An Abstract of the Thesis of Kathryn M. Nock for the degree of Bachelor of Science
In the Environmental Studies Program to be taken June 6, 2017

Title:
RE-EXAMINING THE SCIENTIFIC REVOLUTION: THE ADVANTAGES OF ANALYSING THE HISTORY OF MODERN WESTERN SCIENCE IN CONTEMPORARY ENVIRONMENTAL DISCOURSE

Approved: _____, Dr. John Baumann

Descartes's famous declaration, "*I think therefore I am*," is one of the most referenced statements from the Scientific Revolution in 16th-17th century Europe. His words mark a turning point in science by exposing a new foundation for examining the natural world. However, his words imply that those we do not perceive as having intelligence- the ability to *think*- are *not* and places humans in a role far superior to our surrounding environment. Fueled by the Scientific Revolution, this shift in perception deepened the rift between humans and nature. Despite having roots in natural theology, the Scientific Revolution also encouraged the divorce of science from religion that endures today. I show that the changes that occurred in the two relationships continue to contribute to the current environmental crisis by reflecting the patriarchal, hierarchical, and anthropocentric- "human-centered"- nature of the paradigm of modern western science constructed by the Scientific Revolution. Furthermore, the immense shift in the way the masses understood their reality that resulted from the Scientific Revolution exposes the dynamic nature of cultural thought and provides evidence of the potential for a dramatic transition within the Western worldview to occur again. While there is extensive scholarship around this time in history, including numerous critiques of Cartesian philosophy and mechanistic science, an interdisciplinary analysis of the role that the history of science plays within the current environmental discourse is lacking. In response to claims made in Dr. Carolyn Merchant's *The Death of Nature*, contemporary scientific theories of ecology, plant intelligence, and mycological mutualism that directly combat Descartes's statement provide an opportunity to deconstruct the scientific hierarchies and assumptions of the past, to begin constructing the framework for the next shift in environmental consciousness.

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By:
KATHRYN M. NOCK

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Introduction

It was at the end of a lab meeting when an ecology professor, one of the leading investigators in the ecology lab I work in, casually made a comment that brought my entire interpretation of environmental science into question. She laughed and shrugged, seemingly unaware of the profound nature of her statement, as she commented that I had made a mistake in confusing environmentalists and ecologists. This lead me to wonder- how could one possibly be an ecologist and not be an environmentalist? This question soon lead to a larger one- how compatible is modern science with environmentalism?

The root to understanding the complexity of my boss's statements comes from examining the roots of modern western science and the role that they play in constructing the paradigm we use to understand the representation, responsibility, and expectation of science in the discourse around nature as the threats facing our environment grow in scale and caliber. This essay is an collection of resources that have been compiled and brought into conversation for the purpose of creating a platform or starting point for bringing together the history of modern western science, the conceptualization of science in the contemporary western world view, and particularly, the way both of these impact the way we perceive the relationship between humans and the non-human world.

The way science is interpreted- its purpose, its definition, and its capabilities- within contemporary western culture remains ambiguous and lacks a universal understanding even

within the boundaries of academia. The malleable definition of science is evident in the first volume of J. D. Bernal Cohen's *Science in History,* when he refers to it as both an ordered technique, yet also as rationalized mythology (Cohen, 18). Science has been credited for miraculous medical cures, but has also been used as an excuse for genocide and biological warfare. Additionally, science has unlocked the door to a deeper understanding of much of the workings of the universe and provided enormous amount of quantifiable evidence for climate change, but has this come without consequences?

In a world where peer reviewed scientific information has become something that has to be protested for in the streets, what expectations have we placed on science and what role does it play in our collective western epistemology? Science as "knowledge" as its Greek etymology suggests, or science as objective fact? Science as a weapon, or science as a cure? Science as the alternative to religion, or science as a religion in itself? Science as a savior from the threat of climate change? But what about science, western modern science in particular, as a *cause* of the current environmental crisis? During a period of catastrophic environmental degradation, it is necessary to re-examine the role science plays in the western culture and the role it plays within the current environmental discourse.

To address this challenge, I have compiled an anthology of literature from a multitude of disciplines that offer different perspectives within the conversation around understanding what has lead us to our current understanding of science in the west. They also examine the implications our current perception of science has on the way we interact with and study our environment. Additionally, they address how acknowledging the assumptions that are responsible for the construction of the paradigm of science we exist within today can be used as a tool to dictate the way we will understand, discuss, and teach science in the future.

This essay leans heavily on responding to Dr. Carolyn Merchant's examination of the crossroads of social issues, ecological theories, and the history of science. In *The Death of Nature- Women, Ecology and the Scientific Revolution*, Merchant notes the necessity of reexamining the values and philosophies upheld in the culture surrounding the birth of modern science. She acknowledgement that they encouraged the construction of a version of modern science that is patriarchal, anthropocentric, and hierarchical regarding the dynamic it creates betweens humans and the non-human world. On her accord it is, "by critically reexamining history from these perspectives, we may begin to discover values associated with the premodern world that may be worthy of transformation and reintegration into today's and tomorrow's society" (Merchant, xxiii). She claims that the Scientific Revolution of sixteenth-seventeenth century western Europe is a pivotal period for analysis due to its vast influence on the construction of the scientific paradigm that we exist in today and equates it with the "rise of modern science" (Merchant, 290). Historian Stephen Wootten supports the importance of the rapid change experienced by the educated elite during this period, and points out that it remained unmatched by any other time in history before the technological revolution of the twentieth century (Wooten, 11). Wootten articulates the lasting impacts of the discoveries of this transitional period when he writes:

"Since 1572 the world has been caught up in a vast scientific revolution that had transformed that nature of knowledge and the capacities of humankind. Without it there would be no Industrial Revolution and none of the modern technologies on with we depend; human life would be drastically poorer and shorter and most of us would live in unremitting toil. How long it will last, and what its consequences will be, it is far too soon to say; it may end in nuclear war, or ecological catastrophe, or (thought this seems much less likely) with happiness, peace, and prosperity" (14).

While specific discoveries during the Scientific Revolution will be referenced throughout this essay, the timeline of discoveries and equations in the centuries included are not the focus of this project. It is the cultural implications of what those advancements meant outside of the laboratory in the construction of the western worldview that are of greater interest in this inquiry. The philosophical values encouraged by the Scientific Revolution will be introduced and critiqued by Rosemary Radford Ruether, Fritjof Capra, and Peter Hay, in addition to Merchant and Wootten.

Alternative perspectives that directly oppose the paradigm of science that resulted from the Scientific revolution will be presented as a response to a request Merchant makes in the conclusion of *Death of Nature*. She claims that the exploration of decentralized and less hierarchical structures for science are only beginning to be acknowledged, and emphasizes that a sustainable future, along with human survival, depends on the integration of ideals around how science influences the way we interact with the environment (295). It is here that the bulk of my research lies- in introducing alternative ways for thinking about "science." Our interpretation of modern western science must expand and evolve into a paradigm that endorses a new set of values that are less discipline specific, less anthropocentric, and less mechanistic.

James Lovelock's Gaia Hypothesis, Stephen Harrod Buhner's questioning of scientific hierarchies through allotting agency to non-human organisms, Suzanne Simard's research on plant communication, and Stefano Mancuso's work on plant intelligence, suggest that there are different way of thinking about the natural world that are compatible with environmental values. The way scientific revolutions occur and intellect progresses will be examined using Thomas Kuhn's, *The Structure of Scientific Revolutions,* along with the work of Margaret Osler.

Additionally, the question of if “modern” science even exists will be brought into question by Bruno Latour.

Another introductory note I would like to express is the number of assumptions that this paper is performing under. When trying to deconstruct the complexity of ideas I have laid out, I have consciously chosen to make a number of generalizations regarding the terms *we, western modern science,* and especially *the environment*. *We* refers to the collective body of westerns participating in a society largely influenced by capitalism, technology, and Christianity. *Western modern science* refers to the paradigm of science following the Scientific Revolution. Despite the controversial argument surround the term, in this essay, *environment* refers to the natural world humans are surrounded by.

