more explicit conversation with Haraway, to whom his manifesto is dedicated.

(489n25).[65] In other words, the "proliferation of agencies" is, in part, an aesthetic matter that requires the careful attention of experienced and politically engaged storytellers. The "re-staging of things as lively" (Puig de la Bellacasa 2011, 87) in this literary mode is a different kind of interpretive adventure than those in the natural or empirical social sciences. Their powers come from *other* places and have other styles of composing that their practice produces as relevant. As Stengers writes, we in the humanities, who "trust in the magic of words and ideas," must "fabricate and discriminate" (2008, 58), as we learn how to respond within and as part of our living and breathing biosphere.

Although Latour, writing in the genre of "manifesto," describes tackling the question of animism in the gerundive, as a task "to be done," the re-staging of things as lively has long been a concern of the critical humanities.[66] Under an inspiring array of names—feminist science studies, the post-humanities, the ecological humanities, animal studies, queer theory—humanities scholars have represented their matters of care with an aesthetic (and therefore political) commitment to narrating stories with an emphasis on the relationality among agencies, forces, phenomena, and entities usually kept separate, in the back-ground, or out of the story altogether (Star 1991, Puig de la Bellacasa 2011). Although these accounts share certain sensibilities with the "ANT and after" style

[65] Discussions of reflexivity in the history of STS have occasionally been accompanied by calls for "new literary forms" (see Ashmore 1989 for an overview). Latour critiques this literature as being too cynical and self-referential, "piling layer upon layer of self-consciousness to no avail" (1988, 169). In 1988, he argued that STS scholars should pay attention to style and genre rather than heaping on the reflexivity. In 2010, Latour's point, I think, is more radical, both in terms of its embrace of fiction and its incorporation of S. Leigh Star's critique of the apolitical flatness of ANT agency. Calling upon the arts of humanists (or post-humanities) figures STS as political technoscientific storytelling.

[66] A recent article in the Chronicle of Higher Education, Cary Nelson suggested that we refer to this category of scholarship as the "fierce humanities" (2011).

accounts of distributed agency, they tend to be less grounded in the conventions of empirical social inquiry and always make the redistribution of agency an explicitly political question (see Star 1991). They are more personal, more speculative, more poetic in their composition. Below I explore three recent examples of scholars who teach their readers to inhabit (sometimes joyously, sometimes uncomfortably) radically animate and relational worlds, drawing attention to their narrative techniques and the political stakes that motivate their aesthetic tactics. Not incidentally, they are also some of the most beautiful writers in feminist science studies, poet laureates of queer animacies.

Natasha Myers and Carla Hustak: Relationality

Natasha Myers and Carla Hustak's article, "Involutionary Momentum: Affective Ecologies and the Sciences of Plant/Insect Encounters" is an exercise in careful biological storytelling, guided by specific anthropological, historical, and feminist modes of attention. Like Margulis (to whom this article is dedicated) and Roughgarden, they find the kinds of metaphors employed by neo-Darwinists deeply troubling. They explain that common evolutionary accounts of encounters between orchids and insects emphasize individualism, competition, and efficiency, often figuring the ways that orchids attract male insects in terms of trickery and "sexual deception" (75). These metaphors not only naturalize capitalist and military values, but, as Myers and Hustak demonstrate, they constrict our collective imaginations and shut down our ability to recognize and respond to agencies other than our own. Neo-Darwinian accounts give us disenchanted "ecologies, populated by blind, reactive automatons" (79). In "stultify[ing] both orchid and insect agency" (79), the standard narratives are not

able to "admit pleasure, play, or improvisation within or among species." (77).

Myers and Hustak devote relatively little space to critiquing dominant accounts; instead, they begin to spin a different set of tales. In their article, they counter *evolutionary* stories with *involutionary* stories, vivid accounts of how organisms become *involved* with one another's lives. Their descriptions of orchid and insect encounters are sensuous, sensual, and depending on your interspecies proclivities, downright sexy. These are seductive narratives where "mimetic relations among plants and animals take shape in the thickness of the space between bodies, where affects and sensations are *transduced* through *excitable tissues*" (78, italics original). We learn about how the specialized structures and volatile chemicals released by the *Ophrys* orchids "entice male bees to 'indulge' in the pleasures of pseudocopulation" (78) and how the tobacco plants "synthesize and release a concentrated plume of volatile chemicals" to attract carnivorous insects to sup on the tobacco's herbivorous predators (99). Myers and Hustak cast their spell of re-enchantment not just through thick description, but viscous, syrupy, sticky description, that adheres to their readers like the pollenia of Darwin's orchids.[67]

In this article we see "reading against the grain" employed as a critical feminist practice. Myers and Hustak read "chemical ecologists *as if* they're

[67] Like Roughgarden and Margulis, Hustak and Myers connect materialism with struggle by insisting that there is more that matters than what is recorded in Neo-Darwinian accounts: "Practices that fall outside the domain of reproduction and survival, including organisms improvisations and playful experiments, do not record themselves in evolutionary memory" (95).

involutionists,"[68] grabbing ahold of radical claims of plant communication, savoring the most savory speculations before they are retracted by their authors in favor of more conservative narratives. They skip over the functionalism in Charles Darwin to identify and amplify more muted stories of "affinities, attractions, and intimacies" (79). They glean juicy phrases from biological texts and *involve* them in other stories—stories of affective ecologies, intimate encounters, and articulate orchids. In this particularly striking example they use Darwin's own words to sensuously describe his scientific practice:

> [Darwin] took special note of each species' labellum, that special petal that extends out of the flower like a platform and "affords" both an "excellent landing-space" (98) and a "good standing place" (57) for the insect. In one species, he showed how its "two prominent ridges, sloping down the middle" acted as a "guide" to lure the insect towards the nectary. The insect's "flexible body" would allow it to reach the nectary and contact the pollinia (25)...He wanted to understand how the labellum "induced" an insect "to alight" (77). To do so, he noted the pleasures of taste that might attract the insect. In one case he noted, the labellum secreted enticing drops of nectar at a distance from "the true nectary" (77). (86)

Here, Myers and Hustak practice a kind of "involutionary poaching," hunting for precious empirical details from the game preserves of respectable scientific history (see de Certeau 1984).[69] They invite us to share in the secreted bounty,

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[68] This quotation is from an earlier draft of the paper. The published article reads "We read chemical ecologists as involutionists" (101). I prefer the speculative "as if" of the earlier draft since it draws attention to the sf worlding of the paper; they compose another world from within the texts that they read.

[69] During a panel at The Politics of Care in Technoscience Workshop (April 20th–22nd, 2012 at York University). Natasha Myers explained that this paper was a response to the trauma she experienced during her training as a biologist, hearing scientists' unbridled enthusiasm for stories structured by military and economic tropes. Myers' refiguration can be understood as reparative, in Eve Segdwick's sense (2003). I used the language of "poaching" from de Certeau above to how reading can be a betrayal of textual authority and an act of survival. I like to teach Sedgwick and de Certeau together.

beckoning their readers with meaty Latinate words like "pullulate" and "loquacious" (79).

Their reparative readings and lush writing are complemented by morsels of speculative historical fiction—stories of Darwin's encounters with orchids. These vignettes are, in part, grounded in Darwin's own papers. His sensuous curiosity is documented in his accounts of his methodology. There is ample textual evidence that details how Darwin intimately studied orchids, "insert[ing] himself into the scene of pollination" (Myers and Hustak 90), probing the flowers to discover what kind of stimulation would persuade each species to ejects its pollenium (86–90). Alongside stories of well-documented practices, Hustak and Myers engage these historical texts in a speculative anthropological mode, imagining how Darwin involved his own body in his experiments. They discuss a passage where he translates the position of Catasetum antennae to human anatomy, describing the difference between species by invoking a man holding his arms at different angles. Myers and Hustak read this not as a simple anthropocentric metaphor, but as possible evidence that Darwin was conducting "body experiments" (93), bending his arms into the shape of the Catasetum antennae. This reading is animated by Myers' anthropological work, which details the experiments performed by protein crystallographers when they contort their bodies into the shape of proteins (2006) and PhD scientists who dance their dissertations (2012).

Even if Darwin never performed these kinds of body experiments—though I certainly hope he did—this story matters.[70] It engenders different possibilities for what it means to do evolutionary biology and whets our appetite for passion-

[70] Besides, wasn't it the belief in truly true stories that allowed us to fall for functionalism in the first place?

ate embodied inquiry. Here we have history as sf—speculative fable; Myers and Hustak open up a space of possibility within a history we thought we already knew, creating sticky new attachment sites for thinking human/plant relations. Although this is a different way of writing history than the one that Bynum describes in her AHA address, their approach shares with Bynum commitment to "crafting our stories with attentive, wondering care" (25). Myers and Hustak deploy multiple writing tactics—thick description, refiguring, reading against the grain, citational poaching, and speculative fiction—to *move* their readers, to draw us into their matter of care. By the end of the paper, I can *feel* how "the air hangs heavy with significance" (105) and I begin to wonder how we can further attune our senses, our bodies, and our instruments to the ways that "plants *articulate* their experience and desires in an aromatic *atmospherics* of volatile chemicals" (100, italics original). Like Berndt Heinrich, I am learning to listen to the language of trees.

