Ecocentric Science Education: More-than-human Ethics, Goethean Science, and Poetic Pedagogy

by

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Abstract

This thesis includes an introduction, an extended narrative, and eight essays integrating philosophies on science education, poetic inquiry, and place-based learning. This collection explores a range of questions and philosophical concepts, including environmental ethics, contemplative practice, Goethean science, arts-based learning, and reflective pedagogy. The introduction first reveals my personal motivation and contextual milieu, and then identifies the thematic relationship—ecological literacy for undergraduate students fostered through ecocentric theory and practice—across the essays. My research is positioned within the germane literature, and I clarify the relational provocation that poetry and other arts-based scholarship afford. Part I (Ground) includes an extended narrative that serves to situate my lived experience and place-based connection, a personal journey in the North Cascades that led me to question anthropocentric science education. Carl Leggo's "Living poetically" is discussed as a methodology that cultivates more-than-human connection that promotes contemplative practice and a reciprocal relationship with life phenomena. Part II (Roots) explores human exceptionalism and self-interest towards other-than-humans. The aesthetic, holistic and moral qualities of Romanticism are considered in regards to science education. Goethean science, where students understand nature inwardly, offers an alternative to Newtonian science by incorporating the intentionality of phenomenological learning. Part III (Trunk) examines what we mean by "science education" and the reduction of nature to the order of the inanimate. Incorporating Goethean science in today's natural sciences classrooms steps us away from conventional reductionist science methodology and moves us toward a conscious-process-participation epistemology. Part IV (Branches and Leaves) uses Leopold's land ethic as a philosophical framework for relational education, and outlines the practical application of the GPS ecocache, and its integration with Kolb's model of experiential education. Reflections on KPU's Amazon Interdisciplinary Field School through narrative, journal entries, and photography elucidate the importance of teacher adaptability, confident mentorship, contemplative education, and nature as teacher. Part V (Fruit and Seeds) considers being a wild researcher, positionality of the natural world, embedded anthropocentrism in animal experimentation, and provides examples for ecocentric teaching and research in science.

Keywords: environmental ethics; science education; holistic pedagogy; place-based education; Goethean science; poetic inquiry

Sola, Felix & Samara
for why I walk this Earth

and

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for your gentle strength

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PART I – GROUND

Journey to the Sacred Mountain

And so the choir hints a secret law,
A sacred mystery.

Flinging the chain unto the end of time—
The whole reflected in each separate part.

~Goethe

Introduction: The Whole Reflected

The Call

When I was two my family moved out west for the ocean. My birth raised the population of Arkell, Ontario to one hundred. Only a single memory of that time remains, a vivid image of a weeping willow.

Eighteen years later, a family road trip across Canada was my first return to Stonehaven, the old family home. Built in 1852 by Scottish stonemasons for the teacherage—as the local school at the time was right next door—Stonehaven's walls were eighteen inches thick with beautiful gothic windows. It was the day of my parents' 20th wedding anniversary. When we reached the backyard, my older brother asked "Wasn't there a big tree here with flowing leaves?" It was gone now, but his question answered why I had always considered *Salix babylonica* my favourite tree: a magnificent weeping willow, overflowing with a fountain of lanceolate leaves once stood here. My oldest imprinted memory.

When we moved to the west coast, my parents bought a house on Zero Avenue. Just down the road towered the Peace Arch, built in 1921 to mark the friendship between Canada and the United States. I spent much of my childhood outside, digging up centipedes, concocting imaginary adventures, and building forts. This happened in the tiny patch of trees—a vast forest to my young eyes—behind the garage. For my third fort, a slender red alder grew where I wanted to build. I found my Dad's hatchet and started to chip away. I cut a quarter of the way through, less than an inch, when I stopped to consider my actions. Driven to construct my fort, my single-mindedness demanded this obstacle be removed. Only when I stopped to take a breath did I recognize this other to be alive. My actions were doing harm. I didn't need this tree—about the same age as I—for shelter, or warmth, or essential tools. My human entitlement wanted it gone.

At thirteen, I did not ponder the ethics or dwell on the moral rights of trees. My heart made it clear that chopping down this alder was wrong, so I stopped. I put my hand over the shredded bark and inner flesh, which almost felt like my own, and

offered...something. An apology? A healing? Or perhaps, with this touch, I asked for forgiveness. Each day I returned, I stood next to this tree, palm against the wound, feeling for what I could learn.

Trees were not my only teachers. One summer afternoon, I flipped my bicycle upside down to reaffix the chain. From beside the garage emerged a golden apparition. A doe. We both froze, each taking in the other. Her sleek fur twitched, and her alert ears swivelled to take in my bated breathing. Something gleamed in the deer's voluminous eyes that I could not fathom. How did I appear to her? A two-legged, greasy-scented mammal with alien-coloured fur.

In our locked gaze, time stood still, my body rooted by wonder. Where had she come from? And how did she experience the world? I blinked, and she leapt forward. Her hooves clattered on the asphalt, bouncing like rubber under her legs. Within seconds she reached the end of the long driveway, bounded across Zero Avenue, and vanished into another country.

Westwood, our family home in British Columbia, hugs the 49th parallel. Bordered by both Blaine, Washington and the Pacific Ocean, our rural suburb possessed many pockets of wonder. I made regular pilgrimages to the sea, down Zero Avenue and past the Peace Arch. Perched on driftwood, alone with the waves, I gazed out into the perennial Salish Sea. The gentle surf breaking over and over again on the pebbled shore, a constant rhythm of water and moon, settled my spirit.

This land is the traditional, unceded territory of the Semiahmoo First Nation. Under the terms of the 1846 Oregon Treaty, their homeland was sliced in two by an invisible border, one further step of genocidal colonialism. I, like most, was ignorant of this history. Not until I was an adult, when the lands around Westwood fell to rampant development, did this settler scholar start to understand the soul-ache of having the area around the place you call home plundered by the industrial-exploitative machine. Although Westwood still stands, many others, along with the trees and countless other beings, have fallen.

Leafless

I drive home to Westwood
the horizon
is wrong

too bright too wide too blue

leafless clouds I should not see

The Trees

have been taken

forty years we grew together
green seedling to longhair

now sidewalked subdivided

another neighbour has developed
a taste for progress

my steady-state universe
tilted perpendicular

the horizon
is wrong

fir
pine
alder
cedar
stacked
delimbed

maple corpses now cast no shade
their last shadows gifted
to those who cut them down

my neighbour has houses to build
yet each tree is home
to one thousand species
now levelled into sawdust
human need
is clear cut

too bright too wide too blue

the horizon
is wrong

to cut an old tree
is to cut a bridge to heaven
the ancients remind me
I too am rooted
in fertile darkness

I stretch my human fingers
not far enough
only leaf veins
touch the blood of the sun

I pull into the driveway
the sky
stares
me
down

these trees cannot be fixed
with a price
leaf's currency is measured
one breath at a time

Let us return to the Salish Sea. To this day, I commune with the ocean for clarity, nostalgia, and spiritual connection. During one of these contemplative journeys I decided to become vegetarian.

My Mom modelled being a voracious reader. I spent Kindergarten in the book nook. My steady appetite for reading—nary a night passed without a paperback in my hands as I fell asleep—led me to read about animals, especially cheetahs. Somewhere along the way, I found an article that spoke to the origins of meat. I loved burgers, pepperoni pizza, and turkey sandwiches. But when I learned of the atrocities and moral outrage of factory farms, I changed my diet to detach myself from this cruelty. I was fourteen. Peers rarely had an influence on this shy introvert, while my family culture encouraged independent thought.

Like the red alder tree I had put to the axe, my heart knew factory farms were indefensible. This time, my mind followed, and I discovered the words of Peter Singer and other philosophers who peered beyond humankind's moral umbrella. I gained a firm understanding that our society was embedded with unfairness and injustice. The deep thinkers I read gave me an invitation to swim against the status quo, which my heart follows to this day.

In high school, I cannot recall a single episode of learning outdoors. Physical education is the notable exception, and my extracurricular cross country running. My enchantment with the natural world, fostered nearly exclusively outside of school, culminated in an obsession with cheetahs. As a cat lover and sprinter fascinated by animal behaviour, this spotted feline became the obvious choice for my insatiable curiosity. I adapted school assignments to do projects on cheetah ecology, genetics, and conservation.

Grade 12 demanded a choice: arts or sciences? Up to this point, I had taken the few options for electives related to creative writing. I combined my passion for cheetahs with prose by penning stories from this great cat's point of view. To accurately portray a cheetah hunt, I needed to know the geography of the land, the lithe cat's anatomy and sensory experience, and the prey's behaviour. This research occurred outside of school (indeed, most of my personal scholarship was clearly outside the purview of the K-12 British Columbia curriculum.) In particular, I was enthralled by what other animal species felt, thought, and experienced. But now, at the crossroads of fine arts and the natural sciences, I had to decide. To study biology, I needed chemistry and physics. I didn't know it at the time, but I was choosing between two disciplines that academia has segregated for centuries.

So I became a grade 12 science student. Not once did we observe natural phenomena in its native habitat, though there were experiments, dissections, and plenty of note-taking, tests, and rote learning.

Science labs engulfed my first-year of university, though I did squeeze in a creative writing elective. I wrote a story that jumped between a leopard and a human's

point of view. My instructor told me that literature centered on the human condition, and commanded that I write from the sole perspective of *Homo sapiens*.

I resented this restriction. I had written from another gender, another age, another country. Why this boundary between the species? Why was it needed? Or was it arbitrary, even an example of speciesism?

Beloved classics such as *The Call of the Wild*, *Charlotte's Web*, *The Jungle Book*, and *Watership Down* broke this rule. The lattermost was read to me by my father while I was in the womb, which I also read to my son. Were these not 'literary'? Or was my instructor bound by an anthropocentric academic system that pursued knowledge by and for humans, regardless of the cost to the trillion other species (Locey & Lennon, 2016) with which we share our planet? I knew the biological sciences often relegated other-than-humans to a strictly utilitarian status. This was my first experience of the arts demanding that I not think from, or consider, an animal's point of view, unless it be human.

Third-year biology presented a more pressing concern. Dissections and other experiments that brought undeniable harm and death to animals, bred for the sole purpose of being taken apart by biology students, were required. Is this what the 'study of life' entailed? The concurrent environmental ethics course I took further cemented my beliefs that harming animals to learn about them was both counterintuitive and unethical.

A lifelong fascination of the living world ignited my passion for the study of biology. Although many of my professors shared this sense of wonder, nearly every instance of experiential learning occurred in laboratories (Dr. Wayne Goodey's courses being a noteworthy exception, where he encouraged discussion, outdoor exploration, and student-led projects). As Aldo Leopold (2013) remarked, "Instead of being taught to see his native countryside with appreciation and intelligence, he is taught to carve cats" (p. 414). Dissections were mandatory. I met with a lab instructor, explaining my worldview and not wanting to harm animals, and I was told to consider another career. For me, this response was devastating and (to my shy and introverted self) felt unequivocal.

So I continued my studies. My labs included dissecting a pregnant cat (my own cat, Kasha, was born on our front porch, where my Mom and I served as midwives), recording a pithed turtle's final heartbeats (pithed is a euphemism for killed; I simultaneously volunteered at an animal shelter with over 100 abandoned turtles), and then there was the mouse. In fact, until writing these words, I have never told a living soul about this experience.

For an animal physiology lab, each set of lab partners was given an Erlenmeyer flask with a single mouse. You could control the airflow via a rubber stopper fitted with adjustable tubing.

Thinking back, I can't remember this lab's objectives. I can't remember the learning outcomes. In fact, I can't remember anything except the mouse herself. Whenever my lab partner adjusted the top tubing, she kept going to sleep. At some point I realized, to my horror, that my lab partner's accidental adjustment of the tubing was cutting off the airflow to the mouse. She stopped moving because she couldn't breathe. When the tubing apparatus was returned to its original position, the mouse recovered.

All these years later, that memory of almost fatal ineptitude horrifies me. The fact that, at first, *I did nothing*, horrifies me even more. I felt like I was in a surreal nightmare where I couldn't control the outcome. Yet I was an active player. Although I had refused to partake in any labs with animal cruelty (a request I was denied), and the lab instructor even offered for me to step outside during these times, this felt like an even greater betrayal. I had an ethical obligation to these laboratory animals whose wild cousins had inspired me to be here in the first place. I observed, while my lab partner kept adjusting the tubing, and the mouse kept becoming listless. I did try to help at one point, with the same result. I should have recognized what was happening sooner and torn off the rubber stopper.

As a child, I had two pet rats, Emily and Charlotte. Devastated when these sweet Brontë sisters died, I still recall the feeling of their lifeless bodies in my hands. I was eleven. As a UBC student at twenty-two, the mouse in the Erlenmeyer flask felt utterly discordant with my previous experience. Further to this, this mouse physiology lab

seemed all too easy to replace with humans. After all, over 95% of animal drug trials fail in humans (Akhtar, 2015) so using ourselves as models not only improves outcomes, but makes ethical treatment unequivocal.

The only bits of undergrad biology at UBC that I clearly remember are going outside with Dr. Goodey's class, the topics I was given the freedom to choose to study (e.g., cheetahs, iguana headbobbing, and algal blooms), and the aforementioned harm done to animals. Despite my resistance, the biology lab instructors I spoke to either outright refused my requests, or questioned my career choice. Fast-forward four years, and I found myself working the very same position, a lab instructor that orchestrates hands-on experiential learning for students. In preparation, I had to re-teach myself nearly everything that lecture and mechanistic-based labs had failed to teach me.

Although the subjects I taught at Kwantlen Polytechnic University (KPU) did not, at that time, include dissections, I eventually found myself facing similar ethical dilemmas. My job required me to rip the heads off *Drosophila* larvae to extract salivary glands, inject sea urchins with (often fatal) potassium chloride to stimulate the release of eggs and sperm, and dole out vials of fetal bovine serum, cruelly harvested from the hearts of pre-natal calves.

I loved (and still love) my job for the wonder-filled experiences I am privileged to facilitate for my students, yet I felt obligated to perform these duties. A familiar and uneasy feeling tugged at my heart. I made a decision. At the next biology meeting I stated that I would not be involved with any activity that caused harm to animals. This experience, specifically in relation to the sea urchins, is described in Chapter 6 of this thesis. Similarly, my experiences with fetal bovine serum is documented in my published essay, "Kidnapping children and calves (of a tender age)," (Beavington, 2020) in the anthology *Scientists and Poets #RESIST*.

Important to note is that both of these essays include poetry to portray the felt relationality of these experiences, and help expose the limitations of biology as molecular matter. The poems also include elements and philosophies spurned by modern scientific practice: emotion, reciprocal relationship between observer and observed, and the

perception and inherent worth of other-than-humans. Many science educators challenge the paradigm of modern science, and point to the importance of art, aesthetics, and embodiment (Sengupta et al., 2019). Poetry can allow for an incubation period where ideas can further unify, relate difficult scientific jargon to everyday relevant experiences, and enhance both understanding of complex concepts and their sound communication (Januchowski-Hartley, et al., 2018). It is my belief that, in a world of environmental and social injustice, all of these are necessary. Poetic inquiry as a methodology and life practice is explained further in Chapter 2.

While books fed my mind, nature fed my body, heart, and soul. A lifelong connection to nature, avid love of words, and a fierce sense of wonder and personal integrity seeded this thesis. As a result of these collective experiences, I began to reflect on alternative ways to teach university science, as described later in this introduction and throughout this thesis. We have to speak out, loud and clear, especially for those who have no voice. Or rather, whose voices we often ignore, or pretend don't matter. Like the animals in a science lab. For dissections, humans used to cut the vocal cords of living animals so they couldn't scream. But to understand and care for the other-than-human members of our community—we need to hear their voices.

Article Thesis

This is an "article thesis" or "thesis by publication," a collection of published (or, in one case, accepted for publication) research papers and book chapters. This current section serves as the introductory essay, or 'kappa', providing context and background information on my thesis. More specifically, the kappa identifies the thematic relationship across the essays, positions my research within the germane literature, clarifies the relational provocation that poetry and other arts-based scholarship afford, and summarizes each essay. In addition to crystallizing the core concepts that underlie my essays, this section also offers an overview of current science education, a love letter to science as a counterpoint to my critical evaluation of Western science, explores the historical context of Romanticism and Goethe, and describes the trajectory of my thesis.

The thematically-related works found herein focus on the philosophy of science education through holistic, relational, and ethical-ecological considerations. The key elements are this introduction, an extended narrative, and eight essays integrating philosophies on science education, poetic inquiry, and place-based learning. These essays explore a range of questions and philosophical concepts, including environmental ethics, contemplative practice, Goethean science, arts-based learning, and reflective pedagogy. Each essay offers part of an interdisciplinary pedagogical puzzle whose pieces have traditionally been siloed into the sciences, expressive arts, and philosophy. What emerges is an ecocentric framework, with both theoretical and practical applications, of how education in the natural sciences can be conceptualized and implemented specifically in tertiary education (but with applications to primary and secondary schooling). Given that tertiary, or post-secondary, instructors receive less pedagogical training than high school teachers, and that pedagogical training improves student outcomes (Jensen, 2011), this necessitates research more specifically aimed at higher education.

Inspired by Robin Wall Kimmerer's (2013b) introductory remarks for her paper on traditional ecological knowledge, I respectfully state the following: this work draws upon nearly two decades of experience as an interdisciplinary instructor and scientist, lived experience within the boundary layers of ecological science, arts-based instruction, holistic education, and poetic pedagogy, the lessons learned from my students, hundreds of peer-reviewed articles and books, and the songs of the river and the tree. Further, this thesis aims to integrate divergent fields of thought to inform science pedagogy that acknowledges the land, creativity, and reciprocity as cornerstones of relational scientific learning and research. Aesthetic learning that occurs in place, underpinned with moral consideration for all subjects, is emphasized.

The five sections of this thesis are introduced by title pages composed of a heading and subheading, a photograph taken by the author, and an excerpt from Goethe's poem, "The Metamorphosis of Plants." Given the centrality of Goethean science to this thesis, as well as Goethe's (and my own) integration of poetry and science and advocacy of holistic methodologies, the inclusion of these poetic pearls of wonder feels pertinent. Further, they underscore Goethe's unified knowledge of nature and early ecological

sense; the word and scientific discipline “oekologie” would not be coined by German zoologist Ernst Haekel until 1866, more than 70 years after Goethe wrote the following:

> …and now we will raise our observation to a higher level to consider the structured world itself as an interrelationship of many elements. We will see the entire plant world, for example, as the oceans and rivers are to the existence of individual fish, and we will observe that an enormous number of living creatures are born and nourished in this ocean of plants. Ultimately we will see the whole world of animals as a great element in which one species is created, or at least sustained, by and through another. (Goethe, 1988c, pp. 55–56)

Objectives and Research Questions

My doctoral work conceptualizes the potential shifts in worldviews of undergraduate students engaged in immersive, arts-based outdoor education that fosters in students a vital environmental ethic. During my 19 years of university science instruction at KPU, I have come to realize that the positivist paradigm of scientific hegemony still prevails in science teaching. In carefully considering the disparity between ecological thinking and science pedagogy (Evernden, 1993; Luoma, 1999; Mathews, 2008; Panikkar, 1995), I began to incorporate arts-based and contemplative approaches (Bai, 2015; Walsh et al., 2015) into the way I teach science.

This research relies both on the natural world, and on key scholars and scientists. My discourse emphasizes the wonder of nature, the multi-species benefit of time spent outdoors, the importance of healthy ecosystems, yet also the intrinsic value and worth of my other-than human co-researchers. I have attempted to acknowledge the natural world as a source of personal, academic and poetic inspiration.

My work is interdisciplinary and draws upon a range of scholarships: philosophy, ecology, poetic inquiry and contemplative sciences. The following questions support and inform this research:

1. How can positivistic science education, specifically biology, move away from a dominant lab-based model with dissections and animal cruelty toward an interdisciplinary, field-based focus where land is pedagogy? (Simpson, 2017).

2. How does contemporary science sanction a mechanistic and atomistic worldview, and what ontological innovations occur when a primary sense of mutuality and interdependence (ecocentrism), such as Aldo Leopold's (1949) land ethic, is offered as an alternative to an anthropocentric perspective?
3. What epistemological ideas emerge when poetic inquiry, métissage (Hasebe-Ludt et al., 2009; Hasebe-Ludt & Leggo, 2018), and other imaginative approaches to education, where students utilize storytelling, embodiment and emotion to connect with the world around them, are applied to undergraduate students' learning in place-based environments?
4. How can the aesthetic and moral qualities of Romanticism, and the "zarte Empirie*"* (delicate empiricism) of Goethean science that promotes empathy and prolonged looking towards a non-dualistic unity (Holdrege & Talbott, 2010; Reynolds, 2007; Robbins, 2005; Wahl, 2005), help guide science education toward a more ecologically literate curriculum?
5. How can the scientific method be approached with wonder and ethical-ecological holism, which offers an alternative paradigm of, and methodology for, science that fully acknowledges and requires humans' moral responsibility toward all earthly beings and our mutual flourishing?

Position and Significance

My unique position as a university instructor and learning strategist, published author and photographer, interdisciplinary scholar, and outdoor educator has readied me to answer the urgent call of my supervisor Heesoon Bai (2009): "How shall we recover the sensations and feelings in our numbed psyche so that we see, hear, feel the joy and pain, wonder and despair, in experiencing the earth and all its biotic communities?" (p. 136). With climate change, oil pipelines, and environmental catastrophes topping headlines daily, a marriage of philosophy and science (Schulz, 2014) has the power and potential, as this work will show, to cultivate compassionate and ecoliterate scientists.

In my doctoral research, any representation of the more-than-human world—be they plant, fungi, animal, or the larger environment—was done without harm or removal. Photos or video are one way to capture what I'm studying, or writing a narrative or poem of the lived experience. Causing harm or suffering to the organisms or ecosystems that

originally inspired my love of biology is not only antithetical to my research goals, but spiritually damaging to my personhood. How would the natural world want to be represented? I would argue that a poem would be a more authentic representation than statistics, or a painting over a lab report.

My intention is to inspire further inquiry, rediscover meaning in the natural world, and promote a set of principles centered on mutualistic identity and ecocentric integrity toward a sustainable future for Canada. I will recommend changes to science education and develop new philosophical frameworks for teacher education that incorporates Goethean science. Ethnobotanist Nancy Turner (2005) explains the "direct and reciprocal relationship between [indigenous] people and their environment, in which the consequences of wrongful action are seen to be immediate and direct" (p. 20). Here, sustainable ecological principles are braided with cultural traditions, since the natural and spiritual exist in the same venerated realm. This thesis hopes to offer this possibility through a shift from anthropocentric science education to the discovery of ecocentric models of pedagogy.

Major Works

Although my scholarship draws upon many sources, human and otherwise, there are four nature-minded philosophers whose ideas resonate throughout my thesis. Each of these diverse thinkers propose similar themes: we are deeply entangled in and with nature, a study of life means immersion in natural environments, and contemplative practice on the land is vital to learn and respect what the land has to offer and teach us. Applying their philosophies to science and science education results in an active, agential, experiential, reciprocative, and reverential practice.

Of the four primary scholars whose work I explore and analyze in this dissertation, Goethe, Kimmerer, and Leopold share some notable commonalities. First, they were/are scientists by trade. Secondly, they had/have experience both in lab science and in field settings. Thirdly, they all felt/feel a deep kinship toward land stewardship and

land-based pedagogy. Aldo Leopold shunned orienteering gadgets and promoted lengthy learning opportunities for his students directly on the land.

David Abram – Ideas from Abram's two books, *The Spell of the Sensuous* (1996) and *Becoming Animal* (2011) and other essays are interwoven throughout my essays. I attended a weeklong workshop, The Ecology of Wonder, with Dr. Abram at Hollyhock on Cortez Island, and also completed a course, EDCP 585B, Between the Body and the Breathing Earth, which he taught at the University of British Columbia. His arguments for direct sensorial experience, relationality, indigenous ways of knowing, and storytelling are embedded throughout my thesis, as I relate these to university science education.

Johann Wolfgang von Goethe – Goethean gentle empiricism, or "zarte Empirie," is discussed at length in multiple essays in this thesis. His "conscious-process-participation" (Wahl, 2005, p. 59) involves prolonged looking, direct attention, and deep empathy, with an "emphasis on the metamorphosis of the scientist" (Robbins, 2005, p. 115). I have adapted this holistic and participatory approach to the contemporary context of science education as a way to offer an alternative, immersive understanding of the world's phenomena. By incorporating a science of qualities rather than *only* a science of quantities (Reason & Goodwin, 1999), we engage in a reciprocal relationship more inclined to reveal our mutual interdependence with other life phenomena.

Robin Wall Kimmerer – Kimmerer's two books, *Gathering Moss* (2003) and *Braiding Sweetgrass* (2013a), and various papers on traditional ecological knowledge, blend scientific and indigenous/ecological knowledge with education and the idea of nature as teacher, both foundational themes in my thesis. She contends that "The scientific way of knowing relies only on empirical information from the world, gathered by body and interpreted by mind. In order to tell the mosses' story I need both approaches, objective and subjective" (2003, p. vii) and that "Traditional knowledge is rooted in intimacy with a local landscape where the land itself is the teacher" (p. 101). By weaving together science, art, and spirituality, Dr. Kimmerer lives a transdisciplinary life, an idea I explore and promote in my research and teaching. The way she braids such

diverse scholarship into her writing might be called métissage, a methodology I utilize in my thesis (I elaborate on this in the Research Methodology section).

Aldo Leopold – Leopold's land ethic has proven deeply influential for conservationists, philosophers, and environmentalists. Although many indigenous peoples have embraced nature as possessing inherent value, Leopold's writings were, perhaps, the first time a Western thinker published such an idea. The land ethic has comparable roots to ecocentrism, and I use this concept to develop the theory and practice of the GPS ecocache, an activity to promote outdoor learning that connects learner to place.

In addition to these four deep thinkers, my thesis also draws upon ecology science, ecopsychology, poetic inquiry (Carl Leggo), Indigenous Science (Gregory Cajete), and Romanticism in science education, detailed further in the Research Methodology and Essays Overview sections.

Current Science Education

Although the scholarship of this thesis is often relevant for K-12, the primary focus is post-secondary education in the natural sciences. The reason is twofold: I have taught at university for nineteen years, predominantly in lab- and field-based settings, and secondly, post-secondary science pedagogy receives far less attention.

There is a push in STEM education toward interdisciplinarity (Lekies & Moore, 2020; Wolfson & Armstrong, 2020), and a "call for the inclusion of people, knowledge, and practices in defining STEM learning, beyond the disciplinary hegemony of science" (Takeuchi et al., 2020, p. 236). Increasing educational research in STEM is leading to cross-pollination across traditionally segregated fields, and emphasizing the importance of experiential, relational, and decolonizing teaching and research in science, and reducing the focus from human capital discourse (e.g., career success). These are hopeful signs, though evidence of implementation (especially at the post-secondary level) are lacking. STEM fields recognize the benefits of experiential learning and active pedagogical approaches, though their effective application remains uncertain. Of note, is

that the use of the alternate acronym STEAM (science, technology, engineering, *arts*, and mathematics) is rarely adopted.

Science education is an interdisciplinary field. Outside 'subject matter,' the most common fields supporting science education research are pedagogy, constructivism, cognitive psychology, and philosophy of science (Chang et al., 2010). The prestigious journal Nature promotes creativity, integrated learning, and learner-centered approaches to science teaching (Hatch, 2018). However, in a recent review study (Li et al., 2020), where nearly 800 articles across 36 journals with a STEM education focus were analyzed, "post-secondary teacher and teaching" emerged as the *least* published topic category, with only 18 articles between the years 2000 and 2018. That's an average of one article a year on university pedagogy in science education, a serious lack of focus in this area. Another study (DeCoito, 2016) on Canadian STEM education concluded that "There is a dire need for conducting further research on the impact of STEM initiatives on teaching and learning in K–12" (p. 123); given the dearth here, we can surmise an even greater lack of scholarship in post-secondary science education. A third study (Skamp, 2020) reviewed nearly 1,000 articles published between 1994 and 2018 in *Research in Science Education*. On the side of diversification, his "Findings indicate the increasing diversity of areas investigated, the mix of research approaches used, and a plurality of research designs" (p. 1). Yet in the 'Educational Level' section, where secondary students accounted for 44% of the articles, and 22% for primary schooling, post-secondary education (other than preservice teachers) is not even listed as a category, despite the journal's explicit inclusion of tertiary education in its focus. In North America, in terms of science textbook analysis, the focus of researchers dominates in tertiary level textbooks (Voljir & Rusek, 2019). Thus, for university and colleges, science textbook research is a priority, but pedagogy is not. In the major science education journals, there is little to no focus on outdoor, place-based, or ecocentric education.

A review of the *Journal of Natural Sciences Education*, the *Journal of Biological Education*, the *Journal of Science Teaching*, *Life Sciences Education*, and *Bioscene–Journal of College Biology Teaching*, revealed research more pertinent to this thesis. Even so, anthropocentrism is rarely mentioned, and ecocentrism never. Although

experiential learning research does appear in these journals, and despite the noted importance of outdoor experiential learning (Jose et al., 2017), this application often takes place in indoor teaching environments (Howe & Barrientos-Velazquez, 2020) or even through remote instruction (Terkowsky et al., 2013; note the date of publication is seven years prior to the COVID-19 pandemic). The cognitive domain for science learning predominates, though the affective domain is increasingly being considered (Jelinski et al., 2020). An expanded interest in emotions and emotive reasoning retains a focus on younger learners.

In the new British Columbia course curriculum (https://curriculum.gov.bc.ca), implemented in the 2016/17 school year, there are hopeful shifts toward creative and reflective thinking, as well as personal and social awareness and responsibility. First Peoples knowledge is also incorporated throughout the curricula, though many teachers remain uncertain on executing this integration. On occasion, the utilitarian nature of science and anthropocentrism still persists. Listed as one of the 'big ideas' in grade 1: "Matter is useful because of its properties." In grade 5, machines are introduced as "devices that transfer force and energy." There is reference to natural machines, and students are asked to identify them in their local environments, inferring that plants and animals (and, indeed, humans) are machines. Although the curriculum includes study of the seasons, climate, and the environment, there is no indication that any of this must occur outside. By grade 10 the science curriculum, unsurprisingly, turns largely molecular and abstract, paralleling the historic shift in prominence from natural history studies to the so-called 'hard' sciences.

Natural history is seeing a re-emergence in post-secondary education (Ernst et al., 2015). After the structure of DNA was discovered by Rosalind Franklin, Francis Crick and James Watson in the early 1950s, the focus of biology literally went microscopic. Fields such as genetics, molecular biology and biochemistry took prominence, and supplanted courses in entomology, mammalogy, and other biodiversity-focused areas, which Watson scorned (in Wilson's words) as mere "stamp collectors who lacked the wit to transform their subject into a modern science" (1994, p. 219).

Lab-based science is easier to fund, given that it's easier to control, schedule and predict, and promises to be more profitable than field studies which may require higher travel and equipment costs. Despite the so-called war between naturalists and molecularists, the "reductionist revolution" (Lyman, 2017) that relegated many organismal courses to elective or even non-existent status, and the decline of natural history for decades if not centuries (Hampton & Wheeler, 2011), a revival may be occurring. Citizen science with GPS-enabled smartphones are seeing a rise, annual bird counts keep gaining popularity (The Great Backyard Bird Count had a record 268,674 participants in 2020), and Berkeley and Harvard are resurrecting courses in entomology, ichthyology, mammalogy, ornithology, and vertebrate paleontology.

Ecologists, conservation biologists, and natural history museums may study organisms in their native habitat, though sometimes the benefit is clearly anthropocentric. For instance, when it was proposed in a letter to Science magazine that we should reconsider specimen collection (i.e., killing and preserving an organism in order to study it now and in the future) museum curators and post-secondary researchers (including E. O. Wilson) from 66 institutions co-signed a letter explaining the absolute necessity of 'voucher' specimens (Rocha et al., 2014). To these scientists and museum curators, the human-perceived importance of learning the life history and characteristics of a species justifies the killing of this same species. Their claim is that habitat is what matters; individual nonhuman animals hold little to no intrinsic value, except what human researchers may glean for their own use. Should we be collecting organisms if doing so causes their death?

Killing life to study life is an idea as old as science, a rule many ecologists obey. E. O. Wilson, the 'father of biodiversity,' along with graduate student Daniel Simberloff, killed everything on six small islands in order to study recolonization (Simberloff & Wilson, 1969). They called this defaunation—that is, eradicating every animal, mostly invertebrates, in their study sites—a term used today to refer to global extinction of faunal species. After failed attempts at spraying the highly toxic parathion insecticide, which seeped into the aquatic ecosystem, they put tents over six small islands in Florida Bay and fumigated them with methyl bromide, "the standard method used by professional

exterminators" (Wilson & Simberloff, 1969, p. 272). They called this an exemplary 'natural laboratory,' meaning they could dispatch any creature without moral regard.

Their two celebrated papers relating to this ecological experiment include statements such as "For those trees where browning of leaves and shoots appeared complete by 72 hr the damage was irreversible" and "A year later there was no evidence of life" and "The damage we observed seemed too drastic and certainly too immediate" (Wilson & Simberloff, 1969, p. 273). This is a lauded experiment, considered by some to be Wilson and Simberloff's greatest contribution to ecological science, cited as one of the forty most significant papers in ecology (Real & Brown, 1991). No discussion of ethics is found in these papers. Co-investigator Simberloff recently stated that, although more forms might be required, given the chance to repeat this experiment today he would follow the same methodology (Sridhar, 2018), while an applied entomologist enthusiastically exclaimed "What a cool project; defaunation in progress" (Leather, 2017).

Here is a paradox. Simberloff is a distinguished ecologist, awarded (among many other honours) the Eminent Ecologist Award from the Ecological Society of America, and he served on the board of the Nature Conservancy. This, in part, is due to his applying rigorous statistics to ecology science. He wanted to study mathematics, but switched to biology. Later in his career, his focus turned to eradicating invasive species. As for Wilson, he is a preeminent scientist who helped shape the disciplines of biodiversity, ecology, and sociobiology. In his biography *Naturalist* (1994), he reflects on creating this outdoor laboratory to quantify island biogeography: "the targeted islets were no more than clumps of red mangrove" (p. 269) and "In order to run a proper experiment, we had to start with islets scourged of all animal life, with no exception" (p. 273). To study life, these ecologists are clearly prepared to first end it. This anthropocentric lens allows the potential benefit for humans and science to supersede any rights or values of the organisms under study.

Wilson recently stated that "We're entering the environmental-science era, where we want to take care of the environment around us, treat the earth the way we would a

person and keep it healthy" (Tyson, 2019). This is more in line with ecocentrism, where all life, not just human life, is considered to have intrinsic worth.

James Watson once quipped, "Anyone who would hire an ecologist is out of his mind," (Wilson, 1994, p. 220). This statement doesn't stand the test of time, given the dozens of ecology subfields that have emerged, from microbial ecology to urban ecology. I have taught the field component of university Ecology for nearly twenty years. The integration of ecological science and thinking with numerous other disciplines is needed to address unsustainable resource management, infectious diseases, defaunation, and myriad other urgent issues. To quote Wilson's (2011) axiom: "*The wellspring of the new biology is scientific natural history*" (p. xi). The question remains, can we approach this scientific natural history with a reverence and moral consideration for *all* life?

A Love Letter to (Outdoor) Science

In this thesis, I am often critical of Western science (see Chapter 9). The atomistic, positivist, reductionist approach offers a fine-tuned focus, restricted to a supposedly impartial and empirical view of the world. The limiting boundaries of the natural sciences—negating subjective experience, taxonomical hierarchy, a lens exclusive to biophysical processes—are clearly outlined in my thesis. To balance my judgements and ethical appraisals, this section elaborates on my appreciation for, and lifelong passionate pursuit of, the life sciences.

As a child, I built terrariums for millipedes, mesmerized by the wave-like pattern of their accordion legs. I observed the neighborhood cat stalk birds, ears flat and tail twitching. I noted how fast my toenails grew, and hypothesized why I saw spots after staring at the sun. As a child, I saw my first cheetah and developed a fascination for this beautiful feline. Later, I was enthralled by Carl Sagan's enthusiastic exploration of the cosmos, and Neil deGrasse Tyson's spacetime odyssey flying his microscopic spaceship past tardigrades. These mentors, including Laurie Marker chasing big cats in Namibia, inspired my own academic and career path, and instilled a wonder for the diversity of life.

Today, I work as a scientist, and a teacher of university science. During my undergrad, I studied headbobbing behaviour amongst 75 green iguanas, and designed cheetah conservation strategies. I appreciate the precise, thorough, painstaking detail that scientists reveal through their work. Having taught eight different biology labs, from ecology and genetics, to animal behaviour and advanced molecular biology, I possess a comprehensive understanding of biology instruction at the university level.

In teaching science, I have witnessed first-hand the unmitigated wonder of my students. I recall their delight when setting eyes to a microscope for the first time, observing chloroplasts circle an *Elodea* cell like tiny, green race cars. The screech of anxious excitement when a student plucked a crayfish from Serpentine River, pincers fully splayed. The fascination of isolating DNA, the code for life, onto a slide. The students who arrived at the cell biology lab one day dressed as a Golgi apparatus.

In 2020, I led a forest ecology walk at Campbell Valley Park for first-year biology students. Every student brought their own questions and curiosities. One in particular maintained a quiet reverie, as though the towering conifers and chittering nuthatches were speaking to her. Given the opportunity to feed the black-capped chickadees, she held open her seed-filled hands, quivering with anticipation. When the chickadee arrived, her awe in this moment was palpable (Figure 0.1).

Figure 0.1. Biology student in direct, participatory relationship with her subject of study.
Credit: Taken by Lee Beavington, 2020.

Of course, these birds are habituated to humans. Those in more remote wilderness would give two-leggeds a wider berth, though perhaps less so an experienced birder. Yet this did not matter to the students, who had a sensory experience (birdsong, black-flecked feathers, tiny talons perched in palm) through direct, participatory engagement. Something reciprocal was shared between avian and human, and perhaps forever rooted in memory.

This is one of those moments you wait for as an educator. Unpredictable, spontaneous, and the confluence of numerous factors: an inclusive learning environment, a group of engaged students, an openness to novel experiences, and my need to step aside. The outdoors, in this case a drizzling afternoon in the forest, is conducive to such transformative experiences.

A lab is excellent for carrying out ELISA assays, observing your own cheek cells magnified 1000X times, and extracting leaf pigments for chromatography. I have guided students through semester-long projects, where they sequenced yeast DNA, or prepared a tissue sample from processing and infiltration right through to staining their final microscope slide. Despite these detailed and informative lab experiences, they can't compare to the experimental (and experiential) possibilities of a forest ecosystem, only a fraction of which we understand (Luoma, 1996). Like Frank Egler said, "Ecosystems are not only more complex than we think, but more complex than we can think" (as cited in Bekoff, 2014, p, 26).

Even though I typically teach indoor science labs more than I teach outdoor field experiences, the engagement, connections, and wonder sparks are nearly always more prevalent in the natural world. Perhaps this is partly due to my own enthusiasm for teaching outdoors. There is also an opportunity for invitational learning, the "moment when an instructor's passion for the natural world becomes their own. These pivotal events are *invitational* in that an experienced individual with a deep sense of place invites a newcomer to adopt that same landscape" (Fleischner et al., 2017, p. 565). The fuller-bodied engagement in a forest—laboratories are sight dominant, whereas even a park affords the prospect of interpreting bird language, stroking the mouse tails of Douglas-fir

cones, tracking pollen and blooms through scent, and savoring a ripe huckleberry—is likely to confer a richer bodily (and biological) experience. Field studies can also be long-term (Audubon Christmas Bird Count carried out since 1900), in-depth and advanced (agronomy experiments continuously running for nearly 180 years at the Rothamsted Experimental Station in England; Debreczeni & Körschens, 2003), as well as interdisciplinary and wide-ranging (a collective chimpanzee study in seven sites across Africa; Arcadi, 2018).

In addition to the cognitive gain and augmented academic performance for biology students (Easton & Gilburn, 2012), as well as improved implementation of the scientific method (Goldberg & Castellón, 2017), field studies also provide foundational skills to behaviour, conservation, ecology, and evolution-focused scientists-in-training. However, while journal publications for data analysis showed an 800% increase since 1980, field-based publications showed a 20% decrease (Ríos-Saldaña et al, 2018). The contrast between lab-based and field-based learning is further explored in chapters 9 and 10.

Teaching outdoors can be difficult. As Fleischner et al. (2017) explain, "A field instructor plays multiple roles: natural historian, observer, experimentalist, theoretician, translator, teacher, mentor, and risk manager" (p. 565). Facilitators of learning in these environments must adapt to changing seasons, animal encounters, student biophobia, and myriad unexpected events. Ross Laird (2019) also points to "Issues such as safety, equipment, transport, communications, weather, and a host of other factors contribute to the fluid and unpredictable quality of outdoor facilitation" (Possibilities and practicalities section, para. 3). Academic culture places learning in a classroom, with repeatable outcomes (much like a good science experiment), where emotion is typically unwelcome or at least unfamiliar. Laird finds that outdoor learning can "invert these norms: learning takes place outside; learning is unpredictable and unique to a given participant and moment; and learning is a deeply emotional process—which, ideally, also contains intellectual discoveries" (para. 6). Compared to the laboratory environment, the outdoors enables holistic learner engagement through mind, body, and emotion.

Science is a journey of exploration that unearths objective truth through meticulous methodology and exquisite passion. Without science, we would not have kidney transplants, airplanes, penicillin, or cell phones (all things that I admittedly try to avoid). I could not type on this computer, send emails, or search the vast online libraries of knowledge from my home. Climate and environmental science are critical parts to addressing myriad environmental crises. Our technology, medical innovations, and science laboratories have expanded human life and understanding of the world. Without medical science, my beloved daughter (photo on page 137) might not be here. Lab science has its place, yet field studies and outdoor education that nurture an environmental ethic—through immersive nature experience, where we reflect on the ethical ramifications of our actions—is essential towards building a better relationship with the planet. Goethean science offers this alternative.

Romanticism, the Scientific Revolution, and Goethe

> Whenever you're observing Nature,
> Be aware, in one and all,
> How nothing is internal or external—
> For what is inward is always outward.
> Then you will be quick to grasp
> Nature's sacred open secret.
>
> Enjoy true appearances,
> Take games seriously.
> Nothing alive is a single thing;
> It is always a multiplicity.
> (Goethe's poem *Epirrhema*, 2015, p. 127)

Romantic science seems like a misnomer. Sentimental, emotional, and subjective are not words typically associated with science, though one word cross-resonates: mysterious. Romanticism invokes a passionate embrace of the mysterious, and the scientific enterprise attempts the same, if through a more precise, and less poetic, lens. The enchantment of the natural world draws both Romantics and scientists, the former for artistic and aesthetic inspiration, the latter to discern the mechanics and mechanisms behind natural phenomena. The Age of Wonder might easily apply to both, except "Wonder is the absence of interpretation" (Evernden, 1993, p. 139), and the proposed

explanation of natural phenomena that is a hypothesis detaches us from surprise. As recent Romantic science scholar Yannis Hadzigeorgiou told me "many scientists are not motivated by the universal mystery and the wonder of nature but by other things" (personal communication, August 10, 2020). One can surmise that these 'other things' include curiosity about how the world works, to better humankind, intellectual challenge, making discoveries, and earning money. Yet for many, wonder still serves as the root of initial inspiration.

The disparity between Romanticism and scientific thinking is well established: "The polarity of these two seems obvious: the Romantic Movement with its flights into fantasy, emotion, disorder, and uncertainty opposes science instruction with its typical emphasis on order, objectivity, quantification, and rationality" (Miller, 1981, p. 9). On the one hand, you have a movement, encompassing much of the 19th century, that promoted passion and sentiment, sense experience, nature beauty, and imagination. Romanticism was a response to the Age of Enlightenment's "static, mechanical, disembodied view of the world formulated by Descartes" (Berkes, 2018, p. 2). Whereas the Scientific Revolution, from early conceptions by Aristotle, to later thinkers Francis Bacon and Newton (among many others), persisted from the mid-1500s to the late 1600s, and followed inductive reasoning, systematic logic, and a reductionism still deeply ingrained in modern scientific practice.

Bacon developed the experimental method, and asserted that knowledge was derived by having power over nature. Even Goethe, writing in 1807, conceded that when a "man undertakes to confront the world of nature, he will at first experience a tremendous compulsion to bring what he finds there under his control" (Goethe, 1988b, p. 61). While both Goethe and Bacon promoted direct, empirical observation of the material world, the latter questioned the blending of science and philosophy that Romanticism would later endorse. Bacon distrusted philosophical discourse as a path to the truth. He states his misgivings in his book, Novum organum; *Or, true suggestions for the interpretation of nature*:

> words still manifestly force the understanding, throw everything into confusion, and lead mankind into vain and innumerable controversies and

> fallacies…For men imagine that their reason governs words, while, in fact, words react upon the understanding; and this has rendered philosophy and the sciences sophistical and inactive. (Bacon, 1902)

In other words, science needs to be divested from philosophy.

Evernden (1993) describes the 'shallow' stream of Romanticism as sentimental and utopian, with a desire to "return to some idealized state of nature" (p. 29). E. O. Wilson (1998) contends that Romantics privileged emotion and fantasy over scientific reasoning. Even Goethe rebelled against Romanticism. He "could not stand the 'neo-Catholic sentimentalism' that so many Romantics promoted" (Robertson, 2016, p. 57), and referred to the classical (real) as "strong, fresh, happy and healthy" (p. 57) and the Romantic (ideal) as "feeble, sickly and sick" (p. 57). Two pieces of historical context are important: first, that Goethe was reacting here toward French Romantic literature (rather than scientists, or natural philosophers as they were called then), and second, that a year later Goethe remarked, "I myself, contrary to my own will, was a Romantic" (Richards, 2002, p. 3). Although he made the anthropocentric claim that "in certain cases the work of art can surpass nature" (Fischer & Nassar, 2015, p. 13), Goethe refused "to reduce qualitative experience to quantifiable abstractions" (p. 10). In this phenomenology of nature, morality, beauty, and poetic imagination are manifested with and by the natural world. Romantics were defenders of value and meaning, and endorsed a "holistic metaphysical conception of nature, an aesthetics based on the immersion in nature, and an ascription of normative qualities to nature" (Greif, 2015, p. 54).

If we are to bridge the two cultures between the humanities and the natural sciences (to paraphrase my conversation with Yannis Hadzigeorgiou), we can look to the mutually transformative approach of Goethe's *zarte Empirie* (delicate empiricism), the "mature articulation of fifty years' work to establish an explicitly participatory, phenomena-based scientific practice" (Holdrege & Talbott, 2010, p. 204). If "ethical questions about how we should relate to the natural world cannot be separated from either epistemological or ontological questions" (Fischer & Nassar, 2015, p. 8), then a re-marriage of science and philosophy is vital.

Goethean science has been analyzed by numerous historians, yet "within the broader contemporary scientific community his efforts are virtually unknown or deemed irrelevant to the advancement of science" (Holdrege & Talbott, 2010, p. 205). Some portray Goethe as a failed scientist, Romantic philosopher, or sentimental poet (Richards, 2002). Yet Goethe, in addition to discovering the intermaxillary bone in the human jaw, also coined the term morphology, which "became the established mode of biology in the first half of the [19th] century and…cleared the way for the triumph of Darwinian science in the second half" (p. 407). In fact, Darwin referenced Goethe in *The Origin of Species.* Goethe led a distinguished literary career, with *Faust* often referenced and performed today, though he felt his greatest contribution was to science. Admittedly, Goethe's approach to science is more akin to natural history (as we will see in Chapter 9, Leopold lamented the surrender of natural history to laboratory science), but it maintains a methodology equal in rigor (see Chapter 5) to modern Western science.

As Thoreau and Emerson did in North America, Goethe had a profound influence on how Europeans perceive nature. For Goethe, science is about mediating a relationship. Romantics, as the first ecologists, explored this science of relationships. Modern day ecology needs to transcend the mechanistic bedrock of the scientific discipline and embrace lived experience and embodied reciprocity, and guide empirical studies with principles. Similarly, science educators hold a "responsibility not simply to teach scientific principles, processes, and concepts, but also to attempt to instill in students a profound regard for nature…Nature study is valid in its own right" (Miller, 1981, p. 11). Nature, rather than being utilitarian, holds moral significance. "Starting with mechanistic assumptions, [ecological research] can only discover machines" (Evernden, 1993, p. 21) that bear no intrinsic value. To "restore the lived world its sensuous concreteness and human values, thereby [making] it possible for human beings to feel that they belonged" (Abrams, 2012, p. 135) is to restore a sense of wonder, poetry and mystery. Romanticism offers us this gift. As Goethe himself stated in 1772,

> What we see of nature is energy that consumes energy, nothing static, everything transient, a thousand seeds crushed every minute and a thousand born, great and momentous, infinitely various; beautiful and ugly, good and

> evil, everything existing with an equal right alongside everything else. (as cited in Robertson, 2016, p. 27)

Conventional Newtonian science, established practice in the modern natural sciences, is unlikely to shift paradigms in the short-term. In contemporary North American schools, Goethe is a small dot in the largely siloed landscape of Western science education. Schumacher College in the United Kingdom offers a Master's of Science founded in Goethean delicate empiricism, advertising that they "blend the analytic-synthetic and the narrative-experiential" (Franses & Wride, 2015, p. 4). Evolutionary biologist Marc Bekoff (2014) argues that "We do not need more science. We need a new mindset and social movement that is transformational and centers on empathy, compassion, and being proactive" (p. 57).

The Metamorphosis of My Thesis

This dissertation follows the rough arc of my family ancestry. My ancestors, primarily British, though also Irish, French and Czechoslovakian, settled in Canada in the late 1800s and early 1900s. Thus, my familial roots are European, which gave rise to Romanticism and natural philosophers such as the German polymath Johann Wolfgang von Goethe. Goethean science is examined as a way to complement Cartesian dualistic Western science. The reciprocal engagement, prolonged looking, and creative response of delicate empiricism are braided through many of the essays herein (see especially chapters 4, 5, and 6), with a dash of Arne Naess' deep ecology thrown in; like my great-great grandmother, Naess was Norwegian.

Central to Goethe's work *Versuch die Metamorphose der Pflanzen zu erklären* (*The Metamorphosis of Plant*s) is the idea of transmutation. The transitional stages, such as a tadpole to frog, or caterpillar to butterfly, can often be the most intriguing and transformative. In Goethe's (2009) words:

> If I look at the created object, inquire into its creation, and follow this process back as far as I can, I will find a series of steps. Since these are not actually seen together before me, I must visualize them in my memory so that they form a certain ideal whole…nature leaves no gaps, and thus, in the

> end, I will have to see this progression of uninterrupted activity as a whole. (p. 105)

Applying a plant analogy to this thesis, the ground and roots honour all that came before, including Indigenous peoples, philosophers, lived experiences, and the natural world, while the fruit and seeds offer new theoretical and practical conceptions for the future.

Since the age of two, my life has progressed on the southwestern coast of British Columbia, Canada. First on Zero Avenue, the unceded, ancestral territories of the Semiahmoo First Nation, where the ocean was a short walk past the Peace Arch delineating the Canada-United States border. Recently, my wife, children, and I have made our home on Mayne Island, territory of the Tsartlip First Nation, enveloped by the Salish Sea. Like the plantain, I am naturalized to southwestern Canada. I am the descendant of European-colonial-settlers. Perhaps some of the lessons learned from the Romantics in Europe can work alongside in a reverential and collaborative way with the traditions of the Coast Salish peoples.

The trajectory of my thesis shifts from the personal and subjective to the more conventional, general, and objective academic discourse. Specifically, Chapter 1 is told through narrative, Chapter 2 is an essay articulated via conversation, and then we move into more typical essays. Chapter 8 employs reflective writing as a way to contemplate our own pedagogical practice. Since this thesis is interdisciplinary, regularly integrating poetry and photography, such shifts in methodological and stylistic approaches emphasize the richness afforded through métissage and more holistic and relational scholarship.

Research Methodology

As my research is interdisciplinary, my methodology reflects this approach. Hence, I integrate and employ diverse modes of research inquiry and engagement. My inquiry is largely informed by literature that focuses on place, values and holism. Where ecology attempts to study scientifically everything in relation, holism is its philosophical twin. Reductionism, or the investigation of phenomena in isolation, “can only give us a

partial view of anything it dissects" (Miller, 2000, p. 21). As such, métissage (Hasebe-Ludt et al., 2009; Hasebe-Ludt & Leggo, 2018) will help integrate and conceptualize this inquiry. Métissage serves as both a frame and a guide for heterogeneity and transdisciplinarity, as well as a bridge between mainstream and alternative pedagogy. I will braid lenses of inquiry with a variety of my own personal voices: academic papers, literary vignettes, poetic works, narratives and lived-experiential writing. This métissage fits suitably into my article thesis as a whole, and can sometimes be found within individual essays. My own photographs are also often included as a visual and aesthetic element to emphasize physical positionality and place.

Contemplative and Sensorial Engagement with Nature

My mindfulness practice—being attuned to the present moment, and aware of my own thoughts, feelings, and surroundings—was explored in two ways.

First, by visiting 'sit spots' (Young & Gardoqui, 2013) in nature, where I sat in silence for an extended period, always at the same locations. Since commencing my PhD in 2014, I have regularly visited several sit spots. These include (a) Elgin Creek, a salmon spawning stream in South Surrey, BC, (b) the backyard of our Gulf Island home, which I refer to as the 'yard of infinite poems,' where raven wings beat as clear as thunder, deer squeeze through loose fence boards into the garden, and bats snap up mosquitoes at dusk, (c) the courtyard pond at KPU Surrey, and (d) the dock at Calanoa in Colombia, which extends over the Amazon River. This sit spot method facilitates a deeper familiarity within particular environments. "There is an interaction between the people's inner and outer realities," writes Cajete (1994), "that comes into play as we live in a place for an extended time" (p. 83). When our inner realities (mind, thought, imagination) intertwine with the outer realities (nature, environment, creativity) we unearth ecological threads of vital connection. Perhaps such a rich relationship to place can help shift our species from instant gratification to farsighted prudence. Speaking to my own experience, these intentional engagements nurtured a need to slow down, to enhance clarity and work through my often frenetic thoughts and emotions, and return me to the wisdom of my heart.

The second contemplative practice involved walking mindfully—that is, in a careful, reflective, purposeful manner—in both remote and urban natural areas (Judson, 2018). I documented these experiences through writing (poetry, journaling, and reflective) and visuals (photography and video). This multi-modal approach informs this work beyond the traditional printed word to offer a richer aesthetic interpretation. Many of the ideas and arguments formulated in this thesis were seeded and germinated while on the trail.

My research is grounded in a direct immersion in the environment of study, namely the taiga and temperate rainforests, riverine watersheds, intertidal shorelines, bogs, mountains and other wilderness habitats of the Pacific Northwest. Part of my research also included my travels to the Amazon rainforest in Colombia and melting glaciers in Norway. As Macy and Johnstone (2012) write, "Developing a partnership with Earth involves listening for guiding signals and taking them seriously when we hear them" (p. 117). To understand the physical and psychological influences of the natural world, I needed to experience them first-hand, and develop the ability to acknowledge and consider voices beyond those of my own species. To truly listen to the other is not to simply recognize a sound, and the physical sensation of sound waves reaching my ear drum, but to understand the perspectives and feelings of another (Macnamara, 2018).