The goal of this essay is a deeper understanding of the role science plays in the western worldview in hopes of foreseeing the way that role will change in the future as our lifestyles are forced to change as a result of the changing climate. In addition, I would like to strongly acknowledge the complexities and depth of each idea introduced. Each is worth a lifetime of study on its own behalf. In no way do I wish to present the Scientific Revolution as the only, first, or most important moment in scientific history, nor as a model that all intellectual revolutions occur within.

This exploration excludes an adequate record of scientific achievements in the traditional East by only referencing the central concepts of Eastern philosophy by contrasting them with those of the West. In addition, this essay fails to appropriately address the class, gender, and racial determinants of who has historically been allowed access to formal contributions and publications in the natural and physical sciences. It is specifically the environmental consequences of western science, in opposition to indigenous or eastern, that this essay explores.

Lastly, this work will take the assumed understanding of the historical connection between women and nature. Extensive scholarship exists on ecofeminism, many of which are acknowledged throughout this paper including Merchant and Ruether. Through history, women and nature have been exploited simultaneously at the extend of the progression on the middle-class white man (Merchant, 75, Ruether, 330). Merchant articulates that due to the patriarchal and stereotypical label imposed upon both throughout history and the liberation of both is interconnected as is their past (Merchant, xxi).

The Birth of Modern Western Science

Only through examining the formation of a worldview and scientific paradigm that dictates the domination of both women and nature can we fully understand the roots of our current ecological crisis (Merchant, xxi). It is necessary to examine the Scientific Revolution as more than just a turning point in the history of science, but in the context of the history of the western worldview as a whole including science, religion, and philosophy. Historians generally agree that the period sanctioned as the "birth of modern science" begins with the Copernican revolution 1543, and concluded with the discovery of Newtonian physics in 1678- the later being a discovery referred to by Wootten as, "the end of the beginning" (Wootten, 5). Though the emphasis of this essay is not the particular discoveries that occurred in the science, to understand the cultural and philosophical impacts, a general, though in this case greatly simplified, timeline must be understood.

Throughout the Middle Ages, Western Europeans maintained a relatively stable cultural understanding of the way their world functioned that was strongly upheld by the Catholic church (Wootten, 70). The canon of science preserved Greek and Roman concepts surround truth, logic and reason as pillars of scientific understanding (70). As the Renaissance developed in the 12th

century, advancements that were made in botany and anatomy drew the doctrinal passivity of the past into question. This reconsideration elevated to a larger scale when Nicholas Copernicus (1473-1543) began to study heavenly bodies that inspired conclusions regarding the way the universe functioned that were in direct opposition to the beliefs upheld by the Catholic church (104). The Catholic church relied on Aristotelianism, geocentrism, and the Bible to construct their understanding of reality (61).

Upon the arrival of the 17th century, Francis Bacon's philosophy of empiricism and inductive reason was in full-swing of constructing the parameters of what would eventually become the modern scientific method. An understanding of the telescope, Rene Descartes' advancements in mathematics, and Johannes Kepler's (1571-1630) discoveries about planetary motion allowed Galileo Galilei (1564 1642) the tools he needed to grant the heliocentric theory the evidence it needed to be accepted among physicists. Galileo's discovery directly opposed the teachings of the Catholic church and resulted in his famous conviction of heresy in 1633 (280). The work of Kepler and Galileo largely influenced Sir Isaac Newton (1643-1727) whose discoveries surrounding the functions of the universe made obtainable through calculus, and Newtonian Physics is often seen as the finale of the Scientific Revolution (212, 380).

Merchant highlights that its significance lies in the Scientific Revolution's classification as "the crucial period when our cosmos ceased to be viewed as an organism and became instead a machine" (xx). There was a radical paradigm shift based on the discovery that Earth was not the center of the universe, and that our planet was constricted to the same set of natural laws as all planetary bodies. The church was no longer the only source of explanation of truth, the observation and manipulation of nature now told a more complex and quantifiable tale (Wootten, 460).

"Fathers of modern science"

Merchant suggest that the lasting effect of the time period surrounding the Scientific Revolution can be accomplished through the reevaluation of the people often attributed as the "fathers of modern science" (xxi). Though Newton, Galileo, Kepler, and Copernicus, among others, are all undoubtedly essential players in the transition toward the world of methodological science, it is a title most often attributed to Sir Francis Bacon (1561-1626) and René Descartes (1596-1650) due to their lasting influence in both western science and western philosophy (Merchant, xxi, Ruether, 194). Both men were religious, and abided by the principles of natural theology- the use of science as a method for getting closer to God by closely examining His creation (Wooten, 460). However, it is their contributions to the scientific method, that is still used today, in which they are most often accredited and critiqued.

Deconstructing the writing of men as influential as Bacon or Descartes is troublesome in understanding the balance of the positive and negative influences of their work. On one hand, Bacon was a leading supporter of inductive science that emphasized observation, experiment, hypothesis formation, and the ideal that there is much to learn by verifying "the truth for themselves, the truth of science, by reading nature's book" (Merchant, 164). While Bacon's contribution to inductive, methodological science has had a profound effect on the way science is practiced allowing great progress in understanding climate systems, curing disease, among other valuable discoveries, these benefits did not come without a cost (165).

His pro-nature notion is aggressively undermined by his belief of both women and nature as features that must be "tamed" (169). Bacon used the link between women and nature, exemplified in his common reference to "nature's womb" or to matter as a "common harlot", as a tool to embrace his new scientific knowledge as a way to further the image of humans being in

control of the natural world (165). In an essay published in 1603 titled, “The Masculine Birth of Time,” Bacon wrote that nature must be “bound into service,” made a “slave,” put in “constraint” and “molded” by the mechanical arts (169). In “Thought and Conclusions on an Interpretation of Nature,” Bacon wrote that the purpose of technological advancements of man were to “help us think about the secrets still locked in nature’s bosom” (169). He implies that the mechanical advancements made possible by modern science differed those of the past by providing “ the power to conquer and subdue her [nature], to shake her to her foundations” (172).

Rather than interpreting nature as a book of truth, Descartes is more famously recognized for presenting nature as a machine (Merchant 192, Hay 126, Capra, 8). This understanding produced version of science known as “mechanistic reductionism.” Mechanistic reductionism functions on the assumption that nature can be understood through breaking something into pieces and developing an understanding of how each piece functions. Reductionist science endorses the belief that the knowledge of how each part functions is equivocal with understanding the functioning of the whole, and is often critiqued by ecologists who claim that the capacity of the whole is far greater than the sum of its parts (Merchant, 193, Hay 127, Capra 8). In “Animals as Automata,” of *Discourse on Method,* Descartes makes clear that the mechanistic functioning of nature leaves it lacking of the capacity to carry out cognition, emotion, and devoid of the powers of sensation (Hay, 125). This implements a firm divide between the capabilities of humans and of non-human organisms (125).

This dichotomy is an example of Cartesian dualism- a concept most familiar as the division between mind and matter (Capra, 9). When Descartes’ conceptualization of nature as a thoughtless, emotionless, and feelingless machine is brought into partnership with the dualism between mind and matter, the environmental implication become impossible to ignore. When

Descartes claims “mind vs matter” while operating under the assumption that humans are the only organisms possessing a mind, he is essentially claiming “humans vs nature.” This further implies that humans exist in a separate state of reality and consciousness than that of the environment we are surrounded by, and constructs a hierarchy with human beings at the top. The division created between mind and matter creates a distinction between the thinking subject and the objective reality surrounding them which Hay claims to be a pillar of the framework within which western science has developed (125).

Both a philosopher and a mathematician, Descartes’ mind vs matter dichotomy is embodied by his famous dictum of, “Cogito ergo sum” - “I think therefore I am” (Capra, 8 Hay, 127). Despite the large amount of criticism Cartesianism has received from environmentalists, its influence remains evident (Hay, 122). *I think, therefore I am* directly implies that if *I don't think, I am not,* and endorses the belief that humans are both separate and superior to the rest of nature. Within Descartes’s mechanistic philosophy, it is assumed that if one is not human, then they are intrinsically less valuable and are thus lower on the hierarchy of life. Capra’s criticism of Cartesian philosophy is evident when he writes:

“The natural environment is treated as if it consisted of separate parts to be exploited by different interest groups. The fragmentation view is further extended into society, which is split into different races, religions, and political groups. The belief that all these fragments- in ourselves, in our environment, and in our society- are really separate can be seen as the essential reason for the present series of social, ecological, and cultural cris. It has alienated us from nature and from our fellow human beings. It has brought grossly unjust distribution of natural resources, creating economic and political disorder; an ever-rising wave of violence both spontaneous and industrialized, and an ugly polluted environment in which life has often become physically and mentally unhealthy” (9).