Mel Chen: Vulnerability

In "Toxic Animacies, Inanimate Affections," Mel Chen shows teaches us that relationality is about vulnerability as much as it is about possibility. Porous bodies and permeable tissues risk absorbing toxic substances and "becoming with" (Haraway 2008) chemicals that do not promote uncomplicated survival. However, Chen suggests that we restrain knee-jerk panic about toxic exposure and learn to dwell inside the toxic relations that are becoming more prevalent in industrial and post-industrial landscapes. In this article, she develops toxicity into a figure of queer relationality and seeks out examples of the multiple intersubjectivies

and interobjectivies enabled through toxic bonds.

The first site of toxicity Chen visits is the recent crisis in the United States surrounding the lead levels detected in children's toys imported from China. Chen is interested in the two principle figures in the news stories: "the vulnerable child, most frequently a young, white, middle class boy, and a dangerous painted toy, Thomas the Tank Engine" (268). These media representations, Chen argues, rely heavily on the discourses of the War on Terror. They present secure boarders as the automatic response to biological vulnerability. Safety is figured as a matter of "homeland security."[71] The invasive toxic threat is not only racialized as "Chinese," but also exhibits a nasty strain of U.S. exceptionalism. The problem is not that lead paint exists, but that it has invaded our territory and put *us* at risk: "These environmental toxins were supposed to be 'there,' but were found 'here'" (267). "We" (interpellated by the news story as the parents of the threatened child) are entitled to be free of the consequences of global industrialization, especially in the safety of our own homes.

Instead of focusing on the self/other (U.S./China) relation, the site of xenophobic anxiety in the news story, Chen homes in on the queer love story between the little boy and his toy train. Chen notices that this scene of danger—boy with train in mouth—is conspicuously absent from the media representations. The locus of toxic permeability is displaced onto the national border in the form of demands for "quality control" of imported products; to show the boy licking the train is simply "too much" (271), a site of contamination too emotion-

[71] For another vivid example of this kind of discourse, see Steven Soderbergh's 2012 film *Contagion*, where the threat (virus) is figured as Chinese, the threatened is the family or the homeland, and the scientific heroes are all American.

ally, politically, and sexually charged to represent directly. Chen argues that this displacement gives rise to the fantasy of absolute impermeability, as if a more secure boarder could prevent the act of "queer licking" (271) itself: "It is not only a fantasy that not-licking is a viable way to contain heterosexuality within its bounds, but it is also a fantasy that not-licking is a viable way to contain the interconstitution of people and other people, or people and other objects" (275). When we contain toxic threats within the discourses of homeland security, we miss how bodies are being constituted with toxins within the specific histories and geographies of global industrialization. Instead we concentrate on creating zones of exception, further protecting already protected life (272) and refusing responsibility for exposures that fall outside of our protection.

However, despite our academic cynicism about these media stories, we (probably) do not actually want to encourage queer love between little boys and poisonous toys, however delicious we find the figure to be. This is why, I believe, Chen switches narrative track, introducing stories of her personal experiences with the "peculiar intimacies and alienations" (265) of multiple chemical sensitivity brought on by chronic mercury poisoning.[72] She describes the everyday practices of wearing breathing masks in public places and the pain, overstimulation, and exhaustion of toxic attacks brought on by inhaling the wrong chemical (perfumes, gasoline, cleaning agents, cigarette smoke). She also describes the kinds of relations that she shares with her world during these toxic periods. For example, Chen describes how she had remembered being embraced

[72] As Chen points out, multiple chemical sensitivity is a poorly understood phenomena. I read this with Latour's characterization of animacy in the Anthropocene: "consequences overwhelm their causes" (484). Although Chen has some ideas about the source of her mercury poisoning, she "is not invested in tracing or even asserting a certain cause and effect of intoxication" (198). Instead, it is about learning to live with toxic animacy.

by her lover, when in fact it was the couch's embrace that had comforted her. She reads this misrecognition not as a failure of domestic human sociality, but instead asks after the "inanimate affections" that transpired between her injured body and the supple form of the couch. As in Karen Barad's vivid descriptions of the brittle star, Chen's story eats away at the distinction between the animate and the inanimate, subjects and objects. She characterizes the couch encounter as a form of "interobjectivity" since it "is made possible only to the degree that I am not in possession of human sociality" (280).[73]

Like Myers and Hustak, Chen explores the dynamic agencies that comprise "chemical ecologies." Here too, "the air hangs heavy with significance" (Hustak and Myers 105), carrying molecules that can trigger toxic reactions in their encounters with sensitive tissues. Relationality in these chemical ecologies is concomitant with vulnerability. Rather than dream of a world without vulnerability and therefore without relationality, Chen's stories help us engage with the uneven geographies of exposure. The question is not how to secure our borders, but "which bodies can bear the fiction of independence and of uninterruptability" (274) and who can pretend that the air that "separates" us is empty (and who cannot). Telling stories about toxic bonds allows us to map geopolitical and environmental interconnectedness and disparity, helping us to see harm but also the relations made possible in contaminated places. The point here is not to celebrate relationality and chemical agency as such (we see how deadly these can

[73] Temple Grandin's "squeeze machine" and other tactile innovations of people who are not neurotypical or are experiencing illness also resonate here. They also ask us to consider the forms of inanimate affections (sanctioned and unsanctioned) that give us pleasure in our own lives. My brother and I, for example, both have the same texture aversions and preferences in fabrics. We often give each other soft gifts as a way to care for one another.

be), but to better account for the ways that we are and become with damaged environments and "blasted landscapes" (Tsing).

Chen's queer readings of heavy metal poisoning open up different political and affective responses to living in a toxic world, where contamination is uneven but nevertheless interconnected. This capacity for enabling response comes not only from the readings and arguments presented in the article, but from its aesthetics, how it holds things together. Here, Chen (sometimes uneasily) combines a critical academic narrative about racialized panic and lead poisoning, with a personal narrative that performs an autobiographical vulnerability that— even in the genre of queer theory that recognizes the political value of the personal and intimate— nevertheless risks embarrassment, impropriety, and illegibility.[74] It risks illegibility precisely in the places where the story most matters, like the encounter between the Chen and the couch. I found myself as a reader struggling to grasp the significance of this story. But as she returns to it again and again in the text, it is clear that it is meaningful, that it matters within Chen's cosmos.[75] The question, then, is "how to relate?"

"Toxic Animacies, Inanimate Affections" gives us different stories, different channels, different registers to orient ourselves around the difficult question of how to "think more broadly about synthesis and symbiosis, including toxic vapors,

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[74] Chen comments directly on the feelings of vulnerability that accompany her autobiographical writing: "As academics are often trained to avoid writing in anything resembling a confessional mode, such a turn is fraught with ambivalence" (2012, 197).

[75] It is clear that this vignette is central to Chen's thinking in *Animacies*, especially because she returns to it in the final paragraph of the book: "My care for the couch may well have stemmed from what some deem pathology, but that does not invalidate it as a peculiar kind of care" (237). She goes on to say that "radical affection does not require intentional politics" (237), bringing this story to bear on questions of radical queer politics.

interspersals, intrinsic mixings, and alterations, favoring inter-absorption over corporeal exceptionalism" (Chen 2012, 197). These are pragmatic questions that require not only careful action, but the ability to sit with and think from experiences of susceptibility, porousness, receptivity, and vulnerability (2012, 237). And rather than carve out zones of exception like in the anxious media accounts, learn to tell stories that strengthen care, reliance, and repair within our sometimes toxic chemical ecologies.