As Park et al. (2010) explain, "...human beings have lived in the natural environment for most of the 5 million years of their existence. Therefore, their physiological functions are most suited to natural settings" (para 19). Their study of Shinrin-yoku (forest bathing) reveals that, compared to city environs, forest walks reduce stressful hormone levels, decrease pulse rate and blood pressure, and stimulate relaxing signals from our parasympathetic nervous system. The mind and body response of humans in nature is being scrutinized today in great detail (Louv, 2012; Twohig-Bennett & Jones, 2018). Abram (1990) reminds us of our continual immersion in Gaia, and that "In concert with other animals, with the plants, and with the microbes themselves, we are an active part of the Earth's atmosphere" (p. 77). Writing about Margaret Latta, Donald Blumenfeld-Jones (2014) emphasizes that "multisensory engagements make room for deliberation [which] leads to enlarging what we can know (realize) that allows for us to

see suggested futures" (p. 4). By actively participating in nature, and in concert with the Earth, I plan to lay the framework for suggested futures in science education.

Poetic Inquiry

In response to engaging in a sensorial relationship with nature, I conducted a poetic inquiry to elucidate my findings on a physical, emotional, artistic, scientific and spiritual level. Poetic inquiry uses poetry to study and consider fuller understandings of a research subject (Faulkner, 2009; Prendergast, 2009b; Wiebe, 2008). As Carl Leggo (2004) states, "the poet *is* a human scientist" (p. 30), working with language to construct understanding. Further, Prendergast (2009a) explains that poetry of all forms can "also be argued to be a form of research, a re-searching of experience and sorting into expression and communication through language" (p. xxii). My poetry will provide another avenue of insight into a myriad of topics, including placed-based inquiry (Sameshima et al., 2017; Thomas, 2016), science pedagogy (Gorrell & Colfax, 2012), and mindfulness in nature and education (Madsen, 2017).

As Neilson (2004) writes: "poetry and inquiry ask us to listen deeply. We must put ourselves in the context; we must feel, taste, hear what someone is saying. Sometimes we must learn to listen under the words, to hear what is not being said" (p. 41). Poetry is a way to interweave experience and creativity, and make the inaccessible accessible. By example, here follows an excerpt of a poem I wrote from the *umwelt* (Uexküll, 2010) of a sea urchin, and the hidden wonders our mechanistic-mindedness can sometimes disregard:

> what did Aristotle see
> when he was entranced by her spines?
> that entrance to a geometric jaw
> simple mechanics or a radiant threshold
> window into the urchin universe
>
> the only law she abides is natural law
> a reciprocal rule we have forgotten
> to her wisdom we are blind
> if we held her lantern high
> what question would she ask of us?

Arts-based Inquiry with a Scientific Foundation

Although poetry served as the primary form of arts-based inquiry, I also produced other forms of art as part of my inquiry. These included narrative, creative writing, journaling, photography, and video. As research methods, these arts-based approaches "offer a vision of the interrelationships among art, spirituality, research, and teaching that challenges the sense of risk often engendered by such connections in the academy" (Walsh et al., 2015, p. 1). These "porous and relational" (p. 5) methods consider aesthetics, ethics, and recognition of privilege, with a focus (in this thesis) on the lack of these in conventional science.

The arts-based research that I employed is qualitative, allowing the researcher to include artistic practices and aesthetic principles within the inquiry process, as well as in the products of the research (Eisner, 2002). Art making is also akin to contemplative practice, in that the creative process can often be a time of incubation and reflection. As Goethe (1988a) said, "The human being knows himself only insofar as he knows the world; he perceives the world only in himself, and himself only in the world. Every new object, clearly seen, opens up a new organ of perception in us" (p. 39). This relational epistemology is a practice of imagination that allows for direct and intimate participation with the world. To never immerse ourselves in the natural world is to hinder our thinking and creativity (Fettes, 2013). Goethe found "in imagination not the betrayer of truth but the faculty of creative possibility" (Richards, 2002, p. 438).

As a scientist, I am trained to question everything. "If we want to learn how to live sustainably on this Earth," writes philosopher Kohák (2000), "we need the most reliable information possible about the mechanisms of the whole systems of natural processes" (p. 12). Therefore, my inquiry is grounded in recent and reliable findings from the realm of ecology science (DellaSala, 2011; Gaskell, 2018; Luoma, 1999; Ricklefs & Relyea, 2014). This informs both my art and synthesis of theory and practice.

Interdisciplinary Pedagogical Practice

I work and teach in five faculties at Kwantlen Polytechnic University (KPU): Arts, Design, Science and Horticulture, Academic and Career Advancement, and Educational Support and Development. A variety of ecological principles and ideas serve as foundational in all of my teaching, both within the university setting and via community outreach initiatives. I documented, through journaling, these experiences of teaching both children and adults in natural environments, including KPU Ecology students and the Amazon Field School students, Heartwood Learning Community students, as well as facilitating nature walks to a more general audience. My reflections of these teaching experiences will serve as part of my inquiry, both as a source of art-making and as a response to pedagogical nature experience. Reflective journaling is regularly used in self-study (Makaiau et al., 2015), to enhance student metacognition (Alt & Raichel, 2020) and for teacher professional development. For my inquiry, when drawing upon my journal writing, I utilized less descriptive and more dialogic reflections to help crystallize my articulation of philosophical thinking and pedagogical practice.

Essays Overview

This section outlines the layout and flow of the article thesis. While each essay can be read as a standalone piece, they are grouped in such a way to elucidate common concepts and philosophies that interrelate and support the concepts of ecocentric education, poetic inquiry, and place-based learning. Métissage helped guide these groupings via the understanding that heterogeneous concepts and approaches can often be a strength, since diversity and intentional cross-pollination can open our eyes beyond our primary disciplines and worldviews. Since some essays focus on more theoretical and philosophical deliberations, while others explicitly articulate pedagogical practice, I have grouped my essays into five sections based on topic, style, and contextual flow.

The essays appear in this thesis without modification from their published versions, with two exceptions: minor formatting required to fit SFU's thesis template guidelines, and the addition of a "Preamble" at the start of every chapter to facilitate a

contextual flow. To indicate the end of the new text provided in the preamble, the following symbol is used: ✺.

Part I - Journey to the Sacred Mountain

Part I (Ground) reveals the story of inspiration that led to this thesis, and explores fertile conversations regarding living poetically in a world of ecological turmoil.

Chapter 1, Offerings on the Mountain, is a narrative that serves to situate my lived experience and place-based connection, and describes my profound personal journey that led me to question anthropocentric science education and the discovery of ecocentric models of pedagogy.

Chapter 2, The Life of Blossom: Living Poetically in the Anthropocene, was co-authored with my colleague Dave Chang. This dialogic essay discusses our own complicity in the current ecological crises. Scientists state that we are living in the Anthropocene, an epoch marked by unprecedented human impact on the planet. Our ecological predicament poses a significant challenge to human consciousness as we experience a pivotal moment in planetary history. Following the works of Mary Oliver, Carl Leggo, Kathleen Dean Moore, and other poetic luminaries, we consider what it means to live poetically in the Anthropocene, to experience beauty and meaning amidst depletion and radical ecological change, to weep for the disappearance of species while working toward personal and systemic transformation. We ask: How does poetry contribute to a flourishing life in a time of ecological crisis? Why is poetry an especially potent vehicle of human expression and transformation? In a dialogic format, the authors exchange reflections on poetic inquiry, and muse on the importance of poetry as a vehicle for investigation and reformation.

Part II - More-than-human Ethics and Romanticism

Part II (Roots) digs into the origins of Anthropocentrism and the Romantic era. This section explores how *Homo sapiens* rationalize their species' uniqueness to justify anthropocentrism and self-interest towards other-than-humans. The mechanistic and

reductionist scientific approach promotes an intellectual dissociation and general desensitization toward animals, plants, and the natural environment. Poetic inquiry as a methodology harbours the possibility to foster connection to the other-than-human world that promotes contemplative practice that challenges human exceptionalism and cultivates a reciprocal relationship with life phenomena being studied. The aesthetic, holistic and moral qualities of Romanticism are considered in regards to science education.

Chapter 3, Curriculum Hidden: Contemplating More-than-human Ethics, explores how mandatory dissection and animal experimentation, alongside mechanistic and atomistic assumptions deeply embedded in science curricula, reinforce the idea that other-than-human animals lack moral status. Synergy and deep ecology can move us from exclusively biotic morality toward a more inclusive abiotic morality.

Chapter 4, Romanticism and Science Education: Nature as a Poem, is a philosophical poetic inquiry that argues for relational approaches and creative expression in university science education. Goethean science, where students understand nature inwardly, offers an alternative to Newtonian science by incorporating the intentionality of phenomenological learning and the development of ecological literacy.

Part III - Goethean Science

Part III (Trunk) discloses the gentle strength of delicate empiricism as a pillar of compassionate science. This section examines the history of science education and Goethean science, and also explores the unquestioned use and killing of animals in biological education.

Chapter 5, Science Education in the Key of Gentle Empiricism, was co-authored with Heesoon Bai. This essay begins with an examination of what we mean by "science education" and the reduction of nature to the order of the inanimate. Incorporating Goethean science in today's science classrooms requires us to step beyond the limits of the conventional reductionist science methodology that follows the predominant subject-object-separation epistemology and move toward a conscious-

process-participation epistemology. Finally, we outline the four stages of Goethean gentle empiricism, or "zarte Empirie," with applications for science pedagogy.

Chapter 6, Ethical-ecological Holism in Science Pedagogy: In Honor of Sea Urchins, was co-authored by Heesoon Bai and Serenna Celeste Romanycia. This essay is a mixed-methods study involving narrative inquiry, poetic inquiry, and essay composition. We call for a shift that critically re-examines the foundational philosophical basis of, as well as accompanying psychological work that goes into, the de-animated and desacralized empiricist worldview. This can occur through aesthetic and contemplative practices alongside scientific investigations.

Part IV - Place-based and Reflective Pedagogy

Part IV (Branches and Leaves) extends theory into practice, exploring a practical land-based activity and reaching toward whole-person pedagogy. Leopold's land ethic is used as a philosophical framework for relational education. Reflections on Kwantlen Polytechnic University's Amazon Interdisciplinary Field School through narrative, journal entries, and photography elucidate how the natural world promotes resiliency, active learning, and cross-species communication.

Chapter 7, GPS Ecocache: Connecting Learners to Experience and Place, was co-authored with Jesse Jewell, creator of the GPS ecocache. The experiential, place-based ecocache has learners navigate to sites of ecological significance, where they must answer a question or riddle related to this site. We discuss the contradictory nature of using a gadget to connect with the outdoors, outline the practical application of the GPS ecocache, and integrate the GPS ecocache with Kolb's model of experiential education.

Chapter 8, The Jaguar Walk: Reflections from the Amazon Field School, relates to my three trips with KPU's Amazon Interdisciplinary Field School. Through examples from both the Amazon and my classroom instruction at KPU, I reflect on shifting from being a teacher to being a facilitator of learning who encourages whole-person pedagogy. Four themes are followed: (1) the importance of teacher adaptability in active learning environments, (2) confidence building for teachers to become capable

leaders and mentors, (3) contemplative education that embraces a reflective and relational pedagogy, and (4) the movement toward Nature as teacher.

Part V - Wild Research and Five Seeds for Ecocentric Education

Part V (Fruit and Seeds) elucidates emerging ideas regarding ecocentric research frameworks and Indigenous philosophies. This section considers being a wild researcher, examining more-than-human methodologies, positionality of the natural world, and embedded anthropocentricism in animal experimentation. In addition, five seeds for facilitating ecocentrism in post-secondary contexts are summarized. The limitations of this thesis are also discussed.

Chapter 9, Becoming a Wild Researcher through Goethean Science, Indigenous Philosophy, and Creative Response, was inspired by attending the *Wild Pedagogies Colloquium* in Finse, Norway in August, 2019. Framed by science and environmental education, this essay addresses eight questions presented in *Wild Pedagogies: Touchstones for Re-Negotiating Education and the Environment in the Anthropocene.* These questions, posed by Sean Blenkinsop, ponder more-than-human methodologies, positionality of the natural world, and research implications for the natural world. My responses explore Tim Ingold's notion of a 'modest, humble, and attentive' science, advocates ecocentric place-based research, questions dissection and animal experimentation, and offer Goethean science and Indigenous philosophy as alternatives to rational-reductionist Newtonian science. Lab-based science is contrasted with natural history, and creative, contemplative practice is suggested as tools of the wild researcher. Answering these questions provided me with a suitable conclusion to my dissertation, both as a reflection of my doctoral research and also as an inspiration for future scholarship that engages the more-than-human community.

Chapter 10, Planting Seeds for Ecocentric Education, discusses future areas of research, and provides summaries for five seeds in ecocentrism for consideration in post-secondary: Anthropocentric to Ecocentric Science Education, University Science with Goethe and Leopold, Science and Art, Nature as Teacher/Researcher, and Lab and Field-

based Science. Two examples for ecocentric teaching and research in science are provided with each 'seed.'

References* (for the eight essays that comprise this article-based thesis):

Chang, D., & Beavington, L. (2020). The life of blossom: Living poetically in the Anthropocene. *Art/Research International: A Transdisciplinary Journal*, *5*(2), 257–277. https://doi.org/10.18432/ari29501

Beavington, L. (2016). Curriculum hidden: Contemplating more-than-human ethics, *SFU Educational Review*, *9*. https://doi.org/10.21810/sfuer.v9i.309

Beavington, L. (2018). Romanticism and science education: Nature as a poem, *European Journal of Philosophy in Arts Education*, *2*(2), 6–46. http://www.ejpae.com/index.php/EJPAE/article/view/12

Beavington, L., & Bai, H. (2018). Science education in the key of gentle empiricism. In L. Bryan & K. Tobin (Eds.), *13 questions: Reframing education's conversation – Science* (pp. 473–484). Peter Lang. https://doi.org/10.3726/b11305

Beavington, L., Bai, H., & Romanycia, S. (2017). Ethical-ecological holism in science pedagogy: In honor of sea urchins. In M. P. Mueller, D. J. Tippins, & A. J. Stewart (Eds.), *Animals and science education* (pp. 85–95). Springer International. https://doi.org/10.1007/978-3-319-56375-6_7

Beavington, L., & Jewell, J. (2018). GPS ecocache: Connecting learners to experience and place. *American Association of Philosophy Teachers Studies in Pedagogy*, *4*, 161–180. https://doi.org/10.5840/aaptstudies201922539

Beavington, L. (2018). The jaguar walk: Reflections from the Amazon Field School. *Transformative Dialogues*, *11*(3). https://journals.kpu.ca/index.php/td/article/view/141

Beavington, L. (2021). Becoming a wild researcher through Goethean science, indigenous philosophy, and creative response, *Canadian Journal of Environmental Education.* Accepted.

*References listed in the order that they appear in this thesis.

References (for Introduction)

Abram, D. (1990). The perceptual implications of Gaia. In A. H. Badiner (Ed.), *Dharma Gaia: A harvest of essays in Buddhism and ecology* (pp. 75–92). Parallax Press.

Abram, D. (1996). *Spell of the sensuous: Perception and language in a more-than-human world.* Vintage Books.

Abram, D. (2011). *Becoming animal: An earthly cosmology.* Random House of Canada.

Abrams, M. H. (2012). *The fourth dimension of a poem and other essays*. W. W. Norton & Company.

Akhtar, A. (2015). The flaws and human harms of animal experimentation. *Cambridge Quarterly of Healthcare Ethics, 24*(4), 407–419. https://dx.doi.org/10.1017%2FS0963180115000079

Alt, D., & Raichel, N. (2020). Reflective journaling and metacognitive awareness: Insights from a longitudinal study in higher education. *Reflective Practice, 21*(2), 145–158, https://doi.org/10.1080/14623943.2020.1716708

Arcadi, A. (2018). Seven long-term field studies. In *Wild chimpanzees: Social behavior of an endangered species* (pp. 15–26). Cambridge University Press. https://doi.org/10.1017/9781108178303.003

Bacon, F. (1902). Aphorisms—Book I: On the interpretation of nature and the empire of man. In J. Devey (Ed.), Novum organum; *Or, true suggestions for the interpretation of nature.* P. F. Collier & Son. http://www.gutenberg.org/ebooks/45988

Bai, H. (2009). Reanimating the universe: Environmental education and philosophical animism. In M. McKenzie, P. Hart, H. Bai & B. Jickling (Eds.), *Fields of green: Restorying culture, environment, and education* (pp. 135–151). Hampton Press.

Bai, H. (2015). Peace with the earth: Animism and contemplative ways. *Cultural Studies of Science Education, 10*, 135–147. https://doi.org/10.1007/s11422-013-9501-z

Beavington, L. (2020). Kidnapping children and calves (of a tender age). In S. Faulkner & A. England (Eds.), *Scientists and poets #resist* (pp. 35–42). Brill Sense. https://doi.org/10.1163/9789004418820_009

Bekoff, M. (2014). *Rewilding our hearts: Building pathways of compassion and coexistence*. New World Library.

Berkes, F. (2018). *Sacred ecology* (4th ed.). Routledge.

Blumenfeld-Jones, D. (2014). Reimagining the world, reimaging the self: Ethics, aesthetics, play and curriculum in the work of Margaret Latta. *International Journal of Education and the Arts, 14*(2), 1–10.

Cajete, G. (1994). *Look to the mountain: An ecology of Indigenous education.* Kivaki Press.

Chambers, C. M., Hasebe-Ludt, E., Leggo, C., & Sinner, A. (Eds.). (2012). *A heart of wisdom: Life writing as empathetic inquiry*. Peter Lang.

Chang, Y-H., Chang, C-Y., & Tseng, Y-H. (2010). Trends of science education research: An automatic content analysis. *Journal of Science Education and Technology, 19,* 315–331. https://doi.org/10.1007/s10956-009-9202-2

DeCoito, I. (2016). STEM education in Canada: A knowledge synthesis. *Canadian Journal of Science, Mathematics and Technology Education*, *16*(2), 114–128. https://doi.org/10.1080/14926156.2016.1166297

DellaSala, D. A. (Ed.). (2011). *Temperate and boreal rainforests of the world.* Island Press.

Debreczeni, K., & Körschens, M. (2003). Long-term field experiments of the world. *Archives of Agronomy and Soil Science, 49*(5), 465–483. https://doi.org/10.1080/03650340310001594754

Easton, E., & Gilburn, A. (2012). The field course effect: Gains in cognitive learning in undergraduate biology students following a field course. *Journal of Biological Education*, *46*, 29–35.

Eisner, E. (2002). *The arts and the creation of mind.* Yale University Press.

Ernst, C., Buddle, C., & Soluk, L. (2015) The value of introducing natural history field research into undergraduate curricula: A case study. *Bioscience Education*. https://doi.org/10.11120/beej.2014.00023

Evernden, N. (1993). *The natural alien* (2nd ed.). University of Toronto Press.

Fettes, M. (2013). Imagination and experience: An integrative framework. *Democracy and Education, 21*(1), 1–11.

Fischer, L., & Nassar, D. (2015). Introduction: Goethe and environmentalism. *Goethe Yearbook, 22,* 3–22. https://doi.org/10.1353/gyr.2015.0032

Fleischner, T., Espinoza, R., Gerrish, G., Greene, H., Kimmerer, R., Lacey, E., Pace, S., Parrish, J., Swain, H., Trombulak, S., Weisberg, S., Winkler, D., & Zander, L. (2017). Teaching biology in the field: Importance, challenges, and solutions. *BioScience, 67*(6), 558–567. https://doi.org/10.1093/biosci/bix036

Franses, P., & Wride, M. (2015). Goethean pedagogy: A case in innovative science education and implications for work based learning. *Higher Education, Skills and Work-Based Learning.* DOI:10.1108/HESWBL-06-2015-0037

Goethe, J. W. (1790/2009). *The metamorphosis of plants*. Translated by D. Miller. The MIT Press.

Goethe, J. W. (1988a). Significant help given by an ingenious turn of phrase. In D. Miller (Ed.), *Scientific studies* (pp. 39–41). Suhrkamp Publishers.

Goethe, J. W. (1988b). The enterprise justified. In D. Miller (Ed.), *Scientific studies* (pp. 61–62). Suhrkamp Publishers.

Goethe, J. W. (1988c). Toward a general comparative theory. In D. Miller (Ed.), *Scientific studies* (pp. 53–56). Suhrkamp Publishers.

Goethe, J. W. (2015). *Goethe's poems*. Translated by G. Good. Ronsdale Press.

Goldberg, N., & Castellón, T. (2017). Experiential learning in an undergraduate ecology course: A case study with gopher tortoise (*Gopherus polyphemus* Daudin). *Florida Scientist, 80*(2/3), 117–127. https://www.jstor.org/stable/26361323

Gorrell, N. S., & Colfax, E. (2012). *Writing poetry through the eyes of science: A teacher's guide to scientific literacy and poetic response*. Equinox.

Greif, H. (2015). The Darwinian tension: Romantic science and the causal laws of nature. *Studies in History and Philosophy of Biological and Biomedical Sciences*, *53*, 53–61.

Hampton, S., & Wheeler, T. (2011). Fostering the rebirth of natural history. *Biology Letters*, *8*, 161–163. https://doi.org/10.1098/rsbl.2011.0777

Haraway, D. J. (2016). *Staying with the trouble: Making kin in the Chthulucene*. Duke University.

Hasebe-Ludt, E., Chambers, C.M., & Leggo, C. (2009). *Life writing and literary métissage as an ethos for our times.* Peter Lang.

Hasebe-Ludt, E., & Leggo, C. (Eds.) (2018). *Canadian curriculum studies: A métissage of inspiration/imagination/interconnection*. Canadian Scholars.

Haskell, D. G. (2018). *The songs of trees: Stories from nature's great connectors.* Penguin Books.

Hatch, J. (2018). Better teachers are needed to improve science education. *Nature*, 562, S2–S4. https://doi.org/10.1038/d41586-018-06830-2

Heitler, W. (1998). Goethean science. In D. Seamon & A. Zajonc (Eds.), *Goethe's way of science* (pp. 55–69). State University of New York Press.

Holdrege, C., & Talbott, S. (2010). *Beyond biotechnology: The barren promise of genetic engineering.* The University Press of Kentucky.

Howe, J. A., & Barrientos-Velazquez, A. (2020). Teaching water movement in soil through experiential activities. *Natural Sciences Education*, *49*(1), 1–8. https://doi.org/10.1002/nse2.20012

Januchowski-Hartley, S. R., Sopinka, N., Merkle, B. G., Lux, C., Zivian, A., Goff, P., & Oester, S. (2018). Poetry as a creative practice to enhance engagement and learning in conservation science. *Bioscience*, *68*(11), 905–911. https://doi.org/10.1093/biosci/biy105

Jelinski, N. A., Perrone, S. V., Blair, H. K., & Fabian, M. L. (2020). Growing hearts and minds: Linking landscapes and lifescapes in a soils field course. *Natural Sciences Education, 49*:e20018. https://doi.org/10.1002/nse2.20018

Jensen, J. L. (2011). Higher education faculty versus high school teacher: Does pedagogical preparation make a difference? *Bioscene 37*(2), 30–36.

Jose, S., Patrick, P., & Moseley, C. (2017). Experiential learning theory: The importance of outdoor classrooms in environmental education. *International Journal of Science Education*, *7*(3), 269–284. https://doi.org/10.1080/21548455.2016.1272144

Judson, G. (2018). *A walking curriculum: Evoking wonder and developing sense of place (K-12)*. Independently published.

Kimmerer, R. W. (2003). *Gathering moss: A natural and cultural history of mosses*. Oregon State University Press.

Kimmerer, R. W. (2013a). *Braiding sweetgrass: Indigenous wisdom, scientific knowledge and the teachings of plants.* Milkweed Editions.

Kimmerer, R. W. (2013b). The fortress, the river and the garden. In A. Kulnieks, D. R. Longboat, & K. Young (Eds.), *Contemporary studies in environmental and indigenous pedagogies* (pp. 49–76). Sense Publishers. https://doi.org/10.1007/978-94-6209-293-8_4

Laird, R. (2019). Object-based learning in nature: Utilizing the context of our original human heritage. Rosslaird.com. https://rosslaird.com/resources/educational-development/object-based-learning-nature

Leather, S. (2017, January 19). Ten papers that shook my world – watching empty islands fill up – Simberloff & Wilson (1969). *Don't Forget the Roundabouts*. https://simonleather.wordpress.com/2017/01/19/ten-papers-that-shook-my-world-watching-empty-islands-fill-up-simberloff-wilson-1969

Leggo, C. (2004). The curriculum of joy: Six poetic ruminations. *Journal of the Canadian Association for Curriculum Studies, 2*(2), 27–42.

Lekies, K. S., & Moore, R. H. (2020). Promoting transdisciplinary learning through a summer course on climate, water, and agriculture. *Natural Sciences Education, 49*:e20023. https://doi.org/10.1002/nse2.20023

Leopold, A. (1949). *A Sand County almanac, and sketches here and there.* Oxford University Press.

Leopold, A. (1938/2013). Natural history, the forgotten science. In C. Meine (Ed.), A Sand County almanac *& other writings on ecology and conservation* (pp. 411–415). Library of America.

Li, Y., Wang, K., Xiao, Y., & Froyd, J. (2020). Research and trends in STEM education: A systematic review of journal publications. *International Journal of STEM Education, 7*(11). https://doi.org/10.1186/s40594-020-00207-6

Locey, K. J., & Lennon, J. T. (2016). Scaling laws predict global microbial diversity. *Proceedings of the National Academy of Sciences, 113*(21), 5970–5975. https://doi.org/10.1073/pnas.1521291113

Louv, R. (2012). *Nature principle.* Algonquin Books of Chapel Hill.

Luoma, J. (1999). *Hidden forest: The biography of an ecosystem.* Henry Holt and Company.

Luther, K. (2016). *Boundary layer: Exploring the genius between worlds.* Oregon State University Press.

Lyman, D. (2017). Return of the 'ologies: Natural history makes a comeback on campus. *Undark.* https://undark.org/2017/11/27/natural-history-comeback-campus

Macnamara, J. (2018). The missing half of communication and engagement: Listening. In K. A. Johnston & M. Taylor (Eds.), *The handbook of communication engagement*. John Wiley & Sons. https://doi.org/10.1002/9781119167600.ch9

Macy, J., & Johnstone, C. (2012). *Active hope: How to face the mess we're in without going crazy.* New World Library.

Madsen, A. L. (2017). Mindfulness and nature. *Journal of Childhoods and Pedagogies School of Education and Childhood Studies*, *1*(2), 1–11.

Makaiau, A. S., Leng, L, Fukui, S. (2015). Journaling and self-study in an international research collective. *Studying Teacher Education*, *11*(1), 64–80, https://doi.org/10.1080/17425964.2015.1013025

Matthews, F. (2008). Thinking from within the calyx of nature. *Environmental Values*, *17*, 41– 65.

Miller, J. (1981). Romanticism and science education. *The Science Teacher, 48*(9), 9–11.

Miller, R. (2000). *Caring for new life: Essays on holistic education*. Brandon, VT: Foundation for Educational Renewal.

Neilsen, L. (2004). Learning to listen: Data as poetry: Poetry as data. *Journal of Critical Inquiry into Curriculum and Instruction, 5*(2), 40–42.

Panikkar, R. (1995). A nonary of priorities. *Catalònia, 42*, 5–11.

Park, B. J., Tsunetsugu, Y., Kasetani, T., Kagawa, T., & Miyazaki, Y. (2010). The physiological effects of Shinrin-yoku (taking in the forest atmosphere or forest bathing): Evidence from field experiments in 24 forests across Japan. *Environmental Health and Preventive Medicine, 15*(1), 18–26. https://doi.org/10.1007/s12199-009-0086-9

Reason, P., & Goodwin, B. C. (1999). Toward a science of qualities in organizations: Lessons from complexity theory and postmodern biology. *Concepts and Transformations, 4*(3), 281–317.

Real, L. A., & Brown, J. H. (1991). *Foundations of ecology: Classic papers with commentaries*. The University of Chicago Press.

Reynolds, S. (2007). A Goethean approach to science education. *Journal of Curriculum and Pedagogy*, *4*(1), 160–171. https://doi.org/10.1080/15505170.2007.10411632

Richards, R. (2002). *The Romantic conception of life: Science and philosophy in the age of Goethe.* The University of Chicago Press.

Ricklefs, R., & Relyea, R. (2014). *Ecology: The economy of nature* (7th ed.). W.H. Freeman and Company.

Ríos-Saldaña, C. A., Delibes-Mateos, M., & Ferreira, C. C. (2018). Are fieldwork studies being relegated to second place in conservation science? Global Ecology and Conservation, *14*. https://doi.org/10.1016/j.gecco.2018.e00389

Rocha, L., Aleixo, A., Allen, G., Almeda, F., Baldwin, C., Barclay, M., Bates, J., Bauer, A., Benzoni, F., Berns, C., Berumen, M., Blackburn, D., Blum, S., Bolaños, F., Bowie, R., Britz, R., Brown, R., Cadena, C., Carpenter, K., … Witt, C. (2014, May 23). Specimen collection: An essential tool [Letters]. Science, 344(6186), 814–815. DOI:10.1126/science.344.6186.814

Robbins, B. D. (2005). New organs of perception: Goethean science as a cultural therapeutics. *Janus Head*, *8*(1), 113–126.

Robertson, R. (2016). *Goethe: A very short introduction*. Oxford University Press.

Sameshima, P., Fidyk, A., James, K., & Leggo, C. (Eds.). (2017). *Poetic inquiry: Enchantments of place*. Vernon Press.

Schulz, R. (2014). Philosophy of education and science education: A vital but underdeveloped relationship. In M. R. Matthews (Ed.), *International handbook of research in history, philosophy and science teaching* (pp. 1259–1316). Springer.

Sengupta, P., Shanahan, M-C., & Kim, B. (Eds.). (2019). *Critical, transdisciplinary and embodied approaches in STEM education.* Springer. https://doi.org/10.1007/978-3-030-29489-2

Simberloff, D. S., & Wilson, E. O. Experimental zoogeography of islands: The colonization of empty islands. *Ecology*, *50*(2), 278–296.

Simpson, L. B. (2017). *As we have always done: Indigenous freedom through radical resistance.* University of Minnesota Press.

Skamp, K. (2020). *Research in science education* (RISE): A review (and story) of research in RISE articles (1994–2018). *Research in Science Education*. https://doi.org/10.1007/s11165-020-09934-w

Sridhar, H. (2018, March 12). *Revisiting Simberloff and Wilson 1969*. Reflections on papers past. https://reflectionsonpaperspast.wordpress.com/2018/03/12/revisiting-simberloff-and-wilson-1969

Takeuchi, M. A., Sengupta, P., Shanahan, M-C., Adams, J. D., & Hachem, M. (2020). Transdisciplinarity in STEM education: A critical review. *Studies in Science Education, 56*(2), 213–253. https://doi.org/10.1080/03057267.2020.1755802

Terkowsky, C., May, D., & Haertel, T., & Pleul, C. (2013). Integrating remote labs into personal learning environments. *International Journal of Online Engineering, 9*, 12–20. 10.3991/ijoe.v9i1.2364.

Thomas, S. M. (2016). Geopoetics: An opening of the world. In K. T. Galvin & M. Prendergast (Eds.), *Poetic inquiry II – Seeing, caring, understanding: Using poetry as and for inquiry* (pp. 191–201). Sense Publishers.

Turner, N. J. (2005). *The Earth's blanket: Traditional teachings for sustainable living.* Douglas & McIntyre.

Twohig-Bennett, C., & Jones, A. (2018). The health benefits of the great outdoors: A systematic review of meta-analysis of greenspace exposure and health outcomes. *Environmental Research, 166*, 628–637. https://doi.org/10.1016/j.envres.2018.06.030

Tyson, C. (2019, May 7). A legendary scientist sounds off on the trouble with STEM. *The Chronicle of Higher Education*. https://www.chronicle.com/article/a-legendary-scientist-sounds-off-on-the-trouble-with-stem/

Uexküll, J. (1934/2010). *A foray into the worlds of animals and humans.* University of Minnesota Press.

Vojíř, K., & Rusek, M. (2019). Science education textbook research trends: A systematic literature review. *International Journal of Science Education*, *41*(11), 1496–1516. https://doi.org/10.1080/09500693.2019.1613584

Wahl, D. C. (2005). "Zarte Empirie": Goethean science as a way of knowing. *Janus Head, 8*(1), 58–76.

Walsh, S., Bickel, B. & Leggo, C. (Eds.) (2015). *Arts-based and contemplative practices in research and teaching: Honoring presence.* Routledge.

Wilson, E. O. (1994). *Naturalist*. Island Press.

Wilson, E. O. (1998). *Consilience: The unity of knowledge*. Knopf.

Wilson, E. O. (2011). Forward. In M. R. Canfield (Ed.), *Field notes on science and nature* (pp. ix–xvi). Harvard University.

Wilson, E. O., & Simberloff, D. S. (1969). Experimental zoogeography of islands: Defaunation and monitoring techniques. *Ecology*, *50*(2), 267–278

Wolfson, A. J., & Armstrong, J. (2020). A team-taught interdisciplinary first-year seminar with a focus on blood. *Journal of College Science Teaching*, *49*(3), 22–26.

Young, J. & Gardoqui, D. (2013). *What the robin knows: How birds reveal the secrets of the natural world.* Houghton Mifflin Harcourt Company.

Chapter 1.

Offerings on the Mountain

Preamble: Beginning with Story

This narrative, Offerings on the Mountain, serves as a literary introduction to the rest of my thesis. In addition to providing an example of an intentional, outdoor experience that proved transformative, it also emphasizes and elucidates key thematic points relevant to my thesis. Goethean science involves an acknowledgement of bias, dissolution of the subject-object orientation, and reciprocal exchange with natural phenomena. This narrative reveals each of these, and the fruitions of storytelling, as described by Donna Haraway (2016): "comforting, inspiring, remembering, warning, nurturing compassion, mourning, and becoming-with each other in their differences, hopes and terrors" (p. 150). There are also elements of Indigenous philosophy, phenomenology, nature as co-teacher/researcher, and an emphasis on holistic learning where we "engage all four aspects of our human gifts, mind, body, emotion and the spirit" (Kimmerer, 2013, p. 49). In the Goethean sense, I am following nature, rather than interrogating her (Landman-Reiner, 2020).

As Blenkinsop and Beeman (2010) explain, this is "an example of the direct encounter between an individual and the wilderness where the more-than-human world embraces the learner and provides opportunities for learning, as any good teacher might" (p. 31). Nature is a peerless educator, cultivating humility, yet "also acceptance, forgiveness, gentleness, and even love" (p. 33). The very nature of less structured, deeply intimate, heuristic outdoor encounters facilitates unique experiences for every individual: positive, negative, or neutral. Not all experiences will be exceptional. My sharing is a positive example, and attempts to unearth my relationship with the natural world, a journey of personal growth, and my stepping into a new framework of thinking where nature is neither backdrop nor an other, but rather part of a larger community whose teachings can best be heard through quiet, immersive presence.

Asfeldt and Beames (2017) state, “We need both traditional positivist and more story-based research in our quest for understanding” (p. 81). Stories are increasingly used as research data, especially in realms such as nature experience where quantifying experience is not only difficult, but ultimately limiting. ‘Offerings on the Mountain’ “privileges the richness of human narrative and the role of story” (p. 74), and “constructs characters and events so readers can enter vicariously into a sense of lived experience” (Leggo, 2008, p. 11). Through this telling, the evocative sense journeys and teachings of the mountain may be revealed to the reader. In speaking to ‘animated perception’, Bai (2015) explains, “We know it subjectively when we see, feel, taste, and hear the world differently: more alive, vivid, curious, awe-inspired, present, sacred, meaningful” (p. 144). This was my experience at the Sacred Mountain that I hope to evoke in science education.

As part of my research and self-reflexive praxis, the following narrative relates my experience during the PeerSpirit Wilderness Quest at Skalitude Retreat Center, located on the ancestral lands of the Native American Methow tribe, that occurred during June 9 to 11, 2016. Facilitated by Ann Linnea and Christina Baldwin, this journey coincided closely with the commencement of my dissertation research and writing, and feels apropos to commence my thesis. The PhD journey is a deeply personal process, interrogating one’s own values, confronting personal biases, and managing time for family, work, and school. This journey ultimately led to a metamorphosis of the author, which is reflected in my thesis. ✺

Offerings on the Mountain

“Speak your intention.”

“I want to cultivate spaciousness in a life busy with PhD, work and family. To cultivate space for time with my wife, and our second child soon to come.”

The trembling aspen quiver with anticipation. Twelve disciples of the mountain have travelled from as far as Australia to be here, in the meadow’s dawn. We form a quiet

line, the sun yet to burn away the flickers of dew. Each of us will journey alone, without food, books, or email, staples of life.

I wait my turn to enter a vast stone circle, whose diameter stretches wider than my house. The days leading up to this ritual—circle sharing, reflective writing—call me to a simple act. To raise my hand to my heart. Yet I resist, weighed down by convention and self-consciousness. For fear of being wrong, of judgement, of baring my inner world. Torn between habit and vulnerability, I place one, and then both, palms on my chest, melting into presence.

I cross into the circle. A guide wraps me in a blanket, and the memories of journeys past. We step in tandem, toward the medicine wheel's center lit by the smiles of the second and third guides. Smudged with sage by an eagle feather, an intentional honouring that lifts away my doubts, the first question is asked: "Have you brought a sacred object to leave with us?" I offer a moss-riven branch, gathered from my home, and now accepted and held in tender hands. A palpable tenderness, embraced in the empathic wisdom of our hosts, a triad of wise grandmothers.

I walk east-west across the medicine wheel, each step planted with care. A huge quartz stone marks the center. Its glitter crawls with fire ants, guardians of the sacred. At the western exit, a final question:

"Are you ready to enter the underworld?"

"I am ready."

She removes the blanket and I step from the stone circle into the underworld, now invisible to the guides. This quest is done without the company of humans.

I set out due north. In this long meadow of wind and grass, I hum *The Lord of the Rings*, De-DAH-DAH-de-de-DAH. When I left my Canadian home to be here, my wife sang the Fellowship melody to me in full. She's not a huge Lord of the Rings fan; this act shows why I love her. Pregnant with our second child, to be born twenty-three days from now, she actually recommended this sacred mountain journey.

My steps are quick, fox-like. Growing up, my dad conditioned me to hike with mindful haste. A hurried pace, yet watchful of wonders. However, this journey is antithetical to speed: solitude, stillness, dwelling in deep time. The tall grass ripples. I try to follow the hidden currents. The lullaby of wind whispered by ten thousand green blades. My fingers strain from gripping a full gallon of water in each hand, my sole sustenance for the next forty-eight hours. My tent, sleeping bag and mat, clothes, journal, art supplies—but not a scrap of food—burden my back.

I walk on the ancestral lands of the Native American Methow tribe, whose name means low valley surrounded by hills. In this place, they hunted bighorn sheep and fished salmon, gathered berries and roots, prayed before the harvest. They had songs for every custom, now lost to smallpox, land theft, and genocidal colonization. I struggle to reconcile my own presence here. How to hold the sacred in this place?

I pass the verdant grass surrounding an Artesian well, comforted by this water source. Up the spine of the mountain, pine needles and eviscerated Douglas-fir cones soften my footsteps. A voracious squirrel chatters at me between mouthfuls of conifer seed.

The vanilla-infused scent of pine halts my step. A line of stout ponderosa marks my forward path. Named for its ponderous size, I put my hand on the grooved bark, feeling the might and memory within. I scrape my fingers across blackened bark. Ponderosa is a fiery paradox, both resistant to flame, and reliant on forest fires to grow more seeds. Ponderosa are home to both feathered and furred beings. Once used by natives to make dugout canoes, and now cut down to construct human houses.

Filled with purpose, I follow the fragrant trail of butterscotch. At the end of a ridge thrusting toward the mountain's heart, flanked by a towering, orangey-brown ponderosa, I arrive. Bear dung lumps this otherwise flat patch of earth. The sentinel pine stands to one side, its top half stripped to barkless yellow, the bottom boughs ripe with needles and lichen nests. I presumed my tent site to be beneath the pine, yet the quiet presence of the ponderosa tells me: *this place is to sit*. So I pitch my tent on the other side, put up a shelter tarp, and unfold the tiny chair to serve as my contemplative throne.

But there's more to be done.

The wolf lichen seduces me. This symbiotic fungi, a surge of neon capillaries, drapes on the pines like flashes of lightning. Glowing with a yellow sunscreen of vulpinic acid, this partnership of fungus and algae resembles a lush ball of roots. The fungal partner provides a crusty home, while the alga surrenders their cell walls and captures sunlight to make sugar. This reciprocal union inspires my search.

Like a bowerbird trying to attract a mate, I gather fallen lichen into a semi-circle in front of my chair. Then I unpack six colours of prayer flags, hand cut by me from cloth provided by my hosts. I punch a hole in each with my Swiss Army knife and thread them with twine. Burrs stick to my string of flags. Annoyed, I pluck them off. After attaching either end to ponderosa branches, I sit with an important realization.

The preparation is the work.

The establishment of shelter, ceremony of lichen gathering, and hanging of prayer flags are fundamental to the process. This *is* the work. The same way a spider weaves a mandala, you gather yourself and prepare the space.

A wind gusts up the ridge, sweet with pollen. The prayer flags shift and bunch up. I forgot to tie the string to each flag, so they keep sliding to the centre. All except one.

I look closer. Several burrs attached to the flag hold it to the string. The burrs want to be here. I gather those I discarded, stick them to where the flags meet the string, and they do not move again.

"Thank you."

I linger next to Ponderosa, my tall green relative, breathing in the late morning lull. The longer I'm still, the more I see. The ant highway up the bark. A chipmunk natters between bites of thistle. Clouds fill in the sky blue canvas. My stomach growls. I drink some water. Still hungry. I notice some bear scat near my tent, and I am suddenly overcome with fear.

This is unusual. I don't get bear-fear.

I know they are around. Someone spotted fresh bear poop a few days prior. There's no food to attract this omnivore. So why am I scared now? Because I'm alone? Or am I attuned to something important?

My last meal—the night before—is a distant memory. I drink more water. I need to pee. Again. I find a new spot to mark my territory, completing the circle of urine. That should keep the bears away.

The breeze, or lack of food, goosebumps my skin. I put my windbreaker on. Something crackles in the pocket. A Caramilk bar! Except the wrapper is *empty*. I feel the urge to slap it against my face, breathe in chocolate residue, and lick the wrapper clean. Instead, I put both the wrapper and this thought out of mind.

I can't quench my hunger, but I can quench my fatigue. I slip into the tent, wriggle into my sleeping bag, and tumble into dreamless sleep.

I wake, a dull throb in my temples. There is no book, screen, or device to distract. The mountain, it feels, has a way to both hold and expose vulnerability.

The lichen calls. Bright green tendrils that mesmerize, fertile veins with ends like tapered synapses. Ponderosa looms above me. Branches spiral to the sky. Yet perhaps it's prudent to scale this tree closer to when my 'buddy pile' will be checked. Tomorrow. Each pair of questers has a pre-selected location, roughly halfway between their sites, where they set up rock pyramids, mini-log cabins, or other obviously human-made construction. Then, every twelve hours, one buddy visits the buddy pile and makes an adjustment, removing a stone or turning a log. This way, we check on our buddy without interrupting their journey.

A bee buzzes into my hair. I let it be. I'm happy out here, steeping in this alpine soundscape. The wending wind like low-lying thunder. Drawn out insect calls trill for minutes on end, cut silent by a darting dragonfly. A pair of warblers *chek-chek-chek* at each other. *Where are you?* Over here. *Any food?* The human might have some.

I sit. I write. I drink more water, and strategically mark my territory. Fatigue bears down on me again, and I retreat to the tent. So easy to find sleep. When I wake, the sun has skipped half the sky. Without a watch to tell time, I look to the long arms of shadow.

I feel a familiar push. Be productive. Make use of your time. Reflect, explore, write, accomplish *something*. My brain is well-trained for efficiency: marking during my son's nap, writing papers on transit, updating my academic CV after my wife goes to bed. Juggling fatherhood, work and PhD keeps my adrenal glands well-toned. Yesterday, our guides spoke of the importance of the Death Lodge. This is where I give my focus. However uncertain I am about creating a Death Lodge—something I've never done, let alone erected—this gives my mind a project. I love a good project.

One of the facilitators of this journey has long apprenticed in sacred quests, and makes an annual Death Lodge. She describes it as a 'temple of reconciliation.' It is a spiritual journey into the unknown, into what has been forgotten. I'm responsible for self-generating this ceremony of healing and resolution.

I recall a story of Methow tribal leaders taking the train to Washington, and returning home ill. The unknown disease swept through the tribe, killing many. Later, whenever the train passed, the women and widows lined up, turning their backs on the train. When the train whistle blew, did this invoke the lost dead?

I wander west. Grassy ridges undulate to hollows with skeletal ponderosa. These trees keep close to the earth, limbs drooping like unwatered house plants. A perfect place for a Death Lodge.

Begin the preparation. The ground is a prickly blanket of pine needle and cone, pushed aside with my hiking boot. I clear a circle in the forest floor, like a male pufferfish building their mysterious mandalas on the seabed. What am I calling in?

I line the perimeter with fallen photosynthesizers and germinators. One hundred cones later, I grow weary of the exercise. Yet I have vowed to complete the Death Lodge as envisioned. In my ever-widening search for cones, I come across a large, fallen branch. Barkless, whitened by age, with small branches of its own, I realize this was once a

young tree, now dead. Next to me, this staff towers nearly ten feet. I go to lean this dead offspring against a gnarled trunk. *Is this your mother?*

Then comes the threshold, a place to cross over into the Death Lodge. As I enter, something flutters in the leafless canopy. A bird, lime-bodied with a pink crested head which I have never seen before nor since. Perched on a stunted, barren pine, this exotic bird bears witness.

The moment feels anti-climactic. I'm alone inside the Death Lodge, standing in the same place I was thirty minutes ago. What has changed?

I have come here with an intention. An invitation was made, and now I must answer the call.

"I am Lee, and this is my Death Lodge."

Who is there? Plucking up my resolve, I repeat this question aloud. "Is anyone here?"

Nothing. Even the bird has disappeared.

"Is anyone here? I'm ready."

These last two words feel important. I need to be receptive.

"I am ready."

Twilight settles, dark branches silhouetted against grey. I am no longer alone.

My fun-loving Auntie Chris arrives first. Perhaps because her death is more palpable. I sat with her at Peace Arch Hospital on her final night, placing a hand on her gaunt body. Later that morning, her breathing still, I went with my mother to say a last goodbye. Though Auntie Chris never liked to say goodbye. "Tootaloo," she always said.

Now she's with me, here in the forested slopes of the Cascade Mountains. I ask her what it's like on the other side. Any answer she gives is as amorphous as this

experience. I thank her for making tea for me when I was a child. Letting me use her colour pastels. Borrow her Corvette to do my paper route.

A parade of familial souls visit my Death Lodge.

Free-spirited Uncle Raymond, who died so young. His last gift to me was a watch I never used.

Aunt Betty. Playwright, professor, with a larger-than-life personality, she died when I was five. She let me play with her Russian nesting dolls. “What is the final demand of life?” was her last question. “More and more nostalgia.” My mother told stories of their childhood until her sister died in her arms.

Loud and proud grandpa Tom. What do you think of this Death Lodge business? Silly nonsense, I imagine.

Kit and Bessie, my maternal grandparents. Anglicans, torn apart by a drowning tragedy when my mom was six years old. Her beloved father, Kit, took the sailboat Skylark he had built out on its maiden voyage and drowned. Bessie, my courageous grandmother, was left a young widow with three daughters. Even after all these years, my mother’s stories bring them alive to me.

My heart fills with a terrific wonder. Miracle upon miracle has led me to this moment. My great-grandmother’s cancelled steerage class ticket on the Titanic, my dad hitchhiking across Canada in three days to meet my mom. All the bodies I have passed through to be here, each precise sperm that found a specific egg. I stand here, now, because of the struggle and resilience of countless ancestors.

My first other-than-human visitor arrives. Kasha, the beautiful calico cat. Her mother birthed on our front porch—with my mom and I playing midwives—then moved the kittens to my closet. It was outside this closet, some thirteen years later, where I lay beside her while she took her last, strangled breath. I don’t think I’ve cried more in my life.

There are others. The most important conversation in the Death Lodge is with my final visitor.

Early twenties. Self-conscious, shy, introverted. A budding biologist with a passion for cheetahs. Quietly observant and discerningly judgmental.

"Hello," I offer.

The voice that responds is shaky. A slight stutter, nervous hands, but steady eye contact. I can't make out his words, strung together like an auctioneer's chant.

This is me. Me from two decades ago.

He wanted to study big cats in Africa. To live as a mountain hermit and write fantasy novels. Yet also to get married, have a family, start kitchen dance parties.

The man before me represents the first half of my life. A lot has happened. Some people might be intimidated by this encounter, but (ever the introvert) I quite enjoy talking to myself.

How did we get here? We've changed a lot. *In some ways.* What's different? *What's the same?* We've managed to love ourselves then and now.

Gratitude floods through me for my still-living parents. Their love infused me with self-worth, even if they divorced thirty years after I was born. Though we never did figure out my severe shyness. Perhaps a cross between acute sensitivity and being *too* sheltered from the world. A super feeler, like my son.

A question escapes my lips. "What is our greatest challenge?"

We confer without speaking. Part of the answer is easy. Confidence. Speaking up. Presentations were terrifying. Nothing could be worse than teaching a *whole* class of students. Yet here we are.

Another question pours forth, "How can we be our most authentic self?"

I am busier now than I was then. Productivity brain crowds out emotional processing and heart listening. When the "to do" list is long, the PhD demanding, and parental duties many, I can forget to notice my own feelings, and that of others. I just *do*. Being in nature can bring me back to presence, though I need to be outside long enough to forget my responsibilities.

From this discussion with myself emerges the start of a mantra.

Presence. Confidence.

There's more. I put my hand to my heart. This time, not so awkward a gesture. It's simply needed.

Presence. Confidence. Heart.

We let this sink in, washing over us like a warm summer rain.

Presence. Confidence. Heart.

This isn't enough. We need to speak this out loud.

"Presence. Confidence. Heart."

Try again.

"Presence! Confidence! Heart!"

Okay, we're getting somewhere.

We are quiet for a time, both comfortable not speaking. I sense we are done.

"Thank you."

I step out, and close off the Death Lodge. I pick up the staff I had placed next to a trunk, take a final glance back at that melange of memory, spirit and self, and trek back to my mountain home.

The under-canopy crawls with shadows. I walk unafraid. The staff of confidence has erased any remnant of bear fear. Back at camp, I'm surprised to find the sun still skyborne. A slow tide of darkness rises up the eastern ridge. With my back to the sun, I witness the day meet its end.

Bear scat is *everywhere*. It's morning, and I examine these pancake-like poops more closely, from a place of curiosity rather than fear. *What a fool!* This scat doesn't belong to an omnivore. I am surrounded by circle after circle of manure. Cow pies. The local farmer must let them graze here. It's amazing how anxiety distorts your perception.

A sound floats on the morning air, then disappears. A wind instrument. I pause and listen. This is why I'm here, after all. To notice what I'm usually too busy to notice.

Tender and lilting, born of and on the wind. A flute. For a moment, I can't fathom the sound. How can such a tone carry all the way from the meadow? Yet here it is. Airy, poignant, and utterly heartbreaking. I stop questioning its existence, silence my rational mind, and let this sorrow sing down my spine.

For me, the flute holds a long history. My mom first met my dad in a hospital, where she came to see her sister who was not expected to survive a heart infection. As she hugged her sister she heard the mystical sound of my dad's bamboo flute floating down the hallway. The three elderly ladies in my aunt's hospital room twittered in excitement: "It's Nelson! It's Nelson!" When I was born during a thunderstorm, and began to wail in the delivery room, my dad played his flute. The room went quiet, the nurses stopped fussing with me, and I became still. As my wife-to-be walked to our wedding ceremony site under a 1000-year-old Douglas-fir, the first sound I heard heralding her imminent arrival was my father's flute. Coming to meet my newborn son for the first time, born at home during a power outage, my dad's flute sounds floated up the stairs before he did. His flute epitomizes reverent joy.

Now I'm on this sacred mountain, being serenaded by a flautist's dirge. Only later do I discover the truth. Another quester downhill from me found a baby deer dead. Her song of mourning cuts deep, a flight of melancholy I cannot escape. I think of those I

have lost, and those I will someday lose. Yet later that day, being a master of feigning nonexistence, the baby deer up and left.

I sit for a time, consoled by Ponderosa. I'm ready to climb this tree.

The bark bulges where a branch once grew. Lodging my shoe here, I reach for the lowest bough, and promptly feel something scurry across my fingers. I drop back to the ground. What was that? I can't see anything.

I try again. This time, I pay attention. I watch where I put my hand, right into a stream of ants. Red ants.

Red means trouble. In the Amazon, I've come across bullet ants. The most painful insect bite in the world. I'm not sure if Washington bugs carry such bites. But in trying to climb this tree, there's a message I need to hear. *Remember your pledge to care for yourself. For the group's sake*. If something happens to me—I fall, or get bitten by a nasty ant guard—this might disrupt others on their sacred quest, as they would come to my rescue. Best to let this go.

Time to check on my buddy pile. The line of ancient ponderosa pine serve as signposts to the main trail. With my staff of confidence in hand, I stop to marvel at their brilliant orange bark. Beacons of fortitude in this alpine forest.

That's when I see it. Bear scat. Lumpy, tubular poop, deposited in the middle of the path. I walked this very spot yesterday. This is fresh.

There is a bear in the area, but I don't need to fear him.

I check the buddy pile. My buddy has built a lichen installation, a multi-layered, symbiotic construction. A note is tucked under a stone.

What whispers with quiet insistence?

This day feels less purposeful. Should this matter? At the Artesian well, I watch the current, its endless eddies hypnotic like a water colour painting in constant motion. I dunk my head into the refreshing spring. Something keeps me alert. I'm not scared, exactly. But attentive. If there's a bear about, I don't want to surprise him.

Back at camp, a steady rain carries the afternoon away. Sitting under the tarp, I'm reasonably content not doing much. After the rain, the explorer's bug takes hold.

Up and down three ridges I go, each rise and fall like very slow waves of the mountain. There's a certain point where the neon green lichen disappears, as though the ecological soup is too cold and dry to tolerate this elevation.

As the second and final evening of my sojourn descends, I settle on a high ridge. Sitting in an ocean of seeded dandelion, my sore leg muscles feeling content, I spy ten thousand treetops. Hummingbirds *tsk tsk tsk* then free fall in the open air. A slow breeze, subtle yet insistent, tugs at my awareness. I turn my gaze upward. The wind strengthens, just enough to release the seeds from dandelions that have waited all year for this moment. The seeds float forth as offerings from the mountain. Huge seeds, like miniature hot-air balloons. The biggest dandelion seeds I have ever seen. I once heard Robin Wall Kimmerer call these lion's teeth "global citizens and our global teachers."

That's when I hear it. In this moment of witness something rises up from the valley far below. The breath of the Earth, the transmission of life. I catch a sliver of sound and then it's gone. I cup my ears to mimic the deer that share their mountain with me. The wind shifts to accommodate my desire, and the music is a straight blast to my heart.