As Capra implies, the extent of Cartesian dualism transcends the relationship between humans and nature in early western modern science by additionally influencing the relationship between humans with other humans and between science and other disciplines (Hay, 126). Hay

writes that the fragmented epistemology that is a consequence of Descartes's philosophy of reductionism is responsible for the belief that "science has become the only acceptable form of knowledge in modern industrial society" (126). Furthermore, he claims that this "fragmented view of the world," in addition to the overwhelming faith and dependency placed on science for our understanding of how the world works, is the central factor of the current ecological crisis (126).

The desire surrounding the Scientific Revolution to classify nature as something separate from humans, is matched by the desire for extracting quantifiable information about the inner workings of nature. The emphasis of measurability, objectivity, repeatability, and predictability is known as positivism and its origin is closely linked to Cartesianism (Hay, 143).

The Western World View In Comparison

To understand the relationship between science and the western worldview, we must step back and determine how this way of perceiving the world is defined. In this essay, the western worldview is defined as a set of parameters for understanding the world based upon principles of capitalism, individual identity, competition, Christianity, mechanistic science, and "progress." As we look back through western history, the current environmental crisis seems less and less mysterious as it is observed that western culture endorse the same patriarchal and anthropocentric values that are present throughout the history of modern western science. This definition is heavily centered around the way Richard Nisbett defines the western worldview in contrast with the traditional worldview of the East in *The Geography of Thought*.

Nisbett lays a comprehensible framework for observing the differences between the two general worldviews. This difference is articulated by one of Nisbett's grad students as the

difference between seeing the world as a circle and seeing the world as a straight line (xi). By this he means that in the east time is understood as a circle, constantly recycling itself and interacting with its surroundings, while in the western worldview time is interpreted as a line progressing forward toward a greater outcome (Nisbett, 48). He references phycological research done in universities around the world that support the dramatic difference in the nature of thought processes between easterners and westerners (3). Nisbett claims that westerner's focus attention to the agency of the individual agency, in contrast to the eastern idea of group harmony (5). He summarizes the life experienced by westerners as, "a simpler, more deterministic world; they focus on salient objects or people instead of the larger picture; and they think they can control events because they know the rules that govern the behavior of objects" (xii). This view is in alignment with the paradigm of science endorsed by the Scientific Revolution.

Nisbett provides historic accounts of eastern thought being traced back to Confucius, and Western thought stemming from the writings of Aristotle (9,12). He claims that many attributes of the opposing contemporary worldviews have resulted from the separation of their pasts. Controllability of the environment, assuming stability of situations and characteristics, organizing the world in accordance to categories, relying on logical rules to interpret events, and approaching contradictions in an "either this or that" manner are all cultural tendencies he equates with westerns (45). An alternate list of habits more likely to upheld by the eastern tradition includes an increased likelihood to detect relationships between events, assuming situations and characteristics to change periodically, organizing the the world in accordance to relationships (45). Nisbett's work accomplishes the goal of illuminating the differences between tendencies of the eastern and western way of thinking and exposes the involvement of Cartesian dualism within the western worldview (295).

However, the presentation of Eastern philosophy as a more holistic and ecological alternative to that of the West, excludes the philosophy, tradition, and knowledge of North America's indigenous communities. "Western" thought is a misleading term, due to its exclusion of the philosophy occurring the geographic "west" while typically only encompassing the ideology born in Western Europe. The traditional indigenous knowledge from the collection of tribes inhabiting the Americas before European colonization provides a worldview and lifestyle in considerable opposition to those originating in Western Europe and are indispensable in addressing the current environmental crisis. An addition to Nisbett's work a large variety of literature comparing eastern and western ideology exists, but this familiar comparison excludes many influential philosophies of indigenous communities from the America's as well as around the world.

In *God is Red*, indigenous scholar Vine Deloria Jr. develops a framework for comparing not just east vs west but west vs west as well- meaning the worldview of Western Europe vs the accumulation of beliefs from North America's indigenous communities. Deloria is quick to critique Abrahamic religion- a large influence within Western culture- as he compares its temporal nature to the spatial nature of indigenous thought (Deloria, 73). By shifting the dominant religion to one based on space rather than time, "the universality of truth becomes the relevance of the experience for a community of people, not its continual adjustment to evolving scientific and philosophical conceptions of the universe" (80). This implies that worldviews based on communal experience rather than a linear progression of events don't face the same challenge of disruption from new scientific discoveries or controversies because they don't have the same pressure to withhold their reliance on historical events (82). The ability to incorporate new scientific discoveries into a belief system allows it to remain compatible with

environmentalism as our epistemologies and lifestyles are forced to change. Deloria articulated this when he writes:

"In our present situation, we therefore face a most difficult question of meaning. Ecologists project a world crisis of severe intensity within our lifetime, whereas the religious mythologies projecting the existence and eventual salvation of another world had better be correct in the beliefs. It is becoming increasingly apparent that we shall not have the benefits of this world for much longer. The imminent and expected destruction of the life cycle of world ecology can be prevented by a radical shift in outlook from our present naïve conception of this world as a testing ground to a more mature view of the universe as a comprehensive matrix of life forms. Making this shift in viewpoint is essentially religious, not economic or political" (290).

The Western Worldview and "Progress"

The Cartesian divide between subject and object is a large component the what is considered the western worldview, but its influence is matched by currents of capitalism, individuality, monotheistic religion, and of particular interest, the idea of "progress." In this sense, the western obsession with progress reflects the attention paid to the importance of constant moving forward in a linear manner toward some sort of improved end goal. The dependency the west places on progress has been highly critiqued by many environmental scholars and remains an influential component to the discourse concerning the roots of the current ecological crisis.

George Sarton, the founder of the American History of Science Society believes that it is in the study of science however that illuminates the true progress of humankind (Wootten, 512). While acknowledging critics of the belief in scientific progress like Thomas Kuhn, philosopher John Gray, in a section of book titled *Against Progress and Other Illusions,* claims that "progress within science is fact" (512). Gray supports this by pointing out that advances throughout the different disciplines of science that accelerated the Scientific Revolution directly resulted in a list of new inventions that have vastly influence the quality and longevity of human lives. He uses

the connection between scientific progression and the Industrial revolution as an example (513). Kuhn offers a different approach and believes that there is no such thing as progress in science and that it can only be understood in evolutionary terms (513). To Kuhn, science progresses on its own terms and only so long as the paradigm it exists within survives (Kuhn, 160).

Bacon firmly supported the relationship that growth and progress share with the study of the mechanical arts through scientific invention (Merchant, 179). Merchant reiterates the relationship between Bacon's perspective on scientific progress as a catalyst for the origins of a capitalist society when she writes, "the Baconian program, so important in the rise of western science ,contained within a set of attitudes about nature and the sciences that reinforced the tendencies toward growth and progress inherent in early capitalism" (185). Merchant explains that one of the most influential marks left by the Baconian program of the seventeenth century is the correlations his successors upheld between the mechanical commercial interests and the domination of nature (187).

Alternative Perspectives

The developments of the Scientific Revolution provide evidence of radical transitions in the way the masses perceive their reality, yet has contributed to an epistemology that endorses patriarchy and reductionism (Merchant, xx). The request Merchant makes in the conclusion of *The Death of Nature* rejoins the conversation as we examine an assortment of theories that oppose our current paradigm by deterring anthropocentrism, mechanistic reductionism, competition, and quantifiability. Lovelock, Buhner, Simard, and Mancuso share a common understanding of the controversy that comes along with questioning historically upheld assumptions about the hierarchies within the natural science (Simard, 41, Buhner 110, Mancuso, 21, Lovelock, 31). Addressing these concerns leaves two options- seeking alternative ways of

understanding how science functions, or looking within our current paradigm for the potential to make science more compatible with environmentalism.