Eva Hayward: Resilience

Eva Hayward's article, "When Fish and Frogs Change Gender," also takes hyperbolic media panic as its starting point. Hayward is troubled by the proliferation of articles with sensationalistic headlines that link environmental pollution with the changes in sex organs in animals, such as "Female Fish Develop 'Testes' in Gulf Dead Zone" and "Sex-Changing Chemicals Found in Potomac River." In these articles Hayward finds an overwhelming anxiety about contaminated categories (call homeland security!) in the place of a real ability to grapple with the changing chemical ecologies of our industrial waterways. Like Chen, Hayward is looking for strategies to account for uneven vulnerability without recourse to purity discourses:

> I wonder how we can address the impacts of toxic substances on vulnerable people and animals without appealing to society's basest fears about sexual disruption. Can we foster environmental responsibility without invoking anxiety that our most intimate reproductive environments have been infiltrated by an industrial world? (2011)

Hayward sets out on a project of narrative remediation,[76] to re-story these contaminated landscapes. But as with all stories we are unaccustomed to hearing, they are not without discursive trouble. She cites a scientific study that correlates the rise in transsexual populations to the presence of DDT in the environment. Giving legitimacy to studies like this run a non-trivial risk of pathologizing transpeople; however, Hayward is curious how such a correlation can act as an entryway for thinking the inter-constitution of sex, gender and environment. Although she doesn't believe there could be a single environmental factor responsible for transsexuality, she does not foreclose the possibility that chemicals like DDT could be a part of transsexual relationality, where relationality (as we learned from Chen) is also about becoming with toxins. Hayward's approach is through resilience rather than pathology: "Is there a way to re-evaluate ecological resilience—such as the sex-changing response—and meet the future organisms that we are becoming?" (2011). Hayward looks to the bass in the polluted Potomac: "Chemicals from industrial and residential sources have caused male bass to produce eggs that can be fertilized by their former gender mates" (2011). Sex changing, even in polluted rivers, can be acts of ecological resilience and biological creativity.

Resilience is a tricky thing to narrate in relational worlds abounding with transforming and transformative agencies. In "Spider City Sex" Hayward offers stories spun from her memories of transitioning in the Tenderloin neighborhood of San Francisco as a viscous narrative medium for exploring "the sensuous

[76] Remediation, though unfortunately co-opted by policy-speak, is a useful word in this context. It links "remedy" with the need to "re-mediate," to stage matters of care differently. See the conclusion for more on the arts of mediation.

transaction between body and environment" (225). Although this article does not address questions of becoming with toxic environments, she gives us a sense of what kind of stories are necessary "to meet the future organisms we are becoming"—stories that figure us as constituted, contaminated, vulnerable, agential, creative, and expressive all at the same time. These are difficult elements to hold together, but it can and has been done by sensitive and graceful writers. Hayward calls upon Susan Stryker's luminous phrase to do this delicate narrative lacework: "So much that constitutes me I did not choose, but, now constituted, I feel myself in a place of agency" (quoted in Hayward 2010, 236). In this mode of storytelling that cuts across the toxic dualism of active vs. passive, transsexuality is not aberrant but exuberant: "If sexual differences and sexuality are exuberances, contingencies, then sex is profusive, a superabundant happening" (235). Within an exuberant nature, Hayward tells us that nothing stays put: "surplus liveliness is bumptious, fabulous, *Unheimlich*" (235).

Hayward shares with Myers and Hustak an involutionary approach to the lives, affects, and bodies of organisms: "Energetic forces, coextensive overlappings, shared milieus make species; species are sensuous responses" (233). Here transsexuality becomes an "an expression of bodily capacities" (226), a "creative response" (234) to the environment. Thinking with spiders—both figural and literal—Hayward lyrically describes the process of changing sex. Here are three examples:[77]

[77] I chose three different quotes because Hayward's articles work through a process of poetic accretion. Experimental wordings and phrases build up; they signify in their heaping.

> The expressive potential of the body, its capacity to respond to the world, is substantively modified, transforming the sensuous exchange of self and the environment. Changing sex, then, is also always about changing sense and species in the flesh. (229)

> The transitioning body is also a gossamer outstretch of homeliness, energetic force or potential, a discursive pulse, a throb of sensations distributed across sensoriums, spaces, and times, delimiting territory but also sensing zones, places, and coherences. (244)

> Transitioning is vibratory; transitioning women, are first and most importantly, vibratory beings. She is a creative response between sensation and environment. (245)

Expressive, sensuous, and vibratory, "a gossamer outstretch of homeliness," Hayward performs a poetics of transitioning that challenges her readers' own sensorium: *Can you match that?* (Hayward 2005, 43). Which is not to say that Hayward presents transitioning as a universal experience or invites all of her readers to identify with her, but rather these descriptions—glimmering, pulsating, quivering—unsettle the comfy narratives that buttress taken-for-granted sexualities, genders, and desires. She entices her readers to wonder how they too might be creative responses to their own environments, which (as Isabelle Stengers might remind us) is a pragmatic rather than a general question (i.e. answers will vary!).

And lest we forget these are sf stories as much as they are autobiographical experiences, I conclude by turning to an article about marvelous becoming and ethical response. In "Carnal Light," Lindsay Kelley and Eva Hayward do art criticism as speculative fantasy asking what would it be like to *eat* Alba, Eduardo Kac's glowing bunny spliced with the GFP jellyfish gene. They found that The

Critical Art Ensemble (CAE) had, in fact, written a recipe for *Ragoût Alba à la Provençale*, inspired by the notion that if Alba could not leave the lab alive for fear of environmental contamination, she might be able to leave as meat. Kelley and Hayward take the recipe as an occasion to theorize the recombinant sensuality induced by ingesting this unfamiliar protein:

> With CAE's recipe we can imagine that glowing food intensifies vision through tactile registers; the verb 'to taste' is conjugated through sight. Glowing at the edges of the mouth, *Ragoût Alba à la Provençale* cannot be digested without visual recourse. For *homo sapiens* consuming this entree, the mouth is solicited by light, undoing the eye's propriety of vision. Although for Alba this is an unbecoming, a transformation from companion to meal, for the humans involved, vision is reworked by orality...and jellyfish bio-materialities are sent further adrift. (123)

In this article we are confronted with the wonderful contradiction of two vegetarians imagining what it would be like to eat a genetically engineered rabbit and are asked to share in their involutionary daydream. As our bodies adapt to consuming GFP bunnies, they speculate, our tongues might respond by "growing light receptors in our taste buds" (124). If, as Kelley and Hayward contend, "Ontology is about what there is and what debts we owe to it" (116), involutionary storytelling give us a way of imagining how to respond to these ontological obligations, which includes questions of how we are already responding and what responsive capacities (real and fantastic) we might yet acquire. Returning to the bass in the Potomac, Hayward composes a world where inter-animacies are not only about corporeal vulnerability but also about resilience and creative response even in the most polluted waters.

Fables of Response-ability

In these articles we are invited into the chemical ecologies of plant communication, lead poisoning, multiple chemical sensitivity, bass changing sex in industrial waterways, humans changing sex in the Tenderloin, and glowing transgenic ragout. These are animacy stories that present us with a multitude of agencies, but, importantly, do set the whole world in motion—some things must be stilled and others left out. To highlight the inter-constitution of chemicals and bodies, these authors follow molecular agencies between and among bodies, with an emphasis on worlds that come together through dispersal, induction, volatility, toxicity, and drift. These are not the only stories possible. However, the personal and political investment in telling *these* stories and not others is unmistakable. They are richly reparative compositions —healing spells against mechanistic tropes that do violence to the agency of nature (Myers and Hustak), against anxious stories that demand purity rather than grapple with contamination (Chen, Hayward), against poisonous categories that shut down our ability to think, feel, and account for our lives.[78]

These are also social stories, designed to *influence* their readers. In the ways that they gather their players together and narrate their constitutive relations, Hustak and Myers, Chen, and Hayward's agential stories induce possibilities for action, passion, sensation, and responsibility. These are moral tales that model an ecological attention to relationality, vulnerability, and resilience. They are

[78] Hope is also an important register in these articles and in Sedgwick's discussion of reparative reading: "Hope, often a fracturing, even a traumatic thing to experience, is among the energies by which the reparatively positioned reader tries to organize the fragments and part-objects she encounters or creates" (146).

each concerned with environmental justice and living well in a contaminated world. Even Myers and Hustak, whose sensuous involutionary accounts of orchids and insects may not at first glance appear to be grounded in urgent environmental concerns, explicitly addresses their moral investment at the end of their paper:

> What is at stake in this involutionary approach is a theory of ecological relationality that takes seriously organisms' practices, their inventions, and experiments crafting interspecies lives and worlds. This is an ecology inspired by a feminist ethic of "response-ability" in which questions of species difference are always conjugated with attentions to affect, entanglement, and rupture; an affective ecology in which creativity and curiosity characterize the experimental forms of life of all kinds of practitioners, not only the humans. And it this mode of ecological thinking that we believe we will need in order to do more effective work in challenging the status quo of ecological irresponsibility. (106)

This is a *fable of response-ability*, a story that can teach us how to pay attention to the lively agencies around, within, and among us, such that we become more responsive creatures, able to relate well within our more-than-human ecologies and to "meet the future organisms that we are becoming" (Hayward, above). Like Kelley and Hayward's *homo luxivorus*, a being whose tissues and appetites are attuning to her radiant meals, the reader of these fables might also find herself generating new sensitivities, caught up in unfamiliar economies of attention, moving differently through worlds.