Drums.

Drums from wise grandmothers.

Drums to carry us forward on our sacred mountain quest.

From the valley scarcely in view, our elder hosts are wailing on drums. I cannot see them, but I can feel them. The fickle wind dances snippets into my ears. I stretch my

senses. I can taste the tender and percussive joy of each beat. The drums reverberate inside my chest. My heart wants to reach out and embrace this sound. A wonder and beauty made possible by this place, my attentiveness to this place, the beings that call this place home, and the humans who have crafted this experience with such blessed attention and care.

I pick a dandelion and blow. The seeds drift down, greeted by the vibrations below. In this meeting of seed and sound I sit, transfixed, wondering why I would ever move again.

Presence. Confidence. Heart.

Twilight whispers me toward camp. In a dark grove of stunted ponderosa, I notice some low and sturdy boughs. They easily hold my weight. Up I go, eager to climb this ant-less tree, spiraling up to the highest branch. From this perch, I recall the green bird from yesterday, who perhaps studied me from this very spot. I squint my eyes to see what that feathered prophet saw.

This is a place of deep memory. Not far below, remnants of pine branches form a rough circle. Not my Death Lodge; some time ago, another quester came here to construct a portal to the past. I feel held by this thread of tribal connection, as though my family surrounds me here in the forest.

Back at camp, I'm not ready for sleep. And neither is the day.

In the gloaming hour, the sky turns indecisive. The west-leaning sun crowns the treed horizon in gold. To the east, rain falls, glittering with crepuscular light. My mind struggles to perceive these conflicting meteorologies. On this small ridge I feel a kind of vulnerable awe. I'm at a threshold, but I'm not sure which way to go. These are perfect conditions for a prismatic arc to explode colour across the sky. I turn east, searching in vain for the rainbow that isn't there, until the western ridge swallows the sun.

I feel the wind before the rain. The droplets plummet at an angle, drawn out into long lines like a child stretching play dough. Miniature shooting stars. My mind thinks: sleet. Yet it's not cold enough. I relish in this climatic mystery.

It's hard not to feel what the sky feels. The joy of the sun, the thirst of the rain, the roiling of the clouds. Here on the mountain, I wear my emotion.

What whispers with quiet insistence?

Thunder booms. The sound rolls over the hills like slithering sheet metal. The next blast rattles my eardrums. I am trapped in an orchestra of cymbals. Rooted to the spot, caught in a trance of wonder-terror, I cannot take my eyes off these elemental fireworks. No—that's not right. Although my eyes have adjusted to the dim light of a shrouded crescent moon, the pines bereft of all colour but grey, sight is no longer my primary sense. This experience ripples through my body like lightning.

The air is electric. My skin tingles. Each thunderclap echoes through my skull, shaking my organs. My heartbeat spikes. The deafening sound rumbles away far longer than seems possible, as though the earth is howling in response. I reach out my tongue and taste the sky. Heavy, viscous, charged.

There is too much to hold, too much exposed. I retreat to my tent, grounding myself in my sleeping bag.

Up until this point, sleep has come easy. Without the distractions of meals, good books, or deadlines, my brain swiftly settles. Tonight is different.

I lie awake until the storm scatters. Insects whir back to life, then go silent. I slow my breathing. I try lying down Vipassana meditation, bringing my focus, step-by-bodily-step, from my topmost hairs down to my pinky toe. I feel calm, yet undeniably awake, and desperately alone.

What whispers with quiet insistence?

I thank the day, speaking gratitude for common weeds, drumming grandmothers, for all that the clouds birthed this evening.

What more is there?

A presence drifts into my tent. Someone familiar. My wife enters my heart. During her pregnancy, I was too busy to appreciate everything she was going through. Sure, I accomplished plenty: innovative lesson plans, going to every midwife appointment, garnering multiple scholarships. Yet the more I built up my academic CV, the less I saw and felt her true heart.

With my cup so full of work, PhD, and parenting, when an emotional window opens, I collapse under the other weights. You can't multi-task a relationship. Full presence requires intention and space.

I still can't sleep. There is something more to be said. *Speak up!*

"I'm sorry."

These words float out from the tent, like a balloon disappearing into the sky, a release that brings me some peace. Yet I remain awake.

"I'm sorry I couldn't be there for you the way you needed."

I repeat this, more times than I can remember. There is something more to be said.

I put one palm to my heart, then the other. "I pledge to be more present. To slow down so I can hear your heart. To show you my authentic self."

The darkness responds with silence. My heart feels a poem rising, the one I wrote for our firstborn. I recite:

Welcome to the world
and the light of the sun and magic of the moon

Welcome to this land
and the song of the river and the tree

Welcome to your mom
with jubilant colours and courageous spirit

Welcome to your dad
with fantastic wonder and words so wise

Welcome to your home
where your heart sings and your spirit soars

With these words, my heart softens. My body still holds the thunder that woke the mountain, and stirred something inside me. Yet I notice a calmness to my breath. When I close my eyes, I am back on the ridge. I feel the drumbeats rise like the voice of the valley, calling for the dandelion seeds. This waking dream, of seeds floating ever so gently in search of a home, whispers me to sleep.

I wake to a fine drizzle. Hunched beneath the tarp, I wait out the rain. But I don't feel like sitting. I break camp, giving thanks to the cow pies and ant-highways, to this place of transformation. To my guides, human and otherwise. The bear for confidence, the pines for presence. With a final glance at lichen-draped Ponderosa, and despite the heavy gear on my back, I nearly leap down the mountain. The staff of confidence, towering over my six-foot frame, feels like a twig.

At the other end awaits the medicine wheel, the exit from the underworld. Mist folds through the valley, pearls of dew sparkling the grass. I feel myself beam, bursting with blessing and gratitude. Yet my gaze is drawn backward. A copse of ponderosa pine serve as witness to my return. I have had many love affairs with trees, from the weeping willow's sprawling haven, the profound stillness of Douglas-fir, and the arbutus that curves gold. Pines have always eluded my wonder. Too simple. Too ordinary. Too modest.

The sun has slivered gold over the east ridge. Long pine needles, sheathed in dew, are backlit by the sun. Thousands of icicles catching the light. Paralyzed by wonder, I fall in love with the pine.

Presence. Confidence. Heart.

Figure 1.1. The author on the sacred mountain.
Credit: Painting by Sofia Jain Schlaepfer, 2020.

References

Asfeldt, M. & Beames, S. (2017). Trusting the journey: Embracing the unpredictable and difficult to measure nature of wilderness educational expeditions. *Journal of Experiential Education, 40*(1), 72–86. https://doi.org/10.1177/1053825916676101

Bai, H. (2015). Peace with the earth: Animism and contemplative ways. *Cultural Studies of Science Education, 10*, 135–147. https://doi.org/10.1007/s11422-013-9501-z

Blenkinsop, S. & Beeman, C. (2010). The world as co-teacher: Learning to work with a peerless colleague. *The Trumpeter*, *26*(3), 26–39.

Kimmerer, R. W. (2013). The fortress, the river and the garden. In A. Kulnieks, D. R. Longboat, & K. Young (Eds.), *Contemporary studies in environmental and indigenous pedagogies* (pp. 49–76). Sense Publishers. https://doi.org/10.1007/978-94-6209-293-8_4

Landman-Reiner, A. (2020). Complementing reductionism: Goethean science part 2: Life's unique principles. *EXPLORE: The Journal of Science & Healing*. https://doi.org/10.1016/j.explore.2020.02.015

Leggo, C. (2008). Narrative Inquiry: Attending to the art of discourse. *Language and Literacy, 10*(1). https://doi.org/10.20360/G2SG6Q

Chapter 2.

The Life of Blossom:
Living Poetically in the Anthropocene

2.1. Preamble

I still hold the teachings from the sacred mountain (Chapter 1) close to my heart. Following this journey, the current chapter is a dialogue around living poetically, of which 'Offerings on the Mountain' is a prime example. Context for the current ecological state of the world is provided, and poetic inquiry is presented as not only a tool of the science educator, but also a method of wading through the emotional trauma brought by our species' destructive attitudes and actions. The importance of art-based methodologies is embedded throughout my thesis, and this chapter reveals their potential to shift perspective and consider other avenues of thought and action. ✺

2.2. Prelude

The term Anthropocene has been circulating among ecological theorists and geologists for some time. Thomas Berry (1999) and Zalasiewicz et al. (2010) have alluded to a geological epoch marked by human activity. The extent of human impact on the planet is increasingly alarming, as scientists now consider the unfolding implications of the Anthropocene (Waters et al., 2016) and the ramifications of anthropogenic climate change (Intergovernmental Panel on Climate Change [IPCC], 2014).

The spectre of climate change has the potential to affect most plant and animal life on the planet. The Earth, a primary system that generates the propitious conditions for life, is the great unifier that nourishes all beings. The profusion of human cultural and technological achievement has been supported by the temperate climate of the inter-glacial period following the Pleistocene. However, the advent of the Anthropocene marks a new epoch of geological history, where tumultuous ecological disruptions will dramatically impact global civilization and human culture. Hebrides et al. (2018) and

other Wild Pedagogies philosophers argue that "any educational conception and delivery that results in inculcation into present cultural norms…will do nothing to change the current trajectory nor prepare learners for the new reality" (p. 59). Given this, we must turn to alternative theorists that discern our complicit nature in the industrial-exploitative paradigm.

According to deep ecology, the environmental crisis stems from a fractured human consciousness in relation to land and the web of life (Berry, 2006; Devall & Sessions, 2001). Recognizing our membership in a disruptive species, we, the authors, cannot help but confront our destructive impulses. The path to ecological harmony cuts through our inner landscape—in navigating doubt and despair, we witness our own complicity in modern capitalist-industrial systems of exploitation. Conversely, the possibility of healing and reconnection cannot be found outside the very consciousness that has wreaked havoc. As educators, environmentalists, and nature-lovers in an over-developed, Western nation (Canada), we, the authors, continue to be troubled by our participation in the current system, and have committed much of our lives to personal and collective transformation. How does one abide the inevitable anguish related to the demise of a beloved paradise? How do we hold the pain of watching wildfires burn and rivers run dry? What space is there for joy and delight in a time of ecological turmoil? How does one live meaningfully in the Anthropocene, and how might such a life help to redress planetary devastation? Following the work of Jane Hirshfield (1997), Carl Leggo (2005, 2012, 2019), Kathleen Dean Moore (1995), Mary Oliver (1995, 2016), and others, we present a dialogue that explores poetry as a form of personal practice that shapes and transforms personal consciousness: a method of inquiry, and an emancipatory vehicle of personal development and environmental activism.

2.3. The Conversation

David Chang (DC): Lee, let's start with you. What does it mean to live poetically in the Anthropocene?

Lee Beavington (LB): Poetry brings what Bai (2015) calls an "animated perception" to the world. Objectified nature is lifeless. To address the Anthropocene, we need to cultivate the ability to see and acknowledge

the more-than-human: the winter wren singing at dawn, the Sitka spruce laden with cones, the white-capped mountains and rivers. For me, living poetically is to recognize ordinary beauty, to see a mesmerizing world in a dewdrop, to marvel at leaf veins that convert light into life. As poet Mary Oliver (2016) wrote, "Humility is the prize of the leaf-world" (p. 7). To witness creativity in the world is to witness your own creative being. The concise language of poetry can bring clarity to this vision. Specificity is tied to intention. Precise word choice and imagery can evoke a profound personal expression.

DC: So poetry brings clarity to one's vision. Clarity of language is clarity of thought. In a way, word-craft can be person-craft, a way to shape thinking and being, a way of forging perspective. Carl Leggo (2005) has suggested that language can be used to "question and play with and savour and ruminate on notions of truth" (p. 178). In writing poetry, one becomes not only the author of the poem, but of life's possibilities. To me, poetry is precisely this act of constructing possibilities. Are there times when a poetic thought shifted your views on something?

LB: Certainly. For me, David Abram's writing stimulates the senses in a visceral and relational way. His book *Becoming Animal* (2011) puts forth, rather poetically, countless small and nuanced perceptual shifts that bring me to fuller presence. Being more in tune with my animality, I listen to the wings of birds thrumming the wind, follow the tidal patterns from low ebb to crashing flow, notice how loudly the fluorescent light bulb in my office buzzes. Mary Oliver (2016) writes that "attention is the beginning of devotion" (p. 8). In this state of attunement, I am cognizant of my breath and shadow—but also of noise pollution and smoggy skies, the unrelenting human-centered progress that has numbed my senses. If Abram had written his book less poetically, more in the form of a science textbook, we might gain knowledge, but have little opportunity for ontological shifts.

Furthermore, I find that the act of writing crystallizes thought. To evoke an image both unexpected yet resonant inevitably shifts, however imperceptibly, my worldview toward that new perception. As Leggo (2019) writes, poetry is "a kind of discourse that invites us to slow down and linger with stories and rhythms and silence and possibilities" (p. 39). I've been working on a poem about amoeba called "Intimate Immensity"; the first draft spoke to membranes, cytoplasmic streaming, and the amorphous nature of this creature's existence, with no relation to human experience. Through this poem I discovered my proclivity to initially write from an objective perspective: rational, scientific, alienating. The subsequent draft connected the amoeba to the birth of my first child. Suddenly, emotion and subjectivity entered the poem, pushing/igniting/bringing static facts to wondrous relationality. "We cannot learn to love by attending to the abstract and universal," said Carl Leggo (as cited in Pinar, 2019, p. x). "We need to begin with small acts of love" (p. x). Here's an excerpt from my poem:

inside my every cell
inner nebula fold as a labyrinth
layers of DNA and lipid—
a coiled nest of centipede
legs in constant motion
each part touches every other
yet holds a constant shape
my son folded in the womb
his head on the placental pillow
an umbilical thread that I quiver to cut

How about you, David? Have you had a moment when a poem that you've written or read shifted your views?

DC: Yes. I was once caught in the rain on a cold afternoon in March. I was entirely unprepared for the downpour and found myself drenched. However, I discovered the creative impetus to compose a poem in my mind, which gave voice to my frustration. In doing so, I stumbled onto a different experience of the rain.

I Wish

I wish to be away from this damn rain
Catching me on this dark afternoon
Nothing on me but a thin denim coat
Soaking in this torrent
Hair plastered to my face
Droplets gathering on my chin
I wish I were in my study
Looking out at the gray curtain of precipitation
Perched on my leather chair
I'd be glad to be warm and dry
Pitying the hapless few who must brave the storm
I wish to be away from this damn rain
Each nefarious drop seeping into
The crevasses of my fractured patience
Each step in this tortured slog
I long to be anywhere but here
Soaking, in this damn rain

I was at first resentful of being in the rain, but the poetic apprehension of a momentary affect suddenly transformed my experience. My resentment subsided, and frustration turned into amusement as I shuffled

the words that would become the first few lines. The emotive force of my experience was somehow sublimated through the composition of the poem. I had forgotten about the inconvenience of rain. Tickled by the arrangement of words, I was fully present in my circumstance. Frustration became both the subject and the pathos of the poem, but the act of poeticism transformed my experience—the speaker is resentful and desired to be elsewhere, the poet found a delightful space within the practice of poetry that conferred an acceptance of the moment. So in this case, the act of composition is transformative, a way of holding experience and dwelling more gracefully in the present.

LB: I like how you describe the power of composition. Thomas Berry (1999) portrays the universe as a creative entity and creative expression as a path toward renewal of the world and the self. In a way, poetry attempts to find unity across divergent realms, similar to ecological science that reveals the threads of connection between whale and barnacle, or salmon and Douglas-fir.

DC: It occurs to me that you are a scientist who writes poetry, or better yet, a poet who practices science. How does the poetry play into your science training? Does poetry help you unite with the barnacle and the salmon?

LB: I'm a biological and social and creative scientist, and they don't always get along. The problem with labels is they put you in a box, and once you're quarantined in a specific discipline you have to fight like mad to get out. Kem Luther (2016), in his book *Boundary Layer*, explains that the Greeks saw nature as mind, scientists saw a machine, while the Romantics saw process, an ecological dynamism. As humans and scientists we like to classify, categorize, atomize and ultimately separate. My poem, "The Circle," explores the relationship between the atomistic and the universal.

The Circle

thoughtless breath
sucks in the world
lungs—an inverted tree
windpipe—a trunk to leafy alveoli
spider webs, air sacs
snare oxygen exhaled by gods
into a pulmonary cocoon

hemoglobin
filled with atmospheric spirit
vessels borne in plant and animal
the dance of O_2—chloroplast to mitochondria
leaves the twig for the capillary that

digs into muscle and bone

hormones pollinate
red blood cells—
billions of messenger bees
in an endless circuit
artery to vein, vein to artery
death comes slow to these gods of old
microscopic Hermes
runs the organ gauntlet
spleen to pancreas
to Stygian pituitary
a race toward a galaxy of synapses
home to thought
and mind
and memory
with the nerve to believe
you are different

oxygen is a circle
a ring that holds
gods and bees and blood
every thoughtless breath
exhales carbon for the trees
that still stand upright

what keeps you breathing?

DC: This poem ends with an intriguing question. It seems to me that carbon and oxygen, basic molecules that compose organic matter, is still a step away from "life" on the experiential plane. We don't feel oxygen and carbon per se, but rather air and wind that's warm, or cold and crisp. We know that material matter springs into action in an organism, yet the manifestation of such synchronicity comes across as something irreducible. We can study atoms and molecules, and they have discrete properties and characteristics, but the vivacity and spontaneity of life registers on another gestalt. We can point to the compositional materials, but there is something else that we cannot easily point to. . . something phenomenological that cannot be adequately described by their material composites. So, maybe poetry is a way to suggest the mystery, to point toward the ineffable?

LB: Poetry does this in a way most science textbooks, bound by their objective-rational-reductionist approach, cannot. That's not to say that scientific precision isn't important. Lack of precision on a cellular level would crumble our tissue into entropic dust. The closer you study the human body, the more you recognize the miraculous nature of our existence. Yet

we must be cautious not to overlook our holistic view. As philosopher Kathleen Dean Moore (1995) ponders, "If you take anything down to its tiniest pieces, spread them out and make a diagram, and then put them all back together again, can you be sure you have the thing you started with….Or has it become something different, something less than the sum of its parts?" (p. 113). Wonder stems, not from isolated details, but from the integrated whole.

DC: So we have science on the one hand, which proceeds on the assumption that the cosmos is intelligible; on the other, we have something experiential, numinous, and irreducible. I do not want to suggest that they run counter to each other—in fact, I think they are two takes on the same thing. I'm just wondering how poetry facilitates their integration.

LB: In the book *Einstein and Buddha*, McFarlane (2002) speaks to experience as the foundation of both science and mysticism: "through direct investigation, the mystic and the scientist alike find reality's deeper truths" (p. 33). By dwelling in the ambiguous spaces, in the liminal knots of relation, we can discover the connective tissue between us and the environment. Faulkner and England (2020) similarly argue that "both poetry and science seek to contain chaos through form, and through experimentation and manipulation, to arrive at new (and often complex) understandings or solutions to the conundrums and idiosyncrasies that plague our ever-evolving environment" (p. xxii). Through metaphor and metonym and other figurative language, poetry holds relational capacity, a way to dance within and across boundary layers into ecological and emotional webs of reciprocity. By placing words that seem discordant side-by-side on the page, or inventing an image that compares a rock to a heart or an amoeba to a planet, new meanings can emerge, windows into the ineffable. With my science training, I sometimes throw too much terminology into my poems, which distances me from the reader.

DC: So poetry is a way of knocking loose those familiar, conditioned schemas through novel combinations of concepts, words, and associations.

LB: Exactly. Poetry finds beauty in despair, light in darkness. In this way, writing poetry is an act of resistance, a statement of wonder. Alternatively, poetry can explore our shadow side, the hidden seams of our existence that lurk in the voiceless places. A poem's power is its specificity—sensorial, personal, close to the heart, painfully precise. I find my poetry is enriched by relational experience: that is, by bringing the speaker and the poet closer together. An omniscient voice that makes grand general statements feels detached—or worse, patronizing. I struggle with being too didactic. I'll often revise poems to have less us/we and more I/my statements. Precision and evocation are key, letting the poem present my voice and intimacy via meticulous language and imagery. Evoke more, tell less.

DC: Picking up on your comments about finding beauty in despair—given the seriousness of environmental decline, despair is an inevitable part of my growing awareness. Developments in consciousness, personal and

collective, involve pangs of guilt, anger, and an underlying anguish that never fully subsides. For me, this pain is a writhing tension between modes of consciousness. I am no longer at home in the world that I know; at the same time, I cannot easily affect the arrival of an alternate life, situated as I am in a vast anthropocentric civilization, having internalized the values of a capitalist-consumer culture. Thus, I find myself astride two worlds: one bound to die, the other powerless to be born. This frame of consciousness, marked by contradiction and frustration, produces an ongoing ontological anguish. Yet this anguish, like the febrile volcano, is a generative force. In the smoke of inner turmoil, a new inner landscape is being forged. Recently, bemoaning the rapid warming of the planet, evinced by record-breaking temperatures and the extinction of species across the globe, I once again felt the weight of compunction, mourning the damage that has been wrought upon the planet. Yet, it was spring, and the air was redolent with lilacs and tender new maple leaves. Although heavy with grief, I was at once taken by the fragrant air. In the following poem, I reflect on the jarring incongruity between the experiences of personal complicity while surrounded by gratuitous beauty.

Why Should the Flowers Bloom?

Why should the flowers bloom for me?
This perfume of sweet remembrance
The cold soil stirring to life
The petals opening again to light
Affirmations of ageless elation
Why should the birds sing for me?
The few warblers on my block still recite
Their wistful song of delight
After the verdant canvas of lush velvet
Gave way to concrete blocks and glassy panes
The chorus of jubilant voices
Reduced to a scattered ensemble
The warblers still croon their tremulous song
Why should this beauty still linger
To mesmerize one who lives in bitter spite?
The prodigal son who is prodigal still,
Even at the beckon and cry of his Mother.
I do not understand this tireless munificence
This splendour that ever endures
Even to the ocean's end, the stars' fading light
And why should the flowers bloom for me?

LB: I sense that intense personal voice and inner struggle in the poem. Almost like a self-recrimination. You are drowning in beauty.

DC: Yes, although reading it now, I am struck by how self-consumed I was, as if everything was blooming for me. How self-consumed! On the other hand, the poem articulates a paradox that is central to my own experience of being alive at this moment in human history. I am a member of an inventive and destructive species that has radically altered the biosphere. I am complicit in the Anthropocene, but at the same time I love and cherish this planet—I dwell in lamentation and delight at the same time. This tension stretches my inner capacity and challenges me to see the interpenetrating truths of life: beauty is inseparable from pain, light radiates amidst darkness, joy springs from mourning. To me, no medium expresses such aporias more poignantly than poetry. Poets veer close to the edge, and attempt "the making of a form out of the formlessness that is beyond the edge" (Oliver, 1995, p. 6). This formlessness often takes shape in the paradox, which confounds conditioned intelligence and gives shape to a more capacious awareness.

LB: Transforming the self is, to me, a vital part of the journey. Yet the journey does not end here. In the hero's journey, after the treasure (i.e., wisdom) is found, the next task of the hero or heroine is to return home and share this wisdom (Campbell, 2017).

We are relational beings. And not just humans: tree roots are sheathed in a web of interconnective fungi, flowers attract and gift pollinators, important bacteria live in our belly buttons. No species exists in isolation. Poetry is inherently relational, comprised of language's connective tissue; words are the bone, figures of speech the muscle. So writing a nature poem cultivates a sense of kinship. This kinship, I believe, can lead to changes in belief and then action.

DC: On the subject of connection and action, some people may think that poetry is a very nice, but ultimately frivolous, luxury. The oceans are warming regardless of what poets write. They might say that the sublimation of one's personal experience is merely a retreat to a private heaven. What do you think about this? Of what relevance is poetry to runaway carbon emissions, species extinctions, and the real tragedies that are occurring?

LB: Artists create visions. Before humans make something a reality, someone dreams up that reality. Art has tremendous ability to open windows to alternate worlds or ways of being. Think of the film Blackfish (Cowperthwaite, 2013) and the shift toward no orcas at SeaWorld, or the song "Give Peace a Chance" (Plastic Ono Band, 1969) or Thoreau (2000) and the hippie and environmental movements. I think most, if not all, art has the potential to be activist. Poetry is no exception.

DC: Yes, action comes from activists, who are human beings with views, feelings, outlooks, and ingrained patterns of reaction and behaviour. I would add that the nature of our activism is shaped in large part by our conditioned patterns of thought and behaviour, how we exercise agency, how we understand the world we live in. If we are seduced by the illusion of our separateness and cast a host of characters in the role of villains,

we might initiate conflicts and impose sanctions in the wrong places. We may exacerbate the very problem that spurs us to action. Poetry offers a way to question and challenge the self, a way of shifting our habitual modes of thought, a way to witness anew the internalized values and presuppositions that have been ensconced in our habits. If we do not attend to this aspect of activism, we risk reproducing and aggravating the internal turmoil that we have left unchecked.

LB: So poetry is a method toward "unity in variety." Science does the same. As the poet-scientist Bronowski (1956) wrote, "The discoveries of science, the works of art are explorations—more, are explosions, of a hidden likeness" (p. 19). We are constantly fighting this "illusion of separateness" that you spoke of; we separate ourselves from the rivers we pave over, the fossil fuels we extract, even a glance from another human. Thus, these others can be ignored and exploited. There's a reason that you'll rarely find a poem about divisiveness that actually promotes divisiveness. When you ponder on a topic carefully enough, steep in understanding your subject's root of meaning (something poetry demands), you are offered an avenue toward tolerance and compassion.

DC: I've come across poetry that, although not expressly divisive, are distinctly political, and thus part of a field of social contestation. But I think that is poetry's merit—we don't bar poetic expression from any arena of human experience, conflict and division included. I don't think poetry necessarily steers us toward tolerance and compassion. For that, we need help from culture, ethics, education. Rather, the poetry can help us inhabit our divisions with some perspective and magnanimity; as T.S. Eliot once wrote, "we are united in the strife that divides us" (Eliot, 1993, p. 2168). To awaken from the illusion of separateness is not to collapse all distinctions, or to obviate diversity into one undifferentiated monad. Rather, it's the apprehension of the multifaceted, multi-layered, multi-dimensional faces of an unbroken cosmos. Unity in variety, as you put it. Even division and conflict are part of this unbroken whole.

LB: I love your poetic description of poetry. The unbroken whole, full of fractures, yet somehow still held together by tenuous filaments. Humans are the first species with the capacity to disrupt the whole of our planet. We now possess the power to bring down entire ecosystems, acidify the oceans, and deplete the ozone in the atmosphere that holds the upper limits of life. I'm not sure if our species is capable of the farsightedness needed to avoid the short-term destruction of the environment. To do this, we must shift out of the industrial-exploitative model, a wholesale change of the foundational systems of capitalist economy and consumerist culture, and consider the impact on generations to come.

DC: Here's another thought that I want to put out there, although it may seem too bleak for many to consider. Given that we are have already initiated a mass extinction event, introduced into the biosphere synthetic polymers that will not bio-decompose for tens of thousands of years, and created nuclear waste that will be radioactive into a very distant future, we now have to think about what environmental activism aims to achieve. Our

actions are only a way to slow the bleeding, so to speak. Some say it is already too late to forestall environmental cataclysm. In this situation, we should consider the possibility that the positive outcomes of our activism will be limited, sometimes inconsequential. In this scenario, I submit that we have a responsibility to accept our pending demise as a species. This means learning to die with grace and humility.

LB: And poetry has a way of helping us die with grace and humility?

DC: Potentially. Poetry can help us live our fragility and mortality with greater care and tenderness. I don't think the beauty of poetry necessarily denies tragedy, but it might offer the transcendence of tragedy so that light might shine through the tragedy itself. If poetry is joyful, it is not because there is no more pain, but because the poem becomes the voice through which pain speaks anew. I like what Carl Leggo (2005) says about poetry: "I am not naively blind and deaf to all the clanging, glaring reasons that militate against hope in the world, but I am faithfully committed to composing possibilities for joy" (Leggo, 2005, p. 192). Poetry is the practice of composing joy, not because all will be well, but precisely because all is not well. It is defiance in the face of inevitability, a resilience that "laughs with indefatigable hopefulness" (Leggo, 2005, p. 191). And when we cultivate this indefatigability, we are able to continue the good work of environmental activism, from restoring wilderness to conserving species. It no longer matters whether these labours affect definitive outcomes; the work itself is worthy enough. We can commit to it regardless of what happens.

LB: So poetry can be a ray of hope on a bleak landscape?

DC: Yes, but by "hope" I don't mean to say that everything is made easier or better, as if hope comes to the rescue. I agree with Jane Hirshfield (1997) when she writes: "Hope is the hardest love we carry" (p. 39).

LB: My outlook is not as pessimistic as yours—or perhaps pragmatic is the better word—although I am called, at times, to write pessimistic poetry. Here's an example, inspired by walking dry riverbeds this past summer.

Dry River Run

This streamless stream holds
dreams of pollen
spores I catch on my tongue
sweet natal cells
once fluent with the cool sliver
of glacial current

Everything here runs smooth
  stones like eggs
   polished by absent water
    my soles pace this sandy cemetery

Nothing
          here
    runs
              linear
the breeze rambles with memories—

take current from a river
and what remains?

In this ghostly stillness
  I reminisce with the river—

dew drips
from a maple leaf vein
bacteria-bitten leaf
nibbled by dragonfly nymph
salmon fry snatches the wingless child
darts from kingfisher's flight
beyond the reach of a crayfish claw
into the mouth of bullfrog
who should not be here

bullfrog, you choke the cycle
in this place
sockeye hatch and die
bear hunger tosses them ashore
fish bones flood the soil
root thirst for phosphorus
maple grows once more

How long have you waited
for the mountaintops to melt
for the breath of rain
how quickly we bury
the current in the past

I cling to the lobed leaf
the water returns
memories etched

in
every
meander

DC: That's remarkable. I see it as both a love-song and a eulogy, which are both expressions of appreciation. When we love something, we cannot turn away from its demise. In this poem, you are acknowledging the river and mourning its disappearance. I think we are in dire need of this recognition of our collective environmental impact. This acknowledgement is the basic requirement of love. That is why I don't see myself a pessimist. I try, as Mathew Arnold wrote, to "[see] life steadily and [see] it whole" (Arnold, 1993, p. 1349). In my view, our love of the land requires that we not turn away from its degradation. Mourning is the other side of loving; refusal to mourn is refusal to love. There is no shortage of easy pleasures and quick distractions; a facile happiness is all too ubiquitous. We can prefer a plastic promise that all will be well, or look unflinchingly into the conflagration. Responsibility requires that we not turn away from what is right in front of us. This is why I cherish Jan Zwicky's (2016) words: "come, step closer to the edge, then/You must look, heart. You must look" (p. 8).

You've recently welcomed your second child into the world. How do you hold the view of our ecological situation with the hopefulness for your children?

LB: I wonder what my children will hold as their nature baseline. I grew up on Zero Avenue near White Rock, British Columbia, Canada. You could walk to the park, or forest, or ocean, all within five minutes. Today, the park has cut down all the trees I played in, the neighborhood forest is paved over, and the ocean is nearly inaccessible due to heightened US border measures and unwieldy Himalayan blackberry on the shoreline. Will this fractioned nature paradigm be their standard for a healthy environment? This is one of the reasons we moved to a Gulf Island, for a deeper immersion in nature.

That joy you spoke of is there, in their wide eyes and wondering gaze. We spend time outside, dig in the dirt, admire the ferns, witness the clearing of lots. I need to show them the truth of the world, its tragedy and joy. If anything, I fight harder for ecological justice because I know my children will inherit this legacy.

DC: I think this honest look at both tragedy and joy can be part of our ongoing education. Attention to tragedy doesn't necessarily make us morose. I still laugh when I see my dog splayed out across the bed, and I lose my mind in the ruckus of a concert. Life is still a gift. But every moment of mirth is imbued with the recognition of frailty and ultimate impermanence. Frailty and ephemerality do not diminish beauty—they are inherently beautiful. I think of the most resplendent moments—a splattering of alto-cumulous cloud, a hummingbird rising from the brush,

a writhing moon on the water's surface—they are exquisite precisely because they last but a moment. This is why I admire the Japanese poetic tradition, which boldly proclaims an aesthetic of tragic beauty, or what the Japanese call *mono no aware*—"the natural poignancy in the beauty of temporal things" (Basho, 2000, p. xiv). Consider the following poem from Matsuo Basho:

Lonely stillness —
A single cicada's cry
Sinking into stone
(Basho, 2000, p. 22)

The ease of expression is striking; the clarity of verse that intimates the evanescence of the wild. The poet conveys a majesty that is always dissipating. Pathos is never grasped apart from impermanence. I sense in Japanese poetry this deep love of the world, a devotion too sincere for affectation, an appreciation that can only dwell in the expressiveness of silence. This aesthetic tradition is a continuing source of inspiration for me. To live poetically in the Anthropocene is to give myself further to the wonder of this world in all its ephemerality, my own life included—and to live lightly, not holding on too tightly, as if to brush over rippled waters and the arching cedars like an autumn wind, embracing all and clinging to none.

LB: What a wonderful image. For those people who don't consider themselves poets or poetically inclined, how might they harness the power of poetry?

DC: In an age of great divisions and social strife, poetry itself can be a form of dialogue that operates on a different metaphor. In so far as "argument" and "debate" take the form of war (Lakoff & Johnson, 2003), wherein I attack an opponent while defending my position, the mode of exchange is characterized by aggression, where the stakes are claimed by a victor. This form of political and social exchange deepens division and stokes animosity. By contrast, a poetry circle does not play on adversarial instincts. The texture of dialogue, and the spirit of exchange is different. There is a tendency to share openly, and more importantly, to listen deeply. Poetry circles should not prohibit differences in views, even the most profound ones, but I believe that the fundamental metaphor of the circle is more conducive to relationship, understanding, and mutuality than the oppositional debates that we see in the media and other public forums. If people came together and wrote some poetry about what matters to them, and read their poems aloud to each other, we might have a more open, heartfelt, and vulnerable mode of exchange. We might listen to each other's words as an expression of humanity, not as claims to be discredited, or positions to be dismantled. Perhaps this is a mode of political exchange that can be explored further.

LB: This intentional dialogue bears similarity to the Circle Way process championed by Christina Baldwin (1998), and sharing circles practiced by many Aboriginal peoples. In this age of polarity, perhaps such circles can offer a productive way forward.

I would like to add that poetry can also be activist. As Faulkner and Cloud (2019) contend, "Poetic inquiry represents engaged social science" (p. xii) and "can be an active response to social issues, a political commentary, and a call to action" (p. x). In the newly published book, *Scientists and Poets #Resist* (Faulkner & England, 2020), there is a dialogue between poets and scientists. Every article and poem uses the seven words banned by the Trump administration for use in official documents for Health and Human Service: diversity, entitlement, vulnerable, transgender, fetus, evidence-based, and science-based. In fact, whenever these banned words appear in this book, they are printed in bold. This "collective aesthetic response" (p. xv) is an act of resistance and activism that attempts to reclaim what has been taken.

DC: I appreciate your thoughts and reflections. It's evident that in your poetry practice, you are following Mary Oliver's (2016) call "to observe with passion, to think with patience, to live always caringly" (p. 57).

References

Abram, D. (2011). *Becoming animal: An earthly cosmology.* Vintage Books.

Arnold, M. (1993). To a friend. In M.H. Abrams (Ed.), *Norton anthology of English literature* (2nd ed., vol. 2, p. 1349). W.W. Norton & Company.

Bai, H. (2015). Peace with the earth: Animism and contemplative ways. *Cultural Studies of Science Education, 10,* 135–147.

Baldwin, C. (1998). *Calling the circle: The first and future culture*. Bantam Books.

Basho, M. (2000). *Narrow road to the interior and other writings*. Shambhala.

Berry, T. (1999). *The great work: Our way into the future*. Three Rivers Press.

Berry, T. (2006). *Evening thoughts: Reflecting on earth as sacred community.* Sierra Club Books.

Bronowski, J. (1956). *Science and human values.* Harper & Row.

Campbell, J. (2017). *The hero with a thousand faces.* Yogi Impressions.

Cowperthwaite, G. (Director). (2013). *Blackfish* [Film]. Magnolia Pictures.

Devall, B., & Sessions, G. (2001). *Deep ecology: Living as if nature mattered.* Gibbs Smith.

Eliot, T. S. (1993). Little Gidding. In M. H. Abrams (Ed.), *Norton anthology of English literature* (2nd ed., vol. 2, pp. 2164–2170). W. W. Norton & Company.

Faulkner, S. L., & Cloud, A. (Eds.). (2019). *Poetic inquiry as social justice and political response*. Vernon Press.

Faulkner, S. L. & England, A. (2020). Science-based vulnerability. In S. Faulkner & A. England (Eds.), *Scientists and poets #resist* (pp. xv–xxiii). Brill Sense. https://doi.org/10.1163/9789004418820

Hirshfield, J. (1997). *The lives of the heart.* Harper Perennial Press.

Intergovernmental Panel on Climate Change (IPPC). (2014). *Fifth assessment report* [Synthesis report]. https://www.ipcc.ch/report/ar5/syr

Hebrides, I. et al. (2018). On the Anthropocene. In B. Jickling, S. Blenkinsop, N. Timmerman, & M. De Danan Sitka-Sage (Eds.), *Wild pedagogies: Touchstones for re-negotiating education and the environment in the Anthropocene* (pp. 51–62). Palgrave Macmillan.

Lakoff, G., & Johnson, M. (2003). *Metaphors we live by.* University of Chicago.

Leggo, C. (2005). Pedagogy of the heart: Ruminations on living poetically. *Journal of Educational Thought, 39*(2), 175–195.

Leggo, C. (2012). Living language: What is a poem good for? *Journal of the Canadian Association for Curriculum Studies*, *10*(2), 141–160.

Leggo, C. (2019). Challenging hierarchy: Narrative ruminations on leadership in education. In R. Irwin, E. Hasebe-Ludt, & A. Sinner (Eds.), *Storying the world: The contributions of Carl Leggo on language and poetry* (pp. 38–49). Routledge.

Luther, K. (2016). *Boundary layer: Exploring the genius between worlds.* Oregon State University Press.

McFarlane, T. J. (Ed.) (2002). *Einstein and Buddha: The parallel sayings*. Seastone.

Moore, K. D. (1995). *Riverwalking: Reflections on moving water*. Lyons & Burford.

Oliver, M. (1995). *Blue pastures.* Mariner Books.

Oliver, M. (2016). *Upstream: Selected essays.* Penguin Press.

Pinar, W. F. (2019). The immeasurable idea, identity, and ideology of I. In R. Irwin, E. Hasebe-Ludt, & A. Sinner (Eds.). *Storying the world: The contributions of Carl Leggo on language and poetry* (pp. ix–xii). Routledge.

Plastic Ono Band. (1969). Give peace a chance [Song]. On *Give peace a chance* [Album]. Apple Records.

Thoreau, H. D. (2000). *Walden and other writings.* Random House.

Waters, C. N., Zalasiewicz, J., Summerhayes, C., Barnosky, A. D., Poirier, C., Gałuszka, A., & Wolfe, A. P. (2016). The Anthropocene is functionally and stratigraphically distinct from the Holocene. *Science 351.6269* (aad2622). https://doi.org/10.1126/science.aad2622

Zalasiewicz, J., Williams, M., Steffen, W., & Crutzen, P. (2010). The new world of the Anthropocene. *Environmental Science and Technology, 44*(7), 2228–2231. https://doi.org/10.1021/es903118j

Zwicky, J. (2016). *The long walk*. University of Regina Press.

PART II – ROOTS

More-than-human Ethics and Romanticism

Root, leaf, and germ, pale and half-formed.
The nub of tranquil life, kept safe and dry

Swells upward, trusting to the gentle dew,
Soaring apace from out the enfolding night.

~Goethe

Chapter 3.

Curriculum Hidden:
Contemplating More-than-human Ethics

3.1. Preamble

Chapter 3 examines human exceptionalism and the use of animals in science. Following the previous chapter's elucidation of the world's current state of ecological collapse, here the lens is narrowed to the curriculum of the natural sciences, specifically addressing biological dissections. Philosophical-ecological underpinnings, such as speciesism and ecocentrism, are considered as guides toward less harmful methods of teaching and learning. Although other-than-humans may not philosophize in the manner humans do, they evidently have their own values, philosophizing, and ways of doing things; my intention here is not to negate but to honour and respect this.

A note on the use of 'nonhuman.' Although I use this term, sometimes for the sake of a simpler vernacular, it is not my preferred term. First, stating what something *is not* is less desirable (and less respectful) to stating what something *is*. Second, nonhuman connotes a denying, derogatory statement (e.g., imagine using the term 'non-male'). I sometimes use 'other-than-human' and 'more-than-human,' interchangeably, to emphasize that the state of not being human does not render a being as lesser.

In regards to the word 'human,' I would like to clarify that statements made in regards to humans possessing moral status do not include the many humans who are still not granted rights and respect. Therefore, the use of the word 'human' herein typically, and regrettably, refers to the privileged, white, able-bodied, heterosexual, and the economically secure. All humans, of course, deserve moral status.

We also engage in a conversation with a tardigrade. ✺

the same breath taken by butterfly
curses the infant caterpillar

feather and leather-bound adorn our plates
while furry friends are seldom factory farmed

what separates the pampered purr
from the feline parted from her dissected organs?

3.2. Flagging Our Species' Specialness

Historically, philosophers, scientists, linguists, politicians, religious leaders and educators have distinguished the human species from all others. Self-awareness, tool making, language acquisition, ability to feel emotion and pain, and many other rationalizations legitimize that special status taken for granted by *Homo sapiens*, often with the result (whether intentional or not) of giving legal and/or moral rights for human exploitation of every other creature that isn't a relatively hairless bipedal primate.

As author Michael Pollan (2013) writes, we are obsessed with identifying the faculties unique to us:

> One by one, the faculties on which we thought we could stake the flag of our specialness science has shown belong to other animals as well. Suffering? Reason? Language? Counting? Laughter? Self-consciousness? All have been proposed as human monopolies, and all have fallen before science's deepening understanding of the animal brain and behavior…though perhaps an even sturdier candidate would be this: humans are the only species that feels compelled to identify faculties that it alone possesses. (p. 55–56)

One uniquely human aptitude I would add is our capacity to drastically alter our environment. By staking "the flag of our specialness" we grant our species rights and privileges to factory farm our food, engage in vivisection and animal research, trawl the seafloor, and clear cut entire habitats of wildlife for our species' sole benefit. Should our self-interest concede the suffering and killing of nonhumans? On what ethical basis have we situated ourselves in this place of moral privilege? Even the very definition of a

species is highly variable and ardently contested by biologists and philosophers (Wilkins, 2009). If our specialness is an arbitrary invention, and there exists "a serious asymmetry of power and capacity between the creatures" (Nussbaum, 2006, p. 22), then we need to rethink and deconstruct our anthropocentric worldview.

In this paper I will argue that science education, with its mechanistic and "highly partial and reductionist" (Bonnett, 2009, p. 182) approach, promotes an intellectual dissociation and general desensitization to nonhumans. By flagging our specialness, we become separate from, rather than a part of, the Earth's ecosphere. This places humans in a category unto themselves wherein we lose our "ecological literacy" (Cohen, 2007, p. 118). Forgetting and neglecting our symbiotic relations with other species supplants mutualism with a "union of the theoretical and empirical approaches to our natural environment" (White, 2004, p. 193) whereby utilitarian animal use and resource extraction benefits only the human party. When we lose our "ability to empathize and identify with nonhuman life" (Metzner, 1995, p. 61), we also lose our respect and humility for the mysteries of the natural world, resulting in scientific and economic gain being valued above social and environmental considerations. Science curricula rarely engages with the ethics of science, often focused on *how* to experiment, dissect and atomize and rarely questioning if we *should*. Leopold (1949) asks the pertinent question: "Is education possibly a process of trading awareness for things of lesser worth?" (p. 18). We need to find a path toward holistic education—one that is experiential, embodied, and reciprocative—where ethics are part of the conversation before students use nonhuman animals in their learning and research.

First I will elaborate on the self-interested, and sometimes arbitrary, fashion with which we approach animal use and the ethics therein, and how limiting moral rights to humans sanctions enormous nonhuman suffering. Next I will explore how our science pedagogy is embedded with anthropocentrism, and how teaching practices such as mandatory dissection assumes and reinforces the idea that nonhuman animals are devoid of moral status, or at least given lower moral status. Finally, I will outline a conceptual basis for moving toward Leopold's (1949) ecocentrism, what Panikkar (1996) describes as "Peace with the Earth [that] excludes victory over the Earth, submission or

exploitation of the Earth to *our* exclusive needs. It requires collaboration, synergy, a new awareness" (p. 57).

3.3. The More-than-human Conversation

As David Abram (1996) asks, "How did Western civilization become so estranged from nonhuman nature, so oblivious to the presence of other animals and the earth, that our current lifestyles and activities contribute daily to the destruction of whole ecosystems?" (p. 137). If utilitarianism strives to do the greatest good for the greatest number, this is clearly exercised with extreme prejudice from those who philosophized it into being (because the focus is on human good, and *nothing but* the human good). Thompson (1997) outlines how "ecological abuse [and] animal suffering [are problems] caused by the one-sidedness of a public sphere orientation that emphasizes self-advancement over relational responsibility" (p. 329–330). Our interactions with nonhumans resemble an asymmetrical marriage where one partner exploits and the other lacks any inherent rights.

Nussbaum (2006) paraphrases Aristotle's assertion thusly: "all animals are akin, in being made of organic materials; humans should not plume themselves on being special" (p. 348). The ecology of our existence is utterly dependent upon our relationship with the more-than-human world (Abram, 2011), and yet science has still to describe 75% of Earth's animal and plant species. When we walk through the forests of the Pacific Northwest, more life (in terms of species number, biomass, and organic activity) exists beneath our feet than above. An old growth Douglas-fir has just as much mass invisible to our eyes as that which towers to the canopy overhead, while a single grass specimen boasts 14 billion root hairs that stretch 10,000 kilometers (Luoma, 2006). Every step we take is on the back of 16,000 invertebrates (insects, millipedes, and roundworms among countless others) and each pinch of soil holds hundreds of millions of bacteria vital to the decomposition process without which the Earth would be a vast garbage dump of dead organisms many times over. The vast network of life hidden to our eyes, so easy to ignore, is what helps sustain biological life.

By example, the tiny tardigrade (commonly called the water bear) is ubiquitous on our planet, estimated to be seven billion billion in number, yet many humans are unaware of their existence and the significant ecological role they play in myriad ecosystems. If a tardigrade could communicate with a human through the English language, perhaps a conversation on the topic of species specialness would sound something like this:

Human: We humans can survive on every continent.

Tardigrade: What about under the ocean? To us, hydrothermal vents are like Florida.

H: Er, we don't do well in water for long periods. But we've been in space!

T: You can survive *in* the vacuum of space? Me too!

H: Not exactly, we need our spacesuits. What with the intense solar radiation, absolute zero temperatures, and utter lack of oxygen…

T: Those don't bother us much. We can go dormant for 10 years. Or even be put in boiling water. We'll still reproduce!

H: Okay, but where are your civilizations?

T: There are a billion of us for every one of you. We're fine with moss.

H: *We've* changed the world to fit our needs.

T: Oh, you've made more moss?

H: No, no—

T: More oxygen? Old growth forest? Increased biodiversity? A more hospitable climate?

H: You're missing the point. Hey, where are you, anyway? I can't see you.

T: Here, in this dew drop. Try putting me under a microscope.

H: Okay…wait, you have *eight* legs?

T: Four more limbs than you.

H: You think that makes you superior?

T: Only different.

In order to use animals the way we do, we need to feel superior to them; put another way, we bestow virtues and morals to our species and omit them from others, consequently causing harm for our benefit. We have made ourselves into a pseudo-keystone species whose worth eclipses every other. This line of thinking is antithetical to holistic ecology science.

Two important items should be addressed here. The first is that nonhuman animals obviously can't speak English. There is strong evidence that some of the more complex mammalian species, such as dolphins and gorillas, do have a rudimentary form of language. Koko the gorilla has even been taught sign language, with a vocabulary of over one thousand words (Patterson et al., 1988). Yet such "language use is a frill, constructed by human scientists; [nonhuman primates'] own characteristic mode of flourishing in their own community does not rely on it" (Nussbaum, 2006, p. 364). Secondly, nonhumans do not philosophize the way humans do, nor can they engage in a conversation on ethics. But this should not exclude them from some form of rights. After all, young children and the mentally disabled cannot articulate and understand ethics either.

If being human confers moral status; that is, possessing the specific 23 sets of chromosomes that results in the phenotypic totality of what it means to be human—then it does not matter what genes and traits nonhumans possess. If intelligence, community living, and the ability to feel pain, empathize and express emotion (all qualities shown by nonhumans) do not confer moral status, is this not an utterly arbitrary distinction made at the genetic level? Our reliance upon other species gives us good reason to protect the more-than-human, a point I will return to later in this paper.

3.4. Ecology and Ethics

The word ecology, derived from the Greek *oikos*, means household or family. Every ecosystem is a home to intricately interconnected organisms, and since the first law of ecology is that "Everything is connected to everything else" (Commoner, 1971, p. 16),

it stands to reason that humans are tied to many other organisms. However, the way we use the word *animal* suggests that we are referring to something other than human; that is, something less evolved or inferior in some way, all the while conveniently forgetting that humans hold membership to Kingdom Animalia right alongside the lowly worm. “If life has a meaning only for the victors, only for those who ‘make it,’ we create an artificial hell for all the others” (Panikkar, 1996, p. 52). This artificial hell is justified because only humans fall under the moral umbrella. Yet the root of the word animal, *anima*, means breathing, soulful being; this suggests that an animal is a being endowed with spirit rather than a debased entity subordinate to humans.

When Noddings (2002) asks the question, “If we have established a caring relation with one person at the cost of weakening a larger web of care, can we be said to have cared?” (p. 30) we can, in turn, extrapolate this to a larger, ecological context. In striving to care for one species, we weaken the larger web of organisms, and neglect to care for them—much, I will argue, to our own detriment.

As Nussbaum (2006) points out, “We humans share a world and its scarce resources with other intelligent creatures” (p. 325), and such intelligence is adaptively unique to each species. “Our choices affect the lives of nonhuman species every day, and often cause them enormous suffering. Animals are not simply part of the furniture of the world; they are active beings trying to live their lives; and we often stand in their way” (p. 22). Our human animal needs come first, but at what cost?

One of the most systematic sources of suffering perpetrated on nonhumans by humans is the raising and killing of livestock. Humans are heterotrophs; by our biology we must eat to survive. A vegan lifestyle limits this consumption to members outside of Kingdom Animalia. But for the sake of argument, let us say that a human *must* consume the meat of an animal in order to live a healthy life. In this case, the death of another animal is necessitated by our gastronomical need. Should we not raise these animals in such a way that their suffering is limited?

Factory farmed chickens pumped full of growth hormone wading in their own feces, and pigs unable to turn around in their enclosures, never to touch grass or feel

sunlight, seems utterly contrary to this notion. Yet millions of animals are kept and killed in such conditions every day, well hidden from the public eye. When we buy precut, preprocessed, prepackaged meat at the grocery store, we have removed ourselves from the suffering and blood that went into this plastic wrapped product. Panikkar (1996) describes how "The animal does not 'kill,' it eats. Man does not exploit when following Nature; it grows and evolves" (p. 57). Gary Snyder's (Bromige et al., 1968) poem, "Song of the Taste," (p. 359) eloquently elucidates upon this idea,

> Drawing on life of living
> clustered points of light spun
> out of space
> hidden in the grape.
>
> Eating each other's seed
> eating
> ah, each other.
>
> Kissing the lover in the mouth of bread:
> lip to lip.

In this view, we can celebrate eating as an ecological act; but the way we eat needs to be ethically examined. What if each of us had to care for, grow, and slaughter our own animal food? The question I ask myself is, *Could I kill, process and cook a chicken, goat, pig or cow in order to consume it?* The answer for me is no, and I am therefore vegetarian. As long as we identify nonhumans as beings who cannot suffer, and who have no moral rights, we will not care for their well-being. Epistemologically, we seem unable to see nonhuman animals as beings who are entitled to moral rights. This is partly convenience, partly prejudice, and partly how we are built: for the duration of the human species, we have used other animals in order to survive. Now, our survival may very well depend on monitoring, regulating, and curbing this exploitation of the more-than-human world.

The use of animals in science teaching and research is another utility that benefits our species, obliging the suffering of another. Frogs and other vertebrates are dissected in North American classes as a matter of course, and while no reliable numbers are

available, the existing data suggests that at least six million such animals (many wild caught, in the case of frogs) are used every year for dissection in USA high schools (Animalearn, 2012). Meanwhile, countless other nonhuman animals are experimented upon for medical research, the benefit of which is inestimable: our understanding of and treatments for heart disease, diabetes, epilepsy and a host of other conditions have improved dramatically (Americans for Medical Progress, n.d.). Therefore, the unfortunate pain and ending of nonhuman animal life is justified for the *Homo sapiens'* good. Of course, there is a wide spectrum of animal uses in research, from cosmetics placed on the eyes of rabbits to rats used for cancer studies; the former, more easily categorized with vanity, is not as morally sound as the latter, whose results could produce a cure that saves millions of human lives annually.

In science, model organisms are those that are easy and cheap to care for, and whose anatomy or behaviour is readily extrapolated to the human species. Studies on species that closely mimic our biology give more dependable and meaningful results for humans. For a moment, let us imagine a science-fiction scenario (remembering that science fiction is literature that is not true, but could *theoretically* be). If an alien species a thousand times more evolved than humans came to Earth, and found that humans possessed some key physiological quality that allowed them to experiment upon us to their great gain, would we object? I am certain that we would. Some may argue that both humans and these advanced aliens possess a quality—and thus a moral status—that separates us from the rest of animals, and so humans should still be exempt from being the subject of experimentation. The problem here is that humans (and the aliens in their case) decide to arbitrarily draw the line at their own species. Perhaps chimpanzees—or, for that matter, jellyfish—given the capability, would do the same. Such arbitrary delineation is based on subjective self-regard, and is morally dubious, as similar intraspecific arbitrary distinctions helped bring about slavery, cultural genocide of native peoples, and the Holocaust.

Christian morality posits that humans are meant by God to dominate the world and use other species for human benefit. In a secular context, some ethicists maintain that humans have greater moral rights. Both are human-oriented perspectives founded on our

consciousness and ‘uniqueness’ granting us greater moral rights. Since, to the best of our knowledge, certain nonhuman animal species are sentient, able to feel pain, live in community, even laugh and cry, what trait can we use to separate *Homo sapiens* from the rest? The list becomes thin and capricious. As humans we have decided, by and large, that *only* humans possess moral status. If we are so special, so unique, and so privileged, how then can we justify the current genocide of the natural world?

“What less often comes to mind…is the need to extend our theories of justice outside of the realm of the human, to address issues of justice involving nonhuman animals” (Nussbaum, 2006, p. 21). For this to happen, humans would need to make innumerable sacrifices. If it is wrong that nonhuman animals suffer, and that millions die daily for our research and dietary needs, to recognize and halt this suffering would require a paradigm shift in terms of how humans eat, teach, research and live their everyday lives. But if all of this suffering meant that your own child would be saved from a certain fatal disease, would you still side with the nonhumans? These are the kinds of difficult questions we need to ask.