Lovelock's Gaia Hypothesis is commonly referenced as one of the most radical alternatives to the framework of science stemming from the Scientific Revolution. His theory presents the earth as one interconnected self-regulating organism (Lovelock, 8). Lovelock claims chemical and geological evidence supporting "the entire range of living matter on Earth, from whales to viruses, and from oaks to algae, could be regarded as constituting a single living organism" (Hay, 136). This theory directly combats Cartesian theory by exposing the capabilities of the "whole" as being far more complex and capable than of the sum of each individual species (Hay, 136). Lovelock reiterates this when he writes:

"We, as scientists, had become so used to thinking in terms of cause and effect that we no longer seemed to realize that the whole could be greater than the sum of its parts… The Earth self regulates its climate and chemistry so as to keep itself habitable and it is this that is the sticking point for many, if not most, scientists. Such a conclusion could never have come from reductionist thinking, and that is why arguments with biologists and others over Gaia have been so acrimonious for so long" (Buhner, 132).

While his work provides an alternative lens for understanding the way the world functions and how humans should function within these systems, it has been met with criticism for being the work of mystics due to its inability to be modeled (Lovelock, 34). Harvard geochemist H. D. Holland wrote that he found the hypotheses "intriguing and charming", but "ultimately unsatisfactory" (Lovelock, 32). Lovelock acknowledges this criticism by suggesting that his critiquers may also be at fault. Lovelock believes that the type of reductionist scientific inquiry that has been used in the past is not compatible with the future of the Gaia hypothesis. He claims that many of is critics fail to acknowledge that large influence that living organisms have on the evolution of the geochemistry of our planet (33). He reminds his readers that the

chemistry of the atmosphere is a result of the photosynthesizing organisms, and how many geological assets like chalk and limestone were once components of the shells of living organisms in the ocean (34). He summarizes this by writing,

"Life is not adapted to an inert world determined by the dead hand of chemistry and physics. We live in a world that has been built by our ancestors, ancient and modern, and which is continuously maintained by all things alive today…. The evolution of the rocks and the air and the evolution of the biota are not to be separated" (34).

Lovelock does not see his work as a spiritual mission, but rather as an alternative, yet scientific, way of thinking about the evolutionary processes of the earth (Lovelock, 5). In *The Ages of Gaia*, Lovelock comments on the nature of science by exposing one of the main questions that inspired his work- "Can we as scientists do better do understand life?" (Lovelock, 20). Regardless, the science and philosophical holism that have been inspired by the Gaia Hypothesis are largely beneficial for reconstruction the way we think about environmental science (Buhner, 137).

Stephen Harrod Buhner, the senior researcher of the Gaia Foundation, supports Lovelock's theory and believes in the sentience and intelligence of individual non-human organisms despite their lack of a brain (Buhner, 94). He opposes the strict parameters placed around modern science and writes extensively about how uncomfortable welcoming theories of the Gaia Hypothesis and non-human intelligence can be for "brain chauvinists" because it teaches us that having the capacity to think with a brain in the way that humans do and having intelligence aren't synonymous (94). When we consider the roles of ecological function and species shape, it becomes evident that interpreting a brain as a critical enabler for intelligence is an inaccurate perception (94). In fact, he explains that due to the sessile growth pattern of many plants, and the common risk of predation, having a centralized brain would be an evolutionary disadvantage (Mancuso, 34).

The idea of non-human intelligence forces humanity to give up the idea that it is special and forces us to accept that plants, fungi, and bacteria are all equally as "evolved" as humans (Buhner, 132). He articulates his point when he writes:

"It undermines any claim to specialness on our part; it simply makes us one of many, held to the same constraints as any life form on the planet. It undermines not only the human specialness articulated in many religions but also the belief in our specialness that permeates all Western science" (142).

Unlike Western culture, "Gaia does not use top-down control over the parts that make up the whole" (139). In opposition to top down power structures, most ecosystems could almost be categorized in working from the bottom, up (138). In this case, "the bottom" acknowledges some of the tiniest, yet most powerful, organisms we are surrounded by and especially those that live out of sight, like the fungi and bacteria residing in the soil underground.

Buhner supports his theory with the example of of bacterial intelligence (101). He accomplishes a detailed explanation of the inner workings of bacterial communities including their social structures, ability to mutate around antibiotics, ability to transmit information beyond their own genus, as well as their ability to manipulate their own DNA (102). According to Myra Hird, a professor of the sociology of science at Queen's University, "bacteria are Gaia's fundamental actants" (131). The perspective of the actors responsible for sustaining the circle of life as microbes living beneath the feet of humans direct opposes the anthropocentric pyramid in which humans have remained at the summit since the sixteenth century.

Science writer, Valerie Brown considers the newly acquired knowledge regarding bacteria as a "terminal blow" to the previously conceived notion of humans being separate and superior to all other inhabitants of the biosphere (94). The accomplishment of this theory is in asking the Western epistemology to reconsider what we consider "matter" and how we allot

agency in the natural world. The inner workings and capabilities to bacteria, fungi and plants, suggest that their capabilities are underrepresented, and understudied (95). Buhner claim that this is a result of the controversy that non-human agency places on the hierarchy of nature that is present in the paradigm of science originating from the Scientific Revolution (Buhner, 96).

This controversy not only lies in the assault of the hypothesis on the historical hierarchy of nature, but in assaulting the Christian concept of believing the beginning of human life started in Eden (Ruether, 49). Ruether calls into question the common interpretation of the beginning of human life coming beginning in a luscious, thriving, and fertile garden (Ruether, 49). Despite the interpretation of Genesis as fact or as fiction, it devalues the interconnectedness between humans and world of plants and fungi. Ruther exposes that in the failure to acknowledge the toxic atmosphere and ultraviolet radiation that more accurately describe the origins of our planet. We have also failed to acknowledge the miraculous role that bacteria, fungi, and plants (the organisms often given the least attention in the modern framework of science) have played in allowing human life to begin. Only through processes of plant evolution, like cellular respiration and nitrogen fixation, could the atmospheric conditions develop into the "Garden of Eden" where much of western culture understands to be the origin of life (49). Ruether elaborates by writing:

"Our utter dependency on green plants is made evident when we realize that plants are creators, not only of the food chain that supports all animals, but also for the generation of the breathable atmosphere. The sun and green plants together have been the major creators of the conditions for life as we know it" (49).

The complexities of the relationship between modern science and environmentalism are further illustrated by the realization that it is the scientific method presented by Bacon and Descartes that has opened the door to a deeper understanding of the complex relationships within ecological science, including much of the evidence supporting the Gaia Hypothesis. This

suggests that this discussion includes not only the values endorsed by the Scientific Revolution, but also the way the paradigm for science that resulted from that period dictates what disciplines of science have received, and not received, the most attention.

The Under-representation of Mutualism

The amount of attention paid to mutualistic relationships within and between species is far less than the amount allocated to competition between them. Judith Bronstein, a professor and ecologist at University of Arizona, has done extensive research and writing on the importance and under-representation of the principles of mutualism in hopes of addressing this imbalance. In her article, "Our Current Understanding of Mutualism," she acknowledges that:

"Mutualism studies have not focused on mutualism as a form on interaction. Research on antagonistic interactions commonly attempts to quantify reciprocal effects and then to extrapolate to their ecological or evolutionary dynamics or both. In contrast, researchers have treated mutualism primarily as a life history attribute of one of the two partners" (33).

Bronstein believes that mutualisms have primarily been considered and studied from the unilateral perspective of one of the species involved (40). It is infrequent that the benefits and costs of all impacted species are considered at the same time (40). This is likely due to the difficulties posed by constructing equations that take all other factors and species into consideration beyond predator and prey. In other words, relationships that are beneficial for different reasons to both species involved are challenging to quantify. Quantifiability was a pillar of the Scientific Revolution, and thus concepts that are harder to measure and model have continued to receive less attention.

In an inquiry she carried out regarding the representation of mutualism in scientific publications, she found that within twelve common introductory ecology textbooks, 29.9 percent

of the pages were dedicated to predation, 38.1 percent of the pages taught about competition, and only 6.6 were devoted to mutualism (32). Bronstein acknowledges three potential hypotheses to explain, “why mutualism has nevertheless been viewed as fundamentally unimportant” (32). She postulates that it could be grounded in cultural biases, taxonomic biases, or that it could be purely based in the lack of excitement value provided by good ol’ fashioned teamwork (32).