In her article, "Awash in Urine," about DES (diethylstilbestrol) and Premarin® Donna Haraway helps us to imagine a politics of ecological storytelling as she tells overlapping personal, historical, geopolitical stories of

hormonal agencies across and between species. Haraway's urine-soaked account of hormonal drugs gathers together a range of surprising players:

> fetal calves stripped of amniotic fluid, urinating pregnant Canadian women, pregnant mares and their foals and consorts in Manitoba and beyond, activists in horse rescue and women's health, economically strapped contract farmers, a California menopausal woman worried about familial heart disease in the company of a lucrative market-ready crowd of other menopausal Americans, and German zebras in zoos in the 1930s. (312)

As she knots each of these historical threads into her narrative, Haraway foregrounds her role as technoscientific fabulist with serious moral stakes in the aesthetics of her storytelling practice: "Why tell stories like this, when there are only more and more openings and no bottom lines? Because there are quite definite response-abilities that are strengthened in such stories" (312). Haraway's articles are "medicine bundle[s], holding things in a particular, powerful relation to one another and to us" (Le Guin153), helping us to grapple with a world where DES and Premarin® are part of our chemical ecologies and historical inheritance. These densely knotted stories with their specific historical and ethical entanglements are part of developing practices of pragmatic accountability for the interconstitution of "natural" and "synthetic" estrogens and the bodies of calves, mares, humans, and zebras.

The fable genre, among other things, teaches its readers how to be responsible: "What is at stake in the fable is, more than anything else, the interpretation and practice of responsibility—our exposure to calls, others, and the names with which we are constituted and which put us into question" (Keenan 45). The term

response-ability[79] captures the spirit of Thomas Keenan's "exposure to calls," but also recognizes that not only humans call and not only humans respond. As Hustak and Myers put it: "The world is full of "propositions" waiting to be registered by *interested* bodies. Those who invest their energies in attuning themselves to others can learn over time to discriminate increasingly subtle differences in one another's utterances" (105, emphasis original). Response-ability in this broader sense is not only about taking responsibility for one's own actions and obligations, but entails "an enabling of responsiveness within particular relatings" (Schrader 2010, 277).[80] In the context of experimental scientific inquiry, Vinciane Despret describes the difference between apparatuses that enable responsiveness and those that do not: "An apparatus that does not have a stake in docility is an apparatus that is designed to give the opportunity to the 'subject' of the experiment to show what are the most interesting questions to address to him; what are the questions that make him/her the most articulate?" (2004, 124). Fables of response-ability draw our attention to who is interested and who is made articulate in the apparatuses and ecologies we live inside.

In his book *Letting Stories Breathe,* Arthur W. Frank writes: "If narrative analysis does not improve the quality of companionship between humans and stories, it has failed" (19). One important goal for post-humanist narrative

[79] See Haraway 2008, 2012, Myers 2006, Schrader 2010, Hayward 2010, Barad 2012, Hustak and Myers 2012, Reardon 2013.

[80] Here is a longer definition of Schrader's demanding conceptualizing of response-ability: "Rather than considering responsibility as an attribute of individual scientists or as a 'social' responsibility that merely concerns the subsequent uses of scientific results, I develop a notion of responsibility *in* scientific practices as a consequence of fundamental indeterminacies in *Pfiesteria's* beings and doings. Responsibility in my account entails not a particular response, but an enabling of responsiveness within experimental relatings. I argue that responsible experimentation with the fish killers hinges on maintaining *Pfiesteria*'s ability to respond to their experimental probings, that is, their response-ability." (270)

analysis and agential storytelling, in this context, would be to improve the companionship between humans and non-humans, to generate new sensitivities, and enable different patterns of responsiveness. Inviting scholars to participate in their ecological humanities project, Deborah Bird Rose and Robin Libby imagine that humanities storytelling can help to strengthen ecological connectivity in the Anthropocene: "We need stories of our place in the biosphere, stories of the human organism as a living moment in connection with environment. We need stories of justice that enlarge our thinking, stories of relationships to place that enlarge our thinking." (2004).

However, even as they focus on the worlding power of storytelling they add the caveat that "this does not offer a license to make up stories" (2004). Whether the reason for this caveat is fear of being dismissed as relativists or the violent histories of indigenous knowledge systems being categorized as just "myths" or something else entirely is unclear. Nevertheless, despite the important work this article does to articulate what ecological stories can *do*, I'm struck by the way that this formulation privileges the empirical arts of the natural sciences and risks overlooking the arts of composition practiced by artists, poets, storytellers, and theorists. The term "fables of response-ability" helps us to foreground the craft-work in "making up stories" and to promote efficaciousness over truth (Stengers 2008). What counts as a responsible story and what stories enable responsiveness is not known in advance[81]; it is a pragmatic art.

[81] Everyone who has designed a syllabus or taught a class knows this. How often have I assigned a reading that I was excited about in a specific way only to find that the students could not connect or connected to something that I didn't notice?

Hustak and Myers, Chen, and Hayward collectively draw our attention to the work of the personal, poetic, and speculative for generating promising sensitivities to our more-than-human world. They offer stories that are not only faithful to the toxic and salubrious encounters in their diverse chemical ecologies, but also demonstrate the captivating allure of beautiful and astonishing language and the transformative power of the "what if" and the "as if"—What if Darwin conducted experiments with his body? What would happen if we ate Alba? Let's read chemical ecologists as if they were involutionists! The truths, fictions, speculative fantasies of these pieces all express their commitment to fostering resilience, care, and response-ability—relational values for relational worlds. These authors show us—sometimes gracefully, sometimes uneasily—what it might take to meet Stengers' challenge of "abandoning the opposition between 'faithful description' and 'fiction,' between 'fact' and 'value,' for an openly constructivist approach that affirms the possible, that actively resists the plausible and the probable targeted by approaches that claim to be neutral" (2010, 57). They invite us to ask who we are and who we become when we find ourselves exposed to their calls and propositions. Let us ingest and digest these delectable stories, awaiting the narratively-induced sensitivities to come.

Conclusion: I Wonder If

This chapter has been a return to wonder. A return to wonder with a difference. Unmoored from its historical contexts, wonder has been set adrift, continuing on to form a feminist constellation with speculation, sf worlding, re-enchantment, animacy, and response-ability. I have traced this conceptual and textual constellation in the hopes that it might help others with orientation, navigation and

composing stories just like the astral constellations, constellations that transmit "an etherial fluid" that *influences* "the character and destiny of men" (OED). I wanted to gather the insights of the many remarkable thinkers who have had the hunch that wonder could be a useful word to hold onto in times when it feels like the forces of disenchantment are toxic to livable forms of thinking and feeling—Luce Irigaray, Caroline Bynum Walker, Isabelle Stengers, Sara Ahmed, Scott Gilbert, Bruno Latour, Stacy Alaimo, to name just a few.

In this chapter wonder is the speculative force—"I wonder *if*" —that divorces materialism from elimativism to connect with (scientific, political, worldly) struggle. Wonder is a mode of attention to the perpetual newness of the present (Irigaray), to the other-worldliness of the past (Bynum), and to the aesthetics and politics of sf worldings that generate sensitivities for worlds-to-come (Stengers and Haraway). Wonder is the vital energy circulating in the classrooms of Caroline Walker Bynum and T. Hugh Crawford, in the articles of Natasha Myers, Mel Chen, and Eva Hayward, in the evolutionary theories of Joan Roughgarden and Lynn Margulis, wonder that renders their students and readers susceptible to unfamiliar calls and propositions. Wonder is an incitement to compose stories—and not only true stories!—that world us otherwise and make us a better companion species within a more-than-human nature. Within this feminist constellation of wonder we find that we become with our stories and that fables of attention are also fables of response-ability. How we compose and what compositions we inhabit enable and shut down our capacities to attend and therefore also to respond "within and as part of the world" (Barad 2007, 37).