3.5. Why Care About Nonhumans?

Ecological problems can overwhelm the progress made in the area of social justice. Historically speaking, western society has made only recent provisions to protect the rights of those long underprivileged. Equal rights for women, people of different ethnic backgrounds, the physically and mentally challenged, and the LBGTQ community are relatively new concepts for our species (and in most, if not all, of these cases systemic discrimination is still widely prevalent). Therefore, an argument could be made that we need to sort out the ethics and legalities of our *own* species first before attempting the same with nonhumans. However, this again conveniently limits our philosophical focus to ourselves. Regardless of whether or not nonhuman animals (or other organisms, for that matter) are given moral consideration, a strong (and vital) argument can be made for our dependency upon the other-than-human world. All of our basic necessities are derived from the natural world: food, shelter, clothing, energy, medicine, and that invisible and miraculous gas exhaled by leaves we call oxygen.

Our planet's biosphere houses 8.7 million species (Mora et al, 2011), excluding countless bacteria and viruses. Narrowing our focus to the human body, our best estimates indicate that we are composed of up to 100 trillion cells, and yet more than half of these are bacterial (Sender et al., 2016). This means that the human ecosystem, shared with more than 40,000 species, houses more nonhuman than human DNA, yet because this otherness does not appear to us in a way that we can consciously register, we cling onto an anthropocentric worldview. Our intimate connections with other forms of life should have us call into question what it means to be human and reevaluate the boundaries of human selfhood. By extension, we should care about nonhumans because, even though they are in one sense an *other*, in another, somewhat paradoxical sense, they are *not* separate from us.

Finite resource extraction, habitat degradation, species extinction, climate change, essentially the cumulative pollution of land, water and sky calls for an urgent shift in cultural and ideological principles. Clearly humans can and do benefit by conserving and protecting the rights of other species. However, this should not preclude the idea that other species should be protected *in their own right*, an idea I will return to at the end of this paper.

3.6. Speciesism and Our DNA

If your pet dog is made to suffer, your moral outrage will be greater compared to a stray dog that has no such human association. One may argue that, similarly, if your brother is made to suffer you will be more outraged than if a homeless person is made to suffer. Both are true; the closer ties we have to a living organism, the greater our empathic connection, and thus the more we are affected by its suffering. However, speaking from the perspective of ethics, in both such cases the animal (whether canine or human) that has no direct relation to another human should be protected from suffering regardless. Pain and distress are not tolerable simply because they fail to be witnessed, nor are they permissible because it is a different species that suffers. Yet humans in general have a tendency to show more apathy and less compassion for those with which they are less familiar.

Table 3.1. The genomic differences of *Homo sapiens* compared to other organisms (including other humans).

Note: The genomes of those organisms that have been sequenced are either edible or model organisms in scientific studies. Much of geneticists' time and resources are spent analyzing the genetic information of species that serve to benefit humankind. That is, our research path follows the utility.

Species	Percentage difference in DNA from humans
Human	0.5%
Bonobo and chimpanzee	1.2%
Gorilla	1.6%
Orangutan	3.1%
Cat	10%
Dog	18%
Cow	20%
Fruit fly and chicken	40%
Wine grape	76%
Baker's yeast	82%

Adapted from Pontius et al., 2007 and Zimmer, n.d.

While we might be reluctant to cause unnecessary harm to other primates, who differ only slightly in their DNA constitution, one would be hard pressed to find a human who shows any reluctance in how they use Baker's yeast. Going up the rows in Table 1, we increase the likelihood of moral consideration as we move from plant, to livestock, to pets, and finally the apes. Even so, the owner of a golden retriever would be loath to inoculate their pet with HIV, while chimpanzees are the model species for such research.

Based on the information in Table 3.1, we might claim that we will only experiment on those animals whose DNA differs from humans by at least 1.2%, which distinguishes us from our closest genetic relatives, the chimpanzee and bonobo; the former passes down learned skills to their young, while bonobos have shown creative musical ability (May, 2013)—both characteristics long thought to be strictly human. However, it is not genomic disparity that neglects the rights of others, but the fact that we

classify someone as *human* that grants them special status not reserved for any other species. (In fact, not considering African Americans to be human ensured slaves did not need to be given their constitutional rights, explained away by declaring them "nonhuman" or "sub-human.")

Chimpanzees have been used in a plethora of psychological and medical experiments. Being our closest living relative, their bodies mimic our own better than any other species. The alternative viewpoint here is that, rather than treat our primate cousins the same way we treat an experimental rat (or yeast), we should grant them rights closer to our own. Since their suffering matters (and parallels human suffering closer than any other animal species), they should be considered moral agents. Something is ethically remiss when our closest genetic relatives, possessing many human attributes such as language, community, and tool making, are made to suffer and die for our benefit.

"Killing a mosquito," Nussbaum (2006) contends, "is not the same sort of harm as killing a chimpanzee" (p. 359). Other primates possess sentience, the ability to make conscious choices, which is how Peter Singer (1975) argues for selective animal rights. He uses the example of a human with Down's syndrome possessing fewer mental faculties than a bright chimpanzee. If we won't experiment on a human with Down's syndrome, we should also not experiment on a chimpanzee, as doing so is speciesism—that is, discrimination based on species.

Nevertheless, suffering alone should be enough to consider the moral rights of nonhumans. If suffering matters, and if humans choose to cause suffering for nonhumans (to benefit *Homo sapiens*) in an arbitrary manner, we need to reevaluate how we think about and treat other-than-human species, and consider the ramifications for education and curriculum. How can we embed an experiential learning model that inspires an ecocentric ethic? Within such a pedagogical system, how do we avoid speciesism and disrupt anthropocentrism?

3.7. The Curriculum Connection

Many scientific (and inherently atomistic) assumptions are deeply embedded in our curriculum. When a dead frog is placed in front of a biology student, the implicit statement is that this hour-long lesson is more important than the life of this frog. Science as epistemology assumes, almost as a matter of course, that this animal is an object and its internal organs mechanisms to be atomized and studied. The frog becomes more object than organism, devoid of moral status. In this way, science education can construct nonhuman nature as inert and therefore not worthy of ethical consideration.

Proponents of frog dissections may contend that dissection is hands-on, a literally visceral experience oft-remembered by students. In addition to discussing and relating organ systems to human anatomy, such a lesson can be interwoven with concepts of evolution (such as adaptations linked to leg and tongue length) and ecology (such as habitat and ecological niches). One might also argue that dissection can inspire future surgeons or veterinarians to pursue such careers. Further, there is an enormous invasive American bullfrog population that needs to be stymied (Louette et al., 2014); catching such amphibians in order to remove them from non-indigenous areas and providing these specimens to be used in dissections makes good use of an ecological problem.

However, such reasoning does not, in itself, justify the killing of these animals. None of these reasons address the underlying issue of engaging the world through a human-centered lens, and therefore enabling the arbitrary suffering of nonhumans. The problem goes deeper than what students *can* learn from dissections. We need to address the hidden curriculum and unspoken presumptions that happen as a *result* of mandatory dissections. Dissection invariably moulds the young minds of students given scalpels as tools.

While science does follow its own set of ethics—an unbiased and honest approach with responsible results that get peer-reviewed—the use of animals is a given in the biological sciences. Bioethics is a discipline concerned with the ethics of science, yet while we may be persuaded to be efficient in our use of animals (Festing et al., 2002),

such use is, in many ways, the backbone of biology. In order to study life, we experiment upon and dissect nonhuman life.

When dissections happen, the specimen is already dead and located in a sterile (e.g., not its natural) environment. By negating choice, that is, "by [our] silence on the subject" (Martin, 1981, p. 107) this impresses (or even imposes) a certain moral viewpoint on students. One wonders how many biology students graduate without a single "worry about the uses to which [science] is put" (p. 104). More broadly, educators often neglect to "investigate the particularly acute and very challenging value questions that arise in relation to hidden curricula of all kinds" (p. 108).

Goethe expressed concern that

> to break phenomena down into discrete elements or units is to drain them of life. Life resides in wholes: when organisms are taken apart they are no longer alive. In order to understand, and hence engage with, the aliveness of nature, we have to understand it in terms of its wholeness. (Mathews, 2008, p. 60)

The frog is more than the sum of its parts. The fact the animal is dead omits a significant—and imperative—part of the lesson. Ecology has a lot to teach the other sciences: the interrelatedness of all things is a pertinent concept to shift our worldview toward a more holistic, ecological perspective. Many scientists have deep moral concerns for the nonhuman members of the biosphere, yet all too often this concern arises from an anthropocentric perspective.

How can we approach frog dissections differently? A number of options are available, including (1) giving students the choice to dissect or not. This can include a discussion prior focused on the benefits and drawbacks of dissection, as well as the available alternatives (such as models and online dissections). (2) Moving the classroom outside into a place-based learning environment, where frogs are part of the ecosystem. One can imagine a very different lesson being taught by those students given a dead frog and a scalpel, and those who discover this living and breathing amphibian in its own environment. The former focuses on anatomy and physiology, the latter on ecology and habitat, shifting from anthropocentric to ecocentric attitudes. (3) Widening our scope,

ethics and a sense of social responsibility can be interwoven with many, if not all, lessons. This helps undermine intrinsic speciesist assumptions about what and how we learn. Of course, the above options are dependent upon the age group of learners, available technology, and access to wetland habitat. But with computers being ubiquitous at schools, and online simulations getting more and more sophisticated, dissection alternatives have never been closer to the real thing.

Situations may exist where dissection is ethically defensible. If animal specimens, dead of natural causes, are found in their native environment by students, this gives learners an ecological context. Further, the gathering, preparation, dissection and cleanup of the specimen(s) would be carried out respectfully, with a reverence and gratitude for this opportunity, with students involved and giving input at every step.

3.8. Looking Forward to an Ecocentric Education

This paper has primarily focused on human and nonhuman animal ethics. However, a case is increasingly made for extending ethical consideration not only for all living things, but for inanimate objects as well (Curry, 2011). This is the realm of deep ecology, and although I do not have room to explore this fully, I feel that a brief glimpse at the path ahead is pertinent.

When economic gain consistently trumps environmental ethics, the importance of nature and ecology is overlooked. As Leopold (1949) so clearly prophesied more than half a century ago, "our bigger-and-better society is now like a hypochondriac, so obsessed with its own economic health as to have lost the capacity to remain healthy" (p. ix). Panikkar (1996) contends that, "To have to pay for water, food—and soon even air—is a sign of a sick culture" (p. 51). Given that each human is a "knot in a net of relationships," (p. 55), and since "Aristotelians argued that all of nature is a continuum, and that all living creatures are worthy of respect and even wonder" (Nussbaum, 2006, p. 328), only an ecocentric worldview can help establish such respect and wonder for the more-than-human.

We need what Mathews (2008) calls,

> a *creative co-action,* a form of co-action that might be termed *synergy* [which is] any form of intentional interactivity between two or more parties who engage with each other in such a way that something new and larger than either of them, but true to the inner principle of each, is created. (p. 48)

I would argue that the human body, as a living and breathing ecosystem containing trillions of bacteria, fungi, protists, and tiny animals, is such a synergy. Our own welfare is tied to the flourishing of many ecosystems containing both animate and inanimate members; we thus have ethical obligations to entire ecosystems, up to and including the entire planetary *oikos*. Mathews' synergy concept would enable the import of ecological concerns to move toward the forefront of human thought and progress, and to see "our beliefs as living convictions rather than dogmatic formulae" (Callan, 1995, p. 30).

Synergy and deep ecology move us from exclusively biotic morality toward a more inclusive abiotic morality. "Every natural being is a living cell forming part of a whole and mirroring the whole at the same time. Not only animals and plants are alive, so are mountains and rocks" (Panikkar, 1996, p. 56). Taken this way, even the inorganic elements of the biosphere, from rivers and oceans to minerals and earth, become worthy of moral consideration.

The classroom, as the site of learning, has a pivotal role to play here. Sitting in rows with the authority figure in front sets the stage for learners to be passive and attentive. Learning begins when the first bell rings, and pauses when the recess bell goes off. Prescriptive lesson plans keep surprise and spontaneity to a minimum. Everything is neatly contained in one room. Contrast this with an outdoor classroom, and the conditions dramatically shift. Control is traded for stimuli, walls for sensorial experience, desks for embodiment, moving toward "embodied teaching and learning wherein the whole personality and life of the teacher and learner are involved" (Bai, 2006, p. 17).

Student curiosity is further engaged and the unexpected (whether in the form of clouds, rain, ants, birds or myriad other natural phenomena) gets incorporated into the curriculum of the day. Lessons have a greater potential to become interdisciplinary, cross-pollinating across subjects. While students can benefit from the increased movement and participation of learning outdoors, recent evidence suggests that educators

who teach outdoors develop innovative teaching strategies, in addition to bolstering their confidence and enthusiasm for their work (King's College London, 2011). Pedagogy needs to involve the creation and maintenance of a moral climate of care, respect, sensitivity, and compassion whereby class members become more attuned to and connected with all those who are other (Bai et al., 2013; Cohen & Bai, 2012).

"That land is a community is the basic concept of ecology, but that land is to be loved and respected is an extension of ethics" (Leopold, 1949, p. viii–ix). Can we learn to love and respect what we treat as mere commodities? Further, we must protect and care for entire ecologies based on our recognition that we are inextricably connected to them; their welfare and flourishing is our own. The long trodden road of anthropocentrism leads us to protect a salmon species—but not the river they swim, feed, mate and nest within. A world where rivers are treated with wonder and respect is also a world where students learn outdoors through an ecocentric lens.

References

Abram, D. (1996). *Spell of the sensuous: Perception and language in a more-than-human world*. Vintage Books.

Abram, D. (2011). *Becoming animal: An earthly cosmology*. Random House of Canada.

Americans for Medical Progress. (n.d.). Animal research benefits: Animal research means medical progress. Retrieved from https://www.amprogress.org/animal-research-benefits

Animalearn. (2012). *Frequently asked questions: How many animals are dissected every year?* http://www.animalearn.org/faq.php#.VSqp1EvdJ_u

Bai, H. (2006). Philosophy for education: Towards human agency. *Paideusis, 15*(1), 7–19.

Bai, H., Cohen, A., & Scott, C. (2013). Re-visioning higher education: The three-fold relationality framework. In J. Lin, R. Oxford & E. Brantmeier (Eds.), *Re-envisioning higher education: Embodied paths to wisdom and social transformation* (pp. 3–22). Information Age Publishing.

Bonnett, M. (2009). Education, sustainability, and the metaphysics of nature. In M. McKenzie, P. Hart, H. Bai & B. Jickling (Eds.), *Fields of green: Restorying culture, environment, and education* (p. 177–186). Hampton Press.

Bromige, D., Eigner, L., Langland, J., Sandeen, E., Snyder, G., Sorrentino, G., Stafford, W. E., & Stefanile, F. N. (1968). *Poetry, 111*(6), 359.

Callan, E. (1995). Virtue, dialogue, and the common school. *American Journal of Education, 104*(1), 1–33.

Cobb, E. (1977). *The ecology and imagination in childhood.* Columbia University Press.

Cohen, M. J. (2007). *Reconnecting with nature: Finding wellness through restoring your bond with the Earth.* Ecopress.

Cohen, A. & Bai, H. (2012). Minding what really matters: Relationship as teacher. In C. Chambers, E. Hasebe-Ludt, A. Sinner, & C. Leggo (Eds.), *A heart of wisdom: Life writing as empathic inquiry* (pp. 257–266). Peter Lang.

Commoner, B. (1971). *The closing circle: Nature, man, and technology.* Bantam Books.

Curry, P. (2011). *Ecological ethics.* Polity Press.

Festing, M. F. W., Overend, P., Gaines Das, R., Cortina-Borja, M., & Berdoy, M. (2002). *The design of animal experiments: Reducing the use of animals in research through better experimental design*. The Royal Society of Medicine Press Limited.

King's College London. (2011). Understanding the diverse benefits of learning in natural environments. http://www.lotc.org.uk/wp-content/uploads/2011/09/KCL-LINE-benefits-final-version.pdf

Leopold, A. (1949). *A Sand County almanac and sketches here and there.* Oxford University Press.

Louette, G., Devisscher, S., & Adriaens, T. (2014). Combating adult invasive American bullfrog *Lithobates catesbeianus*. *European Journal of Wildlife Research, 60*(4), 703–706.

Luoma, J. R. (2006). *The hidden forest: Biography of an ecosystem.* Oregon State University Press.

Martin, J. R. (1981). The ideal of the educated person. *Educational Theory, 31*(2), 97–109.

Mathews, F. (2008). Thinking from within the calyx of nature. *Environmental Values, 17*, 41–65.

May, K. T. (2013, Feb. 28). The interspecies internet: Diana Reiss, Peter Gabriel, Neil Gershenfeld and Vint Cerf at TED2013. TED Blog. http://blog.ted.com/2013/02/28/the-interspecies-internet-diana-reiss-peter-gabriel-neil-gershenfeld-and-vint-cerf-at-ted2013

Metzner, R. (1995). The psychopathology of the human-nature relationship. In T. Roszak, M. E. Gomes & A. D. Kanner (Eds.), *Ecopsychology: Restoring the Earth, healing the mind* (pp. 55–67). Sierra Club Books.

Mora, C., Tittensor, D. P., Adl, S., Simpson, A. G. B., & Worm, B. (2011). How many species are there on Earth and in the ocean? PLOS Biology. doi: 10.1371/journal.pbio.1001127

Noddings, N. (2002). *Starting at home: Caring and social policy*. University of California.

Nussbaum, M. C. (2006). *Frontiers of justice: Disability, nationality, species membership.* The Belknap Press.

Panikkar, R. (1996). A nonary of priorities. *Interculture,* XXIX(1), 48–58.

Patterson, F., Tanner, J., & Mayer, N. (1988). Pragmatic analysis of gorilla utterances: Early communicative development in the gorilla Koko. *Journal of Pragmatics, 12*(1), 35–54.

Pollan, M. (2013). *Cooked: A natural history of transformation*. Penguin Books.

Pontius, J. U., Mullikin, J. C., Smith, D. R., Agencourt Sequencing Team, Lindblad-Toh, K., Gnerre, S., Clamp, M., Chang, J., Stephens, R., Neelam, B., Volfovsky, N., Schäffer, A. A., Agarwala, R., Narfström, K., Murphy, W. J., Giger, U., Roca1, A. L., Antunes, A., Menotti-Raymond, … O'Brien, S. J. (2007). Initial sequence and comparative analysis of the cat genome. *Genome Research*, *17*, 1675–1689.

Sender, R., Fuchs, S., & Milo, R. (2016). Revised estimates for the number of human and bacteria cells in the body. *PLoS Biology*, *14*(8), e1002533. https://doi.org/10.1371/journal.pbio.1002533

Singer, P. (1975). *Animal liberation.* HarperCollins.

White, L. (2004). The historical roots of our ecological crisis. In R. S. Cottlieb (Ed.), *This sacred Earth: Religion, nature, environment* (2nd ed., pp. 192–201). Routledge.

Wilkins, J. S. (2009). *Species: A history of the idea.* University of California.

Zimmer, C. (n.d.). Genes are us. And them. *National Geographic*. National Geographic. http://ngm.nationalgeographic.com/2013/07/125-explore/shared-genes

Chapter 4.

Romanticism and Science Education: Nature as a Poem

4.1. Preamble

This chapter broadens the focus of Chapter 3's human exceptionalism and speciesism to include the aesthetic and moral qualities offered by Romanticism, and addresses bringing arts-based learning into teaching science. A pedagogical experience in the Amazon rainforest reminds us that we are part of a larger food web, and that our bodies are more permeable to other species and the biosphere than we might care to admit. (Notably, colonialism leaves a legacy suggesting that travelling abroad can reinforce racism, speciesism, and privilege.) Poetry and photography are included as examples of reflective inquiry and pedagogy. Continuing with the theme from Chapter 2, there is also further discussion around the interrelationship of science and poetry. Examples of ecopoetic inquiry, evoking relationality and "disturbing the illusion of a human/nature divide" (Beavington, 2019, p. 48) are provided, including the political voice. Important to note, is that waxing poetic about nature is not the end goal of ecopoetic inquiry. Rather, this process can open invitations for land-based pedagogy and environmental education through a pluralistic literary lens. ✺

4.2. Introduction from the Amazon

The rain forest is alive with sound. Vines hang like snakes on every branch of every tree. The air is heavy with rain yet to fall. My thirteen students are trekking through primary tropical rainforest, the greatest terrestrial biodiversity on our planet. This setting is their teacher.

I have travelled with Kwantlen Polytechnic University's (KPU) Interdisciplinary Amazon Field School three separate years. Students with diverse backgrounds share an experience of cultural, geographical and ecological immersion. This is a collaboration

between KPU and the Calanoa Project, founded by Marlene and Diego Samper. Calanoa is a private natural reserve located at the very heart of the Amazon Rainforest and offers students the opportunity to engage in an intensive cross-disciplinary field study focused on integrating personal growth, nature experience, and reflective scholarship.

As a poet-scientist-philosopher my intention, both on this field school and in this paper, is to promote reflective and relational learning with university students through poetry, arts-based teaching, and direct nature experience. I will argue that if we approach the scientific method with wonder and reciprocity, we might fully acknowledge our moral responsibility toward the biosphere and all earthly beings. I incorporate my own poems and photography throughout, both as a Romanticism-inspired praxis and to elucidate the vital importance of an ethical-holistic pedagogy in the current era of human-powered climate change, dramatic species extinction, and habitat destruction.

But first, let us return to the Amazon. As my students breathe in the rainforest, serenaded by choruses of insects, amphibians, and the occasional primate, everything begins to feel more permeable, more interconnected. At one point our intrepid guide, named Elvis, gets stung by an aggressive wasp. He retreats from the nest and trail blazes us a new path to circumvent the danger. Here in the Amazon nature commands respect and a reciprocity with the wild. Humans are but a single species in a vast cauldron of biodiversity, no place more evident than here. As David Abram (1996) says, “We are human only in contact, and conviviality, with what is not human” (p. 22). The other-than-human voices of the Amazon are many. Should we learn to listen, each species becomes a unique teacher.

Amazonia
every leafblade watches you
a study for each pupil
unfurls vision that never blinks
mentors through mystery and survival
a million lessons for those who listen

Ants
carve roads with six-legged fortitude
the way Maxine Greene speaks of the quest

a tornado of pheromone forges the path
one antennae twitch perceived by all
a tsunami that ripples through the colony

Dolphin
he glides through water's pedagogy
locating echoes of our evolution
fabled fins that once walked on land
this shape-shifting intelligence
narrates my ocean ancestry

Mosquito
buzz I want to slap
before that bloodsucker slips past my skin
this pest food for bat and bird
shows me a knot in the food web
and the human-made holes we cannot stitch

Strangler Fig
parasitic teacher that means well
star-stretcher first, then root digger
coddles with an overkill of material
the student becomes but a shadow
inner cavity hallowed of creativity

Tarantula
I fear those eight anxious appendages
an undulant of waves along the cabin wall
why does my stomach lurch before this beauty?
such delicacy in her gesture and touch
slows my heart in trepidation

Anaconda
limbless queen of the jungle river
with skin that weds sinuous to simple
no fingers to point or vertebrae to raise
to swim climb slither prey
this boa swallows caiman whole

Sloth
a still and single-minded reminder
patient guru of three-toed precision
slow life in a singular ceiba tree
every blink and breath a precious play
reflected in the year's long second

Amazonia
vast cauldron of leaf and fang
simmers with life's cardinal seed
a place terror and wonder collide
caught in the jaguar's perfect gaze
do you look or
do you look away?

When a student is tasted by a mosquito, gasps at the sight of a dolphin fin breaking the Amazon River surface, or shudders as eight hairy tarantula legs ramble across their cabin wall, such encounters jog our senses and attune our awareness. They remind us of our bodies' amazing vulnerability. Such visceral and pre-rational responses, in this "place where terror and wonder collide," cue us toward the ecological concept that we are but a small part of nature, interwoven into a larger tapestry.

Approaching the end of our trek, I look up to see the rain, tiny flecks caught in equator sunlight. Except behind every leaf the sky is blue. It takes a moment to register: this isn't rain, it's insects. Thousands upon thousands in descent, flitting to and fro, ubiquitous enough to be mistaken for precipitation. The awe of this moment snaps me to attention. Is this the kind of wonder experienced by Humboldt and Darwin in the Americas when they first ventured, respectively, to the Andes and Galápagos Islands?

Our final yet most profound engagement with the forest happens off the well-trodden path. Elvis machetes his way down to a huge ceiba tree, its buttressed trunk grasping the surrounding earth like the talons of a giant harpy eagle. For the Mayans, the ceiba tree served as bridge between the Earth and the spirit-world. "Place your hands on this ancient mother tree," Elvis explains. "Close your eyes for two minutes. Then let out a primal scream into the jungle. This scream is a release of some weight, hurt, or anxiety that we (or someone close to us) carries." The students all take part, and we immerse in an all-too-rare moment of silent reverie. The resultant screams come from a place somewhere deep, a place usually kept behind the walls of reason and etiquette. The macaws perched above tilt their heads in curiosity at the shrill cries of these two-leggeds.

We load back into our small boats, heading out onto Matamata Creek and the twilit tunnels of forest flooded by the wet season. As I paddle the dark waters, I ponder on the teachings of the forest and the river. What lessons, forgotten by civilization, can this wild place teach us?

Matamata

the pulse of flooded Amazonia
thrums through our canoe
the current
every leaf and vein
sparks light
the paddle in my hands
a Colombian Excalibur
king of the river
her sunken secrets
hidden beneath
the turtle's earthen shell

I wipe away
the malarial blood
of squashed mosquitos
my nose wrinkles
at deet mixed
with forest sweat
my pores open
to the vascular
wilderness within
my skin tunnels
a memory of
death and breath

Matamata
you meander
wide round
bending light
your cauldron of algae
captures a
chlorophyll feast
you swallow roots
flood the forest
overflow your banks
with dolphins
under blackwater

tannin-leached artery
palpitates

what lurks?
at the surface mirror
whose nostrils?
anaconda
light falls
insects buzz
black bird cries
a sunset drone
for hunger and sex

remember
your wild blood
and feral heart
recover the soul
of the shaman
his scream silent
as the water lung
louder than
the darkness

Something ancient stirs in this river flooded ten meters deeper by rains in distant highlands. The poem, "Matamata," speaks to the effects of the "sunset drone" and "forest sweat" on our cultured—or even academic—bodies. Beyond the rational, the intellectual, the logically defined is the spirit of our "wild blood" that connects us to this place. This remembrance pokes holes between the civilized and wild, the objective and subjective, the material and spiritual, forming a porous membrane that teaches us to own and embrace, rather than shun, our so-called primitive qualities. Intuition, awakened senses, humid sweat, and even the possibility of lurking dangers are all gifts heightened by immersive nature experience.

Students must prepare for this experience. While the Amazon Field School offers a tremendous opportunity for place-based learning, where the arts (drawing, photography, writing, etc.) can be explored alongside the sciences (chemistry, ecology, fluvial geomorphology, etc.), it also stretches our bodies and challenges our beliefs. Students need to bring a certain level of maturity, an openness to other ways of thinking and being, a willingness to be bitten, sunburnt, sweat-soaked, and an understanding of the power of

vulnerability. Brené Brown (2013) has shown vulnerability to be the birthplace of innovation and creativity, a place for transformative opportunity. Throughout the Amazonia experience, students engage in reflective journaling, group discussion, and debrief sessions, in the hopes that any feelings of overwhelm or discomfort become opportunities for growth, or in some cases transformation.

4.3. Lessons from the Romantics

In the remainder of this paper, I will outline the ideology of Romanticism and the aesthetic, holistic and moral qualities it can offer science education. I will argue that poetry and poetic inquiry (Sameshima et al., 2017) in university can be employed to engage students in a participant mode of consciousness and raise questions about post-secondary science pedagogy that positivism and Cartesian-Newtonian models de-emphasize. Can we engage in holistic-based, wonder-filled science education that happens in local ecosystems, or even within the confines of a conventional classroom? How can we re-integrate science, philosophy and the fine arts? How can we return to a more permeable relationship with nature, one that cultivates an ethical consideration of the more-than-human? Learnings from the Romantic era can help us answer these questions. Writing poetry presents one avenue toward understanding our relationship with the natural world, participating with the other-than-human consciousness, and the interweaving of science and art.

Next, I will examine poetic inquiry as a reflective and inhabiting methodology that can build connective tissue among human, other-than-human, and place, and later outline some science-based poetic teaching practices using ethical-holistic pedagogy. Where ecology attempts to study scientifically everything in relation, holism is its philosophical twin. Reductionism, or the investigation of phenomena in isolation, “can only give us a partial view of anything it dissects” (Miller, 2000, p. 21). As such, we should contemplate the world as an interwoven tapestry lacking loose threads. Métissage (Hasebe-Ludt et al., 2009) will help integrate and conceptualize my inquiry in order to bring forth scientific, artistic and philosophical voices. I will braid lenses of inquiry with

a variety of my own personal voices: academically inspired, poetic works, photography—and the lived-experiential writing found previous.

Western civilization's privileging of the mind over the body enables a human-nature dualism and general desensitization from nature that discourages unity between epistemic object and epistemic subject (Abram, 2011; Bai, 2012; Hadzigeorgiou & Skoumios, 2013; Matthews, 2008). During the Romantic era (late 1700s to roughly 1900) the natural sciences unified human beings and nature, and Romantic scientists enriched their work with aesthetic and moral qualities such as drawings, creative writings, and a deep relationality that blurred the line between subject and object. As Hadzigeorgiou and Schulz (2014) explain, "The 'Romantic' scientists believed in an infinite and mysterious nature, whose study was similar to an aesthetic experience, and which was characterized by the experience of wonder, poetic inspiration and creativity" (p. 1977). Science was not yet siloed from art and philosophy. Goethean science, where students understand nature inwardly, offers an alternative to Newtonian science by incorporating the intentionality of phenomenological learning and the development of ecological literacy (Cohen, 2007). Goethe (1790/1988) asks us to engage directly with our subjects and avoid ontological reversal (Harvey, 1989) where models take on more importance than the phenomenon under study. This common practice happens, by example, when a student studies abstract photosynthetic mechanisms without examining an actual leaf, more concerned with chemical formulae and electrons than the wonder and welfare of the photosynthesizing plant.

Darwin was a Romantic scientist, although he would have called himself a natural philosopher (*philosophia naturalis*), as the word scientist, coined by scientist/philosopher William Whewell, did not enter the popular vernacular until the mid-1800s. The telling difference between natural philosopher and scientist is the removal of philosophy from science. Modern scientific studies seldom engage with ethics or philosophical discourse; this is reserved for other disciplines. Darwin's theory of natural selection, one of science's greatest discoveries, unifies all the myriad fields of biology (Darwin, 1859/1998). Anatomy, ecology, genetics, cell biology, and developmental biology all dance to the rhythms of evolution the same way planets and moons dance to the laws of

gravity. As a Romantic scientist (Richards, 1987) Darwin was able to envision natural selection by examining phenomena in a perennial and inclusive manner, through eyes that saw the dynamic creativity of the world. Such a holistic and prescient ideology that unites divergent disciplines is vital in today's interdisciplinary world where, for example, climate change studies require biologists, geochemists, meteorologists, mathematicians, oceanographers and others to intimately collaborate.

How can holistic education in university, especially one that is experiential, reflective, and reciprocative, cultivate wonder in learners that influences their academic and ethical decisions? If we want to develop a relationally constructed autonomy and responsibility, the often atomistic scientific methodology needs to engage in cross-disciplinary pollination. Miller (2000) warns of strict intellectual training that leads to colonial thinking such as "how to gain knowledge *over* the world" (p. 68); Hadzigeorgiou and Schulz (2014) suggest that we reclaim the Romantic conception of science where aesthetic, contemplative and moral deliberation (Richards, 2002) fosters an ethical-holistic purpose (Kearns, 2015). Holism is an anti-reductionist view that recognizes the wholeness of our beings. Hadzigeorgiou and Schulz (2014) expand on this,

> As a philosophy of education, holistic education is based upon the idea that meaning can be constructed through multiple connections to both the natural world and the community. In this sense, a 'holistic experience' is an experience that encourages unity between a subject and his/her environment (including his/her object of study), through physical, emotional cognitive, and even spiritual involvement with it (p. 1987).

Through the lens of Romanticism, and inspired by Goethean science that promotes empathy and prolonged looking towards a non-dualistic unity (Robbins, 2005; Wahl, 2005), perhaps there is an alternative paradigm of, and methodology for, science that fully acknowledges and requires humans' moral responsibility toward all earthly beings and our mutual flourishing? I will argue that poetry is one such method that promotes contemplative practice and a reciprocal relationship with the phenomena under study. Poetic inquiry can facilitate reflection and sensorial engagement, build connective tissue, and fine-tune our understanding via concise language and poignant metaphor. Poetry opens new doors of perception.

The Mexican poet-diplomat Octavio Paz contends that poetry is the remedy for "resisting modern man's accelerating flight from the Garden of Eden into a world made pallid and plastic by technological glut" (Sherman, 2009, p. 89). Sherman expands this further,

> The remedy is poetry, of course, poetry as fact and as metaphor to repair the augmenting gulf between man and his surroundings, man and his being. There are two necessary steps: first, a profound contemplation of nature until we are in tune with its rhythms, can hear and articulate them, can overcome our instinctive fear of alien forces; and then, an essential recovery of that nothingness which precedes being, that state of benign uncertainty which is the original but corrupted source of the bastardized progeny which currently afflict us: futility, anxiety, boredom. (p. 89)

This suggests that poetic inquiry is more than mere words on a page or language poiesis. Poems have the potential to be transformational both for the poet and for her or his readers, and in a larger socio-political context.

4.4. Poetry as Intimate Inquiry

> I think that we're beginning to remember that the first poets didn't come out of a classroom, that poetry began when somebody walked off of a savanna or out of a cave and looked up at the sky with wonder and said, "Ahhh." That was the first poem. (Clifton, 2010).

Documented poetry, such as Homer's *Odyssey* and Valmiki's *Ramayana*, have existed for thousands of years, while oral poetics in the form of song or hymn date even further back. Poetic inquiry can be seen as a subset of poetry that serves as intentional research. Before I distinguish these further, let us review what several celebrated poets have to say about poetry.

"A poet's work is to name the unnameable," says Salman Rushdie, "to point at frauds, to take sides, start arguments, shape the world, and stop it going to sleep" (as cited in Andrews, 1993, p. 699). Rushdie emphasizes the transformative nature of poetry, and its ability to provoke conversations that matter and keep the truth alive. Robert Frost explicates the way poetry unearths the unknown: "I have never started a poem yet whose end I knew. Writing a poem is discovering" (as cited in Wiggerman & Meischen, 2015,

Junk drawers section, para. 12). Poetry is not a product but a process that comes to light through the act of living poetically, or constructing possibilities in the way Carl Leggo (2015) describes: "language is dynamic and energetic, and opens up possibilities for understanding our lives and experiences and relations" (p. 178). In summary, then, poetry is an engagement with discovery and wonder that acts as a bridge of understanding across divergent realms, prompting us to excavate and access the inaccessible.

Poetic inquiry uses poetry to study and consider fuller understandings of a research subject (Faulkner, 2009; Prendergast, 2009a; Wiebe, 2008). This type of qualitative research is often contemplative in nature, and can help clarify our place in and feelings toward the more-than-human world. Through poetic inquiry—that is, through the rumination of a subject or experience, thoughtful word choice and use of imagery, and careful construction of a poem that may include "metaphor, lyric, rhythm, imagery, emotion, attention, wide-awakeness, opening to the world, self-revelation" (Prendergast, 2009b, p. xxxvii)—one can deepen understanding of both *I* and the *Other*, and the relational space between. The visceral and evocative nature of poetry can bring the subject alive and forge a reciprocal relationship between the observer and the observed, blurring the lines that separate object and subject, human and nonhuman, teacher and student. Ellsworth describes this as "a location that defies the binaries of inside/outside, self/other, subject/object—a space of relation" (McKenzie, 2008, p. 365). Inside this space of relation, and in the expression of affective experiences, we engage with our ecological self and thereby become aware of the larger ecologies that surround us.

Carl Leggo (2004) writes, "the poet *is* a human scientist" (p. 30) who works with language to construct understanding. Science as a methodology utilizes objective data collection and analysis in order to better understand the outer universe, while poetry is a method that subjectively discerns our internal and external worlds and all of the relationships therein. Paz describes poetic experience as "the act of uncovering [that] involves the creation of that which is to be uncovered: our own being" (as cited in Sherman, 2009, p. 89). Put another way, science examines external material truths while poetry (or more generally, art) scrutinizes what it means to be the human animal. In some examples, poetry explores the *umwelt* of other-than-human species (Beavington, 2017).

Poetry acts as a gateway "between inner and outer realities" (Ellsworth, 2005). As de Bolla (2001) writes, "poetic, painterly, or musical knowings arise from a place more elemental than intellectualisation" (p. 8). Poetry thus offers us intimate access to a world largely explained by sterile science, at least in the dominant western culture, and both reconnects our senses with this world and ponders the questions that science has difficulty addressing. What is alive? What is human? What is our responsibility to the world? How are my body and being connected to other life phenomena?

Poetic inquiry can be seen as a specific form of poetry employed with intention for research or teaching. Data collected from interviews, journals, assignments, photographs or lived experience can be mined and moulded into a poem in order to express an idea or experience in a precise and provocative manner. Elliott (2012) defines poetic inquiry (through Emerson) as "the work of truth-seeking contemplation and inward observation itself" (p. 17). Ultimately, Emerson envisions poetry and poetic inquiry as inseparable: "The true philosopher [i.e., the scholar] and the true poet are one, and a beauty, which is truth, and a truth, which is beauty, is the aim of both" (as cited in Elliott, 2012, p. 17).

4.5. An Ecopoetic Inquiry

Prendergast (2009b) explains that poetry of all forms can "be a form of research, a re-searching of experience and sorting into expression and communication through language" (p. xxii). I have used poems as assignments, papers, and research, as a way to find "unity in variety" (Bronowski, 1956, p. 20), that is, to tie tightly together the common themes that underlie seemingly divergent realms. As Bronowski further explains, "The discoverer or the artist presents in [science or works of art] two aspects of nature and fuses them into one" (p. 19) or as Serres (1995) puts it, "A cluster of highly different relations becomes a body" (p. 101). When we recognize our interrelations with other species, and conceive of our human bodies as but a smaller piece of the Earth's body, we may become aware that we are but one knot in the biosphere's infinite relationality. This work deepens my understanding of self and my purpose in the world.

By synthesizing various modes of perception, poetic inquiry becomes a way of paying attention and clarifying intention. With this in mind, I offer the following poems.

Every inhalation and exhalation inextricably connects us to the animals, plants, and geography of our personal locus. Even the air itself is part and parcel of our bodies. "We mistakenly go out into the world to find life," writes Jarvis (2009), "a life which, however, there is no need for us to 'find', since it is, necessarily, just what we already are" (p. 362). Holding firm to this idea that we are life, and that "I mix with the world which mixes with me" (Serres, 2008, p. 80), the poem "The Circle" examines both our connection toward and disregard for the more-than-human world, and brings our focus down to the level of the oxygen atom.

The Circle

thoughtless breath
sucks in the world
lungs—an inverted tree
windpipe—a trunk to leafy alveoli
spider webs, air sacs
snare oxygen exhaled by gods
into a pulmonary cocoon

hemoglobin
filled with atmospheric spirit
vessels borne in plant and animal
the dance of O_2—chloroplast to mitochondria
leaves the twig for the capillary that
digs into muscle and bone

hormones pollinate
red blood cells—
billions of messenger bees
in an endless circuit
artery to vein, vein to artery
death comes slow to these gods of old
microscopic Hermes
runs the organ gauntlet
spleen to pancreas
to Stygian pituitary
a race toward a galaxy of synapses
home to thought

and mind
and memory
with the nerve to believe
you are different

oxygen is a circle
a ring that holds
gods and bees and blood
every thoughtless breath
exhales carbon for the trees
that still stand upright

Can we be mindful of our body, this taken-for-granted vessel that carries us through corporeal life? The backbone of life as we know it is carbon, and oxygen is the gas that allows our cells to respire. Is it possible—or necessary—to show gratitude for mere atoms? The complex efficiency with which our organ systems carry out such precise physiological processes is astounding, an "endless circuit" that runs for more than a century, in some cases. With our "thoughtless breath" we contribute to the carbon cycle, expelling carbon dioxide into the atmosphere so plants or algae can photosynthesize sugars once more. Yet we are ignorant of our role in this cycle, as evidenced by the desperation with which we keep seeking and exploiting fossil fuels. Perhaps if we clearly acknowledged and understood, on a fundamental level, our reliance upon oxygen, our species would make greater haste toward a more sustainable path unreliant upon plants and animals long dead (e.g., fossil fuels such as petroleum and coal).

4.6. A Photographic-Ecopoetic Inquiry

Recently at the optometrist, my first visit in nearly twenty years, the doctor used an optomap to scan my eye. I excitedly asked to see the resultant photo and requested the jpeg, which showed an inverted image of my retina. Fascinated by the capillaries that looked like rivers flowing into my central optic nerve, this became a way to explore the wonder within myself. I wrote the following haiku:

inside my own eye
rivers of sight spiral down
inward crystal ball

Figure 4.1. The right retina and optic nerve of Lee Beavington.
Credit: Taken by Dr. Juliana Jarvis, 2015.

I facilitated an activity with Education PhD students, showing them this image with no context. Their responses reveal the interrelations of thunderstorms, rivers, leaves, neurons and the human eye. These repeating patterns serve as a reminder of the unity in variety found across the biotic and abiotic worlds. Here are a few of their haikus:

Fragmented leaf veins
light shining through the thin veil
guides like a lighthouse

~Tamara Pearl

Moon light and thunder
Power manifesting
In different forms

~Jade Ho

Subaltern vessels
Amazonian Rivers
Bursting by the sun

~Dave Chang

Our bodies are poetry. Patterns found inside reveal “fragmented leaf veins,” “moonlight” and “Amazonian Rivers.” In fifteen words or less, each student explored this image’s mystery to reveal varied and yet unifying perceptions of a natural/human phenomenon.

Microscopic life captivates me. Connor (2006) explains how the invention of the microscope transformed “the deprecation of what were thought to be imperfect and accidental creatures into confirmations of the extent and orderliness of divine design” (p. 80) and that “early observers through the microscope reported their amazed delight at the intricacy and regularity to be found in creatures too tiny to be seen with the naked eye” (pp. 80–81). Thus microbes were granted a more noble status.

Dramatic and diverse life thrives in a single drop of pond water. Through the microscope, I once watched an amoeba ooze in eleven directions at once. I snapped two photographs. Then I pondered, How do these unicellular creatures differ from us? How are they the same? How do they perceive the universe? The following poem, “Intimate Immensity,” borrows its title from a chapter of Bachelard’s *The Poetics of Space*, where he also says “the daydream transports the dreamer outside the immediate world to a world that bears the mark of infinity” (1958/2014, p. 201). My poem searches for the infinite in the small, and elucidates the interrelatedness of all matter from planet to cell.

Intimate Immensity

bits of chromosome and membrane
pregnant with nuclear gods
a cell in a microscope
there lies infinity
my hand
on my wife’s swollen belly
I feel the kick of life
when two cells become one

a labyrinth of folded nebula
layers of lipid and DNA

inside my every cell
a coiled nest of centipede
legs in constant motion
each part in touch with every other
my son
folded in the womb
his head on the placental pillow
an umbilical cord I quiver to cut

welcome to this atomic ocean
that flows as an amoeba in love
morphs swells stretches into you
a spring without shores
caged sunlight
I cradle my newborn
in his first hour
his arms reach out
to hold the hand of galaxies

I watch
the Big Bang throw her chains of light
weave particles into comets of creation
the Little Bang throws her ribosomes
a midwife that delivers the code
an egg turned planetary body
now my son runs through the grass
his tiny body
I love more than my own

I concede to my vast smallness
as we unravel the fluid mosaic
the night sky an eclipse
my son moves his finger
from star
to moon
to his father's eye
as though he is counting the universe

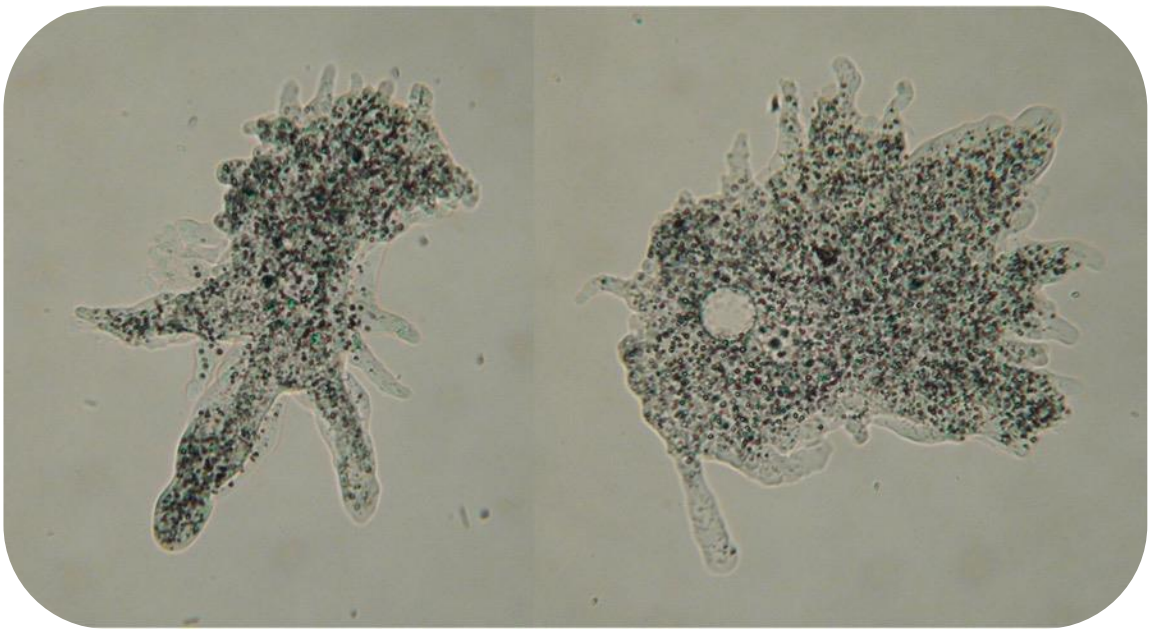


Figure 4.2. The amoeba (*Chaos carolinensis*) as viewed under 100X magnification.
Credit: Taken by Lee Beavington, 2016.

As a biologist who often works in a laboratory, magnified organisms are at once familiar and uncanny, the microscope a window into hidden worlds. The "vast smallness" in this "atomic ocean" opens our perception to new forms of life. Both this amoeba and I are made from stardust, our bodies organized by ribosomes. Whereas science offers a profundity of facts, the relational world is the source of the emotionally profound, the authentically human. Science certainly provides the bedrock for our knowledge of the universe, and a rational approach to objective discovery, yet personal stories and connections are what offer our lives meaning. Poetry can bridge static facts with dynamic feeling.

4.7. Bringing Poetry into the Science Classroom

"Science is the poetry of reality," said Dawkins (2007). At first glance poetry and science seem like odd bedfellows; the former is lyrical, emotional, and multivocal, while the latter is pragmatic, rational, and does its best to stamp out subjectivity. Poetry and science are both informed by bias, and while an exceptional poem relishes some ambiguity, a proper science experiment nullifies uncertainty to the fullest extent possible.

However, both crave exactitude: precision of language and methodology in the search for truth. Sound poetry and science recognize that our knowledge is incomplete. Poetry is not simply inventive words on a page the same way science is not simply a body of facts. Both are ways of knowing, and oblige creativity to be successful in the pursuit to find novel ways of studying something familiar.

Christopher Langton speaks to poetry and science thusly: "There's a reason for poetry...Poetry is a very nonlinear use of language, where the meaning is more than just the sum of the parts. And science requires that it be nothing more than the sum of the parts" (as cited in Horgan, 1996, p. 201).

Science begins with wonder, as both a noun and verb: awe for the beautiful and inexplicable universe, and pondering on how it all operates. Bronowski (1956) explains how "we are moved by the poem, we follow the theorem because in them we discover again and seize the likeness which their creator first seized" (p. 27), suggesting that both science and poetry are paths to wonder. Hadzigeorgiou and Schulz (2014) define wonder as "astonishment and admiration," separate from curiosity which is "a scientific impulse that strives to 'dominate nature'" (p. 1994); we want to cultivate the former through the lessons of Romanticism for a more collaborative engagement with nature. Bronowski (1956) adds, "Science is nothing else than the search to discover unity in the wild variety of nature—or more exactly, in the variety of our experience. Poetry, painting, the arts are the same search…" (p. 16), and if this is true, then arts-based approaches are well-suited to science education.

Poetry strives to be succinct and incisive. A handful of well-chosen words can convey layers of meaning and question conventional thought. This becomes applicable in many contexts of pedagogy—the obvious being creative writing, expressive arts, and language studies—yet I will focus on science education. Theory, concepts and terminology dominate the typical science lecture. If we look at *Biology* (Reece et al., 2014), a standard first-year biology textbook, it speaks to photosynthesis in this manner: "The electrons cycle back from ferredoxin (Fd) to the cytochrome complex and from there continue on to a P700 chlorophyll in the PS I reaction-center complex" (p. 207).

Rich in terminology and pinpoint accuracy, yet lacking emotion and personal relevance, this is the language that inculcates biology students. Part of the problem is that "educators are handed, and largely accept, the mandates of a standardized, 'placeless' curriculum and settle for the abstractions and simulations of classroom learning" (Gruenewald, 2008, p. 317). If "science can only be perceived by life and remains dependent on the body of the scientist" (Noys, 2013, p. 235) then we need to re-invigorate university science pedagogy with sensorial engagement. Ontological reversal displaces us from our senses and direct engagement by giving models and signs more importance than the actual phenomenon under study. Hadzigeorgiou and Schulz (2014) remind us that conceptual details and reductionist approaches can mask the wonder of scientific exploration, and bog learners down in free-floating abstractions.

However, this is not the *only* way to approach science education. The instruction of abstractions and simulations can be complemented (and in some cases, replaced) by reflection, creative exercises, and direct and dynamic engagement. Experiential learning that places student engagement and creativity at the center can be implemented in the science classroom, laboratory and field settings. "The concept of 'the participant mode of consciousness' can indeed help us with the selection of curriculum activities" writes Hadzigeorgiou and Schulz (2014), "that have the potential to lead to holistic experiences. Certain immersion activities, like storytelling, poetry, and the arts, have such potential" (p. 1991). The components of photosynthesis can be role-played so students embody the experience. The differences among animal phyla can be learned by mimicking their movements (Beavington, 2016). Student-led presentations that are creative in nature give learners permission to wear costumes, facilitate interactive activities, and utilize arts-based approaches to engage with science. Such approaches can also be applied in chemistry and physics. Specific examples include having astronomy students embody planetary orbits or the moon's movement in relation to the Earth. In chemistry, chemical reactions can be role-played with signs, or the astonishing properties of water can be presented by students through active and creative methods. And, of course, poetry is an evocative tool that can be used across the disciplines to bring the senses, creative learning, and reciprocity to the fore.

Neilsen (2004) contends that "poetry and inquiry ask us to listen deeply. We must put ourselves in the context; we must feel, taste, hear what someone is saying. Sometimes we must learn to listen under the words, to hear what is not being said" (p. 41). In this way, poetry interweaves experience and creativity, and makes the inaccessible accessible by providing another source of insight into a myriad of topics, including photosynthesis. One activity I facilitate, preferably done outside, starts with students finding and sitting with a leaf. This exercise is similar to Carolyn Elliott's (2012) definition of poetic inquiry as "a mode of thought and discovery that seeks to reveal and communicate truths via intuitive contemplation and creative expression" (p. iv). I invite students to engage with the leaf in silence using multiple senses. With the leaf in their hand, I ask them to ponder: "What aspects of the leaf surprise you?", "If the leaf could speak, what would it say to you right now?" and "How is your hand like the leaf?" This contemplative approach encourages a sensorial and participatory engagement, and students reflect on their experience with the leaf by written reflection. Then they underline a word or short phrase, and one-by-one students place these upon the floor, thus forming a collective poem. This method is less intimidating for those uncomfortable with writing poetry, and promotes collaboration. Prendergast (2009b) questions, "What is the nature of the sediment upon which the poem is written in response?" (p. xxxiv). The sediment here is slow pedagogy and inquisitiveness, which invites more personal and reflective responses.

After facilitating this activity with education PhD students, they constructed the poem below. "Language is the place where alien otherness becomes adventure" (Todres, 2004, p. 40), and here the adventure takes the form of a brittle autumn leaf.

Life is not linear
Death is another beginning, another life

ridges of my fingerprints
kicking up tiny beats against the leaf
or is it the leaf's veins drumming against my fingers?

red five fingered
veined soft and supple
handshake from the tree

the secret underside of the leaf

yet we walk by them
and on them without even thinking twice
Thank you little leaf.

A symmetrical shape none-the-less

linger with the memory
carry forth the joy
live the dying

In the discussion immediately following the leaf activity, the following terms (each mentioned multiple times by participants) were used to describe the experience: aliveness, concise, curious, emotion, heart, imagery, joy, moment, movement, pausing, prolonged looking, tactile, watching, wonder. What a wonderful bedrock from which to build their learning. Post-activity feedback from participants included feeling less daunted by using poetic language in learning, being more curious to hear the science behind the leaf, and opening up to the grief of loved ones recently lost. This is a lot closer to the realm of holism than "The electrons cycle back from ferredoxin to the cytochrome complex" (Reese et al., 2014, p. 207) and cultivates not only a sense of wonder for the leaf but also a relationality that is not possible when ontological reversal is employed; that is, when more abstract models and symbols of the phenomenon dominant, and the leaf itself lay forgotten.

Poetry can be introduced many other ways. Since "an artistic expression and a scientific experience can complement each other" (Hadzigeorgiou & Schulz, 2014, p. 1977), I have used poems to introduce formidable terminology to students, and I have invited students to write poems about mitosis and embryonic development. Other approaches include students writing haikus about scientific phenomena, breaking students into groups to compose a poem on a particular concept, and using prose poetry to grapple with larger ethical issues that relate to scientific research (more on this in the next section). For now, I will address potential concerns and drawbacks of poetic learning in science.