The development of the Lotka-Volterra equation exemplifies the challenge of quantifying mutualism which likely holds responsibility for the lack of attention it has historically received. This equation is used frequently in intro level ecology courses and is essential to the understanding of relationship between predator and prey abundance within an ecosystem. At the beginning of the nineteenth century, Alfred J. Lotka and Vito Volterra both independently released their conclusion of an equation regarding the relationship between consumption and predation within species interaction, leaving out, though likely unintentionally, the role of mutualisms. The equation is intended to expose the relationship between two animals, one acting as predator and one acting as prey, but not factoring in any additional abiotic factors. In terms of writing an accurate and inclusive equation, Lotka and Volterra would have approached major obstacles incorporating mutualism accurately because the impacts on either species can be direct or indirect and are often far from quantifiable.

The emphasis on competition in modern science remains dominant despite Charles Darwin himself endorsing the importance of interconnectedness within and between species. In *On the Origin of Species,* Darwin writes extensively about ecological mutualistic relationships being equally as advantages as competitive ones. In fact it is principles of Darwin's research that inspired Earnest Haeckel's establishment of the discipline of “ecology” (Keller and Golley, 9). Darwin lays out a clear framework of the importance of interactions between organisms in regard

to evolutionary advantageous traits, when he writes,

"Owning the to the struggle for life, any variation, however slight and from whatever cause preceeding, if it be in any degree profitable to an individual of any species, **in its infinitely complex relation to other organic beings** and to external nature, will tend to the preservation of that individual, and will generally be inherited by its offspring" (Darwin, 55).

Darwin's publications provide the fundamental groundwork for the way evolutionary theory is understood, making reexamining key passages from his work essential for better understanding why mutualism is underrepresented in scientific literature as well as within the western world. Darwin clearly acknowledges both the role of advantageous traits being passed on to offspring, as well as the complicated relations between species of all kingdoms. That being said, why are his theories about mutualism so wildly overpowered by the competitive notions of "the struggle for life" and "survival of the fittest?"

Ruether concludes that terms like "survival of the fittest" have been popularized to promote a society based upon competitive individualism that is indicative of western culture (57). She comments that the dualistic belief in the "other" is often misunderstood to mean the "enemy," rather than the more accurate perception of the non-human organisms we are surrounded by as a community in which humans deeply depend on for our own lives (57). She warns that this "false ethic of competition" leads to an alternative version of mutualism, one that is dangerously destructive for all involved (57). The scholarship discussed suggests that the study of mutualism and interconnectivity between species is incompatible with the patriarchal, anthropocentric, and hierarchical pillars of the contemporary paradigm of western modern science. The role that ecology plays within environmentalism will be discussed in further sections.

The Agency of Plants

Beyond the challenge of quantifying Darwin's ideas on interconnectedness, it is the same paradigm of science that has resulted in Darwin's research on the plant intelligence, sense-organs, and agency being additionally overlooked. Since 1880, his publication of *The Power of the Movement of Plants* has been cast aside by fellow scientists as a collection of less important "secondary discoveries" (Balsuka et al. 2009, 1112, Mancuso, 21). Buhner claims, with the support of evolutionary biologist Frantisek Baluska, that this is a consequence still occurring today as a result of the discomfort that plant intelligence or agency places on reductionism (Buhner, 110, Balsuka et al, 106). Balsuka also supports Darwin's claim that plants are far more like animals (or that animals are far more like plants) than we often acknowledge and that science associated with such concepts must no longer be viewed as pseudoscience (Balskua et al, 110).

Darwin's two main claims about the intelligent capabilities of plants include a parallel between the animalia brain and the tip of a plant root, and the sensory ability of the tip of the root to navigate through the soil it resides in (Buhner, 111). Darwin's comparison between plants and animal is articulated when he writes:

"It is hardly an exaggeration to say that the tip of the radicle . . . having the power of directing the movements of the adjoining parts, acts like the brain of one of the lower animals; the brain being seated within the anterior end of the body, receiving impressions from the sense organs and directing the several movements" (Darwin, 263).

A growing amount of research has been carried out regarding plant communication, sensory abilities, and intentional movement in the century following Darwin's publication and continues to draw the Cartesian perspective into question (Buhner, 112). Embodied by the Gaia Hypothesis, the study of the interspecies mutualism of plant agency that Darwin endorsed presents a drastic alternative to the existing belief of plants as passive and sessile organisms with

the only purpose as being the accumulation of photosynthetic products (113). Within the Gaia Hypothesis' symbiotic relationships- relationships where both actors benefit in the form of an exchange- that exists between an interconnected network of fungal mycelium among plant roots allows the "neighborhood" of plants, bacteria, and fungi to be a "self-organized whole that, in itself, possess capacities not perceivable in any of the parts" (112). As members of this sophisticated network, the species involved have the capacity to communicate continually through sending chemical signals, and transfer nutrients to other members of the plant community (125).

The agency of plants is supported through their ability to communicate with each other through an underground network referred to by mycologists, including Suzanne Simard, as the "wood wide web." Simard, a forest ecology professor at University of British Columbia, has spent her life working to understand the way trees communicate and transfer carbon (among other forms of nutrients) to each other through the network of mycorrhizal associations formed between their roots (Simard, 43). She compares birch trees and fir trees to yin and yang as they trade off transmitting carbon to whoever has a greater need at a given moment (43). Simard comments on the opportunity her results provide for seeing forest tree species not as competitors but as co-operators (44). Her evidence supports the existence of an entire unfamiliar world happening within the soil and invites us into the world of mycorrhizae, a word literally meaning, "root fungi."

In opposition to autotrophic plants that make their food, fungi are heterotrophs like humans, meaning that they must "eat" or absorb their nutrient-rich food which is done through the decomposition of the organic matter they are surrounded by. By colonizing a plant's root system, the fungi increase the surface area of the roots allowing valuable nutrients like

phosphorus and nitrogen that have been absorbed or “eaten” by the fungi to enter the vascular system of the plant providing nutrients to their entire structure (40). In return, the mycorrhizal fungi receive high-energy carbohydrates from the plant it is associated with (42). Along with providing nutrients between the tree and the fungi, the mycelium (small, fibrous threads created by the fungi for reproductive purposes) create a dense web intricately twisting and connecting nearby plants and trees through the soil allowing for communication as well as the transferring of nutrients.

Simard explains that the realm of non-human capacity to communicate and cooperate is far greater than what was understood by scientists in former decades. She notes that mycelial communication and plant intelligence have existed far longer than humans have been around and has been happening right beneath the soft soles of our rarely bare feet. A striking image she constructs involves the relationship reaching from grizzly bears to conifers. She summarize the interconnectivity of forest organisms through the following tale in a recent interview for National Public Radio: a grizzly bear pulls a salmon from the river, eats a couple bites and leaves the rest of its body on the forest floor. Fungi and bacteria in the soil break down the fish and the nitrogen (among other nutrients from the fish) is consumed by the fungi. The fungi is an active participant in the mutualistic relationship with the tree roots allowing the nutrients to be transferred from the fungi to the tree in exchange for carbohydrates in return provided by the tree. The scale of the interconnectivity Simard referenced comes when she claims that she hes data supporting that in certain trees up to 75% of the nitrogen in them comes from fish.

The purpose of this essay, however, is not to illuminate the inner chemical structures of the plant kingdom, but rather to emphasize that the implications that this sort of research has on cultural understandings of both nature and science are notable. The explanation of

interconnectivity not only between plants, but between entirely different kingdoms of life, further endorses holistic thinking similar to that of Lovelock's Gaia hypothesis. While listening to the awe of the interviewer as Simard was explaining her research in a recent National Public Radio interview, the vast misunderstanding, and misrepresentation of the way science is represented to the average citizen was illuminated. This suggests that altering the way science is taught to people of all ages has the potential to drastically redirect the way we interpret and interact with our surrounding environment. Simard comments that her evidence may "inform a paradigm shift in our understanding of terrestrial ecosystems as complex adaptive systems" (40).