CONCLUSION

Illuminated Wonder or Living with Tricksters

Illuminate

8. *To decorate (an initial letter, word, or text, in a manuscript) with gold, silver, and brilliant colours, or with elaborate tracery and miniature designs, executed in colours; to adorn (a manuscript, inscription, text, etc.) with such decorative letters and miniatures.* (OED)

Inside its cloth cover enveloped by an intricate gold and silver pattern, between its gilt pages where the purple satin bookmark holds my place, Marian Bantjes' *I Wonder* (2010) invites me, "the reader," to partake in the pleasures of illumination, ornamentation, and wonder. Bantjes, a Vancouver-based graphic artist, resists the striped-down Modernism[1] that predominates contemporary design in a series of 13 essays with illustrations, lettering, and even few fonts that she designed specifically to accompany each essay, employing different styles and materials for their compositions. Borders, backgrounds, and figures were assembled in Adobe Illustrator, but are not only comprised of vector graphics; they are often made up of scanned hand-drawings and photographs of carefully assembled objects: pasta, wheat and granola, leaves, flowers and stems from Bantjes' garden, celestial broaches on display at the Griffiths observatory in L.A., and customizable neon signs used by businesses in Saskatoon, Saskatchewan. Her eclectic compositions are influenced by illuminated religious manuscripts

[1] For an interesting depiction of the influence of Modernism in font and graphic design, see the documentary film *Helvetica*.

and their arts of inducing wonder and connection with the divine; many of the shapes, patterns, and colors in Bantjes' vector artwork, for example, reference the intricate geometry of 14th century Islamic illumination. These are illustrations, decidedly not representations: "My intention," she writes, "was always to illustrate without illustrating; to avoid the *figure a* form of illustration" (7). Bantjes' illustrations are decorative, ornamental, but not superfluous. They have been crafted to complement, enhance, activate (and occasionally obfuscate!) her text.

In her opening essay, Bantjes argues that ornamentation and wonder have been constant companions throughout history of religious manuscripts and architecture: "These intricate artworks are not only visually wondrous, but amaze us with their investment of time, skill, and infinite detail" (18). Her own book, a secular, eccentric and unmistakably 21st century artifact, rekindles the affiliation between text, lettering, and illustration, teaching us how attentive design can transform our sensuous encounters with books.

A polemic runs through the pages of *I Wonder*—a critique of the sometimes automatic association of the unadorned with honesty and utility and of ornamentation with the deceitful and frivolous. Bantjes finds these themes not only in the principles of Modern design but running through the history of Western treatises on aesthetics, from Socrates and Cicero to Adolf Loos and John Ruskin.[2] In an essay titled "Honour," framed by a border made with pasta of different

[2] In a section called "The Politics of Ornament" Bantjes offers a selection of quotations decrying ornamentation as ugly and morally bankrupt, beginning with Shakespeare: "Ornament is but the gilded shore to a most dangerous sea" (quoted in Bantjes 48).

shapes, textures, and shades of yellow meticulously arranged to simultaneously evoke a kindergarten project and the gilded wooden frames of the baroque period, Bantjes challenges one of the most influential principles of Modern type design: Beatrice Warde's concept of "The Crystal Goblet."[3] Warde takes up the crystal goblet as a metaphor to argue that "the type and the page should be visually 'transparent,' allowing one to read the text uninterrupted by any other flavours or distractions from the type or its surround" (Bantjes, 73).[4] This figure has been taken up again and again in the design literature to champion simplicity and function as central values in design and typography; however, as Bantjes points out, the crystal goblet offers only one ideal for imagining the relationship between letters and letterforms. As a graphic artist, she has become particularly frustrated by the implication that form must always be subordinate to content. Designers often deploy the imperative "honour the text" as a reminder to use clean and legible typefaces, so as not to detract from the words and their message. In this essay, Bantjes turns the refrain into a question, asking: "How does one honour texts? For that matter, how does one honour anything?" (74).

Simplicity, Bantjes argues, is not the only way to honour something. She describes how in the Istituto e Museo di Storia della Scienza in Florence, Galileo's objective lens is nested within an elaborately carved ebony-and-ivory frame commissioned by the Medici family, a frame that "considerably dwarfs the lens" but nonetheless helps the onlooker to encounter the cracked glass as a valuable historical object (75). She is not only interested in museum treasures but personal

[3] From her 1932 essay "The Crystal Goblet."

[4] She counters the crystal goblet with the Japanese tea bowl (*chawan*), a drinking vessel that "is an integral part of an experience in which the presentation is as important as the content" (74).

treasures—the love letters and hand-written notes so many of us keep, hidden safely within "secret drawers" (78), letters that express emotional and personal connection (even if they are not beautiful, skillful, or valuable to anyone else). At the end of this essay Bantjes suggests that we not only honour something with simple modern design or rich ornamentation but with our time, our care, and our attention.

Other strategies Bantjes uses to unsettle the rationale of the crystal goblet are to use design to enliven otherwise banal texts (such as in the essay that details how she assembled two Ikea bookshelves) and, more puckishly, to design fonts that obfuscate rather than clarify the text. The essay titled "Secrets" is written in two fonts—one that is legible only with great effort (and eyestrain!) and another made up of glyphs that are not letters, which either require decryption to read or perhaps cannot be decrypted at all. The part of the essay written in the barely legible font explores the "desire to obscure text" (113). Bantjes argues that cryptic lettering need not only be seen as a barrier to reading but as an enticement to decode, to unlock, to look for clues, to intuit. Encoded writing requires time and attention; the rewards of successful decryption bring value and meaning to the text.[5] Although I was personally unable to decode the text set in the second, more cryptic, font, I wonder if, instead of continuing the argument about the pleasures of decryption, it might speak to the mystery of the undecipherable. In a book that enrolls and transforms religious motifs, the experience of reading (or rather not reading) this section evokes the power of occult knowledge, the power of that which is hidden. At the end of *I Wonder*, Bantjes has provided a section called

[5] I feel that this might also be some of the pleasure of reading "difficult" philosophers like Jacque Derrida.

"Notes on the Production," an extended colophon that describes the fonts, artwork, and illustrations produced and/or used for each essay. For "Secrets" she writes, "The entire piece is typeset in two proprietary fonts that I created for the purpose: MB- Secrets and MB- Cipher. They are not available for sale" (192). This statement not only tells us that these fonts are not commodities (their value comes from *elsewhere*), it also means that one cannot buy the fonts for the purpose of decoding the text in "Secrets." Decoding can only come from the reader's own time and attention.

Through each of the essays, but especially in "Secrets," *I Wonder* spins a fine gold thread connecting wonder to illumination, ornamentation, enchantment, mystery, and occult knowledge. And also to questions of craft, skill, care, time, and attention. It asks how we honour something we find to be precious and how to not only illuminate our texts, but to make them radiant. For Bantjes, bibliographic aesthetics are arts of enchantment, vectors for the transmission of value and meaning. Shattering the crystal goblet, Bantjes rejects the relation between the austere and the serious, asking us to wonder again (or for the first time) about the powers of the ornamental. Ornamentation, enchantment, mystery, occult knowledge, craft, skill, care, time, attention, transmission, value, and meaning—these are the themes that ignite my conclusion. I ask what we, practitioners of feminist science studies, might learn from this kind of illuminated wonder.

Why Think and Write with the Aesthetic?

How many academic books are as pleasurable to hold in your hands and take in with your eyes as *I Wonder*? Although there are some lovely aspects of the

academic books on my shelf—the photograph of textile artist Judith Scott on the cover of *Touching Feeling*, the satisfying heft of *Wonders and the Order of Nature*—none of them feel as precious as Bantjes' (though many were more expensive).[6] This, of course, can be ascribed to the conventions and economics of academic publishing. Surely it is impractical to employ expensive illustrators, typesetters, book designers, and materials for books with limited circulation. However, especially in an age of electronic publication, economic impracticality should not keep us from asking: How can we honour our text? What would it mean to illuminate rather than elucidate? How can we make our words radiate?

To me these questions are important not only for book design but writing style as well. The conventions of academic writing, like those of modern design, often reflect the belief that the truthful or serious should be unadorned. But unadorned prose like clean modern typefaces only reflects one aesthetic among many artful possibilities. My fear is that in the field of STS, we left behind the "linguistic turn" before we really began to feel the effects of our own language. The recent focus on matter and ontology in STS has sometimes been at the expense of attention to the form and style of language. For example, Andrew Pickering writes in recent essay about art as "ontological theatre": "I am interested in art because it escapes the linguistic turn. It is not a verbal thing. It can thus, potentially at least, directly foreground agency without any detour through words" (2012, 7). In Pickering's formulation, language is a second order phenomenon at one remove from reality, possibly frivolous and most certainly

[6] The notable exception is Avital Ronell's *The Telephone Book*. Ronell worked closely with designer Richard Eckersley and typesetter Michael Jensen to achieve the singular look of this wonderful book.

circuitous—a necessary evil.[7] In its return to reality, "the ontological turn," seems to call for a stripped down prose that speaks can speak clearly about things, objects, matter, agency, and practices (if language cannot be *completely* avoided).

But what about the book as an object? Writing as a practice? Reading as world-making?