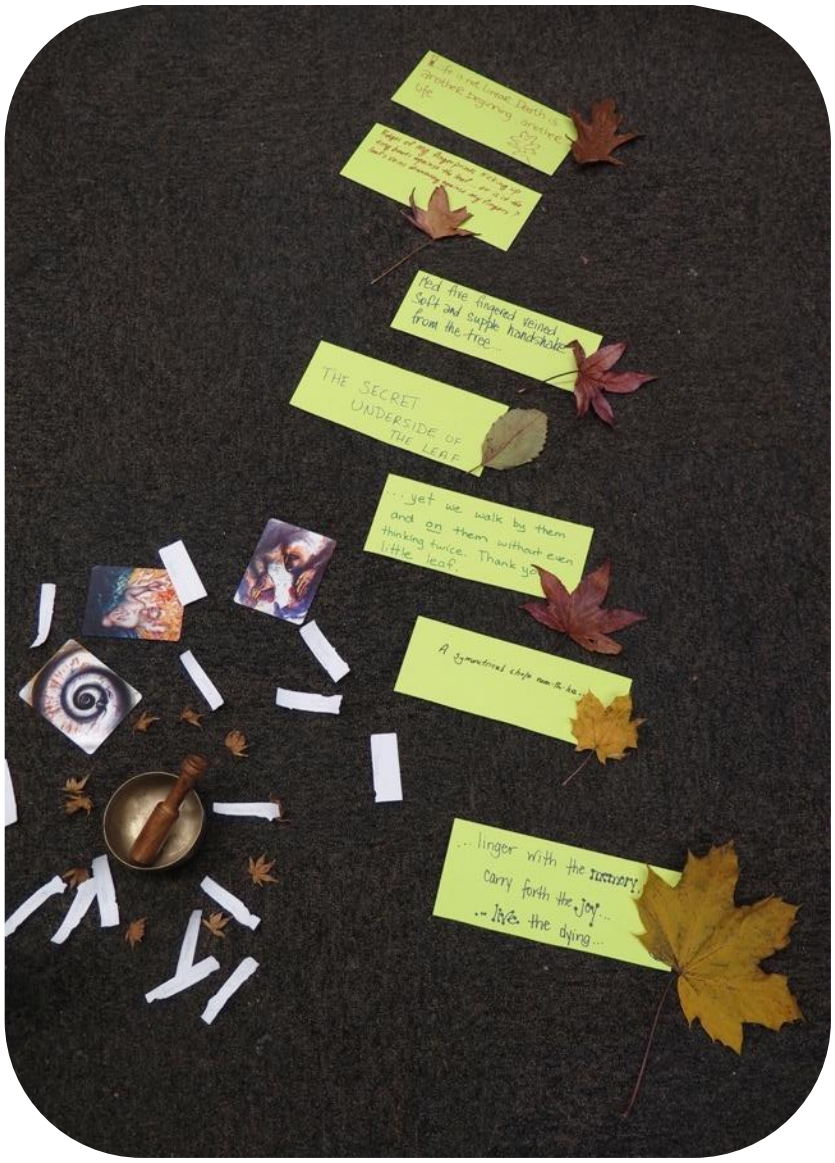


Figure 4.3. A group poem inspired by the leaf.
Credit: Taken by Lee Beavington, 2015.

Poetic language, with its imagery, ambiguity, and artistic license, has the potential to contradict established science. For instance, a poem about amoeba might suggest they have a mind of their own; this is a metaphorical mind, as amoeba completely lack neurons that make up our brain and nervous system. Some poets, such as Gerald Manley Hopkins, choose their words based on sound more than meaning, which can lead to miscontrued ideas about science. Worse still, a poem could trivialize science, promote an anti-science mindset, or anthropomorphize other-than-human organisms. We do not want

to forget the methods with which science excels: unbiased gathering of concrete data. This fountain of dispassionate knowledge can further our health, technology and well-being.

We absolutely need science and scientific language. Poetic inquiry is not a replacement, but a supplement. Poetry can provide learners with an initial relational connection to phenomena, so learners might be more willing to engage with difficult scientific concepts and terminology. Bronowski (1956) reminds us that "We re-make nature by the act of discovery, in the poem or in the theorem" (p. 20). There is an opportunity to fuse "the knowledge, precision, and language of science with the voice, vision, and language of poetry to produce something unique" (Gorrell & Colfax, 2012, p. 13). Poetry can be a bridge between wonder and daunting learning objectives, and a way to link what we learn to our personal lives, with care taken to avoid putting forth pseudoscience.

4.8. The Legacy of Romanticism

The Romantic era provided fertile grounds for natural philosophy, an integration of philosophy and science that reigned until positivism instigated their divorce in the 1840s. What important aspects of Romanticism can we reclaim? Romanticism, of course, embodied more than poetry. Other key characteristics include unity between humans and nature, careful observation via the senses, the importance of the aesthetic dimension, and the revolt against the idea of controlling nature, all of which, one could argue, are vital in today's environmentally tumultuous climate.

When my students in the Amazon Field School gathered around the elder ceiba tree, and placed their hands on that ancient trunk, they were invited to embrace the legacy of Romanticism. That is, to find unity with nature, engage sensorially, and step out beyond reason and etiquette to become permeable with their subjective selves. In this manner, perhaps they felt a kinship toward all their relations on our planet.

Whether students study an intact leaf in the classroom or travel to the remote Amazon rainforest, the objective is the same: to re-enchant science, engage in a

participatory way with the life phenomena under study, and bridge the worlds of art, science and philosophy. Since "every human being lives in three spaces, which interpenetrate and complete but also partially contradict each other" (Uexküll, 1934/2010, p. 54), poetry can serve as a link among these three spaces.

But the larger need, here, is to have science students address philosophical issues regarding the scientific paradigm, the underlying assumptions of the Cartesian-Newtonian outlook—not to mention all of the "shared silences and prejudices" (Bowers, 2008, p. 327) of university education—and the ethical implications of various scientific research such as genetic engineering, stem cells, fetal bovine serum, and the pervasiveness of other-than-human animal experimentation. The reflective and provoking nature of poetry is one path toward philosophical discourse. Descartes (1649/1989) wrote that "wonder is the first of all the passions" (p. 52) to which Irigaray (1993) adds, "The first passion is indispensable…to the creation of an ethics" (p. 74). By starting with wonder, and complementing scientific investigation with poetry or other creative art forms, we as educators can rekindle both a passion for science and a passion for the philosophy of science.

It feels fitting to end this paper with poetry as found through the words of David Abram (2011), whose phenomenological approach to using the senses promotes deep engagement "between the body and the breathing earth" (p. 3). Abram writes poetically, which serves to draw readers into our sensuous and symbiotic world. In his book *Becoming Animal* there is a chapter entitled "Shadow" that moved me to reconnect with my own shadow, and see my shadow as part of myself and the Earth. This final poem was crafted from Abram's words; each line is an intact phrase from *Becoming Animal.* The result is "a hand reaching straight into experience and arranging it with new meaning" (Bronowski, 1956, p. 18), and reaffirms the power of the poem.

Remembering Shadow
(words from David Abram)

born afresh every dawn
night's gloom flees the advance of the rising sun
gift afforded by the sheltering shade of the mountain
torn from the black cloak every morning
defines the mood of this moment where you stand
letting it untangle your senses

the country of shadow
breathing body of the mountain itself
voluminous being of thickness and depth
touching me
at every point of my person

absorbed through the pores of my skin
seeping in to my flesh
my personal night
enfolded within me

tutored by the darkness
disruption of the sun's dominion
inescapable consequence of our physicality
this shadow that eats all other shadows
indistinguishable from me
carries us out of ourselves into Earth's own awareness

References

Abram, David. (1996). *Spell of the sensuous: Perception and language in a more-than-human world.* Vintage Books.

Abram, D. (2005). Between the body and the breathing Earth: A reply to Ted Toadvine. *Environmental Ethics*, *27*(2), 171–190.

Abram, D. (2011). *Becoming animal: An earthly cosmology*. Random House of Canada.

Andrews, R. (1993). *The Columbia dictionary of quotations*. Columbia University Press.

Bachelard, G. (1958/2014). *The poetics of space.* Penguin Books.

Bai, H. (2012). Reclaiming our moral agency through healing: A call to moral, social, environmental activists. *Journal of Moral Education, 41*(3), 311–327.

Beavington, L. (2016). A creative approach: Teaching biology labs through arts-based learning. Article 26 in Tested Studies for Laboratory Teaching, Volume 37 (K. McMahon, Ed.). *Proceedings of the 37th Conference of the Association for Biology Laboratory Education* (ABLE). https://www.ableweb.org/volumes/vol-37/?art=26

Beavington, L. (2017). Aristotle's lantern. In Y. Blomer (Ed.). *Refugium: Poems for the Pacific* (p. 161). Caitlin Press.

Beavington, L. (2019). Ecopoetics of the Amazon. In S. Faulkner & A. Cloud (Eds.), *Poetic inquiry as social justice and political response* (pp. 78–88). Vernon Press.

Bowers, C. (2008). Why a critical pedagogy of place is an oxymoron. *Environmental Education Research, 14*(3), 325–335.

Bronowski, J. (1956). *Science and human values*. Harper and Row Publishers.

Brown, B. (2013). *Daring greatly: How the courage to be vulnerable transforms the way we live, love, parent and lead.* Avery.

Chambers, C., Hasebe-Ludt, E., Leggo, C., & Sinner, A. (Eds.) (2012). *A heart of wisdom: Life writing as empathetic inquiry*. Peter Lang.

Clifton, L. (2010, February 26). Bill Moyers Journal. (Bill Moyers, Interviewer). PBS. http://www.pbs.org/moyers/journal/02262010/transcript2.html

Cohen, M. (2007). *Reconnecting with nature: Finding wellness through restoring your bond with the Earth*. Ecopress.

Commoner, B. (1971). *The closing circle: Nature, man, and technology*. Random House.

Connor, S. (2006). *Fly*. Reaktion Books.

Darwin, C. (1859/1998). *The origin of species by means of natural selection.* Modern Library.

Dawkins, R. (2007). The enemies of reason, "Slaves to superstition" (film), timecode 00:38:16.

Descartes, R. (1649/1989). *The passions of the soul.* Translated by S. H. Voss. Hackett Publishing.

de Bolla, P. (2001). *Art matters.* Harvard University Press.

Elliott, C. (2012). Poetic inquiry [Doctoral dissertation, University of Pittsburgh]. D-Scholarship@Pitt. http://d-scholarship.pitt.edu/12152/1/PoeticInquiryMayETD1.pdf

Ellsworth, E. (2005). *Places of learning: Media architecture pedagogy.* Routledge.

Faulkner, S. (2009). Research/poetry: Exploring poet's conceptualizations of craft, practice, and good and effective poetry. *Educational Insights*, *13*(3). http://www.ccfi.educ.ubc.ca/publication/insights/v13n03/articles/faulkner/index.html

Goethe, J. (1988). *Scientific studies*. Translated by D. Miller. Suhrkamp Publishers.

Gorell, N., & Colfax, E. (2012). *Writing poetry through the eyes of science: A teacher's guide to scientific literacy and poetic response*. Equinox Publishing.

Gruenewald, D. (2008). The best of both worlds: A critical pedagogy of place. *Environmental Education Research, 14*(3), 308–324.

Hadzigeorgiou, Y., & Schulz, R. (2014). Romanticism and romantic science: Their contribution to science education. *Science and Education, 23*(10), 1963–2006.

Hadzigeorgiou, Y., & Skoumios, M. (2013). The development of environmental awareness through school science: Problems and possibilities. *International Journal of Environmental and Science Education, 8,* 405–426.

Horgan, J. (1996). *The end of science*. Broadway Books.

Irigaray, L. (1993). Wonder: A reading of Descartes, *The passions of the soul*. In Burke, C. (Ed.) and Gill, G. C. (Trans.), *An ethics of sexual difference* (pp. 72–82). Cornell University Press.

Jarvis, S. (2009). Michel Henry's concept of life. *International Journal of Philosophical Studies, 17*(3), 361–375.

Kearns, L. (2015). Subjects of wonder: Toward an aesthetics, ethics, and pedagogy of wonder. *The Journal of Aesthetic Education, 49*(1), 98–119.

Leggo, C. (2004). The curriculum of joy: Six poetic ruminations. *Journal of the Canadian Association for Curriculum Studies, 2*(2), 27–42.

Leggo, C. (2005). Pedagogy of the heart: Ruminations on living poetically. *Journal of Educational Thought, 39*(2), 175–195.

Mathews, F. (2008). Thinking from within the calyx of nature. *Environmental Values, 17*, 41–65.

McKenzie, M. (2008). The places of pedagogy: Or, what we can do with culture through intersubjective experiences. *Environmental Education Research, 14*(3), 361–373.

Miller, R. (2000). *Caring for new life: Essays on holistic education*. Foundation for Educational Renewal.

Neilsen, L. (2004). Learning to listen: Data as poetry: Poetry as data. *Journal of Critical Inquiry into Curriculum and Instruction, 5*(2), 40–42.

Noys, B. (2013). Culture or barbarism? *New Formations, 80/81,* 234–236.

Prendergast, M. (2009a). Poetic inquiry is ... 29 ways of looking at poetry as qualitative research. *Educational Insights, 13*(3). http://einsights.ogpr.educ.ubc.ca/v13n03/intro/prendergast.html

Prendergast, M. (2009b). Introduction: The phenomena of poetry in research. In M. Predergast, C. Leggo, & P. Sameshima (Eds.), *Poetic inquiry: Vibrant voices in the social sciences* (pp. xix–xlii). Sense Publishers.

Reece, J., Urry, L., Cain, M., Wasserman, S., Minorsky, P., Jackson, R., Rawle, F., Durnford, D., Moyes, C., Walde, S., & Wilson, K. (2014). *Biology* (Canadian Edition). Pearson.

Richards, R. (1987). *Darwin and the emergence of evolutionary theories of mind and behavior*. Chicago University Press.

Richards, R. (2002). *The Romantic conception of life: Science and philosophy in the age of Goethe*. University of Chicago Press.

Robbins, B. (2005). New organs of perception: Goethean science as a cultural therapeutics. *Janus Head, 8*(1), 113–126.

Rothenberg, D., & Ulvaeus, M. (Eds.) (2001). *The book of nature and music: An anthology of sounds, words, thoughts*. Wesleyan University Press.

Sameshima, P., Fidyk, A., James, K., & Leggo, C. (Eds.) (2017). *Poetic inquiry III: Enchantments of place.* Vernon Press.

Serres, M. (2008). *The five senses: A philosophy of mingled bodies*. Translated by P. Cowley and M. Sankey. Continuum.

Serres, M., & Latour, B. (1995). *Conversations on science, culture, and time*. Translated by R. Lapidus. University of Michigan Press.

Sherman, R. (2009). Piano pieces. In Rothenberg, D., & Ulvaeus, M. (Eds.), *The book of nature and music: An anthology of sounds, words, thoughts* (pp. 84–90). Wesleyan University Press.

Todres, L. (2004). The meaning of understanding and the open body: Some implications for qualitative research. *Existential Analysis*, *15*(1), 38–54.

Uexküll, J. (1934/2010). *A foray into the worlds of animals and humans*. University of Minnesota Press.

Wahl, D. (2005). 'Zarte empirie': Goethean science as a way of knowing. *Janus Head*, *8*(1), 58–76.

Wiggerman, S., & Meischen, D. (Eds.) (2015). *Wingbeats II: Exercises and practice in poetry*. Dos Gatos Press.

PART III – TRUNK

Goethean Science

More delicate the stem that carries now
A wondrous growth. Enchanted is the eye.

The plant-child, like unto the human kind—
Sends forth its rising shoot that gathers limb

~Goethe

Chapter 5.

Science Education in the Key of Gentle Empiricism

5.1. Preamble

The previous two chapters introduced Goethean science. This chapter and the next expand on Goethe's creative and participatory epistemology. A brief history of science education is outlined, and evidence provided that humans have dehumanized the world and our own species. This is followed by the specific methods of Goethe's delicate empiricism, and the movement towards finding intrinsic value in beings other than human, in the hope of eliminating (or at least, minimizing) exploitation, violation and damaging of the natural world. Examples are given for applying Goethean science in today's classrooms or in outdoor learning environments, which bears some relation to the integrative, nature-based work carried out by Craig Holdrege (among others) at The Nature Institute in Ghent, New York. ✺

5.2. The History and Role of Science

Let's begin this thinking about science education at the beginning: with the very meaning of *science education*. Science education may mean instructing in or learning about scientific information, knowledge, and methods in various disciplines. The goal here would be to equip our students with requisite knowledge and skills to become scientists, technicians, and science and technology educators. Our current system of science education is replete with this way of teaching science. And we need this form of education to cultivate future generations of scientists, technicians, and workers in science-related careers.

Science education may also mean educating people to have ways of understanding and approaching the world with worldviews based in or influenced by science. When our school children protest to us that they are not going to become scientists or technicians and so they don't want to and don't need to study science, we might appeal to this second

meaning and tell them that for them to function in today's world, they have to have a certain level of scientific knowledge and understanding of the scientific method. If they press us further and ask us why we have to know science to function in today's world, we will point to the degree to which the construction of our world depends on science and technology. These responses on our part would constitute a justification for not only including science and technology education but also underlying its central importance.

Now comes the troubling part. What if our students, well trained to ask critical questions, ask us this question: "So, you say that in today's world everything is constructed by the modern scientific knowledge and technologies. But look how terribly troubled the world is today. You have been, in fact, telling us that according to many scientists, our world may not continue and cannot be sustained beyond the next few decades, at the rate we humans are consuming and destroying the world. If modern science and technology are what constructed such a world, then why should we continue to study them?" What would be our answer? "Oh, come on! Stop trying to avoid studying science. That won't get you far." Or, "Back to your work! Don't ask such silly questions!" Or, "Your mom and dad want you to be successful, and for that, you need to study science (and math, etc.)." Answers such as these do not address the serious point raised by our students. However, our chapter shall do just that.

The starting point of our discussion on science education is the acknowledgment that science is a human enterprise. What does that mean? It means that what we think science should be bears our metaphysical (literally, going beyond the physical) assumptions about the world: what the world looks like to us humans or how it might look differently when we adopt a different lens of understanding and investigation, and what we value or ought to value. This is apparent when we examine the history of science. Historians and philosophers of science would readily confirm this. Even just in the history of Western civilization, we can point to a diverse set of scientific worldviews, closely aligned with or based on ontological or metaphysical and epistemological views of the world (Pepper, 1970). Moreover, when we add such views from other civilizations, we have a cornucopia of scientific worldviews, notwithstanding the debate, sometimes violent, about which ones are true of reality. We shall also note that our general tendency

is to discredit the scientific views of other cultures, especially from the distant times, as untrue. Our main point of making these observations here is to emphasize that science is not independent from human values and views, commitments, sensibilities, aspirations and tastes of a given culture and people.

Of particular interest to us (the authors of this chapter) are the exploitative and even violent views, attitudes, and resulting conduct that define humans' power relationship of domination over nature, integral to the West's Enlightenment and Renaissance preceding it and Modernity proceeding it (Merchant, 2008). A central figure in this way of thinking about the relationship between nature and humanity is Francis Bacon who *invented* the modern scientific method of experiment that is the hallmark of empirical research to this day. Merchant states: "Distributed among many of Bacon's works and often reappearing in slightly altered phraseology, these terms (such as, 'penetrate,' 'shake,' 'shape,' 'squeeze,' 'subdue,' 'wrest,' etc.) all connote some degree of violence toward nature" (p. 749). For emphasis, let us repeat: violence toward nature is built into the foundation of modern experimental science. So normalized is this understanding that we take it for granted and we think nothing of it. How else do we do science?

The question of "ought" is always a wake-up call for the mind that thinks descriptively as in "that's how it is," or "that's how it goes and how it's done." A master car thief may teach his apprentice, "Let me show you; this is how you steal a car." The apprentice, suddenly waking up from her trance, may ask herself, "Wait a minute. *Should* I be stealing cars? *Ought* I to continue to live a life of crime?" Similarly, many thoughtful people since Bacon's time woke up from the Baconian trance and have been asking: *Ought* we to think of nature as a female that needs to be "penetrated," "squeezed" and so on to have "her" yield, give up "her secrets"? Secrets that will enable us to manipulate, alter, further violate "her"?

Equally disturbing is the reduction of nature to the order of the inanimate. In recent decades, many thinkers (e.g., Erazim Kohak and R. D. Laing) from diverse but interconnected fields of philosophy, psychology, ecology, and health have all spoken

about contemporary humanity living out the worldview of the mechanical universe that the 17th century Western philosophers like Thomas Hobbs and Rene Descartes championed. If the universe, including our planet, is basically made up of inanimate matter ("stuffs"), then there is nothing that would prevent us from hacking and destroying it to satisfy our insatiable desires for consumable goods and services.

The role of science, however, goes deeper than supporting the enactment of the mechanical universe. The process of rendering the universe to the order of the inanimate could not be accomplished without simultaneously numbing our psyche so that we don't feel the pain of snuffing life out of the animate universe. Neil Evernden (1993) speaks of the practice in which lab scientists would cut the vocal cord of animals that they were vivisecting, for the pain of hearing the animals howling in pain is extremely disturbing. By shutting down our senses and sensibility, we dehumanize our selves. It's only in hearing, seeing, and feeling the pain of others that our empathy and compassion are exercised. With all this in mind, we may continue to consider how contemporary science education in North America (and all over the world as the modernist worldview has spread globally) plays a vital two-fold role of continuing to render the world to be an order of the inanimate and simultaneously accomplishing psychic numbing and, hence, dehumanizing. And, against this backdrop of considerations, we may also re-envision a science that heals our psychic numbing and releases us from the practice of dehumanization.

5.3. Science That Heals: The Goethean Approach

The gift of postmodernism—the era we have been in for the last few decades—is its massive questioning of the *grand narrative* and replacing it with many narratives. Monologue is being replaced with dialogue; fundamentalism, by pluralism; hierarchical ordering by rhizomatic networking, and so on. As part of this invitation to seeing in multiplicity and ecological complexity, we can also entertain different paradigms of science. Since, as we saw earlier, our interest in doing science differently ultimately stems from ethical values, such as wanting to see less suffering and more flourishing, less pain and more joy, and in general more support for all beings and their wellbeing, we are

searching for a science that heals and vivifies all beings, including, of course, human beings. It is in this context that we would like to introduce the Goethean "gentle empiricism," zarte Empirie.

Johann Wolfgang von Goethe was a celebrated writer, statesman, and scientist, and prospered during the Romantic era where holism, wonder, science and philosophy could belong to a single discipline (Richards, 2002). He wrote poetry and prose, inspired morphology as a new scientific discipline, and devised an alternative approach to scientific methodology. His "conscious-process-participation" (Wahl, 2005, p. 59) involved prolonged looking, direct attention, and deep empathy, with an "emphasis on the metamorphosis of the scientist" (Robbins, 2005, p. 115). This holistic and participatory approach, when adapted to the contemporary context of science education, offers an alternative way to understand and be immersed in the world's phenomena. Whether studying climate change, biodiversity, plant growth, or other biological or physical entities, zarte Empirie engages the scientist in a relational yet still precise scientific methodology.

Incorporating Goethean science in today's science classrooms requires us to step beyond the limits of the conventional reductionist science methodology that follows the predominant subject-object-separation epistemology and move toward a conscious-process-participation epistemology. In this Goethean approach, the learner provides space for the phenomenon to show up and for the learner to receive from the phenomenon under study, mobilizes his/her imagination as a tool to understand the varied qualities of a phenomenon, and employs intuition in order to more fully comprehend the object's outer and inner contents. By incorporating a science of qualities rather than *only* a science of quantities (Reason & Goodwin, 1999), we engage in a reciprocal relationship more inclined to reveal our mutual interdependence with other life phenomena. The alternate paradigm of Goethean science recognizes the importance of two-way perception where the scientist both perceives and receives and helps us to "recover the life that once pulsed through knowledge" (Reynolds, 2007, p. 160).

Today's scientific method that formulates questions, gathers data, interprets results, makes conclusions, and then formulates new hypotheses, is a precise methodology often documented in a lab report. The most coveted section of a lab report is the results section, "the centerpiece of your report" (Pechenik, 2016, p. 151), providing key data findings, including numbers, statistical parameters, and other relevant observations shown in figures, tables and written text. This is deemed the most important section of a lab report because it presents findings without "reflecting the author's biases, hopes and opinions" (p. 158), without interpretation or analysis, and certainly without subjectivity. In other words, it lacks the qualities that make us human. To a Newtonian scientist, this logical-rationalistic approach removes human folly from the equation and all the subjectivities that might infiltrate the conclusions made in the report. Their observations through one or more of their senses, as well as through their higher faculties—and all of the prejudices and partialities therein—are not to be trusted, because they are all human-generated. The data is seen as eternal, unchangeable, and what future researchers will reference. Ethically, scientists should report any bias involved in their experiments. In reality, the pressure to publish may increase scientific bias (Fanelli, 2010). To a Goethean scientist, however, prizing raw data so highly neglects the fact that all scientists are human and disregards the reciprocal relationship between the observer and the observed, whether the latter is electrons or electric eels.

In her paper on Goethean science education, Sherrie Reynolds (2007) asks: "Is it necessary to eliminate spirit in order that children may learn science?" (p. 160). The use of the word "spirit" will give many scientists consternation. For, how can you measure or analyze such an ethereal entity (if indeed it's an entity) objectively? But her question is pertinent, for her use of the word "spirit" is connoted with passion, ethics, curiosity and attentiveness in an educational context rather than a religious one. Spirit is a phenomenon, not a substance. When science is taught through a mathematical, positivist, formula-driven lens, this can alienate some learners whose primary inquiry in science is qualitative observation, curiosity with how things work, cognitive problem-solving on a meta level, or a fascination with the natural world.

Conventional K-12 science education occurs inside a classroom and focuses largely on the classification, measurement, and manipulation of phenomena. Kindergarten students are encouraged to explore using multiple senses, but by grade 7, in a slow progression that removes creative expression and any degree of open exploration, the dominant focus becomes variables, controls, and hypotheses. In each lesson a clear learning outcome is usually being sought, one that brings clarity for understanding a certain phenomenon, which can discount the pursuit of science as an ongoing and holistic journey where phenomena are examined over time and from multiple frameworks. In later grades, creativity and purposeful unstructured exploration is supplanted by a strict and rigorous scientific methodology that wants us to forget our humanness and the reality of all of the other beings with which we share our planet. Cartesian-Newtonian science does afford us an important way to gather unbiased data and understanding about the world, and all of the atomistic mechanisms that underlie phenomena, but there is an opportunity for its limitations to be complemented by Goethean science.

The four stages of the Goethean approach, as outlined by Isis Brook (1998) and developed by The Life Science Trust, can be listed as follows: (1) exact sense perception, (2) exact sensorial imagination, (3) seeing is beholding, and (4) being one with the object. These stages, detailed below (with examples of how to implement and facilitate each stage), cultivate a relational engagement with the phenomenon being observed over a prolonged spatial-temporal study. The distinct features of Goethean science include "rigorous attention to direct experience, empathy, intuition and imagination" (Wahl, 2005, p. 60), fostering a sense of wonder, incorporating philosophy and ethics in science, using emotional awareness and creativity to fully engage with phenomena, and contemplating the myriad interrelations among phenomena. The observer also becomes the observed, and is immersed, at different times, in direct sense engagement, creative expression, contemplative practice, and finding "unity in variety" (Bronowski, 1956, p. 20) by tying together common themes that underlie seemingly divergent realms; in other words, the observer employs many of the most prized qualities of his/her humanness. "Goethe asserted that the human body is the greatest instrument to evaluate empirical experience because it permits an understanding of nature from the inside out" (Mason, 2014, p. 62), and this holistic understanding is what we are after.

Prior to the numbered steps below is a preparatory stage where the observer makes a note of first impressions and shares these preconceptions about the object of study. If "[w]e all have a history as observers and have formed ideas about the world, which influence what and how we perceive" (Wahl, 2005, p. 62), then acknowledging these formed ideas places us in an important context that emphasizes how our personal history and current state of being may influence our observations. This preparatory stage serves as an individual foundation often absent from current scientific study.

Exact Sense Perception. During this stage the observer steps back from the object of study and, by way of his/her ordinary senses, lists all of the facts and specific data perceivable from the object. Like Newtonian science, the observer is objective in his/her approach, doing his/her best to suspend judgement, evaluation, and personal interpretation. In encountering the phenomenon as it is, the Goethean scientist is present to its patterns, colors, shapes and other details. As Reynolds (2007) contends, "for many natural phenomena, the measuring, mathematical approach is blind to quality" (p. 163); during exact sense perception, qualities are recognized as pertinent observations.

We can apply this to elementary school students by having them go outside and use the five primary senses to perceive a single phenomenon, such as a fern. After the preparatory stage where they can write and share about who they are, how they are feeling right now, and their first impressions of the phenomenon, students will "remain within the realm of phenomena and concentrate on form, color, pattern, and behavior" (Reynolds, 2007, p. 168). The teacher will avoid classifying the phenomena (e.g., the fern) and let students use their own words to describe it. Drawing is an appropriate method here, both in the moment and later from memory (Brook, 1998), the latter as a way to emphasize the parts of the fern the student may have forgotten. Students can also make note of other phenomena interacting with the fern, such as a spider scurrying underneath the fern frond; such interrelations will be focused on in a later stage.

Another example, more suited to middle grade students, would be to have students observe an amoeba under the microscope. While the visual sense would

obviously dominate here, this does not preclude learners from smelling the pond water from which the amoeba came, or using their imagination to make observations on how the amoeba touches with its pseudopodia, and what we might hear if the amoeba were large enough to make audible sounds. Students would record cellular patterns, shapes and structures in written form, and also make multiple drawings of their amoeba at different times or under different conditions (e.g., light intensity, slide mounting medium, time of day). They could also carefully observe, under the microscope, the way an amoeba ingests food, known as phagocytosis: how it surrounds and engulfs, with its pseudopodia, live prey like a protist or bacterium. It is a most fascinating process that students may enjoy drawing and even dance to enact its shape-altering ability.

Exact Sensorial Imagination. This stage involves shifting from a static view of phenomena toward an understanding of transition and metamorphosis. Now, the imagination can be employed to understand the temporal dimension of phenomena. We come to see that the object has a history. It is important here to move beyond the exact sense perception stage, which provided useful observations that are now frozen in time. Imagination is used to bring movement, development and transition to the phenomena, so that, as Daniel Wahl (2005) explains, "we can wilfully imagine a different sequence of transformation than the one that emerged based on our engagement in stage one" (p. 63).

To continue with our fern example, we can have students draw the fern frond and its leaflets as they might appear when the particular frond they examined was younger, and when this particular frond will be older. In the first stage the drawing provided a static image of the fern; now, students imaginatively draw a sequence of development. This alternate epistemology, rather than showing students a textbook figure or a time-lapse film, allows for students to imagine and reason for themselves.

Seeing is Beholding. In this stage the observer enters a state of "receptive attentiveness" (Brook, 1998, p. 56) and receives from the phenomenon with an open mind. The phenomenon is allowed to "articulate in its own way" (p. 56) while the observer closes

down his/her own perception. As the recipient, the observer gives the phenomenon some of our humanness and conscious awareness, and therefore a way to express its gesture. Since "Goethe does not study nature from an observer's view seeking a reason for its existence outside itself, but as an entity that has its own reason to be" (Reynolds, 2007, p. 166) this stage is vital in revealing the phenomenon's purpose and intention in existence.

The observer expresses his/her observations in emotional language. This practice can lead to unexpected insights and the development of "new organs of perception" (Goethe as cited in Brook, 1998, p. 56). We would like to point out that this way of observing the world and coming to know it has a long, time-honored tradition, known as what we now call "wisdom traditions" of the world. These traditions bear ancient roots, reaching back thousands of years into antiquity and beyond, and still bearing abundant fruits on contemporary branches. One of the well-known wisdom traditions—there are many, throughout the world—is yoga in Hinduism, and here, the practice of devotion (bhakti) is central to yoga practice and philosophy (Scott & Bai, in press). It is through the practice of devotion that our organs of perception become attuned precisely and clearly to the exacting beauty and wonder of the world. Devotional practice enlarges and deepens our love for all, enabling us to participate in the phenomenology of life and cosmos. Through devotion, we become lovers, not destroyers, of life. Through devotion, we become part of, not apart from, the world. Our point here is that Goethean science education, too, engenders this profound love of and for the world.

To return to the seeing-is-beholding stage of science education: When students engage with the fern during this stage, they can do so in an extended period of silence. Questions such as "What does the fern possess that you haven't noticed before?" and "How would the thing studied describe itself if it had the ability to speak?" (Reynolds, 2007, p. 168) can help guide this practice for younger learners. Afterward, students can paint, write poetry, or partake in other arts-based expression that fosters an alternative understanding of the phenomena, all of which perhaps lead to a "morally responsive obligation to the observed" (Robbins, 2005, p. 113).

Being One with the Object. This last step of science education is really the fruit-bearing stage. Through this stage, we come to taste the fruit of our labor: full integration with and participation in the world. Thus, we come to realize the truth of ecology: that we humans are interconnected through and through, and that our presence interpenetrates all other phenomena. In knowing this, not just theoretically, but in our senses and heart, in our body, we truly become ethical beings. The manner of our being in the world and our actions we take would be in alignment with the welfare of the world. We would become healing, protecting, and nurturing agents: not the rampant consumers and destroyers that we witness in today's mainstream humanity.

Here, too, this notion of being one with the object has time-honored roots in the wisdom traditions of the world, and is well-known in contemplative arts and science, attesting to the integrative function of arts, science, and spirituality. The habit of separating science from arts and spirituality is typically modernist. Hence, Goethean science education offers an integrative function that can unite all disciplines of learning. Our science students, educated in a Goethean paradigm of science, would be polymaths, well versed in both arts and sciences. (Later, in the concluding section, we will also make the point that specialization in separate branches of sciences is not incompatible with our Goethean science education approach.)

Phenomenologically speaking, this idea of being one with the object is not some spiritualist talk. The phenomenon is eminently verifiable by undertaking the practice and seeing how it works in our consciousness. Anyone who has spent enough time with an object in concentrated attention can verify how a sense of intimacy grows with respect to the object. This phenomenon, known in some circles as engrossment or in others as participation or in Buddhism as non-duality, goes beyond the disciplinary boundaries and belongs squarely in the phenomenology of human consciousness. Human beings are so constituted that, given an opportunity of modeling and practice, they will experience being-one-with, or in contemporary neurobiology, attunement and resonance (Siegel, 2010). It is also known as intersubjectivity in philosophy and psychology (Gunnlaugson et al., 2017).

When we spend attentive time with an object, we come to appreciate its intrinsic value, that is, we come to appreciate its being for its own sake, not as a mere means to meeting our desire and design: “When we spend time in deep contemplation of the structure of a plant, for instance, we come to appreciate the plant as an end in itself rather than a mere means” (Robbins, 2005, p. 123). Again, we can see right away how this kind of science learning is one-piece with ethics learning and practice. Ethics, unlike considerations of prudence, demands us to approach and treat the world intrinsically. The world is not there just to serve us and do our bidding. We, educated in Goethean science, would not exploit, violate, and damage the world. For, the world is our beloved, and we are the lovers, caring about and being devoted to its wellbeing and flourishing.

Goethean science education, being aligned with contemplative arts and sciences traditions, can be supported by learning and practices in arts just as equally as in science. Mindfulness practice, which is frequently being introduced now in schools in North America, can be harnessed to support Goethean science education. Mindfulness, as is practiced in schools, has become an anxiety relief and behavior management tool, which, while beneficial, is a limited practice, and not doing full justice to its rich and important educational potential. Since there is a great deal written about contemplative practices in support of “being one with object,” we will not go into its scholarship here but simply refer the interested reader to such scholarship (e.g., in Zen tradition, Bai, 1997, 2002, 2003).

5.4. Concluding Thoughts

Goethe’s approach to science offers a foundation of ethical thinking, mutuality, and “a more appreciative, qualitative, meaningful and participatory engagement with nature” (Wahl, 2005, p. 60). As Robbins (2005) acknowledges, “the observation of nature is always also a process of self-discovery” (p. 125). In this way the scientist is also changed or transformed. Goethe (1790/2009) saw the need for imagination as complementary to empiricism, allowing the observed to see nature as “complete and unified as both creator and creation” (p. 106). This is also what we propose: that is, a pluralistic approach to K-12 (especially K-9) science education.

Goethean science, with its sensorial engagement, creative expression, and holistic exploration, fits well with elementary school science curricula. Instead of students dissecting frogs, the classroom can be moved outdoors, where frogs are part of the place-based learning environment. The students given a scalpel and dead frog learn to atomize and dissect, while those who share the environment with this living amphibian become part of the ecosystem, and gain intimate knowledge about this frog through delicate empiricism. Rather than focusing on anatomy and physiology, there is a shift in focus to ecology and environment, and a similar shift from anthropocentric to ecocentric beliefs. In later grades, dissection can be a topic of conversation rather than a compulsory exercise left unquestioned, and Cartesian-Newtonian science can supplement Goethean science with more technical training.

The pertinence of disciplines working together in science research (Van Noorden, 2015) is well suited to the holistic and unifying approach of delicate empiricism. "The problem," Reynolds (2007) contends, "is not that positivism has not led to useful science, but that it has substituted for all other forms of knowledge" (p. 164). The wide-ranging implications of climate change, for instance, necessitates an interdisciplinary study, while the Goethean approach ensures ethics and relationality are recognized as not only important but vital ingredients in this study. The largely abstract, and seemingly invisible, science fields such as molecular genetics or quantum physics may seem incongruent to Goethean methodology. How can you use the sense of smell to sequence genes or use intuition to understand atomic particles of matter? However, delicate empiricism is still essential and relevant here for instilling wonder, doing ethical science, and witnessing the interrelation and interdependence among varied phenomena. Goethe himself applied his approach to physics in his study of light and color.

There are core science disciplines best suited to Cartesian-Newtonian science, such as those involved with specialized medical practice. Cartesian-Newtonian science helps us gather data with limited bias, ensure that our findings are statistically significant, and has provided a prolific and profitable database of information on universal phenomena. Such empirical knowledge has produced innumerable rewards for human health and safety. However, this does not preclude Goethean science from supplementing

the more technical scientific fields. If delicate empiricism can "help restore spirit to science education by reuniting a world that we have artificially fractured" (Reynolds, 2007, p. 166), then we need to seriously reconsider how we teach our children and young adolescents science. We can look to Goethean science, and other holistic science education models, such as Indigenous Science (Cajete, 1994), which are increasingly practiced in schools, as models that are compatible with most, if not all, branches of science.

References

Bai, H. (1997). Ethics and aesthetics are one: The case of Zen aesthetics. *Canadian Review of Art Education, 24*(2), 37–52.

Bai, H. (2002). Zen and the art of intrinsic perception: A case of haiku. *Canadian Review of Art Education, 28*(1), 1–24.

Bai, H. (2003). Learning from Zen arts: A lesson in intrinsic valuation. *Journal of the Canadian Association for Curriculum Studies*, *1*(2), 1–14.

Bronowski, J. (1956). *Science and human values*. Harper and Row Publishers.

Brook, I. (1998). Goethean science as a way to read landscape. *Landscape Research, 23*(1), 51–69.

Cajete, G. (1994). *Look to the mountain: An ecology of indigenous education*. Kivakí Press.

Evernden, N. (1993). *The natural alien* (2nd ed.). University of Toronto Press.

Fanelli, D. (2010). Do pressures to publish increase scientists' bias? An empirical support from U.S. States data. *PLoS ONE, 5*(4), e10271. doi:10.1371/journal.pone.0010271

Goethe, J. W. (1790/2009). *The metamorphosis of plants*. The MIT Press.

Gunnlaugson, O., Scott, C., Bai, H., & Sarath, E. (Eds.). (2017). *The intersubjective turn: Theoretical approaches to contemplative learning and inquiry across disciplines*. State University of New York Press.

Mason, D. M. (2014). Holism and embodiment in nursing: Using Goethean science to join 2 perspectives on patient care, *Holistic Nursing Practice*, *28*(1), 55–64. doi:10.1097/HNP.0000000000000010

Merchant, C. (2008). The violence of impediments: Francis Bacon and the origins of experimentation. *The History of Science Society*, *99*, 731–760.

Pechenik, J. A. (2016). *A short guide to writing about biology* (9th ed.). Pearson Education.

Pepper, S. C. (1970). *World hypotheses: A study in evidence*. University of California Press.

Reason, P., & Goodwin, B. C. (1999). Toward a science of qualities in organizations: Lessons from complexity theory and postmodern biology. *Concepts and Transformations*, *4*, 281–317.

Reynolds, S. (2007). A Goethean approach to science education. *Journal of Curriculum and Pedagogy*, *4*, 160–171. doi:10.1080/15505170.2007.10411632

Richards, R. J. (2002). *The romantic conception of life: Science and philosophy in the age of Goethe*. University of Chicago Press.

Robbins, B. D. (2005). New organs of perception: Goethean science as a cultural therapeutics. *Janus Head*, *8*, 113–126.

Siegel, D. J. (2010). *The mindful therapist: A clinician's guide to mindsight and neural integration*. W. W. Norton & Company.

Scott, C., & Bai, H. (2017). Bhakti yoga as intersubjective contemplative practice. In O. Gunnlaugson, C. Scott, H. Bai, & E. Sarath (Eds.), *The intersubjective turn: Theoretical approaches to contemplative learning and inquiry across disciplines*. State University of New York Press.

Van Noorden, R. (2015). Interdisciplinary research by the numbers. *Nature*, *525*, 306–307. doi:10.1038/525306a

Wahl, D. C. (2005). "Zarte Empirie": Goethean science as a way of knowing. *Janus Head*, *8*, 58–76.

Chapter 6.

Ethical-ecological Holism in Science Pedagogy: In Honor of Sea Urchins

6.1. Preamble

This chapter continues the discussion of Goethean science. The sea urchin is highlighted as an organism that is both used by science and holds an intriguing radial perception of the world. As a model organism, sea urchins are readily wild caught and raised in labs for utilitarian use. The three narratives presented are at the heart of this chapter. They reconnect to Chapter 1's 'Offerings on the Mountain' to re-emphasize the power of storytelling and personal connection, which were/are promoted by the four major scholars referenced in this thesis: David Abram, Aldo Leopold, Robin Wall Kimmerer and Goethe. My own narrative, 'A Study in Life,' explicates how I refused to be involved with biology labs that include the killing of animals. Although I have been able to excuse myself from teaching such labs, I still wrestle with their continuance in my absence. How can this be reconciled? ✺

6.2. Prelude

Using model animals in research "forms the core of biological knowledge" (Hedges, 2002, p. 838) and this use has dramatically improved our understanding of and treatments for conditions such as heart disease, diabetes, and epilepsy. While we acknowledge the benefits to science and humankind, we also believe that animal usage for education must be considered carefully in the context of ethics. Such consideration, we argue, would be apropos to humans' self-identity that they have self-awareness as morally responsible beings. But this needed self-awareness undergirding moral responsibility is often misconstrued as sentimentality based on anthropocentricism. Herzog (2005) comments: "[s]cientists often assume that objections to the use of animals in science are based on sentiment and misplaced anthropomorphism"; however, ". . . the philosophical arguments both for and against the use of animals by humans are

sophisticated and complex" (p. 15). We (the three authors of this chapter) are interested in developing a philosophical argument that offers an alternative paradigm for a scientific methodology that fully acknowledges the Other and takes humans' moral responsibility towards all earthly beings and our mutual flourishing. One such alternative that we would like to introduce in this chapter is a Goethean vision of science and scientific method wherein "[w]e develop the capacity to become *ethically responsive* to our obligations to the observed" (Robbins, 2005, p. 123). This ethical responsiveness, it turns out, coincides with aesthetic considerations and sensibility in Goethean science. The philosophical theme of "ethics and aesthetic are one" (Bai, 1997, p. 37) is pertinent here and will be explored in this chapter. Goethean science, as we will see, emerged during the so-called Romantic period in European history. Romanticism in science reminds us of the important "interrelationship of philosophy and science for science education" (Hadzigeorgiou & Shulz, 2014, p. 1999).

This chapter develops the groundwork of holistic science pedagogy through exploring the Goethean scientific paradigm. We will share stories and poems of our reluctant participation or outright refusal in science labs involving animal experimentation. Through these embodied inquiries, we propose a philosophical rationale for moving away from anthropocentricism and an implied hierarchical worth of beings. We contend that students' experiences with dissection, often vivisection, presumes and reinforces the idea that other-than-human animals have a lower moral status, if any status at all. Our collaborative work in this chapter calls for a shift to an ethical-ecological framework for science pedagogy by animating the world and imbuing it with sacredness through aesthetic and contemplative practices alongside Goethean scientific investigation.

We begin our foray into the new vision of science pedagogy with a brief look at the sea urchin, a model organism in North American biology labs. This look is then followed by narratives of our respective experiences of lab work.

6.3. The Sea Urchin: A Model Organism

Model organisms are used in science to research anatomical, behavioral, genetic, and other biological information about the human species (Hedges, 2002). Most of these organisms are easy to care for, abundant, and have physiological functions similar to those of *Homo sapiens*, giving the construed data a certain comparative value. Despite the many limitations of using nonhuman animals to better understand human biology, the use of lower model organisms is not predicted to decline for at least another 20 years (Hunter, 2008).

Sea urchins are model organisms for teaching and researching many biological concepts, including embryology (Vacquier, 2011), genetics (Cameron et al., 2006), molecular biology (Killian et al., 2009), and evolutionary biology (Koga et al., 2014). Aristotle observed sea urchin anatomy and described these organisms in his *Historia Animalium*, circa 343 BCE. The urchin's mouth is named Aristotle's lantern, inspired by his writings and attributed by early zoologists to refer to the jaw structure. However, recent excavations in Greece (Voultsiadou & Chariton, 2008) suggest that Aristotle originally intended his lamp metaphor to refer to the urchin's test, or outer calcite shell. In the late 1870s, H. Fol and O. Hertwig investigated sea urchin fertilization, and in 2006, the purple sea urchin's genome—more than 23,000 genes—was sequenced by a team of over 200 scientists (Cameron et al., 2006).

The sea urchin belongs to the class Echinoidea, a group of marine invertebrates with just over 1,000 known extant members (Kroh & Mooi, 2011). At the phylum level, sea urchins (Echinodermata) are closer to humans (Chordata) than any other phyla. Compared to all the genome-sequenced nonchordate animals to date, sea urchins bear the closest genetic relation to humans (Cameron et al., 2006). Despite their stark dissimilarities from *Homo sapiens*, such as radial symmetry, presence of tube feet, and lack of eyes and other mammalian sense organs, both sea urchins and humans possess complete digestive tracts, internal skeletons, and bilaterally symmetrical embryos (McClay, 2011). This latter point is of importance to biology labs, because the early

embryonic stages—from fertilized egg, to cleavage, morula, blastula and gastrula—bear significant likeness for humans and urchins.

A common biology experiment used to teach embryology involves students extracting sea urchin gametes, fertilizing the released eggs with sperm, and observing the results under a microscope. For this laboratory procedure "adults may require an electric shock of 6–10V to induce spawning" (Vacquier, 2011, p. 554). Another option is to inject urchins with a potassium chloride solution to stimulate gamete release. In such teaching materials, there is no mention of sea urchin distress or limiting sea urchin mortality. Rather, the implicit assumption seems to be that the suffering of sea urchins (which possess a primitive nervous system compared to humans) is not only justified, but also not even worthy of ethical consideration—so far removed, in fact, to be omitted entirely from academic discourse. Science as epistemology assumes, as a matter of course, that this animal is merely an object, and its internal organs are mechanisms to be poked, prodded and studied without an ethical regard.

For studying embryology, purple sea urchins are often wild-caught, which can end their 70-year lifespan prematurely. Students place sperm and eggs on a slide, observe fertilization and the early developmental stages through a microscope, as a mandatory procedure in many North American high school and undergraduate biology classes. What is missing entirely in this performance of vivisection are ethical and attendant philosophical and psychological reflections on witnessing the miracle of new life, which then is merely washed down the drain at the end of the lab period. In this case, the dominance of the human species over all other beings is unquestioned and is an unquestionable assumption. So is the conception that our benefit eclipses the need and suffering of nonhuman species. The speciesism embedded in science curricula, and the definition of what is sentient or even alive, seem to have been completely unnoticed, let alone challenged.

However, as our narratives below will show, many young (and not so young) people experience their relationship with other life forms differently: with genuine love

and respect, with empathy and care. Thus, their experience in the biology lab is often alienating and traumatic.

6.4. Killing the Wonder: Three Biology Lab Narratives

A Study in Life
by Lee Beavington

My trembling fingers inject the needle into the mouth of the sea urchin. The needle point is reluctant. I push the point until it slides deep into the soft tissue, then inject the potassium chloride, the same that Dr. Kevorkian used to stop melancholy hearts. But I am not after death. I am after gametes, the fruit of life. Will it be egg or sperm?

Under the microscope in the biology lab, first-year university students witness that most miraculous genesis called fertilization. A frenzy of sperm compete for a single egg. Of the millions of flagellated vessels of DNA, but one obtains that golden prize. My job, trumping my conscience, is to provide the fertile ingredients; students then play god on a microscopic level.

I watch the injected urchin before me. Is this sea hedgehog older than I? At first, the echinoderm offers no response. Then, slowly at first, its spines begin to undulate. An involuntary response that I perceive as a silent plea for help. In one final humiliation before the scientist, I place the urchin upside down over a beaker to allow gravity to collect the gametes.

Amber spheres emerge and drop into the safety of the beaker's saline solution. Eggs. A female. Somehow, this feels like a greater evil.

Once I have collected both ova and sperm, and placed them in the refrigerator like reproductive fast food, the lesson can begin. The young women are squeamish at having to carry sperm smeared on a slide. The young men poke fun at them. Magnified four hundred times, the sperm resemble vibrating carrots, while the eggs are solemn planets waiting to be colonized.

Most of the eggs reject sperm. Late autumn is not their usual season for fertility. Those that are receptive balloon outward, building a fertilization envelope to prevent subsequent suitors. This one cell divides into life. First into a berry-like morula, then a hollow blastula and—like a good model organism—all the same embryonic stages of a human baby. The students follow this development over the course of a week, when some of the virginal urchins start to move. Then they are washed down the sink.

My students have contrived life, acting as laboratory midwives, only to abort the urchin embryos once they look like something alive.

At the next biology meeting, surrounded by a dozen colleagues, I indicate that I have something to add to the agenda. "I cannot be involved in any activity where I consciously kill an animal."

Silence. Will my request be scoffed at? Will I be ridiculed for contemplating the life of lowly urchin? Have I threatened my job? The department chair sits to my right. Under my clammy but steady hands lies a folder with my next move, should I need it: a letter to the Dean of Science outlining in clear and concise terms my refusal to end life in the lab. Finally a fellow lab instructor says that he understands my request and is fine if I excuse myself from those activities. A brief discussion ensues. I sense others are uncomfortable with injecting the urchins, but they hesitate to agree with my position.

I leave the meeting relieved yet unsettled. I no longer have to compromise my conscience, at least not directly. I walk out of the lab, past the tarantulas, stick bugs and budgies, hermit crabs and hissing cockroaches, each in their own neat little cage. Finally, the saltwater tank with the purple sea urchins. There are five less than before. I watch the remainder in wretched triumph, waving their spines in a tender tremble.

Aristotle's Lantern

blackhole mouth bares sea-shorn teeth
midnight raises her five-fanged pyramids
her radial world balances the tide
as she churns kelp to weed and rock to sand
she keeps the seafood chained

without eyes the urchin holds the sea
perception starbursts beyond her calcite shell
a skeletal test for otters to best
consumes this ecosystem engineer
her mouth made for seaweed

she nurtures the nocturnal intertides
her roving dome an outward panopticon
perhaps this urchin is a philosopher
with senses no mammal possesses
in phase with every rippled wave

what did Aristotle see
when he was entranced by her spines?
that entrance to a geometric jaw
simple mechanics or a radiant threshold
window into the urchin universe

the only law she abides is natural law
a reciprocal rule we have forgotten
to her wisdom we are blind
if we held her lantern high
what question would she ask of us?

Encounter with Horror and Absurdity

by Heesoon Bai

My encounter with senseless killing and suffering took place more than four decades ago, during my teen years in Korea. It was in my biology class. My school, a top academic secondary institution in Korea, was delivering advanced academic courses to students. As part of such advanced modern (read: "westernized") curriculum, we performed vivisection. Thus, one day, I was faced with live frogs, rendered senseless with chloroform. There were some sixty of us in the class, and there must have been close to 100 frogs. I have no memory of exactly what it was that we were studying in frogs. All I remember is the sight and smell of a whole heap of frogs, whose chests and bellies were opened up, still breathing and palpitating. And that was the end of their short lives: no suturing, no bringing them back to life, just thrown in the garbage after our lab session.

At this sickening sight of senseless killing of creatures, I was plunged into existential horror and despair. I loved little creatures! I was friendly towards them, played with them without hurting them, and rescued them if they were in trouble. This was an experience of deep wounding in my heart and soul. And it also illustrated for me what biology was, in the way this subject matter was conventionally taught: it certainly did not promote love of life phenomena.

Decades later, when I was teaching undergraduate and graduate students at my current university, I met quite a few students who told me that they went into biology because they loved life phenomena, but after studying biology (some of them graduating with a major in biology), the love of creatures they experienced throughout their growing years evaporated, and they were sorrowful about this loss.

We choose to study something because we love it; but in the process of studying, we often kill our love. The conclusion to be drawn here is not that study kills. Rather, we need to be aware of what studying may entail. There are different ways to study or research. I am reminded of the comparison that is made, by Erich Fromm (1976), of three poets whose contrasting worldviews and approaches to life phenomena illustrates different ways of studying. Lord Alfred Tennyson (1809–1892), Basho (1644–1694), and Goethe (1749–1832) are the three poets in reference here. I quote their respective poems:

First Tennyson:

Flower in a crannied wall,
I pluck you out of the crannies,
I hold you here, root and all, in my hand,
Little flower—but if I could understand
What you are, root and all, and all in all,
I should know what God and man is

Next, Basho:

When I look carefully
I see the
nazuna

blooming
By the hedge

And lastly, Goethe:

I walked in the woods
All by myself,
To seek nothing,
That was on my mind.
I saw in the shade
A little flower stand,
Bright like the stars
Like beautiful eyes.
I wanted to pluck it,
But it said sweetly:
Is it to wilt
That I must be broken?
I took it out
With all its roots,
Carried it to the garden
At the pretty house

Now, Fromm's (1976) comments at length on the three different, what we may recognize as, research paradigms:

> *The difference is striking. Tennyson reacts to the flower by wanting to have it. He "plucks" it "root and all." And while he ends with an intellectual speculation about the flower's possible function for his attaining insight into the nature of God and man, the flower itself is killed as a result of his interest in it. Tennyson, as we see him in his poem, may be compared to the Western scientist who seeks the truth by means of dismembering life. . . . . What Basho wants is to see, and not only to look at the flower, but to be at one, to "one" himself with it—and to let it live. . . . For Goethe the flower is so much alive that it speaks and warns him; and he solves the problem differently from either Tennyson or Basho. He takes the flower "with all its roots" and plants it again so that its life is not destroyed. Goethe stands, as it were, between Tennyson and Basho: for him, at the crucial moment, the force of life is stronger than the force of mere intellectual curiosity. Needless to say that in this beautiful poem Goethe expresses the core of his concept of investigating nature. (pp. 14–16)*
>
> *Is one paradigm more biophilic than another?*

The Earthworm Protest
by Serenne Romanycia

When I was a child, I had many friends. They lived in deep green forests with mossy carpets, hot sun-bleached meadows filled with buzzing crickets, mysterious lakes, scummy warm ponds, and many other places. The particular friends I speak of in this story made their home in cool, nourishing soil: the earthworms. Sometimes, when my family would garden together, I'd encounter them suddenly unearthed, writhing and wriggling to get back into the safety of the ground. At other times, on rainy nights, I'd go for a walk and find them rain-bathing at the edge of the sidewalk. They'd be stretched out long, half in the grass and half on the pavement, perfectly still. One vibration from my footstep, and they would pull back instantly, disappearing in a heartbeat underground.