Dr. Stefano Mancuso, a founder of the study of plant neurobiology, makes cultural and scientific observations about plants, calling many assumptions of the Scientific Revolution and the way we interpret modern science into question. In *Brilliant Green- The Surprising and Brilliant History of Plant Intelligence,* Mancuso asks pointed questions about the relationship between humans and plants from why there weren't any plants on Noah's ark in the old testament, to asking why no one ever seems to consider Charles Darwin a botanist (12). In addition to referencing Darwin's publication about plant movement, Mancuso analyses the Greek idea of the soul within an individual (15). In *De Anima*, Aristotle wrote, "There are two distinctive peculiarities by reference to which we categorize the soul: local movement and sensing" (13). Mancuso suggests that if we could prove plants to have both of these characteristics, we would begin to be able to break down the Greek hierarchy of nature that places plants just barely above stones (18). He explains that plants expose control over the way they move through both flowering and phototropism- the ability to move or change position to maximise access to light (47). He also provides the example of the physical responses experienced by *Mimosa pudica,* who folds up their leaves at night and to reduce movement

which occurs when their exposed leaves interact with the touch of a human, animal, or fellow plant.

Each of these scholars contribute to the same conversation about conducting and interpreting biological research in a way that doesn't align with the mechanistic and reductionist paradigm in place since the Scientific Revolution. In addition, they agree upon the obstacles they have faced in their funding, research, and credibility due to the controversial nature of their status-quo questioning interests. Non-animal intelligence has faced tremendous criticism exemplified by Yale molecular biology professor, Clifford Slaymen, who blatantly stated, "plant intelligence' is a foolish distraction, not a new paradigm" (8). Despite criticism, the scholars I've introduced continue to question the assumption of isolation, competition, and the "every man for himself" mentality. They provide more holistic approaches to understanding how systems and communities function without assuming the superior nature of humans. Buhner writes about the necessity of abandoning the linear, and replacing it with more perceptual and holistic approaches to interpreting the natural world and I find it safe to assume his contemporaries would agree (154).

As we conclude discussion of current theories of interconnectedness and non-human intelligence I would like to comment briefly, for clarity's sake on the complicated relation they share with the original perceptions of modern science. The knowledge presented here is the result of the scientific method in action. Each conclusion is the result of inductive science-forming hypotheses, designing a repeatable procedure, and finding a way to quantify results. In this sense, the influence of the Scientific Revolution plays an enormously positive role in better understanding the way our biosphere functions. I wish in no way to belittle the contributions that exist within the history of western science. It is the social and cultural assumptions that resulted

from the historic perspective of the mechanistic operating system of the natural environment that these scholars, in addition to myself, call into question. This complex dynamic summits in the discussion around the field of ecology.

The Debate on Ecology

For many critics of western modern science, the establishment of ecology as its own field of science has been presented as the solution to the anthropocentric and mechanistic science of the past (Hay, 129). It was my assumption of this belief that was so startled by the comment distinguishing environmentalists from ecologists that my boss made. As a long term researcher and instructor in an institute dedicated entirely to ecology, her clear understanding that not all of ecology is carried out under the same principle of environmentalism exposes the complexities of the issues and clarifies the need for further elaboration.

Ecology is a discipline of life science that stresses the importance of relational dynamics within and between species and looking at ecosystems an interconnected " whole" (Hay, 131, Ruether, 48). Hay presents ecology as a study of the "means" of science that threatens the "ends-based science that is implicit in a science of fragmentation" (Hay, 131).

Critiques of ecology as a solution include the belief that though it stresses the importance of holistic thinking, it still grew from biology, and because of this falls into the problematic idea that the solution to the problem can not come from within the establishment in which the problem has arose (Hay, 133). Ruether provides the example of the mechanistic language used by conservation ecologist, Paul Ehrlich (Ruether, 58). Despite his recognition for presenting a warning about population growth with limited natural resources granting him many ecological awards, he titled his most popular book *The Machinery of Nature- The Living World Around Us and How it Works* (58). This represents the tendency that ecology has to remain mechanistic and

thus operates under the problematic framework of science stemming from the Scientific Revolution.

The mechanical nature of ecology has been further recognized by Thomas W. Schoener in his essay "Mechanistic Approaches to Ecology: A New Methodology?" To a certain extent, developing an understanding of an ecosystem, or anything for that matter, often comes from simplifying parts of it in order to understand how they work together. Shoener argues that this is not the claim that is up for debate, it is the complexities and analysis required to understand what the pieces mean that differs between reductionists and holists (188). He explains that the desire to construct a quantifiable method with acceptable inclusion of both behavior and physiology variation among species, the complexity of the model would make it "analytically opaque" (190).

Like "science," "ecology" has a definition and responsibility that is equally as convoluted. There are some ecologists who have claimed offense when their practice is seen as an alternative to the traditional version of western science, for it makes their research appear less credible, and associates them ("ecologists") with "a rag tag collection of naturalists, poets, small-scale farmers, and birdwatchers who constitute a visible part of the ecology movement." (Hay, 132). This feeling among many practicing ecologists has only intensified by the association between biological ecology and social ecology starting in the 1960's (132). A tenuous relationship persists, according to Hay, between the "ecology movement" often synonymous with the "environmental" or "green" movement, and those who see themselves a scientists of what they call "ecology proper" (133).

The concept of "deep ecology" exemplifies the crossroads between ecology as a science, and ecology as a social phenomenon. It's origin comes from Arne Naess' belief that the facts and

logic associated with the scientific study of ecology are not enough to answer ethical questions about how we should be living and interacting with the environment (Keller, 206). deep ecology opposes the preservation of ecological health for the use of mankind in the future and blends science and sociology. It is referred to be Naess as "not a slight reform of our present society, but a *substantial reorientation of our whole civilization"* (Naess, 45).

Despite the hesitation many scientists feel about the correlation between ecology as a science and ecology as a social movement, Ruether further emphasized that ethical currents are embedded within the study of ecology regardless (47). She claims that a suggested set of guidelines for the way humans should be interacting with nature is an inherent quality within ecology. Fritjof Capra advocates for ecology when he claims that the fear of not being scientific enough can not be allowed to keep scientist away from such an essential field of study (71).

Western Science and Western Religion

The observations illustrated by Mancuso expose that no discovery occurs in a vacuum, and science can not be separated from other intellectual disciplines. By introducing the roles of non-human organisms in the Old Testament, Mancus has introduced the complex dynamic shared between science and religion. While western science is a discipline that stemmed out of Abrahamic religion, the two are understood to be opposing ideals (Sacks, 8). Osler examines the relationship between the Scientific Revolution and Christianity. She claims that it was ironically through the use of natural theology to demonstrate the existence of God that the separation between science and theology was formed (Osler, 49). By the end of the seventeenth century scientific knowledge had reached the highest rank of authority over Christianity, whose reign had been left unquestioned since the Dark Ages. (Osler, 50). The strict belief in God upheld by many of the key players in the birth of modern western science, especially that Newton, must not be

overlooked. Despite his correspondence with skeptics of creationism, Newton frequently guarded and defended the story of Genesis (50).

The relationship between science and spirituality is further explored by Cambridge scholar and rabbi, Jonathan Sacks. In *The Great Partnership- Science, Religion, and the Search for Meaning*, Sacks elaborates on the cohesive roles throughout history that has been shared between science and religion as paths for bringing "meaning" to human life (Sacks, 3). According to Sacks (who often cites Nisbett's work), humans live with a goal of creating a worldview that makes sense to us and has the potential to bring meaning to this strange, troubling, joyful attribute we call life (23). Sack's thesis is that science and religion are both critically important in the search for "meaning" and are not mutually exclusive despite the division between them experienced in the twenty-first century. The division between the two stems from the separation of disciplines that occurred as a result, but not an intention, of the Scientific Revolution. It must be understood that a divorce of science from religion was not the intent of the founding fathers of modern western science. I have supported the earlier claim that the creation of modern western science is a direct result of the quest for a deeper understanding of God.

Despite his religious background, Sacks firmly believes that both science and religion are of equal importance and necessity. He explains their compatibility when he writes, "science is about taking things apart to see how they work and religion is about putting things back together to see what they mean" (2). The relationship that he believes is shared between spirituality and rationality is further exemplified by the following passage:

"Science is about explanation. Religion is about meaning. Science analyzes, religion integrates. Science breaks things down to their component parts. Religion binds people together in relationships of trust. Science tells what is. Religion tells us what ought to be. Science describes. Religion beckons, summons, calls. Science sees object.