In a recent talk Lauren Berlant asked provocatively: "Why write and think with the aesthetic, since it is isn't evidence of anything?"[8] This question, which she posed but did not answer, simultaneously expresses hopefulness and anxiety. In the hopeful register it suggests that thinking and writing with the aesthetic can inspire us to experiment with "the arts of mediation that would incite absorption, attunement, and excitement" (Berlant 2012). Inquiry into the arts of mediation, offers a promising alternative to Pickering's fantasy of direct access. On the other hand, it introduces an anxious question: Where do our powers come from if not from evidence?[9]

In this question there is more than just academic seriousness at stake, but also the specter of deception. When we collude with enchanting powers of aesthetics, and their abilities to incite absorption, attunement, and excitement,

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[7]The concepts of "material-semiotic" (Haraway) and "material-discursive" (Barad) were introduced to avoid this kind of split between language and reality. However, these terms are generally mobilized by STS scholars at the level of analysis (i.e. how is object x is both material and discursive) rather than at the level of composition (the materiality and semiosis of ones book).

[8] Video of this talk is available here: http://www.ici-berlin.org/docu/forms-of-attachment/. For more of Berlant's thinking on the aesthetic: http://www.socialtextjournal.org/periscope/2013/01/conversation-lauren-berlant-with-dana-luciano.php

[9] I was speaking to an STS/humanities professor. She said that we need to be able to communicate better to scientists about what counts as evidence within our field. I replied that I don't think that I would say that my writing includes any "evidence." Her anxiety around this answer and my own difficulty in describing what is involved in my work helped me formulate this question.

we are exposed to the double definition of enchantment as both "delight in wonderful things *and* the potential to be placed under their spell, to be beguiled" (Saler 138, emphasis mine).[10] Reading a text that traffics in enchantment makes us uneasy: What if we are beguiled? How can we judge its claims? Where is the evidence? The anxiety of the aesthetic goes beyond asking whether the emperor has no clothes. It's even more precarious: "Maybe there no emperor at all under all these richly gilded clothes?"

Here we find ourselves in the territory of Helen Verran and Isabelle Stengers, thinkers who have begun to se t down a language for describing how we make relevant knowledge without recourse to foundations. When we can no longer rely on the criteria of the rational, universal, and objective, we must learn to trust the situated, pragmatic, emergent, and immanent. This is the kind of trust that Verran learned in her classrooms in Nigeria: "I learned to trust in an embodied certainty of time and place. That is not only trusting people as subjects figured in particular ways, often ways that are unfamiliar. It is also learning to trust objects figured in unfamiliar ways" (2001, 236). The kind of trust Verran describes is not a trust that guarantees an outcome: "Trust in the sense that its verification is an event, not a due" (Stengers 2010, 145). A trust where you are always "exposed to the risk of betrayal" (Stengers 2011b, 216). The suspicious refrain "trust no one"[11] is of limited use here; thinking and writing with the aesthetic is a matter of practicing our arts with "attentive wondering care" (Bynum, 25).

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[10] This connection between enchantment and beguilement is prominent in the strains of social theory that have opposed aesthetics to politics. Raymond Williams, for example, "characterizes aesthetics as 'the main instrument' of ideological mystification" (Ziarek 9).

[11] I borrowed this refrain from *The X-Files*. "The truth is out there" also doesn't work very well. "I want to believe" is more promising.

All Out of Sorts

> Sort
>
> 13b. *Typogr.* One or other of the characters or letters in a fount of type. Usu. in *pl.* (OED)[12]

Learning to "trust in the magic of words and ideas" (Stengers 2008, 58) requires pragmatic experimentation because we cannot know in advance how stories, words, refrains, sounds will flow through us. This is a matter of *poetics*, having to do with the arts of language (*poetry*), processes of creation (*poesis*), and questions of composition and form (*poetics*). It requires ongoing attention to form, composition, and *influence*. There are some scholars who have made this kind of poetic exploration central to their thinking and writing practice. For example in "Carnal Light" Eva Hayward and Lindsay Kelley experiment with the arts of antimeria:

> Antimeria…turns nouns into verbs, that mobilizes, incites, activates persons, animals, places, things and ideas. From Greek: anti- 'instead of' and mereia 'a part': incitement rather than determination, for example 'I am rubied by your attention'. (116)

Hayward and Kelley propose that by shifting verbs to nouns and nouns to verbs, "Antimeria expresses the sensual charge of encounter, its amplification, allowing for the percussive distribution of affect" (116). "I am rubied by your attention" animates the blood-red gemstone, setting it in motion, causing the reader to wonder what it could possibly mean as a response to attention (Am I flattered? Am I blushing? Does my aura begin to sparkle?). The surprise of this phrase

[12] The phrase "out of sorts" comes from linotype printing, where the printers would run out of the metal letters, called "sorts," necessary to set their document (see *Linotype: The Movie*).

makes me smile; its ambiguity stimulates my imagination. As "ruby" is enlisted to describe the effect of an encounter between two people (?), the possibilities for what this encounter might mean proliferate. Like Bantjes' design, Hayward and Kelley's writing has a particular aesthetic tentacularity—a beauty that reaches out from the page, grabbing hold of my attention and imagination.

Thinking and writing with the aesthetic does not mean that we all must become poets. We certainly do not need another art to master or another skill with which to out-compete our colleagues. However, since we *are* all writers, it seems worthwhile to set aside some time to play with the relational properties of language—its viscosities, conductivities, velocities. This does not have to be daunting; it can be collective, exploratory, and supportive.[13]

This ethos, I think, is nicely illustrated by a classroom exercise I designed, inspired by Canadian poet Christian Bök's *Eunoia*. Written in the tradition of Oulipo constraint-based writing, *Eunoia* has five chapters, each only employing one English vowel.[14] Not only that but each chapter must "allude to the art of writing," "describe a culinary banquet, a prurient debauch, a pastoral tableau, and a nautical voyage," and "accent internal rhyme through the use of syntactical parallelisms" (111–112). The pleasures of reading *Eunoia* come not only from the surprising and delightful ways that Bök meets the challenge of

[13] For my creative writing workshops I have designed the CFP specifically to downplay the aspect of creative writing that conjures associations with virtuosity and the avant-garde, using words like collective, exploratory, and supportive instead. Simple things like the language on a CFP matter for what kind of work we can do together.

[14] The technical term for this kind of composition is a "lipogram" (from the Greek, meaning "wanting a letter").

these jocular constraints, but how, when artificially separated from one another, each vowel takes on a personality, a feeling, an atmosphere.

To illustrate, here is an excerpt from "Chapter E":

> She enters the deepest sleep—the nether sphere, where sleepers delve the secret depths. Whenever Helen sleeps her essence enters the ether—the deep well, where she feels herself descend deeper, deeper. Her descent seems endless; nevertheless she lets herself be swept wherever the gentle breeze sweeps her. She regresses. She sees levels never seen except when men enter the seven hells [...]: the fell dens where beetles creep, the deep fens where leeches dwell—there the sewers reek. (38)

And from "Chapter U":

> Ubu gulps up brunch: duck, hummus, nuts, fugu, bulgur, buns (crusts plus crumbs), blutwurst, brühwurst, spuds, curds, plums: *munch munch.* Ubu sups. Ubu slurps rum punch. Ubu chugs full cups (plus mugs), full tubs (plus tuns): *glug glug.* Ubu gluts up grub; thus Ubu's plump gut hurts. (80)

The elegiac quality of Helen's descent into sleep and the vulgarity of Ubu's feast (munching, supping, slurping, chugging) comes as much from the sounds of the words as the scene they describe. The experience of reading the poem is determined in part by the materials (letters) available and what these letters sound like when pronounced.

I found myself reaching for *Eunoia* halfway through my class "The Poetics and Politics of Biology" in response to a teaching problem that was vexing me. My seven MFA and MA students understood the critiques of dominant biological narratives we read (such as Emily Martin's "The Eggs and the Sperm"), but they were having difficulty imagining what other stories might be possible. The previous week I had screened a clip from BBC *Life* about the mating habits of the

giant Australian cuttlefish (*Sepia apama*). In this clip we see a large male mate with a female. After they mate he begins "guarding his female" and warding off "rivals" for her affections. We are then introduced to a smaller male; "mimicking a female who wants to mate" he approaches and then "surreptitiously" mates with the female "right under the larger male's tentacles." The narrator, David Attenborough, describes this smaller male as "the sneak," "the sly cross-dressing male," and a "master of deception."