Yes, my earthworm friends were very sensitive, peaceful creatures, and they didn't particularly enjoy bright, exposed, spaces. But sometimes, in the daytime, if it was rainy, I'd find them out and about, wriggling along at a speedy pace to some destination. I've read that worms travel in the rain, as it gives them an opportunity to travel along faster than they would through soil. But it seems to me that there's more danger in this method of travel, too. When I attended middle school, I spent a good deal of time at lunch patrolling the track and the sidewalks, where on rainy days my travelling friends would often be squished by careless or cruel kids, drowned in puddles, or run over by cars. A few of my human friends would help me in my efforts to save earthworms. We would run around and gather up all the worms that were stranded on the pavement or getting washed down the storm drains, and put them back into the soil around the school grounds.

I must confess my friendships with the earthworms, in fact with all of my animal friends, somewhat changed as I entered high school. I still considered them my friends and never lost my connection to and love of the wild. However, my attention was rather diverted to navigating human teenage culture. Most of my time was spent with human friends. I stopped making a concerted effort to save my old earthworm buddies at the

track, and instead made a concerted effort to deal with fluctuating hormones, fluctuating friendships, and fluctuating grades. Yes, I must admit that earthworms were the last creatures on my mind.

Yet, an incident brought my old friends back into my heart, with a shocking jolt. Scene: science class, block before lunch. Me: sitting in the back row, angry. The teacher had just passed out beakers filled with some liquid. I gripped my beaker, feeling sick: here were a few of my old friends, floating around anesthetized, still barely alive, but numb and motionless. We were told we would be dissecting these "specimens" as they were now "slowed down" enough for us to study and learn about them.

Specimens? No, these weren't specimens! They were little living beings! They were my friends, and I was going to be damned before I cut them open alive to "learn" about some scientific fact that was also written right there in the textbook. I told the teacher this, which provoked laughter from my classmates, but a tinge of respect too. I looked around and saw several kids with the unmistakable uncomfortable look on their faces that so often reveals when our internal moral compasses get overridden by convention and pedagogy. It felt wrong, and that wrongness registered physically in my gut: a clenching, sickening, clammy sense of people being blind to the suffering and broken dignity of other living beings. My teacher told me firmly these were "just worms," and it was stupid to feel sorry or compassionate towards them. "Yeah," piped in some taunting kids: "It's not as if worms have brains, hearts or souls!"

I refused to participate in my classroom experiment on grounds that it was unethical, disturbing, and completely useless, revealing "information" that could easily have been found on the internet, as it was a high school experiment that had been performed thousands of times. The teacher responded angrily by docking me marks and offering other classmates higher marks if they would in fact eat a live worm. (I believe some of them actually did, if my memory serves me correctly.) Others, like myself, continued to boycott the experiment.

I still hear the kids' taunting: "It's not as if worms have brains, hearts or souls!" How ironic that they should say that. Worms actually have five hearts, and a "brain" that

is a nerve cord that runs the length of their body (not a vertebrate brain); and I suppose it depends on how you define soul, but they've certainly got life energy that flows through them and responds to the world and its presenting challenges to their sense of well being, just as does every other living being on earth. What was really stupid, I told my teacher, was that we were killing these creatures to "discover" and "study" them, but in doing so we were destroying what was actually of value to learn: the joy and mystery of how these creatures live their lives. I was sure I knew more about earthworms just from hanging out with them in my garden, saving their lives on my middle school track, and stepping around them carefully on a rainy night walk. These were all the times when my powers of "observation" were not detached from my relationship to the creatures themselves. Let us consider: how do we really get to know other people best? Is it by capturing people, drugging them, putting them in captivity, slowly cutting them open and demanding they reveal something to you about the nature of truth as they die? Or is by spending time together, eating food together, sharing good memories, stories, laughter, joy and tears, and developing emotional connections and loving relationships?

I hope the answer is obvious to my readers: it is the latter. The next question is then: why should this answer necessarily be any different if it is posed towards a member of a different species? I believe that, just like humans, other creatures should not be treated as objects to be used, experimented on and disposed of. And, just like studying humans, there are many other ethical alternatives to learning about other life forms than capturing them and putting them under a microscope or a scalpel. We are vastly lacking an ethical-ecological framework within the current scientific pedagogy that recognizes the intrinsic value of all living beings. I suspect my perspective might resonate with many readers, showing up as a stirring of the heart, a shared wish between living beings to live full lives and to be treated ethically and compassionately.

6.5. Goethean Science: Delicate Empiricism

The mainstream modernist western empirical science is based in Cartesian-Newtonian philosophy and worldview that postulated a mechanical universe devoid of sentience. In great contrast, Goethe's approach, known as *"zarte Empirie,"* meaning

delicate empiricism (Wahl, 2005, p. 58), was to know the thing-in-itself. His method observes with empathy and attentiveness, which can help reconnect us with our biophilic nature. Goethe explained that "[l]ife resides in wholes: when organisms are taken apart they are no longer alive. In order to understand, and hence engage with, the aliveness of nature, we have to understand it in terms of its wholeness" (Mathews, 2008, p. 60). The Cartesian-Newtonian model of science obliges a positivist and mechanistic approach, whereby an organism is reduced to its individual components, which takes on primary importance. The breadth of biology covers subcellular components right up to the biosphere—and all levels of organization in between—yet lab dissections often completely omit this consideration. Students put on gloves, cut into an animal specimen, identify the individual mechanics, and finally discard the carcass. This anti-holistic attitude suppresses ethical and philosophical concerns, which can lead to an ontological reversal, whereby symbols and models are assigned greater significance than the actual phenomenon under study (Hadzigeorgiou & Shulz, 2014). If "the search for a philosophy *of* science is imperative" (p. 1999), we need to find an appropriate approach to science pedagogy.

> The Goethean epistemology of conscious-process-participation does not negate the validity of reductionist science, it merely challenges its position as the exclusive source of reliable knowledge about the world and offers a way to overcome the limitations of the dualistic subject-object-separation epistemology. (Wahl, 2005, p. 67)

Goethean science calls for contemplation, in which empathy and prolonged looking promote a participatory mode of consciousness. With reciprocity between the observer and observed, self and other, subject and object, this relationality elicits compassion and ethical consideration (Bai, 2001; Bai, 2004). Martha Craven Nussbaum (2006) mentions that for Aristotle "all animals are akin, in being made of organic materials; humans should not plume themselves on being special" (p. 348). This kinship is too often lacking in science education, where microscopes, scalpels, and needles become tools of separation. Michalinos Zembylas (2004) has explored the importance of emotional labor in science, where reason outweighs emotion, and suggests that learning science through emotion can allow us to follow students' interest and excitement.

Aesthetic and contemplative practices can help transform science education toward a more integrated curriculum. For example, rather than entering a lab where sea urchins have already been probed and their gametes extracted into beakers, students can be given an opportunity to understand the natural world of the sea urchin. How do they survive in the harsh intertidal environment? How do they fit into their environment, and in what ways do they affect the ecosystem? How might their perceptions of the world differ from ours? These types of questions can be explored through narrative, art work, poetry or self-reflection. In studying earthworms, their outdoor habitat or even a well-maintained compost can be used so students can experience these annelids directly, recognizing the earthworm's essential need for a moist environment as it relates to support and their permeable skin, gently feel their segmented movements, and discuss its important role as a detritivore in soil aeration and in recycling organic materials. Such activities, similar to the WormWatch program offered by NatureWatch in Canada, cover science learning objectives without the need for dissection.

Teaching respect for all life should precede any biology education. Our species' survival depends on pollinators, photosynthesizers, and bacterial digesters in our gut; to foster an ecocentric worldview we need a foundation that gives intrinsic value to all life forms. To this end, for example, a creative writing exercise may be undertaken with students to help cultivate this respect. The lesson plan is simple: students employ multiple senses to engage with an item from nature. Preferably, such an item is discovered by students' themselves, led by their own curiosity while exploring the natural world. Students then brainstorm key words, ideas, and make drawings or other art inspired by this sensory engagement. From these inspirations they are given space to write a short story, poetry, or personal reflection essay, either on-site or at a later time. This pedagogic activity follows Goethe's approach, where creative and artistic expression is inspired by receiving from the object under study, thereby having students learn both about and from nature. With such reciprocity, animal neglect and cruelty are less likely to be tolerated. If we want to respect and honor all life phenomena and cultivate reciprocity, we need to open our hearts to an alternative paradigm that considers humans to be but one species among many in the vast cauldron of life.

A Conversation Between Sea Urchins

Specimen

I hear rumours of a sea beyond measure
whose borders slide with the moon.
Tell me of the ocean

All I perceive is a glass cube
that ends with the researcher's budget

I have a filter and lab technician,
my body is an experiment.
What I fear is fertilization day
when what they call the Kevorkian needle
prods my gonads

I heard them call me a "model" organism

A model to be cut, probed, vivisected
until every gene has been sequenced
and each eye to every microscope satisfied

Humans and urchins are kin,
my embryos resemble humans

Being different causes my suffering

But I'm not human enough

Species

Every wave delivers life,
the ebb brings barnacles and sunlight
the flow—fresh intertidals and brine, the world
in constant motion

Do you not see the world
in every direction, every
current from sediment to sky?

Imagine such a way to release life
there must be a reason you were chosen

A model for what?

Were you born in a lab?
When do we stop
being urchins?

So being similar causes you suffering

You said we come
from the same place

References

Bai, H. (1997). Ethics and aesthetics are one: The case of Zen aesthetics. *Canadian Review of Art Education, 24*, 37–52.

Bai, H. (2004). The three I's for ethics as an everyday activity: Integration, intrinsic valuing, and intersubjectivity. *Canadian Journal of Environmental Education, 9,* 51–64.

Bai, H. (2001). Challenge for education: Learning to value the world intrinsically. *Encounter, 14*, 4–16.

Cameron, A., Davidson, E., & Jasny, B. R. (2006). The sea urchin. *Science 314*(5801). JSTOR. http://www.jstor.org/stable/20032769

Hadzigeorgiou, Y., & Schulz, R. (2014). Romanticism and romantic science: Their contribution to science education. *Science and Education, 23*, 1963–2006.

Hedges, S. B. (2002). The origin and evolution of model organisms. *Nature, 3*, 838–849.

Herzog, H. A. (2005). Dealing with the animal research controversy. In C. K. Akins, S. Panicker, & C. L. Cunningham (Eds.), *Laboratory animals in research and teaching: Ethics, care, and methods* (pp. 9–29). American Psychological Association.

Hunter, P. (2008). The paradox of model organisms. *Science and Society, 9*, 717–720.

Killian, C. E., Metzler, R. A., Gong, Y. U. T., Olson, I. C., Aizenberg, J., Politi, Y., Wilt, F. H., Scholl, A., Young, A., Doran, A., Kunz, M., Tamura, N., Coppersmith, S. N., & Gilbert, P. U. P. A. (2009). Mechanism of calcite co-orientation in the sea urchin tooth. *Journal of the American Chemical Society, 131*, 18404–18409.

Koga, H., Morino, Y., & Wada, H. (2014). The echinoderm larval skeleton as a possible model system for experimental evolutionary biology. *Genesis, 52*, 186–192.

Kroh, A., & Mooi, R. (2011). World Echinoidea database. http://www.marinespecies.org/echinoidea

Mathews, F. (2008). Thinking from within the calyx of nature. *Environmental Values, 17*, 41–65.

McClay, D. R. (2011). Evolutionary crossroads in developmental biology: Sea urchins. *Development, 138,* 2639–2648.

Nussbaum, M. C. (2006). *Frontiers of justice: Disability, nationality, species membership.* The Belknap Press.

Robbins, B. D. (2005). New organs of perception: Goethean science as a cultural therapeutics. *Janus Head, 8,* 113–126. Trivium Publications.

Vacquier, V. D. (2011). Laboratory on sea urchin fertilization. *Molecular Reproduction & Development, 78,* 553–564.

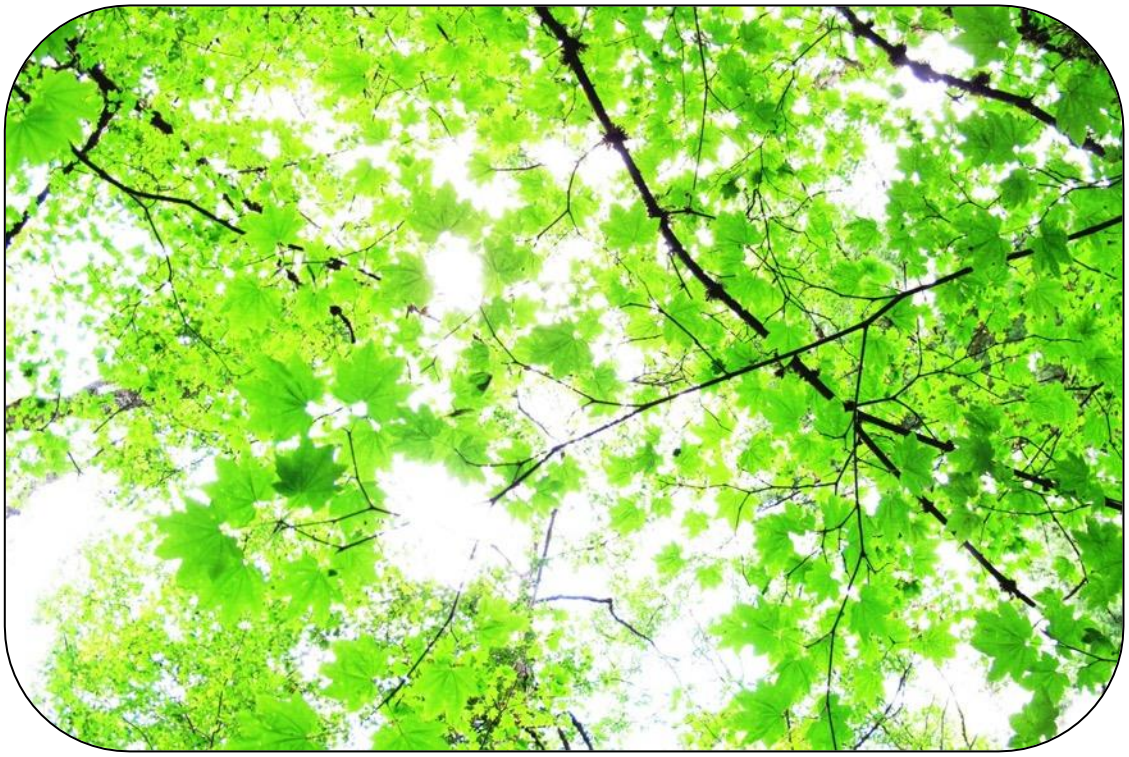
Voultsiadou, E. & Chariton, C. (2008). Aristotle's lantern in echinoderms: An ancient riddle. *Cahiers de Biologie Marine, 49,* 299–302.

Wahl, D. C. (2005). "Zarte Empirie": Goethean science as a way of knowing. *Janus Head, 8,* 58–76. Trivium Publications.

Zembylas, M. (2004). Emotion metaphors and emotional labor in science teaching. *Science Education, 88,* 301–324.

PART IV – BRANCHES & LEAVES

Place-based and Reflective Pedagogy



Commends the unfolding of the delicate leaf
To the sacred goad of ever-moving light!

Of shape and structure shown in succulent surface—
The infinite freedom of the growing leaf.

~Goethe

Chapter 7.

GPS Ecocache:
Connecting Learners to Experience and Place

7.1. Preamble

The first six chapters offered narratives and poetic conversation on the topics of nature- and arts-based learning, questioned deeply embedded assumptions of Western science, and explored Romanticism and Goethe's delicate empiricism as alternate philosophies and methods toward whole person pedagogy. Chapter 7 has theory play out into practice and forefronts the work and conservation ideals of Aldo Leopold. Along with Kolb and Dewey, experiential and holistic education are presented, and can be considered as extensions of Goethean conscious-process-participation. The GPS ecocache activity integrates ecological education, outdoor movement, environmental ethics, and a modified version can even incorporate poetry, and thus serves well as an applied exercise of ideas previously outlined in this thesis. The paradox of utilizing a gadget to connect students with the outdoors is considered, and finally the practical application of the ecocache is outlined. ✺

7.2. GPS Use in Education

Modern GPS devices have been utilized in an educational context for approximately twenty years. Geocaching (Brunsell & Horejsi, 2010) has been the predominant application of the technology. Recent innovations include interdisciplinary connections (Broda & Baxter, 2003) and activity extension, such as the geographic information system (GIS). These innovative practitioners are also utilizing the technology to facilitate learning around twenty-first century competencies (Hagevik, 2011). Research conducted with outdoor educators in Minnesota revealed that the two primary types of digital technology used in their programs were digital cameras and GPS devices (French, 2011). Since cellular phones now can do both of these functions, and given their

prevalence among youth, access to and familiarity with these tools should no longer be a limiting factor.

This essay describes the GPS ecocache as a place-based activity inspired by a Deweyian approach that promotes inquiry and seeks educational experiences that are resonant and purposeful both in the immediate moment and into the future (Dewey, 2004). Aldo Leopold's (1949) land ethic serves as a theoretical framework, emphasizing the importance of seeing land as a community, and questioning how people regard and respond to the land. Finally, the design and implementation of the GPS ecocache in an educational context is outlined. Like Leopold's *A Sand County Almanac*, this essay braids conceptual and philosophical threads with more concrete and practical applications.

Science programs can sometimes focus on the world as a collection of objects to be dissected and defined. Leopold (2013) wanted to reframe education's focus: "I contend that the average citizen does not need [lab work] as badly as he needs some understanding of the living world" (p. 413). Leopold's graduating students completed a project where they spent three days at a particular site, becoming intimately familiar with the history of the land and proposing how the land should be used in the future. In this way, the land ethic is relevant for the skills of the scientist, the natural historian, and the philosopher. David A. Kolb (2015) contends that "[e]ducation is holistic…Educating the whole person means that the goal of education is not solely cognitive knowledge of the facts, but also includes development of social and emotional maturity" (p. 300). The experiential, outdoor GPS ecocache is a path toward this holistic goal, and can foster relationality and a sense of stewardship for nature.

7.3. Experiential Learning: Philosophy and Practice

Kolb (2015) famously stated that "[experiential] *learning is the process whereby knowledge is created through the transformation of experience*" (p. 49). This definition emphasizes process as opposed to content or outcomes. The creation of knowledge hinges on an experience. These experiences are realized in many forms. John Dewey referred to them as *occupations*. He wrote about the necessity of leveraging occupations, such as

games, in education to meet the needs of the social learner. As Dewey (2010) explained, "outdoor excursions, gardening…drawing, singing, dramatization, story-telling, reading and writing as active pursuits with social aims (not as mere exercises for acquiring skill for future use), in addition to countless variety of plays and games, designate some of the modes of occupation" (pp. 188–189). Dewey referenced pairing these occupations with subject matter, as he cautioned that "it is not enough just to introduce plays and games, hand work and manual exercises" (p. 188). Embedding subject matter within hands-on or novel occupations then becomes a key part of Dewey's position. A GPS ecocache game connects strongly to Dewey's model of harnessing a novel occupation while embedding subject matter in order to achieve educational goals.

Dewey thought of occupations less as a noun (e.g., a primary occupation) and more as a verb (e.g., offering a range of ways to be occupied or engaged). The dominant method of instruction is where students sit and listen to a teacher. However, in most schools, according to John Quay and Jayson Seaman (2013), the principal focus of the academic student *is* the primary occupation; that is, the inculcation of skills and sensibilities by which the student will find a job that serves society. This is a far cry from what Dewey had envisioned. Passive experiences and career-finding are not enough. For learner experiences to be transformative they need to be facilitated in an intentional way.

Kolb's (2015) experiential learning cycle offers a framework for such experiences. This cycle flows through a familiar path of concrete experiences, to reflective observation, abstract conceptualization, and active experimentation. The GPS ecocache directly relates to the first two stages, and more indirectly to the latter two. This will be elaborated on later in this essay. If hands-on learning experiences and occupations are to be transformative, and based on the evolution of these learning cycles, such experiences need to be well-facilitated by informed educators who are mindful of learner ability, prior knowledge base, as well as the construction and transfer of knowledge.

A GPS ecocache operates as a hybrid of a geocache and a scavenger hunt. An ecocache consists of a series of downloaded waypoints, much like a geocache, however these waypoints typically represent biotic or abiotic aspects of the natural environment.

For example, the waypoint may mark a specific type of wildflower or tree. Ecocache participants are tasked with navigating to each waypoint and then answering a question or solving a riddle inspired by the site. The primary Educator Role Profile utilized for the ecocache is the facilitator role, except the focus extends from creating "personal relationships with learners" (Kolb, 2015, p. 304) to include facilitating personal relationships with the land.

There are also direct connections to teaching philosophical concepts. Philosophy courses such as environmental ethics explore humans' relationship with and responsibility toward the other-than-human world. To accomplish the objectives of an environmental ethics course, learners could complete an ecocache where they visit both natural waypoints (e.g., trees, rivers, and a bald eagle nest) and human-influenced sites (clear cuts, culverted waterways, and a site where pigeons congregate). Afterward, a lecture or facilitated discussion can cover anthropocentrism, speciesism, and utilitarianism (to include other-than human suffering). Similarly, specific GPS ecocache activities could be designed for indigenous studies, environmental education, ecopsychology, geography, philosophy of science, in addition to any course concerned with the nature of space. Phenomenologist David Abram (1996) underscores the importance of environment, especially in environmental studies. He writes, "Unlike the abstraction of an infinite and homogeneous 'space,' [such as a typical classroom or lecture hall] place is from the first a qualitative matrix, a pulsing or potentized field of experience, able to move us even in its stillness" (p. 190). For learners of all ages, the ecocache and follow-up activities are an opportunity to enter this field of experience, and can help foster a stewardship and appreciation for the land. Leopold's concept of a land ethic and ecological thinking could frame further discussion. Conversations brought forth by my students after a campus-based ecocache included the mistreatment of the natural areas by humans, inquiring about animal species that used to live on the campus, and surprise at the elements of nature they have walked by countless times yet never noticed until now. They also wanted to clarify anything they did not find or understand.

Co-Constructed Developmental Teaching Theory (CDTT) argues that learning is less a cycle and more of a fractal. Jeb Schenck and Jessie Cruickshank (2014)

recommend “extend[ing] the debriefing process over time and with added points of intentionality”(p. 87). Such points of intentionality can be added to a GPS ecocache through reflective pauses, journaling, and post-activity discussion. CDTT has been informed specifically by greater understanding of a student’s cognitive load, which is how much information the brain can handle before working memory is flooded (Cowan, 2005). Since the GPS ecocache involves movement, sensorial engagement, and the sense of going on a journey, this can help avoid memory overload. As the next paragraph elucidates, being outdoors in a relational context is especially conducive for learner engagement, and can also facilitate memory formation via stimulating attention, novel experiences, and the release of dopamine (Gazzaniga et al., 2002).

Numerous ecopsychology studies have reported the benefits of being in nature to health, attention span, creativity, and relaxation (Bratman et al., 2015; Selhub & Logan, 2012). In addition, there is a strong movement in many North American schools toward outdoor, place-based learning where the curriculum is situated in the context of the local environs and ecology (Blenkinsop, 2014; Shannon & Galle, 2017). Often based on principles of inclusion and Deweyian inquiry, outdoor education can facilitate experiential learning for physical, scientific, emotional, and philosophical literacy. This movement is inspired by myriad benefits of experiential, outdoor education, from promoting physical (Chawla, 2015; McCurdy et al., 2010; Sharma-Brymer & Bland, 2016) and emotional well-being to the enhancement of learner enthusiasm, academic performance, resiliency, critical thinking skills, and social skills (Foster & Linney, 2007). These learners are more likely to engage communities and develop civic attitudes and behaviors toward their natural and human ecosystems (LEAF, n.d.).

Student engagement with the local plant and animal species, and the landforms they inhabit, in a relational and reflective manner can build connective tissue between the learner and the natural environment. How the student is occupied makes a difference. For instance, careful attunement of the senses and drawing specific details found in nature results in different learning educational outcomes than playing a game of capture the flag. Such relationship building is vital towards shifting our perception of the natural world as a suite of resources to be exploited explicitly for human consumption (Abram, 1996;

Berry, 1999; Kimmerer, 2013). The pairing of occupations with subject matter, as Dewey argued for, is integrated in the GPS ecocache.

7.4. The GPS Ecocache and Aldo Leopold

We implement the GPS ecocache in different contexts. Jesse Jewell is an Experiential Education Curriculum Consultant who works in all of Yukon's communities. The basic concept of the ecocache discussed here was developed while driving the Alaska Highway in the Yukon from one school to the next. Motivated by the desire to have a more meaningful use for the ten GPS devices beyond a traditional geocache, he facilitated the first ecocache in Haines Junction, Yukon in the winter of 2011. The grade 5 students completed the course on cross-country skis at -20°C. Jewell's GPS ecocache activities typically take place in the northern boreal forest, and are intended for K-12 school learners (see Example Activity A for an example, with more of a treasure hunt focus).

Beavington's GPS ecocache is designed for undergraduate ecology students, and takes place on the campus of Kwantlen Polytechnic University in southwestern British Columbia (see Example Activity B). In addition, he is currently adapting the ecocache to be used in an expressive arts course he teaches, where students visit sites of ecological, social, and cultural importance. This reveals the adaptability of the GPS ecocache to different age groups, subjects, and locales.

Aldo Leopold was a hunter, poet, forester, and outdoor enthusiast who spent many years observing his land alongside the Wisconsin River. His land ethic, which extends ethics to the community of land (e.g., animals and plants but also soil and water), has proven deeply influential for conservationists, wildlife management, and philosophers. Leopold (2013) referred to ecology as the "science of relationships" (p. 415). Quantitative-centered scientists may argue that a GPS ecocache is closer to natural history than science, and therefore of lesser value. Leopold himself observed that "laboratory biology soon came to be regarded as the superior form of science" (p. 413) which supplanted natural history. Biology students, especially in higher education science

labs, spend their time performing experiments, analyzing data, surveying specimens, and doing dissections. “Instead of being taught to see his native countryside with appreciation and intelligence, he is taught to carve cats,” (p. 414) wrote Leopold, pointing to a disconnect between people and environment.

Laboratory work is certainly important for learning anatomy, controlled scientific experiments, and how to use specialized equipment such as microscopes and micropipettes, yet if such studies of biology (or geography) occur exclusively indoors, where is the opportunity to develop an understanding of and appreciation for the land? This assumes, of course, that one needs to be outdoors to develop a sense of place, or something toward the land ethic, which Leopold promoted. Leopold (1949) framed two views of the land: “one group (A) regards the land as soil, and its function as commodity-production; another group (B) regards the land as a biota, and its function as something broader” (p. 221). It is our hope that the GPS ecocache offers an opportunity for learners to see and feel their environment, and is therefore one step toward understanding land as something more than dirt to be exploited. Perhaps, beyond the simple dualism given above by Leopold, we can witness land as an active agent worthy of our respect. As indigenous scholar and botanist Robin Wall Kimmerer (2013) puts it, we could begin to appreciate “land as sustainer. Land as identity. Land as grocery store and pharmacy. Land as connection to our ancestors. Land as moral obligation. Land as sacred. Land as self” (p. 337).

According to Leopold (2013), studying the land as a community by engaging in relational activities is more pertinent, to the average citizen, than memorizing the bumps and grooves of dissected cat bones. If what we teach “does not deal with our relations to the land, it is not teaching at all” (p. 415). In other words, the fact that the GPS ecocache occurs in the living world, and might be classified closer to natural history than the science of biology, is a strength in cultivating a sense of responsibility for the world we live in. As Kimmerer (2013) explains, “science can give us knowing, but caring comes from someplace else” (p. 345). Dissections in a laboratory do not teach compassion and consideration for the living world, but perhaps outdoor exploration fueled by wonder can provide a spark in this direction. Philosophical considerations of anthropocentrism, deep

ecology, and environmental ethics can help learners position themselves on the human-centric to eco-centric spectrum. By teasing out values related to the land ethic, animal suffering, and environmental concerns, learners can develop and clarify their own beliefs and ways of being rather than accepting the status quo of the nonhuman world lacking inherent worth.

Leopold (1949) did not question the importance of conservation education, but rather the approach. He pondered, "but is it certain that only the volume of [conservation] education needs stepping up? Is something lacking in the content as well?" (p. 207). Leopold (2013) certainly preferred learners to spend more time outdoors, observing different aspects of the ecological community, which is the precise aim of the GPS ecocache. He even asked, "what is our educational system doing to encourage personal amateur scholarship in the natural history field?" (p. 413). An ecocache, designed with waypoints specific to the natural history of an area, could easily encourage such scholarship.

7.5. Leopold and Gadget People

Leopold (1949) distrusted "mechanized society" where "bureaus build roads into new hinterlands, then buy more hinterlands to absorb the exodus accelerated by the roads" (p. 166). He spoke ill of the gadgeteer and the gadget industry that "pads the bumps against nature-in-the-raw" (p. 166). He argued that outdoor recreation is meant to be primitive and atavistic, and to provide a contrast to technocratic city life. Leopold specifically condemned gadgets of the "'where-to-go' department," (p. 182) to which GPS units certainly belong, as they can depersonalize outdoor experience.

In this essay, we promote the use of a gadget to engage with and (perhaps) develop a sense of stewardship for land as a living community. Would Leopold approve? Or would he deem us to be modern-day gadgeteers "separated from the land by many middlemen, and by innumerable physical gadgets" (pp. 223–224). While we certainly agree with Leopold's assessment that people have "no vital relation to [land]; to him it is the space between cities on which crops grow," (p. 224) this is precisely why we have

implemented the GPS ecocache. We want learners to experience natural places with attuned senses for the wheels and cogs that construct the ecosystem in question. The GPS ecocache is a way of using something familiar to most students (e.g., handheld devices) to frame the unfamiliar (e.g., nature).

Kolb (2015) defined sensorial engagement in learning as *apprehension*, and further stated that "knowledge results from the combination of grasping and transforming experience" (p. 51). In this way, the GPS unit is a tool to directly facilitate the grasping of experience—what Kolb called *extension*, or external interaction with the world—and indirectly facilitates the transformation of experience—which is *intention*, or internal reflection. As Kolb summarizes, "We learn the meaning of our concrete immediate experiences by internally reflecting on their presymbolic impact on our feelings, and/or by acting on our apprehended experience and thus extending it" (p. 78). Within the three-stage experiential learning theory development framework, Kolb speaks to acquisition, specialization, and integration. Relating this to the GPS ecocache, acquisition becomes (for example) a direct experience with a Douglas-fir cone and an in-the-moment reflection on its shape or location. Specialization could be a critical reflection on the cone's purpose, or the questioning of previous assumptions held about conifers and our relationship to them. Finally, integration or reforming action might occur after learners visit a site with a polluted stream or forest clear-cut, and then later wrestle with the idea of development without destruction.

The over-structuring of learner experience can preclude the many benefits of experiential, outdoor education previously mentioned. The GPS device and its waypoints provides a slowly revealed map for the learner's experience, with enough unmapped terrain to foster self-determination. Without this structured, gadget-driven activity many learners would not have the initiative or focus needed to observe key relationships in nature. Ultimately, we hope to cultivate the values of Leopold's land ethic through the use of a ubiquitously available device, and for learners to engage "land not as a machine but as a community of respected nonhuman persons to whom we humans have a responsibility" (Kimmerer, 2013, p. 338). Handheld devices are integral to adolescent and

post-secondary culture. Let's teach students to use such devices in an active and experiential way, which offers some physical activity and promotes ecological literacy.

Leopold's Alder Fork fishing experience, where the experience of being there was the intent rather than any specific objective, emphasizes one drawback of the ecocache. Young students in particular often rush through this activity, as literally a race to the finish. Although some competition is healthy, it can create scenarios of superficial engagement, where learners linger on a site only as long as it takes to find the answer to the assignment question. Their goal becomes haste rather than reflection, reframing, and reform. In designing and implementing the ecocache (see the next section), the assignment could include learners doing drawings of nature or food webs, discerning specific ecological elements such as soil types, counting tree rings, or other prompts for concrete experience with the natural world (see Example Activity B). While there certainly is an irony in using a gadget to reconnect with the outdoors, the fact that students are actively discovering the sites on their own provides a certain autonomy. This makes possible unexpected discoveries and quiet moments of contemplation, should the learner feel so inspired. We are, by and large, gadget people. Our devices tell us places to go, give us directions to get there, and help us pay for parking. With the ubiquity of smartphones and other gadgets, people can be plugged in 24 hours a day. Despite Leopold's reservations of the gadgeteer, we believe GPS technology can help build a relationship with nature. We will now describe how to use the GPS as a tool for experiential learning.

7.6. Design and Implementation of a GPS Ecocache

In this section, we outline how to design and implement a GPS ecocache for your own learners. As this activity is place-based, the specific sites chosen obviously depend on the ecosystem(s) present. The questions integrated into your activity are similarly reliant on location, the age and experience of the intended learners, and also any philosophical concepts under consideration. At this stage, learner involvement can help determine goals and the steps needed to attain them, since their student-centered insights may prove valuable. Now follows a general approach to purchasing GPS devices,

designing your ecocache to fit your location, implementation factors, and learner assessment considerations—for educators, outdoor leaders, and other facilitators wanting to include a comparable activity as part of their program or curriculum.

Acquiring GPS Devices

For this activity, any GPS device with programmable waypoints is suitable. The Garmin eTrex 10 is a low-cost unit currently available online and in outdoor equipment stores. Of important consideration is the number of units required for your activity. Factors for this decision include (a) institutional funding available, (b) number of learners, (c) if learners are working singly or in groups, and (d) if the activity is completed simultaneously by all learners or on a sign-out basis. On the latter point, by having students sign-out a GPS device over several days, a class of 24 undergraduate ecology students at Kwantlen Polytechnic University has successfully completed the GPS ecocache annually since 2013 with only three units available.

We recommend that learners work in teams of two to three while completing the ecocache. Younger learners, exploring unfamiliar or remote areas of wilderness, likely present a safety concern. This challenge can be overcome by limiting the region to be explored to a clearly delineated or enclosed area, and/or pairing younger participants with older learners or adults. Working in teams promotes collaboration and honing of communication skills. Teams of two or three are ideal, as larger groups may dilute the ability for some team members to be fully involved with the activity. Having teammates also avoids the frustration of a solitary participant getting stuck with how to operate the GPS device or in answering one of the ecocache questions.

Designing a GPS Ecocache

In formulating this experiential learning activity, care must be given to space and time. Kolb (2015) recommends that we "exercise some choice in the learning spaces and times one makes and create the kind of learning space that best facilitates their learning" (p. 349). Both the season and time of day the GPS ecocache takes place, as well as the specific locations chosen for waypoints, can have considerable impact on learner

experience. When we realize that "learning is conceived as a transaction between the person and the environment," (p. 288) the temporal variation and physical aspects of the environment become paramount. Unless you do not plan to reuse your GPS ecocache activity in subsequent years, refrain from focusing your waypoint destinations on more transitory features such as nests, flowers, migratory animals, a single plant specimen, and small ponds that may dry up.

The first step in designing your ecocache activity is familiarizing yourself with the local area and ecology. The ecocache is adaptable to almost any outdoor location, and can be based in remote wilderness or in dense urban settings, including school yards and college campuses. The important ecological elements to make note of for your proposed site include: common plants, animal signs (scat, tracks, tree markings, etc.), invasive species, disturbances (roads, clear cuts, fire, windfall, etc.), geographical features (rivers, mountains, cliffs, rock exposures, berms, stratification, soil type, etc.) and ecosystems (forest, bog, desert, riparian, littoral, etc.). Through familiarizing yourself with the site and setting the waypoints you should also be able to identify both ecologically-sensitive areas for participants to avoid, and significant hazards such as poisonous plants or perilous terrain. If your ecocache will take place in an urban setting, you may also consider gardens, weeds, parks, composts with detritivores such as earthworms, areas with urban-adapted animals such as pigeon and squirrel, and other relevant features to incorporate into your activity.

Before Beavington designed his first ecocache, he explored the area with a student who gave input into waypoint locations and questions of interest. She also indicated what was familiar and unfamiliar to her, which helped ensure the final questions possessed a suitable level of challenge. Leopold (1949) can be used here as a philosophical guide in observing the land as "not merely soil [but] a fountain of energy flowing through a circuit of soils, plants, and animals" (p. 216). What are the keystone producers and consumers in the ecosystem? How are you connected to the carbon cycle? What are the points of interrelation for soil, plants and animals? By using such questions to guide your ecocache design, and Leopold's land ethic as a philosophical framework, your ecocache is more likely to have learners relate to the land and unearth hidden meanings within the

ecosystem. “Scientific discovery is nutriment for our sense of wonder,” (as cited in Callicott, 1987, p. 282) and the experience of outdoor discovery can facilitate learners reading the book of nature.

Once you have your GPS devices and are familiar with the area to be used for the activity, you will need to program waypoints into your GPS unit. This procedure will vary widely, depending on the GPS devices at your disposal, so we will not go into further detail on this process here. One important universal step is to clear all existing waypoints from the unit prior to marking your course. This ensures that each waypoint on every unit corresponds with the same number. Speaking from experience, you want to ensure your waypoints are far enough away from each other (i.e., 10 meters minimum, preferably more) so that students do not confuse one waypoint with an adjacent one. If you are working with a larger group in expansive terrain, you may want to space out waypoints even further (i.e., 100 meters minimum) to spread out learners. Also, instruct students that they can visit the waypoints in any order. There is no reason to constrain students to a specific order in which they need to visit waypoints; in fact, the opposite tact invites agency and the excitement of exploration. If conducting an ecocache with several teams at the same time, consider starting each team on a different waypoint to avoid the entire group, possibly twenty-five participants, moving together.

Implementing a GPS Ecocache

After the waypoints are programmed into the GPS devices, you will need to prepare the questions for the activity. Refer to your field notes for each waypoint and develop your questions based on learner age and knowledge-base, preferably with input from current students. If you marked something specific with flagging tape note this in your question.

Typically, an orientation to the GPS device is done prior to the ecocache. This is best done outdoors where the GPS devices can communicate with satellites. Walk participants through the basic functions such as toggling between different screens. Before starting the ecocache, participants should be able to demonstrate the following to each other, and then confirm with an instructor: power on/off, connect the GPS unit to

satellites, an understanding of what may influence a satellite signal (e.g., dense forest, proximity to buildings), locate the list of waypoints on the GPS device, direct the GPS unit to navigate to a specific waypoint, and how to access the navigation screen with the digital compass (or comparable GPS feature). During this orientation, participants should be shown how to check the battery power remaining on the unit. An explanation of GPS accuracy, often several meters of error, should be explained. Finally, participants should understand that, when navigating, the compass screen functions best while the GPS operator is in motion. Having everyone mark a waypoint together before they start and name it *The End* is a great way to make sure everyone ends up at the same destination. Encouraging participants, particularly younger learners, not to race may be futile. Assignment questions tailored to slow down learners and carefully discern the terrain may help. Supervision style will depend on the age of the participants and the nature of the terrain. When working with young adults no supervision may be necessary other than arranging a check-in time following the completion of the activity.

Assessment and Learning

Having learners gather specific items (e.g., cones, leaves, berries) where appropriate can help ensure that they actually visited the waypoints in question, or their GPS data can be downloaded and examined. Some flexibility is necessary when assessing student answers. Students may interpret questions or see something at a waypoint that provides an equally correct answer (e.g., you may have asked them to identify a prominent invasive species at a waypoint, when there are two invasive species present).

You may have students take an occasional photo as they navigate to certain waypoints. This documentation can be scrutinized at a later time for accuracy or further observations. Written answers, sketches of nature, and/or digital photos can be submitted as part of an assignment. Since reflective observation is a key ingredient of experiential learning, students can be encouraged to journal about their experience either during or immediately after the ecocache. Additionally, a group discussion can be facilitated where students share their experience, discuss different answers to the same question, and elaborate on both their challenges and discoveries. Student responses, especially after the

inaugural offering of a new ecocache, can provide important feedback for how to revise and clarify your ecocache for future incarnations.

A cornerstone of Kolb's four-stage experiential learning cycle is concrete experience. Human learning is sight dominant, yet the ecocache can incorporate sound, scent, touch, and even taste. Such direct sensorial experiences help avoid ontological reversal (Harvey, 1989), where models and abstraction take on more prominence than the actual phenomenon under study. Instead of reading about tree rings in a textbook or receiving passive instruction from a PowerPoint, learners can literally get their hands dirty. After grasping their experience through direct sensorial engagement, and transforming their experience through intention and reflective observation, this work can then lead to abstract conceptualization (e.g., reviewing models of the carbon cycle). Having encountered various components of the carbon cycle, learners can now provide examples and draw interconnections between this nutrient cycle to their own bodies and the larger biosphere.

Getting outdoors can change how the learner is being occupied, provide an opportunity to break the thinking that learning is limited to the classroom, and allows learners to apply their prior knowledge and skills in ecology and geography. The assignment questions asked during the ecocache can direct learners to use their hands and inspect particular elements of the environment. One can argue that such direct experience, perhaps including drawing aspects of nature as Leopold did, have the possibility of being more engaging and meaningful for learners. They will remember the scent of skunk cabbage, the mossy path they followed, and start "to think about what land means," (Kimmerer, 2013, p. 328) which is one step toward cultivating respect for a place. Since the answers are often found within the land itself, in this way the land becomes the teacher. How does a learner's response to the land change when it is seen as a living community? Should we perhaps not use the word *it* to refer to the land? What if land were a verb rather than a noun? These are some questions to ponder, either introspectively during an ecocache or as a post-activity discussion.

Activity Extensions

Leopold developed an appreciation for the land through studious observation, representative drawings of nature, and keeping detailed ornithological records. GPS devices can offer similar opportunities for discernment and data gathering. Once students have participated in the ecocache and mastered how to mark waypoints they can create their own ecocaches. If time permits and you have ongoing access to GPS devices, consider having each group create an ecocache experience for the class. Modern GPS devices can capture a large amount of data relating to student movement. This includes: tracks travelled, distance travelled, average speed, maximum speed, time spent stationary, and elevation gain. Students typically find analyzing data that has a personal connection fascinating, commenting on their movement patterns, unexpected detours, and a peculiar sense of how time passed during the ecocache. This data can be graphed, interpreted and contrasted with other groups in the class. Data pertaining to tracks traveled can be uploaded with relative ease to free GIS such as Google Earth, thus producing a map unique to each participant.

7.7. Concluding Thoughts

The GPS has a lot to offer the science of relationships and transforming our perception of and appreciation for the land. Based on student responses, the most consistent conclusion to an ecocache is participant satisfaction. Enthusiastic students are typically more engaged. Students of all ages relish in the quest aspect and the challenge it presents them, both physical and cognitive, concrete and reflective. Through acquisition of direct experience, specialization with critical reflection, and finally integration where action is reformed, the GPS ecocache holds the potential to be a stepping stone toward transformative learning.

Nearly every environment is a potential ecocache course as the waypoints are living in the landscape. Conducting an ecocache in the same location but in different seasons can reveal entirely new discoveries for learners and serve to emphasize the dynamic nature of the land. Negative feedback for the ecocache, although rare, has arisen

if the ecocache was conducted in inclement weather, was too simple, or a particular waypoint site was unclear. Although the weather is unpredictable, the other issues can be addressed by making ecocache questions more challenging (gathering some knowledge of your learners prior to setting the course can help), and marking specific sites with flagging tape.

The ecocache has room to expand in the urban context. Anthropomorphic phenomena offer rich learning opportunities and a chance for learners to reflect on their own presence and subsequent impact on the earth. Human presences and behavior in the natural world leave behind recognizable traces. Culturally modified objects or trees by First Nations peoples have significance and there may be an opportunity for greater learning and understanding of First Nations' cultures. A First Nations co-worker adapted the ecocache activity and titled it a culture-cache. Any expansion in this direction should be done through respectful collaboration and with permission of local First Nations to honor their traditional territories and peoples.

The GPS ecocache is an opportunity to connect outdoor experience with reflective learning, and shift "sensory experience into action experience" (Zull as cited in Kolb, p. 91). Leopold (1949) contended that "[w]e can be ethical only in relation to something we can see, feel, understand, love, or otherwise have faith in" (p. 214). The GPS ecocache, designed with a holistic intention, has the potential to foster a renewed connection with the land and a sense of wonder and discovery. As learners become more familiar with the living community that is the land, they may start to see something new as Leopold did, and they may also avoid misreading nature's signs, as Leopold experienced when he shot a mother wolf and watched "a fierce green fire dying in her eyes" (p. 130). In this moment, he realized he was killing more than just a wolf. He was killing a way of knowing and being that was different from his own. Ecocache students have made less dramatic reports in regards to observations of the use and abuse of the natural environment by humans, such as cigarette butts as fire starters and paved areas stamping out biodiversity. Ecocache assignments can facilitate intellectual and cognitive development while simultaneously cultivating Deweyian resonant educational experiences that carry into the future.

References

Abram, D. (1996). *Spell of the sensuous: Perception and language in a more-than-human world*. Vintage Books.

Berry, T. (1999). *The great work: Our way into the future*. Three Rivers Press.

Blenkinsop, S. (2014). In search of the eco-teacher: Public school edition. *Canadian Journal of Environmental Education, 19*(1), 145–59.

Bratman, G. N., Hamilton, J. P., Hahn, K. S., Daily, G. C., & Gross, J. J. (2015). Nature experience reduces rumination and subgenual prefrontal cortex activation. *Proceedings of the National Academy of Sciences, 112*(28), 8567–72. https://doi.org/10.1073/pnas.1510459112

Broda, H. W., & Baxter, R. E. (2003). Using GIS and GPS technology as an instructional tool. *The Social Studies, 94*(4), 158–60. https://doi.org/10.1080/00377990309600199

Brunsell, E., & Horejsi, M. (2010). GeoEverything: The magic carpet. *The Science Teacher, 77*(6), 12.

Callicott, J. B. (Ed.) (1987). Companion to *A Sand County Almanac*. The University of Wisconsin Press.

Chawla, L. (2015). Benefits of nature contact for children. *Journal of Planning Literature, 30*(4), 433–52. https://doi.org/10.1177/0885412215595441

Cowan, N. (2005). *Working memory capacity*. Psychological Press.

Dewey, J. (2004). *Democracy and education*. Dover Publications.

Foster, A., & Linney, G. (2007). Reconnecting children through outdoor education: A research summary, *The Council of Outdoor Educators of Ontario*. https://www.coeo.org/wp-content/uploads/pdfs/ReconnectingChildren.pdf

French, B. (2011). How are outdoor educators in Minnesota using technological devices to deliver curriculum? [Master's thesis, University of Minnesota Duluth]. The University Digital Conservancy. https://conservancy.umn.edu/handle/11299/187481

Gazzaniga, M. S., Ivry, R. B., & Mangun, G. R. (2002). *Cognitive neuroscience: The biology of the mind*. Norton.

Gray, H. R. (2015). Geo-caching: Place-based discovery of Virginia state parks and museums. *Journal of Museum Education, 32*(3), 285–91. https://doi.org/10.1080/10598650.2007.11510578

Hagevik, R. A. (2011). Fostering 21st century learning with geospatial technologies. *Middle School Journal, 43*(1), 16–23. https://doi.org/10.1080/00940771.2011.11461789

Harvey, C. (1989). *Husserl's phenomenology and the foundations of natural science*. Ohio University Press.

Kimmerer, R. W. (2013). *Braiding sweetgrass: Indigenous wisdom, scientific knowledge and the teachings of plants*. Milkweed Editions.

Kolb, D. A. (2015). *Experiential learning: Experience as the source of learning and development* (2nd ed.). Pearson Education.

LEAF (n.d.). Outdoor education – research summary, Wisconsin's K–12 Forestry Education Program. University of Wisconsin. https://www.uwsp.edu/cnr-ap/leaf/SiteAssets/Pages/School-Forest-Research/Outdoor%20Education%20Research.pdf

Leopold, A. (1949). *A sand county almanac, and sketches here and there*. Oxford University Press.

Leopold, A. (2013). Natural history, the forgotten science. In Meine, C. (Ed.), *A Sand County Almanac and other writings on ecology and conservation* (pp. 411–415). Library of America.

McCurdy, L. E., Winterbottom, K. E., Mehta, S. S., & Roberts, J. R. (2010). Using nature and outdoor activity to improve children's health. *Current Problems in Pediatric and Adolescent Health Care, 40*(5), 102–17. https://doi.org/10.1016/j.cppeds.2010.02.003

Park, B. J., Tsunetsugu, Y., Kasetani, T., Kagawa, T., & Miyazaki, Y. (2010). The physiological effects of shinrin-yoku (taking in the forest atmosphere or forest bathing): Evidence from field experiments in 24 forests across Japan. *Environmental Health and Preventive Medicine, 15*(1), 18–26. https://doi.org/10.1007/s12199-009-0086-9

Quay, J., & Seaman, J. (2013). *John Dewey and education outdoors: Making sense of the "educational situation" through more than a century of progressive reforms*. Sense Publishers. https://doi.org/10.1007/978-94-6209-215-0

Schenck, J., & Cruickshank, J. (2014). Evolving Kolb: Experiential education in the age of neuroscience. *Journal of Experiential Education*, *38*(1), 73–95. https://doi.org/10.1177/1053825914547153

Selhub, E., & Logan, A. C. (2012). *Your brain on nature*. Wiley.

Shannon, D., & Galle, J. (Eds.). (2017). *Interdisciplinary approaches to pedagogy and place-based education*. Springer International Publishing/Palgrave Macmillan. https://doi.org/10.1007/978-3-319-50621-0

Vinathe, S., & Bland, D. (2016). Bringing nature to schools to promote children's physical activity. *Sports Medicine*, *46*(7), 955–962. https://doi.org/10.1007/s40279-016-0487-z

Example Activity A.
Grade 9 GPS Ecocache Activity Worksheet

Clay Cliffs Ecocache

Use the GPS to navigate to each of these sites. You may visit the sites in any order. At each of these sites, fill in the answer to the question that corresponds to that site.

1. These seeds and the fruit that surrounds them are high in vitamin C and a source of food for bears. _____

2. There are over 150 species of this small tree in Canada. This particular variety is called cotton _____

3. Which direction is the length of the airstrip running and why?

_____

4. This low-lying evergreen plant produces an edible berry.

_____

5. Which small mammal species is living around here?

_____

6. Touch this tree and you'll see—it left white dust on me. Can you identify this tree?

_____

7. Can you see the domesticated tree with bright yellow leaves and red berries? What is it? _____

8. An herb! This small plant is often used in First Nations ceremonies.

_____

9. Smell the buds on the trees around here. The resin is used to make hand salve. What type of trees are these? _____

10. This small green fern-like plant is edible. Rhymes with Faro.

_____

11. Snack time. A domesticated version of this berry has been planted here.

_____

Example Activity B.
Undergraduate Ecology GPS Ecocache Activity

GPS Ecocache for KPU Surrey Campus

At each of these sites, work with your partner to answer each question. You will need a phone or camera to take photos. Note that all questions are site-specific! Orange flag tape is located at some sites to make your destination clear. * = photo required at this site

Questions

* 1. Take pictures of two epiphytes growing on the trees in this area. Name the epiphytes:

(i) _____

(ii) _____

Name and describe a type of interspecific interaction involving one of these epiphytes.

_____

2. Identify the dominant tree species in this copse: _____

In a local forest, what might be the best way to determine its population density? Explain your choice.

* 3. Take a picture of the tree at this spot. Name this tree species:

_____

Pick a cone from the ground and try to knock out some seeds. What are two ways this seed could be dispersed?

(i) _____

(ii) _____

4. Inside this box are four abiotic factors that are essential to all life. Three of these were here before you opened the box—two are visible.

List the four abiotic factors.

(i) _____

(ii) _____

(iii) _____

(iv) _____

What biotic factor, not present in this box, is essential for animals?

* 5. Take a picture of this slice of life. How old am I?

6. Name this plant: _____

Take a berry and crush it between your fingers. It contains saponins (a plant compound similar to detergent) and perhaps it feels soapy to you. Other than being used as a skin cleanser, another traditional use of the mashed berries is to catch fish. Added to a stream, saponins incapacitate or even kill fish, making them an easy meal. How would the seeds of this plant be dispersed?

7. Including the plant you are standing on at this site, draw a simple energy flow diagram that connects the sun's energy to you.

* 8. Take a photo of the unusual star-like structures growing on these two rows of trees (note: this is not referring to the moss or lichens). Tear or cut one open and examine the interior. What is the function of this structure?

9. Pick a leaf from the tree in this area (its bark has horizontal stripes, and its leaves are lanceolate or spearhead-shaped). Look at the point where the petiole meets the leaf blade and take a picture of the two glands found there. These are called extrafloral nectaries. What do they do and how are they advantageous to the plant?

* 10. Take a picture of the Douglas-fir here. Compare its growth to the Douglas-firs lining the street. Explain how the epiphyte (English ivy) on this fir has impacted the tree's growth.

* 11. Look south to the community garden. Go and take a closer look. Take pictures of yourself and your partner next to the raised garden beds.

12. Draw a simple food chain/web that connects you to an organism in this habitat. Include at least 4 organisms in your food chain/web. Be sure to also label your arrows to indicate what process each arrow represents.

13. List three features of this environment that affect a plant's ability to grow here.

(i) _____

(ii) _____

(iii)_____

* 14. The row of trees closest to the building are common to the forests of eastern North America. Take a picture of a leaf. Sadly, the leaf is a poor indicator of the genus this tree belongs to, but the seeds are an excellent indicator. Can you find any winged seeds?

Guess the genus: _____

15. What tree species is this? _____

Take a photo of the reproductive structure of this tree. Stand underneath the tree and look up. Notice the damage to the leaves done by herbivores. Typically, the broadleaf trees in this area lose their leaves this time of year. What is the advantage to dropping their leaves in the autumn? _____

Chapter 8.

The Jaguar Walk:
Reflections from the Amazon Field School

8.1. Preamble

To follow the specific GPS ecocache activity, educational implications are contemplated for teachers in training. Examples of experiential and place-based learning that I have either team taught (Amazon Field School) or instructed in biology or expressive arts are explored. Journaling, photography, and poetry are included, in part, to parallel the interdisciplinary nature of the Amazon Field School and the multi-modal approach to this thesis. Different examples of Nature as Teacher are considered for teacher training, highlighting adaptability, confidence building, and contemplative pedagogy. These were generated from the wisdom of the more-than-human world, my journal entries, and lessons learned from my students. Experiences where nature acts as teacher fit well with the concrete experiences of Kolb's experiential learning cycle discussed in Chapter 7. Yet one can easily imagine such learners moving through observing (reflective journaling), thinking (conceptualizing a theory inspired by their experience and metacognition), and finally reaching Kolb's active experimentation, where students make decisions based on theories they co-constructed with the natural world.

Confidence building is close to my heart. I was a shy introvert throughout my Kindergarten to undergraduate educational experience, and in my formative teaching years. This meant feeling intimidated when speaking in front of groups. As a teacher, being introverted can offer the gifts of being a keen listener and (with practice) a holistic-minded facilitator, as well as being perceptive to the needs and meaning-making of the quieter students. I strive to mentor my own students, and teachers-in-training, to build confidence by cultivating an inclusive and trusting environment modeled, for example, through active listening, sitting in a circle, and learner-centeredness. I also scaffold student opportunities to share and present ideas, enable the opportunity to take risks (e.g.,

sharing mistakes, facilitating low stakes assignments, and celebrating perseverance) and use the positive, strengths-based approach of appreciative inquiry. I teach the way that I would want to be taught. I am now a confident speaker and facilitator, an introvert that has stretched my extrovert muscles.