Religion speaks to us as subjects. Science practices detachment. Religion is the art of attachment, self to self, soul to soul. Science sees the underlying order of the physical world. Religion hears the music beneath the noise. Science is the conquest of ignorance. Religion is the redemption of solitude. We need science explanation to understand nature. We need meaning to understand human behavior and culture" (6).

Sacks offers a compelling and almost facetious critique of neo-Darwinism which has been largely on the rise in the past century. Sacks comments that if the determining factor of reproductive success is based on natural selection, then the wide spread influence (and pure quantity of followers) of Abrahamic religion for the past four thousand years should inspire all neo-Darwinists to immediately leave atheism behind and become a religious convert (8).

As a Rabbi and Cambridge scholar of Judaic studies, it is no surprise that Sacks offers such an in-depth argument in favor of the role of religion. Aside from his argument for the cohesion and necessity of both religion and science, Sacks proposes that, "the cure for bad religion is good religion, not no religion, just as the cure for bad science is good science, not the abandonment of science" (11). If an error was noticed in a scientific publication, let's say in one about physics, that came out decades ago, no one would say, "Get rid of it at once! Since we were wrong one time we must never study physics again!" A good scientist would say, "That's what we understood back then with the information we had, but now that we see that our evidence was problematic, let's re-evaluate our understanding with the new information we have." Why should it be any different when it comes to the role of religion?

Sacks believes that we have constructed a worldview in the west where considering everything as the way it is simply because "it is" and "has always been that way" has become a logical and pragmatic way to perceive the world. This way of thinking doesn't allow for the possibility of change in the way we perceive our surroundings in any way, let alone through

natural science.

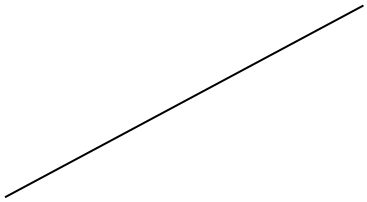
According to Sacks, in terms of handling the current environmental crisis, this essentialist mindset removes the possibility of progressing toward a different way of living or perceiving the world (28). Atheism suggests that everything simply "is what it is because it always has been," and has a tendency to imply that this is the way that everything will always be. Believing in some sort of overarching power coming from outside the system allows one to believe that things are not the way they are "supposed" to be, and thus could and should be different (18). To begin constructing a plan for how to change the status quo, Sacks calls for "genuine, open, serious, respectful conversation between scientists and religious beliefs if we are to integrate the different but conjointly necessary perspectives" (15).

Physics and systems theorist Dr. Fritjof Capra articulates the connections between spirituality and science in *The Tao of Physics* by drawing parallels between modern physics and eastern mysticism. Capra affirms many of Nisbett's observations and argues that despite their differences, they unexpectedly can lead us to two similar views of the world (Nisbett, 4, Capra, 5). Capra also writes about the capacity the human brain has for two different types of knowledge- rational and intuitive (14). He explains that traditionally, rational thought has been associated with science and intuitive thought with religion (14). He shows that the impact of occurrences within modern science transcends the work of scientists and reaches many aspects of culture.

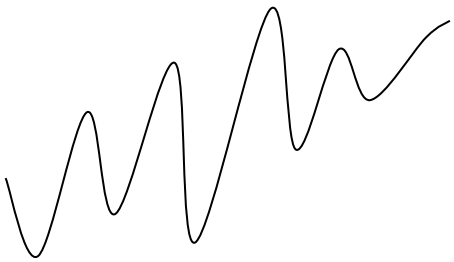
Many agree that a science with no moral boundaries or ethical parameters leads to catastrophe (Sacks, 144). Sacks and Capra suggest that reconsidering the relation between science and religion as mutually important counterparts is compatible with a less-destructive scientific paradigm.

Scientific Paradigms

The use of the term “scientific paradigm” has been frequently used throughout this essay and is a direct reference to the work of Thomas Kuhn as a method to consider the way scientific knowledges developed over time. The concepts introduced throughout this paper all suggest the need for a change in the way we think about science, or what Kuhn would call a “paradigm shift” (Kuhn, 85). Despite the appropriation of this term throughout the many disciplines in academia, Kuhn coined the term in his book, *The Structure of Scientific Revolutions,* for the purpose of articulating the nature of how scientific knowledges changes over time. In opposition to the Whiggish structure of history that preceded him, Kuhn believed that science didn’t progress linearly and teleologically toward an ultimate understanding of truth (48). Whig historiography upholds the assumption that knowledge and the human experience is constantly and inevitably moving in a linear fashion toward an ultimate sense of truth or enlightenment. Kuhn argues that this is incorrect by highlighting the occurrence of scientific revolutions.



Progression of Whig History



Progression of Kuhnian History

To Kuhn, a scientific revolution occurs in phases (10). The first of these phases is "normal science" (10). The role of normal science is to preserve a general perspective between scientists on what types of experiments should be performed, and the models or methods that should be followed to solve them (35). Kuhn uses the term "paradigm" to categorize this concept of a consensus worldview where models, problems, and experiments are expected to produce outcomes that fit within the parameters of the current paradigm. In other words, inquiries are expected to behave in ways that the current paradigm (or current version of normal science) allows scientists to believe is possible.

The next phase occurs when the tools provided within normal science become inadequate or the outcomes don't fit into the current paradigm (40). He explains that such "anomalies" arrive on a spectrum of severity (53). Some anomalies are handled by a new equation or a new discipline, however some anomalies are so destructive that they lead to a "crisis" and force scientists to abandon or radically modify current theories (66). As the accepted theory is replaced or modified, it is not until a new tradition shattering theory has been accepted widely and a new "normal science" has arisen that a scientific revolution has occurred (6). Kuhn uses the term "incommensurability" to further clarify that a scientific revolution is different than incremental change since the theory within the new paradigm and that of the old are incompatible. Kuhn explains this process when he writes:

"The invention of other new theories regularly and appropriately evoke the same response from some of the specialists on whose area of special competence they impinge. For these men the new theory implies a change in the rules governing the prior practice of normal science. Inevitably, therefore, it reflects upon much scientific work they have already successfully completed. That is why a new theory however special its range of application is seldom or never just an increment to what is already known" (7).

Margaret Osler enters a similar dialogue as Kuhn in her anthology, *Rethinking the Scientific Revolution*. Osler argues that the shift away from the philosophy of Aristotle marks the Scientific Revolution as a tipping point that separates science as we understand it today from the "natural philosophy" that preceded it (4). Osler reiterates Kuhn's criticism of Whig history by explaining the flaw in thinking of the, "history of science as the unfolding of ideas by the force of their own, internal logic" (6). Cohen writes that the work of Kuhn is of fundamental importance for, "reorienting the thinking of scientists and historians about science, converting them (or marking them mindful of) the notion that revolutions are a regular feature of scientific change" (xviii).

Osler notes the importance of avoiding analysis of historical figures within our current intellectual paradigm (7). The importance of understanding the contexts in which the actors and ideas of the Scientific Revolution occurred suggests that the same principles should be applied to contemporary science. An alternative historiographical strategy can be applied by asking questions like those suggested by Osler: Why were particular figures attracted to one idea or another? How does the way they ask their questions affect the use they make of ideas they borrow? Why do they ask particular questions in the way that they do? (6). These are the exact same questions we ought to be asking now.

When we talk about the potential for a paradigm shift away from modern science as we understand it today, it is reconsider what is meant by "modern.". Latour asks us to consider if science, or society in general, has even been modern in the first place. In *We Have Never Been Modern* he defines modernity as the process of separating nature from culture (47). He then undermines that by claiming that the hybrid society of politics, nature, technology, and culture is evidence that the separation between nature and culture that we associate with modernity is an

impossible accomplishment. He offers global warming, rainforest deforestation, and the depletion of the ozone as “hybrid” obstacles that support his notion that there is no such thing as “modernity” because it is impossible to keep environmental issues boxed away from cultural ones (47) .

Conclusion

While saying “the next scientific revolution” or referring to “postmodern science” seems like a rather lofty assumption, it is worth considering what the transitions we are experiencing in science, philosophy, and technology will look like centuries from now. The criticism and concepts discussed in their paper from Merchant, Wootten, and Kuhn suggest the importance of critical approach to trying to determine the cultural, and specifically scientific, roots of the current environmental crisis. This collection of perspectives and voices provides evidence that the way science has been considered since the Scientific Revolution is at odds with environmentalism, at least in part.