After we watched the clip I introduced Joan Roughgarden's critique of the gendered tropes commonly used in this kind of sexual selection narrative. She writes:

> In the primary peer-reviewed literature, males are described as being 'cuckolded,' females as 'faithful' or 'promiscuous,' offspring as 'legitimate' or 'illegitimate,' males who do not hold territory as 'floaters' or 'sneakers' (code for 'sneaky fuckers') all of whom are 'sexual parasites,' small males as 'gigolos,' feminine males as female mimics, or even as 'transvestite serpents' or 'she males' (a pornographic reference), and so forth. (2009, 30)

Roughgarden argues that these adjectives not only comprise a moral discourse that figures the territory-holding male as the "reference male" (2007, 31) and assumes proprietary sexual monogamy as an ideal, these stories are not strongly supported by empirical evidence. Germane to the case of the cuttlefish, she argues that it is unlikely that "sexual deception" is the order of the day in species with multiple genders of males: "The territory-holding male is often a visual predator with well-honed skills at sizing up and identifying prey from a distance; he is not likely to be fooled by a feminine male who only imperfectly resembles a female." (2007, 32). If the larger male is not fooled by the smaller male, the

question becomes, how else could we narrate the events we saw in the BBC documentary?

When I first posed the question to my students, they found it too general and our discussion consisted mostly of me proposing alternatives to a silent room. My assumption was that if I took away the dominant story, a multitude of stories would rise to take their place. But what I found was that taking away the dominant story resulted in a frictionless narrative space where everything was possible and therefore, it seemed, nothing was possible. So remembering the generative resistance of *Eunoia*'s constraints, I challenged the students to re-tell the story *using only two vowels*. As opposed to the silence that met my first question, this exercise generated frantic discussion, laughter, awkwardness, frustration, silliness, and most importantly *different stories.* Here are some excerpts from the students' poems and from my own experimentation[15]:

Martha working with A and I, with the smaller male as protagonist:

> Radiant fish, with his skin alight, all arms and charisma. Swimming in amid this captivating pair, his arms in tight, shifting his skin, flashing dark and bright. His timing is right. This striking fish with rippling fins, inviting his mating arm in, is brilliant and satisfying against his skin. As is this vigilant watchman draping his arms, incasing this activity with his vast calm. It is as if it was always like this. *S. apama* bliss.

Students working with O and E, with all three cuttlefish speaking together:

> THE RESPLENDENT WE:
> Only one?

[15] I tested this exercise first myself to make sure it was possible to do in ½ hour. I originally tried with one vowel like *Eunoia*, but it was too difficult. Three vowels, on the other hand, felt more like an annoying inconvenience than an enabling constraint.

To be or not to be two?
Together we three
Sleep sweetly
Between the sheets
The converse of the words spoken by
The sotto voce on the BBC

One of the students (Carlos) writing his own poem with O and E, the speaking subject is ambiguous:

He took me between
Between the rocks
To meet her

As you can see this exercise engendered surprising, often beautiful and sometimes delightfully queer descriptions of cuttlefish mating. I found that it resolved two separate problems: the anxiety of creative storytelling and the recourse to clichéd narratives when describing animal behavior.[16] Doing the exercise as a group and only having limited materials to work with, the students didn't feel the same personal pressure to tell the right story or a virtuoso story; the goal became simply to create *any* story together within the constraints. It was closer to problem-solving that poetry writing. I was most struck by how the frustration of not being allowed to have a desired word quickly gave way to new opportunities, how unanticipated possibilities emerged when you find your narrative pathway blocked. Occasionally an appropriate synonym was available—but even then, your intended meaning is already shifting leading in

[16] However, it also caused some of its own problems. We found that working in a group, under constraints, writing poetry about a potentially embarrassing topic (cuttlefish sex), it was easy to resort to humor, which most often drew on gender stereotypes. The students themselves noted this phenomenon in our discussion.

different directions than you had initially planned; you find "many subtle channels" (Becker 2012) opening up before you.

The constraints not only steered us away from the awful vocabulary Roughgarden catalogued, but also from our own habits of storytelling. You find that the words that you feel you need most are off limits. For example, you cannot even use the word "mating," unless you had taken the vow of A and I.[17] Most strikingly, no poets had at their disposal the full complement of English pronouns.[18] How then does one refer to individual animals of different genders? Without all the pronouns it can be difficult to track the cuttlefish, like in my poem when I used demonstrative adjectives instead of personal pronouns or names—the female is referred to as "this striking fish." Or in Carlos' poem where the speaking subject seems to shift from the male to the female in the space of one sentence. Individuals in this poetic realm are more fluidly defined; bodies are ambiguously delimited. Or they take on an sf atmosphere. The collective student poem was written as a script with speaking parts for HE ONE, HE TWO, SHE, and THE RESPLENDENT WE. "The resplendent we," in particular, has the feel of a social category from an alien culture—three individuals speaking as one from the shallow water of their mating grounds. In all three poems unusual ways of naming, gendering, and individualizing the cuttlefish trio pushed us away from David Attenborough's story of jealousy, possessiveness, rivalry, and trickery.

[17] Thanks to RML for this wording. I'm thinking vows of silence (an enabling constraint) rather than wedding vows (a social contract).

[18] In my own composition I had no "e" so I had to use "his," "him," and "this" to indicate specific individuals.

The strict formalism of *Eunoia* and Oulipo writing in general are often described as virtuoso language exercises, whose pleasures can be located in their joyful detachment from the practices and politics of the everyday. However, my classroom exercise casts these playful experiments with form not as avant-garde, but as a way of activating different bio-poetic and therefore bio-political possibilities. Through the process of collaborative poetry writing we were reintroduced to the cuttlefish. While at first they seemed selfish and tactical, through these feats of constrained language we came to know them as poly-amorous and serene.[19] While I doubt any of my students will continue writing constraint-based poems about amorous cephalopods, I imagine this exercise as akin to the problem-based learning that T. Hugh Crawford designed for his Thoreau class. Instead of learning to work with wood and tools in the process of building a Thoreauvian cabin, "the Oulipo cuttlefish" gave us a feeling for the resistances and potentials of language in the collaborative process of writing a poem. These projects teach us what we are capable of when we work and play with familiar and unfamiliar materials and how these materials shape the possibilities for what we can build together. Not because the skills we learn are practical or necessary or transferable or because the results will endure, but "to see where it takes us." To see what it's like to feel the adze in our hands or the u in our throats. To participate in a collective adventure. In the classroom, protected for the time being from the obligations of seriousness or utility, we find ourselves able to experience the strange richness of missing the letters we need, of being all out of sorts.

[19] It's perhaps no surprise that polyamorous cuttlefish emerged from this "polydisciplinamorous" (Loveless 2010) exercise that combined evolutionary biology and poetry.

Childish Wonder, Naïve Wonder

The things that I find myself drawn to at the end of this dissertation—language games, classrooms, secret codes, precious decoration, adventures—these, I realize, all have a strong affective connection to childhood. Bantjes' work especially evokes not just the childish but the especially *girlish* love of the precious, the personal, and the decorative from sticker books to polished semi-precious stones to quinceanera dresses.[20] These themes are emerging at the end, I think, because of the unavoidable childishness of wonder and of fables. Daston and Park remark in the introduction to *Wonders and the Order of Nature* that wonder is now "redolent of the popular, the amateurish, and the childish" (15). They mirror this judgment in the emplotment (White 1986) of their historical narrative—wonder is banished to the childhood of Western science, to the time before the Enlightenment. For Daston and Park, becoming adult scientists required us to learn to mistrust the powers of wonder and the lure of the marvelous (see Chapter 9, "The Enlightenment and the Anti-Marvelous").[21]

Even those who are working with wonder in their own writing and teaching practices sometimes wish to sever its associations with childhood. Hugh Crawford, for example, wrote that he was looking for a "non-naïve" wonder as he

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[20] In her TED talk, Bantjes shows an image of her chapter on astronomy, noting the association between decoration and childhood: "When we look at works like this we tend to associate them with children's literature. There's an implication that ornamental graphics detract from the seriousness of the content." (http://www.ted.com/talks/marian_bantjes_intricate_beauty_by_design.html)

[21] Daston and Park are critical of what they call "the wistful counter-Enlightenment," writers who want to return wonder(s) to a disenchanted world. They argue that it is a mistake to see "the Enlightenment as the cultural and intellectual analogue of the transition from childhood until adulthood" (361). However, they seem more frustrated with the thinkers like Weber and Dickens who wish to return to a fantasy world of ignorance and innocence than with the problems of plotting the history of science.

found himself slipping into a child-like wonder. But, given the persistence of these associations, I wonder: Does wonder need to grow up? Should it be protected against naiveté? Luce Irigaray may be an important guide here. Irigaray's wonder is a wonder of passionate and potentially dangerous naiveté that draws us towards the unknown: "Before knowing whether the object corresponds or not to my body's good—which would be a matter for the heart and the blood—wonder is the appetite for knowledge of who or what awakens our appetite" (78). There is a risk that that which awakens our epistemological appetite will ultimately be unfriendly, unseemly, unsophisticated, unsuitable. "Wonder," Irigaray insists, "goes beyond that which is or is not suitable for us" (74). Perhaps this is why we have banished wonder to childhood, a time when it's *oka*y not to know (better). The challenge of daring to believe that there is wonder in our knowledge-making practices is learning to think with Irigaray's passionate, exotropic epistemology even when it threatens our status as "serious, adult thinkers" (Stengers 2008, 50).