In this chapter, I explain how the natural world promotes resiliency, active learning, and cross-species communication. The teachings of the Amazon rainforest—in particular the adaptability of leaf-cutter ants, and the confidence of the jaguar—informed this not simply on a cerebral level; I can evoke the leaf-cutter's ingenuity and feel the fearlessness of the jaguar in my own bones when a difficult situation requires this. ✺

8.2. Introduction

I awoke on my birthday to the rush of the Amazon River outside my cabin. As I stepped into the deceptively cool morning, iguanas emerged to catch the sunrise and a troupe of squirrel monkeys scurried overhead. After arepas with fresh guava jam, we would embark on a 6-hour hike through primary tropical rainforest, the finale to our two-week Amazon odyssey. I documented this journey in my journal: "…we set out on the Amazon. Into the maze of side streams we travelled, and then the great trek began. Palm, vine, fern, tree fern, epiphyte, moss, shelf fungus, walking trees, bullet ants, evidence of jaguar, mother spiders and the spirits of the rainforest…Diego said we were heading into the heart of the Amazon" (May 18, 2014).

The Interdisciplinary Amazon Field School (http://amazonfieldschool.ca) is a collaboration between the Calanoa Project in Colombia, founded by Marlene and Diego Samper, and Kwantlen Polytechnic University (KPU) near Vancouver, British Columbia. Two KPU instructors fly down to Colombia with 12–18 undergraduate students from a variety of disciplines. After brief stops in Bogota and Leticia, it's a 3-hour boat ride up the Amazon to Calanoa. The Calanoa Project is an arts, design, ecology, and sustainability learning center that collaborates with aboriginal scholars and artists, and engages both local and global communities with indigenous ways of knowing. From here, students engage in everything from ethnobotany walks, boat rides to find Peruvian

dolphins, pottery workshops, talks from shamans, and many other creative and ecological experiences.

In my three trips to the Amazon, I progressed from observer to faculty to leader, closely mirroring my personal journey as an educator. These experiences have significantly influenced my teaching. I have shifted from teacher or lecturer to being a facilitator of learning. Four key lessons from my journey include (1) the importance of teacher adaptability in active learning environments, (2) confidence building for teachers

Figure 8.1. Students crossing the Amazon River in Colombia.
Credit: Taken by Lee Beavington, 2017.

to become capable leaders and mentors, (3) contemplative education that embraces a reflective and relational pedagogy, and (4) the movement toward Nature as Teacher.

8.3. Lessons from Leaf Cutter Ants (The Importance of Adaptability)

Travelling with a group of students in a country with a foreign culture and climate is fraught with the unexpected. We experienced cancelled flights, tarantulas in our cabins, and flooded forest paths. Having two instructors means two minds for problem solving. Equally as important is a resourceful flexibility: adapting to sudden changes, maintaining composure in front of students, and letting go of expectations.

By way of example, let's return to the start of our six-hour jungle trek. Not long after commencing, the sky opened and turned the hot, dry day into a hot, wet day. Twenty plastic ponchos appeared as we waited out the worst of the deluge. Afterward, senses heightened by the elements, we saw an ecosystem transformed. The whole forest began to *drip drip drip* down to the thin soil below, and the wet leaves glistened with verdant veins as though revealing the fingerprints of the forest. We trekked forward only to find that the trail had become a river. Flooding in the wet season widens the Amazon River by over 30 kilometers. Our guides, Elvis and Jorje, bushwhacked with their machetes in search of an alternate route, leaving us with insistent mosquitoes buzzing in our ears.

The rest of us lingered. We began to notice pockets of wonder: vines that looked like snakes and snakes that looked like vines; mossy lichens on the bark that resembled maps of the world; leaf-cutter ants harvesting chlorophyll like so many marching soldiers. Out came the cameras. The flooding afforded us an opportunity to attune our senses. While some students were impatient, the delay allowed others to settle and appreciate the tremendous biodiversity—the greatest the Earth's surface has to offer—surrounding us.

Adaptability for the classroom instructor is an ever-evolving skill, best learnt through practice. This skill is especially important in environments that foster active learning, group work, class discussions and other experiential approaches. In such classes, uncertainty can be both intimidating and liberating. Students may take conversations to unexpected places, react differently to planned activities, or offer another way of approaching the subject matter at hand. Formal lesson plans may not be the best approach in these situations. Rather, tangential paths often enrich learning by

revealing student biases and misunderstandings, and opening other windows of perspective to the topic. When leaf cutter ants hit an unexpected barrier, they will climb, burrow or build living ant-bridges until they find the path that best serves them.

Figure 8.2. Snakes that look like vines.
Credit: Taken by Lee Beavington, 2017.

I recently gave a presentation on re-imagining the KPU Surrey campus. My co-presenter, Sylvia Borda, the real expert on our topic, was unable to attend. I hastily patched her in via Skype, and had her speak to the 15 participants. About halfway through our hour-long session, she cut out. I had noted the five flip charts in the classroom. At this point, I broke the participants up into five groups, and had them each discuss a different question related to the topic. They wrote their brainstormed ideas on the flip charts, which we discussed as a large group. This was not the plan, but the situation demanded adaptation. The result? From this discussion arose a number of

fantastic conversations and inspirations for transforming the campus. Similar situations have often arisen in my classrooms and labs, where harvesting learners' ideas and creativity proved more fruitful than PowerPoint or lecture.

By example, renovations on the Surrey KPU campus kept the science labs closed the first month of one semester. Instead of delaying the start date of my biology labs, I took students outside to learn about local ecology. Students explored unfamiliar areas of the campus, embodied tree physiology, and taught each other about local species through research they did on-site using their phones.

One day, in my interdisciplinary expressive arts (IDEA) class, two of the three groups scheduled to present cancelled. Instead of ending class early, we entered into a lengthy (but respectful) debate based on the first group presentation's ESL topic, engaged in a reflective writing exercise, and each student shared the progress of their major, semester-long project. Such spontaneous and opportune moments facilitated several experiential exercises that I now carry forward as regular activities.

8.4. The Jaguar Walk (Confidence Building)

Who am I as a leader? Can a (formerly) shy introvert be an effective leader? This question framed my personal inquiry during the Amazon Field Schools.

My first Amazon trip represented, in many ways, the first five years of my university teaching. I didn't know the terrain, and rarely initiated new ideas or took on leadership roles. I made timid but meticulous observations for future reference. During our trip, and because of my background in biology, I became by default the so-called 'expert' in all things scientific. *What's the difference between centipedes and millipedes?* Ask Lee. *How did the universe form?* Ask Lee. Or simply, *What's that plant?* Ask Lee!

In Colombia, there are more than 55,000 different plant species, not to mention nearly 2,000 bird and 3,500 butterfly species, none of which had I encountered in the wild. Each unanswered question put another dent in my sensitive shell, and made me

determined to learn. I also slowly came to appreciate that *not* knowing an answer is an opportunity for collaborative learning.

My second trip, I found myself having to make elbow room for my leadership role. In addition to Lucie Gagné, my co-instructor who founded this field school, we also had hosts Marlene and Diego, an associate dean, another instructor from Design, a student leader, not to mention frequent guides or guest lecturers. "With six people in leadership/instructor roles, there is little room (or need) for additional directions to be given. If I were the only one in a leadership role, I trust and believe I would be the leader that was needed" (May 28, 2015). This surplus of leaders required careful navigation of when to lead, and when to step aside to avoid there being too many cooks in the kitchen. As I struggled to find my place, I pondered the line between being assertive and passive, between confidence and hesitation. Does stepping aside permit others to lead, or does it fail to honor my own leadership role? Extroverts can, at times, become the default leaders through charisma, conviction, or by simply being the loudest.

Later that trip, Marlene facilitated a symbolism workshop. We each chose something to represent who we are. "Besides my familiar symbols—the moon, river, ocean, water, fern, cheetah—I chose the morpho butterfly. I cycle through phases of intense focus (caterpillar), deep reflection (cocoon/chrysalis) and transformation (adult butterfly). Also, its brilliant blue wings are hidden when it's still, only revealed in short bursts which is resonant with how I teach" (June 15, 2015). I recognized that, as an introvert, I offer a quieter, more intentional confidence that emerges only when needed.

The third year, if the students, our guides, Marlene, or my fabulous co-instructor, Farhad Dastur, had a question, they usually brought it to me. "For now, need to take it all in. Explore. Break boundaries. Inspire. Learn. I'm the primary faculty this year. Feels strange. I'm the one people go to for most questions. Me. Lots of responsibility. Humbled by this. Extraordinary, really" (Mar. 2, 2017). This year, there was no student leader to help coordinate and relay information. I became a focal point. Because of my experiences in the previous two field schools, and inspired by leaf cutter ant adaptability, I was prepared for almost every circumstance. Getting through security to our connecting flight, helping

students order food, providing emotional support and, of course, answering the question *What kind of tree is that?*

For myself, confidence facilitates clear instruction, student comprehension, the motivation to try something new, as well as a willingness to be stretched and challenged. A confident instructor, in my case, is more welcoming to uncertainty. At one point during our 6-hour trek, one of our guides stopped next to a tree. “Jaguar,” Elvis stated, as though this were commonplace. I examined the shredded bark of a tree trunk. Then Elvis pointed to the path. “Here are his prints, made not long ago. Maybe yesterday.”

I remember this moment clearly, because both terror and wonder collided inside my head. *A jaguar has hunted here*. I walked next to the print, imagining that great cat padding forward with his bulging muscles and massive paws. To walk like a jaguar is to radiate confidence.

When I teach, I prefer to be the side guide rather than the stage sage. I view instructing less as the imparting of information but more so the finding of one’s path in the academic world (and beyond). Furthering critical and communication skills, emotional and ecological literacy, as well as cooperative and relationship building capacities are all part of this process. “Thinking about leadership. I am not a directive leader. That is not my path. I provide a space for my students’ confidence to grow, for questions to be asked, trust to be built, curiosities followed, and a bridge connecting the outer and inner worlds” (May 28, 2015). In my IDEA courses, students typically run the last three to four classes. They have participated and engaged in various student-centered activities that I have facilitated, and then I move aside so they can lead.

8.5. The Opening (Contemplative Education)

In the Amazon Field School the cohort travelled together, ate together, shared cabins and numerous experiences that stretched them physically, emotionally, and perhaps spiritually. The Amazon also has the power of “cracking people open, letting vulnerabilities loose, and inviting people to share from a deeper well” (May 29, 2015). As the instructor, building solid relationships and a container of trust is paramount. This is true for both the pre-departure classes and while on-site in Colombia. This means being

approachable, inviting all voices to be heard, and cultivating a learning environment where the whole person is welcome to show up. Mind, body, and emotion are all interwoven in this journey. In such an environment, fears and tears are not turned away. Rather, they are acknowledged as valid parts of who we are and supported by the learning community we have co-created.

This field school often took students out of their comfort zones. As my May 3, 2017 journal entry attests, "we will be stretched, smelly, sweaty, humid, hot, mosquito-bitten, rain-soaked, sun-warmed, and having the time of [our lives]." During our travels, many days are packed full with workshops and boat rides to villages, dolphins and flooded forests. Finding time to reflect and share our reflections—both positive and challenging—is vital to help ensure students avoid feeling overwhelmed, get a chance to voice their hardships or worries, and perhaps find the courage to be vulnerable and authentic in expressing their experience.

I aimed to facilitate a daily mindfulness practice through intentional silence, reflective journaling, or both. These purposeful, contemplative pauses enabled students to consider what they've seen and heard, and to integrate these experiences into their learning. In addition, having circle check-ins (either at the start and end of class, or in the morning and at dinner while in Colombia) provided further opportunity for expression and reflection.

"If you give students a safe and supportive space to share, it's amazing what they will express…The cracks are opening, and the light is getting in. Even the quiet students are laughing and animated. The anxious are sharing their beds with cockroaches. The complacent are seeing the world not only through new eyes, but through a complete embodiment of experience" (May 15, 2017). The porous realm of Amazonia has a way of getting under the skin, and bringing the hidden to the surface.

My IDEA classes begin with a few minutes of silence. Circle check-ins allow all voices to be heard, and varying perspectives and ideas to be acknowledged and perhaps incorporated into the current class. For example, one student spoke to their anxiety about presenting that day, and felt the need to take some deep breaths. After this suggestion,

everyone stood up to engage in a collective breathing practice. Other student suggestions to stretch and roll our shoulders were also enacted.

Figure 8.3. The permeable nature of the Amazon.
Credit: Taken by Lee Beavington, 2017.

Whether in the Amazon or a conventional classroom, a contemplative, holistic approach (Miller, 2000) imbues the learning environment with whole person pedagogy. It recognizes each person as unique, harbouring their own fears, worries, talents and daring. When students are allowed to show up as themselves, they can surprise even the most skeptical teacher with their wisdom and heart.

8.6. Bird Language (Nature as Teacher)

"I learn from nature first, people second" (May, 2015).

What does Nature as Teacher mean? This is where students, instead of learning *about* nature via textbooks or otherwise, learn *from* or *with* nature. It often requires place-based, experiential approaches. That is, learning that happens (a) at the actual site of the

phenomenon under study (e.g., learning about intertidal ecology while at the beach during a low tide) and (b) by using the senses to directly engage with the phenomenon (e.g., inspecting algae with your hands or turning over rocks to find barnacles, crabs and limpets).

For nature to be a teacher or co-teacher, other important conditions may include becoming familiar with the site, careful attunement of the senses, being quiet long enough to hear the forest speak, and indigenous knowledge. The lattermost point is relevant because many indigenous ways of knowing are animistic; they listen for teachings from the natural world, hold reverence for nature's wisdom, consider nature to be a subject rather than an object (Mathews, 2008), and give a voice to the more-than-human.

On that birthday trek, "[s]lurping mud on my boots, humid leaf exhalations, rain-soaked fronds, shadows of the canopy, screeching red-throated caracara, roots in 5 meters of water (yet still alive), clothes plastered to skin, drips of the cut water vine on my tongue" (May 18, 2014), we were startled by a terrible scream from above. The sound repeated like a crow on steroids. We were too close to the nest of the red-throated caracara, a large black-feathered bird of prey that becomes raucous when its territory is trespassed.

Listening to this constant screech, we located her near the top of the canopy. I never saw the caracara, but to this day I still remember her cry. Bird language, for those who know how to listen, can reveal everything from place and time to species identification, nest location and even the whereabouts and potential danger of an approaching predator.

Whether teaching biology or expressive arts, and in the Amazon rainforest or the temperate rainforests that I call home in British Columbia, I regularly take students into the forest or other local ecosystems. I facilitate activities that open and attune our awareness, such as 'Expanding our Senses: Animal Senses' from *Coyote's Guide to Connecting with Nature* (Young et al., 2010). I provide space for them to simply listen and notice the pockets of wonder surrounding them. I have them explore the ecosystem and bring back subjects to discuss (e.g., leaves, twigs, insects, fruit, moss, lichen, stones, etc.). They hold these nature subjects in their hand, and in a circle speak to what they

notice about their subject, what it could symbolize, and how it might be connected to other subjects.

Nature is filled with wisdom evolved over billions of years. There are other intelligences we are just beginning to hear, though many Indigenous peoples have long-standing relationships with such other-than-human voices. Even when teaching indoor-based courses, the wonder of nature can be evoked through storytelling, poetry, and other creative modalities.

8.7. A Poetic Conclusion

The sun set on my 38th birthday as we paddled back to Calanoa. Being on River Amazonas was a peak life experience. I hope this reverence spilled over to students. “My greatest moment of wonder, when Diego said: ‘You can use this paddle, if you want.’ And so I paddled through the forests flooded by the Amazon River, floating through tropical canopy, spotting monkeys (woolly and howler) leaping from branch to branch, stumbling upon a fishing grey dolphin, watching the moonrise and her (his?) perfect light reflecting in the water, and of course gliding through the tunnels of trees, eliciting such unfathomable awe not even a poem will capture (though I will undoubtedly try)” (May 30, 2015).

And here is my attempt, as written in the Amazon on May 12, 2017:

> The paddle is in my hands. The meanders of Matamata reflect the heavens above. Squirrel monkeys provide a sideshow. But the River is the flood of wonder.
>
> The paddle is in my hands. Treetops dip into the water’s surface. We navigate through a tunnel of foliage. A forest river. A verdant archway. A leaf-lined corridor.
>
> The paddle is in my hands. Pink clouds betray the sun’s departure. The current is the sky is the stars. Golden light turns a thousand shades of green even more brilliant.
>
> The paddle is in my hands. Each curve of the creek reveals the truth of who we are. Every bend a reminder of life’s meaning. My pores open to all existence.

The paddle is in my hands. The water holds a memory of time and blood and the pulse of Amazonia. This is the wonder that does not sleep.

The paddle is in my hands.

Figure 8.4. Paddling through the flooded Amazon forests.
Credit: Taken by Lee Beavington, 2017.

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References

Abram, D. (2011). *Becoming animal: An earthly cosmology.* Random House of Canada.

Amazon Interdisciplinary Field School. http://www.kpu.ca/amazon-interdisciplinary-field-school

Calanoa Project. http://www.calanoaamazonas.com/philosophy.html

Mathews, M. (2008). Thinking from within the calyx of nature. *Environmental Values*, *17,* 41–65.

Miller, R. (2000). *Caring for new life: Essays on holistic education.* Foundation for Educational Renewal.

Young, J., Haas, E., & McGown, E. (2010). *Coyote's guide to connecting with nature* (2nd ed.). OWLLink Media.

PART V – FRUIT AND SEEDS

Wild Research and Five Seeds for Ecocentric Education

Asleep within the seed the power lies,
Foreshadowed pattern, folded in the shell

A germ begins to burgeon here and there,
As nature welds her ring of ageless power

~Goethe

Chapter 9.

Becoming a Wild Researcher Through Goethean Science, Indigenous Philosophy, and Creative Response

9.1. Preamble

Continuing from the previous chapter's introduction of nature as teacher, Chapter 9 examines this idea, and nature as co-researcher, in further depth. This chapter also braids together many topics and narratives previously explored in this thesis, including Goethean science, arts-based learning, and 'Offerings on the Mountain.' The common ground with Indigenous philosophy is more carefully considered. I also incorporate reflections on my overall doctoral scholarship, including how I represented my more-than-human co-researchers, was inspired by specific places, and explored the implications for the natural world. ✺

9.2. Introduction to Wild Pedagogies

Near the end of the book, *Wild Pedagogies: Touchstones for Re-Negotiating Education and the Environment in the Anthropocene*, Sean Blenkinsop poses eight questions in relation to nature as co-teacher, nature as co-researcher, and just representation of the natural world. These questions ponder more-than-human methodologies, community-based research methods, positionality of the natural world, embedded anthropocentricism, and research implications for the natural world. Wild pedagogies is a project and concept that explores multiple theories and practices used in teaching that, although often framed through ecological and environmental education, are likely relevant across the curriculum. Wild pedagogues aim to reclaim and reimagine (Jickling et al., 2018) an educational system toward intentional praxis less reliant on quantifiable learning outcomes, with a move toward active, "self-willed pedagogy" (p. 161) with an agential nature as co-teacher. This bold enterprise is "a challenge to dominant cultural ideas about control—of each other, of nature, of education, and of learning" (p. 161).

In similar fashion, this reflective and conceptual essay aims to challenge the dominant culture in regards to biological pedagogy and scholarship. I will consider lab-based science that is ecocentric, which requires a reassessment of current animal dissection and experimentation practices. How can we transform science education through the lenses of deep ecology and philosophical posthumanism? How might Goethean science complement Newtonian science? What does it mean to be a wild researcher? The importance of place-based education and Indigenous perspectives are considered, particularly in relation to teaching and research in the life sciences. All of these considerations are threaded through with Wild Pedagogies' "relevance of learning *with* rather than *about* the natural world" (p. 164). By answering the eight questions put forth in the *Wild Pedagogies* book, I hope to contribute to the ongoing dialogue of ecological and environmental education during the Anthropocene, especially in regards to the life sciences and the often unquestioned use of nonhuman animals in science teaching and research.

9.3. Eight Questions on Being a Wild Researcher

1. How does the natural world ask and answer its own questions? What are its accepted methodologies?

Does a corpse plant that blooms once every seven years ask when it is time to flower? Does the grizzly bear ask the winter frost when to hibernate? Does the river ask how long it must flow to reach the ocean? Perhaps such more-than-human customs do not require questions, but are so intimately familiar, more deeply ingrained than DNA, that the answers are provided without question. These answers are carried in the pheromones of *Amorphophallus titanum*, the reflections of nascent ice, and the salmon depositing her eggs in gravel beds. Do humans, and their presumptive free will, possess similar instinctual responses? If so, our walls, screens, and sheltered lives serve to erode such instincts.

The idea of the natural world asking questions and giving answers suggests anthropomorphism, though this assumes questions and answers are the purview of humans. The question above is an effort to disentangle conventional research practices

and “to push against troublesome cultural norms, become activists, build rich communities, and engage with the natural world in different ways” (Crex Crex Collective, 2018a, p. 127). In addition, some evidence suggests that anthropomorphic behaviour leads to higher levels of environmental guilt, and thus to greater environmental behaviours and actions (Tam, 2019), helping foster human-nature relationships.

The methodologies of the natural world show inherent transdisciplinarity. No organism can survive in isolation. Being transdisciplinary means discovering hidden connections, thinking laterally, being engaged in social responsibility, not compartmentalizing, with no separation of subject and object (Bernstein, 2015). Think of Douglas-fir, roots entangled in mycorrhizal soil, stretching outward to connect with other species, tended by the voracious earthworm, which feeds the robin, whose nest rests in Douglas-fir. The more we study how trees interact, the more we realize that each tree is inseparable from the forest.

While the top-down, reductionist approach of experimental biology offers much toward medical research and discerning life’s building blocks, the natural world is principled on much larger webs of relationships. The mechanistic and atomistic approach of Newtonian science deconstructs and deanimates. Thomas Berry (1999) puts it this way: “The world of mechanism has alienated us from the wild beauty of the world about us” (p. 54). The Renaissance man Johann Wolfgang von Goethe offers an alternative approach.

Goethean science, being reciprocal, creative, utterly interrelated, and eliminating the subject-object orientation, fully embraces ecological thinking, and thus bears some kinship with the methodologies of the natural world. Second, is Carl Leggo’s (2005) notion of “living poetically” (p. 178).

During the question period after his “The Sustainability of Everything” presentation, as part of the SFU President’s Dream Colloquium on *Creative Ecologies*, Tim Ingold (2019) declared that we need to “ground our science in poetry.” As both a scientist who writes poetry, and a poet who teaches science with poetry, this statement intrigued my tendency toward interdisciplinarity. But what, exactly, did he mean? Does

grounding science in poetry refer to Earth-centering our science? Literally, grounding, as in fully inhabiting the land? Perhaps Ingold meant something akin to Carl Leggo's statement of "living poetically." That is, to be still, to love, and feel the presence of the world through a visceral connection mediated by the senses.

Poetry offers something evocative, sensorial, relational, and often provokes mystery and wonder. Is this what the modern empirical sciences need? A return to something more Romantic, that parallels the kinds of methods that the natural world might use? Before William Whewell coined the term scientist (to be inclusive of the polymath Mary Somerville), they were called "men of science" or natural philosophers. Goethe, Margaret Cavendish, and Alexander von Humboldt are examples of natural philosophers that engaged concurrently in art, science and philosophy. Today, specialization and compartmentalized knowledge has endangered polymaths, at a time when interdisciplinarity is especially needed to address complex issues such as the climate crisis and the COVID-19 pandemic.

Poetry has a way of building connective tissue among seemingly divergent phenomena. Scientist-poet Jacob Bronowski (1956) called this "the exploration of a hidden likeness" (p. 16), and stipulated "We re-make nature by the act of discovery, in the poem or in the theorem" (p. 20), and perhaps here we can start to see the benefit to science and its oft-siloed disciplines.

The scientific method, applied in the natural sciences, by its own impartial mandate does not engage in a reciprocal relationship with the object of study. In fact, everything the life sciences study must, in essence, be dead: in order to study life, to limit variables, bias, and incorporate controls, you must constrain and de-humanize (or de-animize) the specimen of interest. The social sciences have methodologies, such as multi-species ethnography (Rose, 2017), that provide agency to nonhumans; biology does not. One hundred million rats and mice are used annually in medical experiments in the United States alone (Kopnina, 2017). The lab rat may not be killed (although very often they are), but it will be isolated so extensively from its natural environment that

essentially the rat no longer possesses an animate life beyond its instrumental value. In training to be a biologist—that is, the study of life—you learn to kill what you love.

This is why I refuse to do dissections, both as a post-secondary student and as a lab instructor. Conservationist and professor Aldo Leopold (2013) lamented the fact that by the mid-1900s biology students were no longer learning on and about the land, but were instead "taught to carve cats" (p. 414), and how "the living animal is virtually omitted from the present system of zoological education" (p. 413). Cultivation of moral responsibility for the land has slowly been dismissed, while the wonder for animals that brought many biology students to this study is chiseled away by the scalpel.

In his "The Sustainability of Everything" talk, where Ingold (2019) elaborated on mutualistic engagement with our surroundings, he claimed not to be anti-science, although he certainly expressed reservations toward the current scientific enterprise being "bamboozled by numbers" with "totalitarian impulses". From an anthropologist's perspective, he is clearly frustrated with current scientific practice, and, given the chance, I suspect he would argue for a closer marriage of philosophy and the natural sciences.

Biologists claim that the use of nonhuman animals is absolutely essential to increase our understanding of the human animal, especially in regards to medical breakthroughs. E.g., we can and do reduce human suffering considerably by experimenting on nonhumans. Yet I can't help but see parallels with the climate crisis. We exploit and abuse the planet extensively for human benefit, and are increasingly recognizing the cost of this enterprise. For environmentalists and eco-philosophers, it is becoming more and more difficult to justify harming what is *not* human for the strict benefit of what *is* human. Classical libertarianism and traditional western thought affirm human exceptionalism, where humans, as the most important beings on the planet, can utilize and exploit the nonhuman world as fits their perceived needs. In similar fashion, the life sciences and industrial-capitalist enterprises pave over (sometimes literally) nonhuman considerations as a matter of course. Moral extensionism (Singer, 1975) and deep ecology (Naess, 2008) broaden the moral umbrella, granting rights and values to nonhuman life.

An ecocentric methodology, where the mutual flourishing off all beings is recognized, would cause less harm to nonhumans, yet also requires humans to take and use less. Indigenous scholar and botanist Robin Wall Kimmerer (2013a) points to this paradox: our "need to resolve the inescapable tension between honoring life around us and taking it in order to live is part of being human" (p. 177). A carnivore must kill in order to live, yet top-down predators can support biodiversity through trophic cascades that prevent the overaccumulation of certain species, such as sea stars preying on mussels. If humans were top level predators, then we might claim it's our responsibility to kill in order to conserve. However, our trophic level status is on par with pigs and anchovies, meaning we eat more plants than meat (Bonhommeau, 2013). By this scale, humans are not apex predators, but low-level omnivores.

Ingold spoke to needing a science that is "modest, humble and attentive." The word 'modest' suggests that the scientific view of the world is only one of many. Empirical science is not the one, correct path to investigate the world, but rather one method of procuring useful, semi-objective (or partially impartial) knowledge that can be integrated with other ways of knowing that might include reciprocity, empathy and relationality, as do many Indigenous cultures, leading us toward a moral pluralism.

Next, we have 'humble,' being the diametric opposite of arrogant, suggesting the idea that science sees itself—along with humans—at the top of the intelligence heap. In his paper, "Designing Environments for Life," Ingold (2013) speaks of scientific (high-status) knowledge and inhabitant (low-status) knowledge, which "occupy two poles in a hierarchy of power" (p. 236) with the former clearly at the top, and a unilateral top-down flow. This hierarchy places scientific knowledge above land-based or Indigenous wisdom, and such laddering can lead to condescension, discrimination, or—far worse—cultural genocide. The word humble actually has origins in the Latin word *humus*, meaning earth. It seems Ingold is asking science to be grounded with and of the earth.

Goethean science, which involves prolonged looking and deep empathy, is an antidote to reductionist-mechanistic Newtonian science. Certainly modern science often involves a type of prolonged looking, as some studies take decades to complete. Yet

Goethe points to a reciprocal relationship with the subject of study, whereby the observer (i.e., scientist) also learns from the subject through creative response and philosophical engagement (Beavington & Bai, 2018; Landman-Reiner, 2020). There is an opportunity here for other-than-human players to be given agency, to become co-researchers, with understandings and points of view that differ from that of humans. Further, could we take our scientific and artistic sensibilities into the natural world, and turn these towards answering the questions that nature's community deemed important?

This brings us to Ingold's final and third word, 'attentive.' We can be attentive by considering the impacts of our actions, through metacognition, mindfulness practice, and a fierce sense of wonder. Such attentiveness speaks to shifting from "a world that can be occupied, but not inhabited" (Ingold, 2013, p. 242) toward seeing the world as "a conversation of life itself" (2018, p. 158). Natural science takes place in this world, and therefore should reconsider a return to its foundational focus: the humus from whence we all arrived.

2. How do/did/might I engage with other-than-humans and represent them in my/our work?

In July, 2016, I engaged in a sacred mountain journey among the North Cascades. Facilitated by PeerSpirit Wilderness Quests, this intentional journey involved several days of human connection and preparation—through discussions, writings, and reflections—and then venturing to a solo spot for two days without food. The other-than-humans were my neighbours, my confidants, my annoyances, my mentors. These encounters deepened my understanding of place-based, holistic learning where the natural world informs your experience. Later, I connected this to the wild pedagogies' "premise that an important part of education can include intentional activities that provide a fertile field for personal and purposeful experience without controlling the environment and its actors, the learners, or the outcomes" (Jickling et al., 2018, p. 161).

I learned, slowly, sometimes stubbornly, to listen to the burrs that stuck to my prayer flags (and held them in place), the patience of ponderosa, the dandelion seeds lifting my awe into the sky. They are represented through my eyes, yet with an understanding that, although I cannot wholly comprehend their umwelt (coined by Jakob

Von Uexküll, meaning unique sensory world of an organism), I still endeavour to see them fully with my mind and with my heart. Sometimes, I attempt to relay, perhaps anthropomorphically, the world through another's eyes; this often takes the form of poetry, whose language facilitates metaphor, relationality, and a window to other worldviews. An excerpt from my poem, Riversong, serves as an example.

> on my son's muscled tongue
> wildspeech floods back
> strider's flicking limbs
> trout's pulsing gills
> cedar scales measure each breath
> the murmuration of spirit
> the sound of stone
>
> holds
>
> one hundred years in a heartbeat
> (Beavington, 2018, pp. 328–329)

In life science education, there are two forms of engagement with other-than-humans: field- and lab-based. Field-based studies in the Romantic era, inspired by natural philosophy, included observations, drawings, and specimen collection. Modern field biology, with its shift toward quantitative research, includes (though is not limited to) population estimation, ice core analysis, ecosystem mapping, and invasive species management.

Laboratory biology is frequently microscopic or molecular in focus: gene mapping, chromatography, and cell culture, to name only a few. Of course, the *original* source of this research stems from the natural world, such as DNA samples, animals for dissection, and fetal bovine serum. Laboratory settings are controlled, hold sensitive equipment, and can mitigate confounding variables.

This environment frequently reduces the subject of study to individual building blocks, and then attempts to understand how they fit together in the larger whole. As developmental biologist Scott Gilbert puts it, "once gene theory took over, it became a

biology of things" (as cited in Cepelewicz, 2020, A verb not a noun section, para. 7). The laboratory setting is built to examine nouns: objects, things, items of interest whose ethical consideration is often signed off on a perfunctory form. Yet Gilbert also acknowledged a shift, in that "Twenty-first-century biology is a biology of processes." This new approach, however, remains typically Western: a theoretical foundation for biology that starts "by formalizing the concept of the individual according to a set of principles and measurements" (Cepelewicz, 2020, para. 10). The emphasis is clear: the individual, and the quantifiable. This is troublesome, since it leads to representing other-than-humans as facts and figures, or bits and bytes.

In terms of other-than-human representation, numbers and statistics based on empirical and evidence-based research, of obvious import for objective scientific study, are nevertheless reductive and atomistic, offering a less authentic truth to other-than-human identities. Pickering and Kara (2017) argue that the inordinate focus on details (where natural sciences excel) can limit ethical engagement, since "traditional methods of presentation may sacrifice some scope for engagement and accessibility in return for greater detail and depth" (p. 299). The choice "between 'literal' (empirical, evidence-based) and 'real' (authentic, experiential) truths" (p. 299) has led some researchers to creative representations, such as poetry. They further contend the importance of situational ethical decisions, where ethical engagement occurs throughout the research relationship, "rather than long after extractive encounters" (p. 299).

In engaging and representing other-than-humans, creative responses can avoid portrayals limited to static figures and tables. Interdisciplinary studies that integrate the natural/quantitative and social/qualitative sciences (sometimes referred to as the 'hard' and 'soft' sciences, with the latter often less dehumanizing), might better acknowledge other-than-human preferences and viewpoints. As Kimmerer (2016) reflects, "The data may change our minds, but we need poetry to change our hearts" (p. 48).

The original form of scientific inquiry, such as Darwin's observation of finches or the polymath Alexander von Humboldt's study of biogeography, typically brought scientific instruments into the outdoors. Such scientific enterprise is now referred to as

natural history, often with a derogatory mindset of not being 'real science,' which has led to "the rise of the modern sciences [where] we began to think of the universe as a collection of objects rather than as a communion of subjects" (Berry, 1999, p. 16). GIS has replaced sketches, and ANOVA has supplanted direct experience. If we crunch the numbers long enough, we will get to the truth, leading from the philosophical postulate that everything can be measured and quantified.

With the exception of ecology, my university experience emphasized lab-based science. I recall pithed turtles placed before us in dissection trays, their hearts still beating while their brains were presumably dead. As a scientist-in-training, I needed to turn off my sentiment, and focus on the electrocardiograph readout of a heart that would run its end by the end of the lab period. As Kimmerer (2013a) contends "Science can be a language of distance which reduces a being to its working parts; it is a language of objects" (p. 49). To get through this lab—scientifically and emotionally—I needed to see the turtle as an object.

As a poet, I immerse myself in wildscape for inspiration. The words that come forth are an honouring of the turtle, a wondering of their way of being in the world. Like Mary Oliver (2016), I seek to offer my voice to the more-than-human.

> I would therefore write a kind of elemental poetry that doesn't just avoid indoors but doesn't even see the doors that lead inward—to laboratories, to textbooks, to knowledge. I would not talk about the wind, and the oak tree, and the leaf on the oak tree, but on their behalf. (p. 153)

On their behalf, I offer poetic words. In hopes of a new relationality, one that recognizes the turtle's intrinsic worth, and being worthy of life. My writing is not only reflective and creative, it is an active process of engaging thought into action, "an act of reciprocity with the world" (Kimmerer, 2013a, p. 152). To more fully represent other-than-humans in my work, there is a need for a multivocal plurality and a reflexive "ethics of engagement" (Pickering & Kara, 2017), which both place-based learning and poetic inquiry afford, though there is the trap of falling into hubris and exploitation. In my poem, Aristotle's Lantern, I attempt to enter the *umwelt* of the urchin:

she nurtures the nocturnal intertides
her roving dome an outward panopticon
perhaps this urchin is a philosopher
with senses no mammal possesses
in phase with every rippled wave
(Beavington, 2017, p. 161)

How did the study of life lead us so far from life itself? When I was instructing the Amazon Field School, immersed in entangled threads of lianas and ceiba trees, artist Diego Samper explained, "You can't learn much about life from something that is dead" (personal communication, May 11, 2017). In the place these words were spoken, the maloka (traditional long house of Colombian Indigenous peoples), where plants are considered important beings, and the rocks and rivers are considered animate (nonetheless outside the purview of modern biology), Samper's statement rang especially true. Within a relational ontology, the voice of this place gave credence to his words, and commanded our attention.

Yet whether it's dissection, vivisection, cell culture, or developmental biology (grow chicks and kill them at various early life stages to see how they *would* have developed, had we not killed them) modern biology has firmly shifted its focus from the holistic natural world to molecular, genetic, and laboratory-based study. Thomas Berry (1999) states it bluntly: "As now functioning, the university prepares students for their role in extending human dominion over the natural world, not for intimate presence to the natural world" (p. 73).

3. Where is the natural world positioned in my research? To what and whose end?

In a way, the natural world is the bedrock for my scholarship. Only through direct experience in outdoor environments, such as river walking Elgin Creek during a salmon spawn or hiking to melting glaciers in Norway, did much of my philosophy develop and crystallize. By example, paddling the Amazon River or watching a sea urchin's five-jawed mouth close down on seaweed prey were two wonders that seeded poems. Goethean prolonged looking and deep empathy have the potential to clarify language use and cultivate shifts in perceptual frameworks. Where I once saw the urchin as an

organism for scientific study, I now have a wider-eyed view of the world (much like the urchin's radial symmetry) that considers the mutual flourishing of all that surrounds me. This means my life decisions incorporate the harm and benefits to *all* members of my community. By example, both the origins of purchased items (e.g., where an item was made, how far it travelled, was it produced ethically), and also any future ramifications (e.g., waste produced, environmental damage, accelerated climate change) must be considered.

At this juncture, a few words on 'experience' and its being "grounded in Euro-North American epistemologies" (Fox, 2008, p. 39) bear importance. In the Western notion of experiential education, experience often centers on a linear, individualistic conception. In response, this demands a reflexive approach, examining the Eurocentric "privileged subjective experience" (p. 44) and how it can neglect the cultural, social and political environs in which they are embedded. As Fox elucidates, we should "nourish a practice that is attentive to and accountable for power relationships" (p. 52).

Much of my research begins with place. Of particular concern is cultural appropriation and honouring the traditional lands where lived experienced might occur. In this regard, learning, acknowledging, and reconciling the historical, geographical, ecological and ancestral histories are necessary. For me, outdoor sites serve: as research locations, a habitat to dwell with other-than-humans, and to more fully embody my own relationship with the natural world. In this way, nature has the potential to become a co-teacher and co-researcher.

For nature to be a co-researcher, where the voices of the land are recognized, we must "consider research subjects more as partners not objects and hence, come to practice, present, and understand research differently" (Crex Crex Collective, 2018a, p. 127). Nonhuman co-authors, such as the bonobo apes that provided input on their welfare in captive environments (Savage-Rumbaugh et al., 2007) offer one example. (I can't help but note that APA style requires me to omit the names of the bonobos from the in-text citation, so I present them here: Kanzi, Panbanisha, and Nyota.) Similarly, my research explores nature as a co-researcher where other-than-human voices are heard and

considered, yet also stretches beyond primates—or even domain Eukarya—to include natural ecosystems and wilder places. To avoid simply hearing the voice you want requires intentional immersion in these places, reflection and metacognition around deeply entrenched colonial-cultural beliefs, and acts of reconciliation. My response to question eight further addresses disappearing into one's own thinking.

The purpose of my doctoral research is to promote a philosophical shift toward an environmental ethic for educators and scientists. Through intentional outdoor experiences that integrate science, art and philosophy, the objective is contemplative practice that results in a deeper sense of time, creativity, and ecology. I strive toward authentic listening to the more-than-human (Beavington, 2021), ending animal cruelty in scientific labs (over 115 million vertebrates 'used' in experiments annually), and rekindling a sense of the sacred. This must begin with the land, inspired by ideas (respectfully, with appropriate context and acknowledgement) such as Leanne Simpson's 'land as pedagogy.' I elaborate on this in my response to question six.

As a European-settler-colonialist, I acknowledge that part of my research goals are to garner scholarships, complete a PhD, and be afforded new hiring opportunities. I try to balance these more self-centred motives with a contemplative approach that is mindful of my impact on other-than-humans and humans alike, which can lead into informed action.

4. Have I tried to represent my findings in a way that does justice to the contributions of others?

Have I done justice to the contributions of others? I hope so.

My gratitude is not limited to human scholars; in fact, the more-than-human world contributes immensely, not only to knowledge and experience, but also to our mental, physical, creative and spiritual well-being. For me, the land is the ultimate source of the sacred, and I cannot begin to comprehend how much I do not know. But I *can* honour the teachings afforded to me by the meanders of wild rivers, the spring fiddleheads, and the "epistemic mess" (Lehrer, 2010) that are clouds. When we represent our findings, we can attempt to do so in a manner that both honours the inspiration and recognizes that we

cannot give a full voice to any person, animal, plant or other entity—we can offer only glimpses into their universe, and trust that our portrayals and interpretations are reasonably authentic. I am certain there are times I have failed in this regard. I try to be confident and transparent in this uncertainty.

Given the above, I feel galvanized to honour such places by naming them. I acknowledge the walks in Tynehead Park and the old growth stumps that serve as reminders of what has been lost. I acknowledge the spawning salmon in the urban Elgin Creek that reveal the amazing ecological resiliency that humans keep stretching to the limit and beyond. I acknowledge the dock (built by Diego Samper; see Figure 10.1) at Calanoa that hovers over the Amazon River, Earth's grandest artery through which pink dolphins glide. I acknowledge Georgina Point, that corners onto Active Pass and the Salish Sea, from which I have watched a pod of orcas sail past, made the decision to buy our new family home on Mayne Island, and seen my children scramble among the seaweed-encrusted rocks at low tide. My sincere hope is for the stories of the stumps, the spawning, and the seaweeds to be shared, heard, and recognized as not only important, but part of an ongoing dialogue for the betterment and conservation of those other-than-humans that still remain.

Figure 9.1. The Calanoa dock (left) over the Amazon River, and Georgina Point Lighthouse (right) on Mayne Island, places that informed and deepened my scholarship.
Credit: Taken by Lee Beavington, 2017 (left photo) and 2019 (right).

Beyond these first important steps of acknowledgement and gratitude, doing justice to the colonized, marginalized, consistently voiceless, deeply oppressed position

of the more-than-human world in Canadian culture demands more. We need to question and deconstruct these paradigms and find new paths forward with ecological integrity and multi-species narratives. Teaching and research that are inclusive of the natural world is further considered later in this paper.

5. In what ways did I enter and engage with research locations? Might there be room in community-based research methods to include more-than-human communities as full members?

My primary research locations (see Figure 10.2) were the forest, the river, and the ocean. Often, I did not enter such locations—usually returning to specific sites—with the intent of pursuing scholarship. Rather, the peeling arbutus bark, unexpected stream riffles, or rollicking otter family attuned my focus. From this attentive state revealed communities of patterns that sparked both active wonder and sedulous philosophizing. As poet Mary Oliver (2016) mused, "All the questions that the spider's curious life made me ask, I know I can find answered in some book of knowledge, of which there are many. But the palace of knowledge is different from the palace of discovery" (p. 125). I don't agree that all answers can be found in books, which Oliver herself alludes to at the beginning of her poem, What Can I Say:

> What can I say that I have not said before?
> So I'll say it again.
> The leaf has a song in it.
> Stone is the face of patience.
> Inside the river there is an unfinishable story
> and you are somewhere in it
> and it will never end until all ends.

Whether for a walking colloquium, teaching a field school, or a personal contemplative sojourn, my place-based research was largely serendipitous. This certainly diverts from the scientific method, specifically as taught in first-year biology, and the proposal of a specific hypothesis to test experimentally. Of course, hard-nosed lab-based scientists might say my research isn't really research (since it's not quantitative). They might say these research sites aren't really research sites, because I could have done this research anywhere (since the human brain is the only real researcher, and so it doesn't

matter where the human brain is located). They will say that 'business as usual' needs to continue, if we are to cure cancer (requiring animal experimentation) and solve the climate crisis. Ironically, this same line of thought has contributed to the climate crisis. It is our disregard for the other-than-human world that is drastically affecting the climate, habitats, pollution and biodiversity. I myself wrestle with flying to the Amazon so a small group of students can (hopefully) become more worldly citizens. Climate scientists take ice core samples, store them in freezer farms, and expend tremendous time and energy garnering climate science data *while exacerbating the climate crisis* (Mattern, 2017). When quantifiable knowledge is prized above all else, the repercussions are considered a kind of unavoidable collateral damage.

Such scientific critiques of my research are valid, within the realm of Cartesian-Newtonian science. Yet neither my research, nor my scientific pursuits, are interested in being encapsulated within a single lens. The blend of quantitative and qualitative, objective and subjective, lab and field are exactly what are needed to fully understand the impacts of, and possible resolutions for, the current climate crisis and COVID-19 pandemic. Sound qualitative research is fundamental to sound science, and "makes it possible for humans to produce and to understand science, in a manner that withstands logical and empirical scrutiny [and] solidifies the arch of knowledge" (Sale & Thielke, 2018, 132–133), while advocating multi-narratives and relevant world matters. As Leopold (2006), who himself engaged in careful and rigorous fieldwork, scathingly wrote in regards to the natural sciences, "Science has no respect for the land as a community of organisms" (pp. 277–278). Lab-based quantitative science has its place; my hope is for such research to be more fully informed by ethics, philosophy, and holistic points of view.

What might this look like? Ecofeminist and science studies scholar Donna Haraway recognizes the importance of an interdisciplinary biology, integrated "with many other communities of practice, made up of entangled humans and others, living and not" (as cited in Gane, 2006, p. 133). She devotes a chapter to lab animals in her book, *When Species Meet* (2007). While acknowledging that suffering and killing can be justified in experimental animal labs for the greater good, Haraway also claims we need

to do more than limit cruelty in labs. We need to question lab inequalities, wrestle with moral discomfort, avoid taxonomic hierarchy, and even become active contributors to the research process with multimodal, decolonizing, multispecies studies. Somewhat contradictorily, she supports banning many types of experiments on apes, and certain other animal species. Both nonhumans and humans are subjects, and neither should be strictly objectified or oppressed. She asks, "How can the multispecies labor practices of the lab be less deadly, less painful, and freer for all the workers?" (2007, p. 77) and "What happens if experimental animals are not mechanical substitutes but significantly unfree partners, whose differences and similarities to human beings, to one another, and to other organisms are crucial to the work of the lab[?]" (p. 72). However, the anthropocentric lab environment renders this acutely problematic. As Haraway's colleague Sharon Ghamari-Tabrizi wrote,

> In the lab, not only is the relationship unequal and asymmetrical; it is wholly framed and justified, legitimated, and meaningful within the rationalist materials of early modern humanism. Why? Because it is conditioned on the human ability to capture, breed, manipulate, and compel animals to live, behave, die within its apparatus. (p. 86)

Haraway's justification of the use of nonhuman animals in experiments is not surprising, since biological scientists (Haraway has a PhD in biology) are trained in the utilitarian use of nonhuman animals. The removal of animal experimentation is on par with grounding airlines to mitigate climate change or shutting down factory farms for meat production. That is, it's a paradigm shift that requires re-evaluating our fundamental beliefs and redesigning our deeply ingrained cultural practices. Haraway (2016) does offer a vision for humankind's distant future: "Humus-friendly technological innovation, creative rituals and celebrations, profound economic restructuring, reconfiguration of political control, demilitarization, and sustained work for connecting corridors and for ecological, cultural, and political restoration" (p. 160).

Many Indigenous approaches to teaching and biology research would likely condemn animal experimentation. For Kimmerer (2013a), as both a celebrated botanist and a member of the Citizen Potawatomi Nation, her science training privileged mind and body, yet omitted emotion and spirit. While she appreciates that "science polishes the gift

of seeing" (p. 48), she had to eschew her worldview where plants were "teachers and companions to whom I was linked with mutual responsibility" (p. 42), supplanting her native language with the scientific. We might consider the questions Kimmerer (2013b) poses regarding scientific inquiry being guided by Indigenous philosophy, including: "Have all the research subjects, human and non-human, given their permission to be investigated?" (p. 68).

The Cree and Ojibwa of northern Ontario view animals "as persons in their own right and are treated accordingly" (Driben et al., 1997, p. 101), respecting wildlife "not on scientific-commercial considerations, but rather on spiritual, cosmological, and ethical ones" (p. 102). Nonhumans and humans are governed by the same ethics. Kymlicka and Donaldson (2015) suggest that some aboriginal groups denounce the instrumental view of animal species. Being "agents capable of co-authoring human-animal relations" (p. 166), any teaching or research done with nonhumans should be holistic in nature, in native habitats without suffering or killing. If we engaged in Goethean science, a delicate empiricism seen as a conversation with nature (Holdrege & Talbott, 2010), we might ask "Am I causing too much harm?" or "Have I violated this other?" Deep listening is needed, since the answer may be heard in the gentlest of whispers.

Elgin Creek (Fig. 9.2) is one of my embodied research sites, facilitating encounters that inspired creative thought and response. Could Elgin Creek be a full member of my research team? I'm not sure. This creek certainly provided me with "data" to write and publish. Yet how might they give consent? Or is my role, as the bipedal naked ape, to ensure their membership is inclusive, honoured, and voiced? And how might speaking for the other happen without colonial-hierarchical overtures? Perhaps the edges of my still colonized scientific mind are showing.

Figure 9.2. Examples of research locations and several of my wild co-researchers. Sword fern, bigleaf maple, *Sphagnum* moss, Graham Creek in Central Saanich (left), and Elgin Creek in South Surrey (right), British Columbia.

Credit: Taken by Lee Beavington, 2020 (left) and 2019 (right).

Kimmerer (2013a) invites settlers to look to our plant teachers. Common plantain is a foreign species now—like colonialists—naturalized in Canada. As Kimmerer explains, "Being naturalized to place means to live as if this is the land that feeds you…Here you will give your gifts and meet your responsibilities" (pp. 214–215). Plantain coexists with natives, and even heals wounds, teaching us to be adaptable, respectful, and propagate "a vibrant and vital ecosystem of multi-species, multimodal inter-workings" (Stinson et al., 2020, p. 9). As a settler, I need to situate myself in relation to the environment, and even consider "not doing certain types of research" (p. 13) such as unconsented animal experimentation, species sampling, fieldwork that scars the land, and other extractive and exploitative methodologies. Les Convivialistes (2014), a group of French-speaking scholars that published The Convivialist Manifesto: A Declaration of Interdependence, declared that "Human beings can no longer view themselves as proprietors and masters of nature" (p. 32). Instead, we need to recognize our embeddedness with nature, honour the land and its inhabitants, and pursue ecological justice by reciprocating with the natural world.

Ecology science defines a community as multiple species interacting—via interspecific interactions, food webs, and energy flow—within a particular habitat. As the science of relationships, ecology follows threads of connection that, for instance, connect sunlight, to licorice fern, to aphids, to dragonfly, to belted kingfisher, to soil microbes.

The species that make up this community are always researching each other: sensing, consuming, flowing radiant energy into chemical bond energy into thermal energy, and co-evolving into future generations.

Such research can be intrusive through predation and pathogens. One species of fungal spore spears itself into a single conifer leaf cell. This tiny spore waits until the leaf host dies, meaning five years pass before the maturation and release of new spores (Luoma, 2006). There is a reluctance to harm its host. In fact, this fungus will attack defoliating insects, thus *protecting* the tree. Similarly, moss also acts as a forest steward, offering resiliency to ecosystems through an amazing ability to cling to water: holding excess water during flood, and slowly releasing this surplus during drought. This research is informed by sunlight and shadow, written in tree rings and soil horizons, and characterized by interspecies interaction. The answers are not found through numbers and statistics, but through transmutation and reciprocal transformation.

As a human researcher, we might learn from this fungus and moss, to create human ecosystems that are inherently resilient (almost certainly requiring collaboration with other-than-humans), and how to inhabit the patience of a fungal spore. Suzanne Simard's (1997) research into ectomycorrhizal tree species, or the wood wide web, offers another fungi-inspired lesson. She and her team, armed with carbon isotopes, discovered that birch trees actually contribute nutrients to their neighbouring Douglas-fir through underground fungal partnerships. The prior belief, that birch trees competitively removed resources, meant they were weeded out by foresters. As Robert Macfarlane (2019) puts it, there was a shift "from a fierce free market to something more like a community with a socialist system of resource redistribution" (p. 91). Yet where is the voice of, and research by, the trees? I suspect this exists outside the realm of isotopes and microscopes, enmeshed in a sensory-scape beyond the purview of Western thinking.

I began reading *Ecology of Wisdom*, featuring the writings of Arne Naess, shortly before I hiked to his cabin, Tvergastein, near Ustaoset in Norway. For Naess, I imagine this place was very much a co-researcher. For without Tvergastein, there would likely be no deep ecology; or at least, in a different place, his environment-infused philosophical

thought would have birthed an alternate version. If Naess were in the Gulf Islands off the west coast of Canada, perhaps his deep ecology would embrace the oral storytelling of Coast Salish peoples, or represent the western red cedar's seemingly immortal stature as part of his ecology of wisdom.

6. Where is my research maintaining anthropocentric forms?

Like a root-riven driveway, my research, at times, subconsciously tries to roll everything flat. The terminal goal of my doctoral studies at SFU is to obtain a PhD credential. What's more anthropocentric than these three letters? Leanne Simpson (2017) speaks of an "ecology of intimacy" (p. 8) based on connective relationships without oppression where we "Privilege the relationship over the tool" (personal communication, Oct. 17, 2019). As an Indigenous academic, she promotes "land as pedagogy" and laments the weeks where she spends sixty hours staring at a screen. Western culture prizes academic products such as publications and presentations. As I build up my academic CV, I can't help but feel that the most meaningful and important experiences—namely, gardening, nature attunement and perhaps something akin to "friluftsliv," the Norwegian spiritual practice of 'free air life'—have no place. To de-anthropize the PhD process would require less screens, less walls, less writing, and an embodied, relational, intimate ecology that both works with, and in service of, the biotic community.

Camping alone next to a ponderosa pine, or hearing the quiet cedars punctuated by a raven wings' sharp downstroke deeply inform my personhood, scholarship and pedagogy. They help me slow down, listen deeply, dispense with conventional thought, and rethink ways to privilege the co-created role of all of my relations in teaching and research. These moments offer an avenue toward thinking outside the (literal) box of the classroom and the academy. Yet the academy leaves no quarter for the spiritual. Simpson (2017) explains something akin to my process: "Meaning, then, is derived not through content or data or even theory in a Western context, which by nature is decontextualized knowledge, but through a compassionate web of interdependent relationships" (p. 156). How do computer screens and grey-walled classrooms fit into this compassionate web? Or do they fit at all? I imagine a community-minded, interspecies collaboration whose

knowledge is stirred from land-based Indigenous languages such as ceremony, music, storytelling and dance.

Initial drafts of some of my thesis chapters argued for shifts in worldview, in regards to the environment, because of the benefits wrought by humankind. Colleagues pointed out this anthropocentric view, and I had to decide: could I justify my arguments where the reward for treating the world with care was for the welfare and betterment of *Homo sapiens?* My answer was no: this was not enough, since the industrial-exploitative model can strip the world of its natural resources by way of this argument. Any anthropocentrism, no matter how enlightened, leads us toward choosing humans first in the short-term, no matter the long-term cost. Put more clearly by Curry (2011), "That is what anthropocentrism offers the rest of nature: more or less enlightened, and more or less efficient, slavery" (p. 220). Eliminating anthropocentrism is, admittedly, a daunting enterprise. But to be a non-anthropocentric human is to breathe breathable air, drink unpolluted streams, and step on soil free of pesticide and radioactive waste.