What the collection of alternative perspectives suggests is that we need to broaden our interpretation of the role, responsibilities, and expectations of science within both the western epistemology and the current conversation regarding the environment crisis. There are components to modern science that are unarguably important tools for addressing the ecological crisis, however the belief of science and a static practice of objective facts must be reviewed. Environmental philosopher, John Passmore supports this by writing, “western science is still fecund, still capable of contributing to the solution of the problems which beset human beings; even when those are the problems of the scientists own making” (Hay, 125). This implies that it very well could be western modern science that is at fault for much of our current crisis, but reshaping its role could aid in the solution.

Creating a space for considering the troublesome values involved in the formation of modern western science is a necessity in the discourse around causes and responses to environmental issues. The study of science must be interdisciplinary as it is the consequence of discipline specificity and isolation that we are experiencing right now. In *The Two Cultures and the Scientific Revolution*, C.P. Snow articulates the importance of studying the Scientific Revolution from the perspective of both the humanities and of the sciences. He explains the opportunity that presents itself through the combining of disciplines, and the consequences of failing to do so, by writing,

"..at the heart of thought and creation we are letting some of our best chances go by default. The clashing point of two subjects, two disciplines, two cultures- of two galaxies, so far as that goes- ought to produce creative chances. In the history of mental activity, that has been where some of the breakthroughs came. The chances are there now" (17).

While the developments within the history of science have had profound impacts on contemporary western society, both negatively and positively, an additional contribution of the time period is the evidence it provides for the dynamic nature of human thought. This period of radical and rapid shift in perception around the workings of the natural world exposes that the parameters of the western worldview are unlikely permanent. As the climate continues to change, the western lifestyle will also inevitably change, and the worldview that progresses along side it will evolve as well. Whether the construction of a new paradigm is intentional or unintentional lies in our depth of understanding the factors at play in the one that already exists. While the role science has played in the construction of our current paradigm is of great importance, the role we create for science to play in the future, meaning the responsibilities and expectations we construct for it will determine the way humans interact with the non-human

environment for centuries to come.

While many communities seem to be under the impression that their vague interpretation of “science” will save us from the consequences of our overexploitation of natural resources, a deep understanding of the role of modern science in contemporary science is critical. The anthropocentric version of science presented as a tool to expand man’s dominion over nature will not save us, of this I am certain. However, a new science with the same respect for accountability and peer-review, but that embraces the value of mutualism along with equality between species and genders rather than patriarchy and anthropocentrism might be able to. This doesn’t mean casting aside the scientific method or inductive reasoning in entirety, it means looking at the future of modern western science as a dynamic force that reflects the values and ambition of the cultural views of its scientists. Buhner writes, “the future belongs to... those who are willing to be humbled, who don’t mind, such humbling opens the doors of perception onto a world that is much different than most scientists will admit” (134).

There is reason to argue that the future of science lies not only in the way it is practiced, but in how it is taught. Bronstein's research about the lack of balance between the textbook presence of competitive species interactions and mutualistic ones provides evidence of this claim. Theories pertaining to interconnectedness in opposition to the anthropocentric lens that presently exists must begin in elementary science education. I am confident in my belief that a child who develops into a teenager aware of the fact that each conifer needle they pass on their way to school has the capacity to contain over 800 species of endophytic fungi, protecting it from pathogens and disease in exchange for nutrients, that young person is setup to interact with the natural world differently and develop a more holistic and interconnected perspective of their place within it. The same can be said of a teenager that grows into the adult with an equally

thorough understanding of the interconnectedness of species, the agency of plant movement, in addition to the concept of the "survival of the fittest."

We must admit that something about the role of science has gotten a little off track in the western world. It got a little too specialized, a little too simplified, and a little too stuck in its ways. The goal of this exploration has been to begin creating the platform for understanding "where we are now" in understanding how our perception of the influence of "science" within contemporary society, and specifically in understanding the role it plays in how we relate to and interpret our environment. This work suggests that we need to insure that the expectations and responsibilities we place on modern western science are compatible with those of environmentalism to create a paradigm of science where ecology is synonymous with environmentalism. Science is about asking questions and seeking a deeper understanding of how how our world works. In doing so, there are important questions that must be asked that might not be able to be answered in laboratories: Why do think about science the way we do? What if we're thinking about it wrong? And most importantly, how we think about it differently?

Works Cited

Balsuka, F., Volkmann and D. Menzel. "Plant synapses: Actin-based domains for cell to cell communication." *Trends in Plant Science.* 10 no. 3, 106-111. 2005.

Balsuka, F. S. Mancuso, D. Volkmann, and P.W. Barlow. "The root-brain Hypothesis of Charles Darwin: Revival after more than 125 years." *Plant Signaling & Behavior.* Vol. 4, No. 12 (1121-1127) 2009.

Bronstein, Judith. "Our current understanding of mutualism." *The Quarterly Review of Biology.* Vol. 69, No. 1 (31-51) 1994.

Buhner, Stephen Harrod. *Plant Intelligence and the Imaginal Realm.* Bear and Company. Rochester, Vermont. 2014. Print.

Capra, Fritjof. *The Tao of Physics*. Bantam Books. Boston. 1984. Print.

Capra, Fritjof. "Turning of the Tide", *ReVision*, 16, 59–72. 1993. Print.

Darwin, Charles. *On the Origin of Species by Means of Natural Selection, Or, the Preservation of Favoured Races in the Struggle for Life*. London: J. Murray, 1859. Print.

Darwin, Charles, Francis Darwin. *The Power of the Movement of Plants.* London. J. Murray. 1880. Print.

Deloria Jr., Vine. *God is Red.* Grosset & Dunlap. New York. 1973.

Hay, Peter. *Main Currents in Western Environmental Thought.* 120-153. UNSW Press. Sydney. 2002.

Keller, David R. "Deep Ecology." *Encyclopedia of Environmental Ethics and Philosophy.* 206-211. *Macmillan Reference.* USA. 2008.

Keller, David R, Frank B. Golley. *Philosophy of Ecology- from Science to Synthesis*. University of Georgia Press. Athens. 2000.

Latour, Bruno. *We Have Never Been Modern.* Harvard University Press. 1993. Print.

Logan, Robert K. *The Alphabet Effect- The Impact of the Phonetic Alphabet on the Development of Western Civilization*. William Morrow and Company Inc. New York. 1986.

Mancuso, Stephan. *Brilliant Green-The Surprising History and Science of Plant Intelligence.* Island Press. Washington D.C. 2015.

Merchant, Carolyn. *The Death of Nature- Women Ecology, and the Scientific Revolution.* HarperCollins Publishers. New York. 1989.

Naess, Arne. ‘‘The Shallow and the Deep, Long-Range Ecology Movement: A Summary.’’ *Inquiry: An Interdisciplinary Journal of Philosophy and the Social Sciences.* 16: 95–100. 1979.

Nisbett, Richard E. *The Geography of Thought: How Asians and Westerners Think Differently and Why.* New York Free Press, 2003. Print.

Osler, Margaret. *Rethinking the Scientific Revolution.* Cambridge University Press. USA. 2000.

Ruether, Rosemary Radford. “Ecofeminism: Symbolic and social connections of the oppression of women and the domination of the environment.” *This Sacred Earth- Religion, Nature, Environment.* Rutledge. New York. 1996. Print.

Ruether, Rosemary Radford. *Gaia and God: An Ecofeminist Theology of Earth Healing.* HarperCollins, San Francisco. 1992. Print.

Sacks, Jonathan. *The Great Partnership: Science, Religion and the Search for Meaning.* Schocken Publishing. 2011.

Schoener, Thomas W. “Mechanistic Approaches to Ecology: A New Reductionism?” *The Philosophy of Ecology.* University of Georgia Press. Athens. 2000.

Simard, Suzanne et al. “Mycorrhizal networks: Mechanisms, ecology and modelling.” (39-58) *Fungal Biology Review- British Mycological Society.* 2012.

Snow, C.P. *The Two Cultures and the Scientific Revolution. The Rede Lecture 1959.* Martino Publishing. New York. 2013.