To my mind the worst consequence of the Sokal Hoax,[22] as with any mean-spirited hoax, is that it punishes this hungry naiveté.[23] The thrust of Sokal's

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[22] In 1996 physicist Alan Sokal published a "nonsense" article about postmodern theory and quantum gravity in the journal *Social Text* in order to demonstrate that "some fashionable sectors of the American academic Left have been getting intellectually lazy" (64). Although the journal at the time was not peer reviewed, Sokal argued that successful publication of the article showed that when it comes to science studies and critical theory that "the emperor has no clothes" (64). This was the opening salvo in the "The Science Wars," a conflict that captured all of the anger but none of the complexity about the epistemological differences between scientists and STS scholars.

[23] In Book I of *Cosmopolitics* Stengers offers her own fable of the Science Wars as a way to frame her project. She argues that STS scholars made the mistake of denying science its singular power. Our explanations "explained away" the practices and passions of scientists. I think Stengers' Science Wars story offers important insight for STS and its possibilities of communicating better with scientists and other knowledge practitioners. However, I don't think all of the blame is ours. Plus I have little patience for hoaxes that are intended as instruments of public shaming.

message was that if we (STS scholars) were going to play like *that* with science, we did not deserve to be trusted with it. Not until we grew up and learned to treat it with due reverence. The Sokal Hoax relied on shaming as a means of policing who gets to say what about science. Its implicit reprimand: *how dare you*. This kind of reprimand, whether accurate or not, tends to engender a particular reaction: It compels us to prove that we are not childish by doing work that is respectable, sober, bound closer to reality. One of the lasting effects of The Hoax, I feel, is a tendency towards self-censorship that arises from the fear of being thought foolish. The temptation is to plug the holes in the wall that let in these charges of naiveté, to build a stronger citadel against professional derision.

But what would happen if we, feminist science studies scholars and our allies, refused this kind of self-censorship and risked the naiveté of wonder? This is not to promote childishness as such nor to embrace naiveté for its own sake. It is not to advocate for a Peter Pan epistemology that refuses to grow up and take responsibility for its participation in a shared world (see Haraway 1997, 111). However, serious, adult thinking cannot be the only path to responsibility, and may actually shut down our ability to relate to others. Rather than enabling responsiveness, growing up requires becoming inured to the pull of agencies and affects that do not fall in line with adult life. [24] Response-ability, on the other hand, might involve becoming sensitized again to the pull of these forces. Neither innocent nor cynical, this kind of wonder requires openness to the unfamiliar and new approaches to the familiar, together with an accountability

[24] Many of our interspecies encounters (romantic and sinister) are as children: love for a pet hamster or burning ants with a magnifying glass.

for our practices of relating and the arts of self-protection, which must be learned through attentiveness and experiences, through good and bad encounters. Like many of Modernity's Great Divides (Latour 1993), the bifurcation of childhood and adulthood gets in the way of thinking and doing otherwise.[25] Serious adult thinking gives us de-mystification, but it is only when can also re-connect with the naïve and childish that we can also participate in the arts of *re-enchantment* (Suchman 2007).

Re-enchanting the World

To think and write and breathe and thrive with a trickster nature, to tell enchanted stories, we must struggle against the fear of being tricked. For it was this aversion to trickery that motivated one of the greatest intellectual crimes against non-human agency: Descartes' beast-machine hypothesis. His theory that animals are automata was not formed ex nihilo but in his encounters with technology designed to trick the eye: "The 'diverse automatons and moving machines that human industry can make out of a few simple pieces,' mentioned in the Discourse, were the work of the French engineer Salomon de Caus, who built animated grottoes and fountains for rich estates in France and Germany" (Senior 62).[26] The clockwork animals and gods that populated these grottoes

[25] Like all of the other Great Divides, the child/adult divide is an achievement. For an excellent discussion of the material culture that provided the infrastructure for the invention of childhood in the Victorian Era see Adrian Forty's *Objects of Desire: Design and Society Since 1750*. Incidentally, this is also a nicely designed book.

[26] Descartes wrote extensively about a fountain he had visited where a "robotic Diana" (Senior 64) retreated behind a rock when the viewer trigged a hidden lever.

provided Descartes a site where animality and technicity were collapsed and both were rendered as deceptive.[27]

In my classrooms and our culture,[28] there remains an abiding skepticism about non-human agency and a charge of anthropocentric naiveté at the suggestion that animals and machines (still often collapsed) are anything but inanimate.[29] As feminist science studies scholars, caretakers of non-human agencies, we are practitioners to the arts of enchantment, as both delight and beguilement. Not pulling back the veil of Isis to reveal the truth, but *colluding* with Isis, a formidable and beautiful alien goddess, whose "body bristles with a multitude of breasts" (Macrobius quoted in Hardot 236). And also with her sister, "robotic Diana" (Senior 64), the clockwork goddess who troubled Descartes' dreams. But to do so requires that we continue to risk child-like naiveté and to dare to be taken in, to be *influenced*, by the forces of enchantment. To refuse the reproach of the hoaxer and to dare to be at risk with our craft. The fear of being tricked is lethal to the project of cultivating wild facts, the enemy of a material-ism without elimativism.

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[27] The inspiration thinking about non-human agencies and gullibility came from a panel I attended at the "Apparatus; Matter; Materialities" conference at York University in the Spring of 2011. The papers were on spirit writing, primate language, and crittercams. I notice that a common thread in all of these papers (especially the one on spirit writing) was this fear of being tricked. Animals, spirits, and technologies have dubious agencies. See also Suchman 2007, 228.

[28] The trickster agencies of animal-like automata are at the center of Sherry Turkle's *Alone Together: Why We Expect More from Technology and Less from Each Other.* Turkle begins her book with the story of Miriam, an elderly woman living in a nursing home, who had bonded with Paro, a robotic seal. Miriam would tell stories to Paro and seek comfort from him. Turkle, in no uncertain terms, believes that Miriam was duped: "Miriam experienced intimacy with another but she was in fact alone" (9). Descartes beast-machine anxieties are still with us.

[29] See Latour 2010. He explores the unseemliness of suggesting that nature is agential: "It immediately gives a sort of New Age flavor to any such efforts, as if the default position were the idea of the inanimate and the bizarre innovation were the animate. Add agency? You must be either mad or definitely marginal." (481)

Feminist science studies is, in many ways, an occult knowledge, passing sacred questions down from generation to generation. We learn to ask "whose science? whose knowledge" (Harding), "what counts as nature, for whom, and at what cost" (Haraway) and "cui bono?" (Star).[30] We teach these powerful refrains again and again in our classrooms. We are thinkers who mingle with activists and witches[31]; we have animal familiars, fungal loves, and bacterial consorts. We narrate strange agencies and recite magic words. We are enchantresses who have (often) been trained in the arts of science, but our allegiances lie *elsewhere*. Our cry: "Another science is possible!" (Stengers 2011) is a cry that may also resonate with scientists, who are yearning toward and lured by something we may as well call passion and wonder.[32]

Wonder might be one word that can put us in touch with the magic of what we are doing, to connect us with our influence. It gives us permission to think and write with the aesthetic as a practice of living well and crafting efficacious forms. We can illuminate our manuscripts. We can write lullabies, fables, and spell-books. We can decorate the things that we find to be precious. Maybe not in the world-destroying materials of ebony and ivory, like the frame of Galileo's objective lens, but like the Wertheim twins and their worldwide kin crocheting

[30] At "The State of Science and Justice: Conversations in Honor of S. Leigh Star" (June 2–3 2011) Donna Haraway pointed out that "cui bono" derives some of its force from the occult power of being written in Latin.

[31] E.g. Maria Puig de la Bellacasa, Isabelle Stengers, and Susan Leigh Star.

[32] See the conclusion to Ruth Müller's dissertation "On Becoming a Distinguished Scientist. Individuality and Collectivity in Postdoctoral Life Scientists´ Narratives about Living and Working in the Academic Sciences."

bleached coral reefs from plastic bags,[33] creating beautiful objects that give charismatic form to their matters of care. This to me is the power of an illuminated wonder, to ask after what kinds of honour, what kinds of enchantment we are capable of when we give to this more-than-human world our time, our care, and our attention. I wonder. I wonder if...

[33] http://crochetcoralreef.org/about/toxic_reef.php See Eva Hayward's wonderful article on the project: http://www.indyweek.com/indyweek/the-crochet-coral-reef-project-heightens-our-sense-of-responsibility-to-the-oceans/Content?oid=3115925

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