7. What are the implications of this research for the natural world?

To reference Tim Ingold again, my research aims to be "modest, humble, and attentive." I do not declare my research to offer absolutes, nor do I expect conventional scientists to suddenly abandon, overnight, dissection and vivisection as pedagogical and research methodologies. What I *do* hope for is an opening to wonder, both verb and noun. Wonder at the world's beauty, and to wonder at a science education where all life holds intrinsic value, that is "valuing something not for its utility or instrumental value to us, but for its own existential integrity and legitimacy of right to *be for itself"* (Bai & Scutt, 2009, p. 95). What would science education and research look like through a more contemplative, honouring and reciprocal lens?

Recently, an excited co-worker told me they were attaching electrodes to cockroaches in the animal physiology lab. The purpose was for students, by use of their phones, to control (and therefore study) the movements of these arthropods (Stojnić, 2017). I could not help but think of this as a microcosmic vision of how humans view and treat the planet, where "Every aspect of life has been absorbed into the commercial-

industrial context" (Berry, 1999, p. 109). Human industry and desire, led by economic demand and lacking a reverence for the land, results in extensive fossil fuel extraction. This is how Royal Dutch Shell, Imperial Metals and Fortune Minerals can propose to mine and extract methane from the Sacred Headwaters in the Rocky Mountains of British Columbia (Davis, 2011). These salmon-bearing headwaters of the Stikine, the Skeena, and the Nass Rivers, are found within a mountain range home to the world's single greatest population of stone sheep. The companies proposed to "frack the coal seams by massive injunctions of 350,000 gallons of benzene and diesel injected like a hypodermic syringe into the very meadows that give birth to the salmon rivers" (TEDx, 2011, 7:11).

Pause for a moment to let this sink in. These proposals were made by people who, at the time, had *never visited* the Sacred Headwaters. The Earth, in this view, is an object for exploitation. This is certainly exacerbated by the fact that this land is settled land. As Berry (1999) states "To the European settlers the continent had no sacred dimension" (p. 45). Furthering this idea, he adds "Reduction of the Earth to an object primarily for human possession and use is unthinkable in most traditional cultures" (p. 61). This explains why Indigenous peoples who live on and with these lands successfully blockaded access to the Sacred Headwaters.

Even the commercial industry may recognize that, through mining, fracking, and extracting we are increasing atmospheric carbon dioxide concentrations, polluting waterways, and facilitating species extinction. But this is justified in order to fulfil our human wants. If the aforementioned cockroaches with electrodes attached are a synecdoche for the climate crisis, then we need to find a way to study and care for *all living things and their ecosystems* with compassion and respect, requiring, for many, a significant shift in lifestyle. This can start by buying less, buying local, growing your own food, and living in smaller homes. On a larger scale, corporatocracy, oligarchy, technocapitalism, and giant agribusinesses—which make the aforementioned near impossible for many citizens—need to be acknowledged as our inheritance and then deconstructed, and from this humus or compost (as Haraway might call it) can emerge a diversely ecological, intermutual, communal, interspecies society.

Our current trajectory leads to massive species extinction and ecosystem collapse. To prevent this, we need to embrace an ethics of care for all living beings. Not because an "entangled empathy" (Gruen, 2014) that fosters collective care for all species and environments is in *our* best interest, but because an ecocentric vision, where all life possesses inherent value, is the clearest path forward that conserves the collective ecological integrity. Humans need to balance the benefit of enhancing natural ecosystems—increased biodiversity, healthier environments, mitigating climate change—with necessitated sacrifices—decreased consumerism, tempered wealth, and sharing habitat. Though habitat sharing can ultimately be rewarding for nonhumans and humans, such as the dual benefit garnered by selective harvesting of sweetgrass (Kimmerer, 2013a).

For the lab cockroach, the value given to this animal by science relates to its ability to be an educational and/or research tool. The Cartesian worldview is a "campaign to portray animals as merely objects or, rather, quasi-mechanics" (Curry, 2011, p. 78). If there is any innate value offered the cockroach, it is superseded by our human need. Whether lab cockroach or planet Earth, Western science and the industrial-exploitative model seeks to control, manipulate, and extract what we want from the more-than-human world. Our species benefits, many others suffer. Whether we are attaching electrodes to cockroaches, or fracking in sacred headwaters, our purpose remains penetrative, damaging, and entirely anthropocentric.

Now, at this point, some might say: it's a cockroach. Why should we care about a cockroach? My response: if we can find a way to regard a cockroach with respect and compassion, then the human species may have a chance at tackling the climate crisis. Further to this, "any educational conception and delivery that results in inculcation into present cultural norms"—such as a de-animated Earth and science that is competitive, individualistic, and dualistic—"…will do nothing to change the current trajectory nor prepare learners for the new reality" (Crex Crex Collective, 2018b, p. 59). Western culture pushes pipelines through Indigenous lands and fragile coastal waters. Education that questions cultural norms, is quiet long enough to hear other-than-human voices, and reflects on our environmental impacts are vital. Whether we are in a sixth mass extinction

event, or simply eradicating biodiversity (conservative estimates put species extinction rates at 100 times higher than natural background rates; Ceballos et al., 2015) the industrial-exploitative model is not sustainable. An education system that maintains the status quo upholds this destructive paradigm.

The implications of my research are to facilitate creative, place-based experiences in the natural world. My hope? To nurture an environmental ethic with my learners through "deep immersion, careful listening, and respect for the other-than-humans inhabiting the[se] shared communities" (Crex Crex Collective, 2018c, p. 32) and the inclusion of activities led by curiosity and interdisciplinary exploration rather than prescriptive outcomes. When you come to know a place, undergo intentional and contemplative appreciation for and with an ecosystem, and bear witness to and understand the interdependent ecological processes that shape and inform such a community, there is a greater capacity for empathy and ecoliteracy.

8. How do I deal with what seems to be the researcher's paradox—balancing being present and listening to the other-than-human against disappearing into my own thinking?

The scientific researcher listens, in a way, to their subjects. In biology, this might be mediated via a microscope, electrophoresis gel, or even the human ear. Data is collected, collated, perhaps run through a chi-square test, and presented with bias squeezed out of the process as much as humanly possible (i.e., some invariably lingers). There is little doubt that scientific researchers are present to their subjects, certainly in a rational-reductionist-analytic manner. This garners sound empirical science. Yet this Newtonian approach has carved itself out of naturalism, based on reason but omitting "the kinds of question that most urgently need asking, questions of meaning, value and justice" (Curry, 2011, p. 27). Do they really hear the heart of the other-than-human? As Kimmerer (2016) states, "We need to listen to the land, not merely for data, but for wisdom" (p. 49).

Trained to view the world through specific lenses (scientific, photographic, poetic, philosophical), pushing these lenses aside is not only difficult, it might very well be impossible. Two methods I employ to get past my brain are stillness and movement: (a)

entering a more contemplative state—through breathing exercises, visualization, or meditation—or (b) embodying the experience more fully through off-trail exploration or other tricky terrain, where my heightened senses focus on navigation, a steady handhold, the slick of algae.

I am human. This I cannot escape. My brain is conditioned to frame the world certain ways, my neurons stretched by how I was schooled, mediated by the media, and cultured in an industrial-exploitative society. Recognizing how my beliefs have been contained, constrained and confined—inspired by undergraduate philosophy courses and people that challenged dominant cultural norms—was my first step toward negating conventions that actually oppose my principles. How do we recondition? Teaching for critical thinking and independent thought is a start, yet we must also step outside the consumeristic, technocratic, dominant culture that equates economic gain with happiness. Try walking into a forest.

Mindfulness practice, such as a sit spot, allows us to reflect on meaning, priority, and values. During my sacred mountain journey, I often fell into my own thinking. What time is it? Am I being productive enough? What makes ponderosa pine bark so orange? Most humans cannot turn this off. But what we *can* do is linger in a place long enough, so that we start to sink into its folds and furrows. Attune to the other-than-human world, leaf by leaf, ant by ant, noting climatic rhythms and circadian visitors. Mary Oliver (2016) speaks to the "unsolvable disharmony of such work—the mind so hotly fired and the body so long quiescent" (p. 157–158). When a place inspired a poem, can I know how much I served as vessel for the natural world, and how much was stirred forth from human memory? "We are first of all creatures of motion," Oliver (2016) says, pointing to our animality and need to search for food, shelter, and other sustenance. Yet we are also inherently creative. "The dancer dances, the painter dips and lifts and lays on the oils, the composer reaches at least across the octaves. The poet sits" (p. 157). This might explain how contemplative inquiry and poetic inquiry contextualize and deepen my scholarly research. Poetry can offer new metaphors for the more-than-human world as we cultivate new orientations and genuine engagement with other species and ecosystems. From this stillness, this work "will come sooner or later to revolution, will demand action!" (p.

157–158). Put another way, contemplation and creativity are directly tied to informed action, and this is what our current geopolitical climate demands of us.

References

Bai, H., & Scutt, G. (2009). Touching the Earth with the heart of enlightened mind: The Buddhist practice of mindfulness for environmental education. *Canadian Journal of Environmental Education, 14*, 92–106.

Beavington, L. (2017.) Aristotle's lantern. In Y. Blomer (Ed.). *Refugium: Poems for the Pacific* (p. 161). Caitlin Press.

Beavington, L. (2018). Riversong, *Ecopsychology*, *10*(4), 328–329. https://doi.org/10.1089/eco.2018.0035

Beavington, L. (2021). Bird language and contemplative education in the Anthropocene. *Fusion Journal*, *19*, 53-63.

Beavington, L., & Bai, H. (2018). Science education in the key of gentle empiricism. In L. Bryan & K. Tobin (Eds.), *13 questions: Reframing education's conversation – Science* (pp. 473–484). Peter Lang.

Bernstein, J. H. (2015). Transdisciplinarity: A review of its origins, development, and current issues. *Journal of Research Practice, 11*(1). http://jrp.icaap.org/index.php/jrp/article/view/510/412

Berry, T. (1999). *The great work: Our way into the future*. Three Rivers Press.

Bonhommeau, S. Dubroca, L., Le Pape, O. Barde, J., Kaplan, D. M., Chassot, E., & Nieblas, A-E. (2013). Eating up the world's food web and the human trophic level. *Proceedings of the National Academy of Sciences*, *110*(51), 20617–20620. https://doi.org/10.1073/pnas.1305827110

Bronowski, J. (1956/1972). *Science and human values.* Harper and Row Publishers.

Ceballos, G., Ehrlich, P., Barnosky, A., García, A., Pringle, R., & Palmer, T. (2015). Accelerated modern human-induced species losses: Entering the sixth mass extinction. *Science Advances*, *1*(5), e1400253. https://doi.org/10.1126/sciadv.1400253

Cepelewicz, J. (2020, July 16). What is an individual? Biology seeks clues in information theory. *Quanta Magazine.* https://www.quantamagazine.org/what-is-an-individual-biology-seeks-clues-in-information-theory-20200716

Crex Crex Collective. (2018a). Afterwords. In B. Jickling, S. Blenkinsop, N. Timmerman, & M. De Danan Sitka-Sage (Eds.), *Wild pedagogies: Touchstones for re-negotiating education and the environment in the Anthropocene* (pp. 109–131). Palgrave Macmillan.

Crex Crex Collective. (2018b). On the Anthropocene. In B. Jickling, S. Blenkinsop, N. Timmerman, & M. De Danan Sitka-Sage (Eds.), *Wild pedagogies: Touchstones for re-negotiating education and the environment in the Anthropocene* (pp. 51–62). Palgrave Macmillan.

Crex Crex Collective. (2018c). On wilderness. In B. Jickling, S. Blenkinsop, N. Timmerman, & M. De Danan Sitka-Sage (Eds.), *Wild pedagogies: Touchstones for re-negotiating education and the environment in the Anthropocene* (pp. 23–50). Palgrave Macmillan.

Curry, P. (2011). *Ecological ethics: An introduction*. Polity Press.

Davis, W. (2011). *Sacred headwaters*. Greystone Books.

Driben, P., Auger, D., Doob, A., & Auger, R. (1997). No killing ground: Aboriginal law governing the killing of wildlife among the Cree and Ojibwa of northern Ontario. *Ayaaggwaamizin: The International Journal of Indigenous Philosophy, 1*, 91–108.

Fox, K. (2008). Rethinking experience: What do we mean by this word "experience"? *Journal of Experiential Education, 31*(1), 36–54.

Gane, N. (2006). When we have never been human, what is to be done? *Theory, Culture and Society, 23*(7–8), 135–158. https://doi.org/10.1177/0263276406069228

Gruen, L. (2014). *Entangled empathy*. Lantern Books.

Haraway, D. J. (2007). *When species meet*. University of Minnesota Press.

Haraway, D. J. (2016). *Staying with the trouble: Making kin in the Chthulucene*. Duke University.

Holdrege, C., & Talbott, S. (2010). *Beyond biotechnology: The barren promise of genetic engineering.* The University Press of Kentucky.

Ingold, T. (2013). *Designing environments for life*. In K. Hastrup (Ed.), *Anthropology and nature* (pp. 233–246). Routledge.

Ingold, T. (2018). One world anthropology. *HAU: Journal of Ethnographic Theory, 8*(1–2), 158–171.

Ingold, T. (2019, September 26). *The sustainability of everything* [Video file]. YouTube. https://youtu.be/2EX1r8vJ8_Q

Jickling, B., Blenkinsop, S., Morse, M., & Jensen, A. (2018). Wild pedagogies: Six initial touchstones for early childhood environmental educators. *Australian Journal of Environmental Education, 34*(2), 159–171. http://dx.doi.org/10.1017/aee.2018.19

Kimmerer, R. W. (2013a). *Braiding sweetgrass: Indigenous wisdom, scientific knowledge, and the teachings of plants.* Milkweed Editions.

Kimmerer, R. W. (2013b). The fortress, the river and the garden. In A. Kulnieks, D. R. Longboat, & K. Young (Eds.), *Contemporary studies in environmental and indigenous pedagogies* (pp. 49–76). Sense Publishers. https://doi.org/10.1007/978-94-6209-293-8_4

Kimmerer, R. W. (2016). Interview with a watershed. In N. Brodie, C. Goodrich, & F. J. Swanson (Eds.), *Forest under story: Creative inquiry in an old-growth forest* (pp. 41–51). University of Washington Press.

Kopnina, H. (2017). Beyond multispecies ethnography: Engaging with violence and animal rights in anthropology. *Critique of Anthropology*, *37*(3), 333–357. https://doi.org/10.1177/0308275X17723973

Kymlicka, W., & Donaldson, S. (2015). Animal rights and aboriginal rights. In P. Sankoff, V. Black, & K. Sykes (Eds.), *Canadian Perspectives on Animals and the Law* (pp. 159–86). Irwin Law.

Landman-Reiner, A. (2020). Complementing reductionism: Goethean science part 1: Qualities and wholeness. *EXPLORE: The Journal of Science & Healing*, 1–6. https://doi.org/10.1016/j.explore.2020.02.015

Leggo, C. (2005). Pedagogy of the heart: Ruminations on living poetically. *Journal of Educational Thought, 39*(2), 175–195.

Lehrer, J. (2010). Breaking things down to particles blinds scientists to big picture. Wired.com. https://www.wired.com/2010/04/st-essay-particles

Leopold, A. (2006). On a monument to the pigeon. In C. D. Meine & R. I. Knight (Eds.), *The essential Aldo Leopold* (pp. 277–278). University of Wisconsin Press.

Leopold, A. (2013). Natural history, the forgotten science. In C. Meine (Ed.), *A Sand County Almanac and other writings on ecology and conservation* (pp. 411–415). Library of America.

Les Convivialistes. (2014). Convivialist manifesto: A declaration of interdependence. *Global Dialogues*, *78*(3). doi:10.14282/2198-0411-GD-3

Luoma, J. (2006). *The hidden forest: The biography of an ecosystem.* Oregon State University Press.

Macfarlane, R. (2019). *Underland: A deep time journey*. Hamish Hamilton.

Mattern, S. (2017). The big data of ice, rocks, soils, and sediments, *Places Journal.* https://doi.org/10.22269/171107

Næss, A. (2008). *Ecology of wisdom: Writings by Arne Næss*. Counterpoint.

Oliver, M. (2016). *Upstream: Selected essays*. Penguin Books.

Pickering, L., & Kara, H. (2017). Presenting and representing others: Towards an ethics of engagement. *International Journal of Social Research Methodology*, *20*(3), 299–309. https://doi.org/10.1080/13645579.2017.1287875

Sale, J. E. M., & Thielke, S. (2018). Qualitative research is a fundamental scientific process. *Journal of Clinical Epidemiology*, *102*, 129–133. https://doi.org/10.1016/j.jclinepi.2018.04.024

Savage-Rumbaugh, S., Wamba, K., Wamba, P., & Wamba, N. (2007). Welfare of apes in captive environments: Comments on, and by, a specific group of apes. *Journal of Applied Animal Welfare Science*, *10*(1), 7–19. https://doi.org/10.1080/10888700701277261

Simard, S., Perry, D., Jones, M., Myrold, D., Durall, D., & Molina, R. (1997). Net transfer of carbon between ectomycorrhizal tree species in the field. *Nature, 388*, 579–582. https://doi-org.proxy.lib.sfu.ca/10.1038/41557

Simpson, L. B. (2017). *As we have always done: Indigenous freedom through radical resistance.* University of Minnesota Press.

Singer, P. (1975). *Animal liberation: A new ethics for our treatment of animals*. New York Review.

Stinson, M., Grimwood, B., & Caton, K. (2020). Becoming common plantain: Metaphor, settler responsibility, and decolonizing tourism. *Journal of Sustainable Tourism*, 1–19. https://doi.org/10.1080/09669582.2020.1734605

Stojnić, A. (2017). Only cyborgs and cockroaches. *Performance Research: Turning Animal, 22*(2), 123–128.

Tam, K. (2019). Anthropomorphism of nature, environmental guilt, and pro-environmental behavior. *Sustainability*, *11*(19), 5430. https://doi.org/10.3390/su11195430

TEDx. (2011, April 23). *Wade Davis: The sacred headwaters* [Video]. YouTube. https://www.youtube.com/watch?v=BGzDNfMumYU

Chapter 10.

Planting Seeds for Ecocentric Education

10.1. Preamble

When I began my PhD journey, my wife offered a provocation: engage in scholarship at the opposite end of the research spectrum. I accepted this challenge as I knew it would diversify my thinking. When one way of knowing is reinforced again and again, it is hard to escape this singular lens. My undergraduate studies in biology centered on the scientific method: measurable, testable, replicable, with an objective approach. The natural progression from this would be sitting in a controlled lab, counting fruit flies, or sequencing DNA, or dissecting octopuses, or putting electrodes on cockroaches. Control, dichotomize, restrain, manipulate, quantify.

When my graduate studies commenced, I did not appreciate the method or merit of qualitative research. But my natural wonder led me into the biotic landscape, where the confounding variables served as inspiration rather than as sources of error. The mountain offered seeds of scholarship, the forest a lucid clarity amidst an entangled web of animacy, the river carried away my jumble of preconceptions, and the ocean brought me back to center. These were my study sites, the places of 'data' collection, analysis, interpretation, and provocation. My environment was not fixed or standardized, but dynamic, free-form, polymorphous and kaleidoscopic. As a result, I developed expansive hypotheses instead of testing narrow ones. I was stretched into thinking what research can be, what teaching in science can be, and questioned my species' role in all of this. While the empirical and quantifiable methodology on which I was raised serves a vital purpose for climatic, medical, and myriad other scientific study, I started to ask questions outside the purview of science, in order to comprehend how science could be done differently and more ethically.

Of course, there was also human discourse, interaction, and pedagogy, for which I hold deep gratitude. Though even here, the most relevant and resonant experiences

occurred in the natural world. In writing this final chapter of my thesis, I struggled to discern how to gather and synthesize all that had come before, while living through social and environmental injustice. My mind stuck on the screen, and my heart deflated by world events, I ventured down the road to find some peace. Knowing that nature helps to ground me, I walked the perimeter of Edith Point on Mayne Island. In this embodied state, my thoughts and feelings swirled in a maelstrom of despair.

It took a long time to settle into presence, to get out of my head and back into the body's wisdom. A shorebird murmuration animated the sandstone. The company of long-legged plovers darted forward on the coastline, stopped, and then darted again. As I watched this flock skitter across the intertidal to feed, dancing with the sun glitter, I felt a shift. A sense of something larger than myself, an opening and relaxing into being, a slowing down to listen to—and share in this research with—the other-than-humans in this place.

Yet there was more to this experience than being grounded, attuned, and aware. We've had millions of years for the natural world to stimulate and evolve our multi-sensory awareness. Being amongst the thick trees or rocky shoreline rarely fails to snap me into attention. This enlivenment is recognizable to many wilderness-goers. What enlivens us? The pollen-infused wind, the song-language of birds, the rife photosynthesis, and the interrelation of all of these. Sitting indoors, thinking into a screen, I fell into the habitual anthropocentric way of being, forgetting the voice of the natural world. This disregard and neglect of animate nature, a closing down of the holistic world, can be construed as a kind of violence. To ignore our community, and not listen to the voices of the natural world (as when using fetal bovine serum or doing vivisection in a science lab) is a complicity in their suffering.

As I neared the final point, I caught movement. Below me, a body emerged from the ocean. The seal heaved herself onto the rocky shore, her grey skin glistening as she transitioned between worlds. A mossy seat called to me (Fig. 10.1). For a long time, I did what might seem like nothing to a neutral observer. I remained still and aware. A hollow croak rang out from the highest crag of branch overhead. I listened to this raven call for

minutes on end, a voice that compelled me to simply be. Then an eagle screeched in the distance, and the raven gave a final guttural cry before taking flight. He circled above me once, twice, and a third time, black wings like the dark side of the moon, and then vanished.

Figure 10.1. Co-researcher location where the author outlined the concluding chapter of this thesis.
Credit: Taken by Lee Beavington, 2021.

Sitting on that ridge of root and moss, with the ocean lapping her waters onto the shore below, the ideas started to pour forth onto the page. I became the interpreter and recorder. The downstroke of the raven's wings called for recognition. Why was this sound, like a thunder in my heart, one that I failed to hear for most of my life? What human constructs kept getting in the way?

In many ways, this thesis was a collaboration with the natural world. This final chapter gathers the ideas herein, and offers five seeds for the reader to carry forward on their journey. Finally, the limitations of this work are addressed.

10.2. Five Seeds

The interdisciplinary nature of our scholarship aims to provide an alternative framework for science education that integrates ecological science, poetic inquiry, place-based learning, and holistic education. This thesis is an exercise in contemplative, interdisciplinary, and philosophical conceptualization. This experiment in métissage, a literary-photographic-reflective investigation, is framed around ecological science education. It is my hope that the experimental nature of this methodology, especially in relation to science, may encourage others to engage in less conventional approaches, decenter the human, and consider other-than-human members as co-researchers. We need to move beyond non-contextual facts to holistic understanding, ecological literacy and informed citizenship. When learners master self-determination, critical reflexivity and the ability for active experimentation, they are, perhaps, more likely to become free thinkers, effective leaders, and change makers.

Below I offer tangible seeds for the reader to take and plant in their own thinking and practice. A way to frame our pedagogy through a pluralistic lens grown from a humus rich with poetry, embodiment, and ecology, rooted to the land, and anchored by ethics leading to right thought, speech and action. At the end of each 'seed' are two examples of how to implement the ecocentric concept in question for teachers, researchers, and learning strategists in post-secondary contexts. These examples are assumed to take place in the future, and therefore sometimes reference past events that (in 2021) have yet to occur. This assumption avoids the restraints of the current pedagogical paradigm for university science education (e.g., cognitive focussed, heavy content load, largely lab-based) and allows for future possibilities that may not be feasible under the current educational system. Tertiary schooling is the focus here because (a) this is the primary realm of my pedagogical practice, and (b) the literature for science education in post-secondary, as discussed in the Introduction, trails behind the K-12 scholarship.

The pedagogical goal, a biology of subjects, can be framed as a mutualistic relationship, like lichen's tangle of multi-species life, where diverse "knowledge systems retain their unique identities and intellectual sovereignty as distinctive species of

knowledge" (Kimmerer, 2013, p. 64). Both the scientist and the subject of study are agential knowledge-bearers. The "direct participatory relationship between observer and observed" (Kimmerer, 2012, p. 321) bears some kinship to Goethean science, which encourages exact sense perception and imagination, including creative engagement. Rather than having a narrowly-framed hypothesis, we engage in a conversation with nature, a science that "entails 'mutual interaction' with the phenomena" (Holdrege & Talbott, 2010, p. 206).

Anthropocentric to Ecocentric Science Education

What would a shift from anthropocentric to ecocentric science education look like in practice? First, learners would be outdoors as much as possible. The very walls of a classroom or lab desensitize us to the natural world, prioritize book-learning and sterility, and limit sense engagement, embodiment, and relationships with anything other than humans and confined nonhumans, and thereby continue the inculcation of dominant cultural norms. Even in writing this, I am called to go outside. Staring at a screen, downloading and scouring research articles, and typing digital words confine me to my visual mind. An anthropocentric world can be lived through data bits, YouTube videos, and hermetically sealed labs. An ecocentric world is lived with lichen-clad boulders, bird language, and the clouds that gift rain, snow and shade. Ecocentric science education engages and includes the natural world as co-researchers, leaving space for their myriad voices.

Second, the learning community would include other-than-human members. The local fauna and flora would be equal members (given prominent roles, inherent respect, and a decision-making voice) in learning and research. This entails practices that go against current emphases on technology and (especially in tertiary schooling) heavy content loads (Petersen et al., 2020) for students. The latter is a common complaint from first-year biology students. When cognitive overload is consistently reached there is no time to reflect on the *how* and *why* of learning. Metacognition is important for effective learning (questioning how we study, and which strategies serve us best to acquire and synthesize knowledge), yet metacognition is equally important for effective ethical

considerations (questioning why and through what methods we are studying something, particularly in relation to working with live organisms, and which methods best serve collective ecological wellbeing). Regular contemplative and sensorial practice, and learning fewer topics in more depth, would facilitate the consideration of more-than-human ethics, human-nature interactions, and deeper inquiries into student selected topics.

Bringing animals, plants, or other species or beings into ecocentric education and research requires mutual consent and active listening. We must hold silence, lest our noise pollution cast a sound shadow over the other-than-humans we hope to engage. Genuine co-creation becomes possible only when we are attuned, responsive, and empathic toward the other.

Example 1: You are a learning strategist. A student arrives for an appointment to address concerns regarding study strategies for biology, procrastination, and inability to focus. You take them outside to the trees next to the courtyard, and have them sit in awareness for five minutes, not speaking. The student fidgets at first, her hand repeatedly going to the phone in her pocket. Then she hears the trill, c*hickadee-dee-dee.* Once, twice, a third time. The small bird, habituated to campus life, appears from the underbrush and approaches her. The student reaches out an open hand. The bird cocks his head, jumps side-to-side, and then flits away. After a long pause, I ask the student about her studies. What biology topics has she covered so far? She mentions taxonomy, levels of organization, and the properties that define being alive. I invite the student to use the chickadee as her ally in her studies. How is the chickadee classified? How does he fit into the hierarchy of biological organization? What qualities make him alive, according to science? For this student, this location becomes a site of restoration, reflection, and co-created learning.

Example 2: You are an Ecology instructor. You introduce the Ecology and Colour in $1m^2$ study (Beavington et al., in-press). Students choose an outdoor site, close to home, where they make repeated visits with a contemplative focus that engages different senses (Haskell, 2020). Future visits (meditations might be a better word) include astute

observation, creative response, and reflective journaling. Students begin to ask questions and focus their inquiry on specific animal and plant species. Fine art students are engaged in the same practice through a colour theory lens. The science and art students collaborate, sharing their findings and asking questions of each other. Ecology students write up detailed reports on the species they directly engaged with, and incorporate photos, drawings, paintings and other media. They also consider human-nature dynamics, such as environmental damage, invasive species, and Indigenous philosophies. An interdisciplinary celebration for both sets of students is held at the end of the semester.

University Science with Goethe and Leopold

Let's imagine an alternate path for science, beginning with German scientist-artist Goethe. If the conscious-process-participation of Goethean science were the primary methodology, and the objective-reductionist-atomistic Newtonian secondary, where might we be today? Our scientific approach would involve deep listening to the subjects under reciprocal study, fuller acknowledgement of bias, preconceptions, and other-than-human members, and both creative and contemplative engagement. With a moral responsibility developed toward the subject both studied and studied by, vivisection would rarely (if ever) be practiced, the temporal nature of phenomena (perhaps including past and future environmental crises) would be emphasized, and there wouldn't be articles in the preeminent journal Nature titled "Best way to kill lab animals sought" (Cressey, 2013) or "How to kill wild animals humanely for conservation" (Marris, 2017).

Conversely, the analytical and molecular sciences would be impeded, since participatory Goethean science is difficult to apply here. Medical studies might not be as far advanced, since the current usage of at least 115 million vertebrates a year (Taylor et al., 2008) would not pass moral standards. Humans would need to sacrifice certain privileges and assumed entitlements, such as animal experimentation, but perhaps also fossil fuels, hydroelectric dams, factory farms, and air travel; a subject worthy of its own thesis. An organization like The Society for Humane Science would govern the use (and eradication) of animals in scientific teaching and research, chiefly for ethical

consideration, but also because “cost, efficiency, and the need for swifter and more accurate predictions” (Taylor, 2019) are afforded by many non-animal alternatives.

Continuing down this path, we meet Aldo Leopold, and his six principles of learning (Beavington et al., in-press; Meine, 2015). He promotes cultivating perception, tangible experience, independent judgement, integrating disciplines, sound communication, and linking ethics with science. This blends well with delicate empiricism. Both encourage heightened sense perception, critical thinking, integrated science, and offer the subject of study animacy. What Leopold adds is a sense of place, and recognition that humans and the land should be governed by similar ethics.

The vital need of environmental education requires land and ecology-based pedagogy. Whether studying business, design, economics, engineering or philosophy, the place becomes the center of learning. Through contemplative practice that brings us into presence with the land, the confidence to learn and teach with compassion and empathy, and leading from the heart as well as the mind, we can shift toward an ecocentric worldview. What might examples of this phenomenological, participatory, place-based approach that considers the temporal nature of phenomena (as Goethe did) look like in today’s post-secondary institution where cognitive learning dominates?

Example 1: You are teaching animal behaviour. For their research project, students are invited to explore their local environment, and use sight, sound, and scent to encounter neighbours with whom they share their community. Animals receptive to interaction (robins at dawn, earthworms after rain, squirrels tightrope-walking power lines) are invited to co-research a topic. When consent is given (what this looks like will be highly variable, but always involves a daily mutual agreement between human and other-than-human that the process can proceed), students write down and reflect upon their current state of mind, prejudices, and subjectivities. The other-than-human community helps generate research questions, and inquiry occurs through exact sense perception, exact sensorial imagination, seeing is beholding, and being one with the object (see Chapter 5). They draw the subject’s behaviour as imagined in the past, present and future, and learn from and about our own human behaviours based on this

experience. No animal is harmed in this process, and students generate ideas for how to best honour and reciprocate to the biotic community for their co-participation.

Example 2: As a histologist (a cell biologist who researches microscopic tissue structure), you want to prepare slides of cephalopod tissue. A deceased giant Pacific octopus, accidentally caught by a fishing vessel, is donated to your lab. You cut cross and longitudinal tissue sections. After processing, infiltrating, embedding and microtoming the specimens, the final slides are stained and viewed through the microscope, and you realize that you also want a female specimen. You consider breeding octopuses in the lab, but reject this upon recognition of their intelligence and inherent rights. Next, you arrange a trip to this octopus species' habitat (fortunately, close to home in the Pacific Northwest). After extended time diving in this octopus's world, noting the ecological relations of the kelp forest, and the extraordinary hardships and adaptations to survive to reproductive age required by this octopus (which you were previously aware of mentally, but not emotionally) you decide not to proceed with this research. Instead, you decide to become the world's first place-based ecophysiologist.

Science and Art

Interdisciplinary pedagogy provides more relevant and meaningful learning, enhances higher-order thinking, and "expands the explanatory capacity of knowledge" (You, 2017, p. 72). In addition, bias and ethical considerations become more recognizable. In practice, deeply embedded divisions between disciplines can make interdisciplinary collaborations difficult. Technology, engineering, history, politics, and industry are more obvious disciplines to integrate with science, yet the creative arts—painting, drama, music, film and poetry—are equally important collaborators. Creativity is pivotal for strong art *and* strong science.

Mathematician Ada Lovelace wrote poetry, and poet John Keats was a surgeon. Poetry is steeped in metaphor that invites "conceptual blending" (Fredriksson & Pelger, 2020). Poetry also facilitates language play. More-than-human ethics involves finding new words, definitions, and images to describe and represent beings that are not human,

and help loosen or reject colonialist-hierarchical baggage. For instance, the words *it, thing,* and *object* can be replaced with *kin, being,* and *subject.*

Ecopoetry is not enough. Romanticizing the natural world can elicit wonder in the poet and reader, but deeds are needed beyond the words. Biology and other scientific disciplines are siloed and "decontextualized from a social milieu" (Aikenhead, 1997). The arts offer a bridge for public communication and decision-making, and avoids the "scientific nominalizations and the frequent use of passive voice" (Nichols & Petzold, 2021) that can impede public interest and understanding.

Some experiences and ideas are difficult to convey, such as the often spiritual feeling of forest bathing, or mycorrhizal fungi linking the wood wide web. Artistic response is a way to express the ineffable and seemingly divergent concepts. Nutrient cycling and energy flow—two core ecological concepts—can be brought to life through drawing, painting, or other creative modalities. In addition, "there is considerable evidence that exercising creativity through poetry writing, reading, or speaking can develop, maintain, and enhance empathic and innovation skills" (Januchowski-Hartley et al., 2018), vital for today's scientist engaged in cross-curricular and biodiversity research. Poetic science (or scientific poetry) is an invitation to incubate ideas, rethink methodologies and results, and acknowledge and act ethically upon feelings and emotions that might arise during scientific investigation.

Example 1: You are teaching a genetics lab. To prepare for their first lab, students are asked to draw, embody, or creatively visualize the lab procedure. For their second lab, students write a found poem, using only words and phrases included in the lab writeup. Students post these before lab time, and the lab instructor (or students) read out a few examples. They note any new meanings or cross-pollinations and how this might influence their approach to today's lab (or science in general). Later in the semester, students write poetry to help them remember difficult terminology, the fruit fly life cycle (performed as a rap; this was actually done by one of my students!), and complex procedures such as polymerase chain reaction. Students reflect weekly on their lab work,

journaling to express their mind, body, heart and/or spirit. Any challenges or concerns, such as discomfort with certain lab procedures, are seriously considered and addressed.

Example 2: You are researching the genetic bottleneck in cheetahs. Every paper you publish includes a poem. The first paper starts with a found poem, crafted using specific phrases pulled from the paper. The second paper has an acrostic poem that uses the word 'cheetah'. The third paper's poem is an anagram of the four DNA base pairs: adenine, cytosine, guanine, and thymine. To communicate the cheetah's endangered status, made especially vulnerable by their restricted genetic variation, you write a poem titled "Can't Swim in This Gene Pool." You ask a friend to record a song with these lyrics, and it goes viral on Twitter, sparking a GoFundMe campaign.

Nature as Teacher/Researcher

This brings us to the idea of Nature as Teacher and Researcher. Wild Pedagogies outlines the theoretical (and some practical) applications in their book (Jickling et al., 2018), elaborated on in Chapter 9 of this thesis. What are the implications in science education, or, more specifically, the natural sciences? Ecology is a natural fit for experiential, place-based, nature-allied education. But what about geography, chemistry, physics or mathematics? These are, in fact, where the greatest shifts can occur.

Biophysical processes are the domain of the natural sciences, not inclusive of the three R's put forth by Kimmerer (2002, 2012)—respect, reciprocity, and responsibility. Given the climate crisis, the origins of the COVID-19 pandemic, and exponential human-caused species extinction, a recognition of our impacts on, and relationship with, the natural world are not only germane, but imperative to maintaining ecological integrity and a habitable planet for the countless species we take for granted, including our own. For every science experiment, the natural world should be honoured with a gift. When an ice core is sampled, a cell culture is taken, or a stream is surveyed, the glacier/organism/river is asked what can be offered in return (of course, initial consent must also be given). Active discussion on reconciliation needs to occur, where science, often in connection with the industrial-exploitative model, names the harms and

destructive actions it has carried out, and a clear path is laid toward conciliation of science, the land, and the biotic community.

Perhaps there is a path allowing "students to experience that 'being a scientist' and being 'someone who is on the side of people and the earth' are not mutually exclusive" (Kimmerer, 2013, p. 72). How many science students lose confidence in this educational path, as I nearly did, "because of the perception that science prohibits the expression of personal connection to nature" (Kimmerer, 2002, p. 438), and the requirement to push ethics and compassion aside in order to complete degree requirements involving dissection, fetal bovine serum, and animal experimentation? Evernden (1993) points out that university biology students "seldom encounter a living creature. The animal is replaced with abstractions" (p. 15). Yet, as Kimmerer (2016) writes, "Most of us scientists were drawn to our work not by the love of data but by love of the land" (p. 46). An approach that allows, even supports, compassion, empathy, and heart-centering will better equip knowledge-seeking scientists with ethical, ecoliterate, behaviour.

Example 1: You are a teacher in the Department of Earthly Gifts, formerly Natural Resource Management. For the land management unit, students spend a week on the land area in question, a stretch of old growth forest. They walk barefoot, draw a sound map, and write a poem composed of the sense experiences they had during this stay. You facilitate a stakeholder analysis for logging old growth that includes a Council of All Beings. One student represents a human, and all other students represent other species, the river, and the lake. The humans are asked to "*Be still for once and listen*" (Macy & Brown, 2014, p. 163). Each being is heard and voiced in equal measure, explaining their concerns, challenges, and gifts. A collective vote is made to not log the ancient forest. Ideas are generated on how best to honour and provide human gifts for the forest, such as carbon offset projects, wildlife corridors, selective harvesting, and buffer zones around riparian areas.

Example 2: You are a limnologist, a scientist specializing in streams and lakes. You are doing water quality assessments to determine the environmental impact of

repeated chemical spills into local waterways by a petrochemical company no longer in operation. Before you begin, you listen for the river's story: where it flows from, what biotic members receive the gift of its current, and where the waters reach their reservoir home. You listen and sense for the harm that was done here. At some point, you begin to feel that your own body is a part of the river, and that the river is a part of your body. On behalf of your species, you ask for forgiveness. You find areas where your sampling would be least intrusive, and listen for any objection from the river. After each sampling, you offer gratitude, and a gift of presence in return. When you are finished, you feel the river has taught you something valuable, something you find difficult to articulate. You turn to water colour and poetry to express what you're thinking and feeling, which is a natural response since the arts were integrated with your science training. But this does not feel like enough. You attempt to represent the river and lake through your artwork, share this with the public, and actively campaign to permanently end all future chemical spills.

Lab and Field-based Science

During the 20th century, science education was typically promoted for its instrumental value connected to industry. In the late 1800s, however, learning science (specifically in a laboratory) was linked to the development of personal virtue and moral character (Rudolph, 2020), and getting closer to god. The lab was where students could seek the one 'truth' "by moving students out of the living world into the highly controlled, sterile confines of the laboratory [where] the right kind of learning could occur" (p. 898). The lab environment—despite its synthetic design—was believed to be "the space where students and nature came into direct contact" (p. 898). Lab-based learning can certainly be experiential, hands-on, and practice-based. However, the fault in the logic here is that natural subjects, separated from the environments in which they are embedded, can still serve as reliable and complete substitutes. They cannot, and must be recognized as reductionistic and atomized stand-ins. To use a classic example, take a frog out of her pond, and place her dead body on a dissection tray, and the result is "arid, parched, and lifeless" (Mann, 1906, p. 197), a notion recognized over a century ago, and much lamented by Leopold. One option for dissections is for them to occur in the field, in

spontaneous fashion, when a suitable deceased specimen is stumbled upon during outdoor learning; certain locations and times of year provide this opportunity.

Lab-based science isn't going anywhere, and nor should it. Countless lab studies have improved our understanding of our world, our human bodies, and our climate crisis. Teaching and research in science labs leads to medical breakthroughs, allows us to source pathogens and develop vaccinations, and gives us technology that hastens communication and creative possibilities. Yet these are human benefits. How can lab science be ecocentric, and join the community members of the outside (field-based) world, to facilitate mutual flourishing of other-than-human and human alike? One option is to combine molecular studies with ecological and social considerations (see Example 1 below). Another is to re-embrace the natural history side of science, an opportunity to rekindle the moral growth once promoted for such education, but lost to industry interests, tighter budgets, and risk-averse liability concerns. Being in fuller relation with subjects of study, by studying them when they are still breathing, immersed in their native habitats, can elicit a more complex and profound learning.

Bekoff (2000) calls for a "holistic and heart-driven compassionate science" (p. 59) by "rewilding our hearts" (2014, p. 40). As respect and responsibility start to underscore science education, perhaps fewer animals—apes, other vertebrates, even cockroaches—will be used in medical and other experimentation. Substitutions might include cell culture lines that use synthetic serum instead of the ethically dubious fetal bovine serum (Beavington, 2020), human trials instead of animal trials that fail more than 95% of the time they are transferred to *Homo sapiens* (Akhtar, 2015), or a proactive, holistic lifestyle that relies on consistent nature experience and attunement instead of a reactive medical system that focuses on treating symptoms in isolation through prescriptions and surgery. Perhaps vivisection and wildlife trafficking (Goyes & Sollund, 2018) will end, and dissection will be replaced with intentional field studies and digital, as well as synthetic dissection models, that have proven more effective for student learning than using an actual once-living organism (Ledger, 2016).

The GPS ecocache I developed (Chapter 7), based on Jesse Jewell's innovative idea, also clings to anthropocentric forms. A human holds the device (i.e., a GPS unit), the sites to visit are mapped by a human (i.e., me), and the focus remains on the human experience. However, my hope is for this activity to offer a small step toward experiencing and understanding the larger local ecological communities. Such wayfinding won't lead to solutions for decolonializing and capitalism. Yet perhaps the subtle shift in perception, the attunement to the natural wonders around them, and contemplating the more-than-humans with which we share the world in a more mindful way could offer one step toward a life-sustaining society.

Example 1: You are teaching a cell culture lab. The cell line used is from *Cyprinus carpio* (common carp). The tissue sample was originally obtained from a commercial hatchery a decade prior. This cell line, maintained in the lab for ten years now, is used to study immunology, molecular biology, cellular physiology, and in vaccine production. Students are asked to research this species, which reveals that this carp was previously introduced to a nearby Okanagan lake. A field trip is planned to visit this habitat. At the lake, students wade into the water, sensing temperature, wave action, and the bottom substrate, though they aren't able to see any of the carp in the turbid lake waters. You brought a carp that's been kept in the freezer for some years. Students observe this specimen, and make three drawings: what they imagine the carp would look like in this aquatic ecosystem when this fish was (a) first introduced into this lake, (b) in the present, and (c) ten years in the future. With gratitude for this carp (despite its pest status), the lab work continues. Back at the lab, the cell culture is passaged (transferred into a new flask, and the old one thrown out), using an alternative to fetal bovine serum (FBS) as a growth medium, given that extraction of FBS from fetal calves was banned in 2028. Every time the carp cell line is passaged, the carp are remembered and honoured. Students reflect and collaborate on how cell culture could be less wasteful and more efficient.

Example 2: You are researching science education motivation. You observe a group of students engaged in lab-based study, and a similar group engaged in field-based study. Your qualitative study determines what factors led to higher motivation. You also

ask the more-than-human members for their input. What do they prefer? Do they consent? Next, students are asked to contemplate their respective learning environments. They imagine the experience of plants and animals in either environment, and draw specific environmental features that stand out to them. The lab students draw a microscope, a biohazard bucket, and a tree seen outside the window. The field students draw dewy moss, a moth caught in a spider's web, and a swamp lantern's flower. Students write down three sense observations. From this, they construct a collective poem, one for the lab, and one for the field. Being outside, the society feels larger than just humans. You conclude that, despite the increased cost and unpredictable nature of outdoor learning, that field-based studies offer increased learner motivation and a richer student experience. These students show higher curiosity, engagement, and more progressive and proactive attitudes towards biodiversity issues.

10.3. Limitations of this Work

Some may question using poetry in science education. Poetry is often seen as the domain of the elitist few. Many students do not write, or even read, poetry, but the lyrics of their favourite songs hold great meaning for them. Song lyrics are, after all, a form of poetry. A gently guided introduction to writing poetry, such as the leaf poetry exercise outlined in Chapter 3, can lead students to a greater appreciation of poetic expression.

Poetic inquiry is qualitative; it does not gather data on species decline, or analyze statistics on effectiveness of pharmaceuticals, or even teach us proper grammar. This is not the intention. Poetry is biased to the poet, to the reader, and to the world. But this bias can be well-imagined and tolerant of discriminations. Cultivating this creative force can be transformative for the poet, for the reader, and for the world. In the words of Carl Leggo (2016), who served on my PhD committee until he passed away in 2019:

> A poem can heal.
> A poem can teach us.
> A poem can show us the way.

The limitations of Romanticism and Goethean science were outlined in the introductory section of this thesis, and therefore will not be repeated here. Though a few concluding words from Goethe (2009) feel apt:

> Thus I have tried to be as clear and thorough as I could in presenting a view I find rather convincing. Nonetheless, the evidence may still seem insufficient, objections may still arise, and my explanations may sometimes not seem pertinent. I will be all the more careful to note any suggestions in the future… (p. 103)

Taking guidance from Goethe, I will now address such insufficiencies and explore future directions for similar scholarship.

Although this thesis focuses on science education, particularly the life sciences, many concepts and ideas are applicable in other areas. Environmental education is not limited to specific disciplines, but, like river to salmon or soil to roots, it is fundamental to mutualistic school curricula, inclusive of K-12 and post-secondary education. On a deeply cultural level, humans appear to be anti-environmental (e.g., rampant consumerism, the perpetuation of vivisection and factory farms, climate change apathy, complacency, or even denial) with lack of clarity regarding effectual environmental action (e.g., negative footprint illusions, compensatory green beliefs, quantity insensitivity). As Blenkinsop and Ford (2018) point out, "power-based hierarchies, consumptive economic systems, and damaging resource extraction methods" (p. 322) emerge even in creative, outdoor teaching settings. Minor shifts in pedagogy, or implementing activities such as the GPS ecocache, will hardly be enough to change this paradigm. A substantial re-envisioning of the educational system is in order.

After the academic walls are taken down, and the institutions disengaged from financial and corporate interest, the collective compost of capitalism, industry, art, science, and philosophy can be regrown as mycorrhiza. Interconnected, curious, a shared community whose sum is greater than the sum of its parts. My children have inherited an ecological deficit and a climate crisis that threatens their future. The next generation needs a curriculum rooted in the land, and land-based practices, team-taught with other-than-humans. To make this change obliges a foregrounding of environmental study and

local ecology such that science, art, health, languages, social studies—namely, any subject of this good earth, from which all subjects arise—are experienced as place-based and interrelated with the natural world.

Anthropocentrism has seeded many of our environmental problems. As long as humans perceive themselves as separate, and above, nature, the environment remains a backdrop that can be exploited to fulfill our species' ever-increasing demands for food, energy, timber, minerals, and water. These instrumental resources, lacking intrinsic value in and of themselves, are extracted at an astonishing rate. In this thesis, I have argued for a shift to ecocentrism, something akin to Blenkinsop's (2020) query: "What does intra-relationality and post-anthropocentric education look like when the humans are immersed in places where bear-ness, moss-ness, brook-ness, tic-ness, and chickadee-ness are still allowed to flourish on their own terms?" Other thinkers promote a shift to multicentrism that "envisions a world of irreducibly diverse and multiple centers of being and value—not one single circle, of whatever size or growth rate, but many circles, partly overlapping, each with its own center" (Weston, 2004, p. 25). This move away from geometrically-framed environmental ethics decenters the human, distributes power among multi-species, and incorporates more local decision-making. This requires further exploration, and ecofeminism, ecopsychology, and post-colonial work can offer much to this discussion.

Decolonization is another vital component of modern environmental education, which has not been addressed in this thesis. Although ecological science, Romanticism, delicate empiricism, and arts-based practices bear some affinities (and many incongruencies) with Indigenous philosophies, effective and principled decolonization requires engaging with Indigenous peoples and the land as pedagogy. Recognizing that the natural world is colonized (Blenkinsop & Ford, 2018) means acknowledging nature as teacher, engaging in community-based education, considering social and ecological justice issues, and reflecting on one's own identity, privilege, and our very notion of what it means to be human.

References

Akhtar, A. (2015). The flaws and human harms of animal experimentation. *Cambridge Quarterly of Healthcare Ethics*, *24*(4), 407–419. https://doi.org/10.1017/S0963180115000079

Aikenhead, G. S. (1997, September 22). Integrating the scientific disciplines in science education. [Conference presentation]. Gesellschaft fur der Chemie und Physik, Universitat Potsdam, Germany. https://education.usask.ca/documents/profiles/aikenhead/berlin1.htm

Beavington, L. (2020). Kidnapping children and calves (of a tender age). In S. Faulkner & A. England (Eds.), *Scientists and poets #resist* (pp. 35–42). Brill Sense. https://doi.org/10.1163/9789004418820_009

Beavington, L., Huestis, A., & Carson, K. (in-press). Ecology and colour in $1m^2$: A contemplative, place-based study. *Cultural Studies in Science Education*.

Bekoff, M. (2014). *Rewilding our hearts: Building pathways of compassion and coexistence*. New World Library.

Bekoff, M. (2000). Redecorating nature: Reflections on science, holism, community, humility, reconciliation, spirit, compassion, and love. *Human Ecology Review*, *7*(1), 59–67.

Blenkinsop, S. (2020). Teaching towards the post-human: The courage to entangle. *Studies in Philosophy and Education*, *39*, 453–457. https://doi-org.proxy.lib.sfu.ca/10.1007/s11217-020-09726-9

Blenkinsop, S., & Ford, D. (2018). The relational, the critical, and the existential: Three strands and accompanying challenges for extending the theory of environmental education. *Journal of Outdoor and Environmental Education*, *21*(3), 319–330.

Cressey, D. (2013). Best way to kill lab animals sought. *Nature*, *500*(7461), 130–131. doi:10.1038/500130a

Evernden, N. (1993). *The natural alien* (2nd ed.). University of Toronto Press.

Fredriksson, A., & Pelger, S. (2020). Conceptual blending monitoring students' use of metaphorical concepts to further the learning of science. *Research in Science Education*, *50*, 917–940. https://doi.org/10.1007/s11165-018-9717-8

Goethe, J. W. (1790/2009). *The metamorphosis of plants*. The MIT Press.

Goyes, D. R., & Sollund, R. (2018). Animal abuse, biotechnology and species justice. *Theoretical Criminology*, *22*(3), 363–383. https://doi.org/10.1177/1362480618787179

Haskell, G. H. (2020). The aromas of trees: Five practices. *Emergent Magazine.* https://emergencemagazine.org/story/the-aromas-of-trees-five-practices

Holdrege, C., & Talbott, S. (2010). *Beyond biotechnology: The barren promise of genetic engineering.* The University Press of Kentucky.

Januchowski-Hartley, S., Sopinka, N., Merkle, B., Lux, C., Zivian, A. Goff, P., & Oester, S. (2018). Poetry as a creative practice to enhance engagement and learning in conservation science. *BioScience*, *68*(11), 905–911. https://doi.org/10.1093/biosci/biy105

Jickling, J., Blenkinsop, S., Timmerman, N., & De Danan Sitka-Sage, M. (Eds.), *Wild pedagogies: Touchstones for re-negotiating education and the environment in the Anthropocene.* Palgrave Macmillan.

Kimmerer, R. W. (2002). Weaving traditional ecological knowledge into biological education: A call to action. *BioScience*, *52*(5), 432–438. https://doi.org/10.1641/0006-3568(2002)052[0432:WTEKIB]2.0.CO;2

Kimmerer, R. W. (2012). Searching for synergy: Integrating traditional and scientific ecological knowledge in environmental science education. *Journal of Environmental Studies and Sciences*, *2*(4), 317–323. https://doi.org/10.1007/s13412-012-0091-y

Kimmerer, R. W. (2013). The fortress, the river and the garden. In A. Kulnieks, D. R. Longboat, & K. Young (Eds.), *Contemporary studies in environmental and indigenous pedagogies* (pp. 49–76). Sense Publishers. https://doi.org/10.1007/978-94-6209-293-8_4

Kimmerer, R. W. (2016). Interview with a watershed. In N. Brodie, C. Goodrich, & F. J. Swanson (Eds.), *Forest under story: Creative inquiry in an old-growth forest* (pp. 41–51). University of Washington Press.

Ledger, R. (2016, April 10). Pet therapy: Virtual dissection offered as a humane alternative. *Vancouver Sun*. https://vancouversun.com

Leggo, C. (2016). A poem can: Poetic encounters. *LEARNing Landscapes*, *9*(2), 351–365. https://doi.org/10.36510/learnland.v9i2.780

Macy, J., & Brown, M. (2014). *Coming back to life*. New Society Publishers.

Mann, C. R. (1906). On science teaching. *School Science and Mathematics*, *6*, 194–197.

Marris, E. (2017). How to kill wild animals humanely for conservation. *Nature, 543*(7643), 18–19. doi:10.1038/nature.2017.21536

Meine, C. (2015, March 14). Teaching tomorrow's conservation leaders: Lessons from Aldo Leopold [Conference presentation]. 2015 National Science Teachers Association Conference, Chicago, IL, United States. https://www.aldoleopold.org/post/six-lessons-from-aldo-leopold

Nichols, M. D., & Petzold, A. M. (2021). A crisis of authority in scientific discourse. *Cultural Studies of Science Education*. https://doi.org/10.1007/s11422-020-09989-1

Petersen, C., Baepler, P., Beitz, A., Ching, P., Gorman, K., Neudauer, C., Rozaitis, W., Walker, J., & Wingert, D. (2020). The tyranny of content: "Content coverage" as a barrier to evidence-based teaching approaches and ways to overcome it. *Life Sciences Education*, *19*(2), 1–10. https://doi.org/10.1187/cbe.19-04-0079

Rudolph, J. L. (2020). The lost moral purpose of science education. *Science Education, 104,* 895– 906. https://doi.org/10.1002/sce.21590

Taylor, K., Gordon, N., Langley, G., & Higgins, W. (2008). Estimates for worldwide laboratory animal use in 2005. *Alternatives to Laboratory Animals*, *36*, 327–342.

Weston, A. (2004). Multicentrism: A manifesto. *Environmental Ethics, 26*(1), 25–40. https://doi-org.proxy.lib.sfu.ca/10.5840/enviroethics200426139

You, H. S. (2017). Why teach science with an interdisciplinary approach: History, trends, and conceptual frameworks. *Journal of Education and Learning*, *6*(4), 66–77. http://doi.org/10.5539/jel.v6n4p66

"Poetry and poetic inquiry dance an Argentinian tango in the heart's light."

~Carl Leggo, 2015

"More light!"

~Goethe's final words, age 82

Presence. Confidence. Heart.

Joy.